Green Infrastructure Stormwater Management Options in an Ultra-Urban Redevelopment

Sandy Doyle-Ahern
sdoyleahern@emht.com

NEXTGENERATIONGREEN
sustainable solutions that make business sense EMH&T™

- The City of Columbus' Downtown Business Plan was developed in 2002 with the goal of revitalizing the downtown area for the Bicentennial Celebration in 2012.

- The revitalization of the district will see the creation of a dense, mixed use urban neighborhood.

- The development plan for the district includes a mixture of condominiums, lofts, and apartments at multiple price points.

- Neighborhood retail is planned for the district to support the influx of residents.

- Government offices and civic buildings will bring workers and visitors to the district.

- A significant challenge in the development of the RiverSouth district has been inadequate infrastructure to meet the needs of a high density, mixed use neighborhood.

- Existing waterlines and sewers are at or beyond their life expectancy and do not contain the additional capacity required to support the revitalization.

- Most roadways in the district are one-way, which in general tend to experience higher traffic volumes, higher speeds and larger free-flow speeds than an equivalent two-way road.

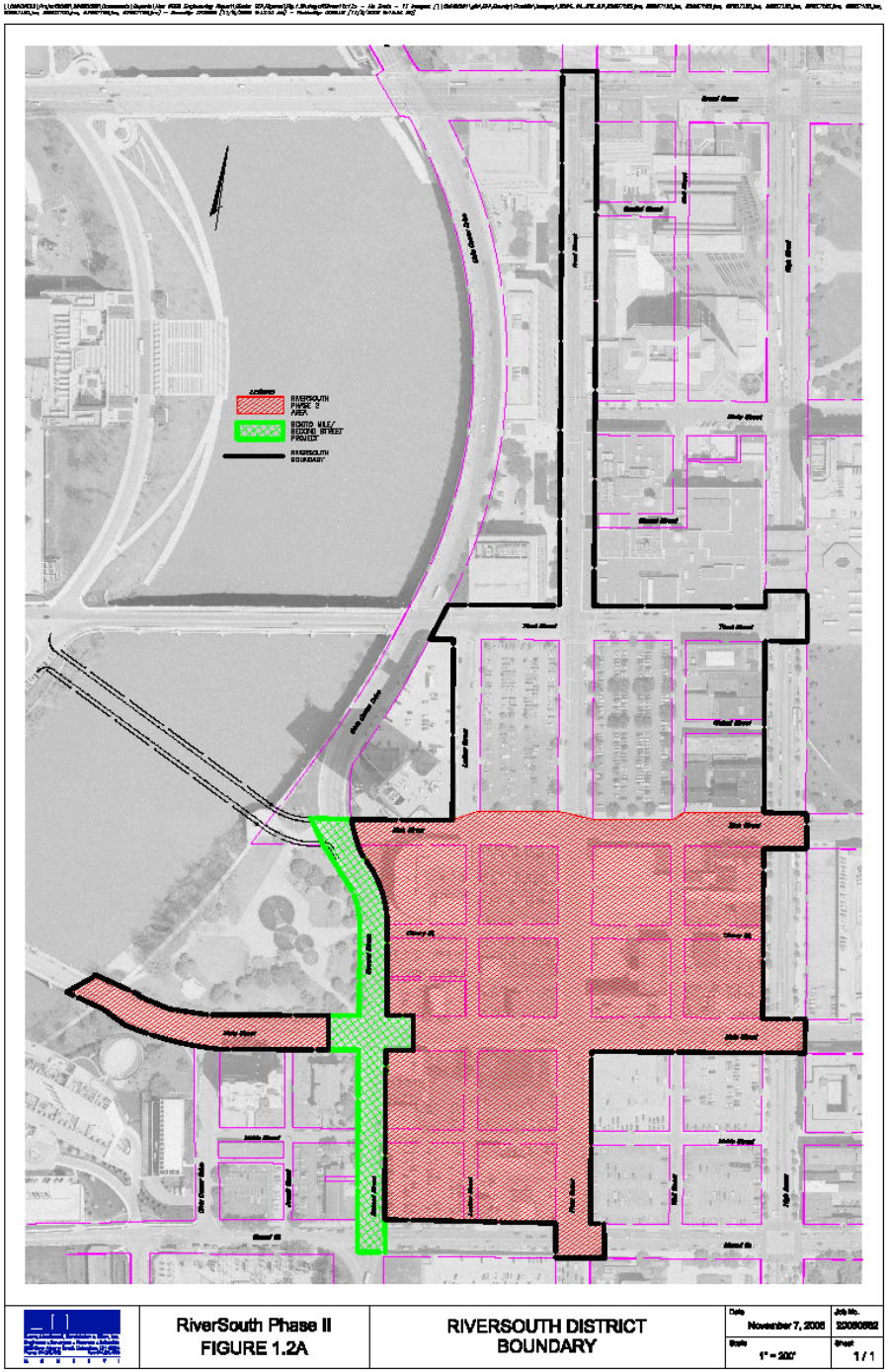
- While the existing roadway network performs well in conveying peak hour traffic demands, it has the adverse effect of creating an inhospitable environment for residents, workers, and shoppers during all other hours of the day.

+ The RiverSouth District consists of approximately 39 acres.

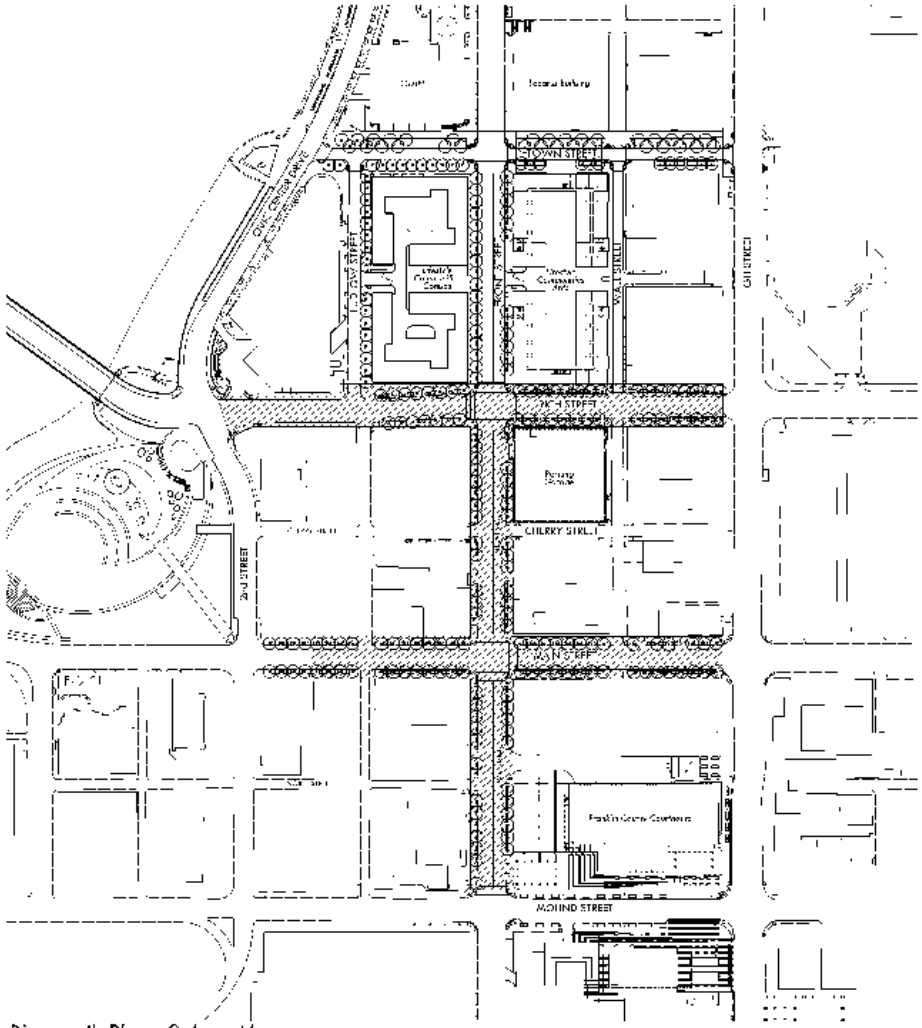
+ The area currently does not have stormwater quantity or quality controls and is drained by a mix of combined sewers and storm sewers.

