Getting More Green for your Stormwater Infrastructure

Tuesday, May 5th, 2015
1:00 – 2:30pm EDT

Speakers:

Chris Kloss, U.S. EPA
Dan Christian, Tetra Tech
Andrew Potts, CH2M HILL

Sponsored by U.S. EPA Office of Wastewater Management

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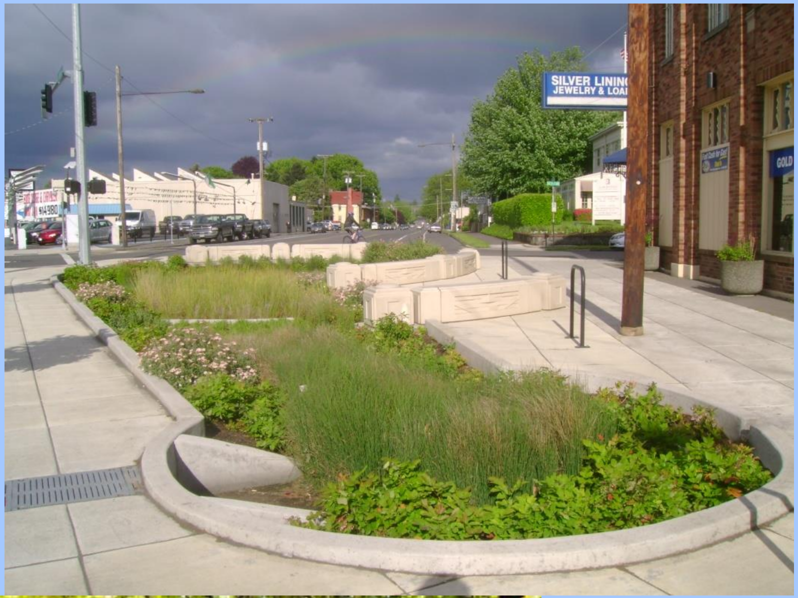
Webcast Agenda

- Speaker introduction
- **Chris Kloss,** U.S. EPA
  - EPA cost analysis of post construction stormwater BMPs
- **Dan Christian,** Tetra Tech
  - Quantifying benefits of green infrastructure – tools and resources
- **Andrew Potts,** CH2M HILL
  - Case studies on cost savings from green infrastructure
- **Q&A session**



***slides will be made available at www.epa.gov/greeninfrastructure**

Interpreting the Costs of Green Infrastructure & Stormwater Control

May 2015

2015 Green Infrastructure Webcast Series

Chris Kloss

US EPA Office of Water

EPA GI Cost-Effectiveness Study

Table 2. Summary of Cost Comparisons Between Conventional and LID Approaches[a]

Project	Conventional Development Cost	LID Cost	Cost Difference[b]	Percent Difference[b]
2nd Avenue SEA Street	$868,803	$651,548	$217,255	25%
Auburn Hills	$2,360,385	$1,598,989	$761,396	32%
Bellingham City Hall	$27,600	$5,600	$22,000	80%
Bellingham Bloedel Donovan Park	$52,800	$12,800	$40,000	76%
Gap Creek	$4,620,600	$3,942,100	$678,500	15%
Garden Valley	$324,400	$260,700	$63,700	20%
Kensington Estates	$765,700	$1,502,900	–$737,200	-96%
Laurel Springs	$1,654,021	$1,149,552	$504,469	30%
Mill Creek[c]	$12,510	$9,099	$3,411	27%
Prairie Glen	$1,004,848	$599,536	$405,312	40%
Somerset	$2,456,843	$1,671,461	$785,382	32%
Tellabs Corporate Campus	$3,162,160	$2,700,650	$461,510	15%

[a] The Central Park Commercial Redesigns, Crown Street, Poplar Street Apartments, Prairie Crossing, Portland Downspout Disconnection, and Toronto Green Roofs study results do not lend themselves to display in the format of this table.

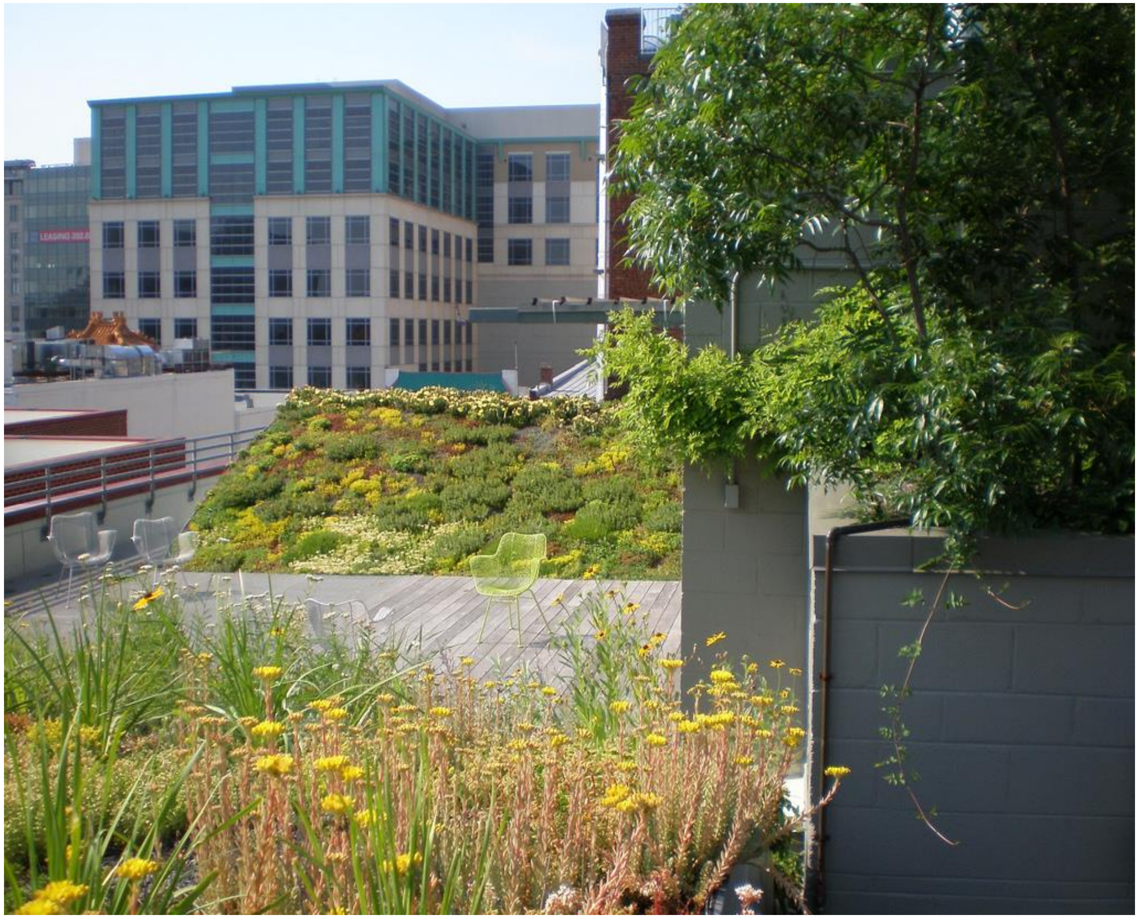
[b] Negative values denote increased cost for the LID design over conventional development costs.

[c] Mill Creek costs are reported on a per-lot basis.

U.S. EPA*, Reducing Stormwater Costs through LID Strategies and Practices, 2007.*

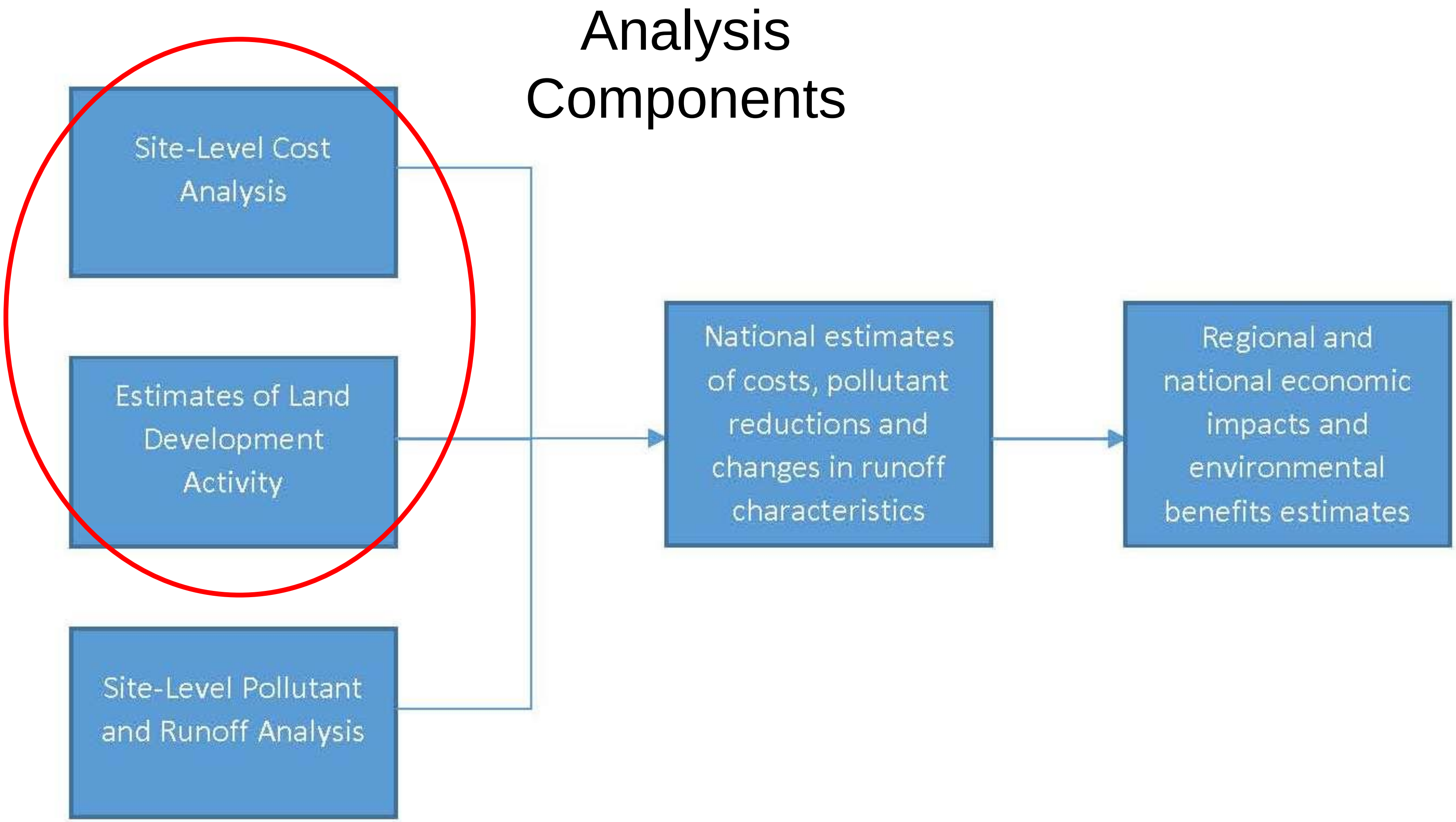
Other Sources of Information for the Costs of Green Infrastructure

- ASLA case studies (www.asla.org/stormwater)
- 479 case studies identified.
- Half of the case studies were retrofits of existing properties, 31% were new developments and 19% were redevelopment projects.
- 44% of case studies found a decrease in costs by using green infrastructure; 31% found green infrastructure did not influence costs while 25% found increased costs.



Green Roof at ASLA Building, Washington, DC.

Analysis of Costs and Performance of Different Stormwater Practices



Site-Level Analysis Goals

- Determine costs and performance of stormwater management strategies at new and re-development projects reflecting existing state/local requirements
- Determine costs and performance of various different stormwater management strategies (e.g., retention)
- Evaluate changes (increases, decreases) in costs, pollutant discharges and hydrologic performance at various scales (MS4s, states, national) due to nationwide application of different strategies

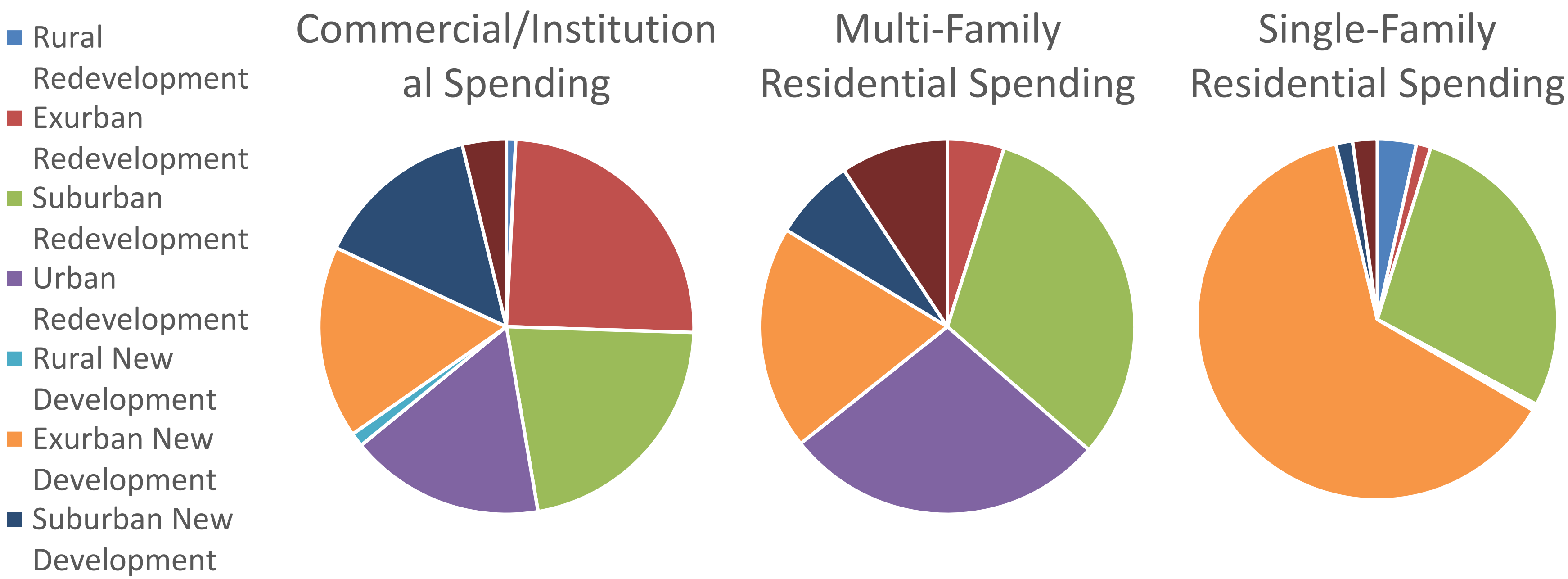
BMP Types: Retention/Treatment

- Retention Only:
  - Greenroof
  - Pervious Area Dispersion
  - Dry Well
  - Cisterns
  - Infiltration Trench
  - Infiltration Vault/Gallery
  - Infiltration Basin

- Retention and/or Treatment:
  - Bioretention
  - Permeable Pavement

- Treatment Only:
  - Flow-through Planters
  - Treatment Vault
  - Sand Filter
  - Wet Detention Basin/Wet Pond

Summaries of Predicted Construction Spending & Predicted Projects for years 2020 - 2040



	Projects		Development Acres		Impervious Acres	
	#	%	#	%	#	%
New Development Inside Reg MS4s	536,030	36%	9,443,322	35%	2,747,609	29%
Redevelopment Inside Reg MS4s	497,003	33%	8,992,294	33%	3,825,437	40%
New Development Outside Reg MS4s	282,595	19%	4,864,890	18%	1,454,198	15%
Redevelopment Outside Reg MS4s	176,729	12%	3,600,671	13%	1,453,597	15%
Total Development	1,492,357		26,901,177		9,480,842	

Some Example Results

- All costs are in 2012 dollars, and presented as costs/acre
- All data are specific to Illinois

Retention Estimates

- Assumed a retention standard of 90^{th} percentile rainfall event for new development, and 85^{th} percentile for redevelopment
- Retention standard is applied statewide (inside and outside of MS4s)
- EPA also assessed impact of reducing impervious surfaces which includes:
  - Modest reductions to street widths and parking stall sizes
  - EPA did not change parking ratios, address shared parking or other changes that can more significantly reduce impervious surfaces

Commercial project type

- EPA projected 24,000 commercial projects in IL from 2020-2040 (most are redevelopment in MS4 areas).
- Median project size 3 acres.
- Average 45% impervious surface.
- Most common BMPs are soil amendments and soil/vegetation conservation (99%), downspout disconnection (69%), bioretention (65%), and infiltration basins (44%).

