# Low Impact Development

"A Comprehensive Innovative Stormwater Management Technology to Protect Both Aquatic Living Resources and Water Resources"

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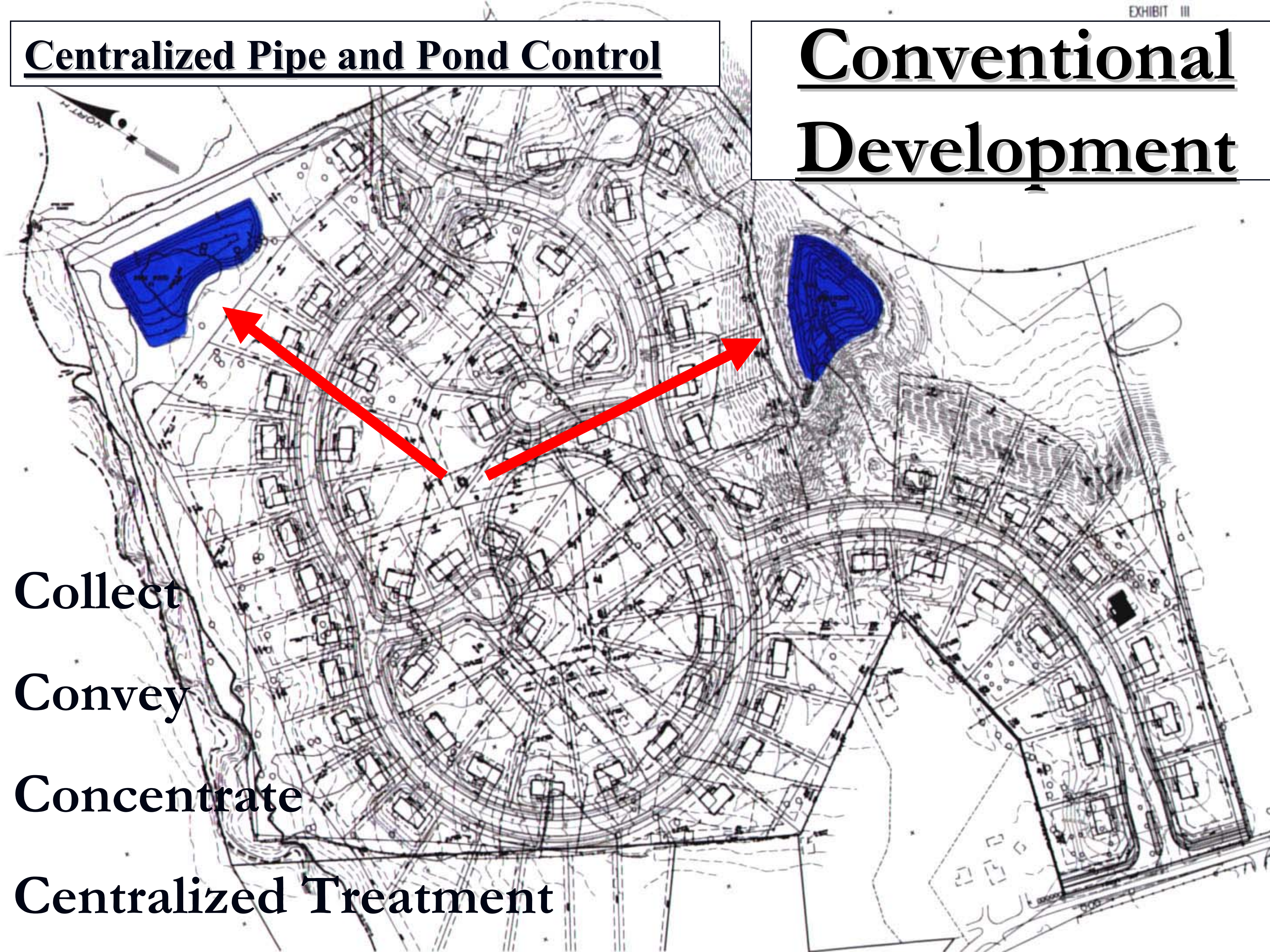
# Low Impact Development Technology Overview

- New Philosophy
  - Ecologically Functional Design (Mimic Nature)
  - Decentralized Source Control
- New Principles
  - Terrestrial and Aquatic Ecosystem Linkages and Processes
- New Practices
  - Decentralized / Multi-functional / Multi-beneficial
- New Process
  - Conserve / Minimize / Maintain / Integrate / Prevent

## Centralized Pipe and Pond Control

# Conventional Development




Collect

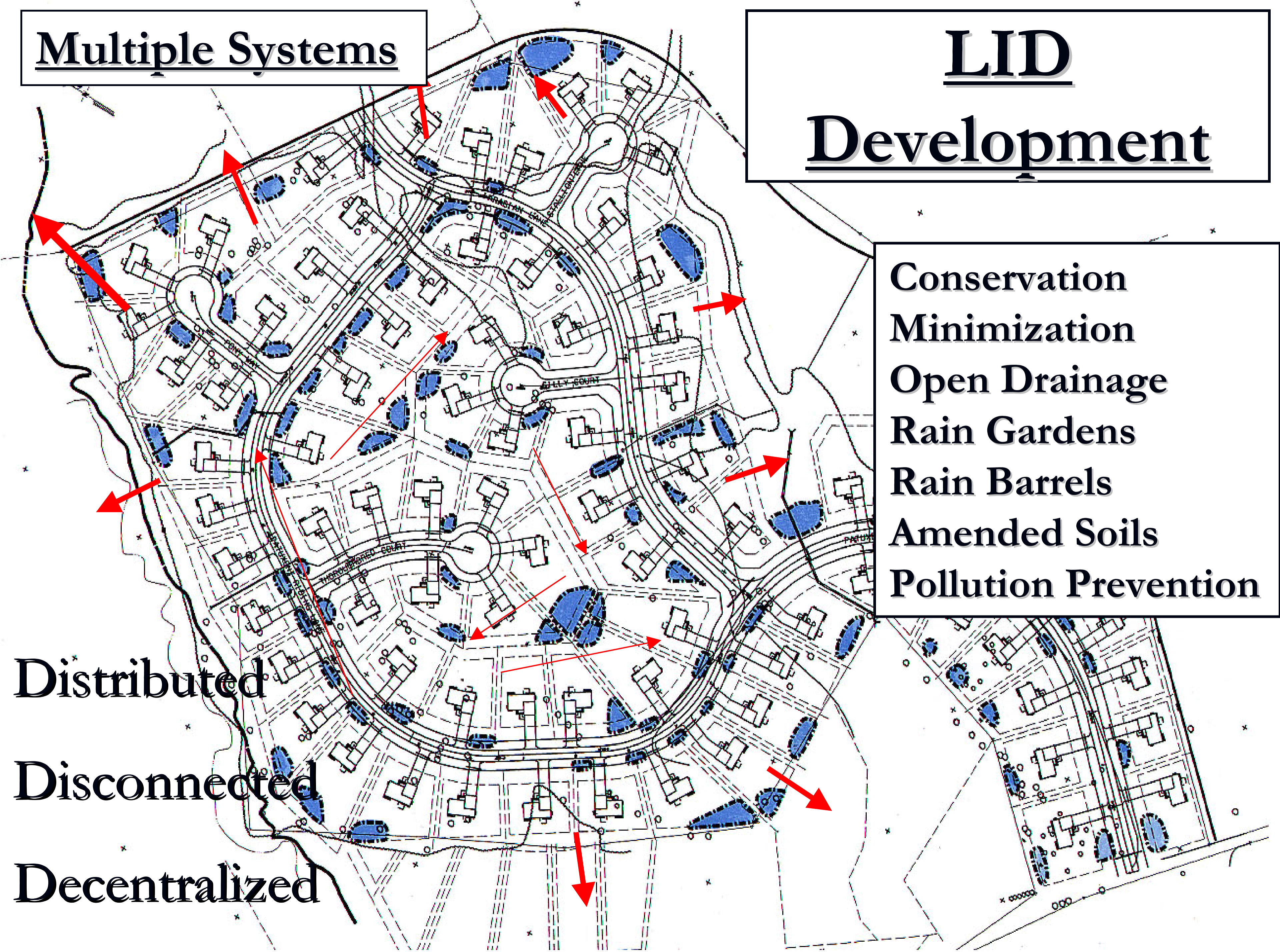
Convey

Concentrate

Centralized Treatment

# Multiple Systems

# LID Development



Conservation
Minimization
Open Drainage
Rain Gardens
Rain Barrels
Amended Soils
Pollution Prevention

Distributed

Disconnected

Decentralized


Conventional
Low Impact
Good Drainage
Functional Lanscape Design

# Limitations of Conventional Stormwater Approaches

- Economics
  - Cost of Maintaining a Growing / Aging Infrastructure
- New Objectives (Public Health / Ecological)
  - Source Water, CSO's, Living Resources / Streams
  - Regulations
    - NPDES / TMDL's / ESA


Issues
West Nile Virus
Safety
Maintenance

# Limitations of Conventional Stormwater Approaches

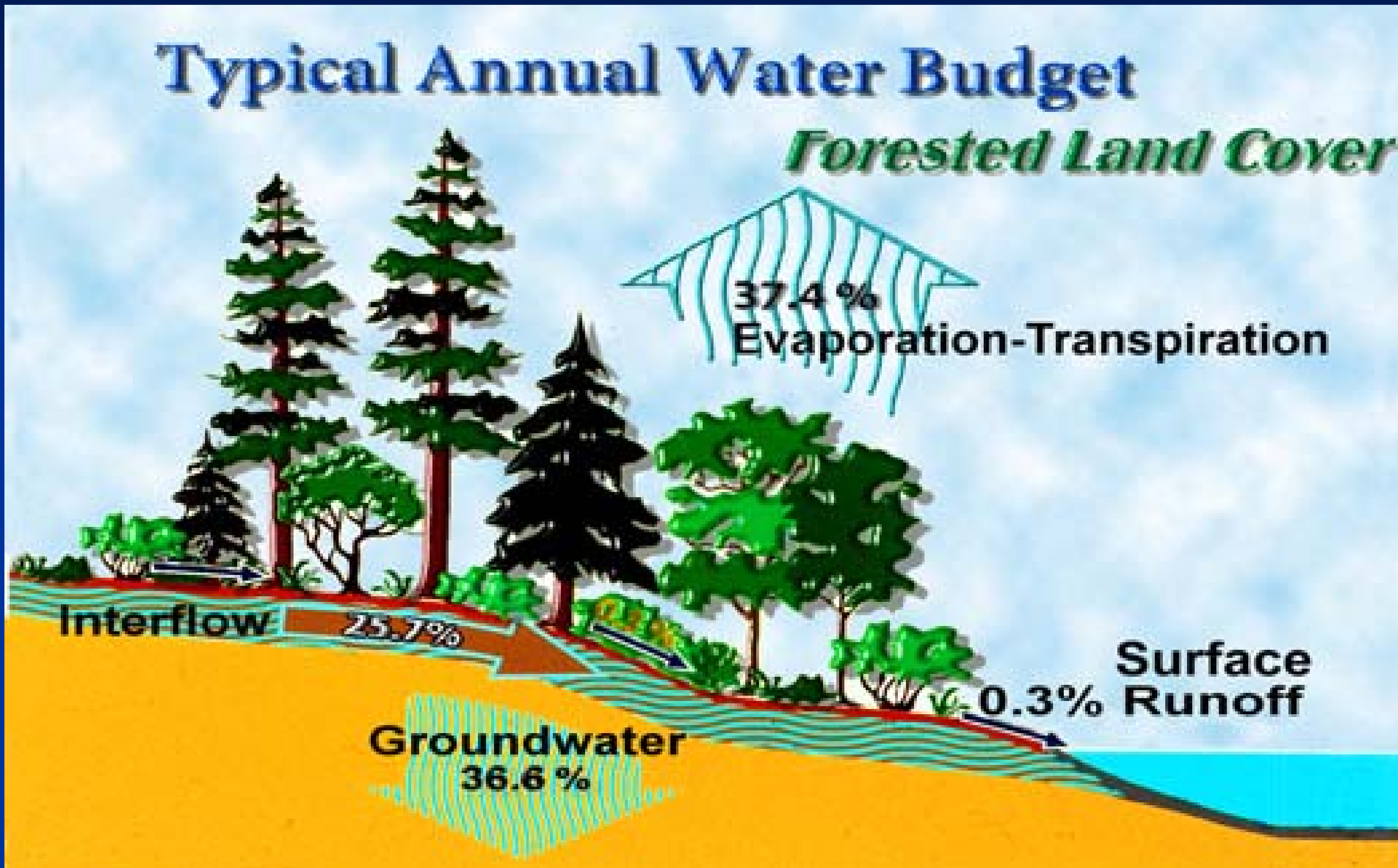
- Technology Gaps
  - Not an anti-degradation strategy
  - Allows hydrodynamic modifications
  - Allows continued stream degradation
  - Allows cumulative impacts
  - Limited use for urban retrofit
  - Unsustainable maintenance burdens

