SUSTAIN Pilot Projects

Developing a Roadmap Towards Reaching TMDL Targets in Urban Watersheds

Lower Grand Project Update Meeting
January 20, 2011

SUSTAIN Pilot Projects

Discussion Overview

- ***"Driving Forces"***
- **Technical Background**
- **Intro to SUSTAIN**
- **Project Areas**
- **Common Themes & Issues**

Stormwater Pilot Projects

Transition to Implementation

"Driving Forces"

- ***Storm Water Management Programs (SWMP)***
- ***MS4 Permits*** ***(Benchmarks / Performance Measures)***
- ***Local Ordinances***
  (Land Use Plans)
- ***Long Term CSO Control Plans***
- ***TMDLs***

Driving Forces

Storm Water Management

Minimum SWMP Measures under NPDES

- ***Education & Outreach***
- ***Public Involvement***
- ***Illicit D&E***
- ***Erosion Control***
- ***Post Development BMPs***
- ***Prevention and Maintenance***

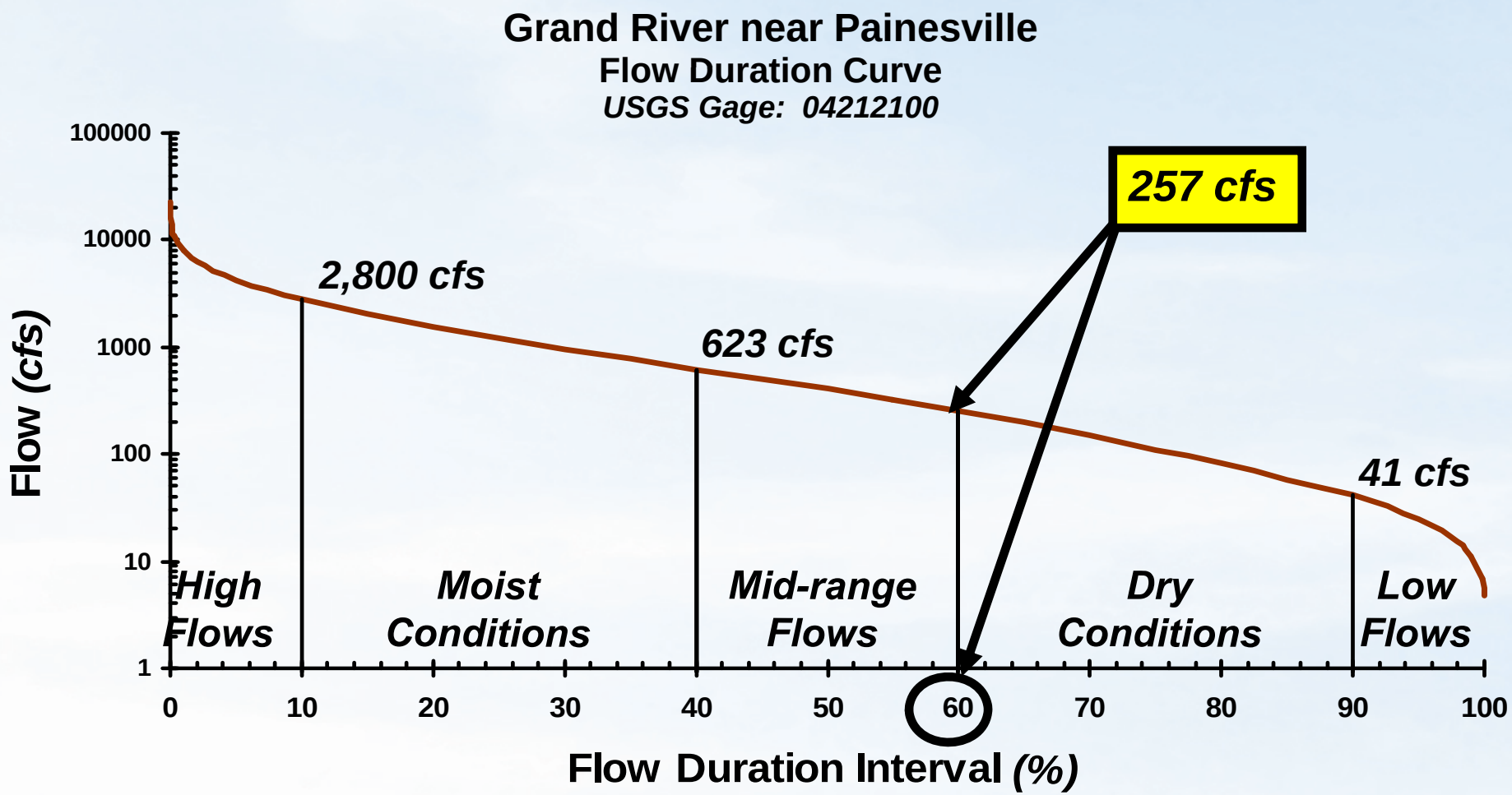
Driving Forces

TMDL Development

- **Practical approach using key questions …**
  - ***WHY*** ***the concern***
  - ***WHAT*** ***reductions are needed***
  - ***WHERE*** ***are the sources***
  - ***WHO*** ***needs to be involved***
  - ***WHEN*** ***will actions occur***

