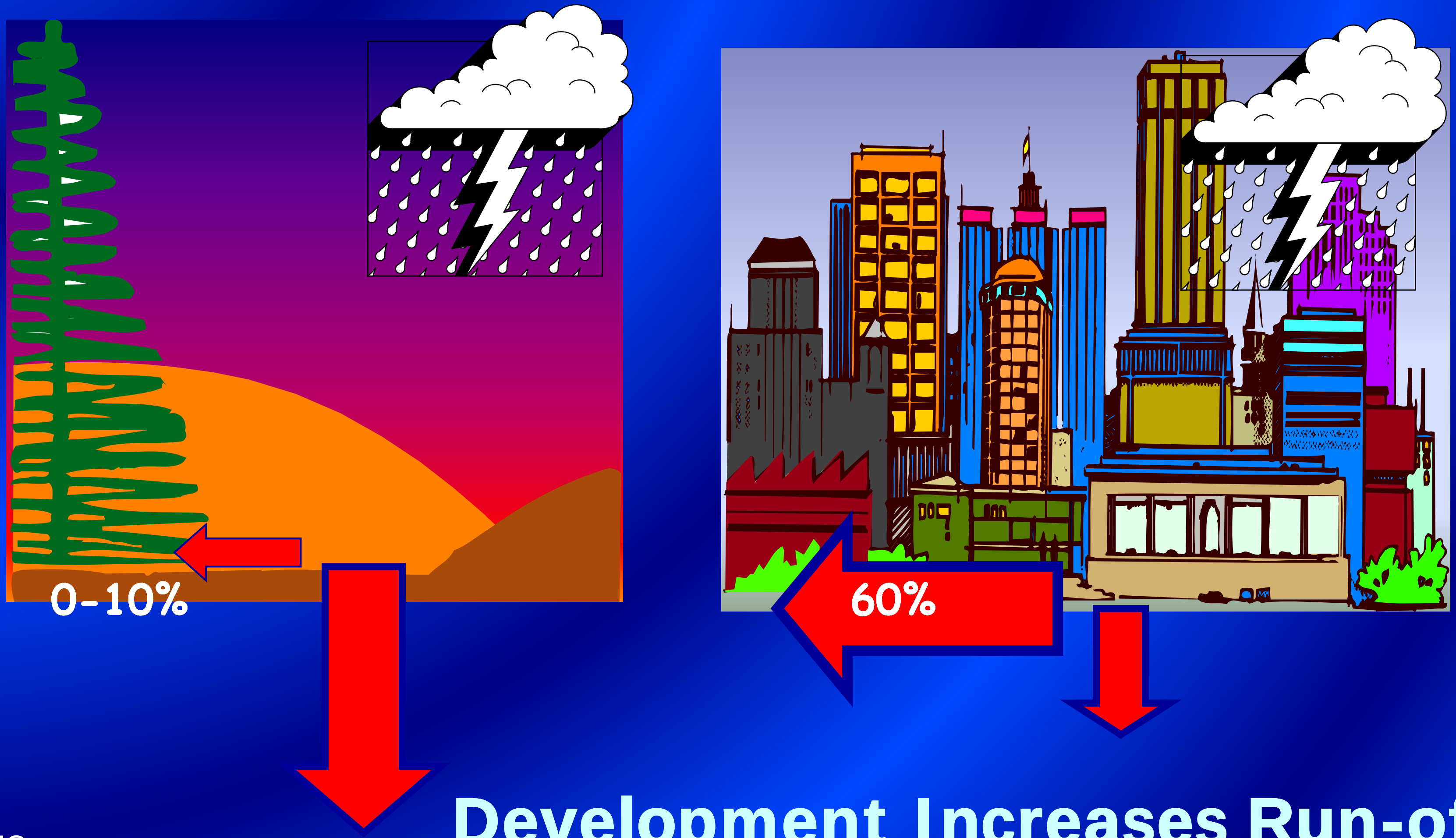
Green Infrastructure in NPDES Permits and CSO Long-term Control Plans

Bob Newport
U.S. EPA
October 25, 2011

Topics

- Stormwater rulemaking
  - Why
  - When
  - What
- Green Infrastructure in permits
- Green Infrastructure in CSO long-term control plans
- Costs
  - Maintenance costs
- Co-benefits

Stormwater Rulemaking – Why?

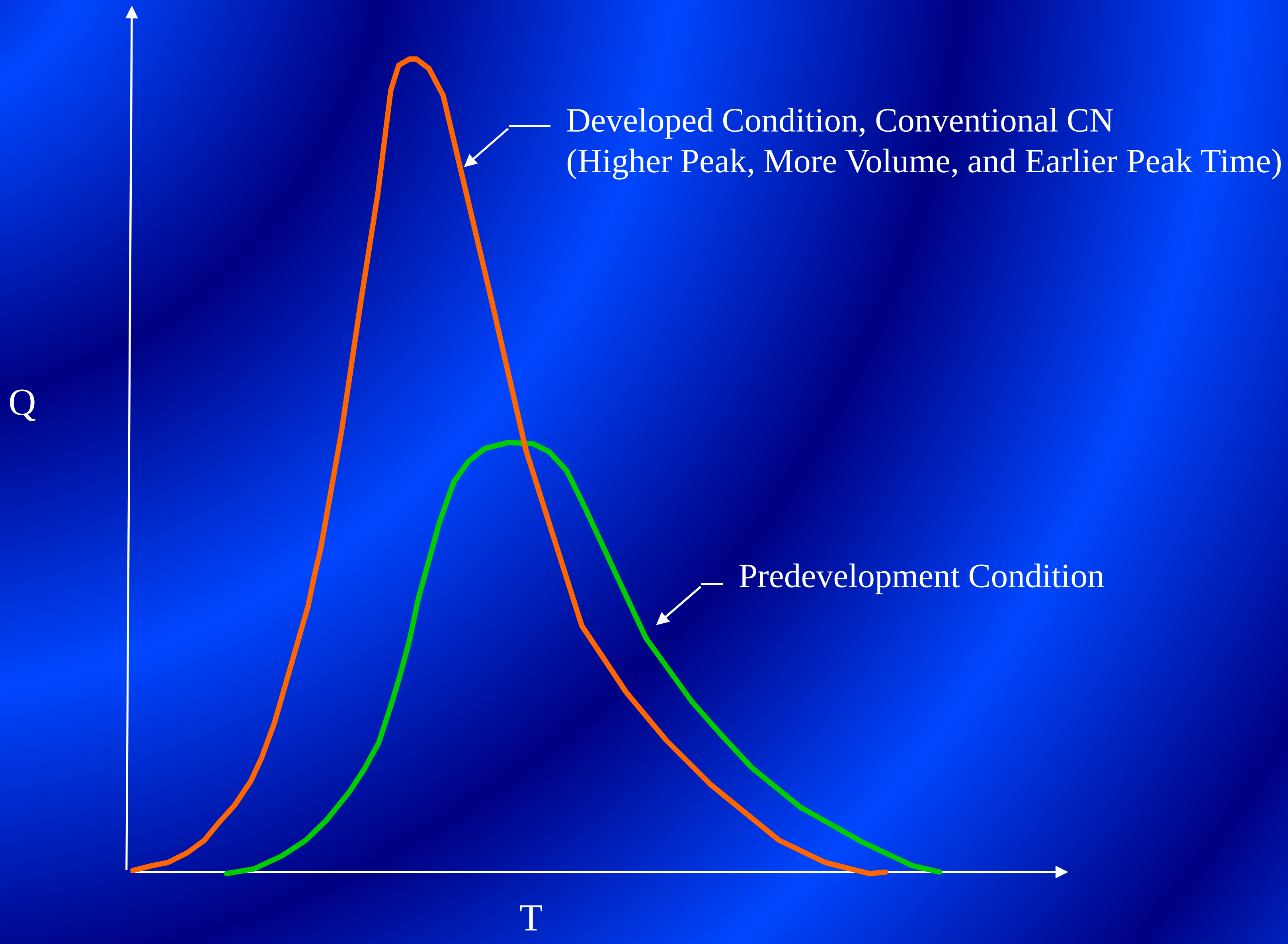


Development Increases Run-off

Increased Run-off due to Impervious Surfaces

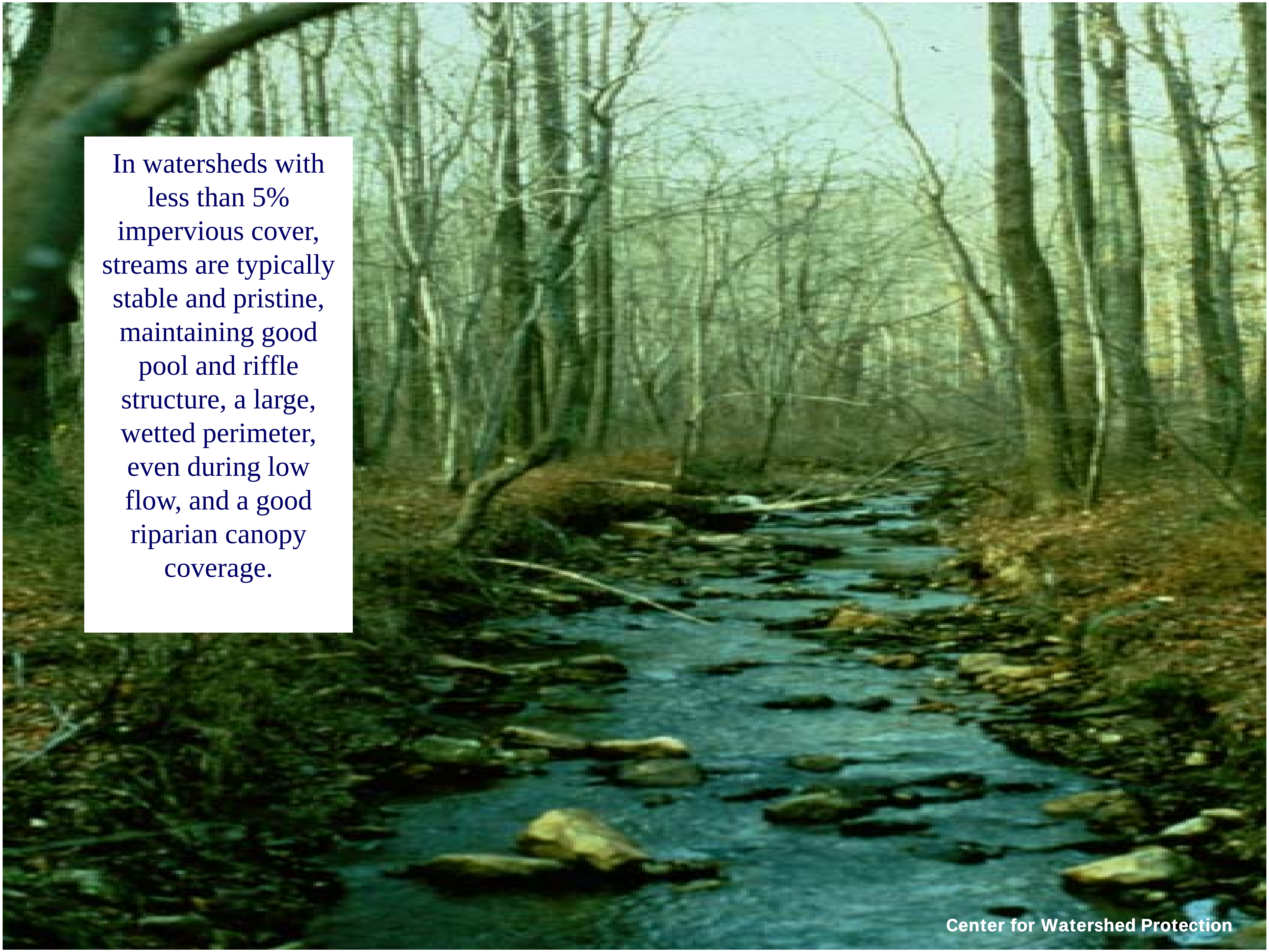
Center for Watershed Protection

Increased Run-off Changes Stream Flow Characteristics



Effects of Higher Flow Volumes and Higher Flow Velocities…

- Stream widening and erosion
- Decreased channel stability
- Reduced fish passage
- Loss of pool-riffle structure
- Lower summer base flows
- Loss of riparian tree canopy
    - Temperature impacts
- Decreased substrate quality
    - Embeddedness (fine sediments become embedded into the coarse substrate)



In watersheds with less than 5% impervious cover, streams are typically stable and pristine, maintaining good pool and riffle structure, a large, wetted perimeter, even during low flow, and a good riparian canopy coverage.