# Ecosystem Protection

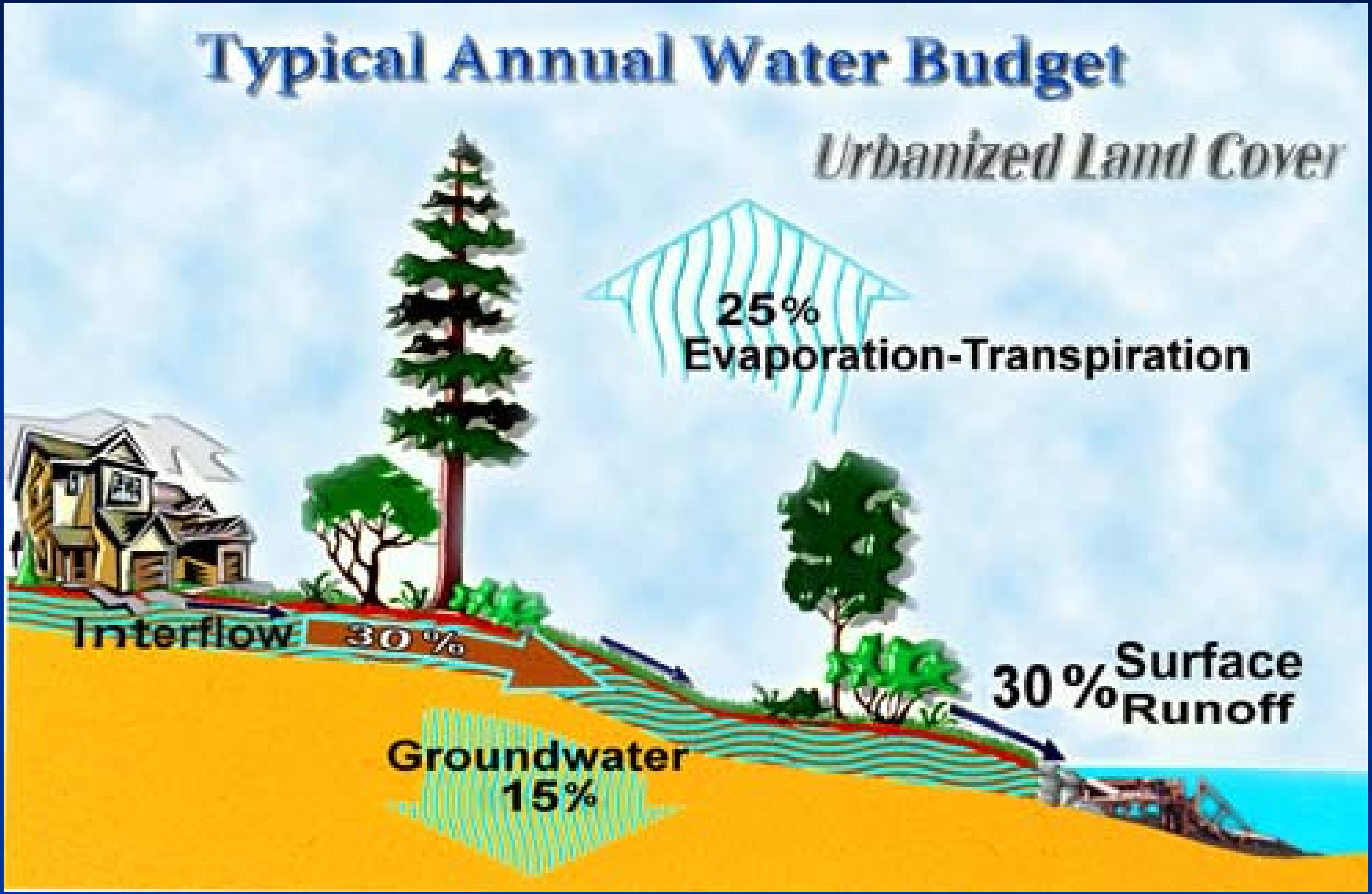
**Protecting or restoring the natural functions, structures, and species composition of an ecosystem, recognizing that all components are interrelated.** -- **U.S. Fish and Wildlife Service**

**Apply ecology, science and engineering to ensure homeostasis between the terrestrial and aquatic ecosystems for long-term sustainability.**

# *Natural Conditions*



# Developed Conditions

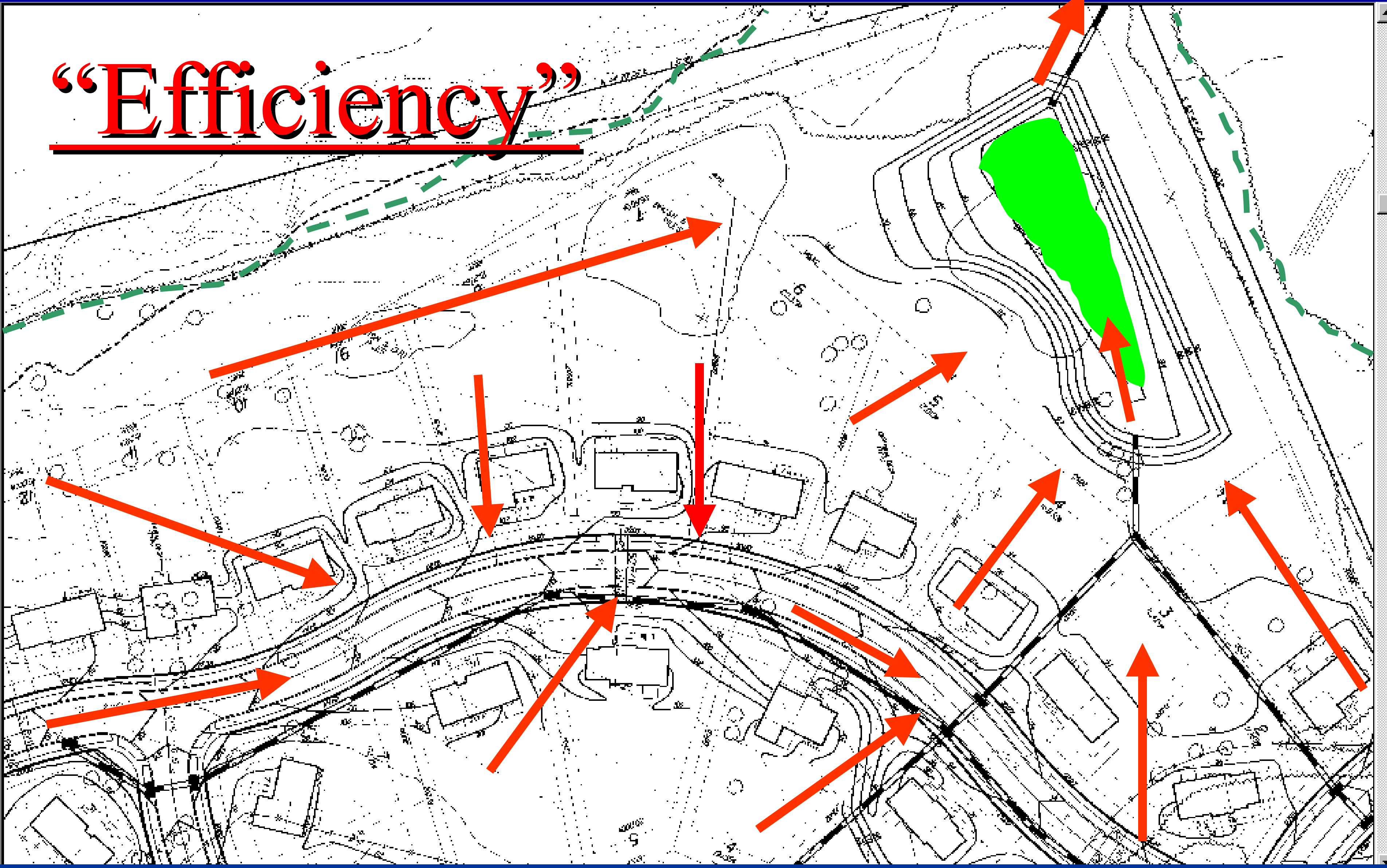



The Problem: Conventional Site Design
Collect
Concentrate
Convey
Centralized
Control
Good Drainage Paradigm

***Hydrologically Connected***

***Ecologically Dysfunctional***

# Conventional Pipe and Pond  Centralized Control



# Compacted Dysfunctiona Soils

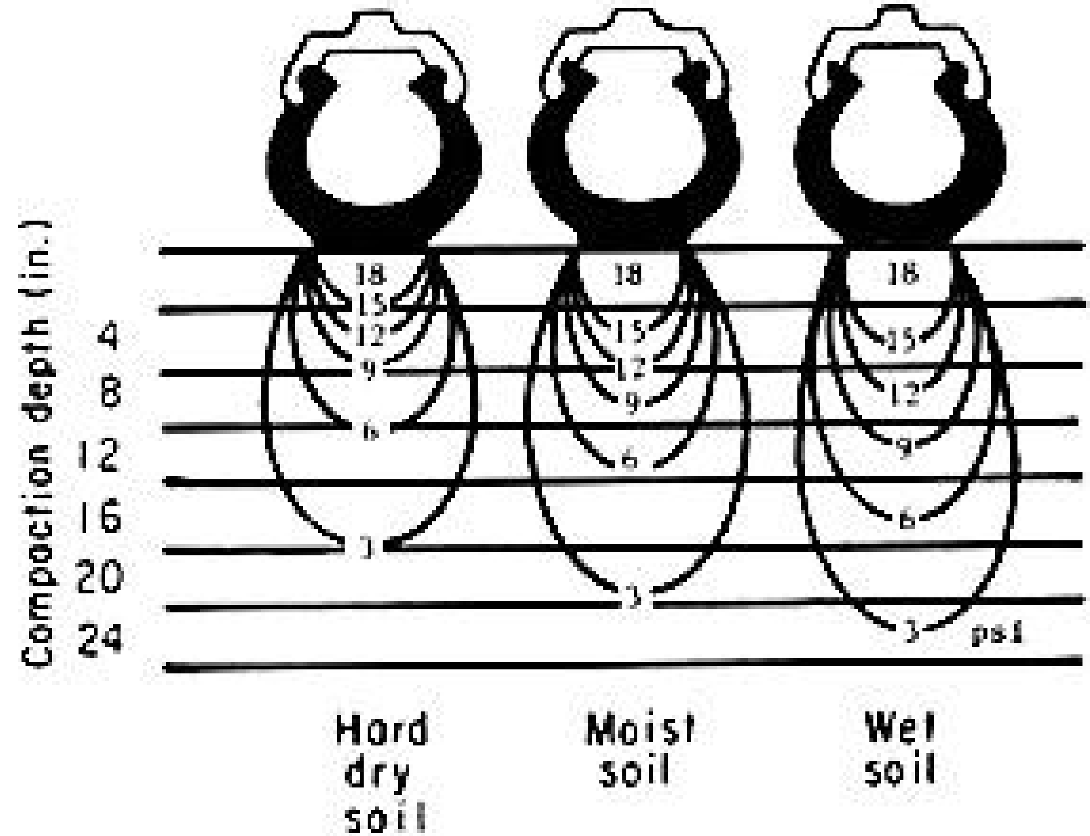
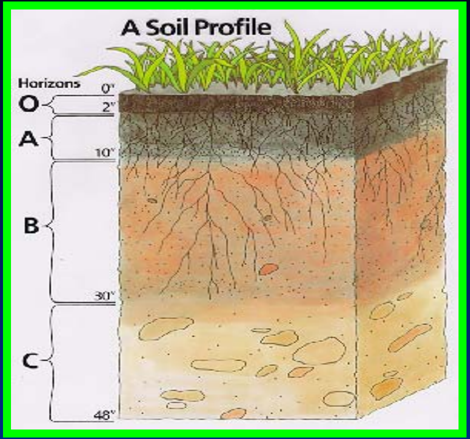



Figure 3. How soil moisture affects soil compaction. The lines in the soil under the tire represent curves of equal pressure. In all three situations the tire size was 11 x 28, the load was 1,650 pounds and the pressure 12 psi. On wet soil, pressures were transmitted to depths of more than 24 inches. (Source—Soehne, Jour. of Agr. Eng., May 1958.)