+ With redevelopment, combined sewers will be disconnected and all stormwater will drain directly to the Scioto River.

+Stormwater quantity and quality controls are required for redevelopment projects as defined in the City of Columbus Drainage Manual.



Water Quality Summary



Riversouth Phase 2 Area Map

Water Quality Summary

Phase II River South R/W: 4.81 acres

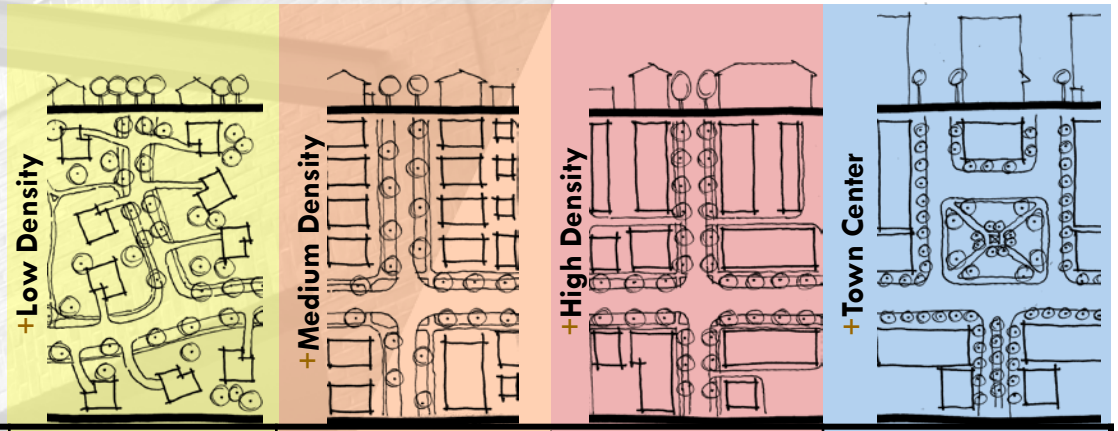
Treatment Requirement:	*20%*
Required treatment Area:	*.96 acres*

EPA Classifications:	*Ultra-urban*
	Tributary to 4th Order Stream
	Redevelopment

The EPA requires that 20% of the area be treated for water quality or a 20% decrease in impervious area or some combination of the two.

Additional widening on the south side of Main Street between the Main Street bridge and Civic Center Drive may be performed. Alternative geometrics are being prepared for review by Public Service. If this widening is required, an additional 0.1 acre of disturbance shall be added to the calculations presented above.

Stormwater Management Options by Density



+Best Management Practice (BMP)	+Low Density	+Medium Density	+High Density	+Town Center
Bioretention / Rain Garden	■	■	■	■
Detention (Dry Basin)	■	■		
Detention (Wet Basin)	■	■		
Detention (Underground Storage)			■	■
Vegetated Swale	■	■		
Manufactured Systems			■	■
Pervious Pavement			■	■
Stormwater Wetland	■	■		
Vegetated “Green Roof” System			■	■

Low Impact Development Controls

Permeable Pavement – unit pavers, concrete or asphalt systems designed for storage, conveyance, and treatment of stormwater.

+ Lower life-cycle costs versus concrete or asphalt
+ Upfront capital costs are higher
+ Infiltrate up to 400 inches per hour
+ Construction sequencing very important

+Photo by Greg McKinnon from Puget Sound Online

Low Impact Development Controls

Bioretention – includes Rain Gardens, using landscaping and soils for water quality and quantity control.

+Indianapolis, IN

+ Reduces runoff volume, metals, nutrients and thermal impacts of runoff
+ Can look identical to traditional landscaped areas
+ Landscaping costs can be higher than traditional site for native plants

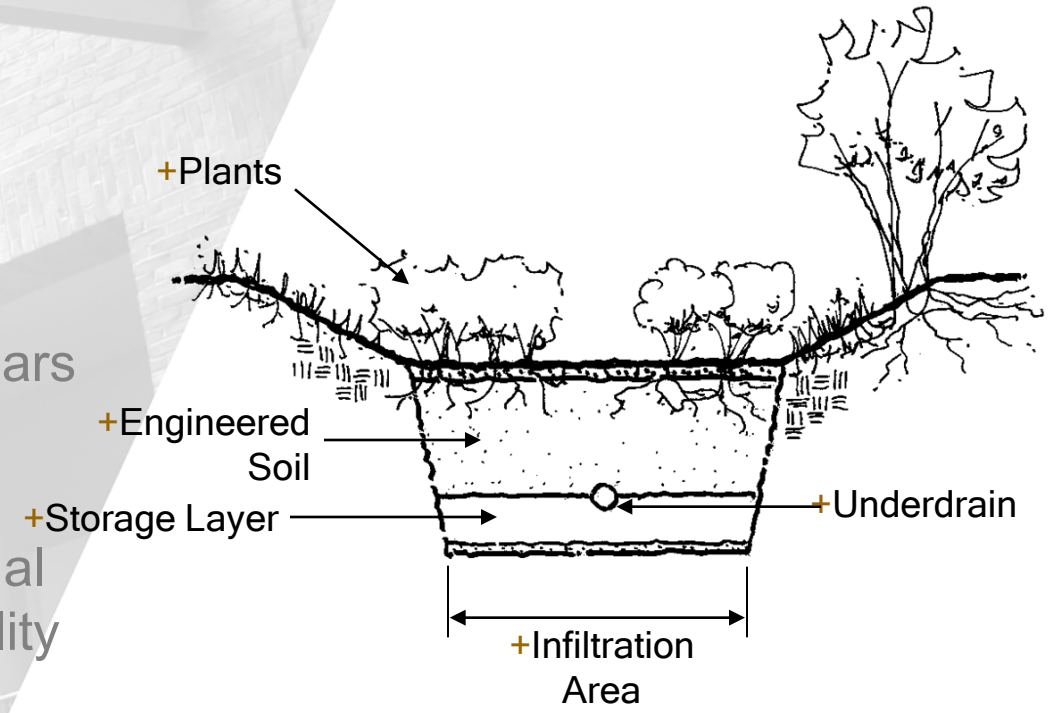
+Photo by Greg McKinnon from Puget Sound Online