Single Family Residential project type

- EPA projected 12,400 SFR projects in IL from 2020-2040 (most are new developments outside MS4 areas).
- Median project size 6 acres (15 acres average).
- Average 20% impervious surface.
- Most common BMPs are soil amendments and soil/vegetation conservation (100%), downspout disconnection (93%), permeable pavement (48%), and infiltration basins (25%).

Stormwater retention's estimated impacts on commercial developments

	Current Regs	New Retention Standard	
	Current Cost	With imp. surface reduction	Without imp. surface reduction
New Development in MS4	$12,700/ac	- $1,500/ac	+ $300/ac
Redevelopment in MS4	$16,400/ac	+ $3,500/ac	+ $5,000/ac

- Most cost savings are from impervious surface reduction. Additional savings from O&M and reduced size of detention pond needed for flood control.

Retaining stormwater saves money for single family home developments

	Current Regs	New Retention Standard	
	Current Cost	With imp. surface reduction	Without imp. surface reduction
New Development in MS4	$9,000/ac	- $3,100/ac	- $2,400/ac
Redevelopment in MS4	$14,300/ac	- $3,000/ac	- $1,000/ac

- Most cost savings are from impervious surface reduction and reduced O&M costs.

Changes to Site Design and Performance Can Save Money

- Environmental Site Design
  - Reducing impervious surfaces (parking lot areas and narrowing street widths) lessens the runoff volume that needs to be controlled
  - EPA is actively encouraging states and metro areas to conduct reviews of codes and ordinances that may limit the use of environmental site design and green infrastructure
- Reduced need for Flood Storage
  - Retaining stormwater can reduce or eliminate the need for other water infrastructure that is currently required
  - Most projects need to meet local flood storage requirements - typically through detention ponds (wet/dry) or detention vaults
  - Retention practices offset the volume that needs to be captured for flood storage

How Green Infrastructure Can Save Money – Boulder Hills, NH (UNH Stormwater Center)

- 24-unit active adult condominium community built in 2009
- Makes use of porous asphalt for road, driveways, and sidewalks
- The use of green infrastructure practices resulted in project costs 6% lower than conventional approaches

Boulder Hills, NH (UNH Stormwater Center)

ITEM	CONVENTIONAL	LOW IMPACT	DIFFERENCE
Site Preparation	$23,200.00	$18,000.00	–$5,200.00
Temp. Erosion Control	$5,800.00	$3,800.00	–$2,000.00
Drainage	$92,400.00	$20,100.00	–$72,300.00
Roadway	$82,000.00	$128,000.00	$46,000.00
Driveways	$19,700.00	$30,100.00	$10,400.00
Curbing	$6,500.00	$0.00	–$6,500.00
Perm. Erosion Control	$70,000.00	$50,600.00	–$19,400.00
Additional Items	$489,700.00	$489,700.00	$0.00
Buildings	$3,600,000.00	$3,600,000.00	$0.00
PROJECT TOTAL	**$4,389,300.00**	**$4,340,300.00**	**–$49,000.00**

How Green Infrastructure Can Save Money – Greenland Meadows, NH(UNH Stormwater Center)

- Three, 1-story retail units on 56 acres (25 acres of impervious surface) built in 2008
- 4.5 acres of porous asphalt and gravel wetland used for stormwater management
- The use of green infrastructure practices were estimated to save 9% in overall project development costs

Greenland Meadows, NH (UNH Stormwater Center)

TABLE 1: Comparison of Unit Costs for Materials for Greenland Meadows Commercial Development

ITEM	CONVENTIONAL OPTION	LID OPTION	COST DIFFERENCE
Mobilization / Demolition	$555,500	$555,500	$0
Site Preparation	$167,000	$167,000	$0
Sediment / Erosion Control	$378,000	$378,000	$0
Earthwork	$2,174,500	$2,103,500	–$71,000
Paving	$1,843,500	$2,727,500	$884,000
Stormwater Management	$2,751,800	$1,008,800	–$1,743,000
Addtl Work-Related Activity (Utilities, Lighting, Water & Sanitary Sewer Service, Fencing, Landscaping, etc.)	$2,720,000	$2,720,000	$0
Project Total	**$10,590,300**	**$9,660,300**	**–$930,000**

*Costs are engineering estimates and do not represent actual contractor bids.

TABLE 2: Conventional Option Piping

	TYPE	QUANTITY	COST
Distribution	6 to 30-inch piping	9,680 linear feet	$298,340
Detention	36 and 48-inch piping	20,800 linear feet	$1,357,800

TABLE 3: LID Option Piping

	TYPE	QUANTITY	COST
Distribution	4 to 36-inch piping	19,970 linear feet	$457,780
Detention*	—	0	$0

*Costs associated with detention in the LID option were accounted for under "earthwork" in Table 1.

Inver Grove Heights, MN

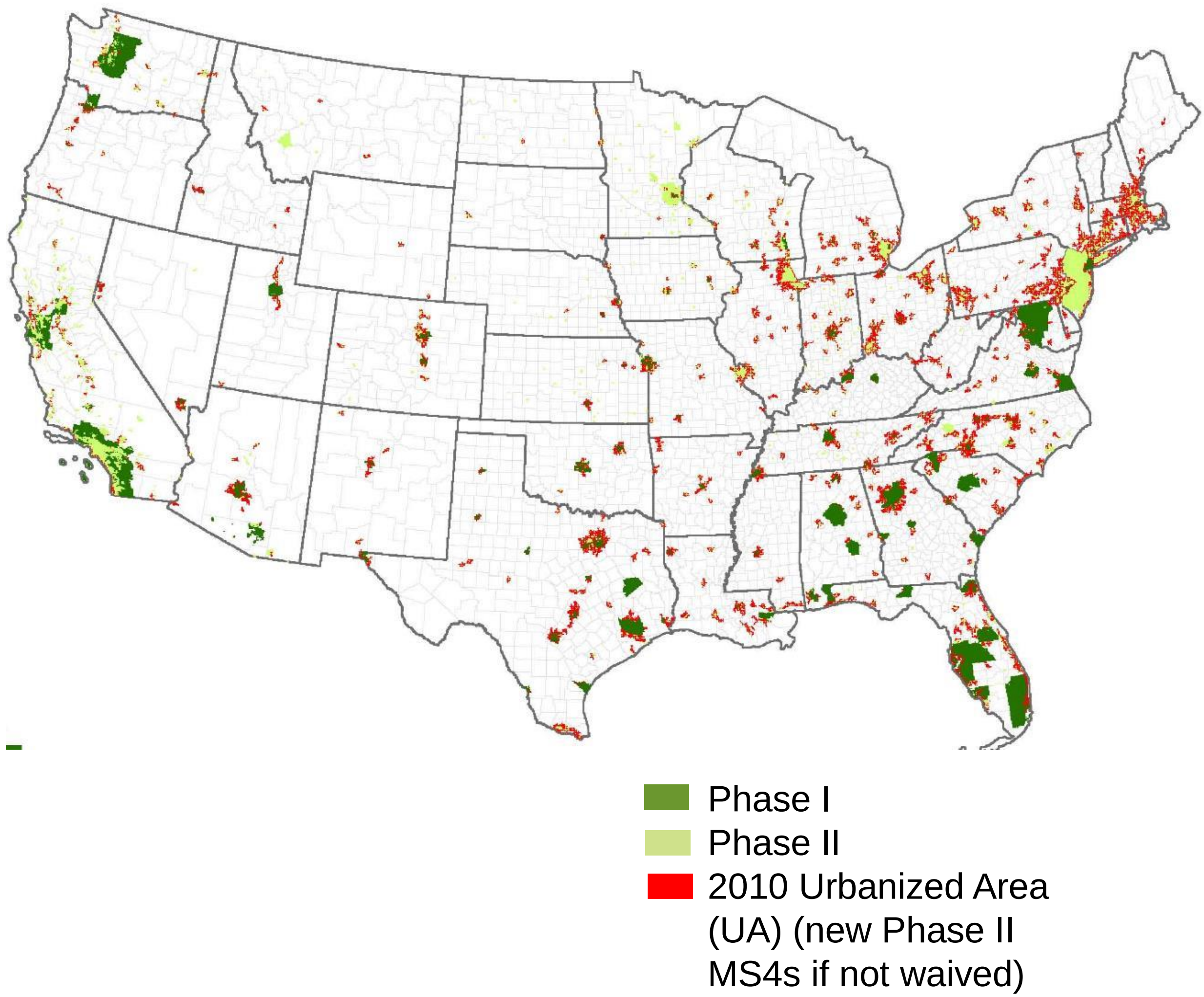
In 2014, nearly 10" of rain fell over a 4-day period causing flooding in other parts of the Twin Cities-metro area. Minimal runoff reached the regional infiltration basins and no stormwater left the City.

The 134 acre retail & residential development used a train-treatment approach, that included:

- 35 raingardens,
- 274 permeable asphalt parking stalls,
- 2 permeable paver intersections,
- 2 infiltration basins
- and a biofiltration swale

Regulated MS4 Program Universe

- Individual Permits
  - 250 Individual MS4 permits cover 855 Phase I MS4s
  - 100 Individual MS4 permits cover ~106 Phase II MS4s
- General Permits
  - 54 General MS4 permits cover 6,589 Phase II MS4s
- 3 watershed MS4 permits cover ~3 Phase I and 40 Phase II MS4s



Opportunities

Bioretention Cell in El Monte, CA. *Photo courtesy of Bill DePoto.*

Lancaster, PA Alley 148 Greened for 10% Added Cost + 200,000 gallons captured per year

Before (July 2011) ~$20.30/SF

After (February 2012) ~$22.40/SF

trench)

US EPA Green Infrastructure Program

Thank you

BENEFITS OF GREEN INFRASTRUCTURE

Getting More Green For Your Stormwater Infrastructure

Tuesday, May 5, 2015

EPA Webcast

TETRA TECH

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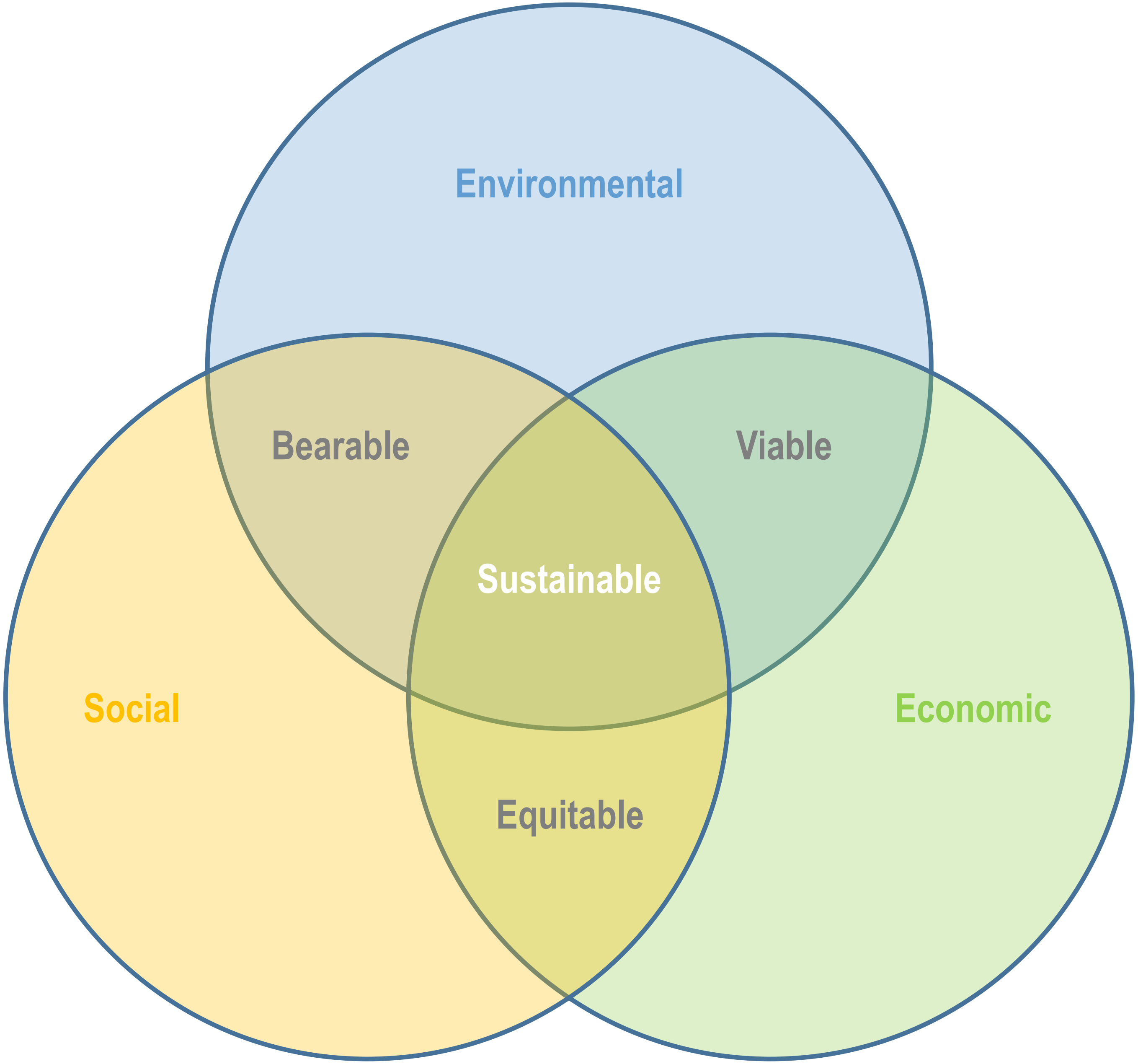
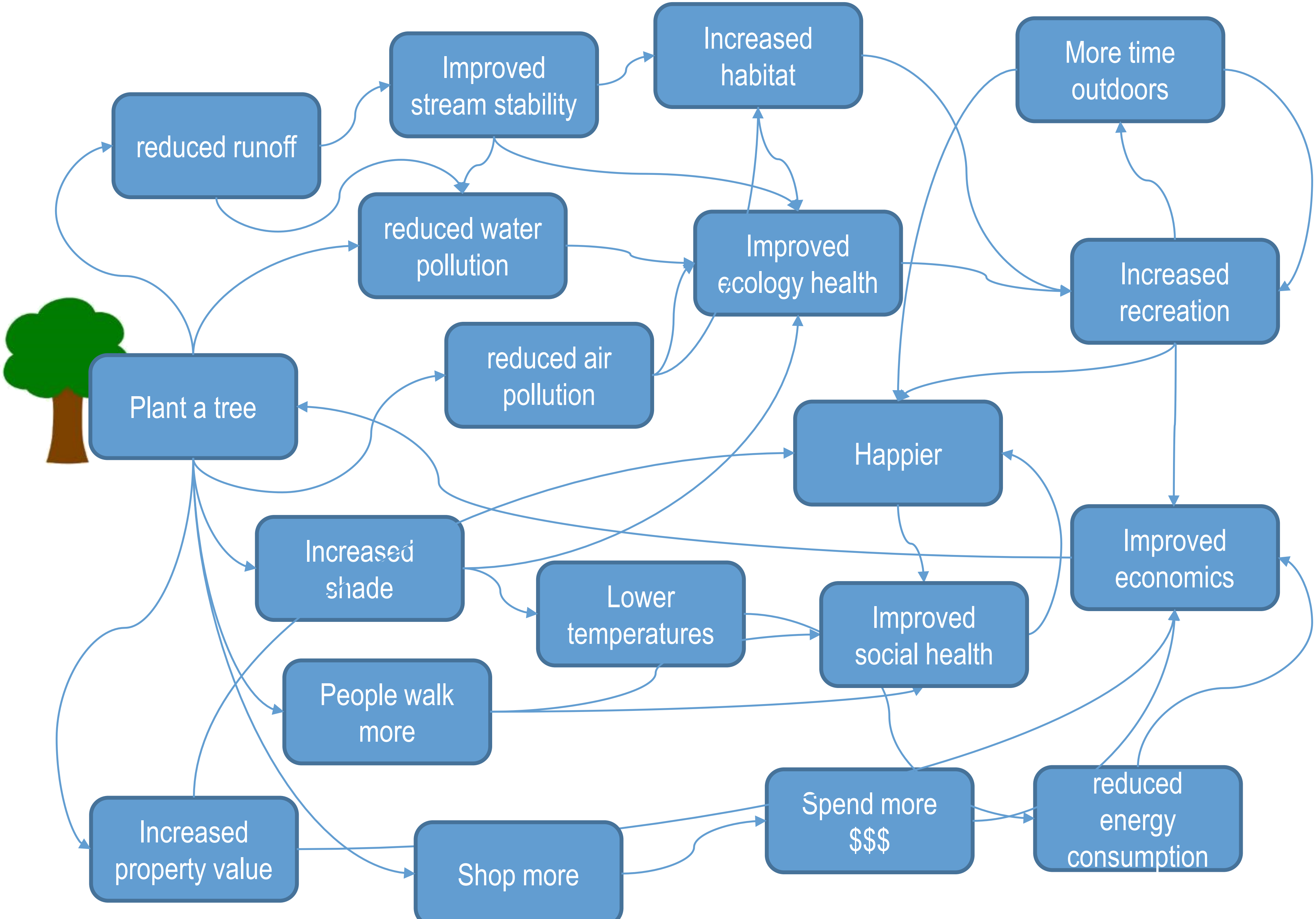