Center for Watershed Protection

Impacts of Stormwater Volumes

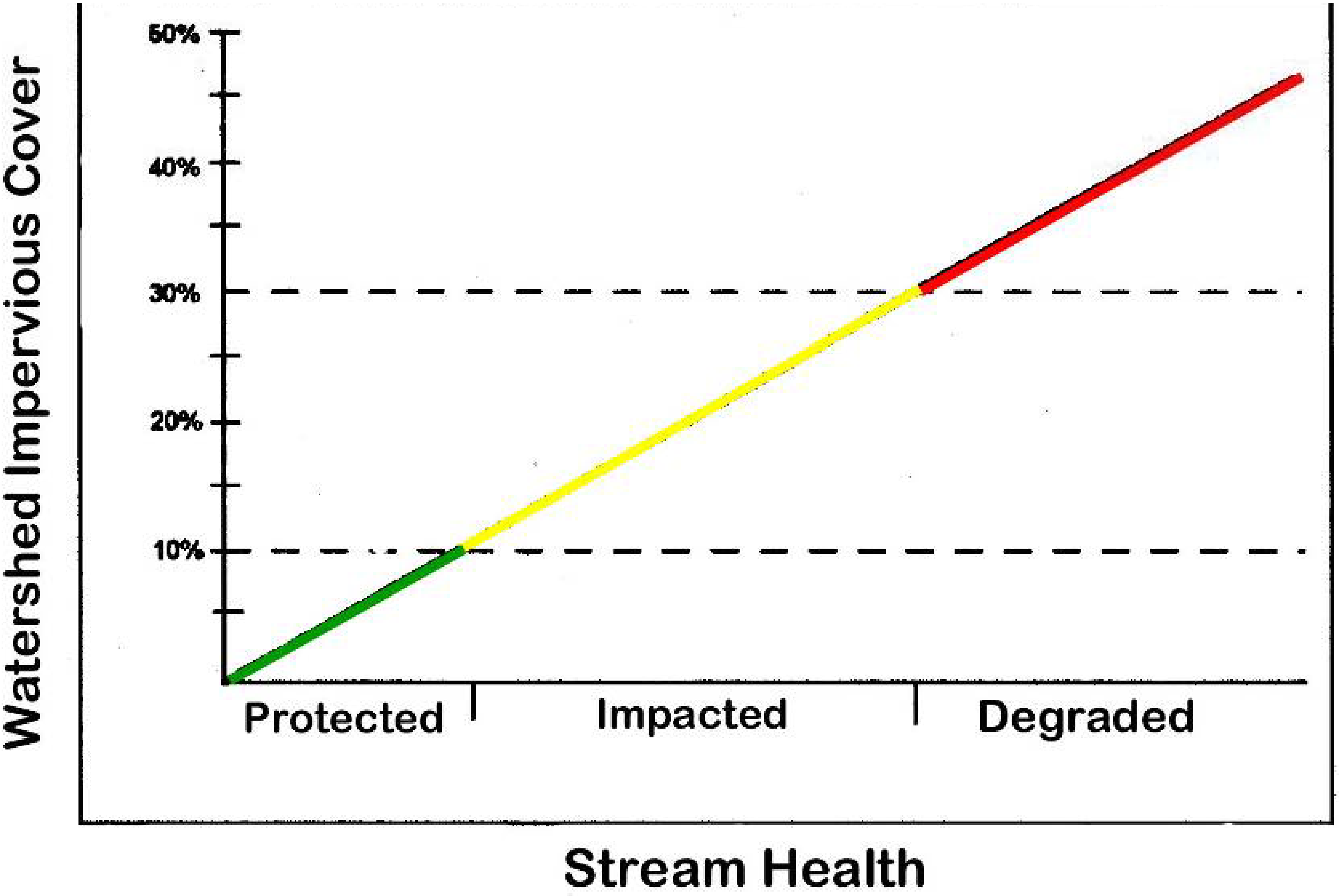
Pollutants in Stormwater Discharges

- Nutrients
- Pathogens
- Sediment
- Toxic Contaminants
- Oil and Grease
- Thermal Stress

Increased quantity

Decreased quality

Stormwater Volumes and Pollutant Loads Result in Water Quality Degradation

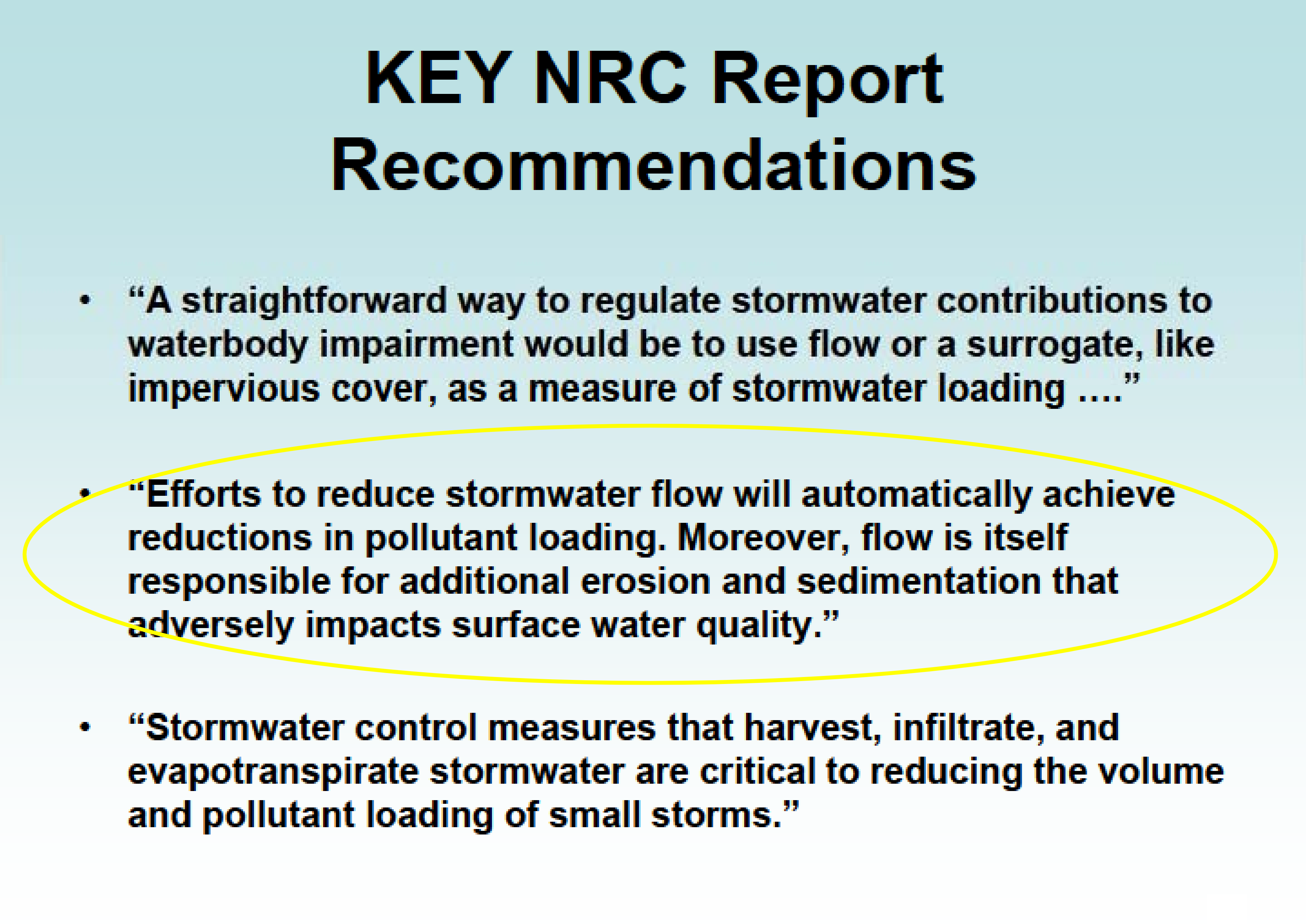


Center for Watershed Protection

National Research Council Report

Urban Stormwater Management in the United States

“Presently the regulation of stormwater is hampered by a statute that focuses primarily on specific pollutants and largely ignores the volume of discharges”



KEY NRC Report Recommendations

- “A straightforward way to regulate stormwater contributions to waterbody impairment would be to use flow or a surrogate, like impervious cover, as a measure of stormwater loading ….”
- “Efforts to reduce stormwater flow will automatically achieve reductions in pollutant loading. Moreover, flow is itself responsible for additional erosion and sedimentation that adversely impacts surface water quality.”
- “Stormwater control measures that harvest, infiltrate, and evapotranspirate stormwater are critical to reducing the volume and pollutant loading of small storms.”

Stormwater Rulemaking - When

- Rulemaking initiated fall 2009
- Data collection and outreach throughout 2010
- Drafting of rule and cost estimates during 2011
- Propose rule for comment late 2011
- Finalize rule late 2012

Stormwater Rulemaking - What

- Establish quantified post-construction stormwater management requirements for new and redevelopment sites
- Address stormwater discharges from existing development through retrofitting
- Extend MS4 areas to include areas where growth will be occurring

Volume Control Performance Standards

- Discharges from New Development Sites
- Options under consideration – Retain on-site:
  - 95th percentile storm and smaller storms?
  - 90th percentile storm and smaller storms?
  - 85th percentile storm and smaller storms?