TMDL Development

Hydrology-based Framework



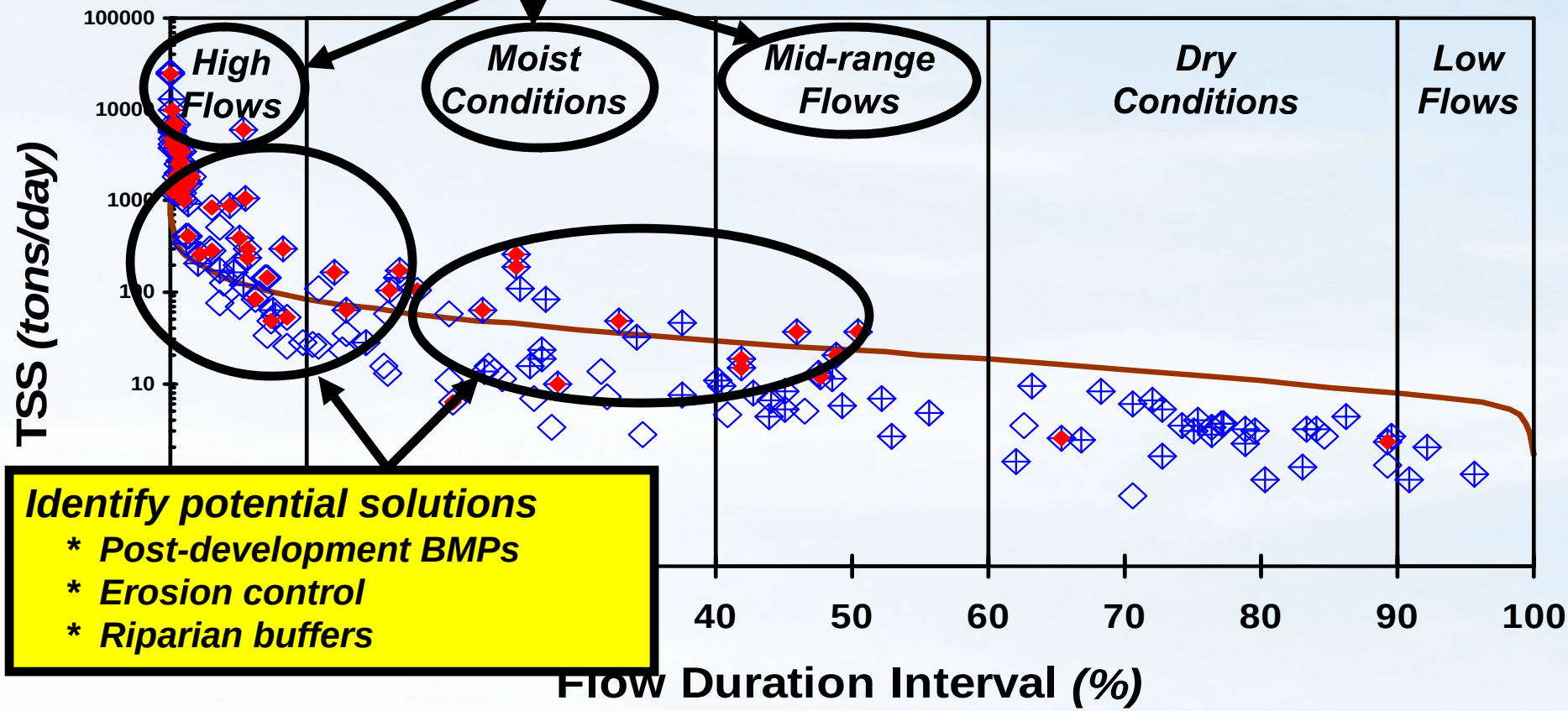
USGS Flow Data

685 square miles

Connecting the Pieces

Developing Solutions

Highlight conditions associated with concern



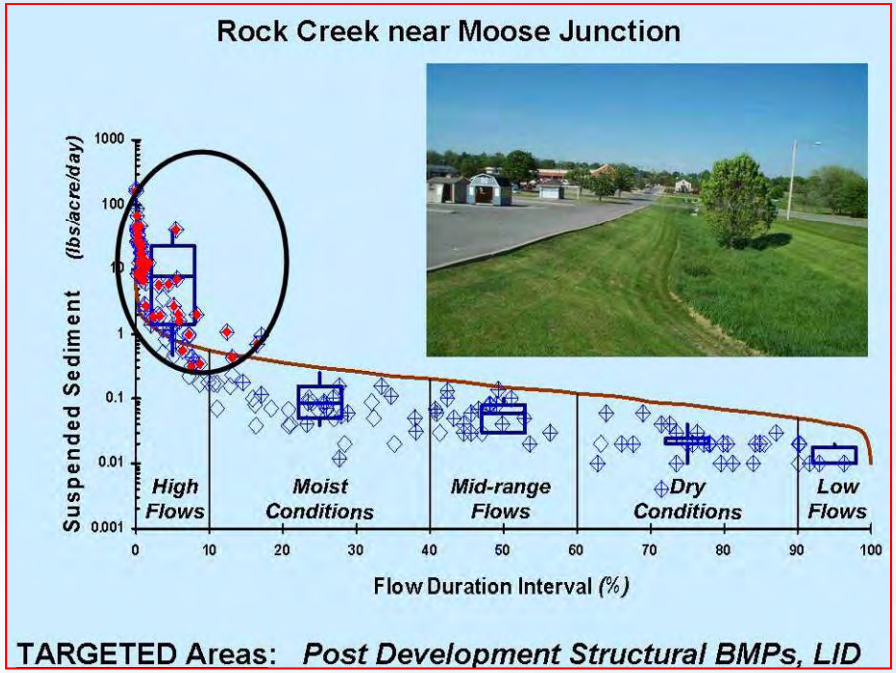
Identify potential solutions

- ***Post-development BMPs***
- ***Erosion control***
- ***Riparian buffers***

TMDLs & Storm Water

Getting to Solutions

Post Development

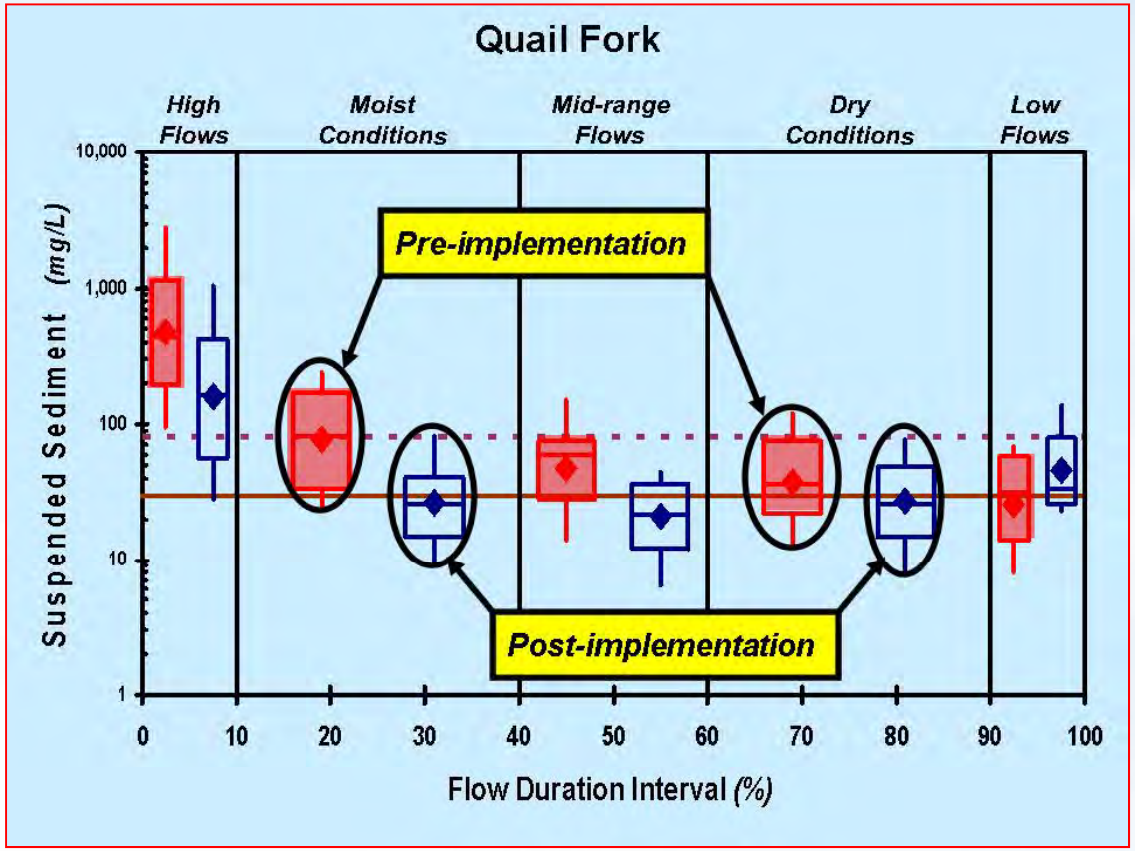


- **WQ Concern**
  - ***Aquatic Biota, Sediment***
- **Condition**
  - ***High Flows***
- **Solution**
  - ***Post Development Structural BMPs, LID, etc.***

