Costs for Green Infrastructure and Stormwater Controls

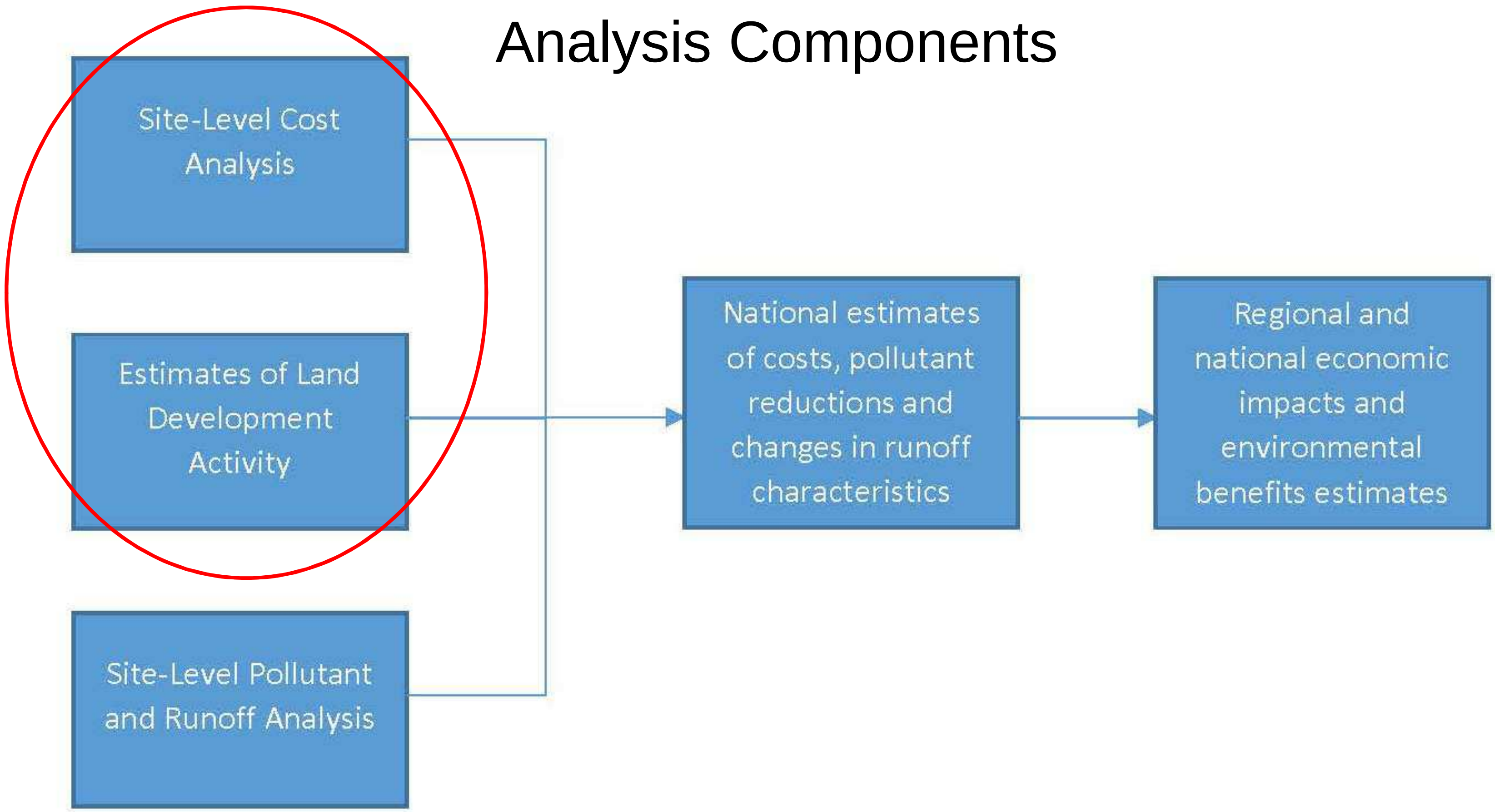
June 4, 2015

Bob Newport
U.S. EPA Region 5 (Chicago Office)

Topics to be Covered

- EPA data collection and cost analysis focused on post-construction stormwater BMPs
  - Methods
  - Some results
- Factors influencing BMP selection and costs
- Case studies
- Co-benefits of green infrastructure