  - Standard would accommodate site constraints: volume that cannot be retained onsite could be handled through off-site mitigation, payment in lieu, and/or treatment

- Discharges from Redeveloped Sites
  - Likely to be a less stringent standard for redevelopment sites
  - Recognizes the difficulties associated with installing stormwater controls due to site constraints

Storm Sizes Vary Regionally

City, State	95th percentile storm	90th percentile storm	85th percentile storm
Baton Rouge, LA	2.30	1.68	1.36
New York City, NY	1.68	1.22	1.00
Los Angeles, CA	1.60	1.26	1.02
Washington, DC	1.51	1.14	0.95
El Paso, TX	1.04	0.76	0.60
Phoenix, AZ	1.02	0.80	0.67
Portland, OR	0.98	0.76	0.63
Helena, MT	0.73	0.55	0.45

What Might These Requirements Look Like – State Examples

Wisconsin

- NR151 Performance standards include requirements for total suspended solids, peak flow, infiltration
- Infiltration. This performance standard requires that a portion of the runoff volume be infiltrated:
  - Residential – 90 percent of pre-development infiltration volume
  - Non-residential – 60 percent of predevelopment infiltration volume
- To protect groundwater, the WI standards identify areas where infiltration is discouraged
- This post-construction program reduces stormwater discharge volumes

New Jersey

The New Jersey Stormwater Management Rules require that a “major development” project must comply with one of the following groundwater recharge requirements:

- ***Demonstrate through hydrologic and hydraulic analysis that the site and its stormwater management measures maintain 100 percent of the average annual preconstruction groundwater recharge volume for the site; or***
- ***Demonstrate through hydrologic and hydraulic analysis that the increase of stormwater runoff volume from pre-construction to post-construction for the 2-year storm is infiltrated***

North Carolina

Permit to Construct, Operate and Maintain Impervious Areas and BMPs Associated with Residential Development Disturbing < 1 acre

...control and treat the stormwater runoff from all built upon areas of the site from the first 1.5 inches of rain

Dubuque County, IA

Post-development runoff shall be infiltrated such that a rainfall depth of 1.25 inches is recharged to the ground

West Virginia MS4 Permit

Municipalities must implement a program to protect water resources by requiring all new and redevelopment projects to control stormwater discharge rates, volumes, velocities, durations and temperatures

The first 1 inch of rainfall must be 100% managed with no discharge to surface waters

Runoff volume reduction can be achieved by using green infrastructure

West Virginia – Incentives for Sustainable Development Practices

A *credit* of 0.2 inches from the one inch runoff reduction standard may be applied to any of the following types of development:

- Redevelopment
- Brownfield redevelopment
- High density (>7 units per acre)
- Vertical Density (Floor to Area Ratio of 2 or >18 units per acre)
- Mixed use and Transit Oriented Development (within ½ mile of transit)

Reductions are additive up to a maximum reduction of 0.75 inches for a project that meets four or more criteria

Illinois MS4 General Permit

Post-Construction Stormwater Management for New Development and Redevelopments

- Develop, implement and enforce a program to address and minimize stormwater runoff from new development and redevelopment
- Each permittee should adopt strategies that incorporate stormwater infiltration, reuse, and evapotranspiration of stormwater to the maximum extent practicable
- Develop and implement strategies which include a combination of structural and/or non-structural BMPS that will reduce the discharge of pollutants, the volume and velocity of stormwater to the maximum extent practicable

Illinois MS4 General Permit – Post Construction Stormwater Management

Develop and implement a program to minimize the volume of stormwater runoff and pollutants from public highways, streets, roads, parking lots, and sidewalks through the use of BMPs

- That result in physical, chemical, or biological pollutant load reductions, increased infiltration increased evapotranspiration, and reuse of stormwater

The program shall include:

- Training for MS4 employees
- Training for contractors
- Ensure adequate long-term maintenance of BMPs

What Measures Can Be Implemented to Meet Volume/Hydrology-based Performance Standards?

Green infrastructure practices

- Increase Infiltration
- Increase Evapotranspiration
- Harvest and Re-use Stormwater

These Practices Reduce the Volume of Runoff

Infiltration Practices

Rain Gardens

Maplewood, MN

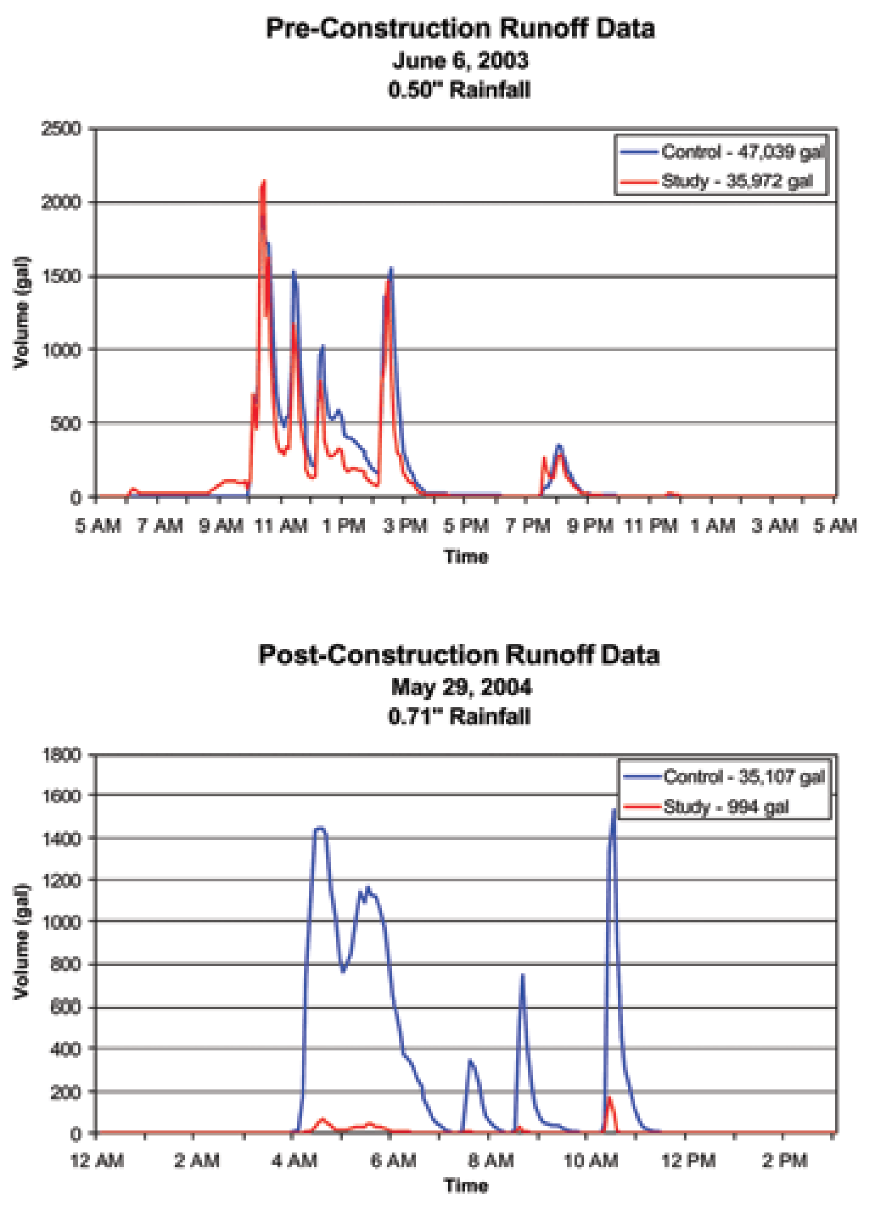
Vegetated Swales

Tellabs, Naperville, IL

Burnsville, MN

Rain Gardens Throughout a Neighborhood

Do Rain Gardens Really Work?



Blue: Runoff from control neighborhood

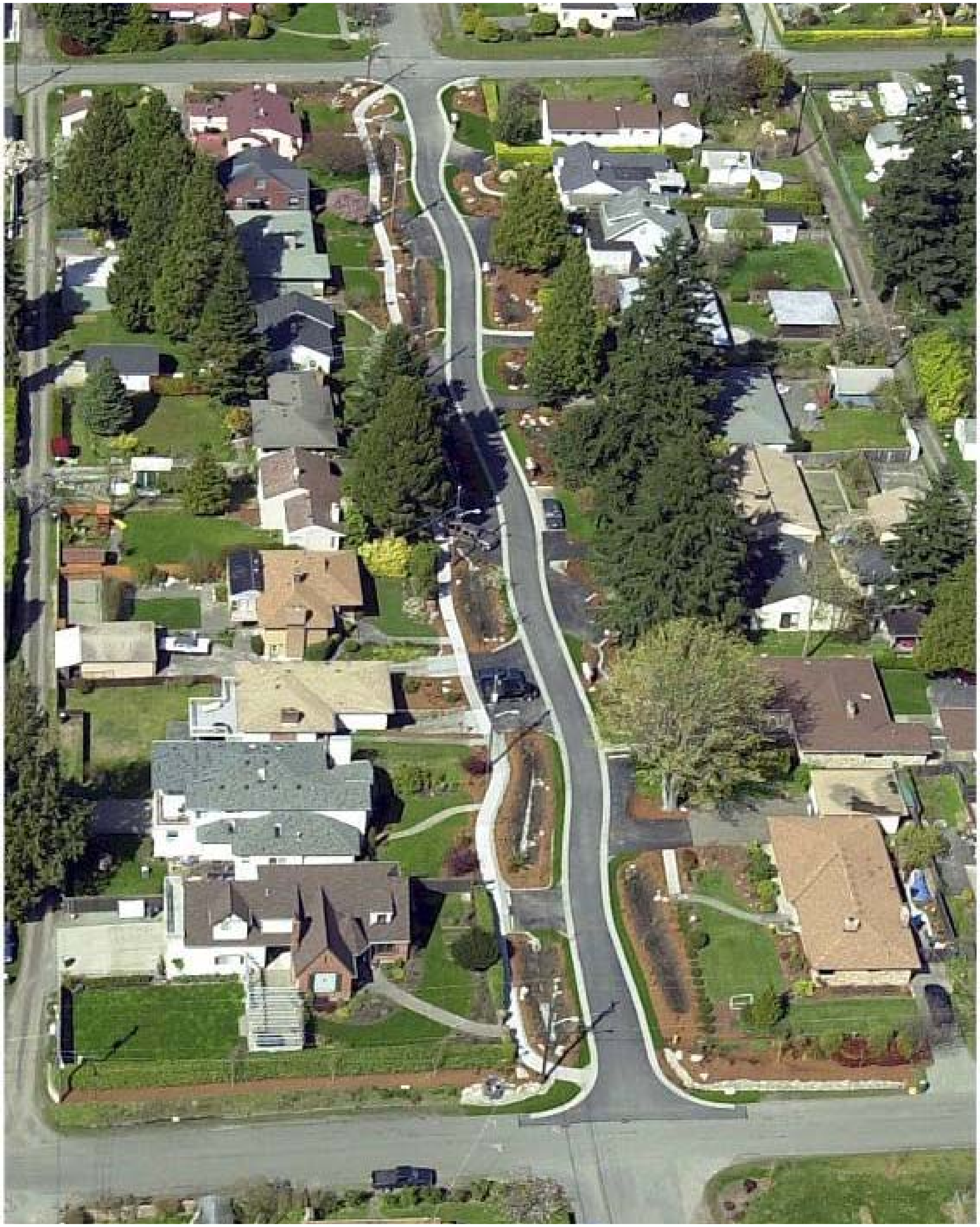
Red: Runoff from neighborhood retrofitted with rain gardens