Connecting the Pieces

Developing Solutions

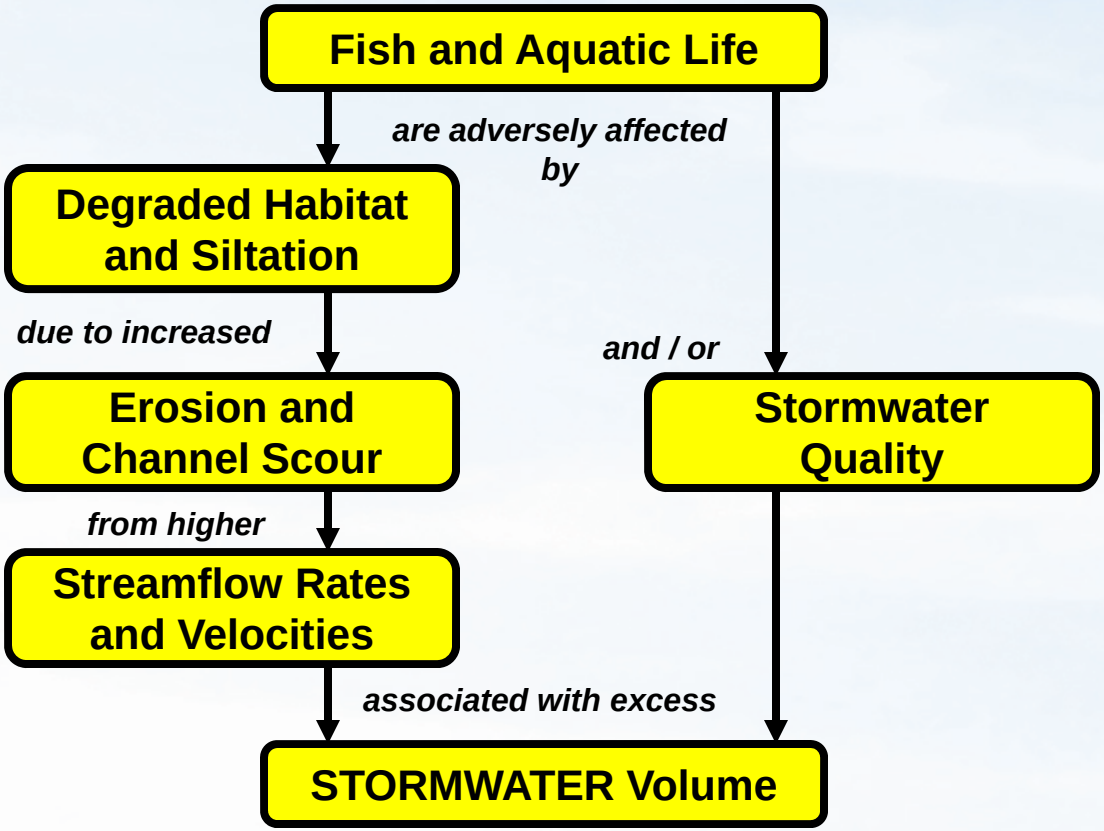
- **Erosion Control Actions**

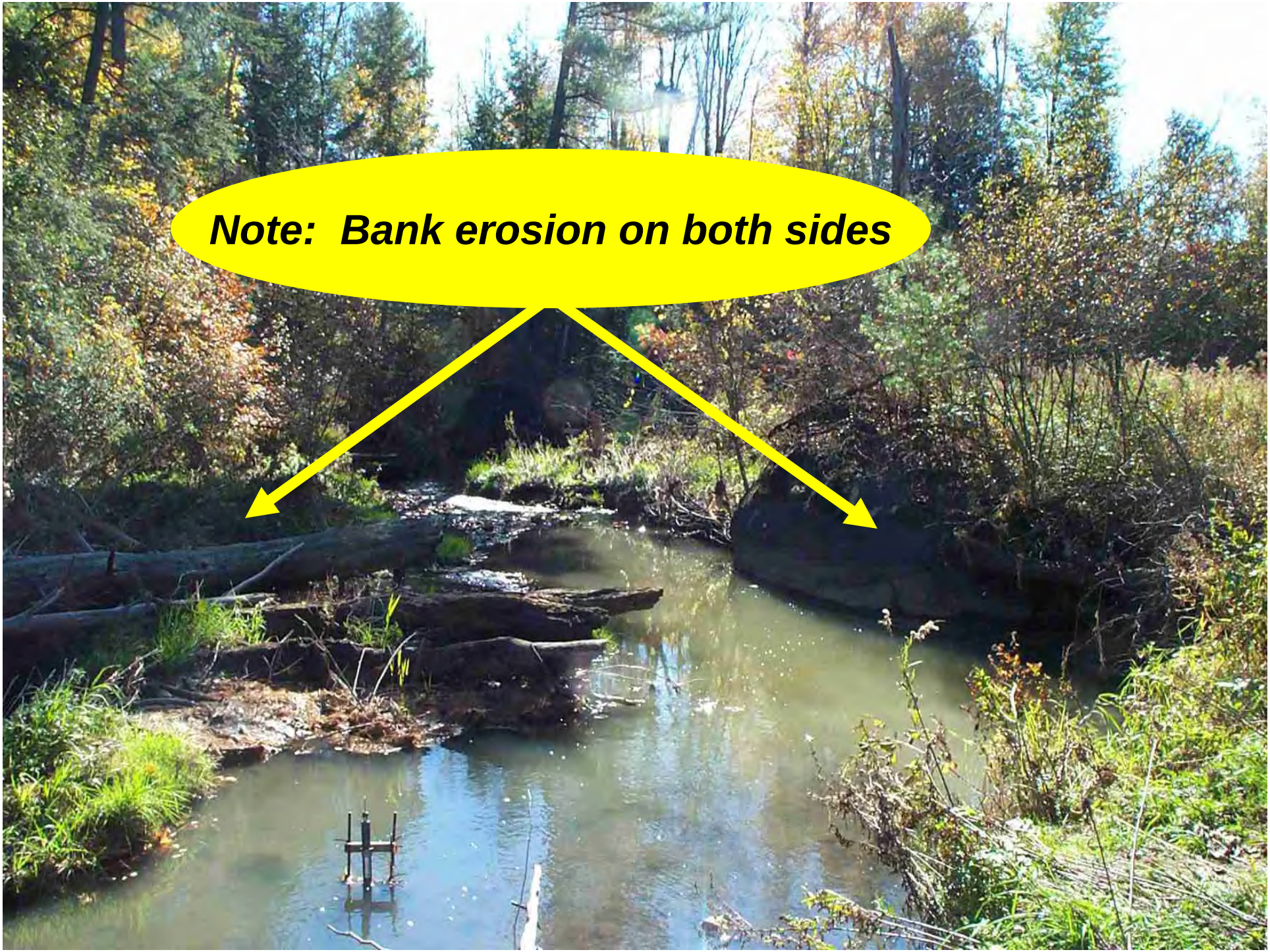


Storm Water Pilots

Innovative Approaches

Identify key relationships




Note: Bank erosion on both sides

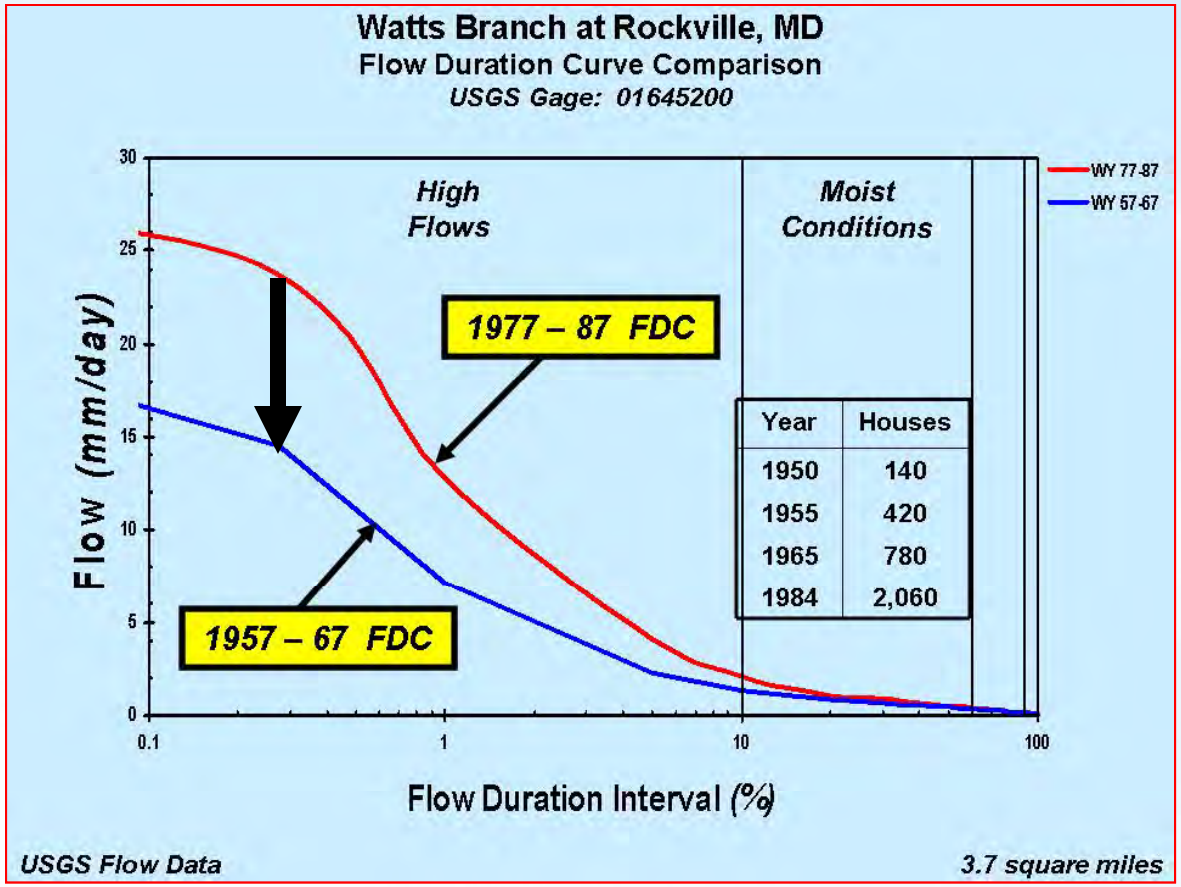
Note: Location of gully photo
USGS

Note: Parking lot drain pipe responsible for gully formation

Innovative Approaches

Logic Path

Hydrology-based Target



Identifying Priority Areas

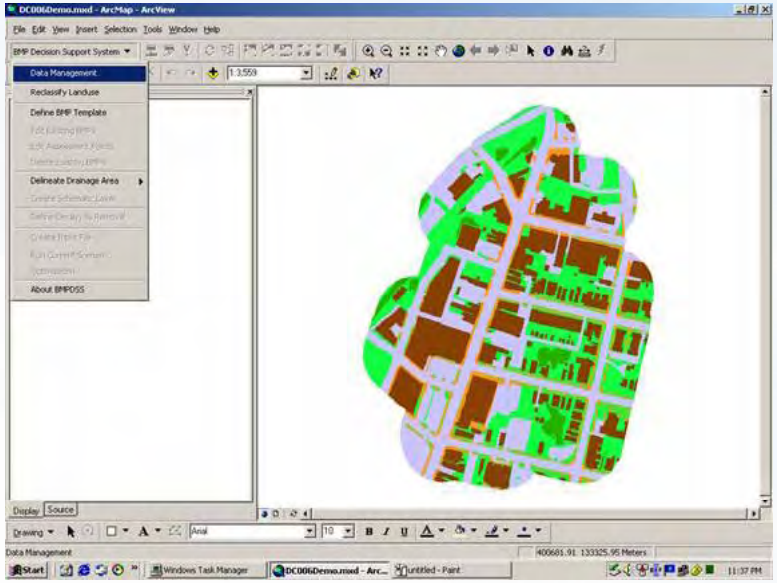
Challenges

- ***Logistically difficult***
  - ***Potentially expensive***

BMP Targeting & Optimization

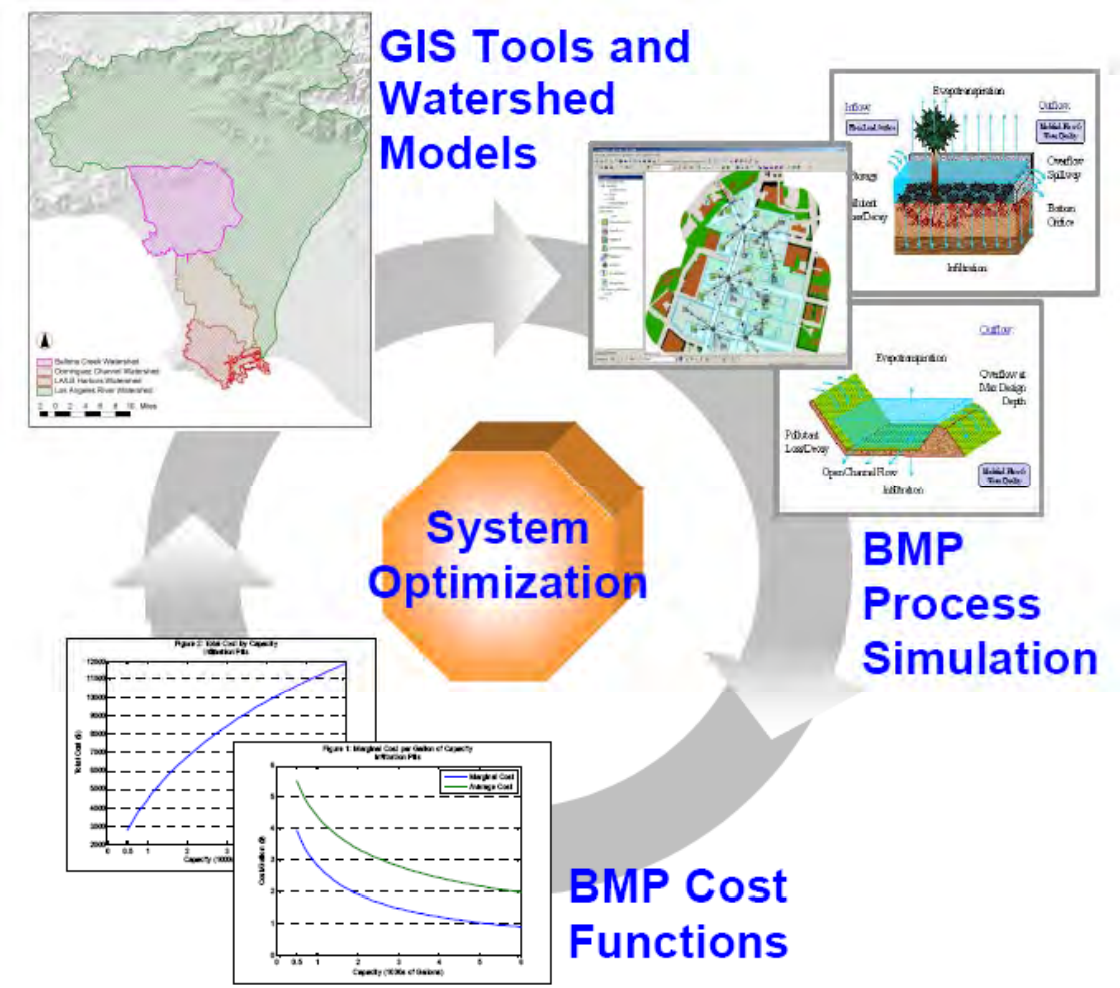
Type & Placement

- ***Evaluation Criteria*** ***(hydrology or WQ-based focus)***
  - ***Maximize reduction***
  - ***Minimize cost***