Analysis of Costs and Performance of Different Stormwater Practices



Data Inputs and Sources

- Existing standards (state, MS4) for stormwater management (baseline)
- Project characteristics (% IC, runoff coefficients, source area composition) from WinSLAMM
- BMP cost data
- Hourly precipitation data from NCDC (~350 stations)
- Evapotranspiration data from NASA NLDAS
- Land value data from Lincoln Land Institute and other sources
- Developed land pollutant concentrations from WinSLAMM
- BMP pollutant event mean concentration (EMC) data from International Stormwater BMP database

BMP Types: Retention/Treatment

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

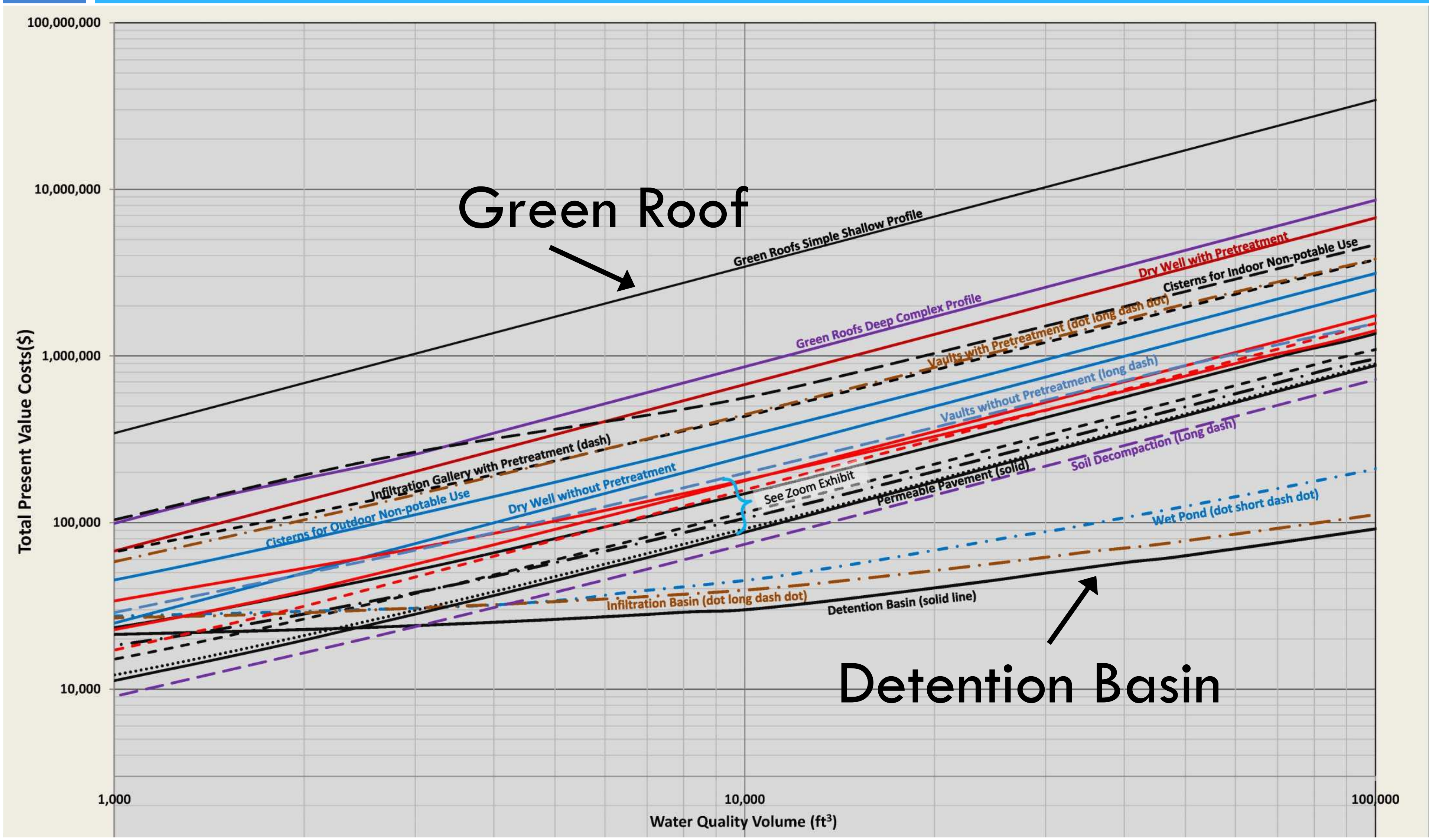
- Retention and/or Treatment:
  - Bioretention
  - Permeable Pavement