Environmental
Bearable
Viable
Sustainable
Social
Economic
Equitable


Increased habitat
More time outdoors
Improved stream stability
reduced runoff
reduced water pollution
Improved ecology health
Increased recreation
reduced air pollution
Plant a tree
Happier
Improved economics
Increased shade
Lower temperatures
Improved social health
People walk more
Spend more $$$
reduced energy consumption
Increased property value
Shop more

Green Infrastructure Benefits and Practices

This section, while not providing a comprehensive list of green infrastructure practices, describes the five GI practices that are the focus of this guide and examines the breadth of benefits this type of infrastructure can offer. The following matrix is an illustrative summary of how these practices can produce different combinations of benefits. Please note that these benefits accrue at varying scales according to local factors such as climate and population.

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

Hydrology

- Increased interception
- Increased onsite storage
- Increased infiltration
- Increased plant-water uptake
- Increased time of concentration
- Decreased runoff volume
- Decreased runoff rate

<u>Leads to</u>

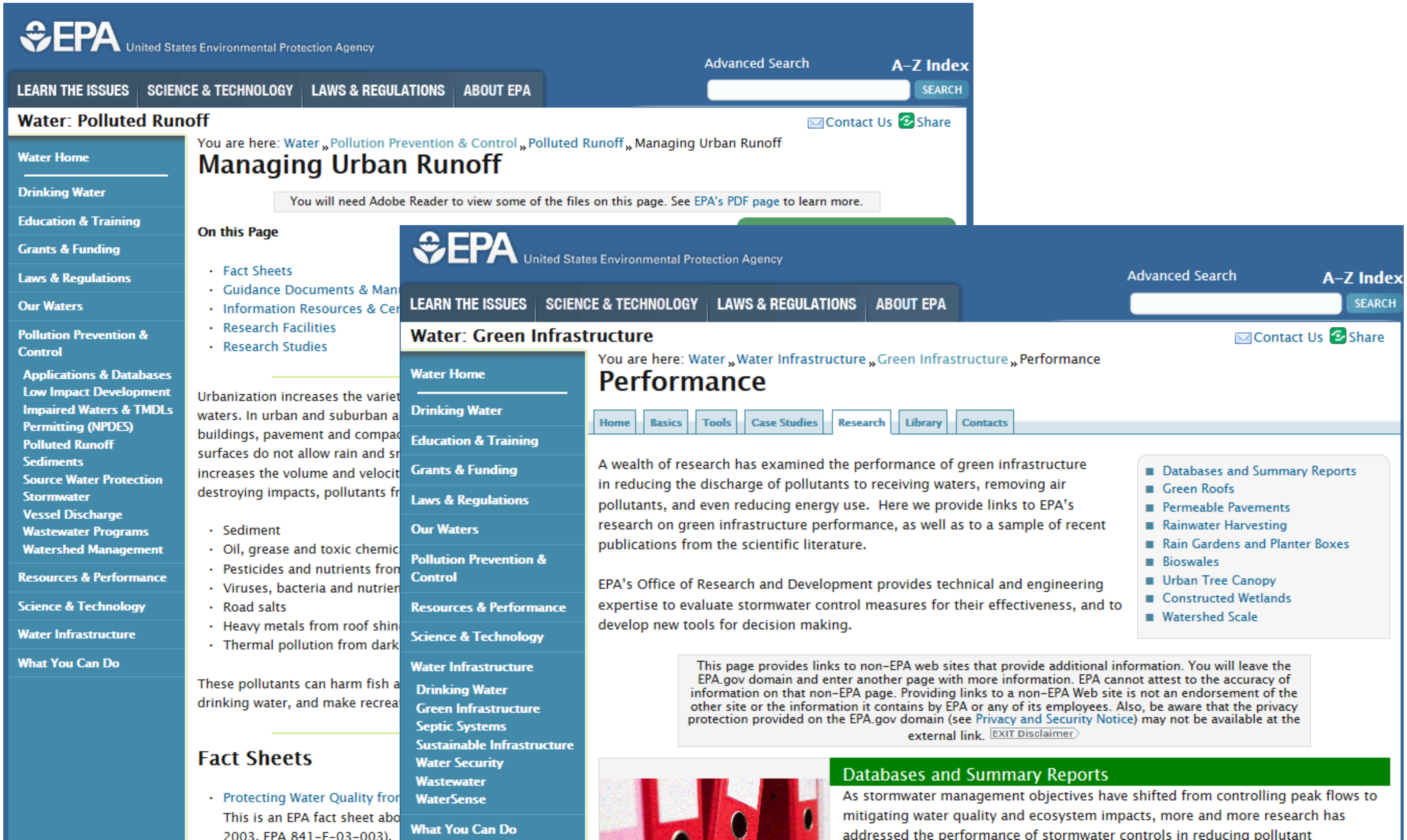
- Reduced infrastructure needs
- Reduced flooding
- Increased water supply

EPA Nonpoint Source Pollution

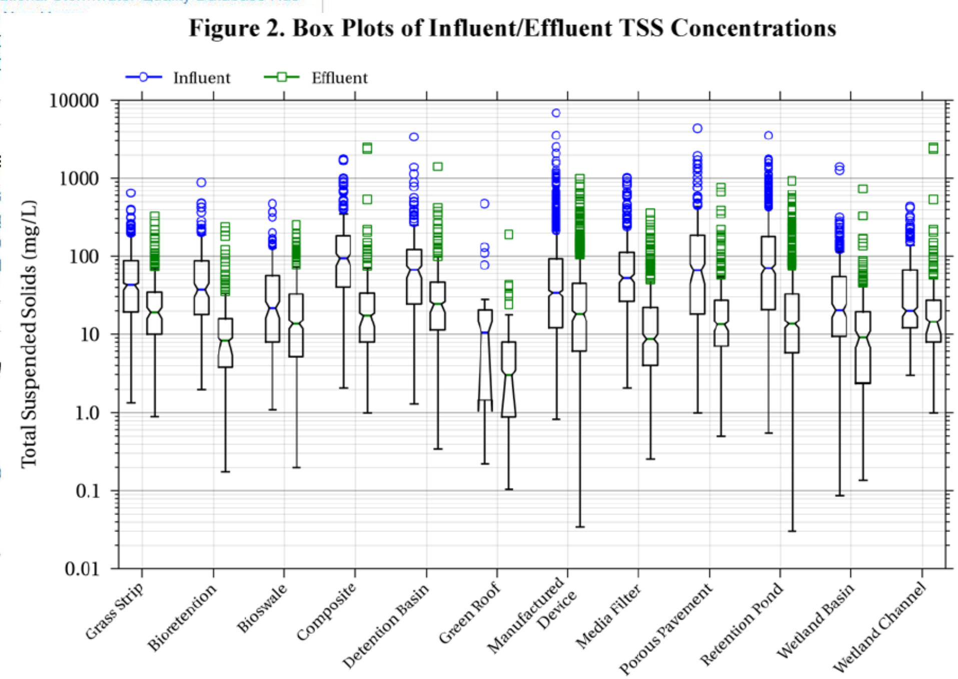
epa.gov/greeninfrastructure

water.epa.gov/polwaste/nps/urban.cfm

water.epa.gov/infrastructure/greeninfrastructure/gi_performance.cfm

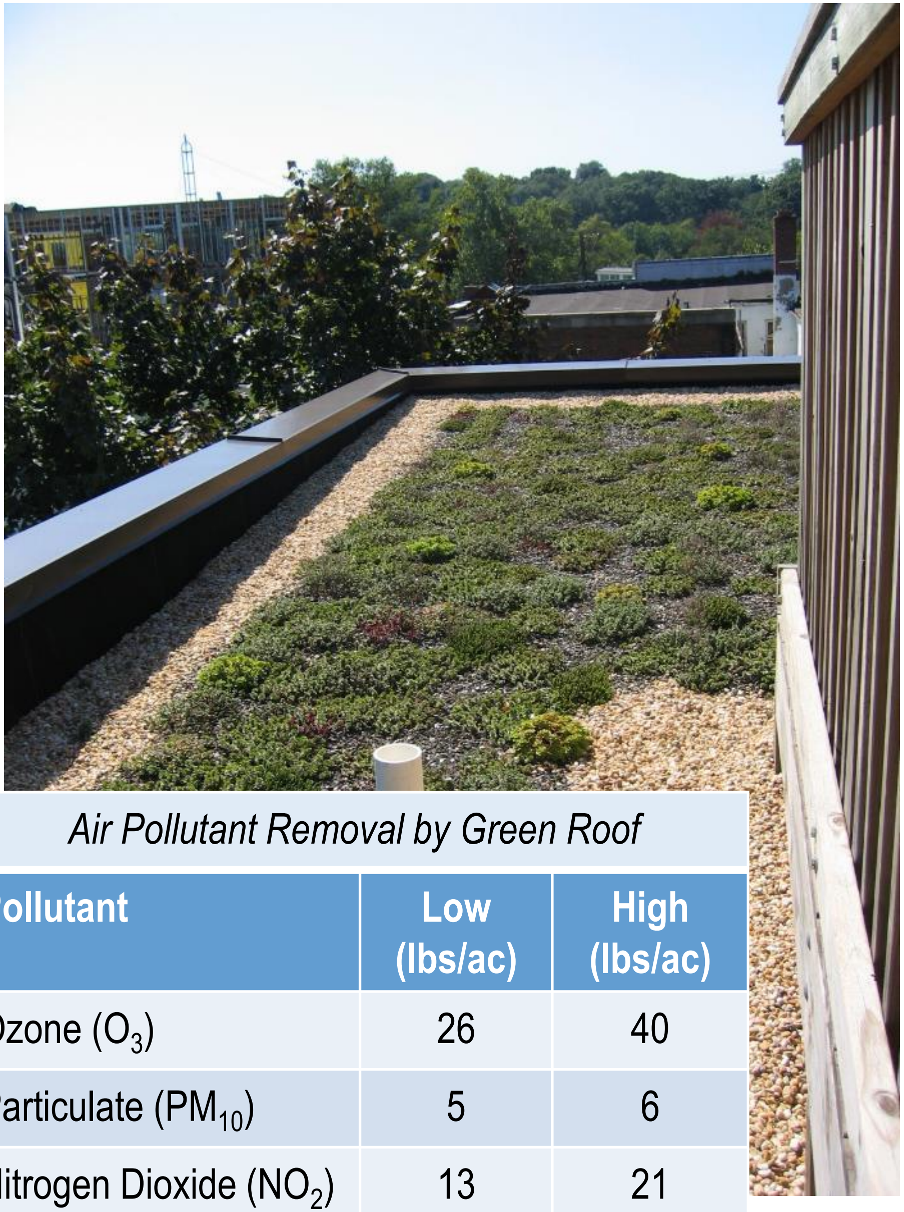


International Stormwater BMP Database (bmpdatabase.org)



Air Pollution Reduction

- Urban trees and shrubs offer the ability to remove significant amounts of air pollutants.
- Urban tree canopy cover could be a viable strategy to improve air quality and help meet clean air standards.
- Green roofs can be used to supplement the use of urban trees in air pollution control



Air Pollutant Removal by Green Roof

Pollutant	Low (lbs/ac)	High (lbs/ac)
Ozone (O_3)	26	40
Particulate (PM_{10})	5	6
Nitrogen Dioxide (NO_2)	13	21
Sulfur Dioxide (SO_2)	10	18

Currie B. (2008); Nowak, D. (2006); and Yang J. (2008)

Urban Heat Island Effect

- Temperatures in urban areas are higher than in surrounding rural areas
- Results from the generation and retention of heat by urban buildings and paved surfaces
- Results in higher energy demand during the summer
- Ambient temperatures may be reduced by increasing
  - Albedo (solar reflectivity)
  - Vegetation density
- Example practices
  - Green roofs
  - Trees

Akbari, H. (2001); Kevern, J. (2000); Schlesinger, W (1997)

Greenhouse Gas Emissions

- Greenhouse Gas Emissions contribute to climate change
- Target
  - Reduced emissions from reduced energy consumption
  - Increased sequestration of carbon dioxide by vegetation
- Energy consumption linked to urban heat island effect
- Carbon Sequestration, impacted by:
  - Age of vegetation
  - Type of vegetation
  - Density of vegetation

Vegetation Type	Mean Plant Biomass (grams of Carbon/sf)
Temperate Forest	743.5
Temperate Steppe	278.8
Wetland	250.9
Cultivated Land	130.1

Schlesinger, William H., 1997, Biogeochemistry: An Analysis of Global Change. Academic Press, San Diego, California

Greenness and General Physical Health Benefits

- People perceive streets with trees and gardens as more attractive for walking
- Access to a garden or short distances to green areas from the dwelling are associated with less stress and a lower likelihood of obesity
- The amount of green areas in the vicinity of the participant's residence and the short distance to green areas suitable for recreational use increased the number of close-to-home outings among residents.
- Higher greenness was significantly associated with lower BMI regardless of residential density characteristics.
- Greener environments can reduce mortality rates for populations that would normally have higher mortality rates due to socioeconomic factors such as income and available health services.