# Soil Ecosystem Functions
# Physical / Chemical / Biological




1. Hydrology

   storage / evaporation / recharge / detention

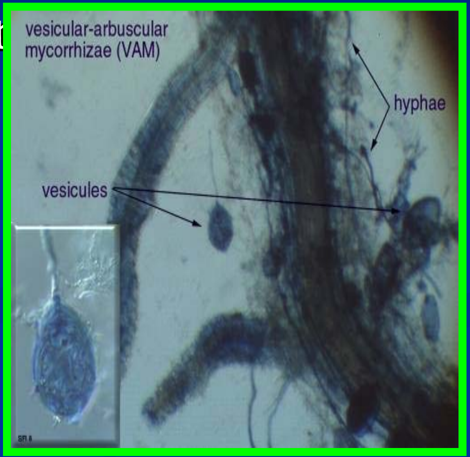
2. Storing Cycling Nutrients (bacteria / fungi)

   phosphorous / nitrogen / carbon

3. Plant Productivity (vigor)

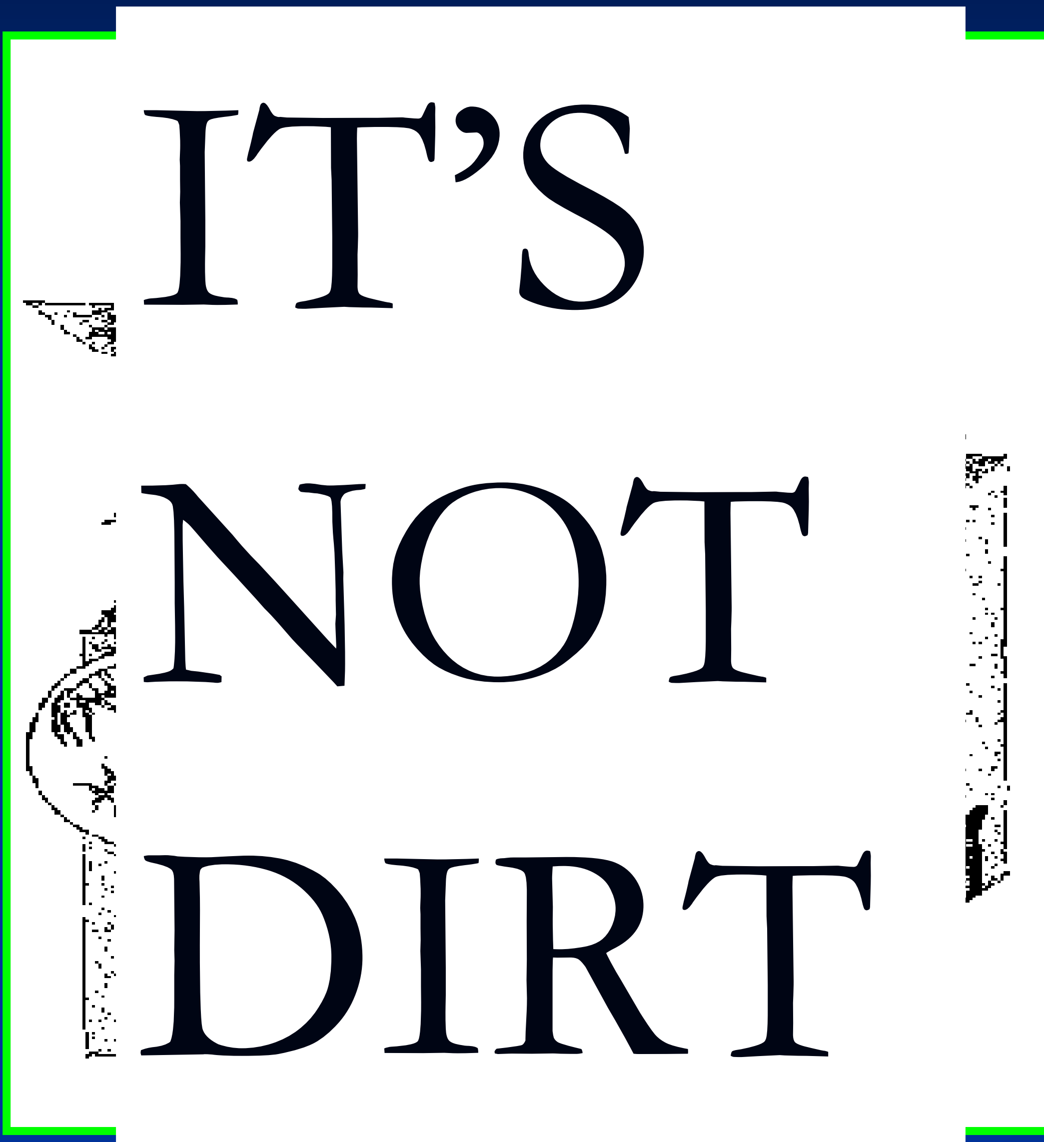
4. Water Quality

   filter / buffer / degrade / immobilize
   detoxify organic and inorganic materials




***"Most diverse ecosystem in the world"***

# Ecological Structure – It's Alive!




**Soil / Plant / Microbe Complex**

**A Dynamic Living Ecosystem Cycling Nutrients, Chemicals Water and Energy**

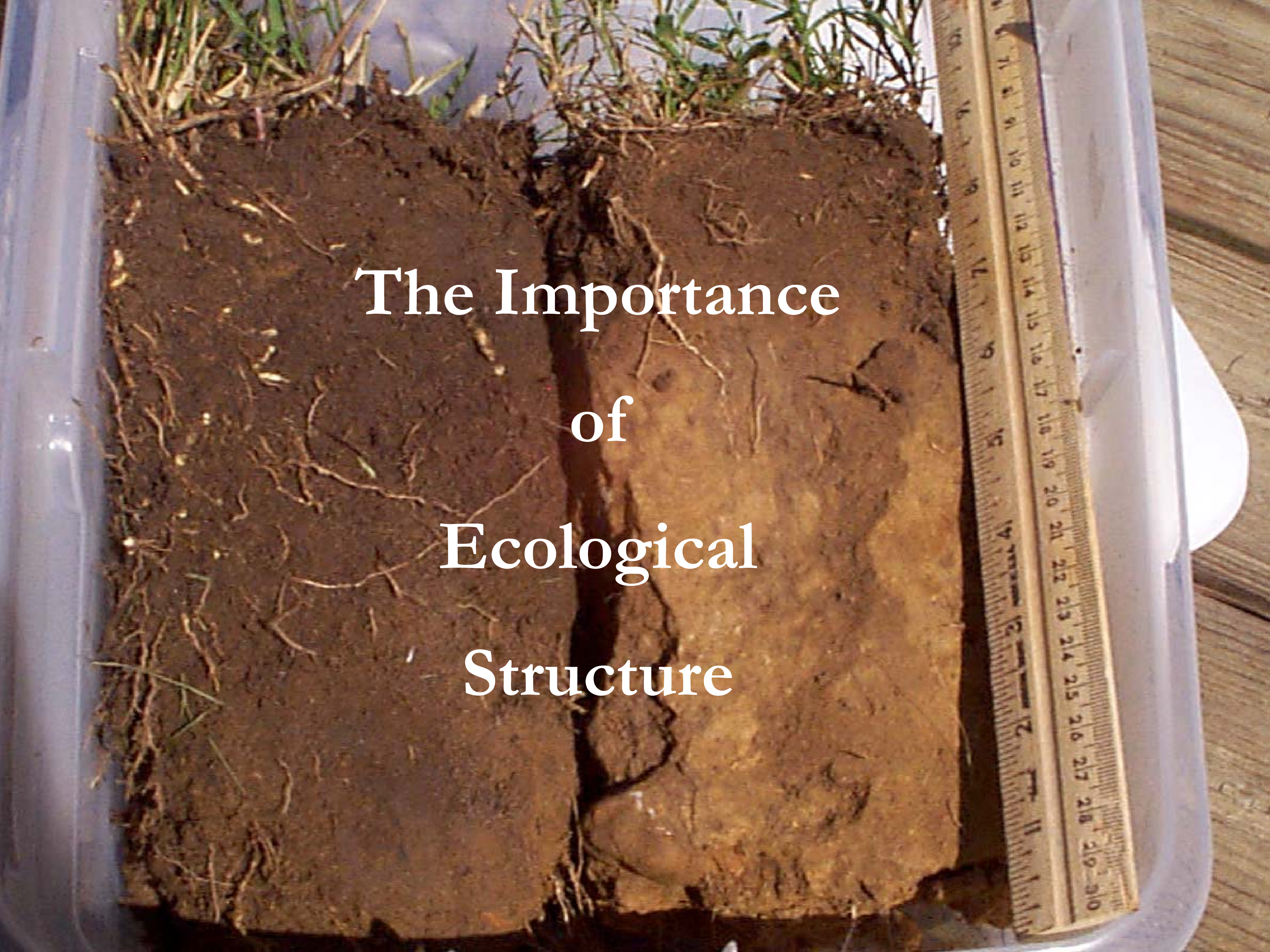
**Synergistic Relationship**

**Plants / Bacteria / Protozoa**

**Fungus / Worms* / insects /**

**Mammals**

# The Importance of Ecological Structure

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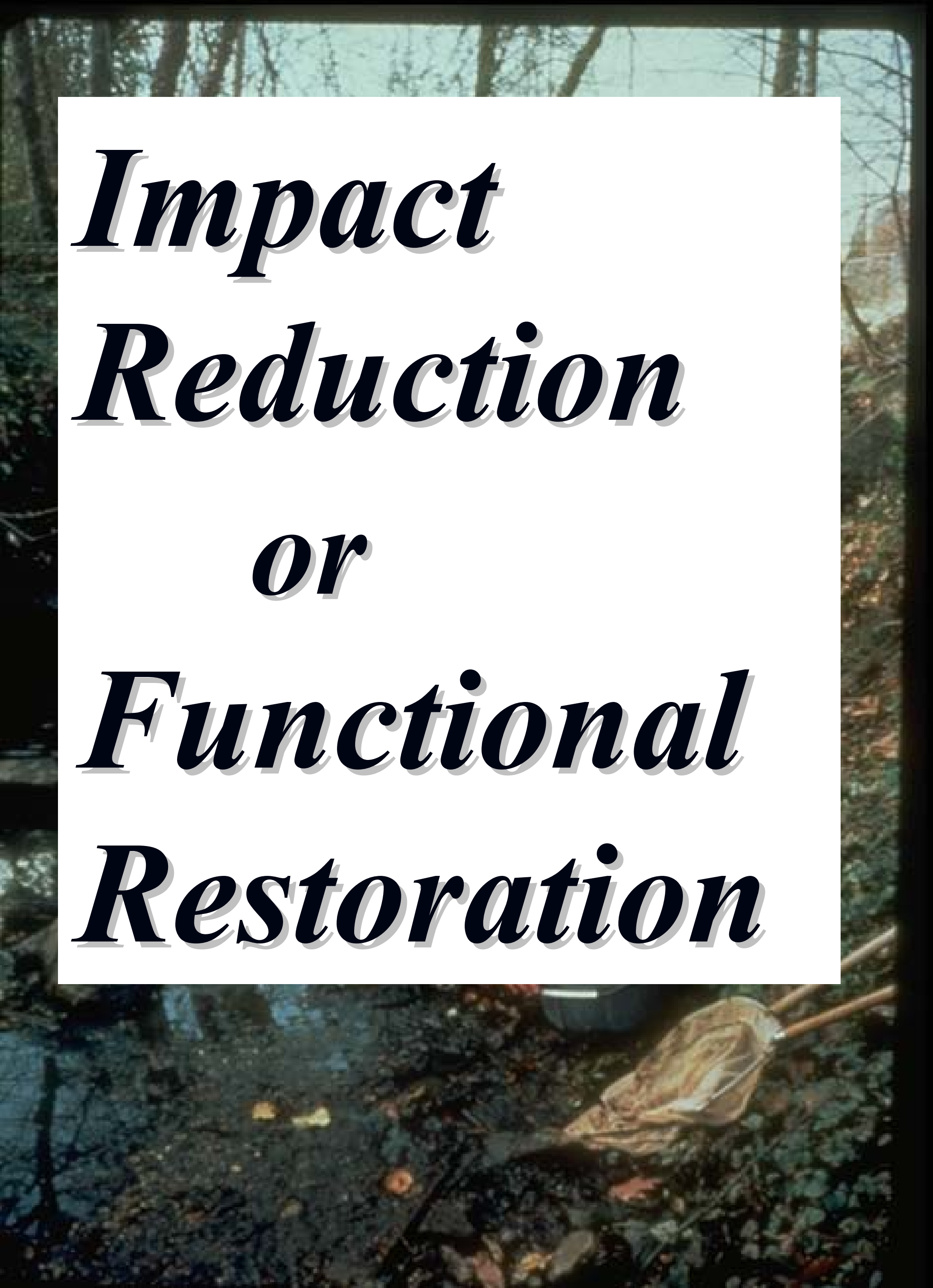



# Ecological Integrity Protection

**Species – Fauna / Flora**

**Structure – Spatial / Temp / Distribution**

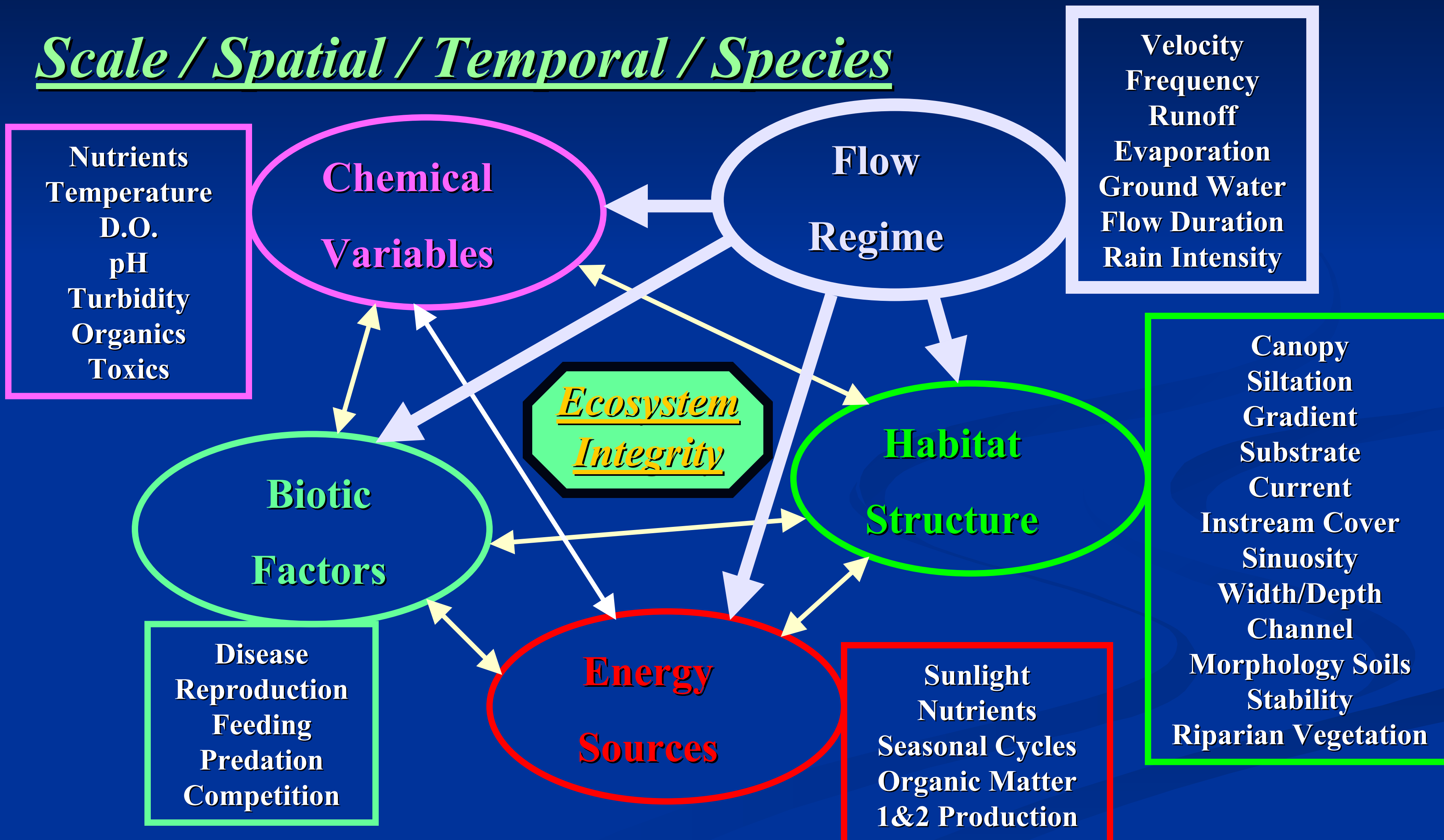
**Processes – Cycling (Energy / Nutrients)**