Barr Engineering

Street Retrofits – Narrower Streets + Swales

Seattle Street - Before

Seattle Street – After



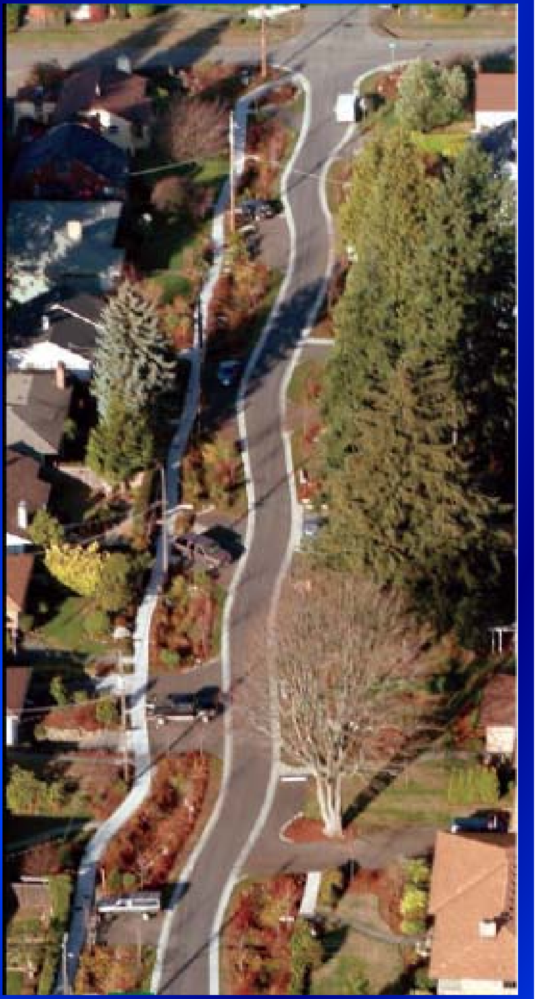
Seattle street retrofit monitoring results for two years:

98-99%

reduction in total runoff volume

Seattle SEA Streets

- 11% reduction in impervious surface
- 25% cost savings compared to conventional design



Permeable Pavement Parking

Morton Arboretum, Lisle, IL

Shorewood, MN
Pervious Concrete Public Street

¾ mile-long pervious concrete roadway

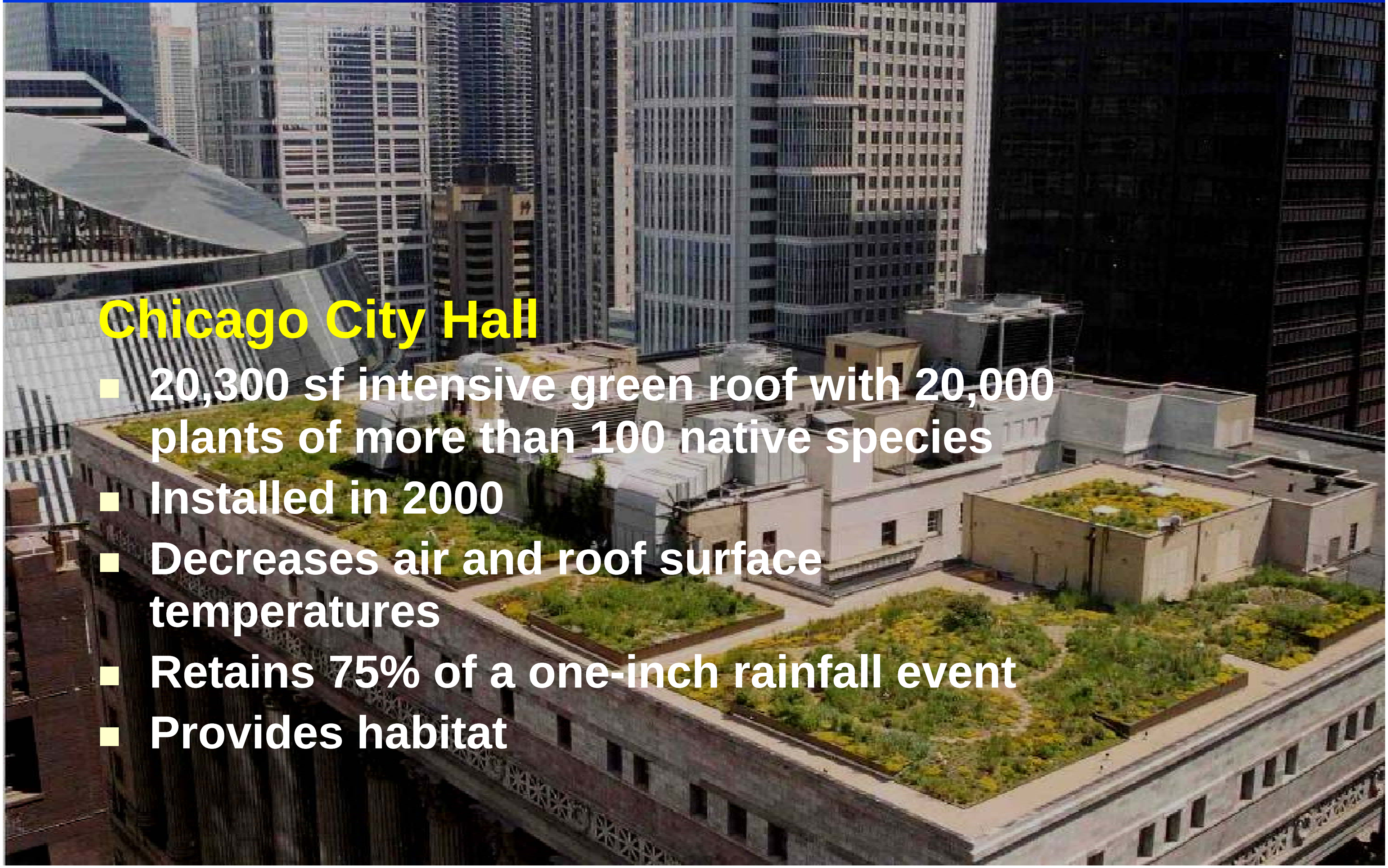
Pervious concrete is 7-inches deep, with 18-inches of aggregate underneath

http://www.cemstone.com/

Storing and Reusing Rainwater

Cisterns

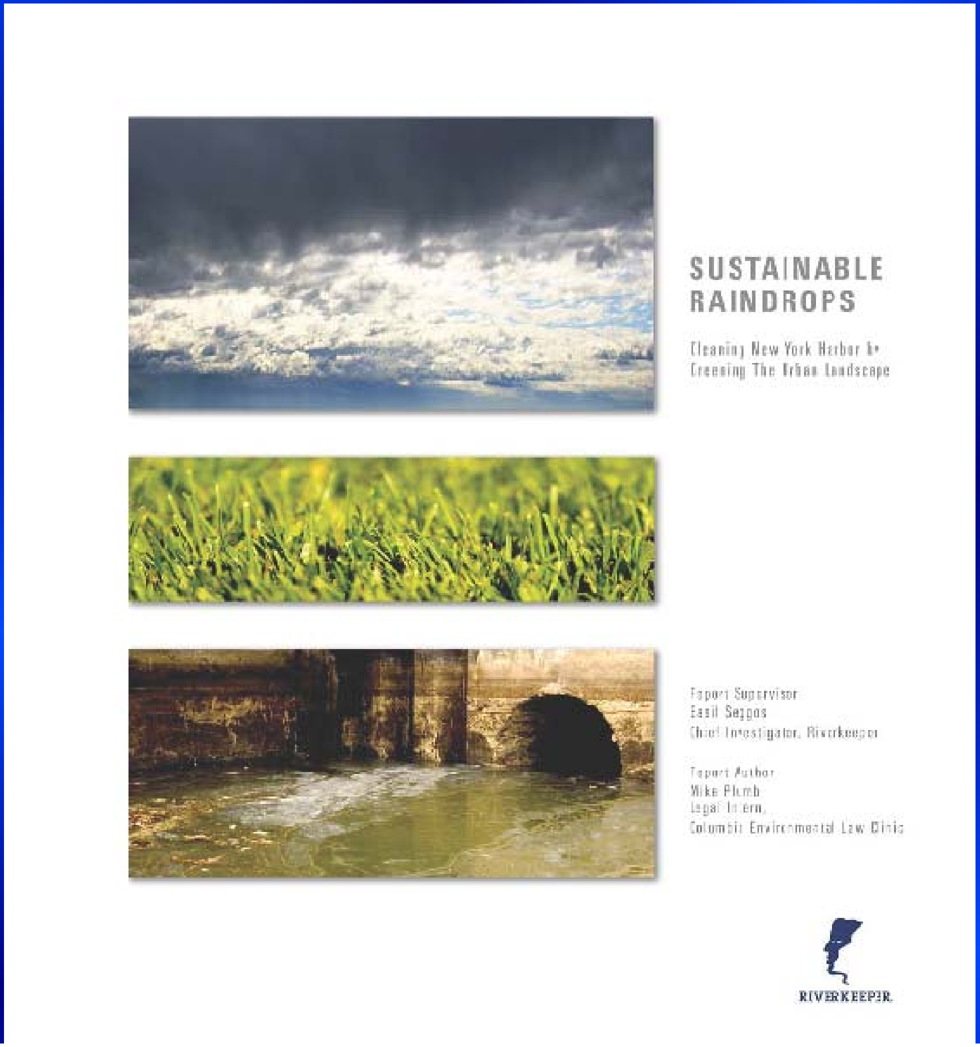
Green Roofs



Chicago City Hall

- 20,300 sf intensive green roof with 20,000 plants of more than 100 native species
- Installed in 2000
- Decreases air and roof surface temperatures
- Retains 75% of a one-inch rainfall event
- Provides habitat