Bioretention examples

Bioretention Swale

Attributes

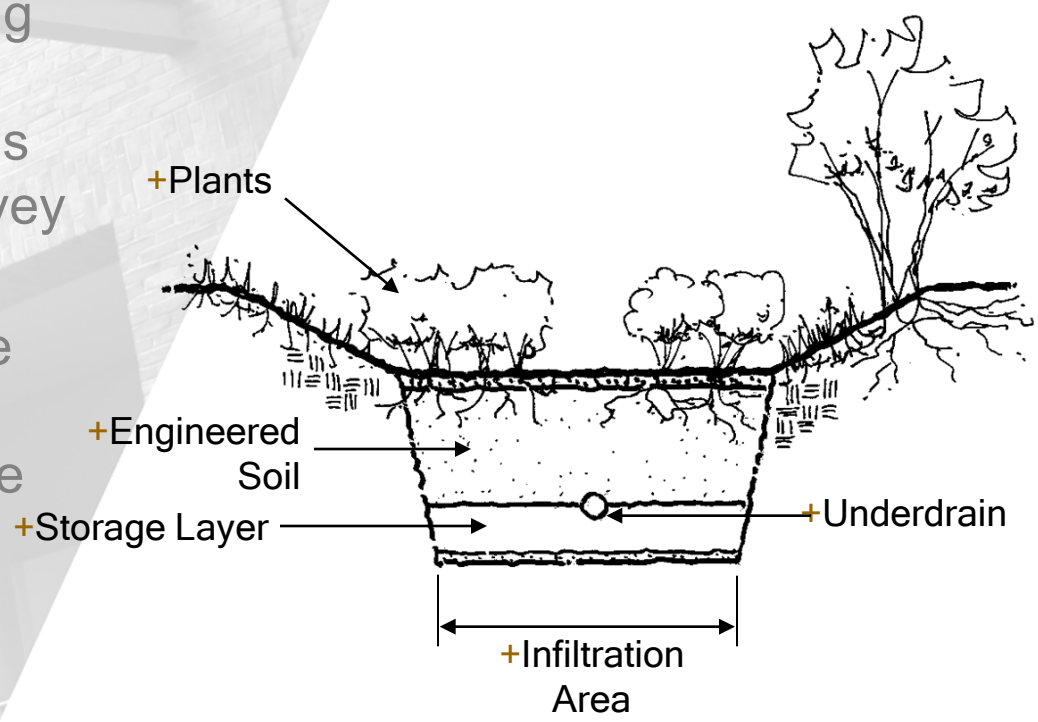
- Reduces volume of runoff
- Reduces concentrations of metals and nutrients
- Temperature reduction of runoff
- Aesthetically pleasing, appears to be a **normal** landscaped area
- Meets most local and national post-construction water quality standards
- Promotes groundwater recharge



Bioretention Swale

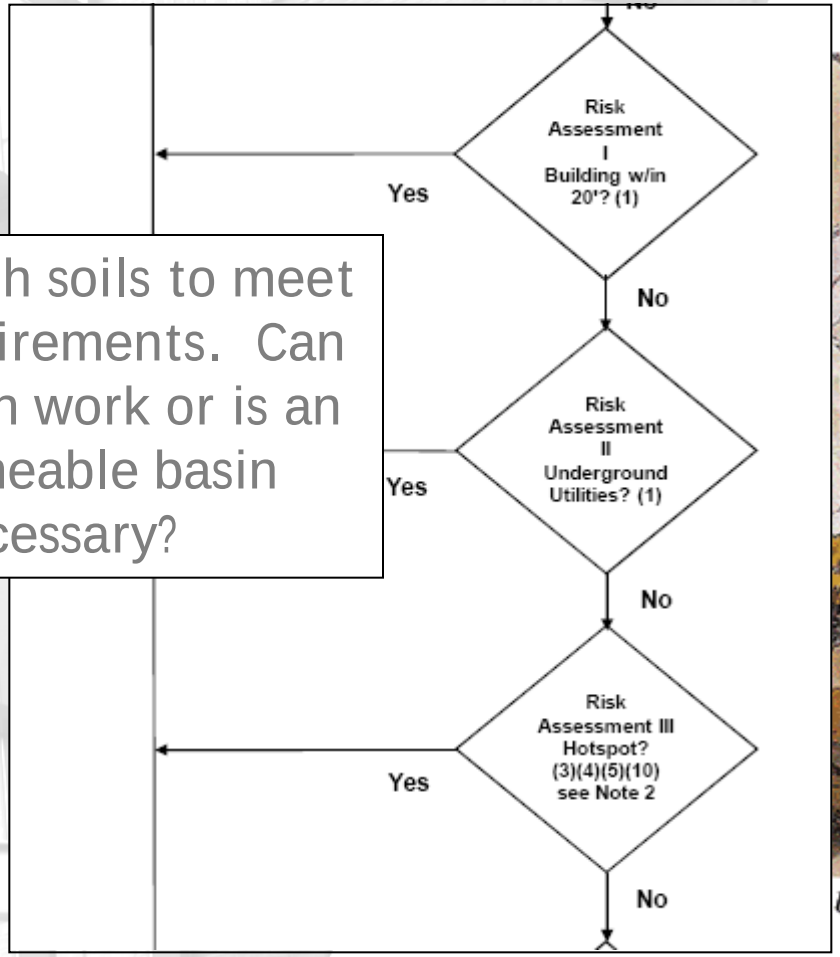
Concerns

- Costs can be high depending on the local availability of engineered soil if the basin is installed in an area with clayey soils
- Requires more maintenance than a wet pond, but is very similar to a typical landscape bed
- Construction oversight and sequencing is a major issue during construction



Ultra-urban challenges

+ Build with soils to meet local requirements. Can infiltration work or is an impermeable basin necessary?