## Ecological Factors

1. Hydrology / Hydraulics
2. Habitat Structure
3. Water Quality
4. Energy Sources
5. Biotic Interactions

# How well do we maintain the ecological integrity (functions) of aquatic systems (small streams)?

***Scale / Spatial / Temporal / Species***



# Stressors

Habitat Availability

Temperature Regimes

Food

C

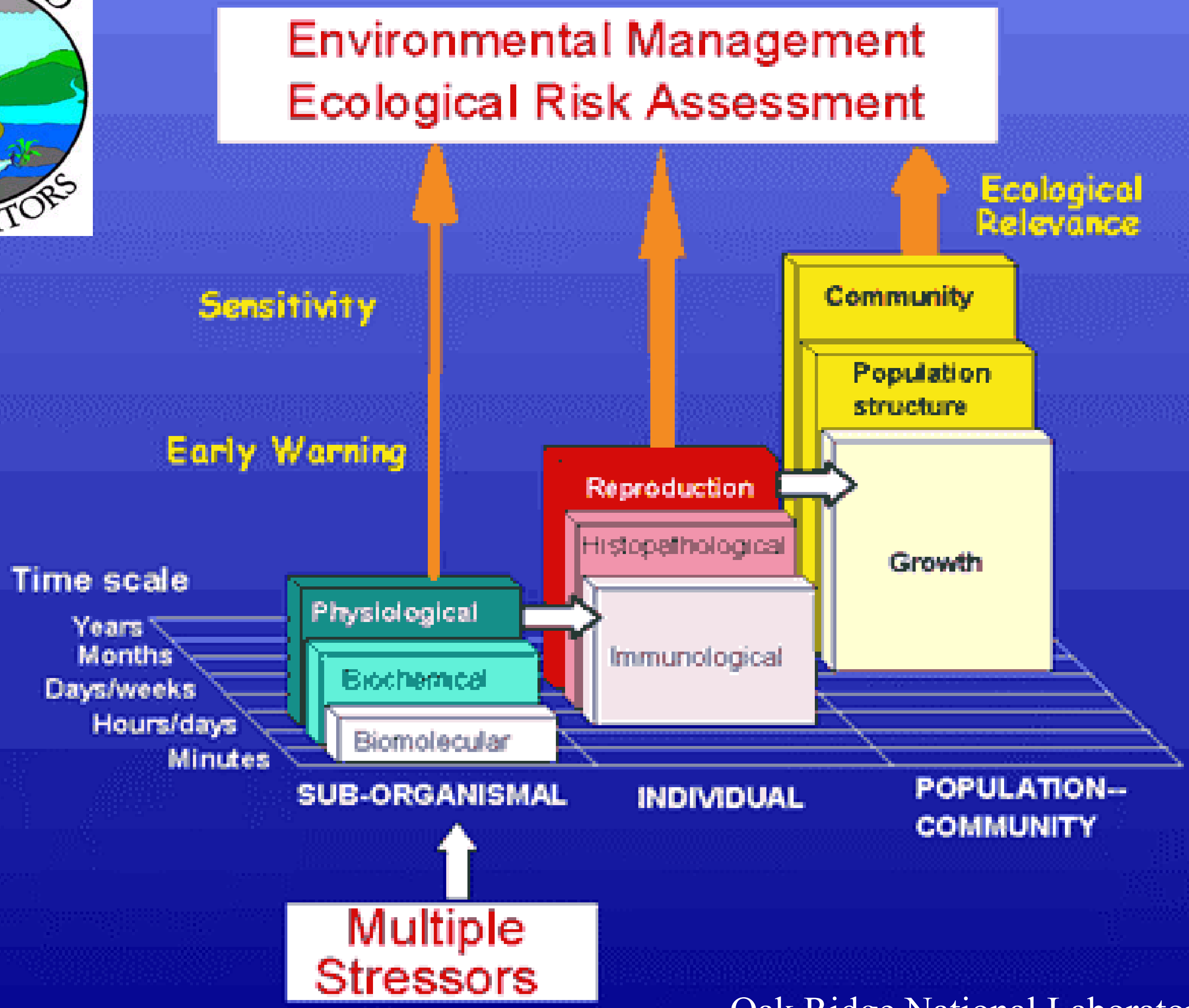
Vary
Physio
Fact

inants

# Response

Population Response

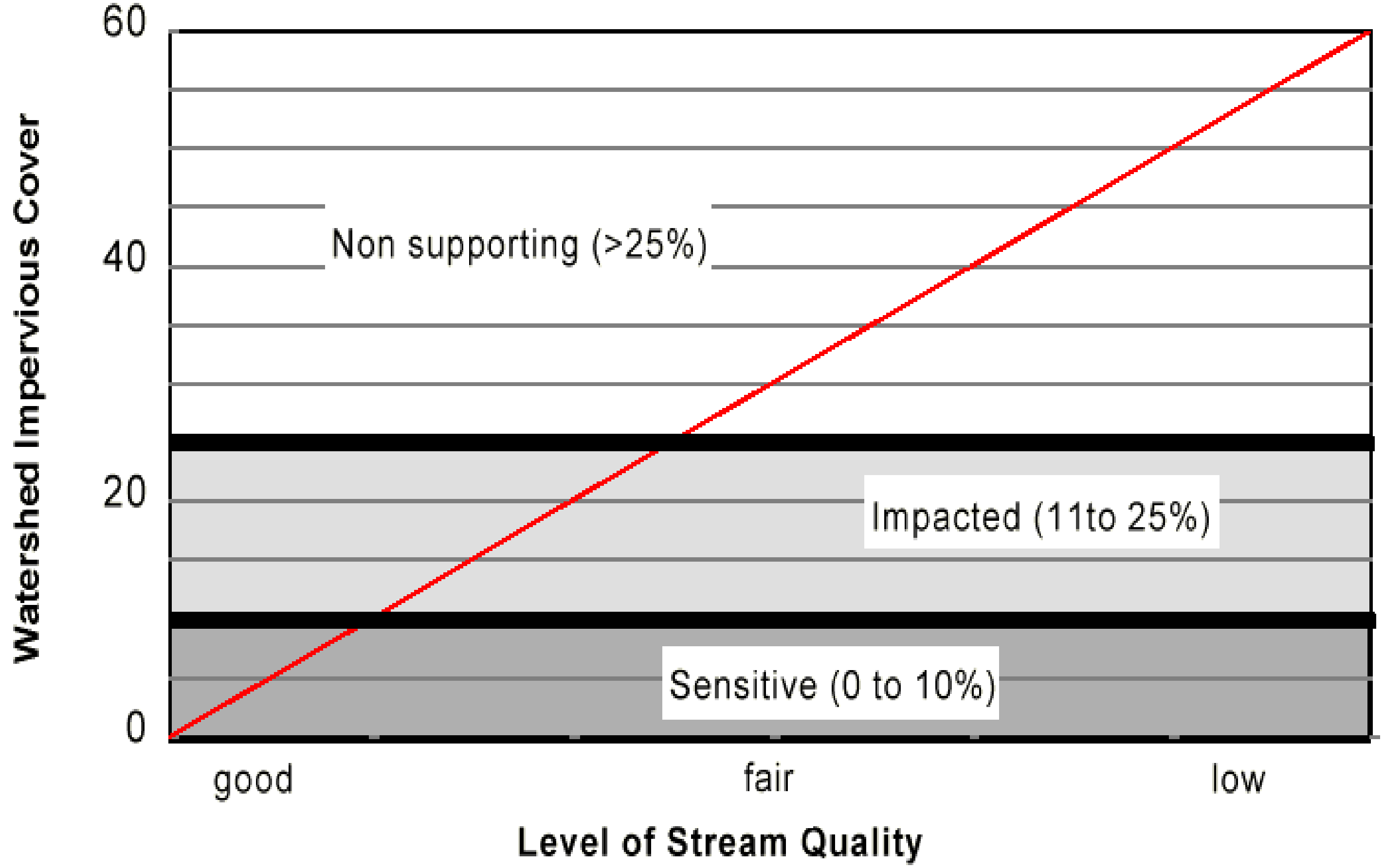
ORNL ESD BIOINDICATORS




Oak Ridge National Laboratory

# Imperviousness & Threshold Theories

## It's not so simple - very complex!

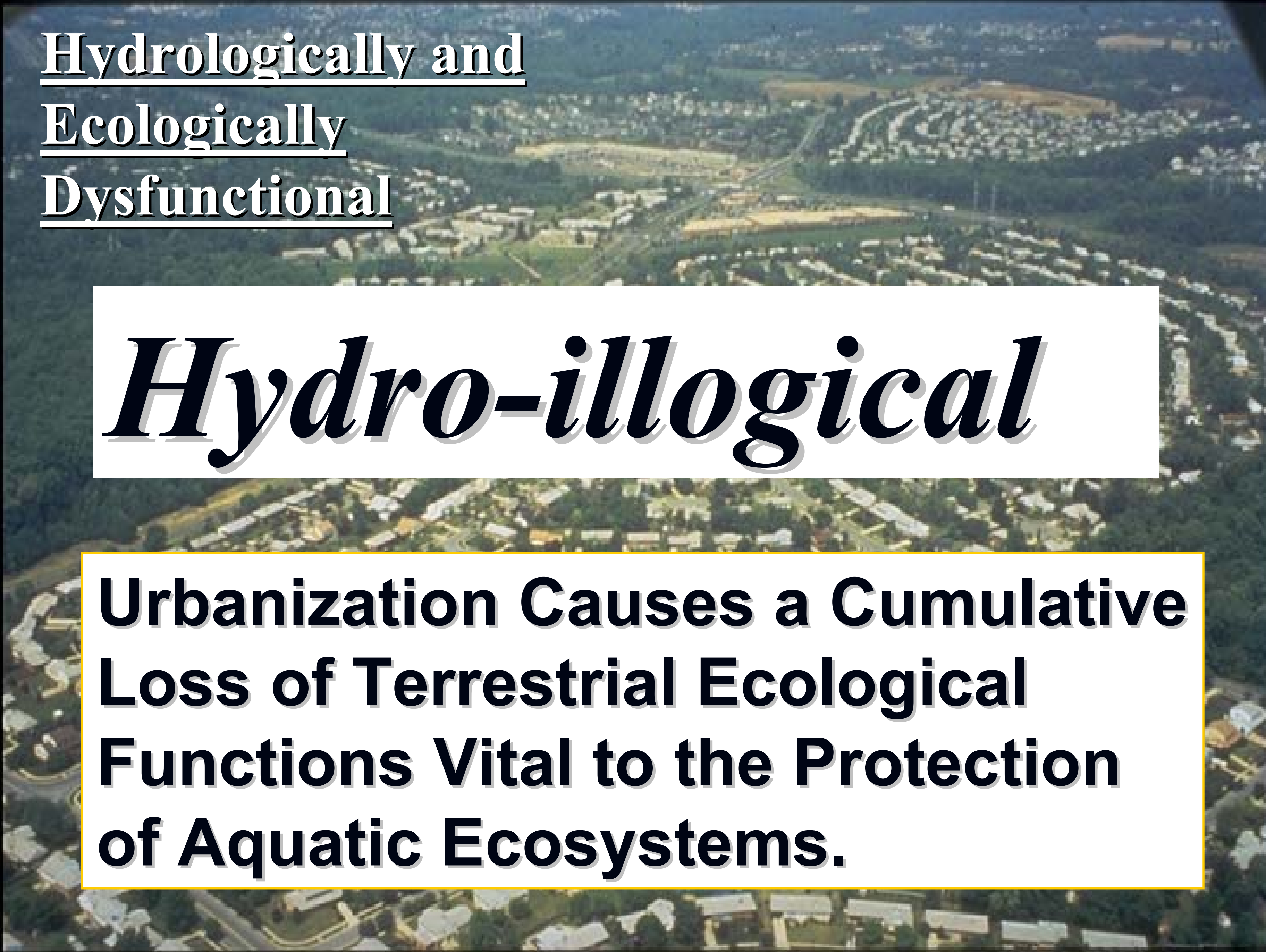



**Source: Schueler and Claytor, 1995**

**Hydrologically and Ecologically Dysfunctional**

# *Hydro-illogical*

**Urbanization Causes a Cumulative Loss of Terrestrial Ecological Functions Vital to the Protection of Aquatic Ecosystems.**