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

BMP Cost Curves

- Cost per unit volume for each BMP type
- Represent costs that would be typical for the majority of development projects
- Differentiate between new development and redevelopment projects
- Line item unit cost estimating framework (RS Means) based on generic BMP designs
- Cost types:
  - Capital costs
  - Routine operation and maintenance costs
  - Major corrective maintenance
  - Replacement costs
  - Soft costs (20% of capital costs)
  - Land costs

BMP Total Present Value Cost Curves



Cost Tool

- For a given combination of conditions (SLDM, soil type, climate station, etc.) tool iterates to determine the least-cost BMPs able to meet given standard – BMP feasibility defined by series of logic rules
- 10-year simulation using hourly precipitation data tracks BMP storage and water balance (infiltration, ET, discharge, bypass) to determine BMP performance
- Outputs for a given scenario are written to database

Lots of combinations evaluated

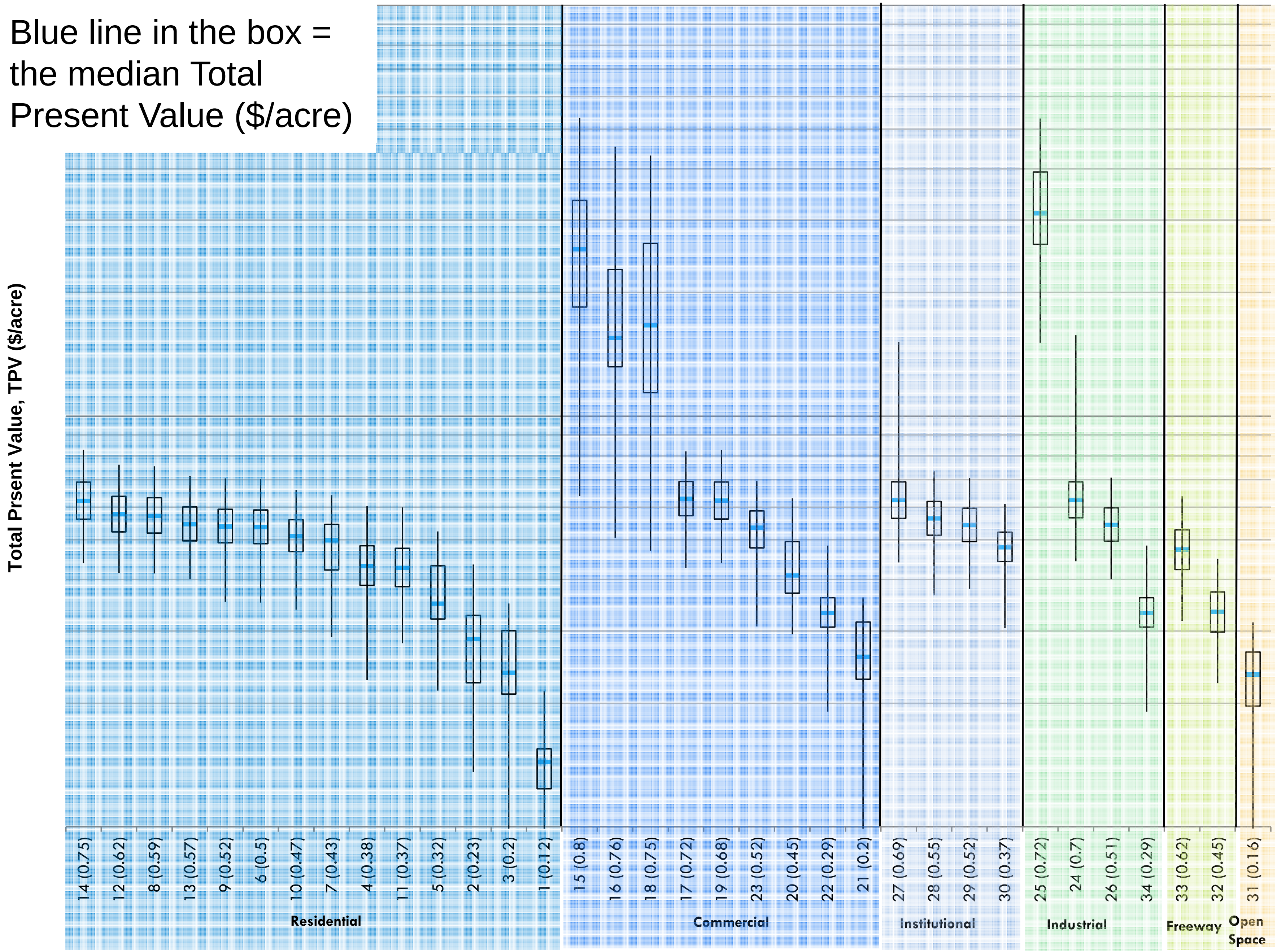
- Stormwater management alternatives
  - Existing state and MS4 baseline
  - Retention standards
  - Treatment standards
- New development and redevelopment cost curves
- 34 land development models
- 4 project sizes
- 7 soil infiltration rates
- 347 climate stations