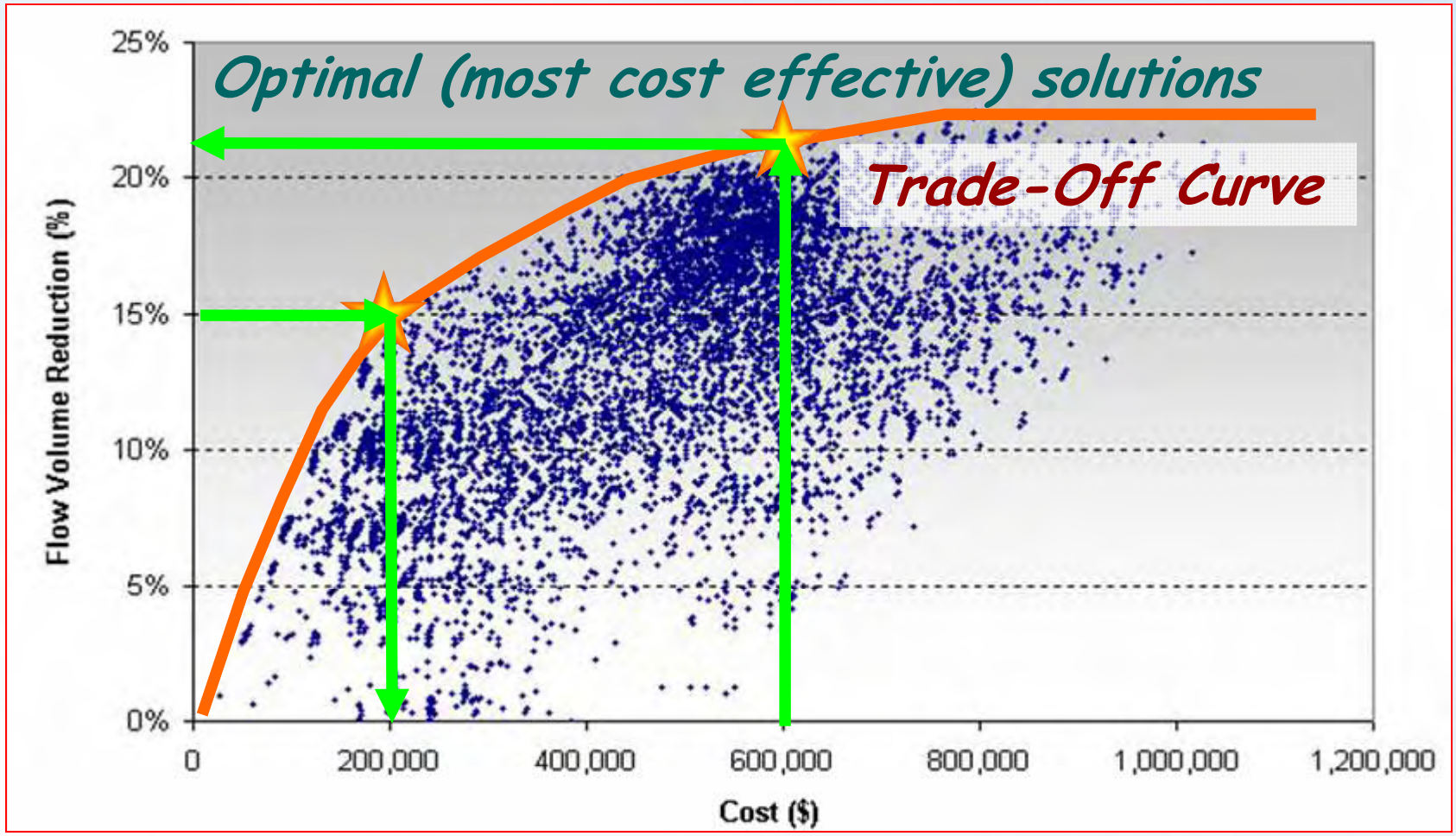
BMP Targeting & Optimization

Utilize New Tools



Stormwater BMP Optimization

Solutions

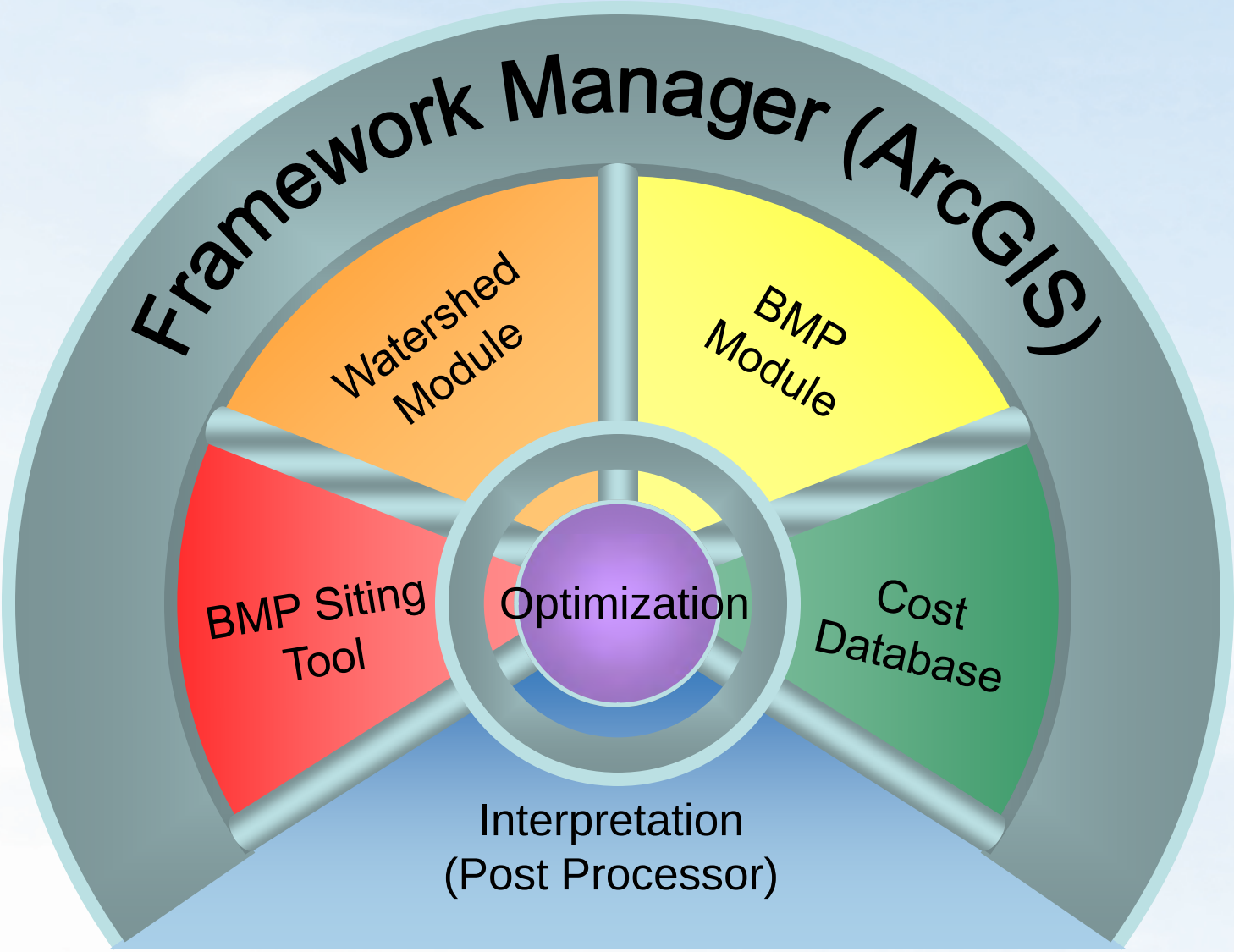


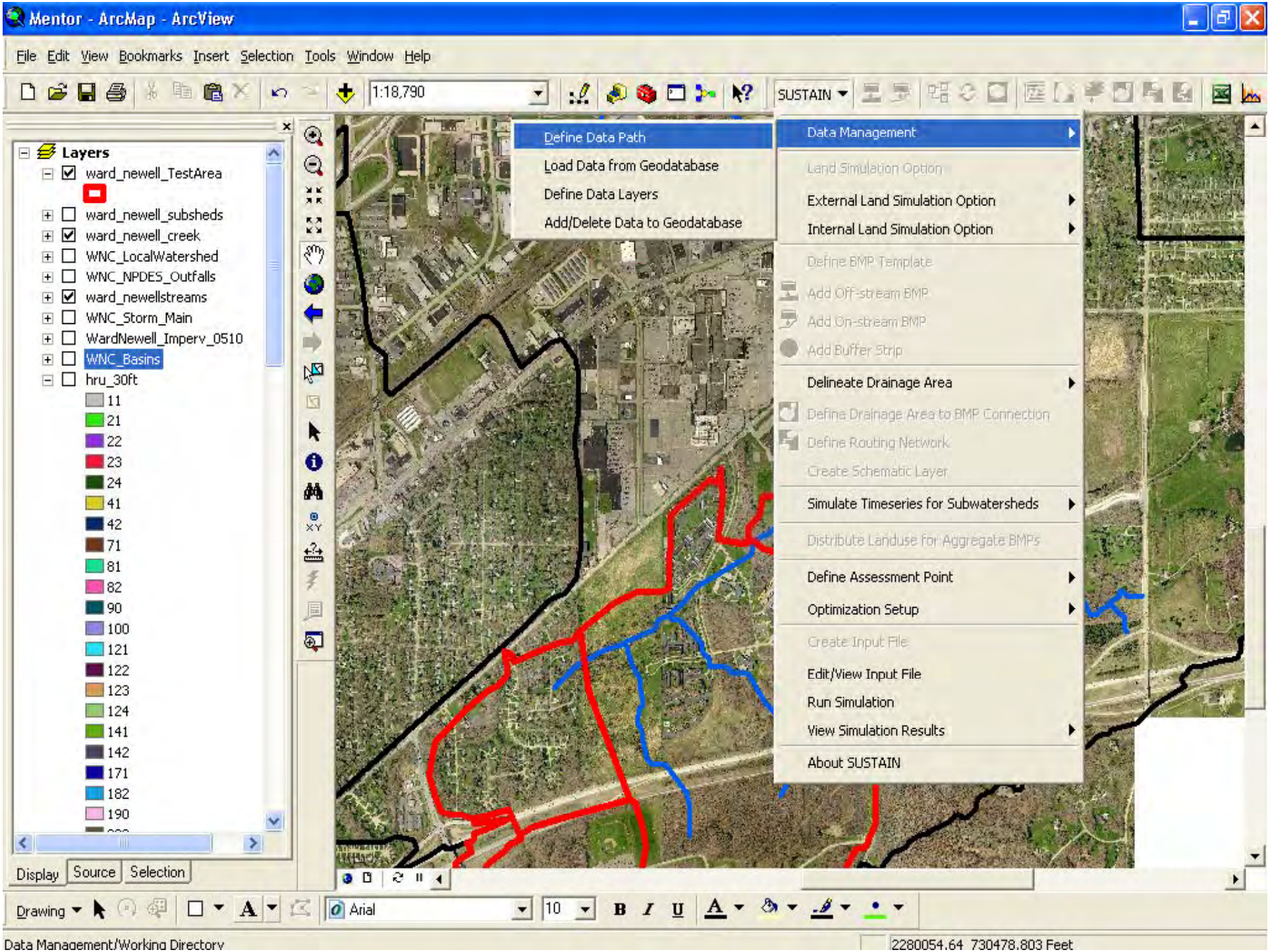
What is *SUSTAIN*?

- ***SUSTAIN*** – **S**ystem for **U**rban **S**tormwater **T**reatment, and **A**nalysis **IN**tegratration

- Evaluation and Decision-making framework:
  - How effective are BMPs or green infrastructure (GI) in reducing runoff and pollutant loadings?
  - What are the most cost-effective BMP options meeting the water quantity and quality objectives?
    - Where, what type, and how large?

SUSTAIN Components

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WNC_NPDES_Outfalls
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WNC_Storm_Main
WardNewell_Imperv_0510
WNC_Basins
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Display
Source
Selection
Define Data Path
Load Data from Geodatabase
Define Data Layers
Add/Delete Data to Geodatabase
Data Management
Land Simulation Option
External Land Simulation Option
Internal Land Simulation Option
Define BMP Template
Add Off-stream BMP
Add On-stream BMP
Add Buffer Strip
Delineate Drainage Area
Define Drainage Area to BMP Connection
Define Routing Network
Create Schematic Layer
Simulate Timeseries for Subwatersheds
Distribute Landuse for Aggregate BMPs
Define Assessment Point
Optimization Setup
Create Input File
Edit/View Input File
Run Simulation
View Simulation Results
About SUSTAIN
Drawing
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SUSTAIN Pilots

Project Locations

- **Chagrin River, Ohio**
- **Salt Creek, Indiana**
- **Swan Creek, Ohio**
- **Amity Creek, Minnesota**
- **Lower Grand River, Ohio**

How to Apply *SUSTAIN*

Case Study Objectives

Question to be answered:

"How to address water quality & hydrology-related concerns?"

Control Targets:

- Peak flow rate – 10 yr design storm
- Total Phosphorus load – 40% average annual load reduction

Data Collection & Analysis

- Study area review
- GIS data: land use, stream, DEM, BMP sites, etc.
- Watershed and BMP information/data
- Compile monitoring data (calibration/validation)

Project Setup

- BMP representation: placement, configuration, and cost
- LAND/WATERSHED Representation
- Routing network
- Assessment point(s)
- Test system application (externally calibrated model)
- Calibrate/validate model (internal model)

Put Optimization Processor to Work!

- Select decision variables (BMP dimensions)
- Select assessment points (BMP/Outlet locations)
- Select evaluation factors, control targets (end points)

Results Analysis and Representation (Post-Processor)

- Optimum BMP dimensions
- Alternate solutions

SUSTAIN Pilot Projects

Test Site Characteristics

- **Different Land Uses & Development Densities**
  - ***Residential***
    - ***Current***
    - ***Proposed development***
  - ***Commercial***

- **Focus on current impaired waters**

SUSTAIN Pilot Projects

Common Themes

- **Evaluate utility of SUSTAIN to prioritize retrofit opportunities**

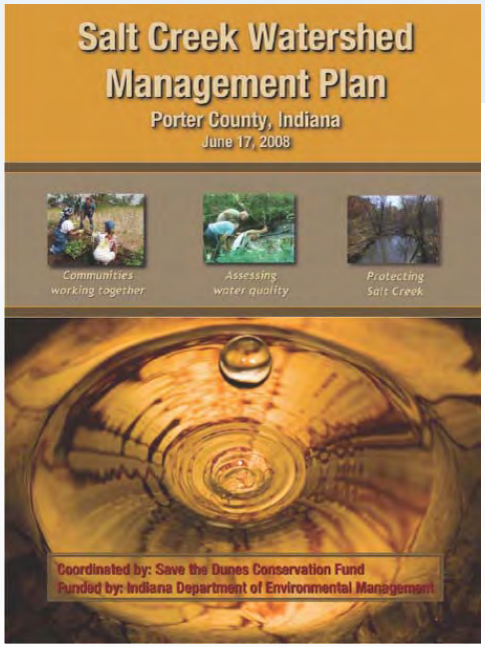
- **Identify recommendations for BMPs on new development**