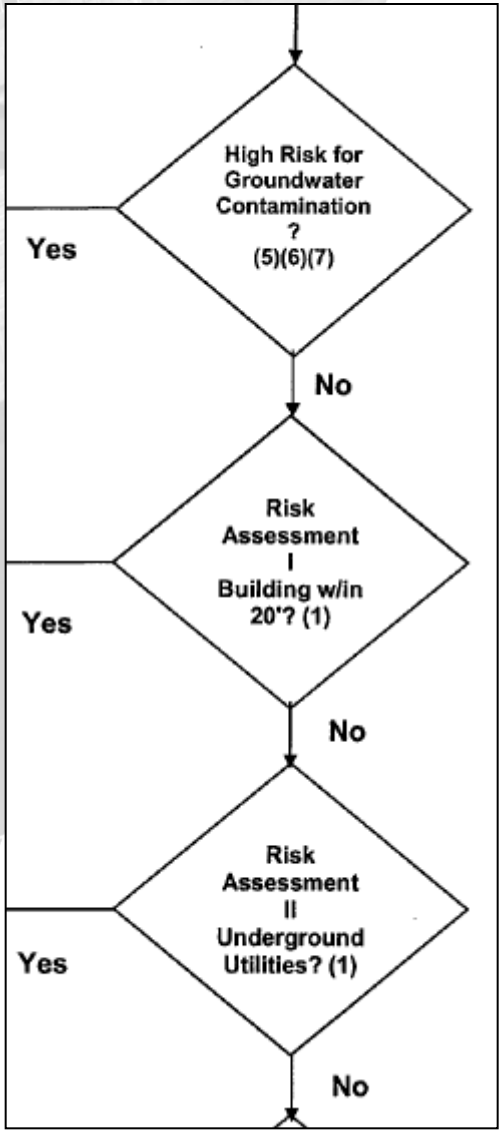


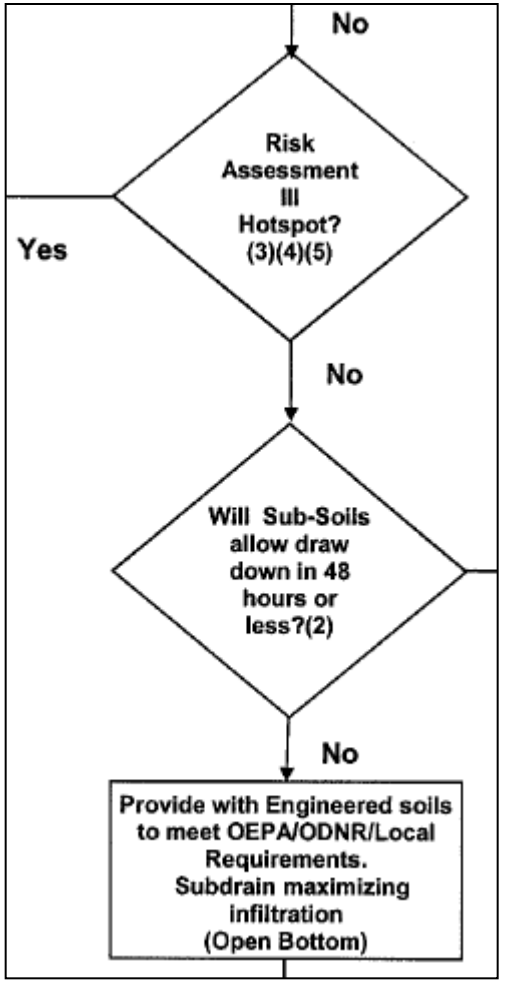
Underground Congestion.

+Courtesy UNEP

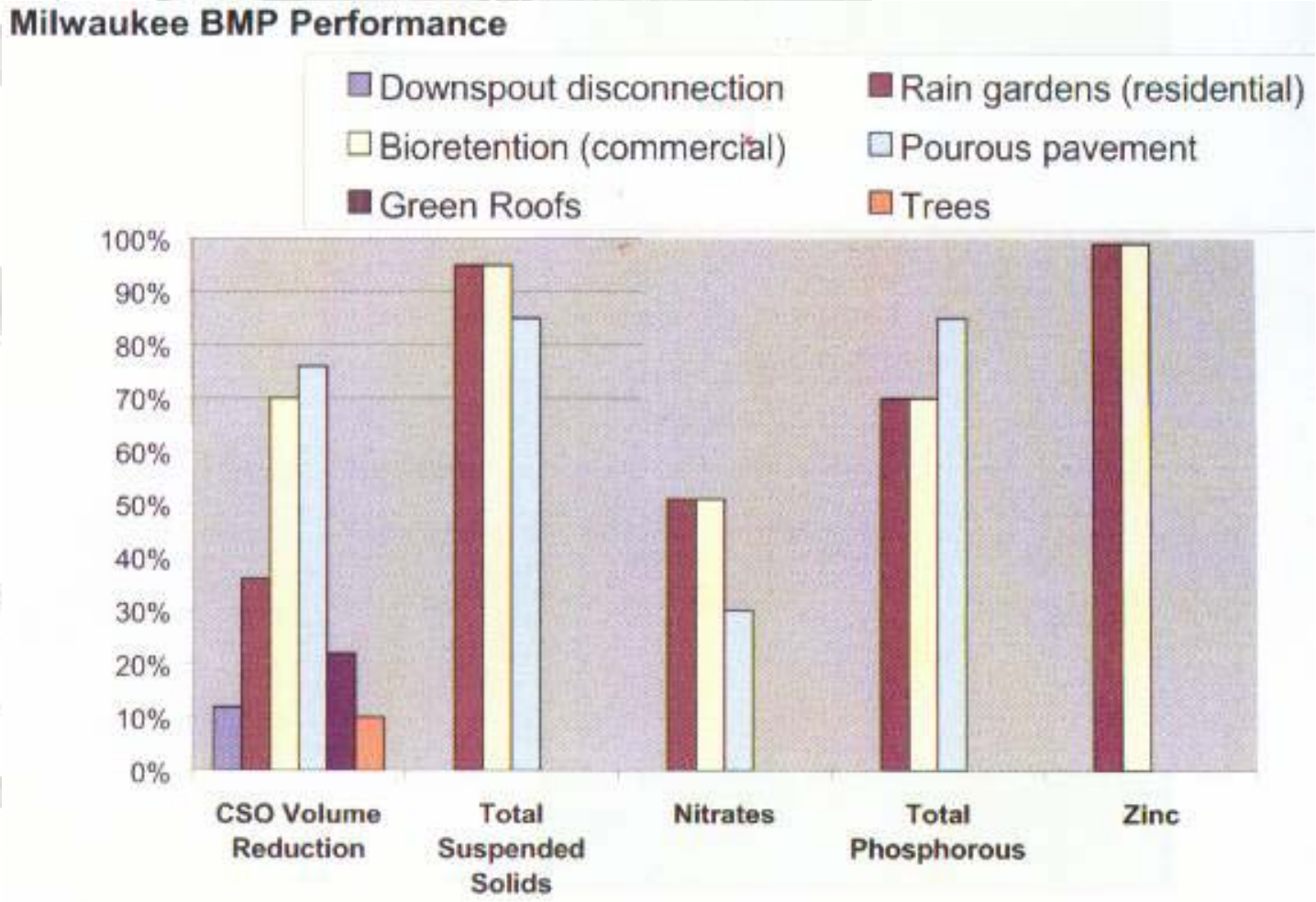
Design Considerations – Site Due Diligence Support