Green Infrastructure as a CSO Control Measure



SUSTAINABLE RAINDROPS

Cleaning New York Harbor by Greening The Urban Landscape

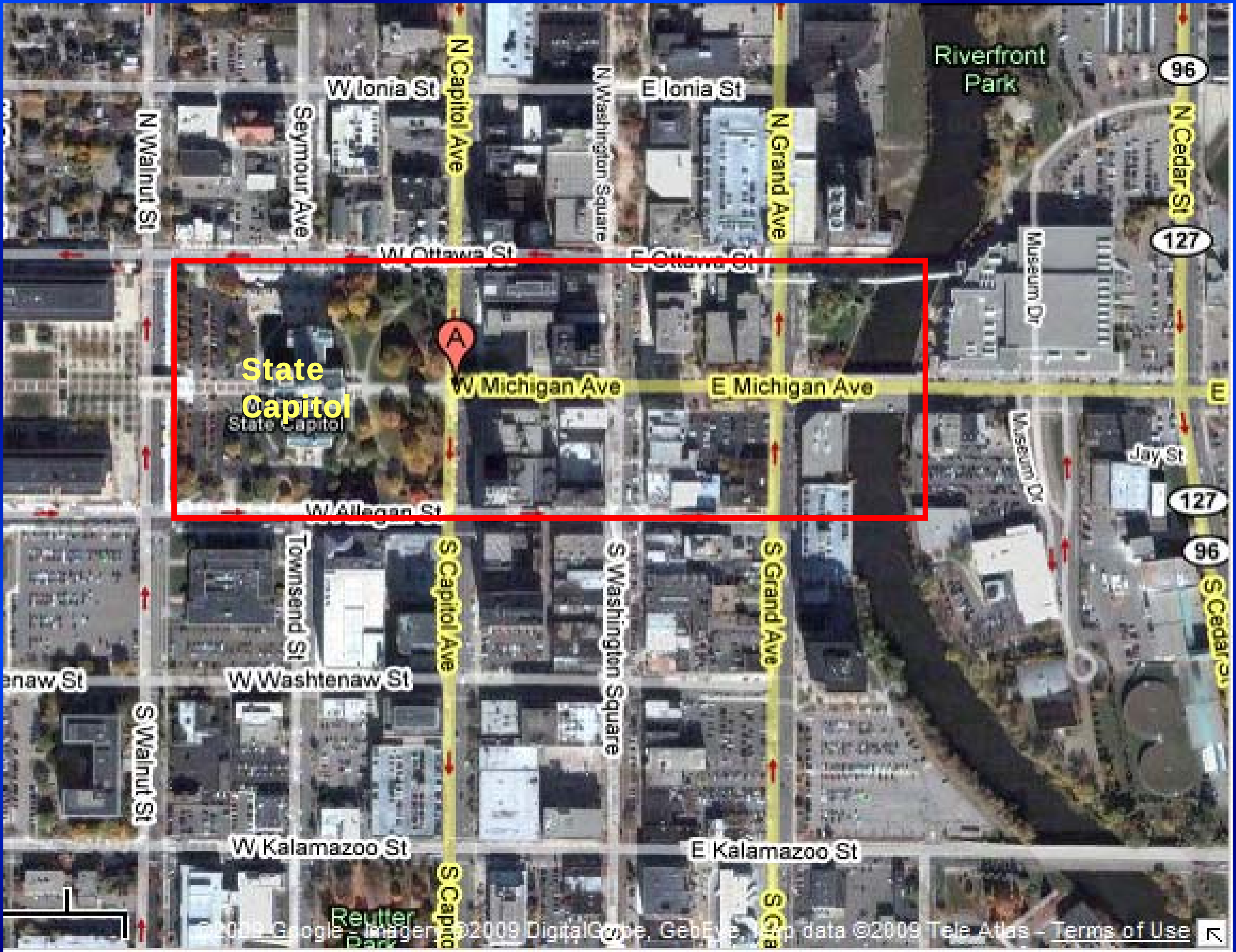
Report Supervisor
Basil Seggos
Chief Investigator, Riverkeeper

Report Author
Mike Plumb
Legal Intern,
Columbia Environmental Law Clinic

RIVERKEEPER

"Source Control is the Economical and Sustainable Alternative."

Michigan Avenue, Lansing, MI



Michigan Avenue, Lansing, MI

TetraTech

- Creation of attractive, walkable streetscapes as part of the City's combined sewer overflow (CSO) control program

Michigan Avenue

TetraTech and C2AE

Before


JESUS SAVES
CLASSIC WINES

Michigan Avenue

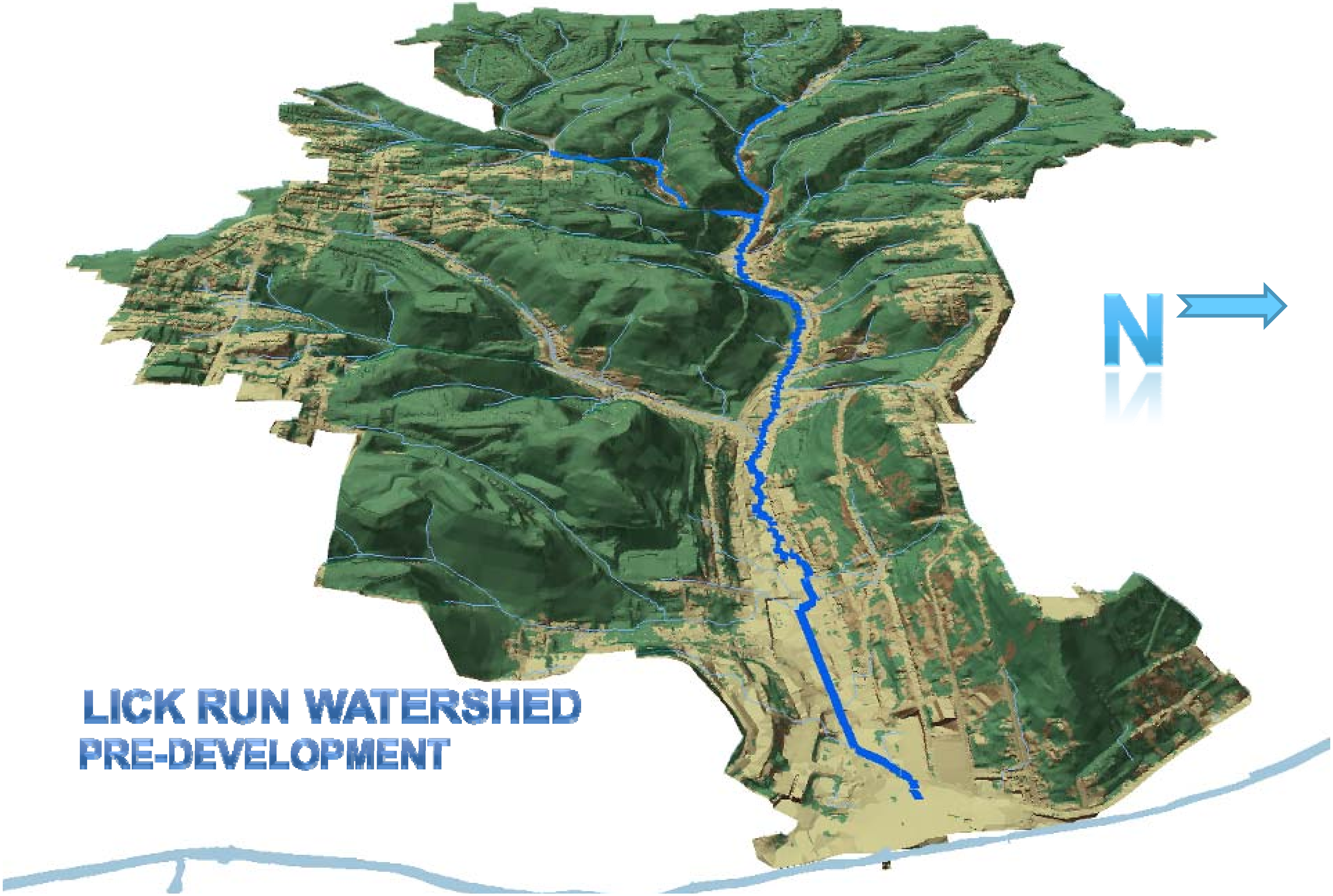
- 4 city blocks, both sides
- Typical garden, no overflow for 1-inch event
- 600 block north side, no overflow for 4.1-inches (25-year event)
- $122/square foot

Metropolitan Sewer District of Greater Cincinnati

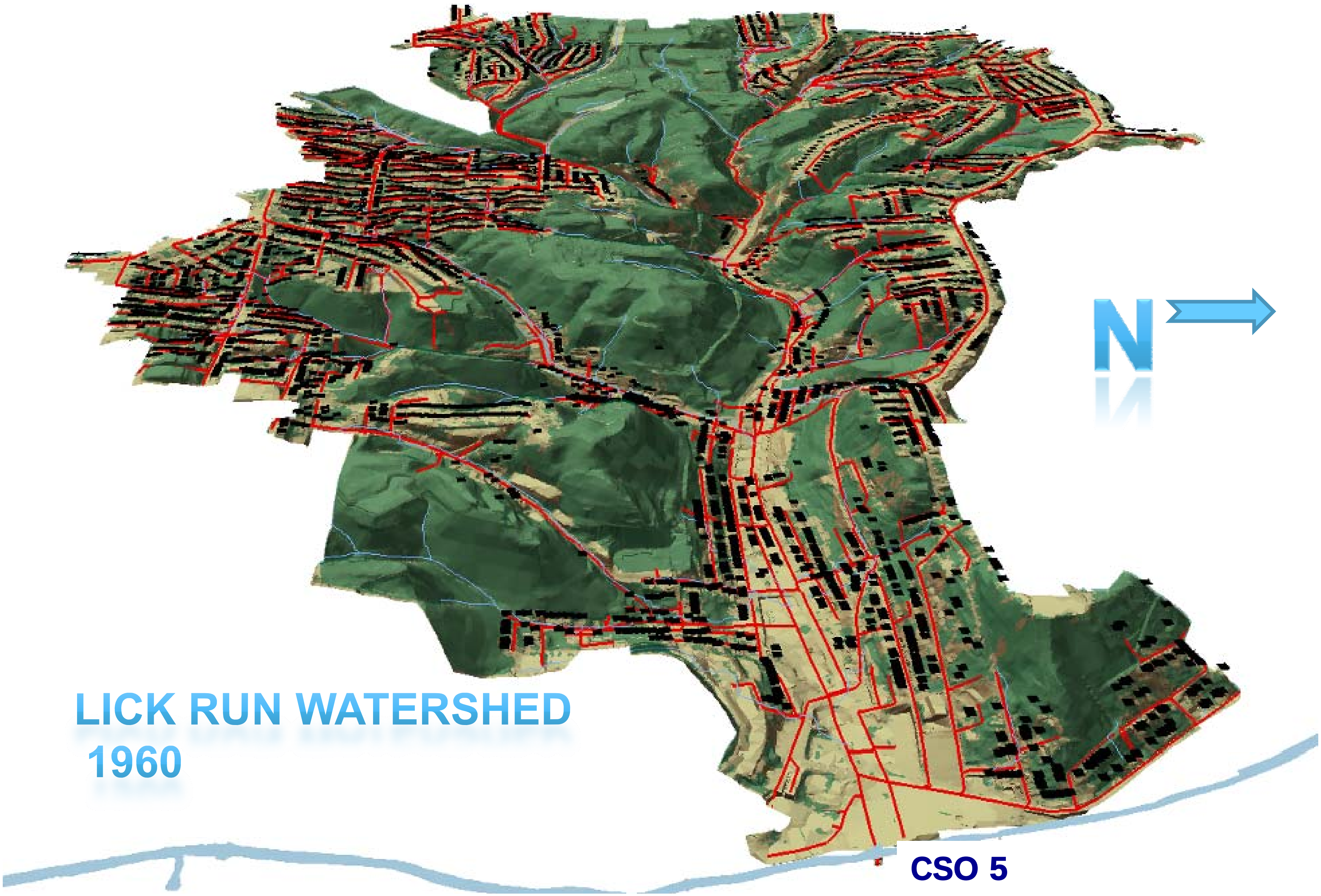
- Approved wet weather plan allows for proposal of an alternative plan for the Lower Mill Creek sewersheds, which could include source control and green infrastructure, and also allows for proposals to substitute specific green measures for planned gray infrastructure control measures
  - Currently in a 3 year study and design period