# *It's not <u>what</u> but <u>how</u> you do it!*

- Hydrologically Functional Designs
- Increasing Assimilative Capacity
- Multifunctional / Beneficial Landscape and Architecture

**<u>LID Provides Powerful New Tools to Restore Terrestrial Ecological</u>**

# “Technology can be a common ground for agreement by all parties if it does not increase costs and meets resource protection goals”

LID Technology is Supported by both the

National Association of Home Builders

and the

Natural Resources Defense Council

# How Does LID Maintain or Restore The Hydrologic Regime?

- Creative ways to:
  - Maintain / Restore Storage Volume
    - interception, depression, channel
  - Maintain / Restore Infiltration Volume
  - Maintain / Restore Evaporation Volume
  - Maintain / Restore Runoff Volume
  - Maintain Flow Paths
- Engineer a site to mimic the natural water cycle functions / relationships

# LID Basics

## Principles
## Practices
## Process

# Key LID Principles "Volume"

## "Hydrology as the Organizing Principle "

- Unique Watershed Design
  - Match Initial Abstraction Volume
  - Mimic Water Balance
- Uniform Distribution of Small-scale Controls
- Cumulative Impacts of Multiple Systems
  - filter / detain / retain / use / recharge / evaporate
- Decentralized / Disconnection
- Multifunctional Multipurpose Landscaping & Architecture
- Prevention

# Defining LID Technology

Major Components

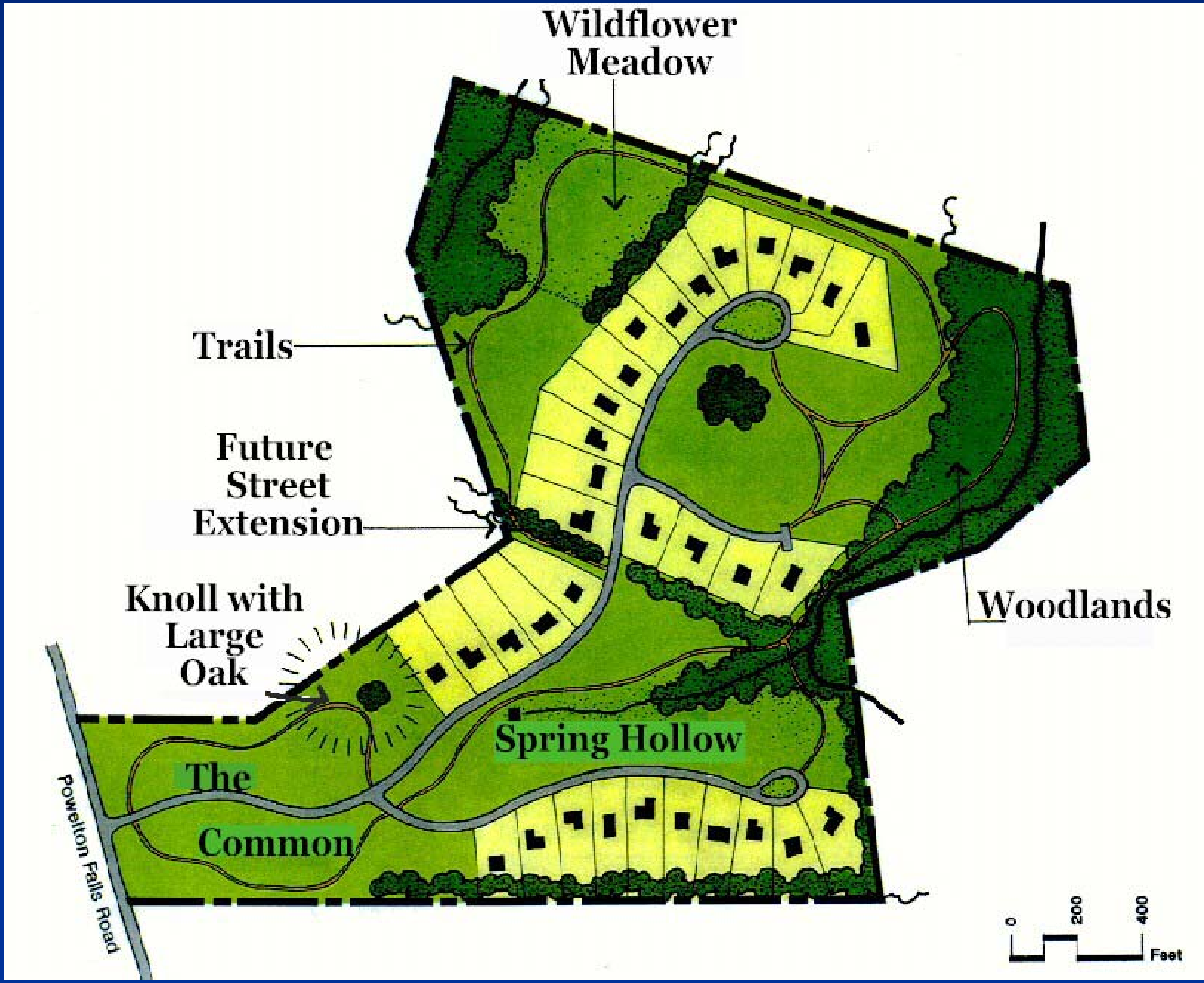
1. Conservation (Watershed and Site Level )
2. Minimization (Site Level)
3. Strategic Timing (Watershed and Site Level)
4. Integrated Management Practices (Site Level)

   Retain / Detain / Filter / Recharge / Use
5. Pollution Prevention

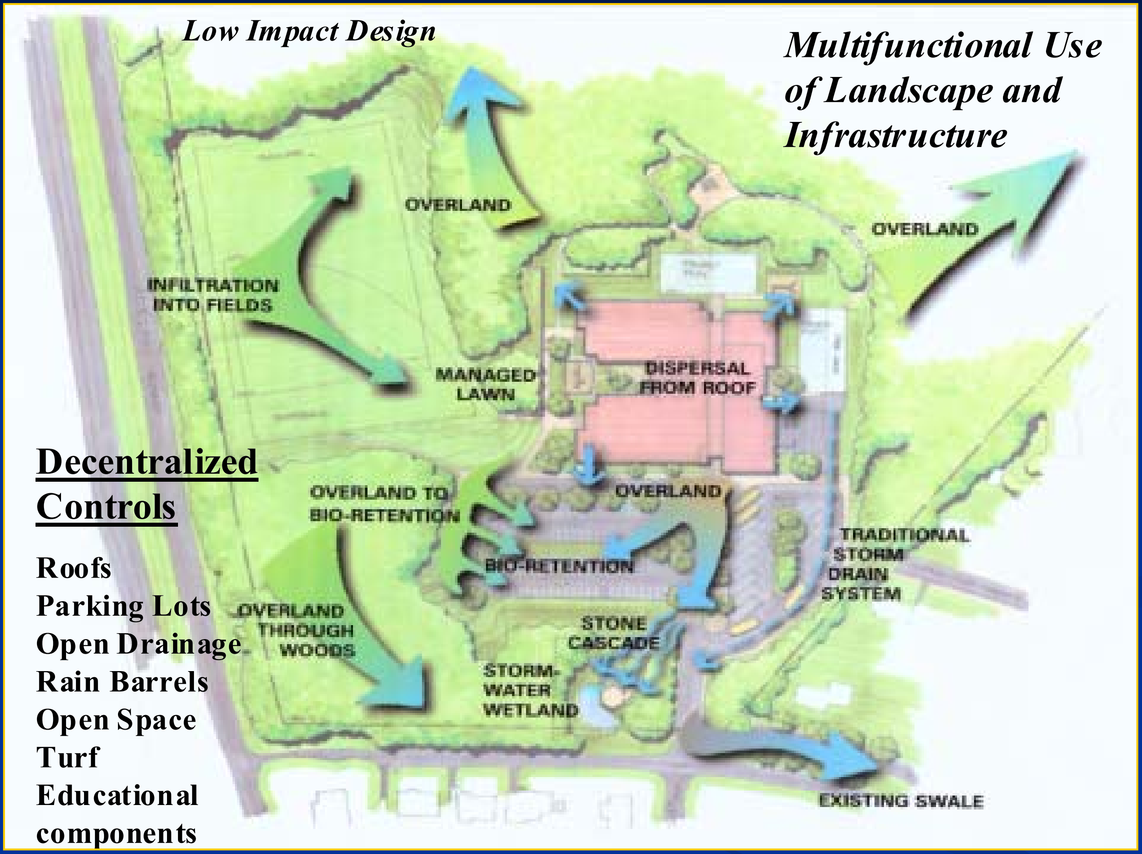
   Traditional Approaches

# 1. Conservation Plans / Regulations

- Local Watershed and Conservation Plans
  - Forest (Contiguous and Interior Habitat)
  - Streams (Corridors)
  - Soils
  - Recharge Areas
  - Wetlands
  - Habitats
  - Step Slopes
  - Buffers
  - Critical Areas
  - Parks
  - Scenic Areas
  - Trails

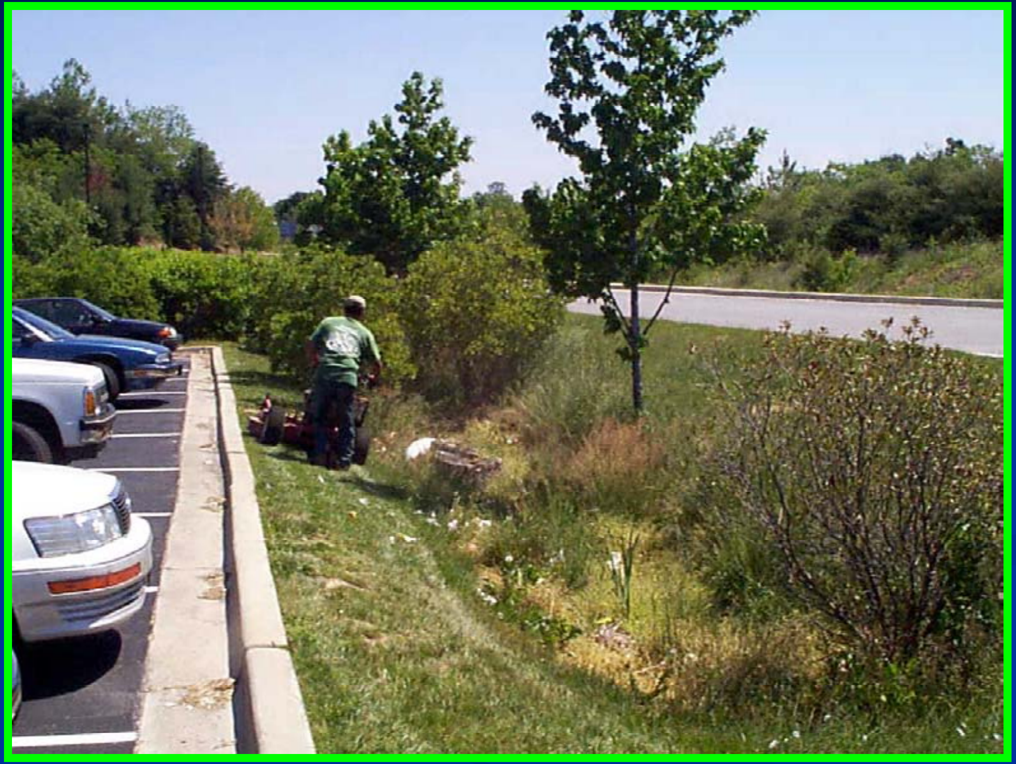


# 2. Minimize Impacts




- Minimize clearing
- Minimize grading
- Save A and B soils
- Limit lot disturbance
- Alternative Surfaces
- Reforestation
- Disconnect
- Reduce pipes, curb and gutters
- Reduce impervious surfaces

# 3. Maintain Time of Concentration



- Open Drainage
- Use green space
- Flatten slopes
- Disperse drainage
- Lengthen flow paths
- Save headwater areas
- Vegetative swales
- Maintain natural flow paths
- Increase distance from streams
- Maximize sheet flow

# 4. Storage, Detention & Filtration

# “LID IMP’s”

- Uniform Distribution of Source Controls
  - Open drainage swales
  - Rain Gardens / Bioretention
  - Smaller pipes and culverts
  - Small inlets
  - Depression storage
  - Infiltration
  - Rooftop storage
  - Pipe storage
  - Street storage
  - Rain Water Use
  - Soil Amendments*