+ Infiltration BMP selection process schematic example





Milwaukee, WI



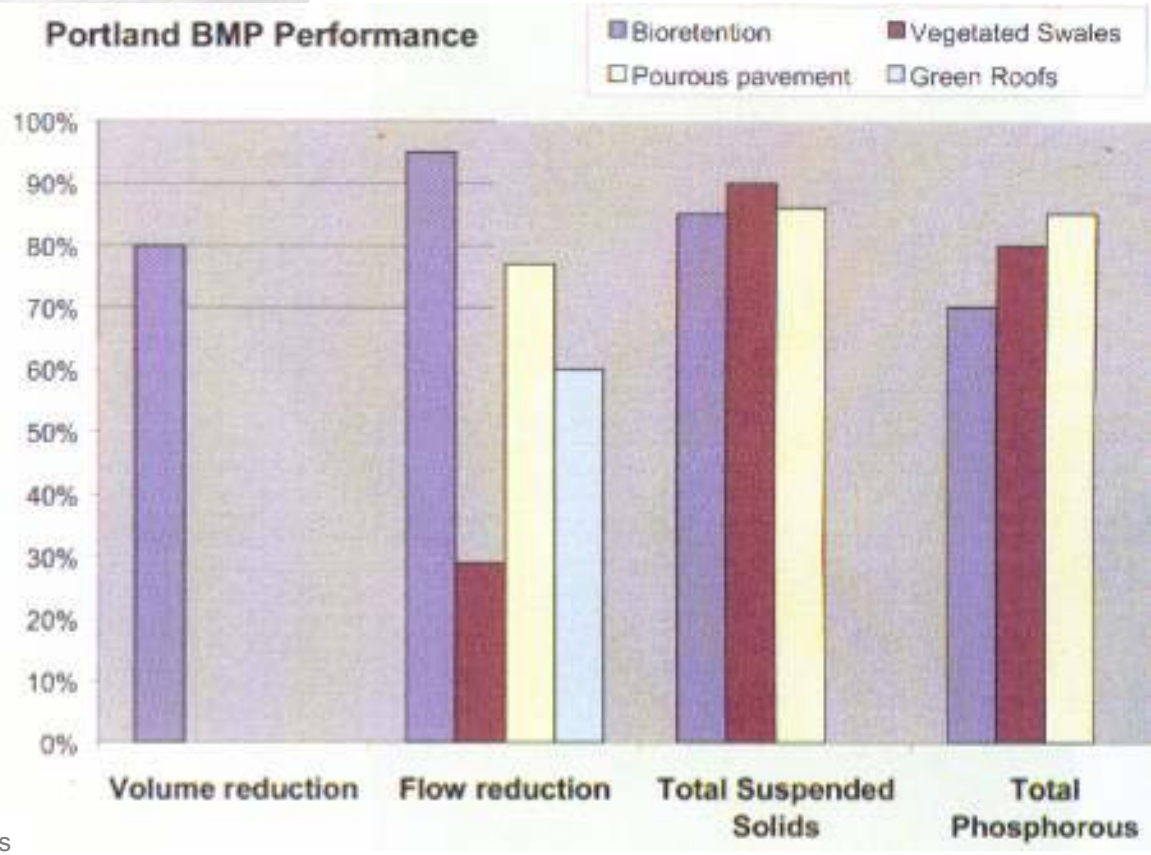
+Data Courtesy of the Center For Neighborhood Technology

Portland, OR

+The Portland Bureau of Environmental Services performed an effectiveness evaluation of all the BMPs currently in use in the City.

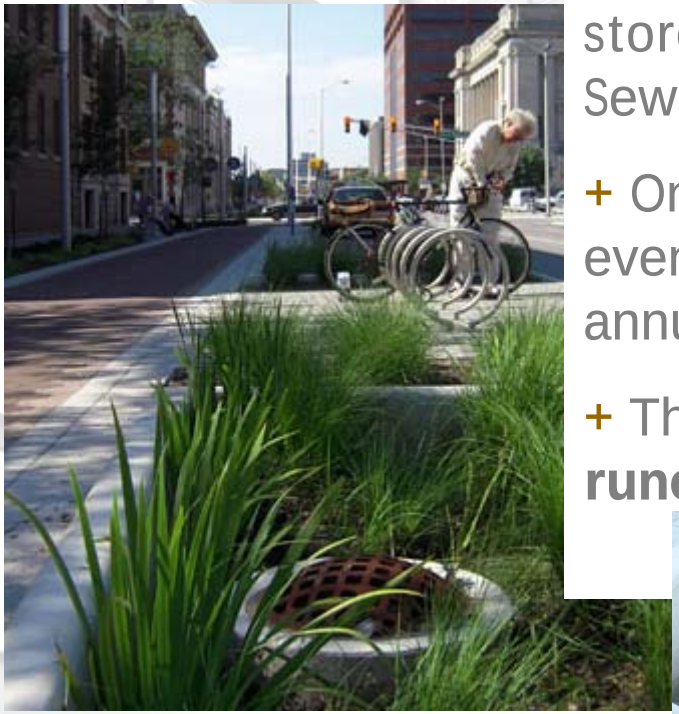
+ Photo courtesy of Portland Bureau of Environmental Services