- Lick Run project in Mill Creek

Lick Run, Cincinnati



Lick Run, Cincinnati

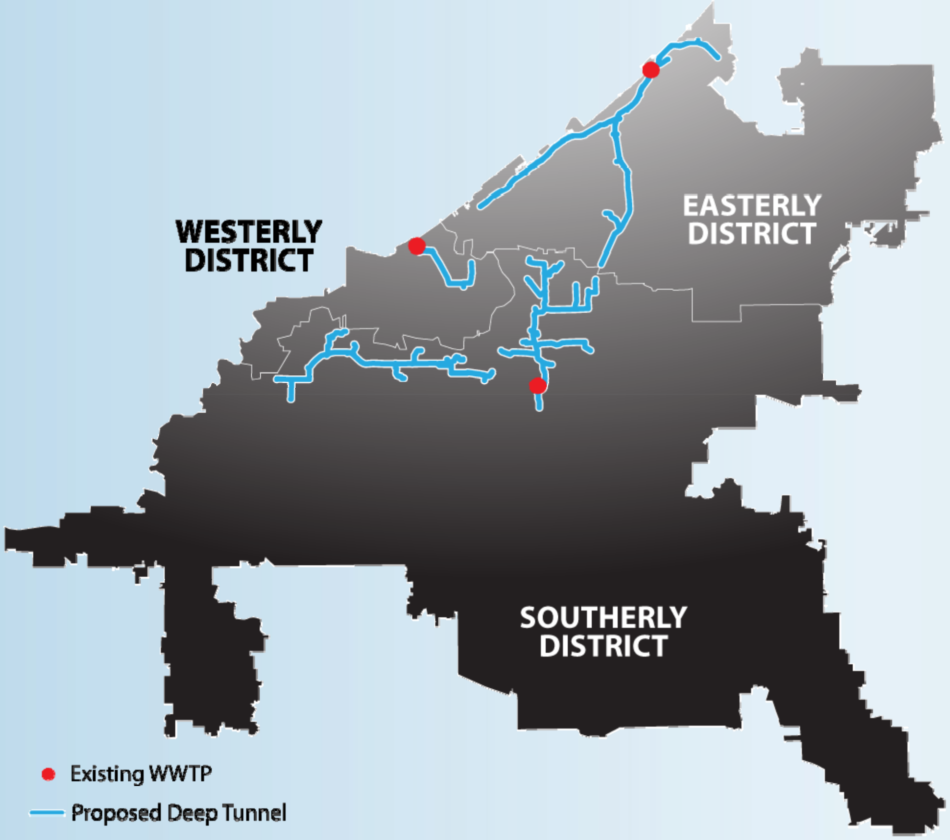


Concept Plan for Lick Run Watershed, Cincinnati

"Source Control is the Economical and Sustainable Alternative."

Northeast Ohio Regional Sewer District

(Cleveland Metro Area)

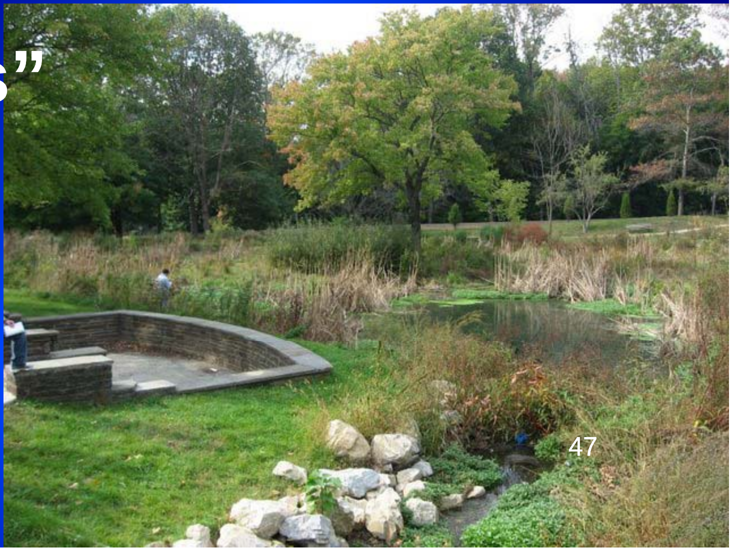


Level of Control: **2-3** overflow events per year

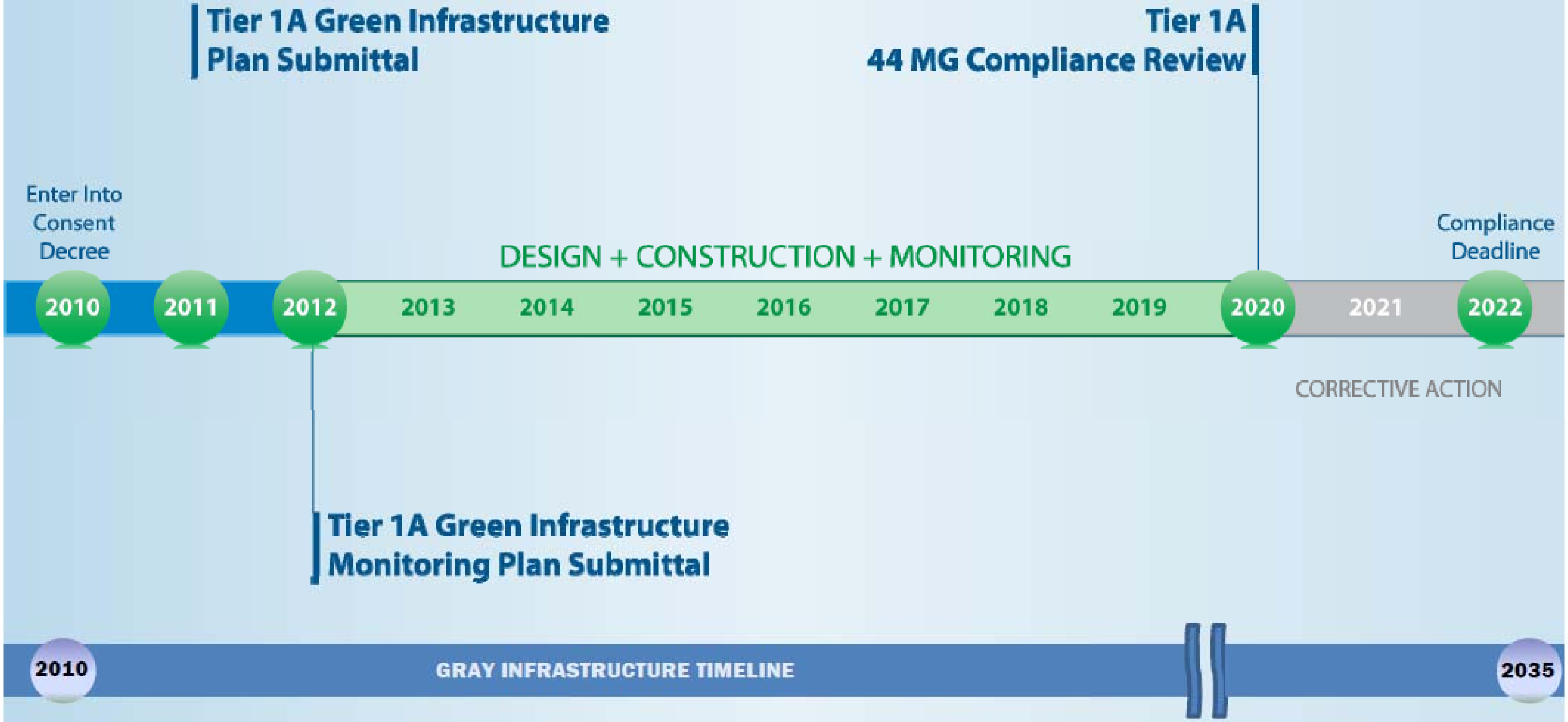
Cost: **$3 billion**

Northeast Ohio Regional Sewer District

- Minimum of $42 million on GI
- Minimum 44 million gal/year reduction in CSO discharges in a typical year from GI (over and above reductions from gray)
- Emphasis on relatively larger practices on vacant land parcels
  - – Create "stormwater parks"
- Opportunity for other green for gray substitutions



The District's Consent Decree



Tier 1A Green Infrastructure Plan Submittal

Tier 1A 44 MG Compliance Review

Enter Into Consent Decree

DESIGN + CONSTRUCTION + MONITORING

Compliance Deadline

2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022

CORRECTIVE ACTION

Tier 1A Green Infrastructure Monitoring Plan Submittal

2010 GRAY INFRASTRUCTURE TIMELINE 2035

Source: Appendix 3 to Consent Decree in *United States and State of Ohio v. Northeast Ohio Regional Sewer District*, N.D. Ohio – 11/12/10 Pre-Approval Draft.

EPA Study: Reducing Stormwater Costs through Low Impact Development Strategies and Practices

- Background on LID
- Discussion of benefits and costs
- Case studies
  - 17 projects
  - LID costs vs. traditional stormwater management on a site or neighborhood scale

www.epa.gov/owow/nps/lid

Key Findings

- In most cases LID designs showed cost savings over traditional stormwater designs
- Capital cost savings ranged from 15% to 80%

Factors Affecting Costs

Cost Savings

- Reduced site grading
- Reduced site preparation
- Reduced infrastructure (curbs, gutters, pipes)
- Reduced site paving
- Less expensive landscaping

Cost Increases

- Green roof costs
- Increased site preparation
- More expensive landscaping practices and plant species selection

Example

Green vs. Grey Infrastructure

Project	Conventional vault cost estimate*	Rain garden cost
Bloedel Donovan Park parking lot (4400 ft^3 wet vault)	$52,800	$12,800
City Hall parking lot (2300 ft^3 wet vault)	$27,600	$5,600

* City of Bellingham’s estimate using approximate cost of $12.00/ft3 for an in-ground storage and treatment device and based on construction costs for similar projects in the Bellingham area