Salt Creek

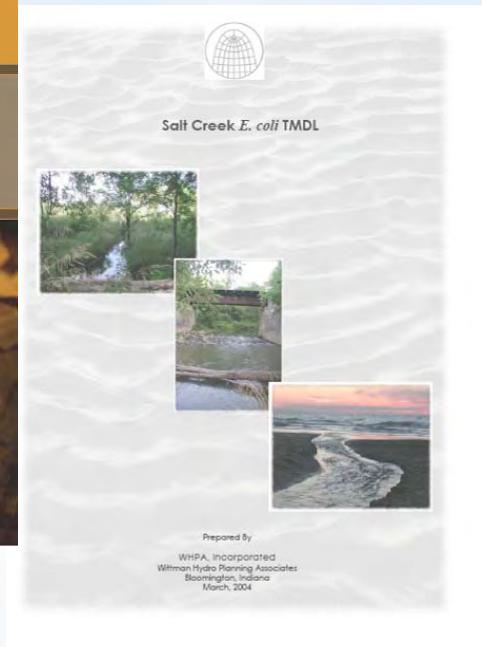
Salt Creek

Integrated Watershed Pilot

The Path

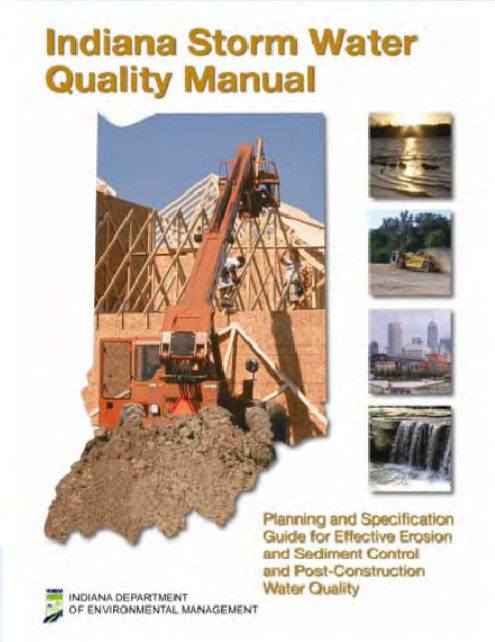


Targets



Local Rules

Tools

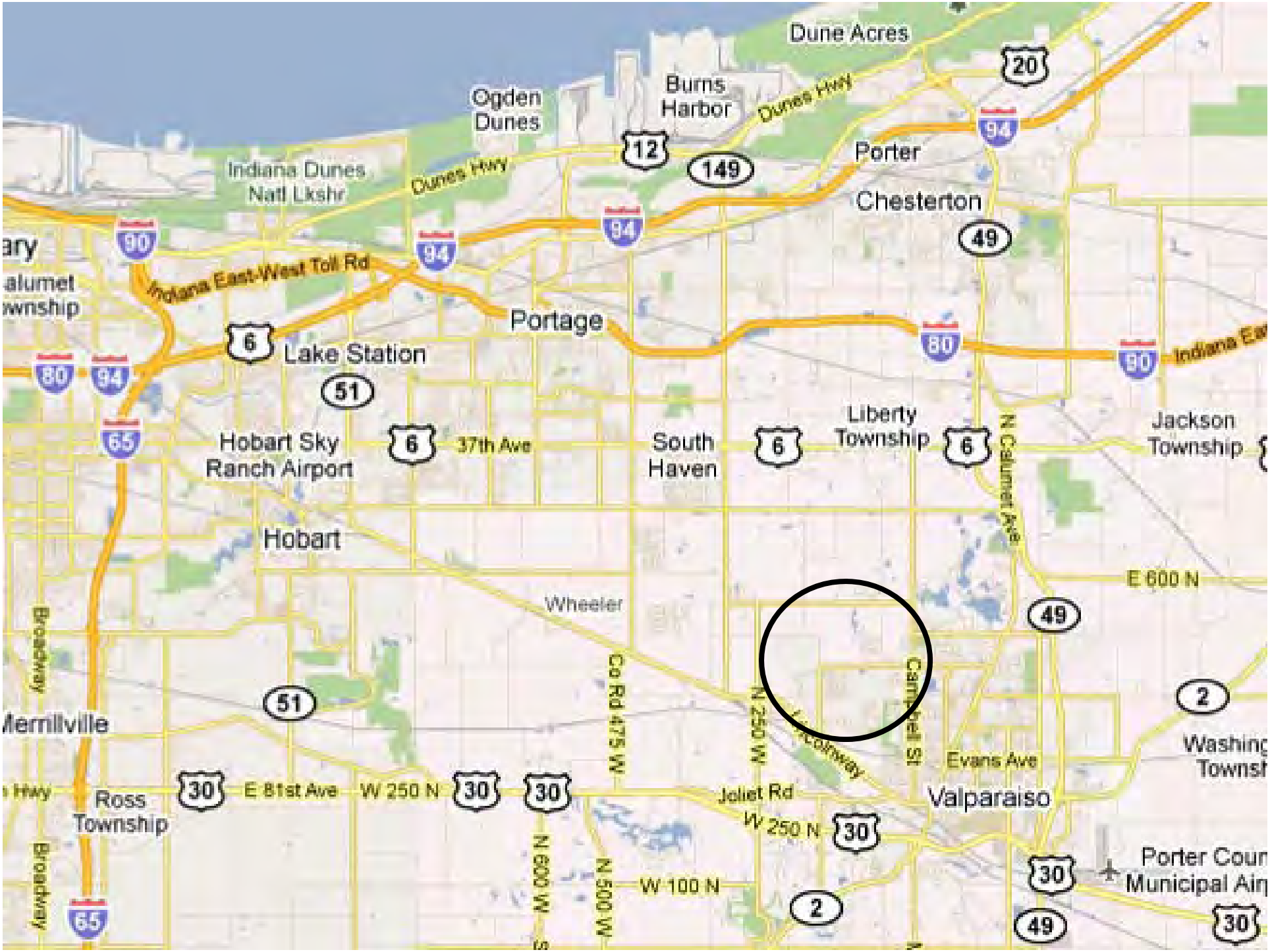


Salt Creek

Integrated Watershed Pilot

Identify desired outcomes ***(quantity & quality)***

- ***Flood control***
- ***Stream channel protection***
- ***Groundwater recharge***
- ***Water quality***
- ***Wetlands restoration***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N 500 W
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Newell Creek
Chagrin River Watershed

Highly Developed Subwatershed

- ***Channel affected by altered hydrology***
- ***28% impervious cover***

SUSTAIN Pilot Projects

Chagrin River: Newell Creek Objectives

- **Augment current efforts in promoting low impact development in the watershed**
- **Improve water quality in degraded stream**

  - ***Both flooding problems & impact on biology***
  - ***Explore infiltration opportunities***
    (Suitable soils)

SUSTAIN Pilot Projects

Chagrin River: Newell Creek Objectives

- **Watershed Action Plan / TMDL Implementation**
- **Permit related items**
  - ***How can SUSTAIN help inform development of Chagrin specific stormwater permit?***
  - ***Evaluate effectiveness of treating WQ volume requirement***

Roadmap to Implementation

Considerations/Inputs | **Analysis Step**

- Watershed hydrology
- Rainfall / runoff patterns
- Land use / source loads
- Management goals
  (load/flow reduction targets)

Establish Baseline Conditions

- Goals to be met
- Impervious analysis
- Opportunities & constraints
  (environmental, physical, political)

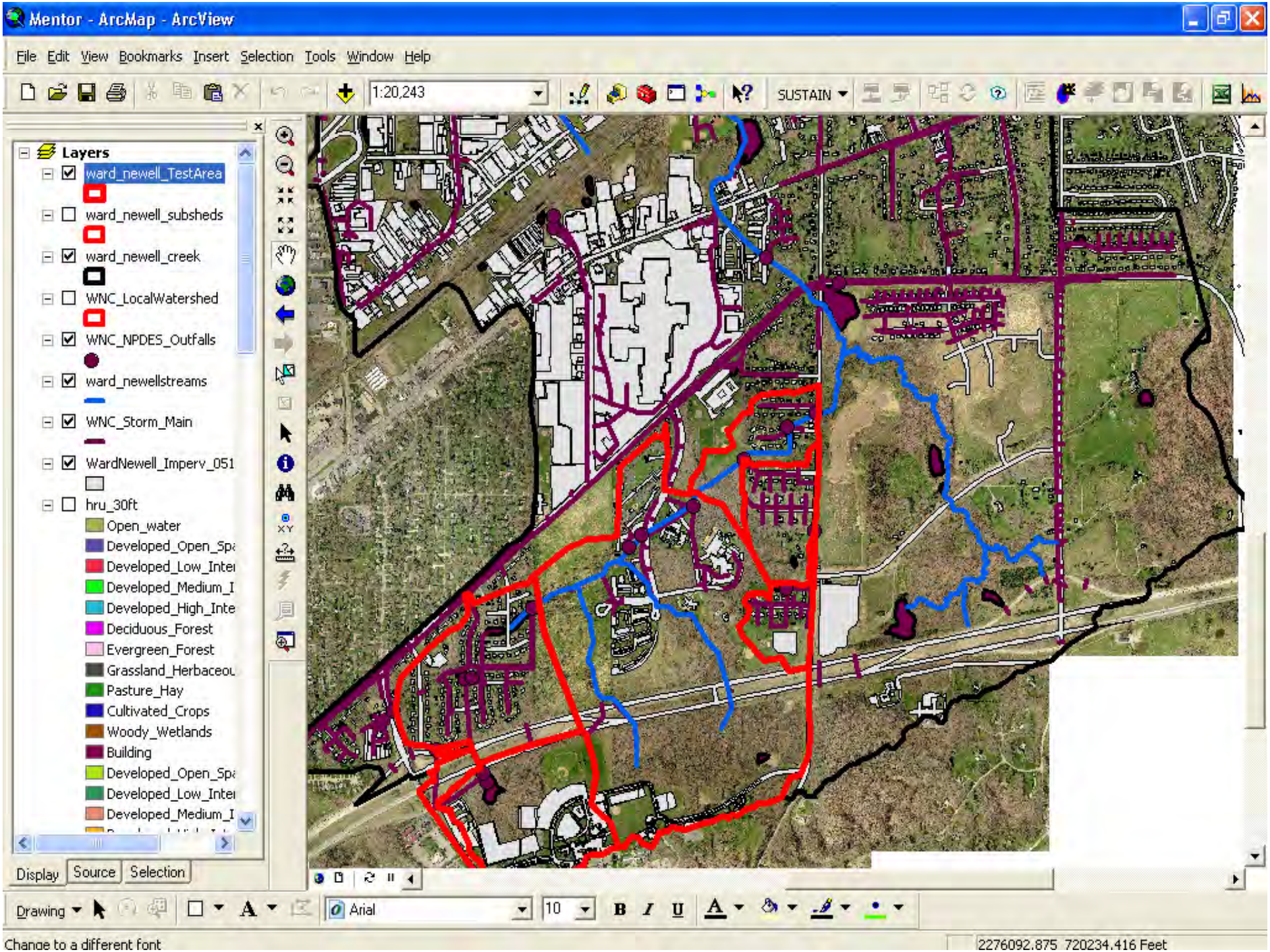
Identify Potential BMPs

- BMP types
- BMP locations
- BMP design specifications

Determine BMP Configurations/ Performance

Identify BMP Costs

Perform BMP Optimization Analysis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Identify Potential BMPs

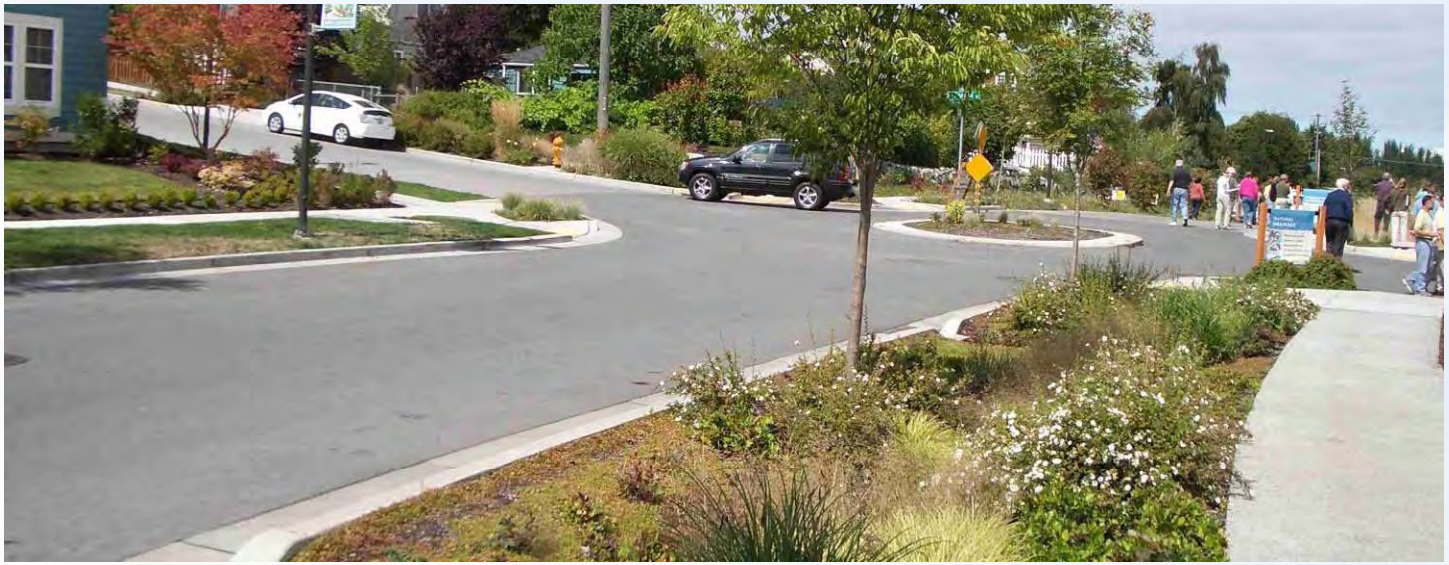
Example: Bioretention

- **Data Requirement**
  - **DEM**
  - **Soil type**
  - **Roads**
  - **Imperviousness**
- **Design Criteria**
  - **Drainage area (< 2 acres)**
  - **Drainage Slope (< 5 %)**
  - **Soil type (A, B, C, D)**
  - **Imperviousness (> 0 %)**
  - **Road Buffer (100 ft)**