+ Bioswales on Portland's Division Street



+ Data Courtesy of the Center For Neighborhood Technology

CSO Control – Indianapolis, IN



+Courtesy of Rundell Ernstberger Associates, LLC

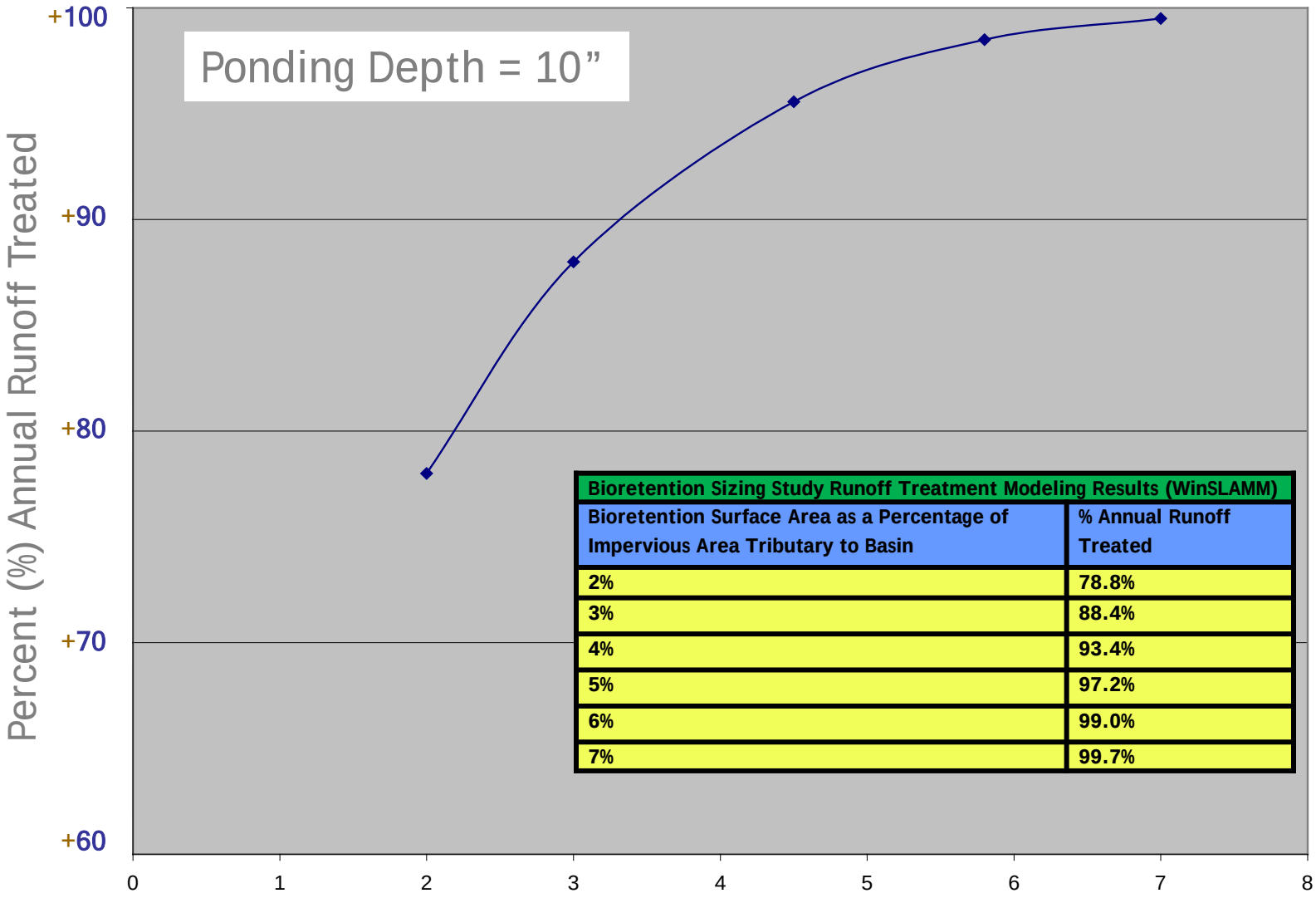
+ Analyzing 5 years of historical rain records, the bioretention rain gardens designed and constructed in the Phase 1 - Alabama Street (1/2 street only) provided the following results for potential CSO abatement:

+ **100% of all rain events about an inch or less** are stored, infiltrated and **removed** from the Combined Sewer System

+ On average, the bioretention areas for all rain events will remove **240,000 gallons** of rain runoff annually.

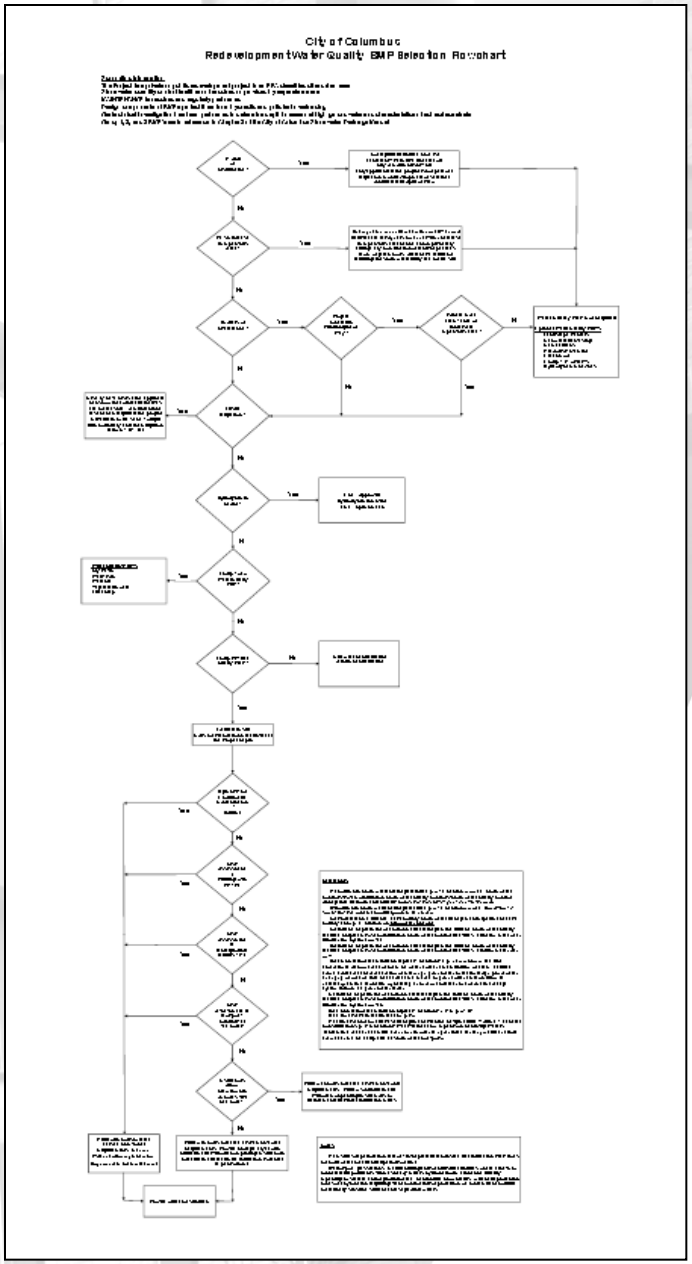
+ This equates to keeping **91% of all** annual **rainfall runoff from the combined sewer system.**

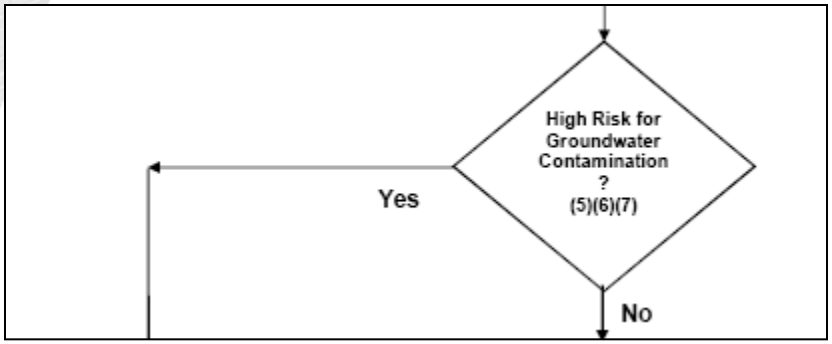
Bioretention Study Results



Bioretention Sizing Study Runoff Treatment Modeling Results (WinSLAMM)	
Bioretention Surface Area as a Percentage of Impervious Area Tributary to Basin	% Annual Runoff Treated
2%	78.8%
3%	88.4%
4%	93.4%
5%	97.2%
6%	99.0%
7%	99.7%