Engineering Analysis Results

- Cost by project type
- Cost by standard/soil type
- BMP selection by standard
- Incremental costs - baseline to performance standard
- Incremental performance (pollutants and hydrology)

Example Output

Blue line in the box = the median Total Present Value ($/acre)



From Engineering Analysis Results to National Costs

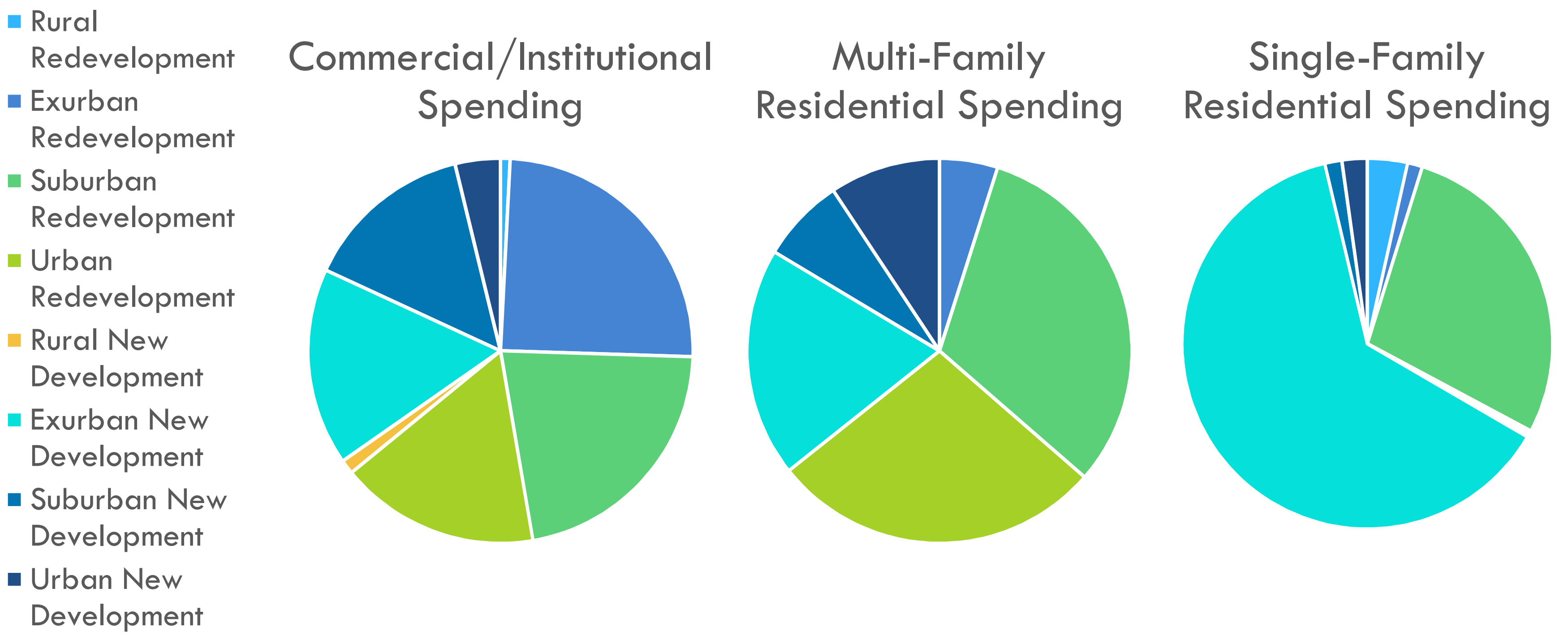
- The engineering analysis produced results for the set of model projects using numerous combinations of possible site, regulatory, and market conditions (approximately 20 million combinations)
- To derive national cost estimates, we needed to predict how frequently each of the various combinations occurred
- EPA developed the Project Prediction Model to forecast future development projects, which could be combined with the engineering results to estimate implementing different scenarios and what the resulting costs would be