# 5. Pollution Prevention

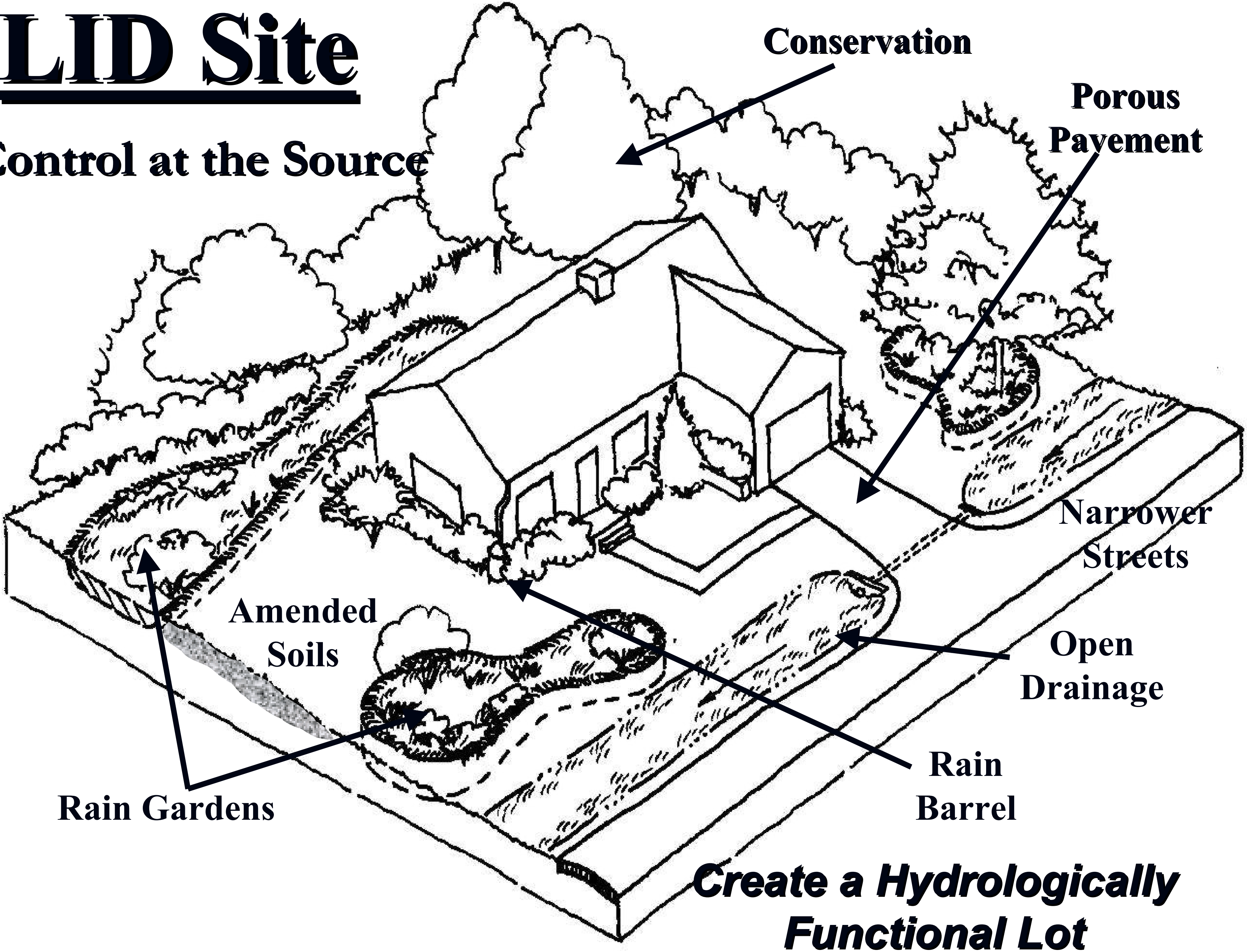
***30 - 40% Reduction in N&P***

***Kettering Demonstration Project***

- Maintenance
- Proper use, handling and disposal
  - Individuals
    - Lawn / car / hazardous wastes / reporting / recycling
  - Industry
    - Good house keeping / proper disposal / reuse / spills
  - Business
    - Alternative products / Product liability

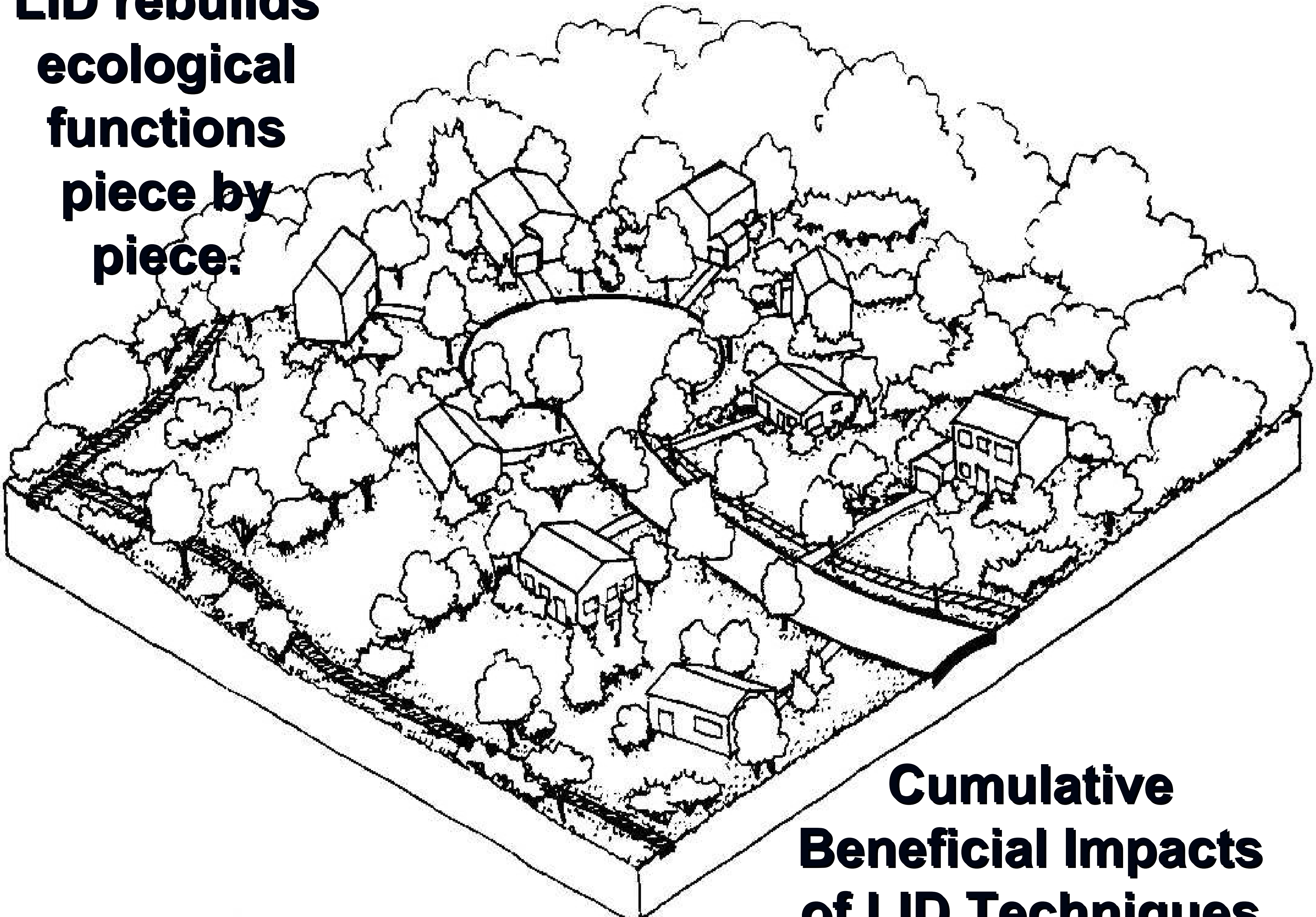
# LID Site

## Control at the Source




***Create a Hydrologically Functional Lot***

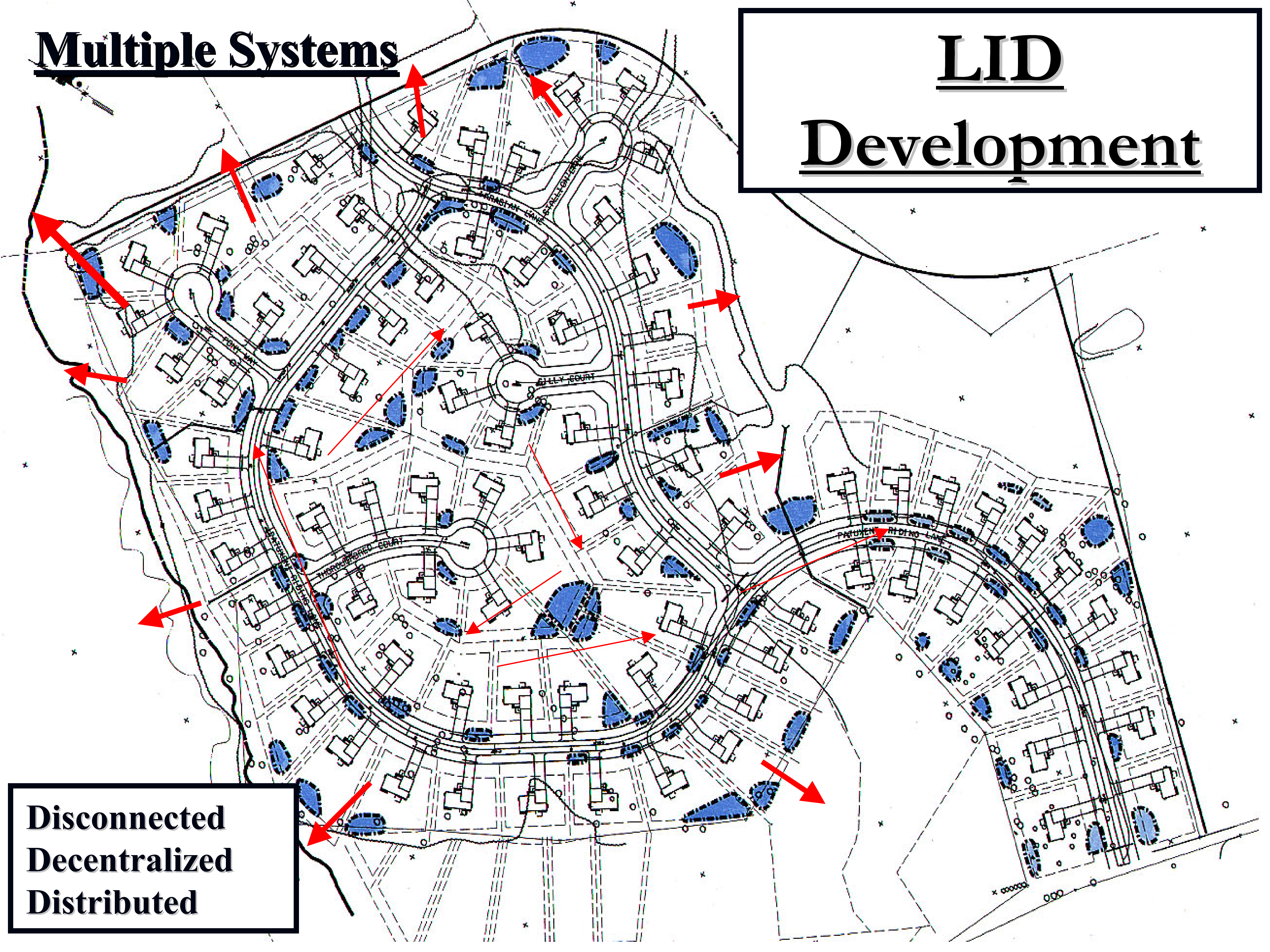
**LID rebuilds ecological functions piece by piece.**



**Cumulative Beneficial Impacts of LID Techniques**

# LID Development

## Multiple Systems

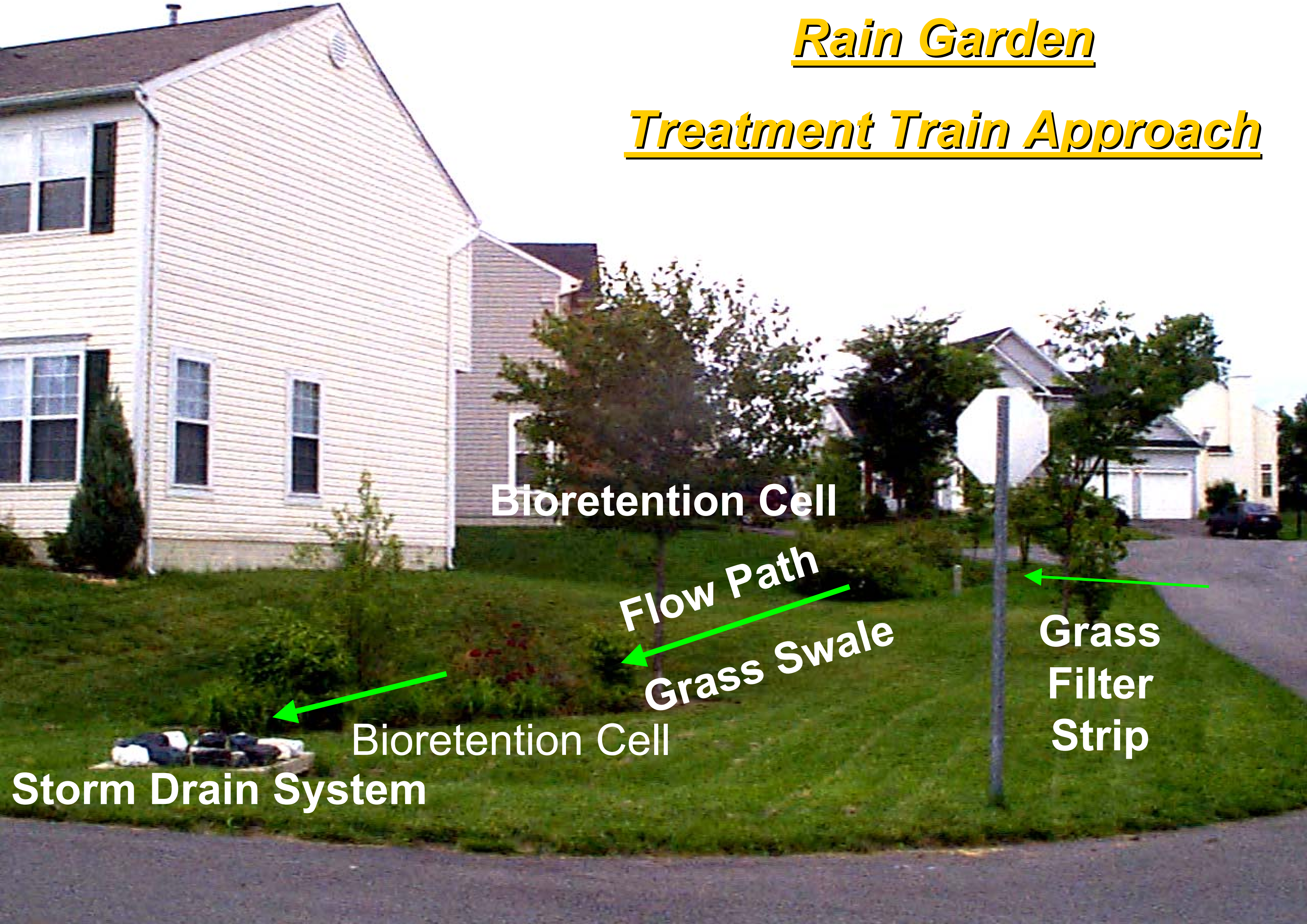



**Disconnected**
**Decentralized**
**Distributed**


Rain Gardens
Typical Landscape Maintenance Practices

# Rain Garden

## Treatment Train Approach



# VIEW OF LOT WITH STORAGE AND BIORETENTION


SOLOMONS
LANDING

# Rain is Resource

## Capture & Use

- Toilet Flushing
- Car washing
- Irrigation
- Mixing / Washing
- Gardening
- Recharge