Bell J. (2008); Borst, H. (2008); Mitchell, R (2008); Neuvonen, M (2007); Nielsen T. (2007); Wendel-Vos, G. (2004)

Mental and Emotional Health Effects

- Significant relationships have been found between the use of urban open spaces and experiences of stress
- Other research has shown that time in natural settings can help mental fatigue recovery and improve one's capacity to concentrate
- Results indicate that children function better than usual after activities in green settings
- The "greener" a child's play area, the less severe his or her attention deficit symptoms
- Desk workers surveyed about their rate of illness and level of job satisfaction claimed 23% fewer incidents of illness in the prior six months if they had a view of nature from their desks

Faber T. (2001); Kaplan R. (1989); Kaplan, S (1995)

Crime Reduction

- Within the same housing development, building with high levels of vegetation had 48% fewer property crimes and 56% fewer violent crimes than building with low levels of vegetation
- Medium levels of vegetation were associated with 40% fewer property crimes and 44% fewer violent crimes than low levels of vegetation.

Kuo, F. (2001)

Community Cohesion

- In a series of studies involving over 1,300 person–space observations, 400 interviews, housing authority records, and 2 years of police crime reports, tree and grass cover were systematically linked to a wide range of social ecosystem indicators.
- These indicators included <u>stronger ties among neighbors</u>, <u>greater sense of safety and adjustment</u>, more supervision of children in outdoor spaces, <u>healthier patterns of children's play</u>, <u>more use of neighborhood common spaces</u>, <u>fewer incivilities</u>, <u>fewer property crimes</u>, and <u>fewer violent crimes</u>.
- In residential areas, barren, treeless spaces often become "no man's lands," which discourage resident interaction and invite crime.
- The presence of trees and well-maintained grass can transform these no man's lands into pleasant, welcoming, well-used spaces.
- Vital, well-used neighborhood common spaces serve to both strengthen ties among residents and deter crime, thereby creating healthier, safer neighborhoods.

Kuo, F. (1998); Kuo, F. 2003.

Property Value

- Trees add $7,020 to the price of a house, a 2.4% of the mean sale price
- Open spaces have a statistically significant effect on a home's sale price
- Introduction of LID increased property values by 3.5 – 5 percent.
- These results suggest people are willing to pay for the combination of neighborhood amenities and environmental services provided by LID stormwater controls.

Distance Variables Evaluated at the Mean Open Space for each Open Space Type (1990 Dollars)

Variable	Urban Park	Natural Area Park	Golf Course	Speciality Park/Facility
Distance ≤ 200	$1,926***	$11,210*	$13,916*	$7,396***
Distance 201–400	2,061*	10,216*	7,851*	5,744**
Distance 401–600	1,193***	12,621*	2,814	10,283*
Distance 601–800	817	11,269*	8,842*	5,661*
Distance 801–1,000	943	8,981*	8,898*	4,972*
Distance 1,001–1,200	1,691*	8,126*	4,391***	4,561*
Distance 1,201–1,500	342	9,980*	4,366**	t3,839*

Number of observations 16,747; $\lambda = 0.0995^*$; adjusted $R^2 = 0.656$

*, **, *** denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Donovan G. (2008); Lutzenhiser, M (2001); Ward B. (2008)

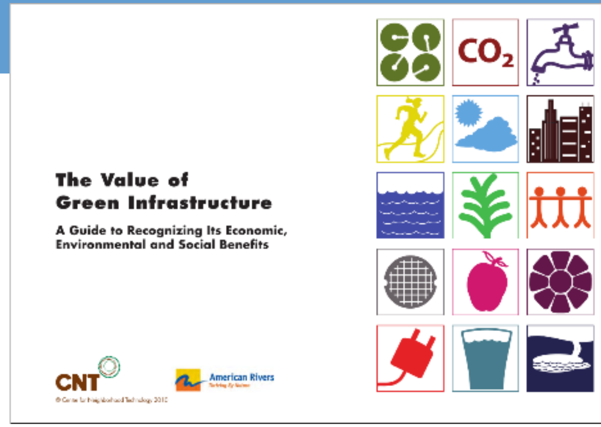
Porous Pavements

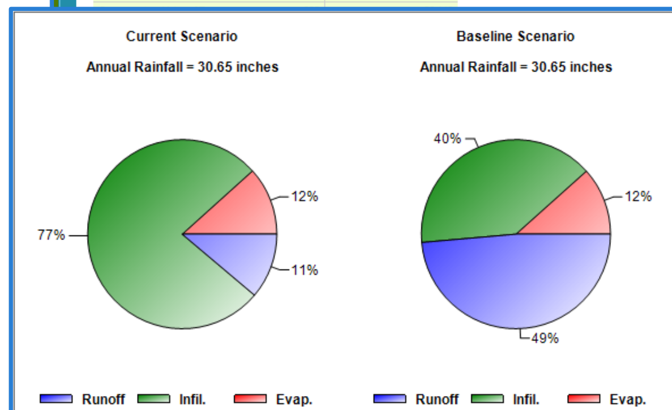
- Melting water seeps through the pavement instead of refreezing
- Lack of refreezing melt water eliminates the need for additional deicing applications
- Observational data supported by laboratory biomechanical investigations
- Pavement noise is generated through tire pavement interaction and block compression of tire tread against the pavement surface
- 5 to 6 dB reduction in noise level
- Decreased hydroplaning
- Decreased glare

Kevern J. (2012), Neithalath N. (2005),

Quantifying Benefits

- Reduced Runoff
  - Computational Methods – Curve Number, Rational, Small Storm Hydrology, SWMM Runoff
  - Models: By hand, TR-20, TR-55, SWMM, National Stormwater Calculator, etc.
- Trees – iTree (https://www.itreetools.org/)
- Green Values National Stormwater Management Calculator (http://greenvalues.cnt.org/)
- CNT and American Rivers (2010)
  - Benefit quantification
  - Valuation



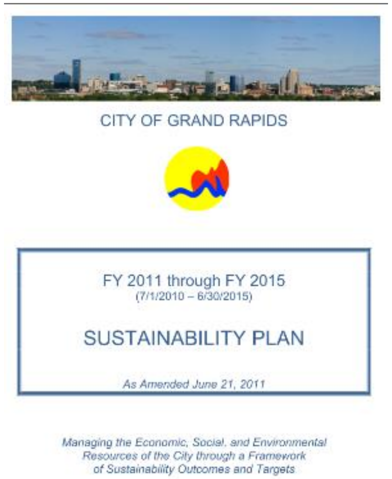


Statistic	*Current Scenario*	*Baseline Scenario*
Average Annual Rainfall (inches)	30.65	30.65
Average Annual Runoff (inches)	3.43	14.96
Days per Year With Rainfall	69.80	69.80
Days per Year with Runoff	6.70	42.07
Percent of Wet Days Retained	90.41	39.73
Smallest Rainfall w/ Runoff (inches)	0.31	0.11
Largest Rainfall w/o Runoff (inches)	0.99	0.26
Max. Rainfall Retained (inches)	1.86	1.06

Center for Neighborhood Technology and American Rivers. The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits. 2010.

Example Project Integration

Sustainability Plan Targets


CITY OF GRAND RAPIDS

FY 2011 through FY 2015
(7/1/2010 – 6/30/2015)

SUSTAINABILITY PLAN

As Amended June 21, 2011

Managing the Economic, Social, and Environmental Resources of the City through a Framework of Sustainability Outcomes and Targets

Target	Approach
Soc 4.2-2: Increase the wellness of City employees and their families	• Identify projects with vegetation as assisting with this target • Correlate project areas with crime locations
Soc 5.1: Reduce the occurrence of crime	
Soc 5.4-2: Increase by at least 5% the neighborhood conditions (safety and/or appearance)	
Env 1-3: Reduce total direct/indirect CO2 emissions by 10,000 metric tons	Quantify carbon sequestered from vegetation and avoided CO2 emissions from energy savings
Env 2.1-4: Increase reuse of captured water and/or gray water	Quantify water harvesting use
Env 2.2-4: Reduce wastewater flow by at least 5% by 2014	Quantify runoff reduction in combined sewer areas
Env 2.2-6: Increase the number and square footage of green roofs	Quantify green roof area
Env 2.2-7: Reduce stormwater discharge by at least 50,000 gallons per rain event	Quantify runoff reduction in separate storm sewer areas
Env 2.2-9: At least 5% of reconstructed streets, alleys and City parking lots to be constructed of pervious pavement	Quantify pervious pavement installed
Env 2.3-1: Increase the percentage of tree canopy in the city to at least 37.5%	Count trees installed and estimate canopy area
Env 2.3-2: Increase the percentage of low-maintenance grasses and native plants used in landscaping by at least 25%	Quantify the vegetation area installed
Env 3.2-7: Increase the number of acres of City owned park property using LID	Quantify green infrastructure practices installed in parks

Sustainability Plan Targets

- LID in city parks
- Water harvesting
- Green roof
- Porous pavement
- Tree canopy
- Low maintenance grasses and native plants
- Vegetation for social wellness
- CO2
- Runoff volume reduction

Conceptual Green Infrastructure Planning DRAFT

Example Walsh St

North side of Walsh St. between Martin Ave and Eastern Ave

LAND COVER / HYDROLOGY RUNOFF (CF)

Description	Area (sf)	90%	2-yr	10-yr	100-yr	Avg Annual
Streets & Roads | Paved; curbs and storm sewers (excl. ROW)	6,241	418	1,223	1,850	3,148	13,250
Urban | Paved Parking, Roofs, Driveways (excl. ROW) |100% impervious	1,881	126	369	558	949	3,994
Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover >75%)	1,583	10	86	176	407	323
Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover >75%)	18,939	125	1,034	2,103	4,865	3,869
Total	**28,644**	**679**	**2,712**	**4,686**	**9,368**	**21,436**
Runoff (in) ->		*0.28*	*1.14*	*1.96*	*3.92*	*8.98*

PROPOSED IMPROVEMENTS

Green Infrastructure

SCM Practice Selection	Surface Area (sf)	Volume Retain (cf)	Volume Detain (cf)	Volume Total (cf)	Unit Cost ($/sf)	Capital Cost
Bioretention - Curb Extension, at intersection	650	663	150	813	$31	$20,150
Bioretention - Curb Extension, mid-block	550	561	127	688	$31	$17,050
Pervious Pavement - Parking	2,000	1,200	0	1,200	$23	$46,000
Subtotal	**3,200**	**2,424**	**276**	**2,700**		**$83,200**
Runoff (in) ->		*1.02*	*0.12*	*1.13*		

Linear Conveyance

Conveyance Practice Selection	Length (ft)	Unit Cost	Capital Cost
6" PVC, Shallow	400	$34	$13,600
Subtotal			**$13,600**

OPINION OF PROBABLE COST

Capital Cost		$96,800	**Average Annual O&M**	**$4,600**
Contingencies (as a percentage of construction cost)	25%	$24,200		
Engineering, Inspection, Testing, Legal, Administration, and Financing	20%	$19,360	**50-yr Net Present Value**	**$404,000**
TOTAL Capital		**$141,000**		
Unitized Capital Cost		**$214,000** per acre		**$7** per gallon

BENEFITS

Targeted Practices and Locations

Drainage area (DA) | Area green infrastructure (GI) | Ratio DA:GI | Ratio Imp:GI	0.66 acres	0.07 acres	9:1	2.5:1
Green roof [Env. 2.2 #6] | Pervious pave [Env. 2.2 #9]	NA sf	2,000 sf		
New trees planted [Env. 2.3 #1] Quantity | 10-yr Canopy | 50-yr Canopy	2 each	600 sf	3960 sf	
Area of low maintenance grasses and native plants used [Env 2.3 #2]	1200 sf			

Social Benefits

Increased wellness [Soc. 4.2] and reduced crime [Soc. 5.1] with vegetation Yes ADA Ramp(s) [Soc. 1.3, Target 6] Yes

Environmental Benefits

Total direct and indirect CO_2 emissions reduction [Env 1 #3]	metric tons	
Water quality treatment volume (90%) managed and retained	Volume Managed: Yes	Volume Retained: Yes
Average annual runoff volume retained on-site	0.15 Mgal	91% percent of total runoff retained

THANK YOU

TETRA TECH

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Cost Saving Approaches for Implementing Green Stormwater Infrastructure

Andrew Potts, P.E., LEED AP, CPESC

EPA Webinar

May 5, 2015

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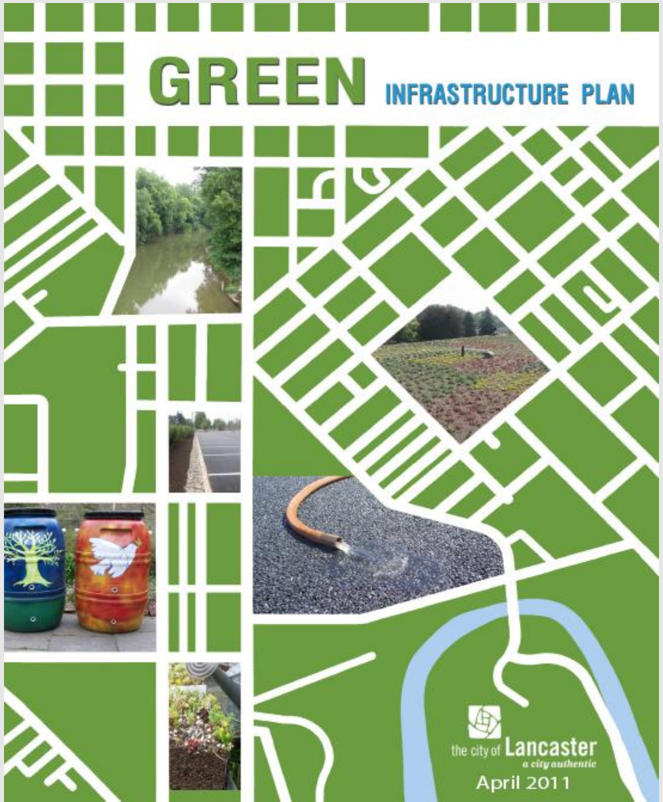