Project Prediction Model:

Forecasts future development projects

- Combines forecasts of future construction spending, population growth, and migration patterns with historical data on project characteristics (i.e., size, value, impervious cover, new or redevelopment status)
- Generates a set of future projects potentially needing post-construction BMPs for the years 2016 – 2040, and at HUC12 watershed scale.
- Projects are classified as single-family residential, multi-family residential, commercial/institutional, or industrial
- Additional project characteristics are:
  - Nearest of climate station (300 possible)
  - Soil type
  - Development density type (urban, suburban, exurban, rural)
  - Regulatory status

Summaries of Predicted Construction Spending



Summary 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	

Project Cost Model

Combines project forecasts with engineering results to predict national costs

- For each project:
  - selects two modeled projects from engineering analysis with the closest site conditions, weights the engineering results based on % impervious surface;
  - estimates implementation costs using different assumptions regarding potential opportunity costs;
  - estimate the future occurrence of local codes and ordinances that can affect compliance decisions;
  - estimates potential site design changes to reduce impervious surface and lower compliance costs.

Potential Changes to Site Design

- Environmental Site Design
  - Impervious surface now costs more relative to greens space
  - Reducing 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
  - Most projects need to meet local flood storage requirements
  - Typically through detention ponds (wet/dry) or detention vaults
  - Retention practices that would be implemented to meet a performance standard offset the volume that needs to be captured or detained for flood storage

Some Example Results

- All costs are in 2012 dollars, and presented as costs/acre

Retention Estimates

- The numbers you will see 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 impacts 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

Retaining stormwater can save money on new 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 is from impervious surface reduction. Additional savings from O&M and reduced size of detention pond needed for flood control.

Retaining stormwater can save 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 is from impervious surface reduction and reduced O&M costs.