Revisiting Due Diligence



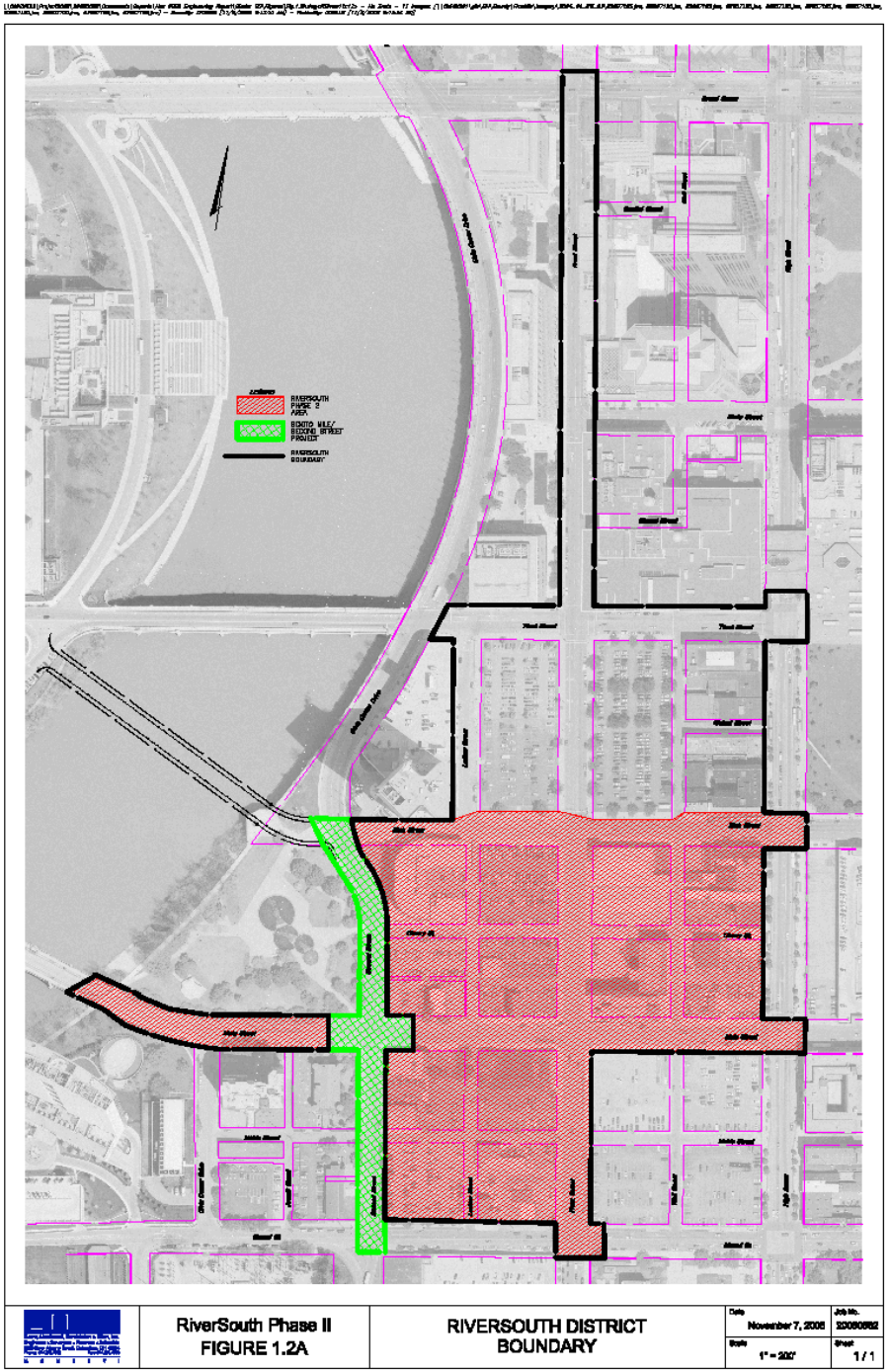


+ The RiverSouth District consists of approximately 39 acres.

+ The area currently does not have stormwater quantity or quality controls and is drained by a mix of combined sewers and storm sewers.

+ With redevelopment, combined sewers will be disconnected and all stormwater will drain directly to the Scioto River.

+Stormwater quantity and quality controls are required for redevelopment projects as defined in the City of Columbus Drainage Manual.



Water Quality Options Matrix

Water Quality Options:	A	B	C	D	E	F	G	H	WF
Economy									
Low construction cost	■	■	■	■	◪	■	■	■	
Ease of utility coordination and relocation	■	■	◪	◪	◪	■	■	■	
Low maintenance	■	■	■	■	■	■	■	■	
Little or no irrigation required [1]	■	■	■	■	■	■	■	■	
Ease of design and construction	■	■	■	■	■	■	■	■	
Ease of access and repair	■	■	■	■	■	■	■	■	
Economy Subtotal:	14	14	9	8	7	19	20	22	
Environment									
Streetscape appearance	■	■	■	■	■	■	◪	□	
Quality planting environment: Trees	■	■	■	■	■	□	□	□	
Quality planting environment: Planters	■	■	■	■	■	■	◪	□	
Meets OEPA requirements	■	■	■	■	■	□	□	■	
Provides water quality benefit	■	■	■	■	■	■	■	■	
Allows for infiltration [2]	□	■	■	■	■	■	◪	□	
Visible to public as green infrastructure	■	■	■	◪	◪	■	◪	□	
Allows trees to access roadway SW	□	■	■	■	■	■	□	□	
Environment Subtotal:	21	25	32	30	30	22	7	8	
Total:	35	39	41	38	37	41	27	30	

□ Not Applicable / 0

◪ Poor / 1

■ Fair / 2

■ Good / 3

■ Excellent / 4

Key of Water Quality Options:

A: Phase 1 Design
Current Riversouth Phase 1 Design

B: Modified Phase 1 Design
Riversouth Phase 1 Design modified to allow infiltration and share stormwater with street tree plantings.

C: Silva Cells with Bioretention Basin
Silva Cells used to support bioretention walls and share stormwater with street tree plantings.

D: Silva Cells with Infiltration Gutter and bioretention under sidewalk
Modified ODOT exfiltration trench detail.