Reining in the Rain, City of Bellingham, WA 2004

Conservation Design

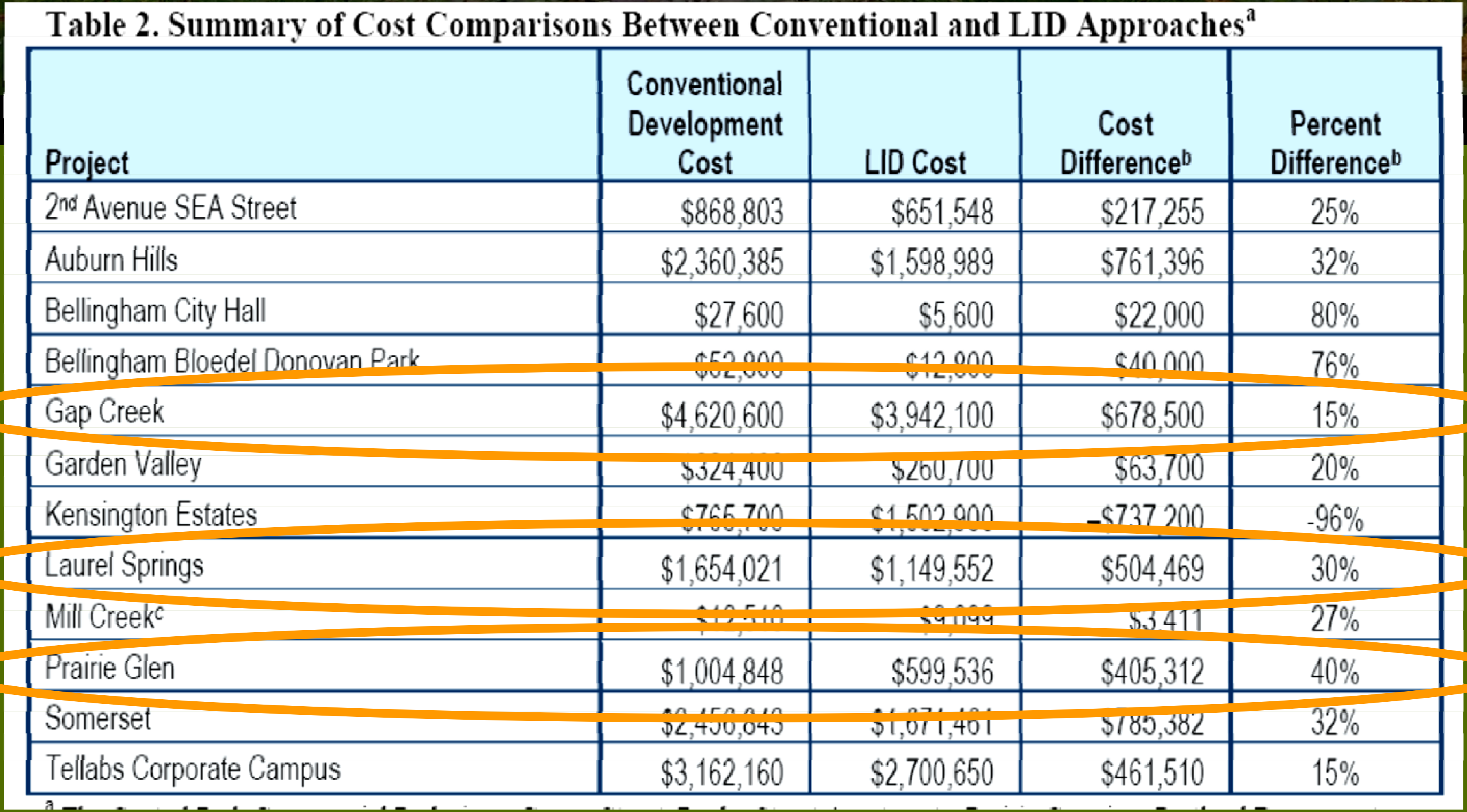


Table 2. Summary of Cost Comparisons Between Conventional and LID Approaches[a]

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%

Conservation Design

Where do the Savings Come From?

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

Case Study: Grayslake, IL Prairie Crossing

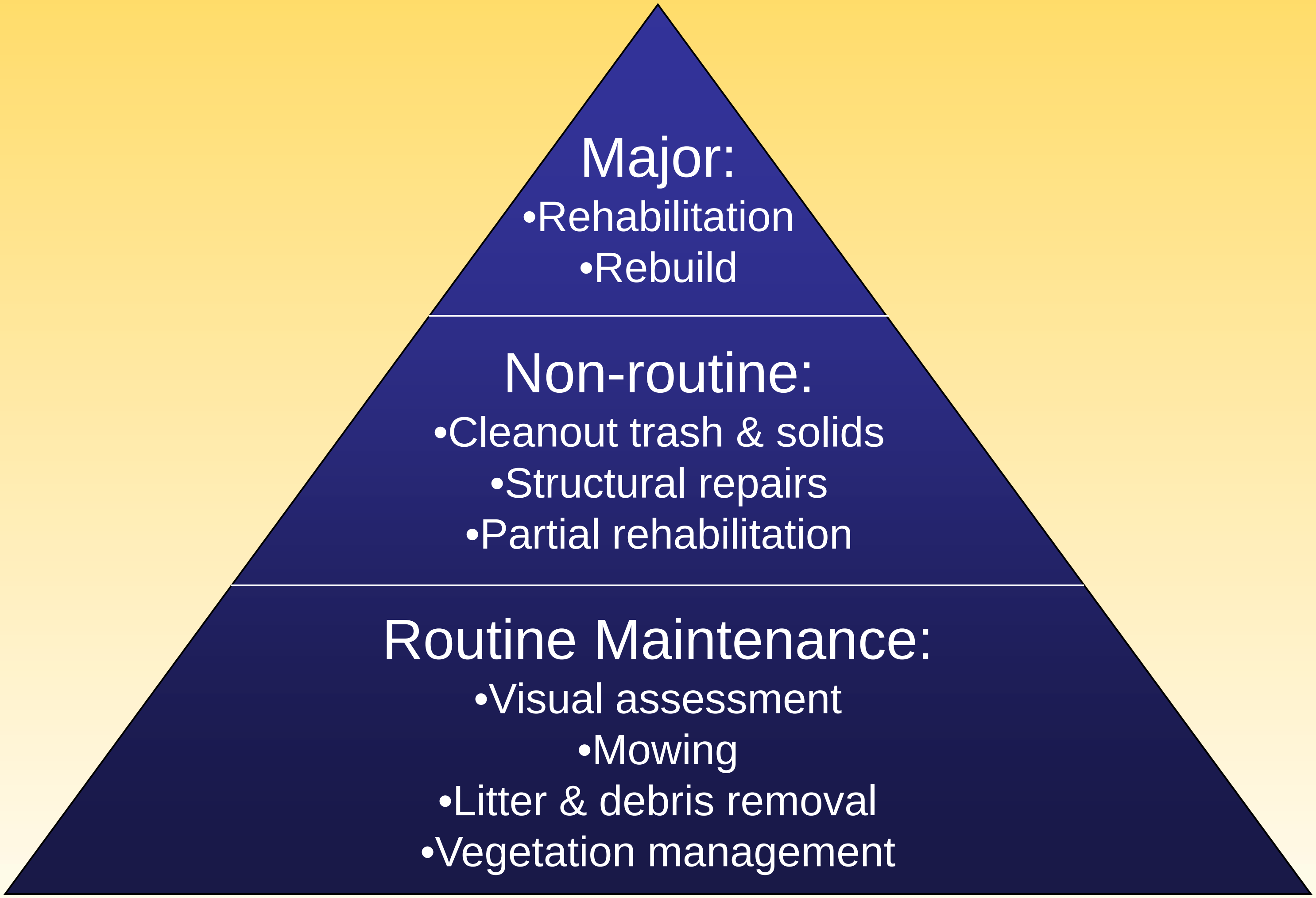
- Stormwater managed with bioretention cells and vegetated swales
- Benefits
  - Preserved 470 acres of open space
  - Mixed use: commercial + residential, schools, community center, biking trails, lakefront beach, farm
- Savings
  - Estimated at $1.4 million, or $4,000 per lot
  - Less paving, less infrastructure

Stormwater BMP Maintenance Practices

Andy Erickson, Research Fellow
St. Anthony Falls Laboratory

UNIVERSITY OF MINNESOTA
Driven to Discover℠

Components of BMP Maintenance



Major:

- Rehabilitation
- Rebuild

Non-routine:

- Cleanout trash & solids
- Structural repairs
- Partial rehabilitation

Routine Maintenance:

- Visual assessment
- Mowing
- Litter & debris removal
- Vegetation management

Maintenance Survey

- Objectives
  - Investigate current status of BMPs and associated maintenance in Minnesota (MN) and Wisconsin (WI)
  - Identify most common maintenance practices and corresponding costs
  - **Obtain information to establish guidance for scheduling and budgeting for maintenance of BMPs**
- 28 Minnesota cities, 8 Wisconsin cities and 2 Wisconsin counties responded

Survey Questions

Q1. Number of BMPs

Q2. Frequency of regular inspection and maintenance

Q3. Staff-hours for regular inspection and maintenance

Q4. Complexity of maintenance

Q5. Factors affecting performance of BMPs

Q6. Cost of non-routine maintenance activities

Q5. Factors affecting performance of BMPs (multiple-answers allowed)

	Underground Sedimentation Devices	Rain Gardens	Filter Strips or Swales
Sediment buildup	58%	33%	21%
Litter & debris	21%	22%	26%
Pipe clogging	11%	7%	5%
Invasive vegetation	0%	26%	26%

Typical O&M Costs for BMPs

Annual Cost as percentage of Construction Cost

	USEPA (1999)	Weiss et al. (2005)
Sand Filters	11% -13%	0.9% - 9.5%
Infiltration Trenches	5% - 20%	5.1% – 126%
Infiltration Basins	1% - 3% 5% - 10%	2.8% - 4.9%
Wet Ponds	Not reported	1.9% - 10.2%
Dry Ponds	<1%	1.8% - 2.7%
Rain Gardens	5% - 7%	0.7% - 10.9%
Constructed Wetlands	2%	4% - 14.2%
Swales	5% - 7%	4% - 178%
Filter Strips	$320/Acre (maintained)	-

Weiss, P.T., J. S. Gulliver and A. J. Erickson, (2005). “The Cost and Effectiveness of Stormwater Management Practices,” Minnesota Department of Transportation Report 2005-23. http://www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=1023

WERF Whole-Life Costing Tool for Green Stormwater Management Practices

WERF Whole Life Cost Estimating Tool

- *"Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems"*
- Spreadsheet cost estimation tool designed to estimate whole life costs of several BMPs
  - – ED and retention ponds
  - – Swales
  - – Permeable pavement
  - – Green roofs
  - – Bioretention
  - – Cisterns

WERF

Stormwater

FINAL REPORT 2005

Performance and Whole Life Costs of
Best Management Practices and
Sustainable Urban Drainage Systems

(Final Report for Phases 1 and 2 of Project 01-CTS-21T)