## Benefits

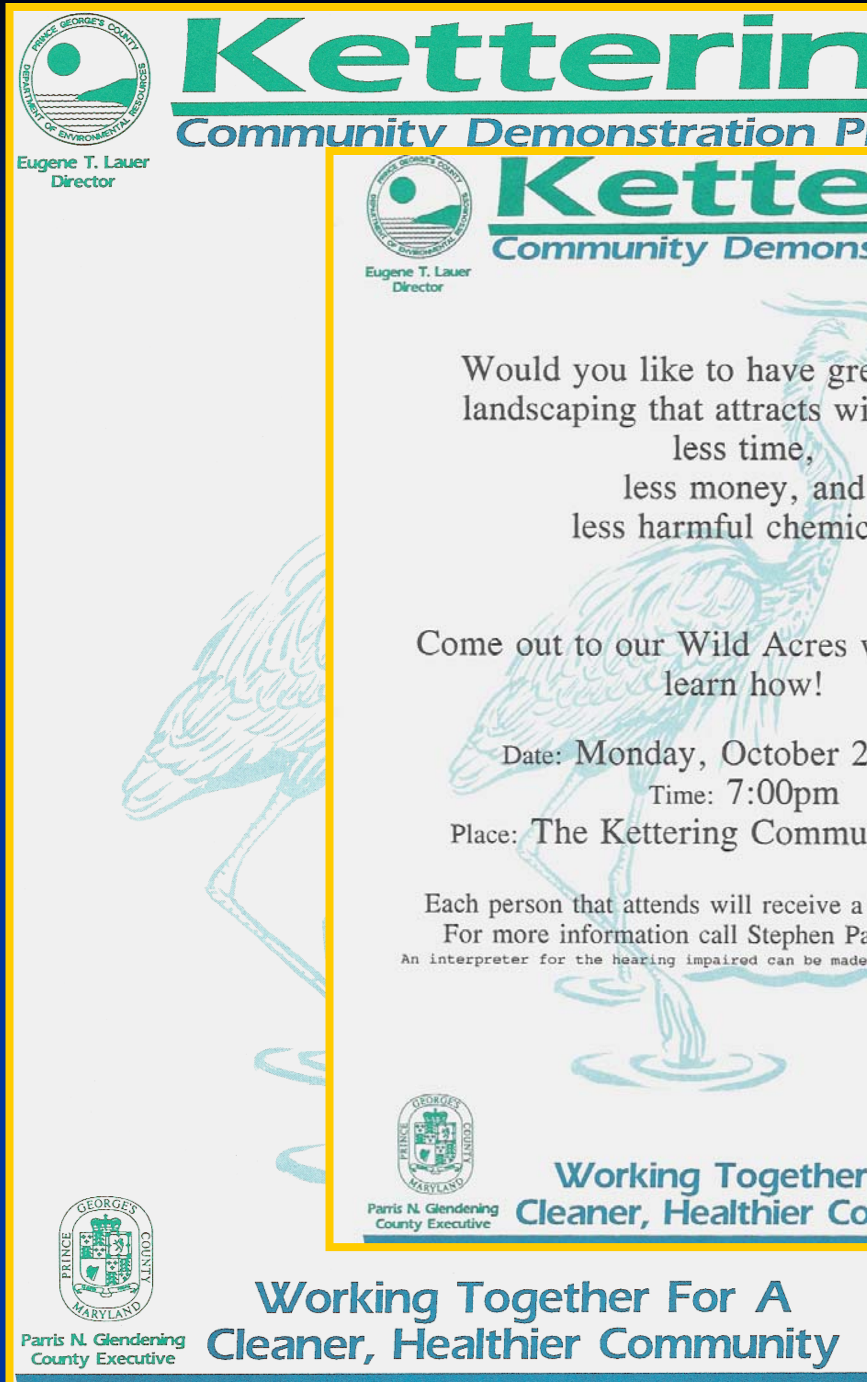
- Reduce Demand
- Self-sufficiency
- Save Money


Caring For Your Car Without Harming The Environment
ANTI-FREEZE
OIL
Rain Gardens
THE NATURAL SOLUTION
Green Lawns
The Smart Way
pollution prevention
it's everyone's business


ANTIFREEZE


LITTER


Corbis.com




# Did You Know:

Kettering residents discharge approximately 1,277 quarts of detergents each year to the local stream from car washing alone?

Approximately 2,533 quarts of oil are disposed of improperly in Kettering each year and have the potential to contaminate the stream?

Approximately 2,992 quarts of antifreeze are drained onto the streets of Kettering where it then runs directly into the stream?

Approximately 23,643 pounds of nitrogen have the potential of being washed off of Kettering lawns each year from fertilizer applications?

Approximately 80% of Kettering residents apply some form of chemical pesticides to their yards each year?

When our environmental education program began last summer, 58% of Kettering residents did not know that neighborhoods like Kettering cause water pollution?

The stream that flows through the eastern part of Kettering into the Northeast Branch is so polluted that it can support almost no aquatic life?

# LID Practices (No Limit!)

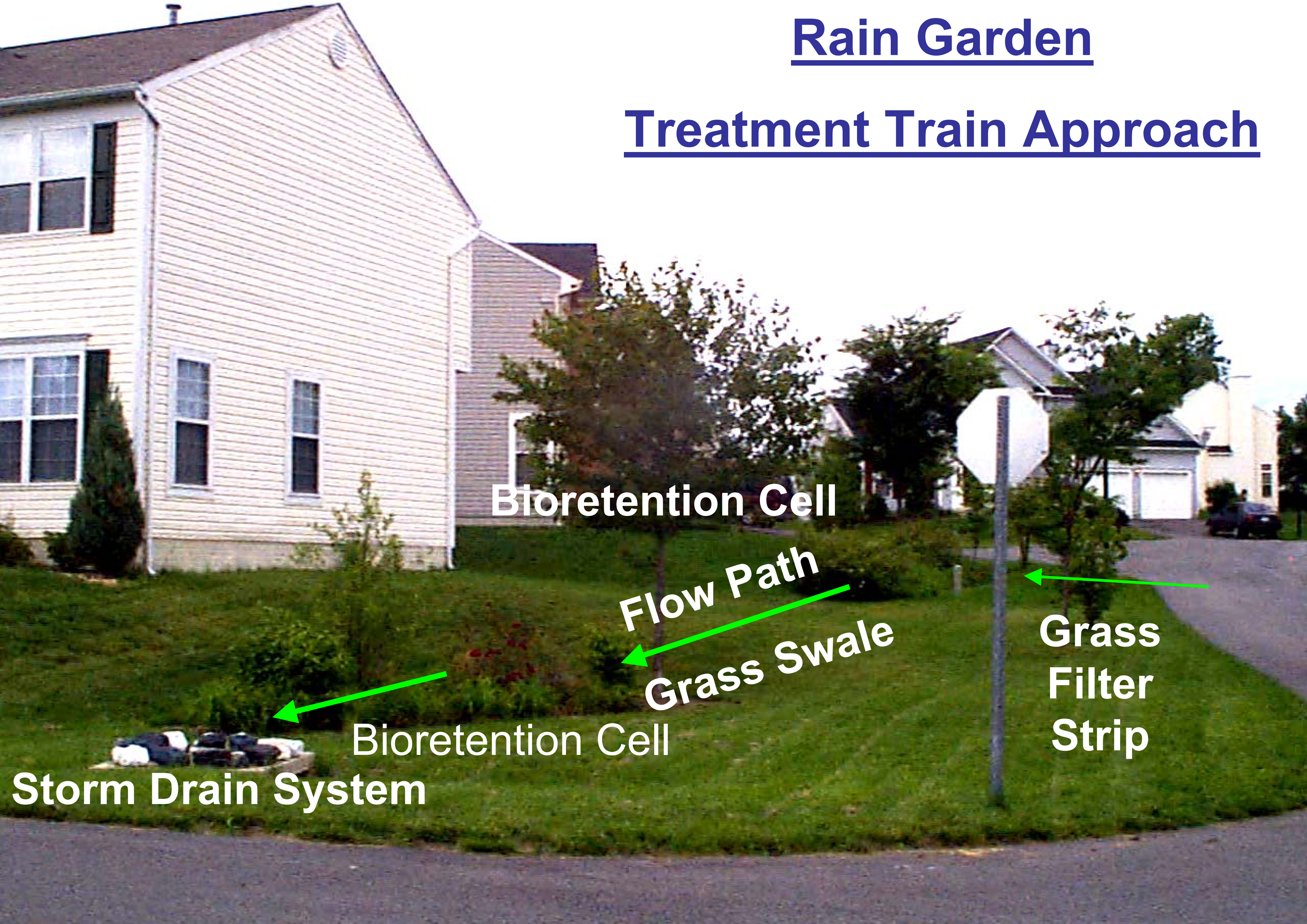
"Creative Techniques to Treat,Use, Store, Retain, Detain and Recharge"

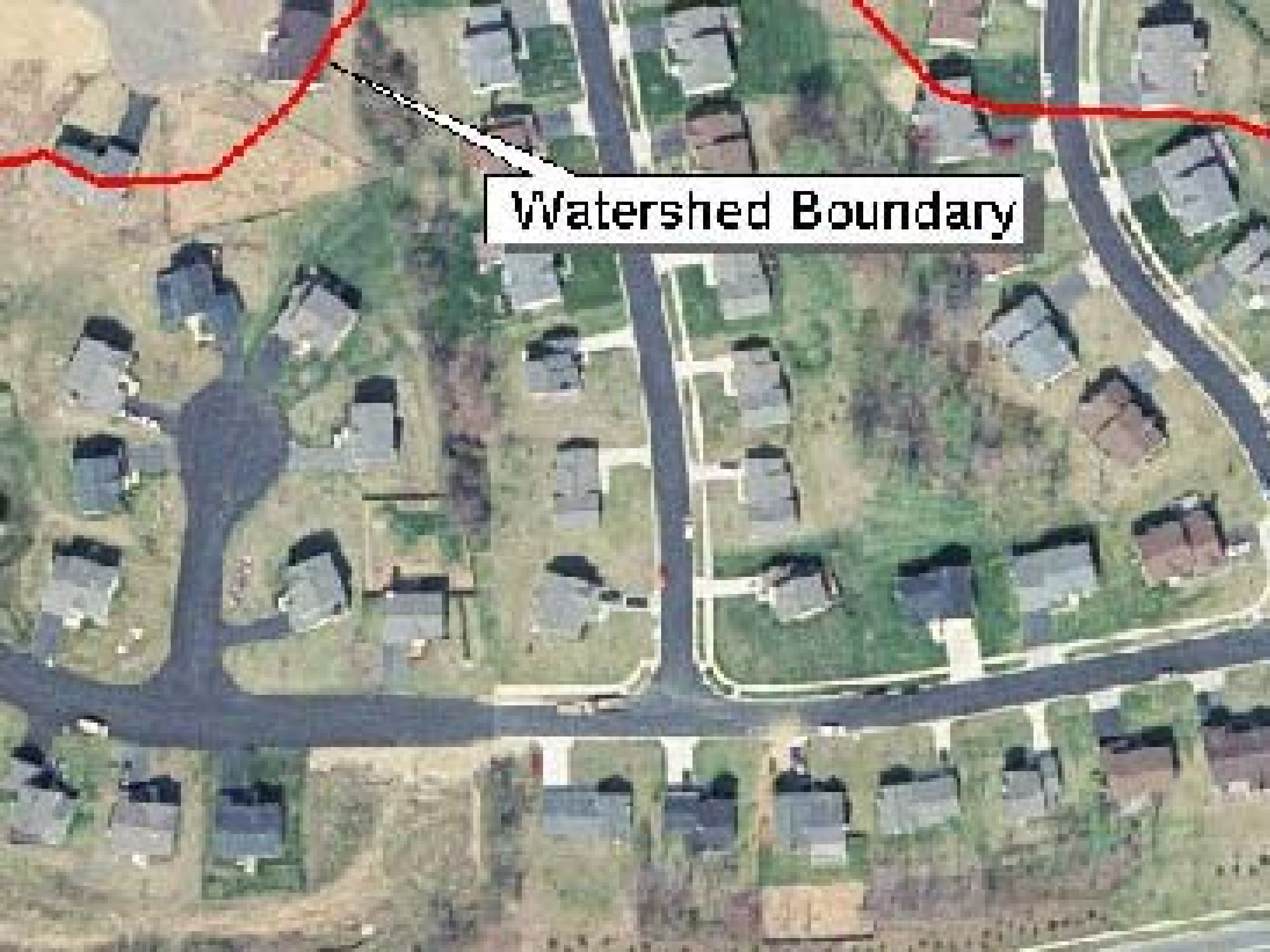
- Bioretention / Rain Gardens*
- Strategic Grading*
- Site Finger Printing
- Conservation*
- Flatter Wider Swales
- Amended Soils*
- Long Flow Paths
- Tree / Shrub Depression
- Turf Depression
- Landscape Island Storage
- Rooftop Detention /Retention
- Disconnection*
- Parking Lot / Street Storage
- Smaller Culverts, Pipes & Inlets
- Alternative Surfaces
- Reduce Impervious Surface
- Surface Roughness Technology
- Rain Barrels / Cisterns / Water Use*
- Catch Basins / Seepage Pits
- Sidewalk Storage
- Vegetative Swales, Buffers & Strips*
- Infiltration Swales & Trenches
- Eliminate Curb and Gutter
- Shoulder Vegetation
- Maximize Sheet flow
- Maintain Drainage Patterns
- Reforestation………………..
- Pollution Prevention…………..