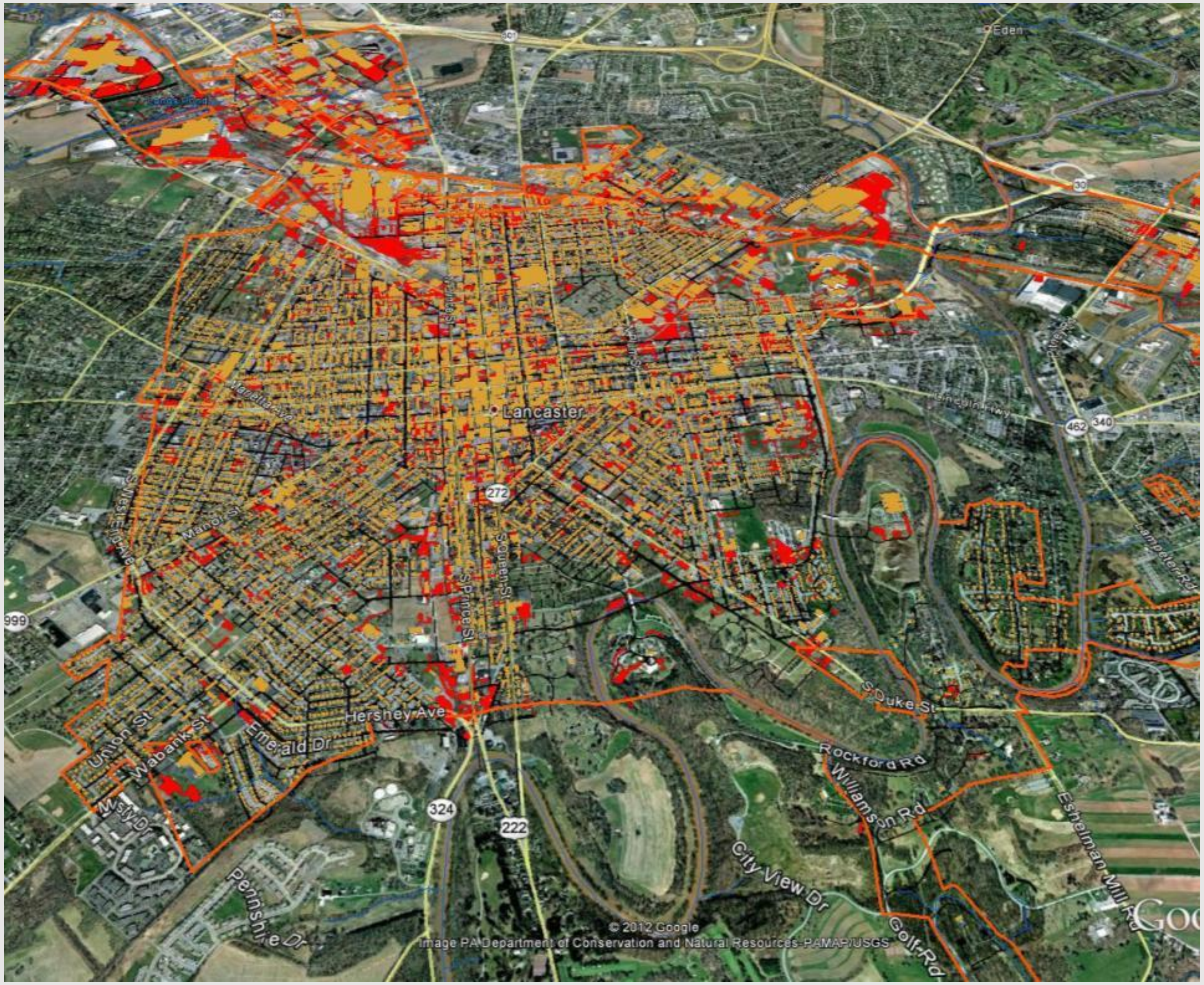
Outline

- City of Lancaster (PA) Green Infrastructure Program Overview
- Integrated Infrastructure Programs – achieving multiple benefits to stretch our public investments
  - Parks
  - Roads/Sidewalks
  - Other utilities
- Public-Private Partnership Program
- Additional Information
- Questions

City of Lancaster – Overview

- **55% separate** sewers / **45% combined**
- Conestoga River → **Chesapeake Bay (TMDL)**
- 7.34 square miles with **60,000 residents** in the 2010 census, significant poverty levels
- **Incorporated in 1742** as a borough and in 1818 as a City
- **Historic building stock** (median home age of 100 years)

2011 Green Infrastructure Plan Envisions Widespread GI

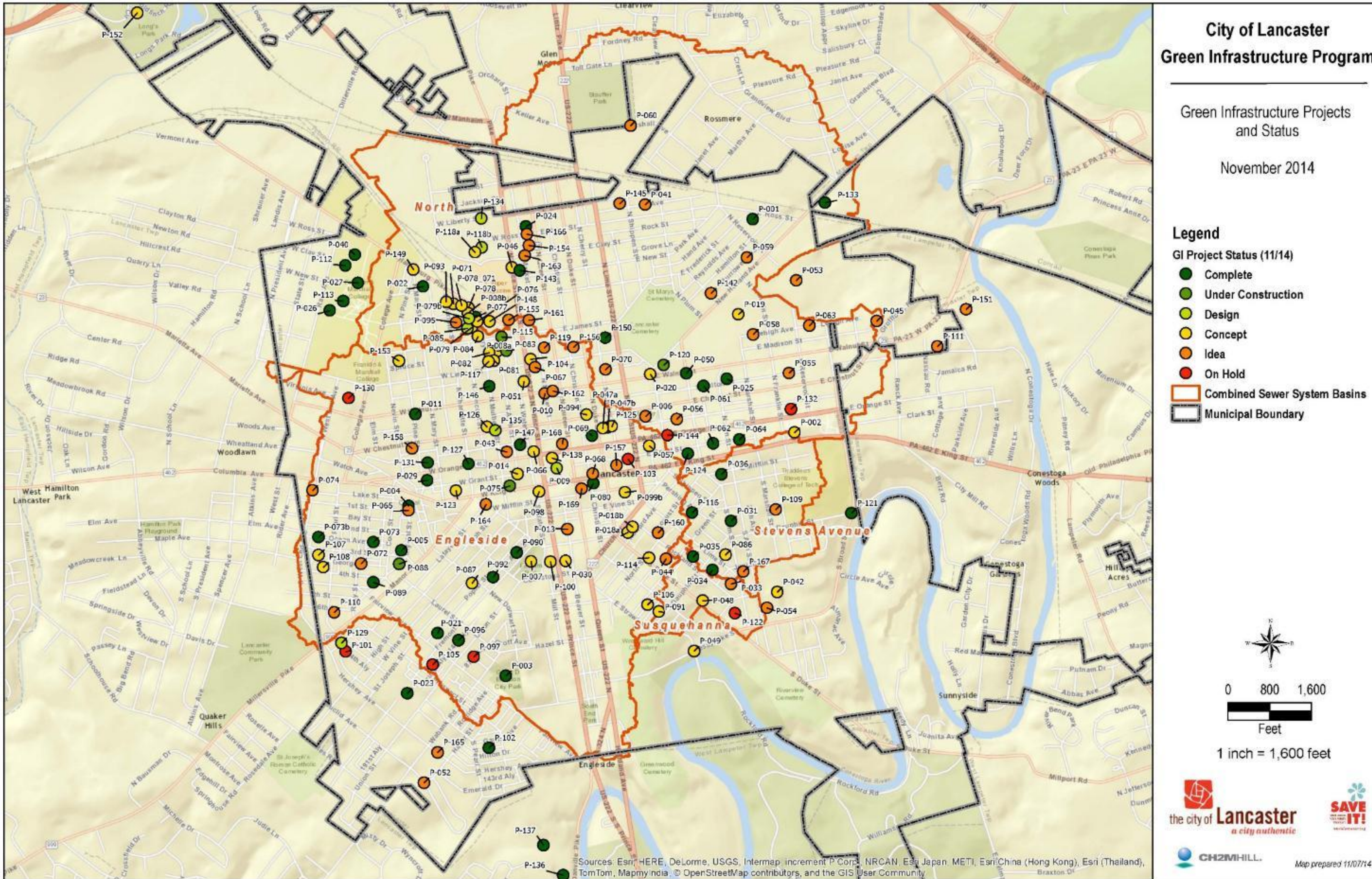


Roads & Alleys

Parking

Rooftops

Green Infrastructure Program Status



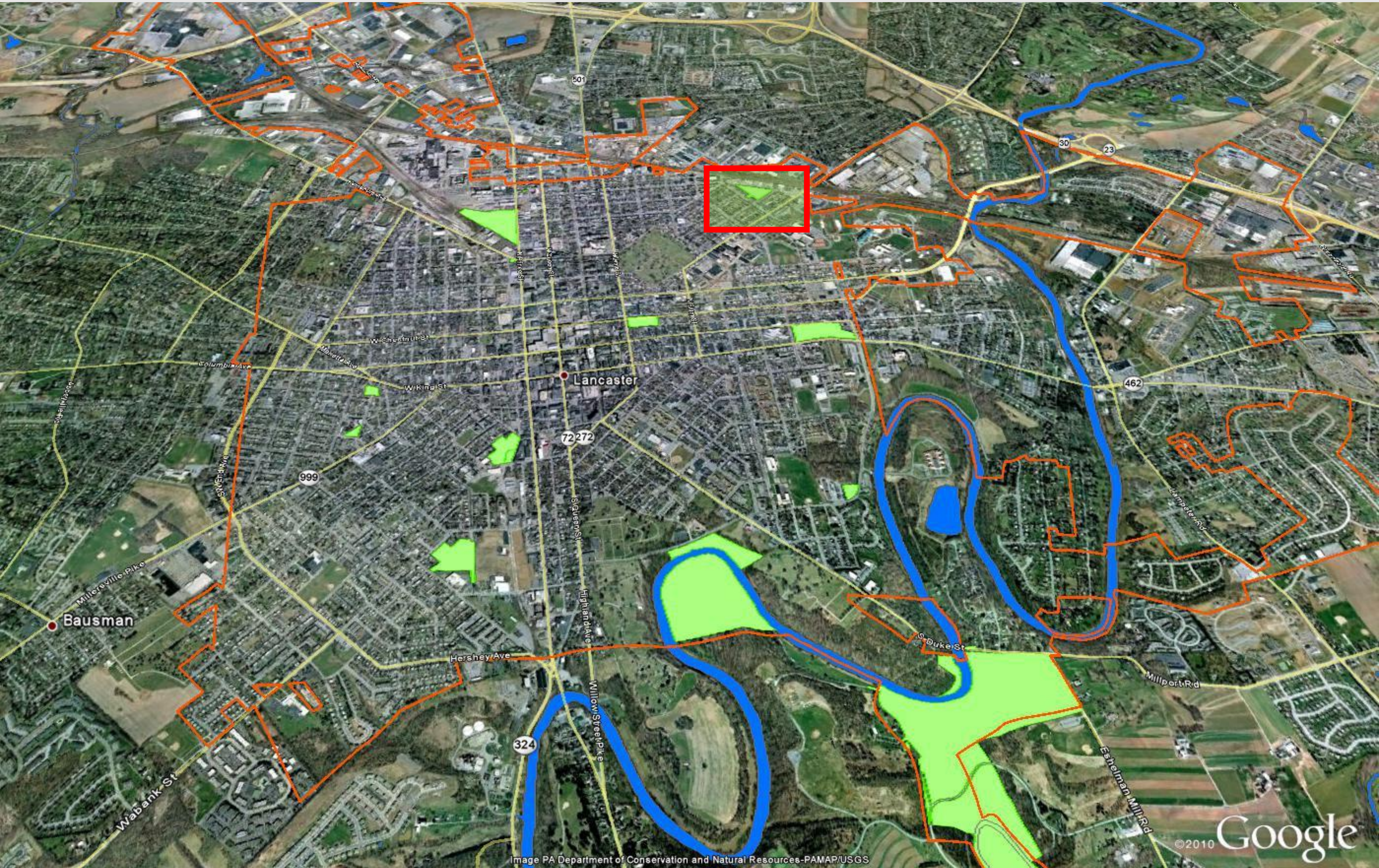
Green Infrastructure Program Status

Status	Number of Projects	Impervious Area Managed (sq. ft.)	Impervious Area Managed (acres)	Annual Runoff Capture (Gal/yr)
Constructed / Under Construction	52	1,009,587	23	20,172,000
In Design for Construction	14	943,000	22	17,984,000
Conceptual Designs (non-PV/GGP)	24	640,000	15	12,262,000
PENNVEST Concepts	19	367,000	8	7,033,000
Growing Greener Plus Concepts	1	46,000	1.1	881,000
In Project Planning	52	-	-	-
Total	**162**	**3,005,587**	**69**	**58,332,000**

Building off existing plans: Parks

- Lancaster's Urban Park, Recreation and Open Space Plan (2009) called for renovations of a number of City parks
- Green Infrastructure Plan recommended GI be integrated with park improvements
- Significant GI successfully included in the 4 renovation projects completed to date

Integrated Infrastructure: Green Parks



Expanding the Benefit of the Park – 6th Ward Park (2010)

Sixth Ward Park

- Porous basketball court with storage infiltration bed
- Funding from DCNR, DEP and Chesapeake Bay Stewardship Fund (NFWF)

Runoff Reduction	713,000	gallons / year
Bid Cost (Total Project Cost)	$ 116,300	
Cost of Basketball Court Only	$ 49,650	
Incremental Cost of GI	$ 66,650	
Total Cost	**$ 0.16**	**/gallon / year**
Incremental Cost of GI	**$ 0.09**	**/gal/yr (<u>$87k per acre</u>)**
	[over 40% savings from full project cost]	