Identify Potential BMPs

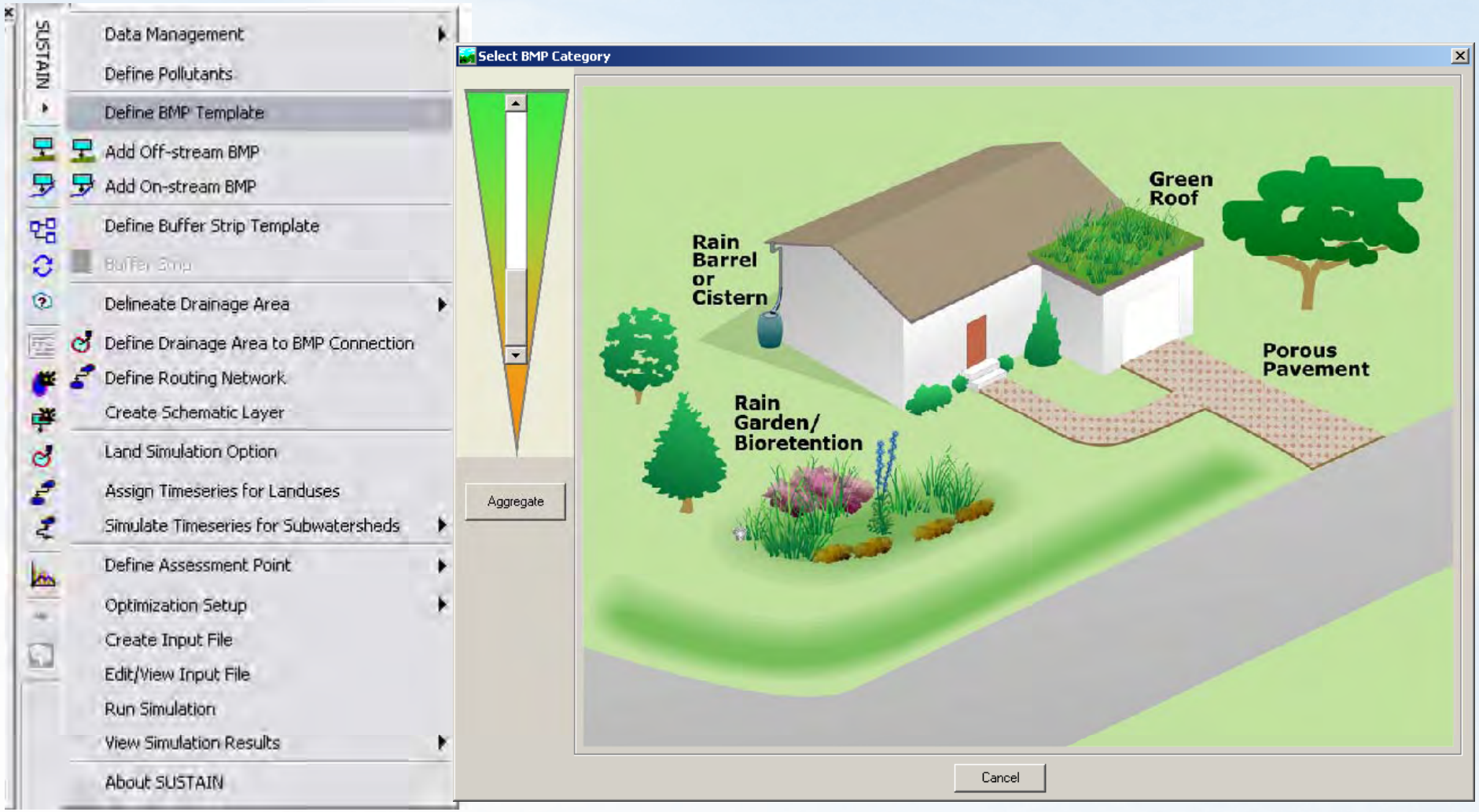
Example: Infiltration Trench

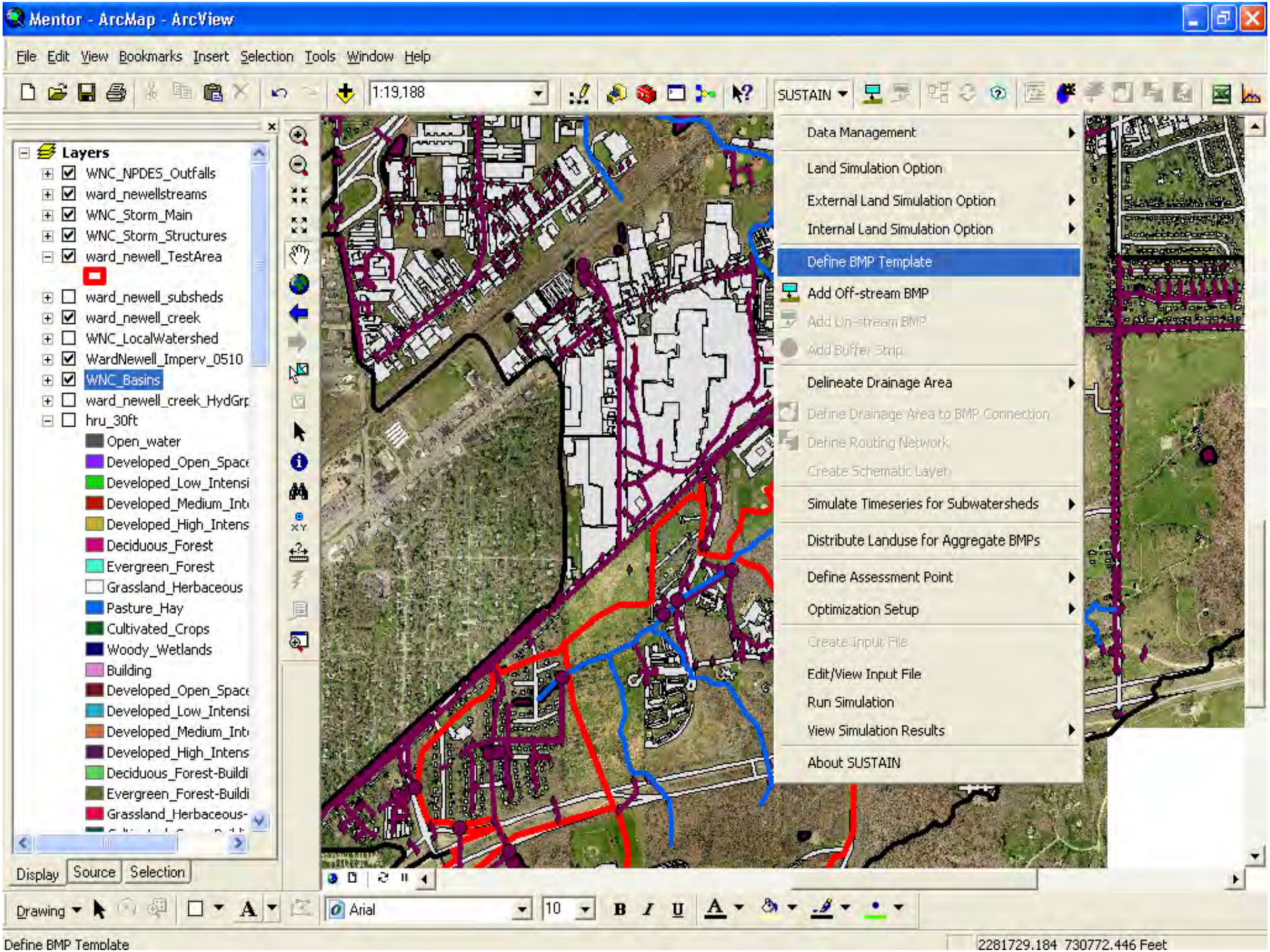
- **Data Requirement**
  - **DEM**
  - **Soil type**
  - **Imperviousness**
- **Design Criteria**
  - **Drainage area (< 5 acre)**
  - **Drainage Slope (< 15 %)**
  - **Soil type (A, B)**
  - **Imperviousness (> 0 %)**



Potential BMPs

Scale Driven

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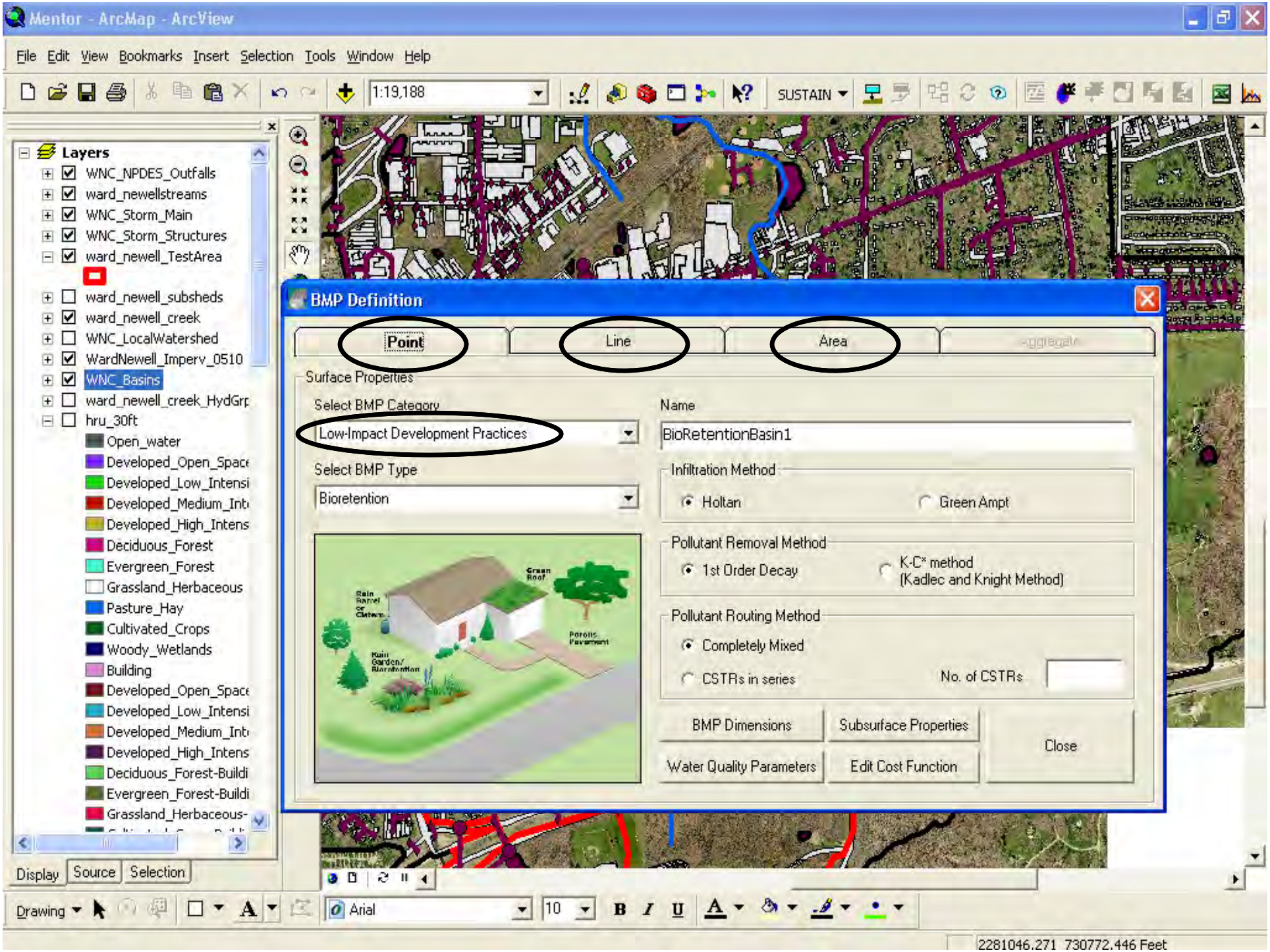
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Green Ampt
Pollutant Removal Method
1st Order Decay
K-C* method
(Kadlec and Knight Method)
Pollutant Routing Method
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CSTRs in series
No. of CSTRs
BMP Dimensions
Subsurface Properties
Water Quality Parameters
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SUSTAIN Pilot Projects

BMP Templates

Group	Category	BMP Type
Point	**LID**	**Bioretention**
		Rain Barrel
		Cistern
	Conventional	**Wet Pond**
		Dry Pond
Linear	**Conventional**	**Infiltration Trench**
		Vegetative Swale
	Generalized	**Buffer Strip**
Area	**LID**	**Porous Pavement**
		Green Roof

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Display | Source | Selection

Drawing

Define BMP Parameters

Dimensions | Substrate Properties | Growth Index | Water Quality Parameters | Cost Factors | Sediment