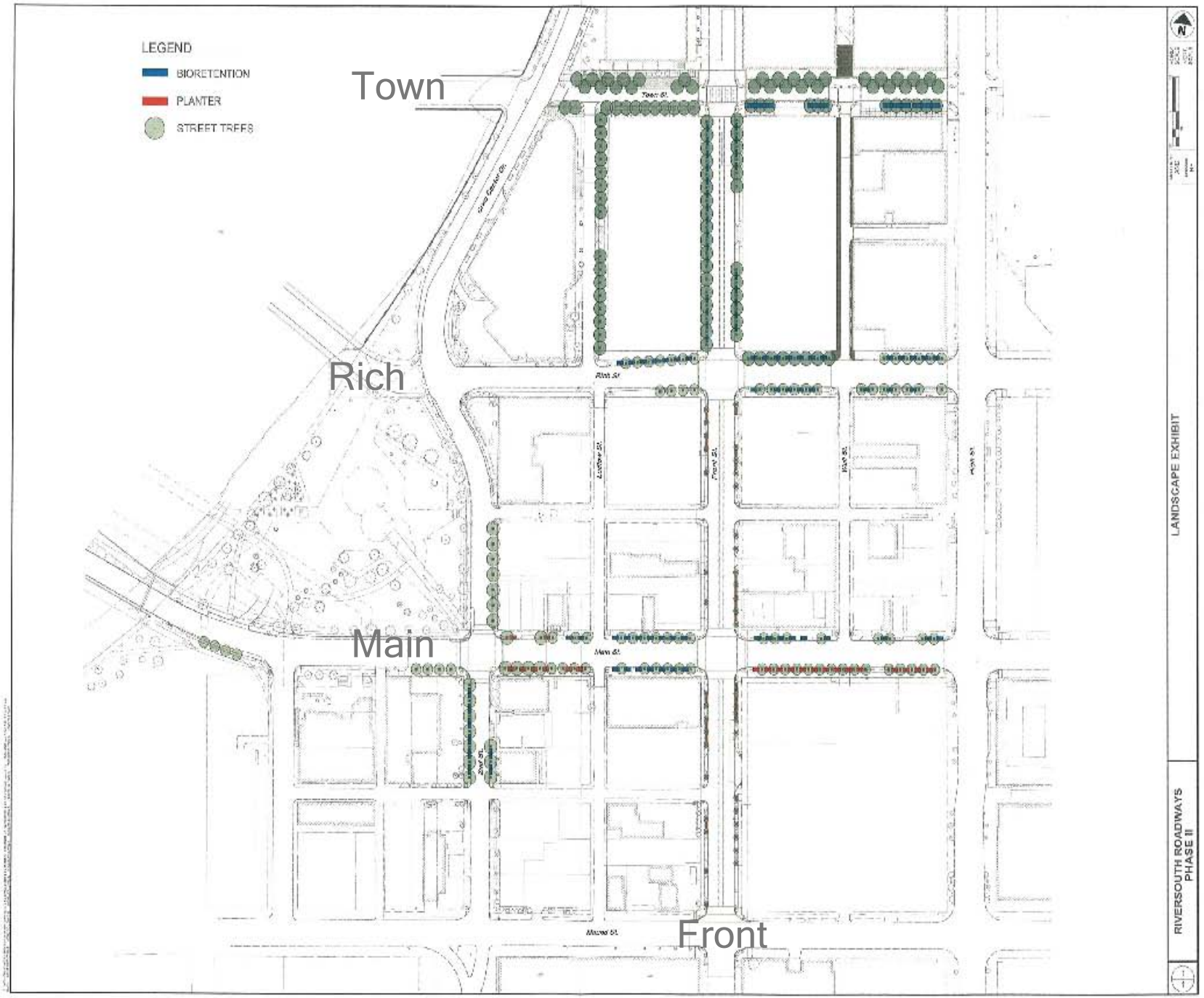
E: Silva Cells with Pervious Pavers and bioretention under sidewalk
Pervious pavers are currently not approved for use in ROW.

F: Shallow Rain Garden
May provide WQ benefit, but does not meet OEPA requirements for soil profile design. Use with other options.

G: Proprietary System, i.e. Filterra
May provide WQ benefit, but may not be approved by OEPA. Shown for comparison, not a recommended option.

H: Hydrodynamic Device
Shown for comparison, not a recommended option.

Notes:
1. Supplemental irrigation is recommended for all vegetated options including bioretention basins, rain gardens and street trees.
2. Open bottom options will allow for infiltration, but actual infiltration will be limited by the native subgrade condition. A piped underdrain system is recommended for all open bottom options.


LEGEND
BIORETENTION
PLANTER
STREET TREES
Town
Rich
Main
Front
LANDSCAPE EXHIBIT
RIVERSOUTH ROADWAYS
PHASE II

Bioretention and Planter Vegetation

Shrubs

+ Sixteen Candles Summersweet
+ Densa Compact Inkberry
+ Jim Dandy Winterberry
+ Red Sprite Winterberry
+ Silver Sprite Bayberry
+ Silver Sprite Bayberry – Pollinator
+ Alfredo American Cranberry Bush

Ornamental Grasses

+ Creeping Lily Turf
+ Heavy metal switch grass
+ Upright switch grass

Aesthetics

- The bioretention basins will be constructed of cast-in-place concrete. To provide high quality finish the concrete will be integrally colored and sandblasted.

- Basins with deep and narrow storage areas will be enclosed with an ornamental steel fence. This fence was selected for its superior coating to resist salt spray corrosion and for its ornamental style.

2009 Cost Estimate

- Current 2009 estimate is $12,500 per water quality unit with plantings at an additional $22/square foot.
- Total cost for 25 basins on Main Street and 20 on Rich Street is $562,500.

Maintenance

Task	Frequency	Note/Comments
Watering	Determined by automatic ET control system	Based on irrigation plan
Fertilization	Once at installation	
Pruning	1-2 times per year	
Mulching	Annually	
Mulch removal	2-3 years	Excess mulch decreases soil infiltration rate and reduces rain water storage volume
Up-Keep	Periodically, as needed	Weeding, trash removal and the removal and replacement of dead plants

Winter Conditions

- A fully established vegetated bioretention area still has infiltration capabilities (albeit reduced as compared to summer)
- The plants and associated root systems still assist with infiltration even during dormancy.
- Bioretention systems typically require a 3-4 inch shredded hardwood mulch, which provides an insulating layer (however minor) that assists with maintaining infiltration.
- A specific winter bioretention system infiltration study on systems in Minnesota support this premise.

Town Street Prior to Improvements

Roadway Reconstruction and Basin Placement

Basins in Summer Condition

Basins in Summer Condition

+Questions?

Special acknowledgment to:

City of Columbus, Department of Public Utilities
City of Columbus, Department of Public Service

EMH&T Staff:
Travis Eifert, PE
Miles Hebert, PE
Rob Ferguson, PE
Doug Turney, PE, LEED
Franco Manno, LEED
Brian Neilson, PE, LEED

NEXTGENERATIONGREEN
sustainable solutions that make business sense EMH&T™

5500 New Albany Road . Columbus . Ohio . 43054
8790 Governor's Hill Drive . Suite 110 . Cincinnati . OH . 45249
7400 North Shadeland Ave. . Suite 150 . Indianapolis . IN . 46250
301 McCullough Drive . Suite 109 . Charlotte . NC . 28262
655 Engineering Drive . Suite 150 . Norcross . Georgia . 30092

www.emht.com