6th Ward Park Re-dedication Ceremony

GREEN PARKS

Lancaster
Bausman
Hershey Ave
Millport Rd
Wabank St
Willow Street Pike
Eshelman Mill Rd
S Duke St
W Chestnut St
W King St
Columbia Ave
Millersville Pike
Lampeter Rd
501
30
23
462
999
72
272
324
Image PA Department of Conservation and Natural Resources-PAMAP/USGS
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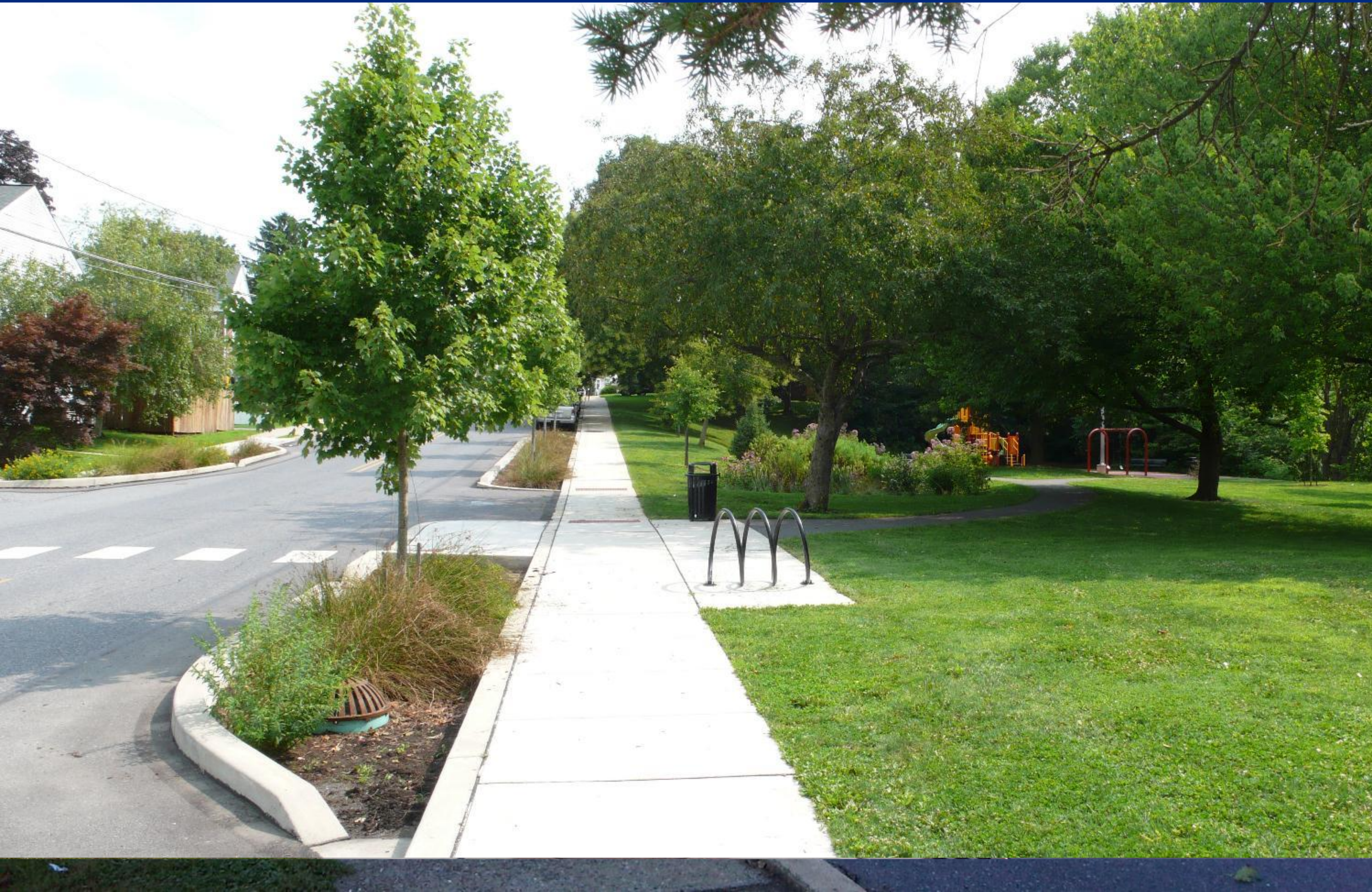
BRANDON PARK

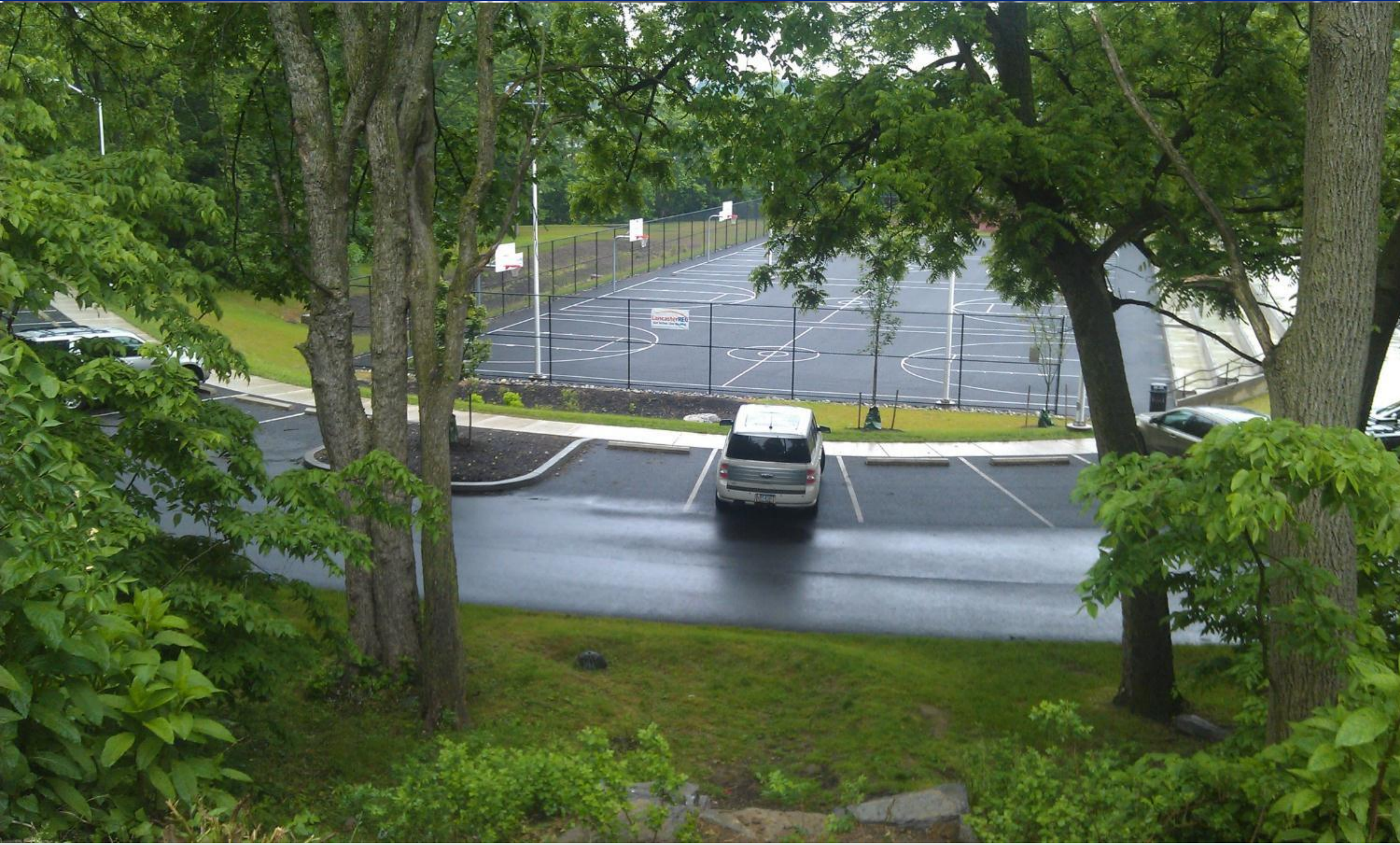
4 Million Gallons / year r*eduction in runoff volume*

$0.15 / gal

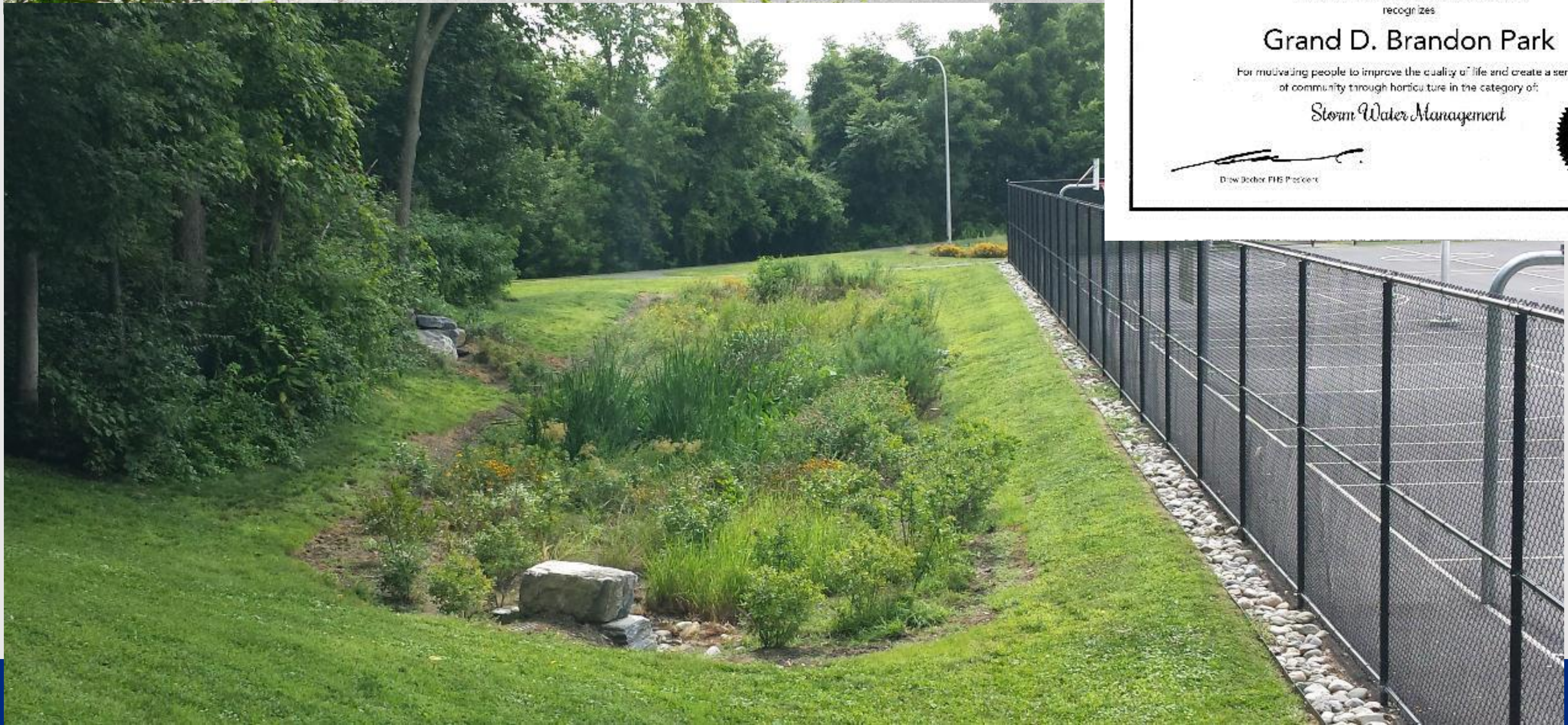
BRANDON PARK – WABANK ST. CURB EXTENSIONS



BRANDON PARK



BRANDON PARK



PHS PENNSYLVANIA HORTICULTURAL SOCIETY

PHS Gardening and Greening Contest

THE PENNSYLVANIA HORTICULTURAL SOCIETY
recognizes

Grand D. Brandon Park

For motivating people to improve the quality of life and create a sense of community through horticulture in the category of:

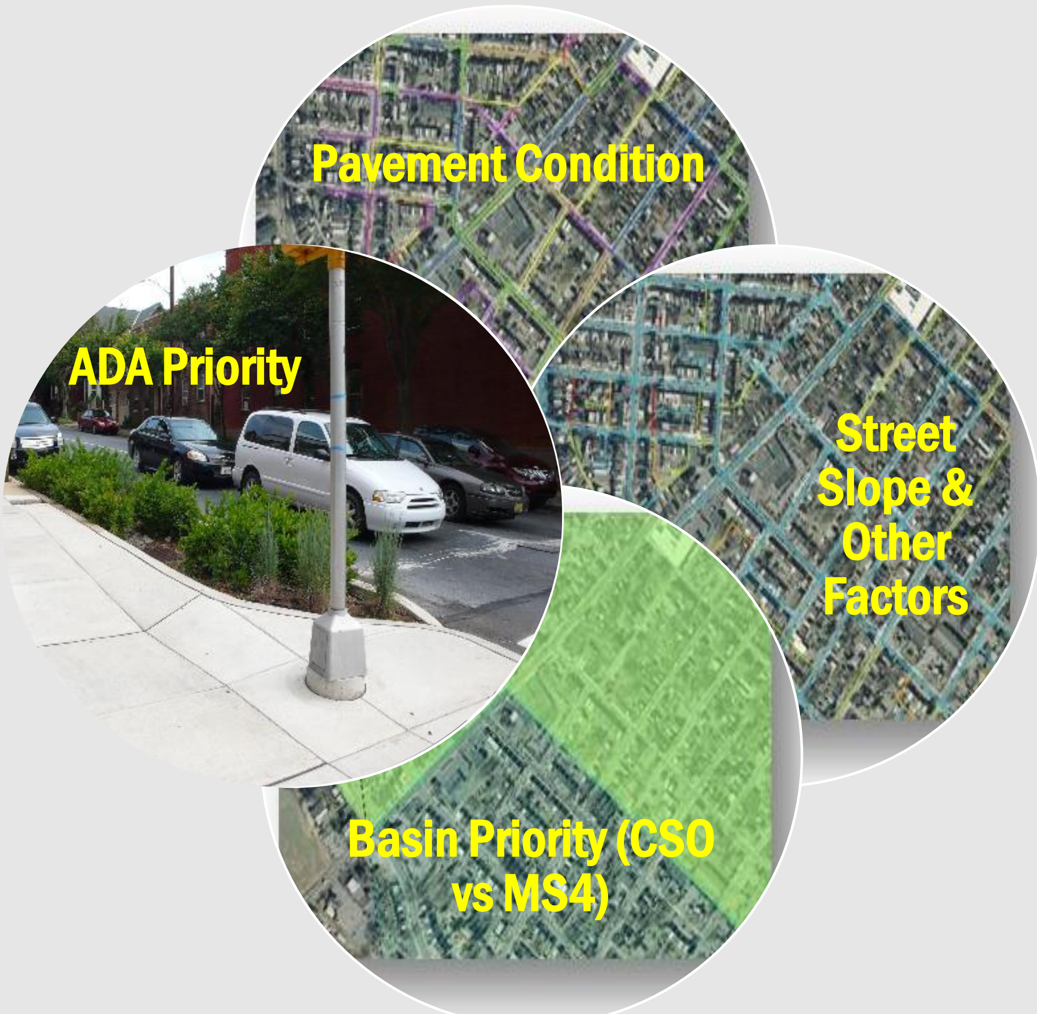
Storm Water Management

GARDEN OF DISCTINCTION

Drew Becher PHS President

Integrated Infrastructure: Green Streets & Alleys

Composite Prioritization Criteria Yielded Most Cost-effective Green Streets Opportunities



Road Type
- *- Width*
- *- Traffic ("Functional Class")*
- *- Ownership (City, State, private alleys)*

Tree Canopy
Flooding locations
Overhead Wires
Sidewalk Condition
Inlet Condition

Lowest Overall Green Street Cost

Alley 148 Greened for 10% Additional Cost, Captures 200,000 Gallons per Year

Before (July 2011)