OK

Cancel

General Information

Name: BioRetentionBasin1

Basic Dimensions

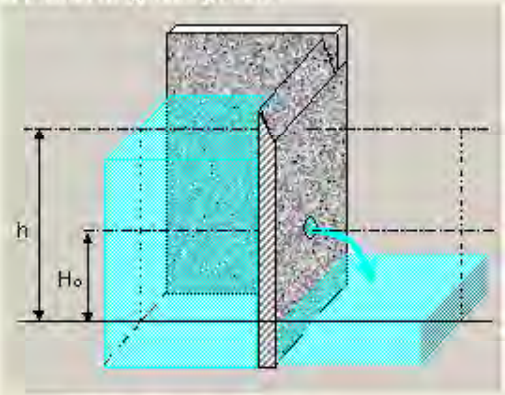
Length (ft): 10

Width (ft): 5

Number of Units: 0

Design Drainage Area (ac): 0.1

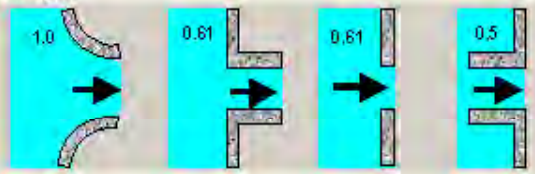
Surface Storage Configuration



Orifice Diameter (in): 0

Orifice Height (Ho, ft): 0

Exit Type

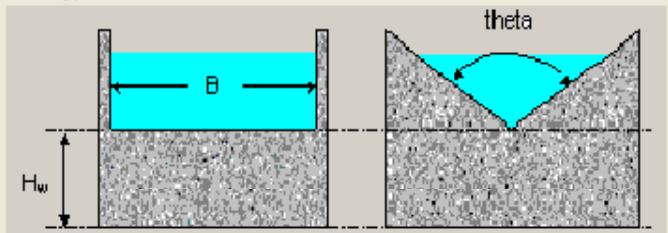


Release Option

- Cistern — Number of People
- Rain Barrel — Number of Dry Days
- None

Weir Configuration

Weir Type



Weir Height (Hw, ft): 0.5

Rectangular Weir
Weir Crest Width (B, ft): 1

Triangular Weir
Vertex Angle (theta, deg):

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  - Grassland_Herbaceous-

Display | Source | Selection

Drawing

Define BMP Parameters

Dimensions | Substrate Properties | Growth Index | Water Quality Parameters | Cost Factors | Sediment

OK

Cancel

Select components and sources from the list

☑ Include NRCS Sources

Functional Components: Backfilling

User Defined Component:

Source Locale: Average of available data

Source: Average

Source Year: 2005

Unit: Cubic Feet

Number of Units (Per Unit): 1

Volume Type

◉ Total Volume ○ Soil Media ○ Underdrain Volume

Unit Cost: 0.0656 Cost Exponent:

☑ Adjust cost based on ENR Construction Cost Index

Source Details

Average cost - Combination of many sources

Add | Edit | Remove

Selected components

Component	Locale	Source	Year	Unit	Uni

2281046.271 730772.446 Feet

BMP Templates

BMP:	RAIN GARDEN	SUSTAIN Template:	Bioretention

Dimensions

- Length *(feet)*
- Width *(feet)*
- Design drainage area *(acre)*
- Ponding depth defined through one of following options:
  - Surface storage configuration
    - ✓ Orifice diameter *(inches)*
    - ✓ Orifice height *(feet)*
  - Weir configuration
    - ✓ Weir height *(feet)*
    - ✓ Weir configuration *(rectangular or triangular)*

Substrate Properties

- Depth of soil *(feet)*
- Soil porosity *(0 - 1)*
- Soil field capacity
- Soil wilting point
- Vegetative parameter A
- Soil layer infiltration *(inches / hour)*
- Underdrain structure *(if applicable)*
  - Storage depth *(feet)*
  - Media void fraction *(0 - 1)*
  - Background infiltration *(inches / hour)*
- Green Ampt Infiltration *(if applicable)*
  - Suction head *(inches)*
  - Conductivity *(inches / hour)*
  - Initial deficit *(fraction)*

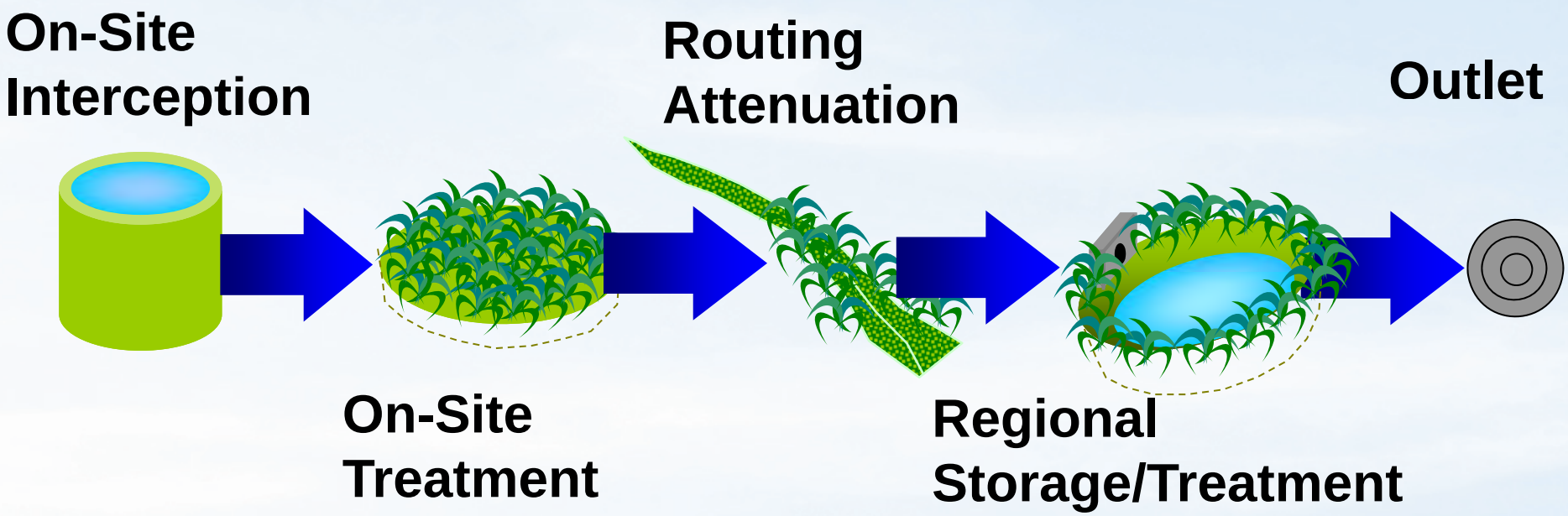
BMP Templates

BMP:	RAIN GARDEN	SUSTAIN Template:	Bioretention

Vegetative Growth Index	
• Specified as monthly values *(0 - 1)*	
Water Quality Removal	
• Decay factor: by individual pollutant *(1 / day)*	
• Underdrain removal rate *(if applicable)*: by individual pollutant *(1 / day)*	
Costs	
Cost factors can be either "User Defined" or by any of the following individual components:	
• Excavation • Grading / Finishing • Backfilling • Soil / Planting Media • Filter Fabric • Gravel	• Underdrain Pipe • Mulch • Grass • Perennials • Small Trees • Woody Shrubs

Potential BMPs

Generic Treatment Train



Potential BMPs

Impervious Cover Type

Rooftop

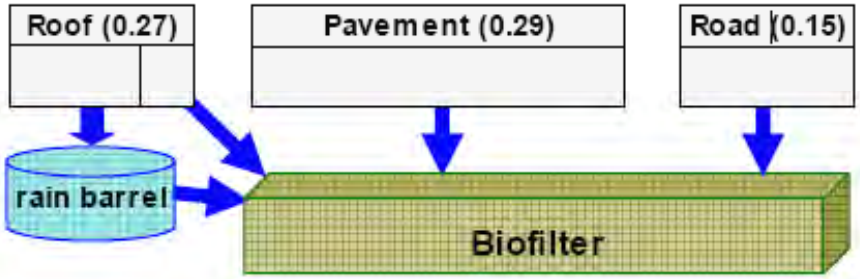
Agg Rain Barrel

Agg. Rain Garden

Driveway

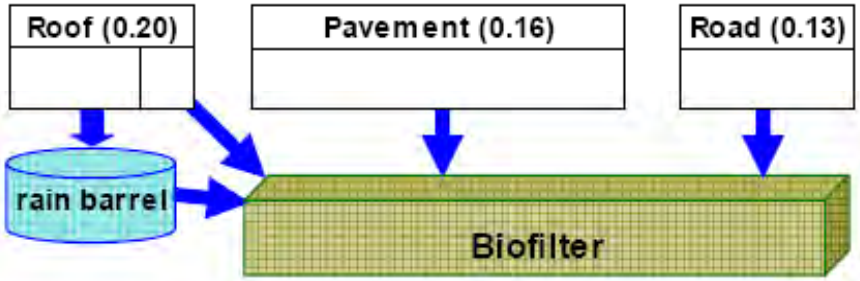
BMP Opportunities

High-Density Residential



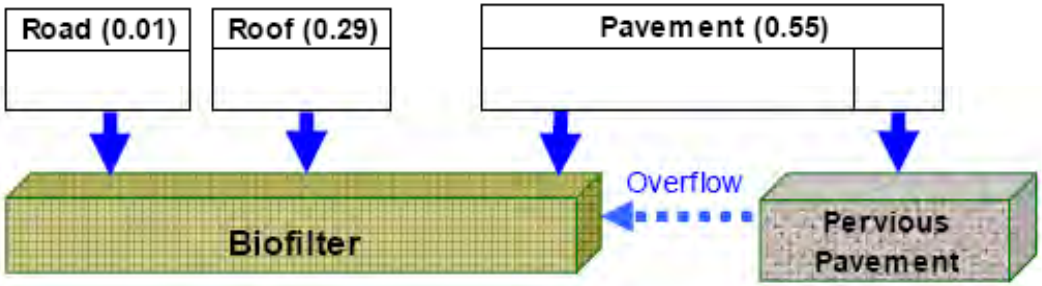
- Flow from rooftops drains to both rain barrels and biofilters
  - Overflow from the rain barrel drains to biofilters
- All pavement runoff flows to biofilters
- All road runoff flows to biofilters

Multifamily Residential



- Flow from rooftops drains to both rain barrels and biofilters
  - Overflow from the rain barrel drains to biofilters
- All pavement runoff flows to biofilters
- All road runoff flows to biofilters

Industrial



- All road runoff flows to biofilters
- All rooftop runoff flows to biofilters
- Flow from pavement drains to both pervious pavement and biofilters
  - Overflow from the pervious pavement drains to biofilters

S_Test - ArcMap - ArcView

Define BMP Parameters

Dimensions | Substrate Properties | Growth Index | Water Quality Parameters | Cost Factors | Sediment

OK

Cancel

General Information

Name: BioRetentionBasin1

Basic Dimensions

Length (ft): 10

Width (ft): 5

Number of Units: 0

Design Drainage Area (ac): 0.1

Surface Storage Configuration

Exit Type

Orifice Diameter (in): 0

Orifice Height (Ho, ft): 0

Optimization Parameters

Consider As Decision Variable

Minimum: 0

Maximum: 300

Increment: 30

OK | Cancel

Weir Configuration

Weir Type

theta

Weir Height (Hw, ft): 0.5

Rectangular Weir

Weir Crest Width (B, ft): 1

Triangular Weir

Vertex Angle (theta, deg)