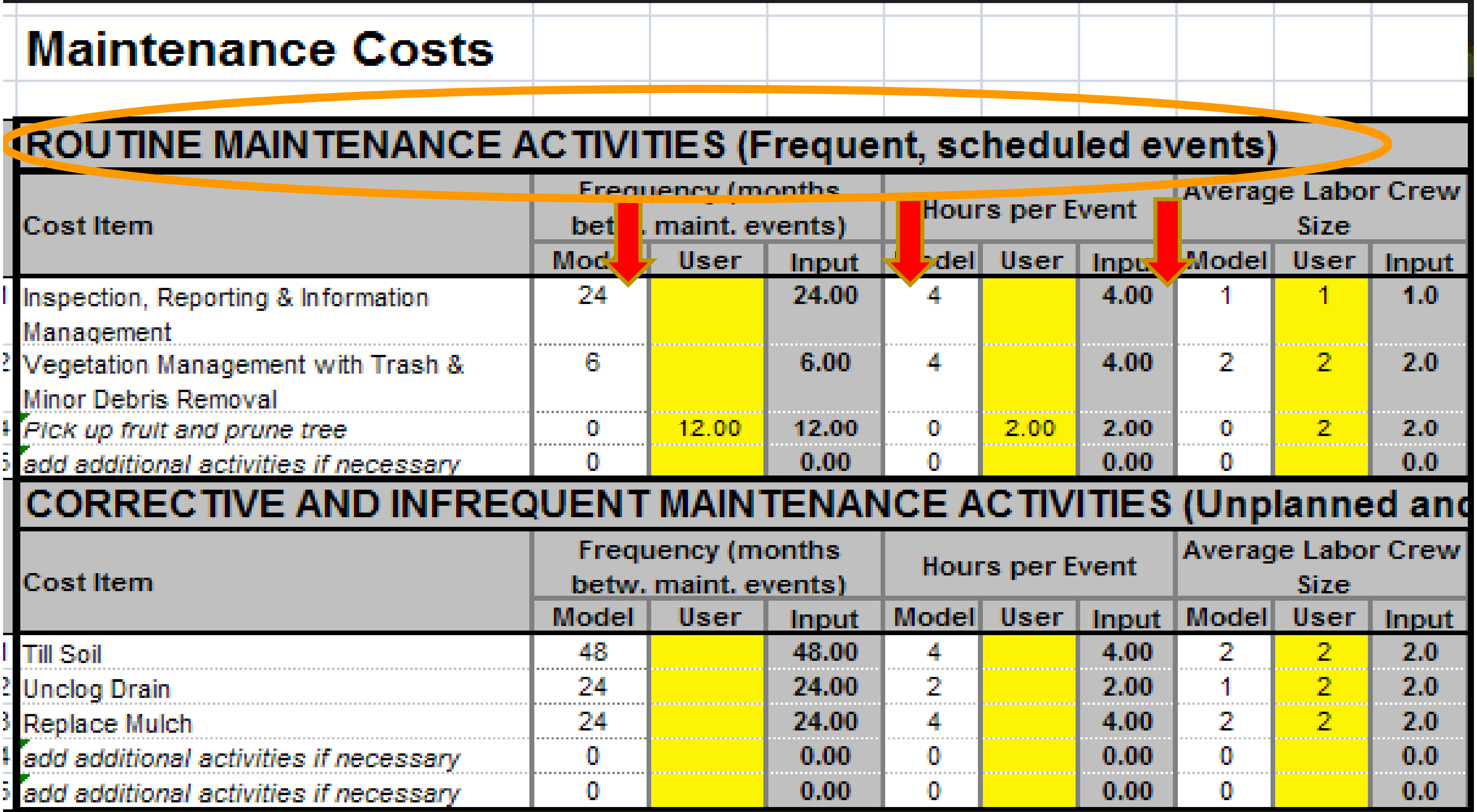
Project Approach

- Literature Review
  - **Capital costs and maintenance costs**
- Collect and review manufacturer’s data
- Collect data on cost and construction elements for existing systems – lit review in spreadsheets
- Review by professional cost-estimator (RS Means costs)
- Review by environmental economist
- Peer review

Excel Spreadsheet Overview

1. Design and Maintenance Options
2. Capital Costs
3. Maintenance Costs
4. Cost Summary
5. Whole Life Costs
6. Present Value Graphs
7. Design and Cost Information
8. References

Routine Maintenance



Maintenance Costs

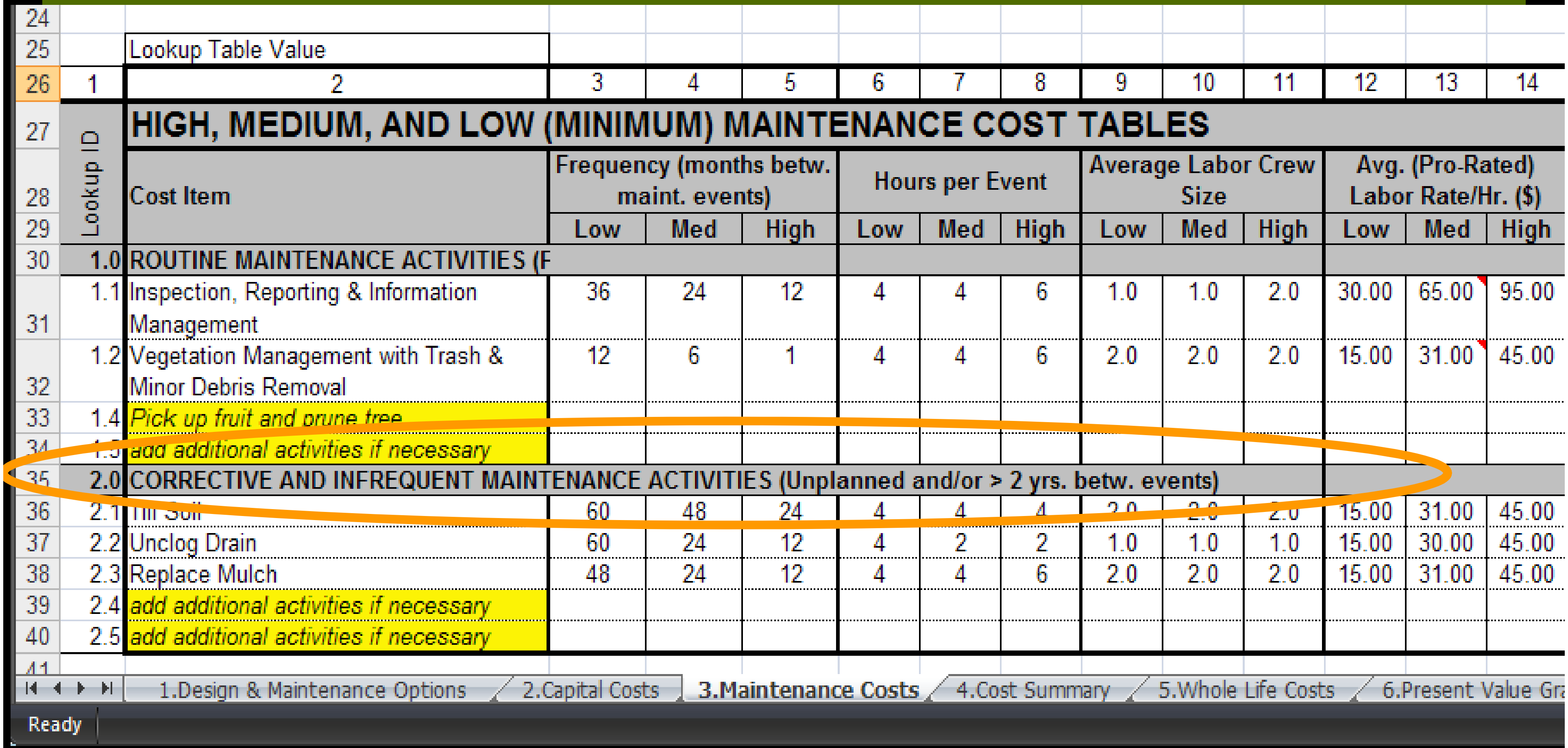
ROUTINE MAINTENANCE ACTIVITIES (Frequent, scheduled events)

Cost Item	Frequency (months bet . maint. events)			Hours per Event			Average Labor Crew Size		
	Mod	User	Input	del	User	Inpu	Model	User	Input
Inspection, Reporting & Information Management	24		24.00	4		4.00	1	1	1.0
Vegetation Management with Trash & Minor Debris Removal	6		6.00	4		4.00	2	2	2.0
Pick up fruit and prune tree	0	12.00	12.00	0	2.00	2.00	0	2	2.0
add additional activities if necessary	0		0.00	0		0.00	0		0.0

CORRECTIVE AND INFREQUENT MAINTENANCE ACTIVITIES (Unplanned anc

Cost Item	Frequency (months betw. maint. events)			Hours per Event			Average Labor Crew Size		
	Model	User	Input	Model	User	Input	Model	User	Input
Till Soil	48		48.00	4		4.00	2	2	2.0
Unclog Drain	24		24.00	2		2.00	1	2	2.0
Replace Mulch	24		24.00	4		4.00	2	2	2.0
add additional activities if necessary	0		0.00	0		0.00	0		0.0
add additional activities if necessary	0		0.00	0		0.00	0		0.0

Corrective and Infrequent Maintenance



24														
25		Lookup Table Value												
26	1	2	3	4	5	6	7	8	9	10	11	12	13	14
27	Lookup ID	**HIGH, MEDIUM, AND LOW (MINIMUM) MAINTENANCE COST TABLES**												
28		Cost Item	Frequency (months betw. maint. events)			Hours per Event			Average Labor Crew Size			Avg. (Pro-Rated) Labor Rate/Hr. ($)		
29			Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
30	1.0	ROUTINE MAINTENANCE ACTIVITIES (F												
31	1.1	Inspection, Reporting & Information Management	36	24	12	4	4	6	1.0	1.0	2.0	30.00	65.00	95.00
32	1.2	Vegetation Management with Trash & Minor Debris Removal	12	6	1	4	4	6	2.0	2.0	2.0	15.00	31.00	45.00
33	1.4	*Pick up fruit and prune tree*												
34	1.5	*add additional activities if necessary*												
35	2.0	CORRECTIVE AND INFREQUENT MAINTENANCE ACTIVITIES (Unplanned and/or > 2 yrs. betw. events)												
36	2.1	Till Soil	60	48	24	4	4	4	2.0	2.0	2.0	15.00	31.00	45.00
37	2.2	Unclog Drain	60	24	12	4	2	2	1.0	1.0	1.0	15.00	30.00	45.00
38	2.3	Replace Mulch	48	24	12	4	4	6	2.0	2.0	2.0	15.00	31.00	45.00
39	2.4	*add additional activities if necessary*												
40	2.5	*add additional activities if necessary*												
41														

- Present value of capital + future maintenance
  - Useful for alternatives analyses
- Annual cost projections for 20 year period
  - Useful for budgeting

www.WERF.org

Knowledge Area: Stormwater

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Green Infrastructure Co-Benefits
One example is energy consumption

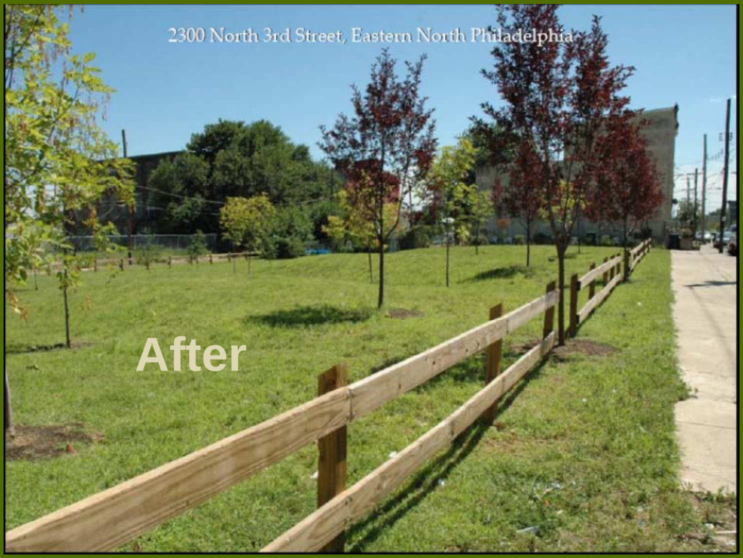
City Hall Green Roof vs. Cook County Building

Data source: Weston Design Consultants

Real Estate Value: *A Philadelphia Story*

- **Vacant land improvements increased surrounding housing values by as much as 30%**
- **New tree plantings increased surrounding housing values by approximately 10%**

(University of PA data)



PA Horticultural Society photos

Quantifying Co-Benefits

CNT / American Rivers Report, "The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Social and Environmental Benefits"

1. Water
2. Energy
3. Air Quality
4. Climate Change
5. Urban Heat Island
6. Community Livability
7. Habitat Improvement
8. Public Education

Illinois Green Infrastructure Grant Program

- **IEPA is once again accepting applications for the Illinois Green Infrastructure Grants Program for Stormwater Management (IGIG)**
- **This year's deadline is Dec. 15, 2011**
- **Grants will be awarded for a range of project sizes and types, such as installation of permeable paving, bioinfiltration systems, and downspout disconnection programs**

http://www.epa.state.il.us/water/financial-assistance/igig.html

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www.epa.gov/greeninfrastructure