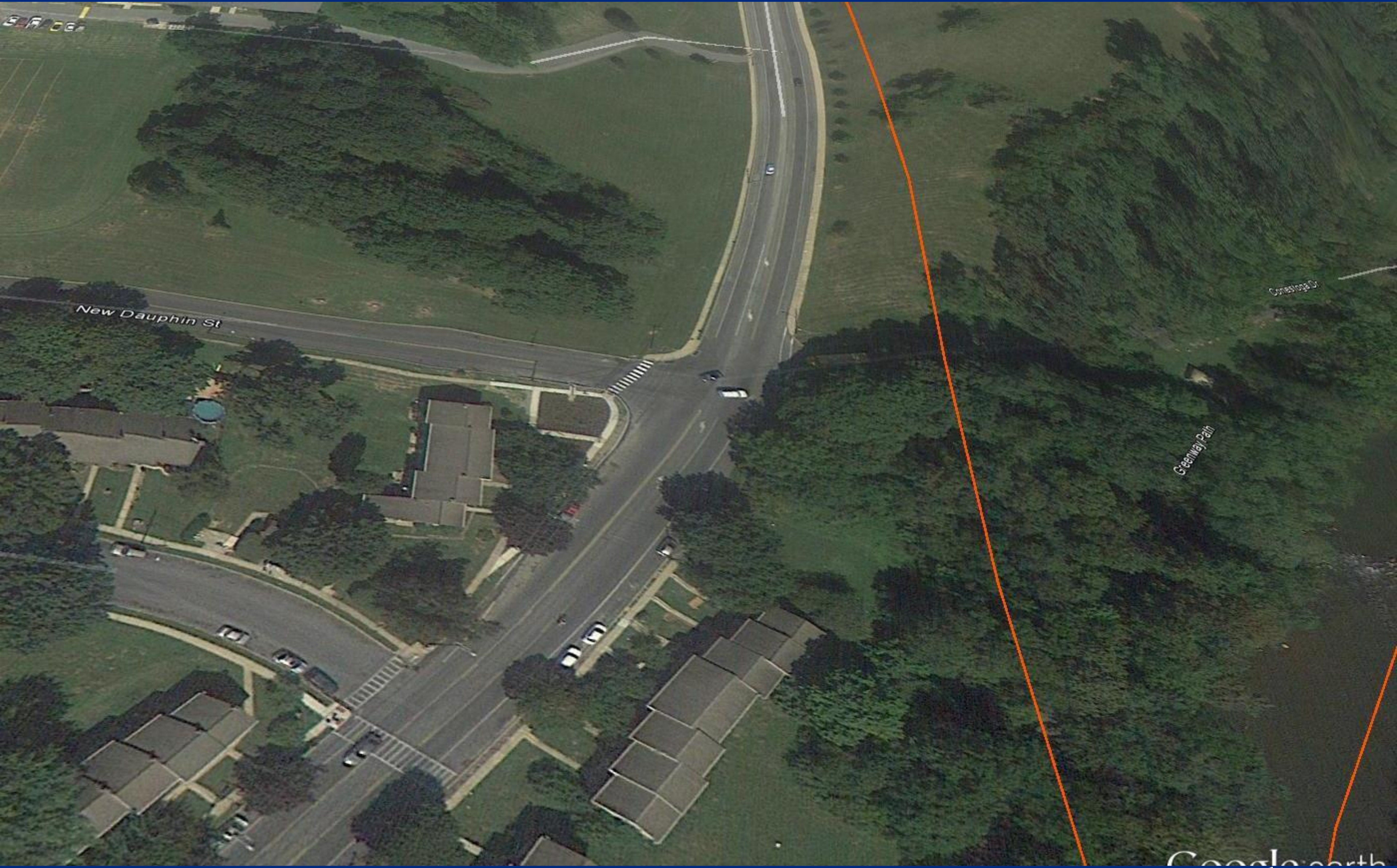
After (February 2012)

Component	Conventional Unit Cost ($/square foot)	Green Unit Costs ($/SF)
Pavement Removal/Excavation	$1.08	$1.08
Crushed Stone w/ geotextile	$0.35	$1.39
Pipes/Cleanouts/etc.	---	$0.82
8-inch reinforced concrete	$18.89	$18.89
Permeable Pavers	---	$19.44
Total Weighted Average	**$20.32**	**$22.37**
Additional Green Cost ($/SF)	---	$2.05
Additional Green Cost (%)	---	10%

Conventional reconstruction (8-inch reinforced concrete) ~$20.30/SF

Green alley retrofit (permeable pavers with infiltration trench) ~$22.40/SF

Broad St. & New Dauphin St. Green Street



Project Reference ID	P-121
Project Name	Pavement Removal at New Dauphin and N. Broad St.
GI Prototype Project Type	Alley/Street
Construction Year (Actual)	2012
Impervious Area Contributing (ft2)	31,000
GI Area (ft2)	3,000
Calculated Estimated Capture Volume (gal/yr)	554,000
Estimated Constructed Cost (Class 3)	$86,000
Bid GI Construction Cost	$80,000
Cost / Stormwater Volume ($/gal)	$0.14

550,000 Gallons / year reduction in runoff volume

Using Traffic Safety & Transportation Funding To Reduce Accidents and Runoff while Enhancing Local Business

Integrating Traffic Improvements Improves Safety, Local Business, and Brings New Funding Sources

- Built with Transportation and GI Grant funds
- Helps local business
- 2014 *Best Urban BMP in the Bay Award*
- Pennsylvania *Governor's Award for Environmental Excellence*
- *$0.24/gal/year*

New Outdoor Seating with Permeable Pavers

Integrating with water and sewer upgrades – Greening Spruce Street

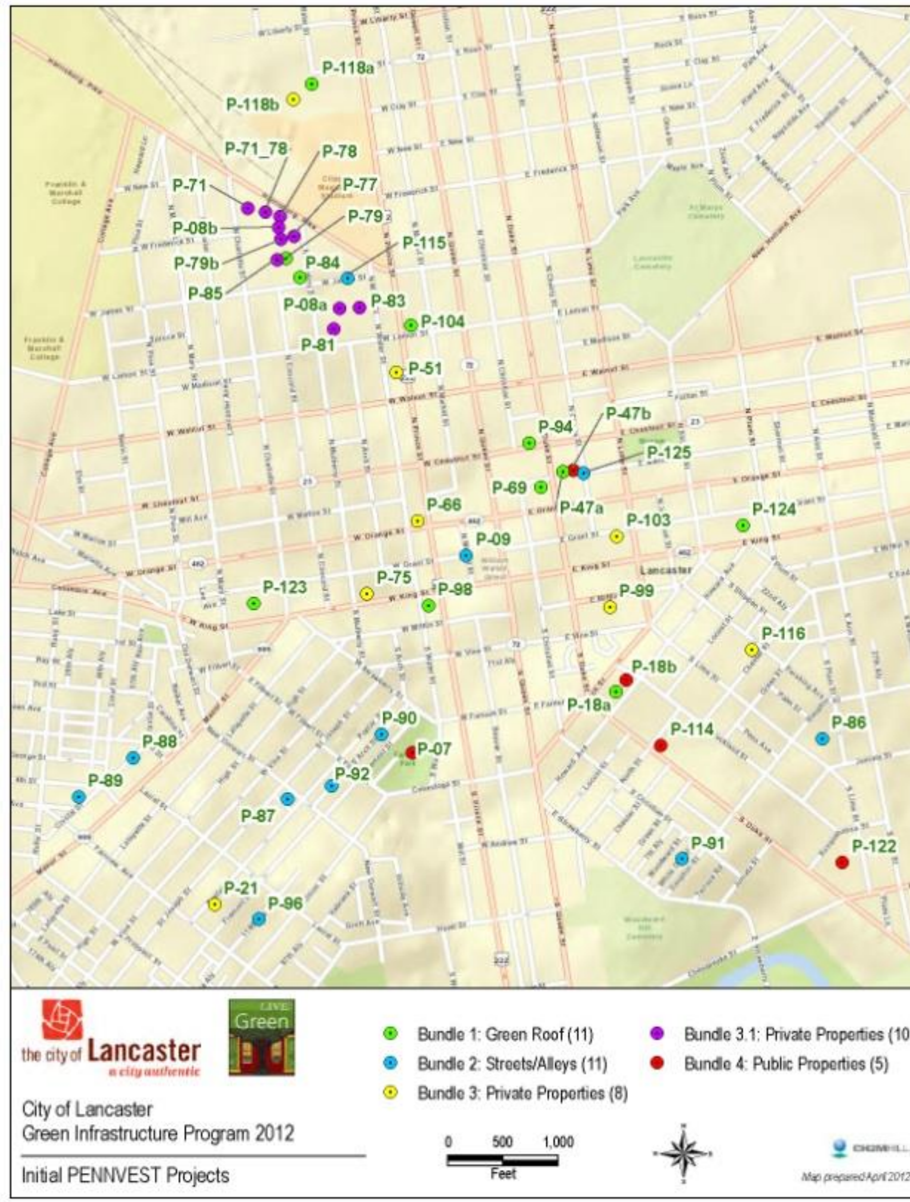
Impervious Area Contributing (ft^2)	GI Area (ft2)	Calculated Storage Volume (ft^3)	Calculated Capture Depth (in)	Calculated Estimated Capture Volume (gal/yr)	Actual Construction Cost (Bid)	Construction Cost / Stormwater Volume ($/gal)
13,000	1,000	1,000	1.01	250,000	$21,000	$0.08

Spruce Street Greening Project (2013)

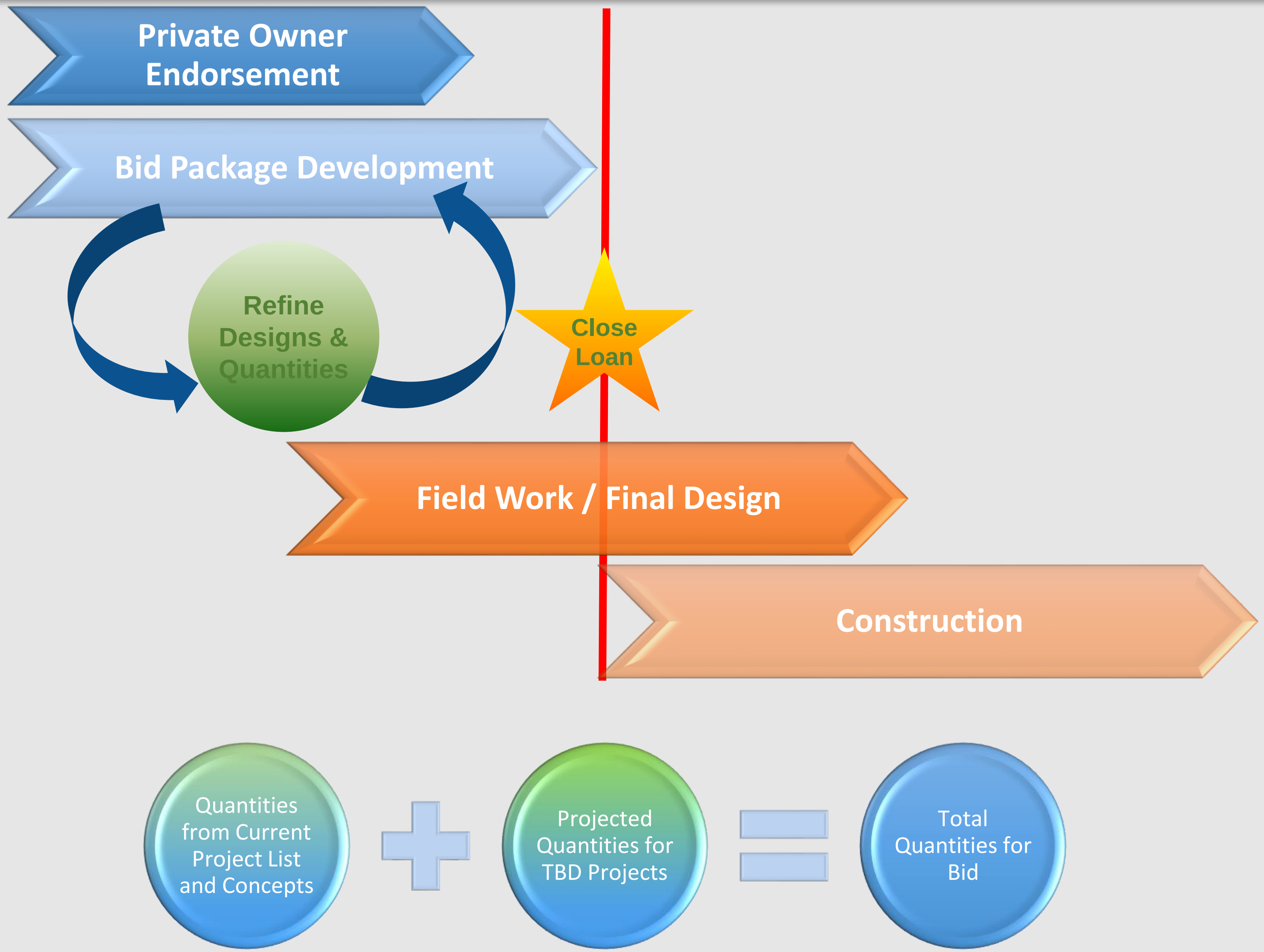
250,000 Gallons / year reduction in runoff volume

Innovative Public-Private Partnership Using State Revolving Funds (PENNVEST in PA)

- $7M SRF PENNVEST Loan to fund implementation of GI on public & private property
- 45 initial GI sites with an additional ~25% to be determined (TBD)
  - Divided into 5 bundles for bidding
- City pays up to 90% of GI Costs
- Property owner pays remainder and signs on to



Overall PENNVEST Processes



Cost Estimating Tool Based on Unit Prices in Bids

P-XXX BID COST FORM	**Bid Bundle No:** 2	Enter Project Runoff Capture Volume (CF): 1,671	Capture Volume (Inches): 1.22
Unless covered by a separate Pay Item, Unit Prices shall include all materials, labor, equipment, etc. required for their applicable Pay Items (e.g., procurement, delivery, installation, compaction, parts, fittings, incidental work required, etc.) in accordance with the contract documents, drawings, details, specifications and industry standard construction practices.		Enter Project Capture Area (SF): 16,423	Estimated Annual Runoff Capture (%): 89.8%
******NOTE: USER INPUTS VALUES IN GREEN BOXES AND ITEM QUANTITIES ONLY***			Estimated Annual Runoff Capture (gal): 386,441
			Cost Efficiency of GI Improvements ($/gal): $ 0.01

Pay Item	Name	Unit	Estimated Quantity	Unit Price ($ or %)	Total GI Cost ($) (Quantity x Unit Price)	Non-GI Improvements[1] Estimated Non-GI (NGI) Quantity	 Non-GI Cost ($) (NGI Cost x Unit Price)
Site Preparation and Restoration							
1	Site Clearing and Disposal (removal of grass, shrubs, small trees, debris, etc.)	SY	10	$ 43.80	$ 438.00	0	$ -
2	Structure and Pavement Demolition (includes sawcutting, demo and disposal)	CY	10	$ 25.90	$ 259.00	0	$ -
3	Asphalt Milling - up to 2" Depth (includes disposal)	SY	5	$ 6.00	$ 30.00	0	$ -
4	Common Excavation, Grading, and Backfill (includes disposal)	CY	20	$ 23.90	$ 478.00	0	$ -
5	Rock Excavation and Disposal	CY	0	$ 75.00	$ -	0	$ -
6	Reset Brick Pavers (Roadway or Sidewalk)	SY	0	$ 71.50	$ -	5	$ 357.50
7	Establish Turf	SY	5	$ 13.90	$ 69.50	5	$ 69.50
Granular Materials							