SUSTAIN

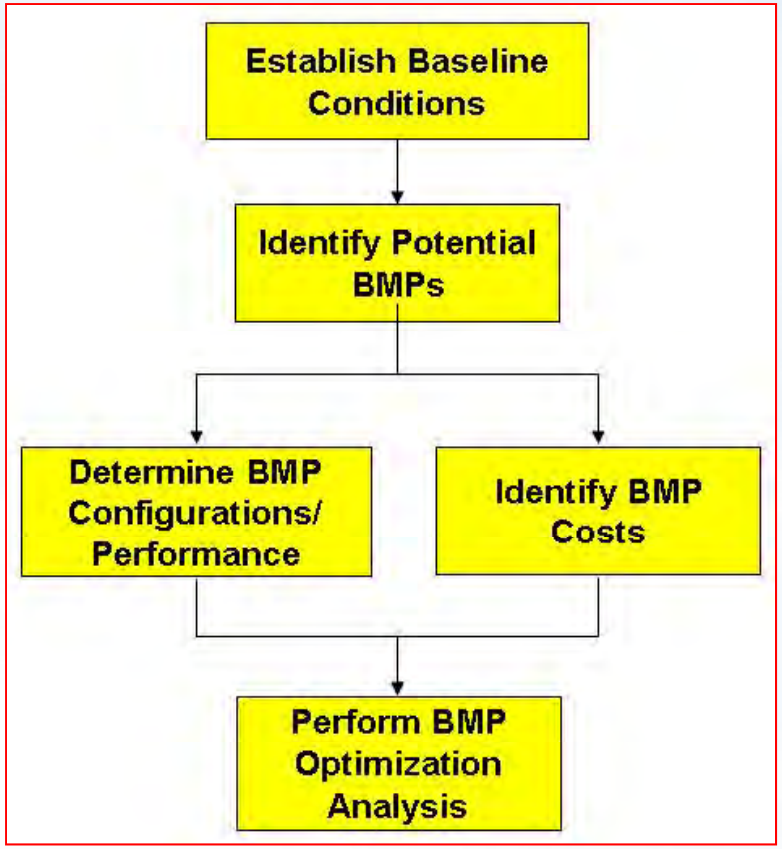
A4

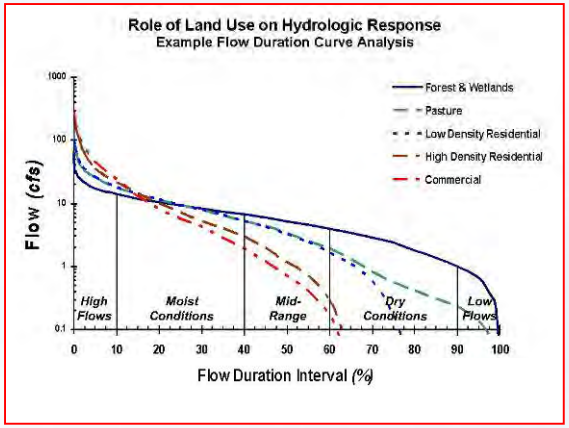
2277455.56 720840.04 Feet

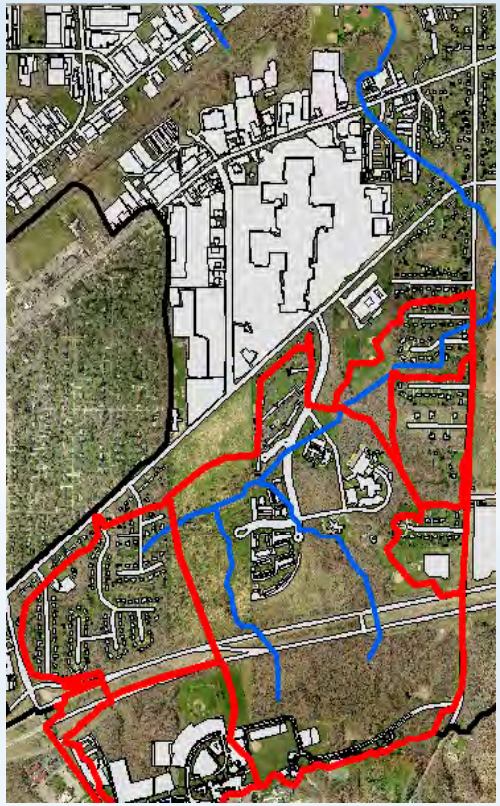
SUSTAIN Pilots

Roadmap to TMDL Implementation

- **Tool to organize stormwater management efforts**



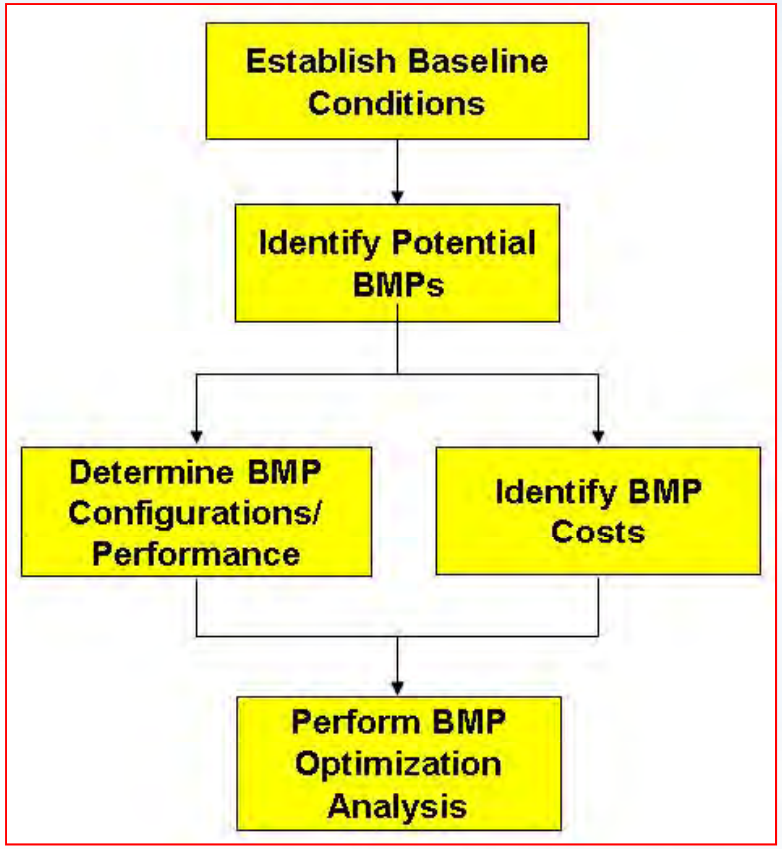


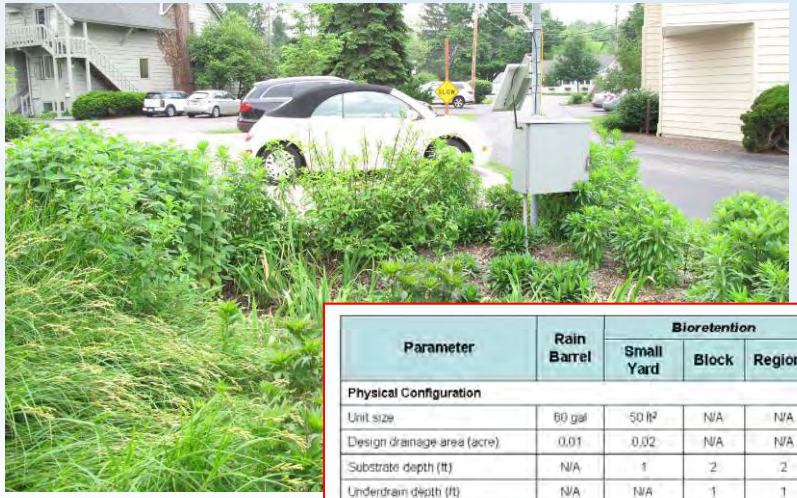


SUSTAIN Pilots

Roadmap to TMDL Implementation

- **Tool to organize stormwater management efforts**

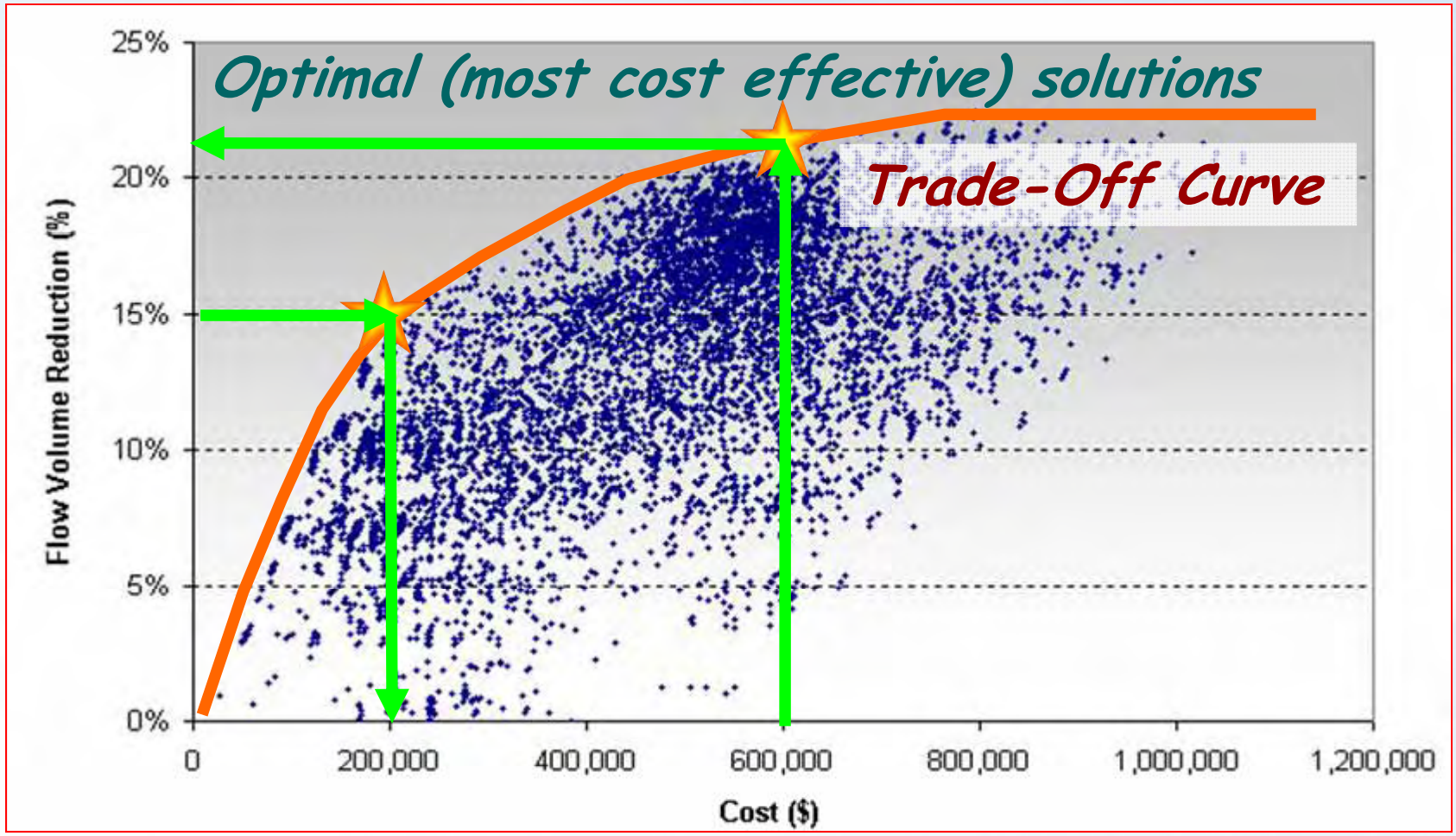




Parameter	Rain Barrel	Bioretention			Porous Pavement	Green Roof
		Small Yard	Block	Regional		
Physical Configuration						
Unit size	60 gal	50 ft²	N/A	N/A	N/A	N/A
Design drainage area (acre)	0.01	0.02	N/A	N/A	N/A	N/A
Substrate depth (ft)	N/A	1	2	2	2	0.5
Underdrain depth (ft)	N/A	N/A	1	1	1	1
Ponding depth (ft)	N/A	0.5	1.5	2	0.1	0.1
Infiltration*						
Substrate layer porosity	N/A	0.5	0.5	0.5	0.5	0.5
Substrate layer field capacity	N/A	0.3	0.3	0.3	0.2	0.4
Substrate layer wilting point	N/A	0.15	0.15	0.15	0.05	0.15
Underdrain gravel layer porosity	N/A	0.5	0.5	0.5	0.5	0.5
Vegetative parameter, A	N/A	0.6	0.6	0.6	1	0.6
Background infiltration rate (in./hr), f_c	N/A	0.25	0.25	0.25	0.25	0.25
Media final constant infiltration rate (in./hr), f_c	N/A	2	2	2	2	2
Cost Data						
Unit Cost	$70 ea.	$4 / ft²	$8 / ft²	$5 / ft²	$3.44 / ft²	$15 / ft²

SUSTAIN Pilots

Roadmap to Implementation



SUSTAIN Pilot Projects

Take Home Message

- **Driving Principles**
  - ***Technically-based*** ***(logic path)***
  - ***Meaningful*** ***(easily understood)***
  - ***Value-added*** ***(connect to implementation efforts designed to solve problem)***