Changes to Site Design 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

Green Infrastructure Can Save Money

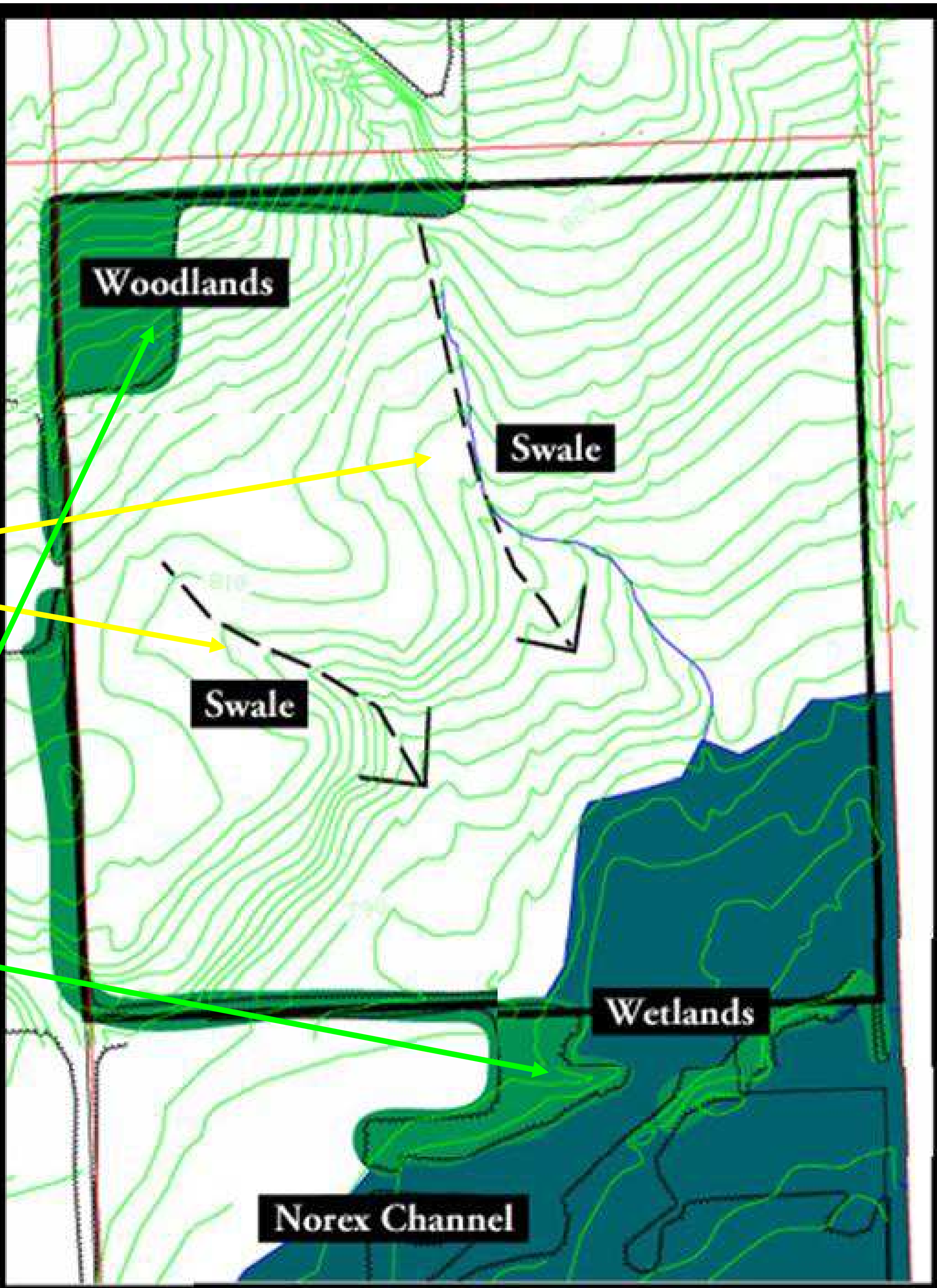
- Retaining stormwater with green infrastructure practices can reduce or eliminate the need for other water infrastructure that is currently required (e.g., pipes, detention ponds)