								Total LNC Cost ($) (Total GI Cost x 90%)	Partner GI Cost Share ($) (Total GI Cost x 10%)	Total Partner Cost ($) (Cost Share + Alternate Cost)
SECTION 2 - ALLOWANCES (ENTER UNIT COST FROM BID BUNDLE)										
97	Performance Bond/Insurance	%	-	$ 0.01	$ 13.51	0.0106	$ 4.53			
98	Mobilization and Demobilization (per notice to proceed on one or more projects)	EA	1	$ 3,500.00	$ 3,500.00	-	-			
100	Temporary Maintenance and Control of Traffic	%	-	$ 0.01	$ 9.81	0.0077	$ 3.29			
101	Coordination with Other Contractors (assume 1 coordination meeting and follow-up notifications)	EA	1	$ 300.00	$ 300.00	-	-			
TOTAL OF ALL ITEMS					**$ 5,097.82**		**$ 434.81**	**$ 5,735.09**	**$ 637.23**	**$ 6,169.91**

Two Dudes Painting Company

Impervious Area Contributing (ft2)	17,000
GI Area (ft2)	4,000
Calculated Estimated Capture Volume (gal/yr)	295,000
Estimated Constructed Cost (Class 3)	$93,000
Estimated Construction Cost (Class 4)	$93,000
Cost / Stormwater Volume ($/gal)	$0.32
Primary Funding	PENNVEST


TWODUDES
PAINTING COMPANY

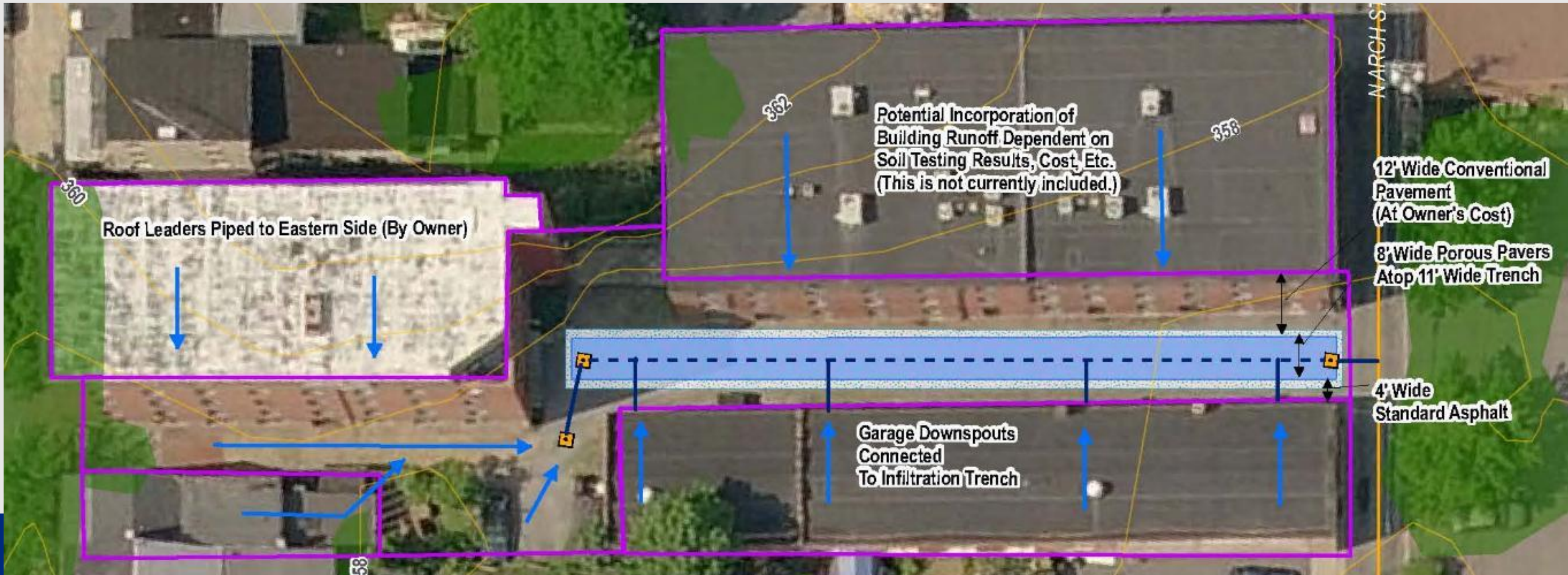

TWODUDES
PAINTING COMPANY


TWODUDES

317 N. Mulberry

Impervious Area Contributing (ft2)	20,000
GI Area (ft2)	2,000
Calculated Estimated Capture Volume (gal/yr)	399,000
Estimated Constructed Cost (Class 3)	$75,000
Estimated Construction Cost (Class 4)	$75,000
Bid GI Construction Cost	$75,000
Cost / Stormwater Volume ($/gal)	$0.19
Primary Funding	PENNVEST

- PENNVEST project coordinated with redevelopment
- Challenging coordination/sequencing
- Developer expanded decorative pavers to full driveway
- Captures large neighboring building
- Hosted EPA Press Conference on Green Infrastructure in April 2014

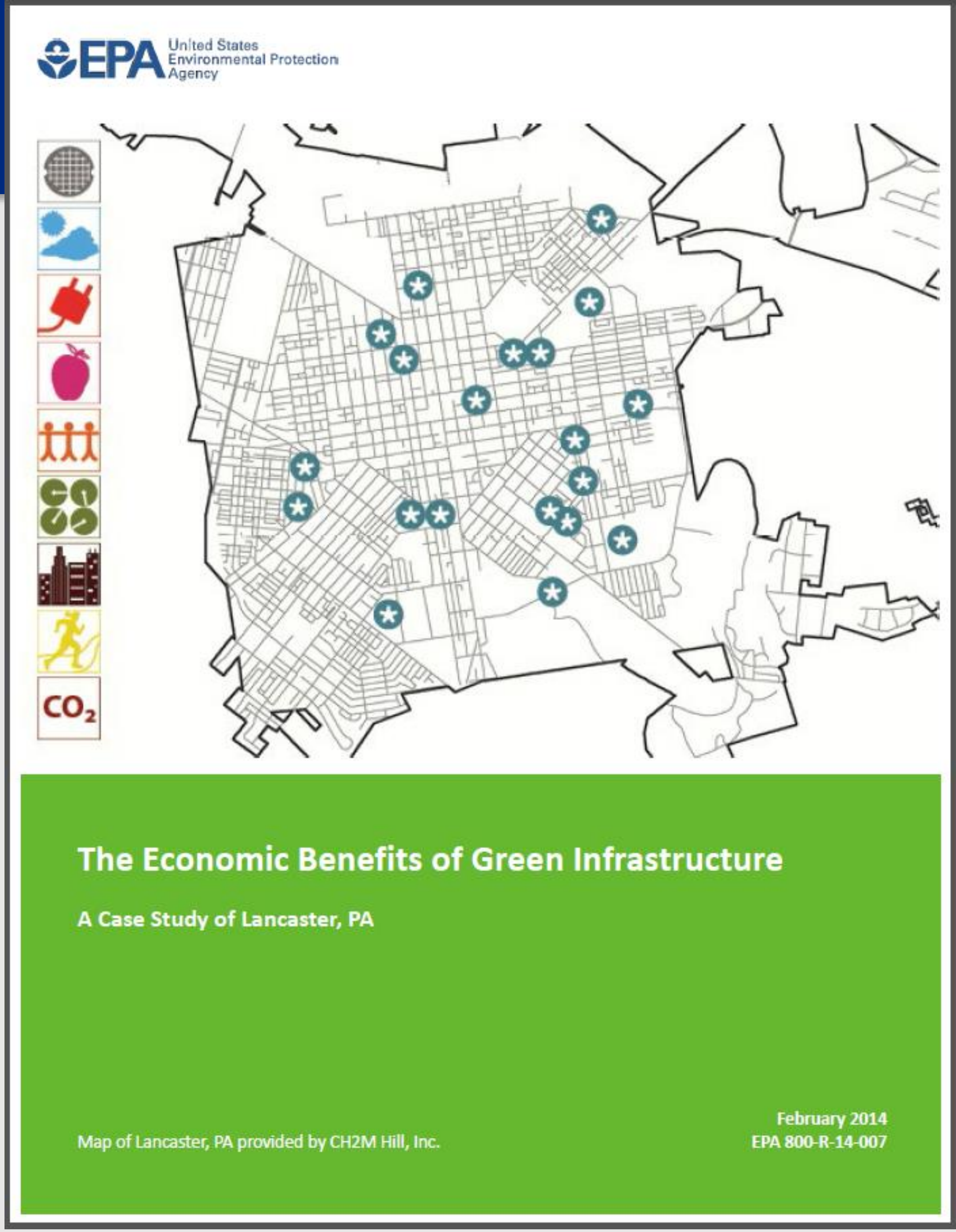


Triple Bottom Line Benefits

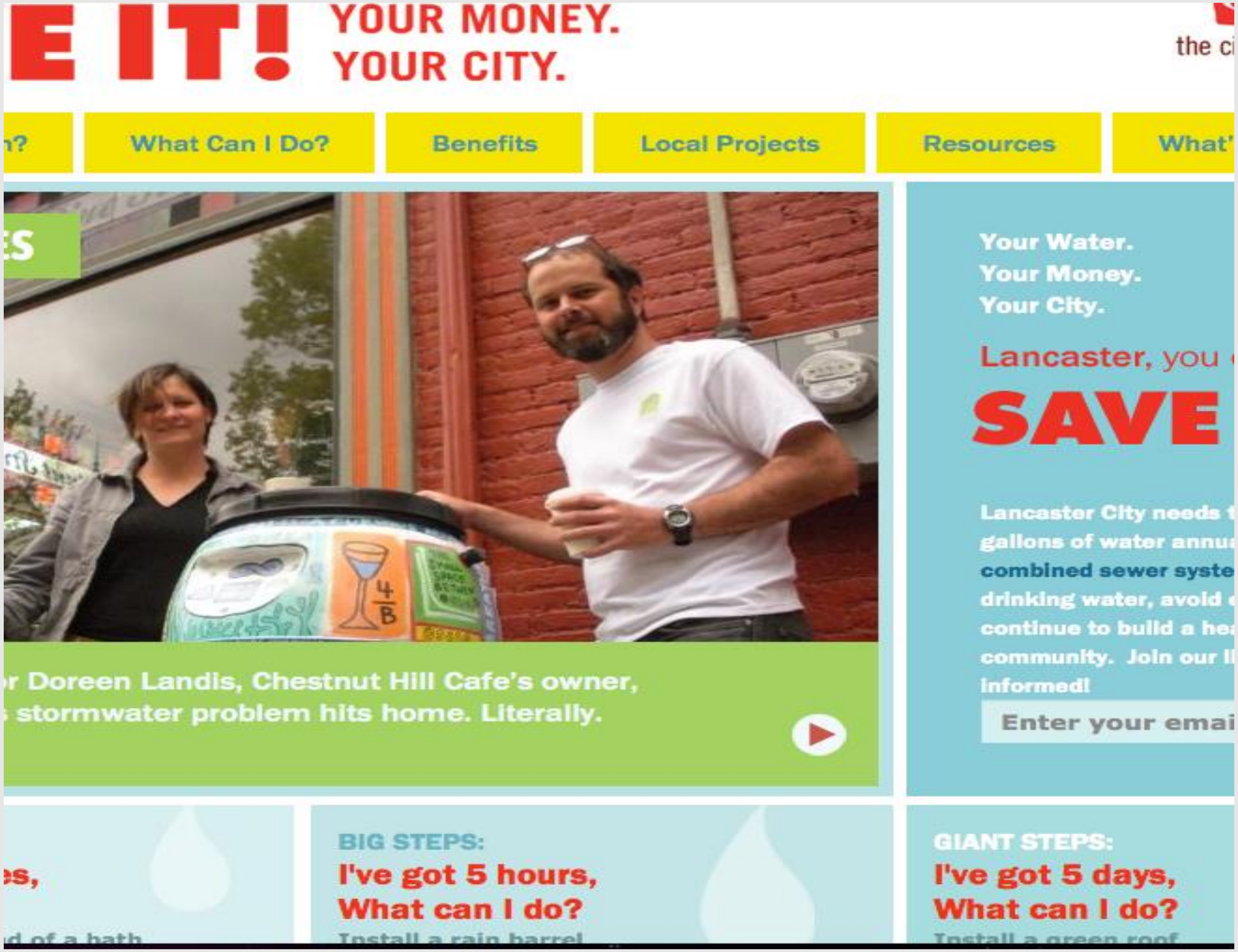
2014 EPA report estimates the following benefits of implementing the GI Plan:

- **$4.2 million/year in energy, air quality, and climate-related benefits**
- **$660,000 annually in reduced wastewater** pumping and treatment costs (at current costs)
- $120 million in avoided gray infrastructure (e.g., tanks, tunnels)

For an GI investment of $80 - $140 million over 25 years (depending on level of integration)



Additional Information



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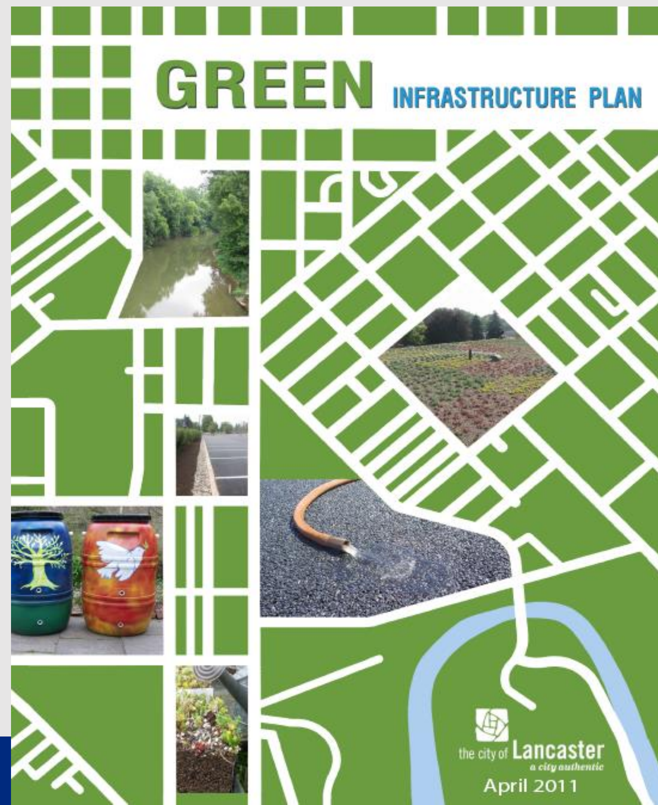
QUESTIONS?

Cost Saving Approaches for Implementing Green Stormwater Infrastructure

Andrew Potts, P.E., LEED AP, CPESC

EPA Webinar

May 5, 2015



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Next Webcast – July 7, 2015

Paying for Stormwater – The Benefits of a Utility

- **Robert D. Chandler,** Assistant Public Works Director, City of Salem, OR
  Shelia Dormody, Director of Policy, City of Providence, RI
- **Andrew Reese**, Vice President, AMEC Foster Wheeler

Registration in late June

Information and registration will be posted at
http://water.epa.gov/infrastructure/greeninfrastructure/gi_training.cfm