PRAIRIE GLEN

Site analysis

Natural Topography includes two predominant drainage patterns

Some valuable Green infrastructure on the site



PRAIRIE GLEN

Concept Plan

Site acreage: 39 acres

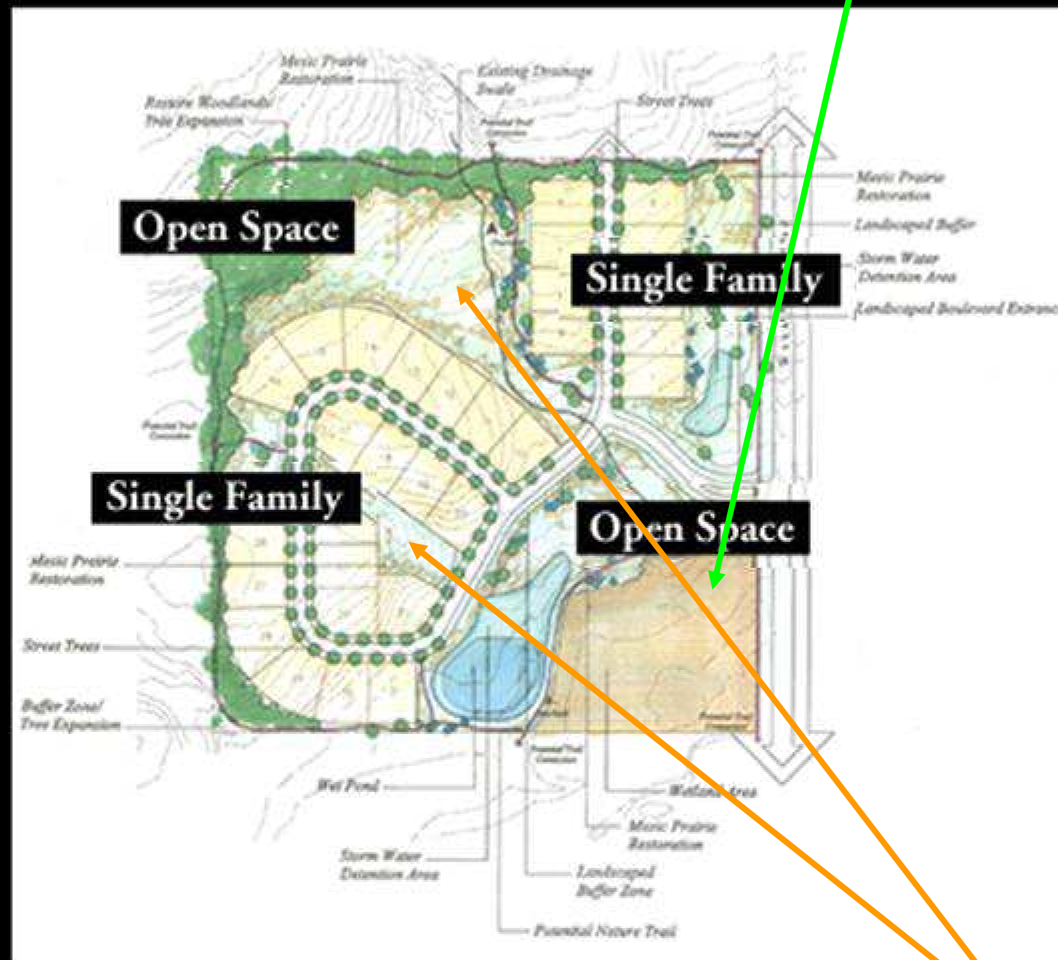
Single family: 11.5 acres

Open space: 23.1 acres
Buildable – 18.9 acres
Wetland – 4.2 acres

Infrastructure: 4.4 acres

* 59% of site is Preserved Open Space

Wetlands Preserved



Natural Drainage Patterns Maintained

Bielinski Homes

PRAIRIE GLEN

With Environmental Site Design the Development is LESS expensive!

Cost Analysis

Conventional: $1,758,385

Conservation: $1,194,621

Conservation Cost Benefit: $563,764

32% Cost Savings

Description	Conservation Costs	Conventional Costs
Grading	$168,785	$257,043
Paving	135,688	201,968
Concrete (sidewalks, curb)	107,019	261,579
Storm Sewer	114,364	215,158
Sanitary Sewer	166,827	189,402
Watermain	146,868	166,260
Miscellaneous	20,000	20,000
Utilities	39,680	64,790
Landscaping	53,680	50,100
Impact Fees / Permits	17,600	33,100
Professional Services	82,500	90,000
Financing Expenses	87,050	154,425
Real Estate Tax	54,560	54,560
Totals	$1,194,621	$1,758,385

Bielinski Homes

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.

Integrating GI with Other City Projects

Lancaster, PA

Permeable Asphalt Basketball Court

Runoff Reduction	694,600	gallons / yr
Bid[1]	$ 116,300	
Cost of Court Only[2]	$ 49,650	
Marginal Cost of GI	$ 66,650	
Total Cost	$ 0.17	/gallon
Marginal Cost of GI	$ 0.10	/gallon
Grey Storage Cost	$ 0.23	/gallon

Lancaster, PA – Green Alleys

Alley 148 Greened for 10% Additional Cost + Captures 200,000 gallons per year

Before (July 2011) ~$20.30/SF

After (February 2012) ~$22.40/SF

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%

Lancaster, PA – Parking Lots

Parking Lot	Drainage Area	GI Area	Capture Volume	Capital Costs with Contingency
Plum Street	23,402	4,680	511,000	$89,862
Dauphin	20,582	4,516	411,000	$61,822
Penn	22,758	4,219	455,000	$60,749
Mifflin	13,242	1,324	265,000	$27,013
TOTAL			1,642,000	$239,446

COST PER GALLON = $0.14/gallon

Other Sources of Information of Green Infrastructure and Costs

- 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 infrastructure can provide significant co-benefits

Green infrastructure…

- **Can increases energy efficiency and reduce energy costs** (green roofs, street trees increase energy efficiency; retention increases aquifer storage and reduces cost of transporting water)
- Can **reduce the economic impacts associated with flood events**
- **Can protect public health and reduce illness-related costs** (reduced CSO events decrease incidents of waterborne illness and shellfish closures; increased trees and plants improve air quality)

Source: Banking on Green, 2012

Newport.Bob@epa.gov

www.epa.gov/greeninfrastructure