# Rain Gardens

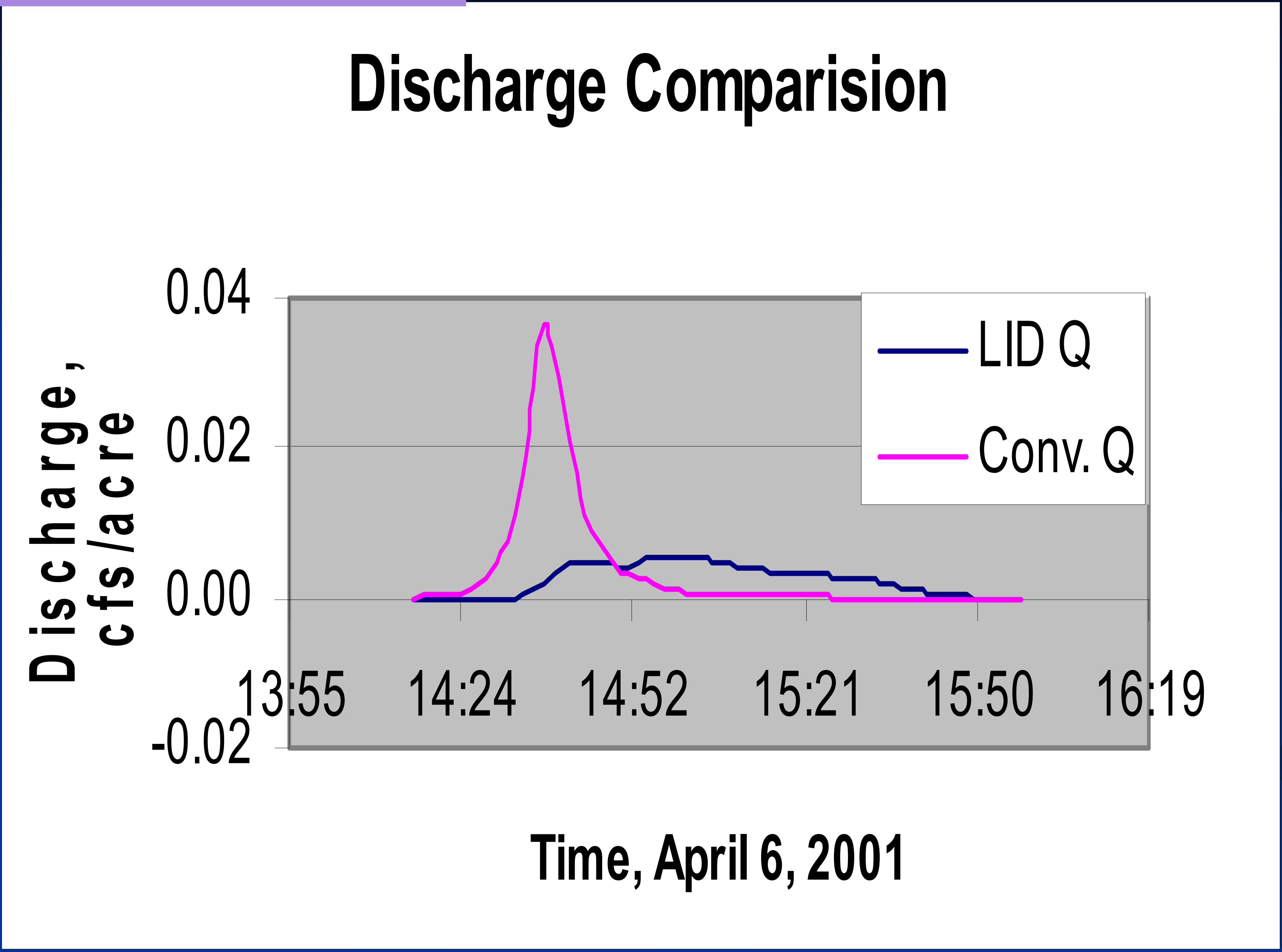
# Rain Garden

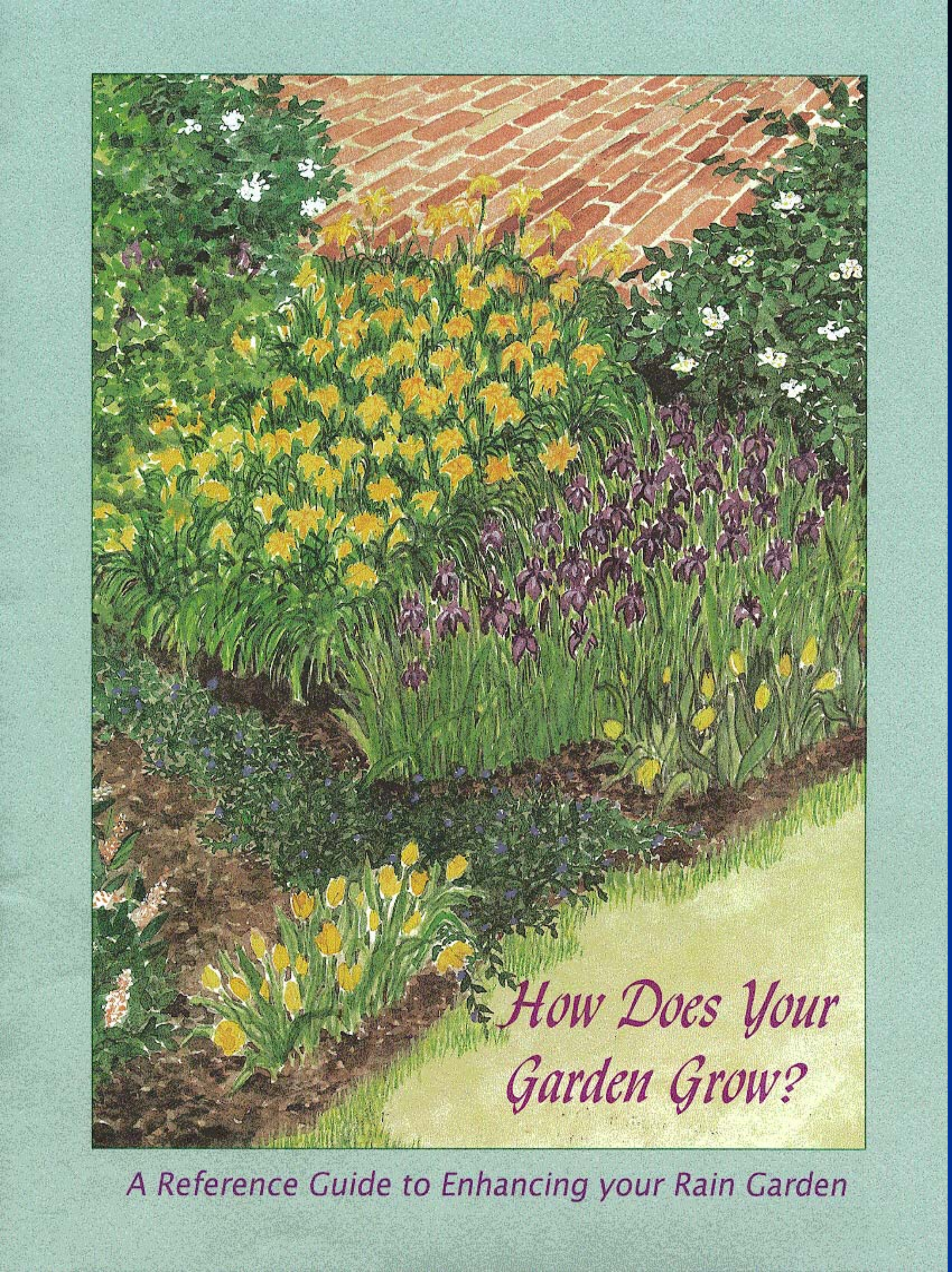
## Treatment Train Approach




Watershed Boundary

# Monitoring Results






**Education**

**Participation**

**Property Values**

Maintenance

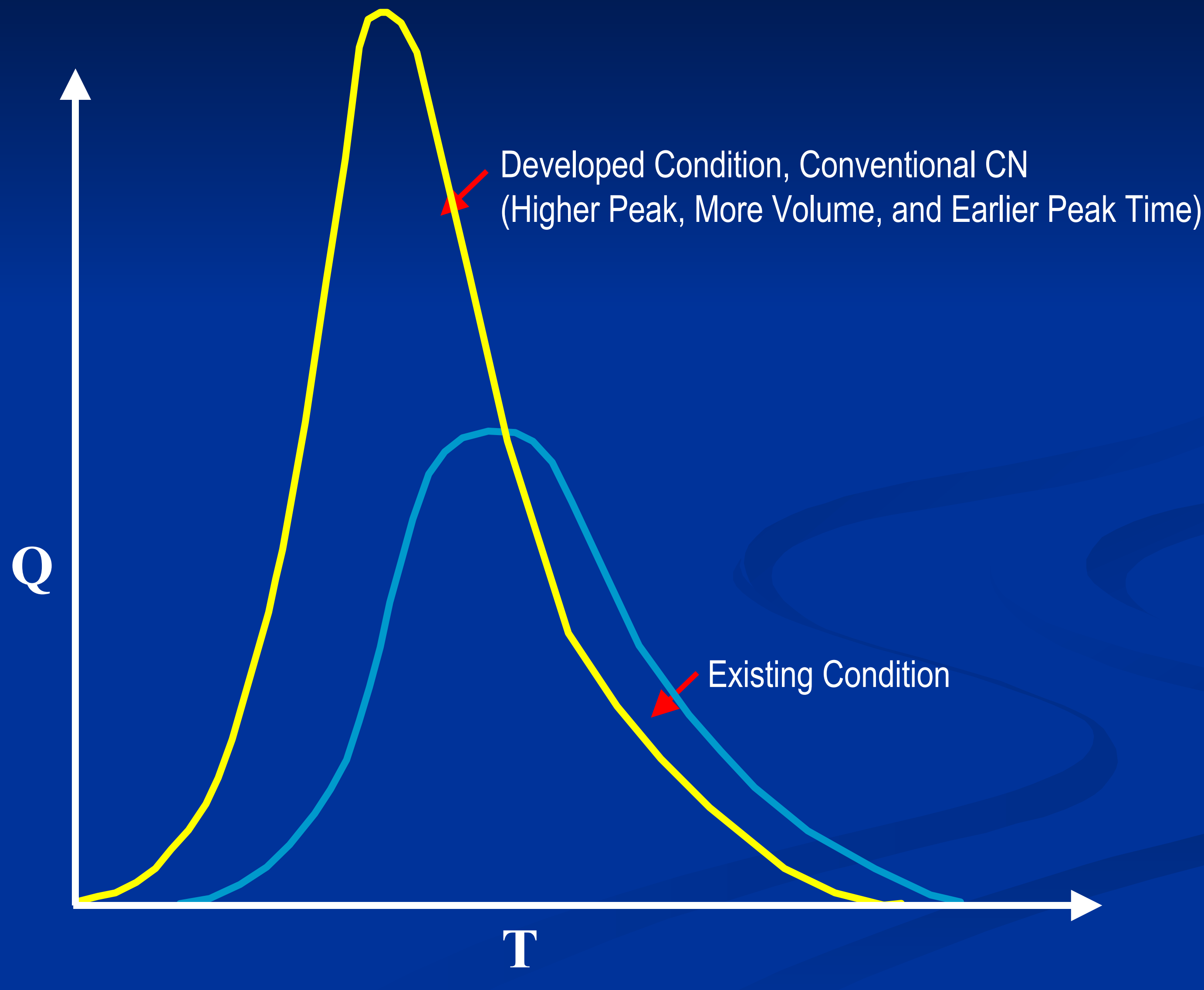
# Construction Cost Comparison

| | Conventional | Low Impact |
|---|---:|---:|
| Grading/Roads | **$569,698** | **$426,575** |
| Storm Drains | **$225,721** | **$132,558** |
| SWM Pond/Fees | **$260,858** | **$ 10,530** |
| Bioretention/Micro | — | **$175,000** |
| Total | $1,086,277 | $744,663 |
| Unit Cost | $14,679 | $9,193 |
| Lot Yield | 74 | 81 |

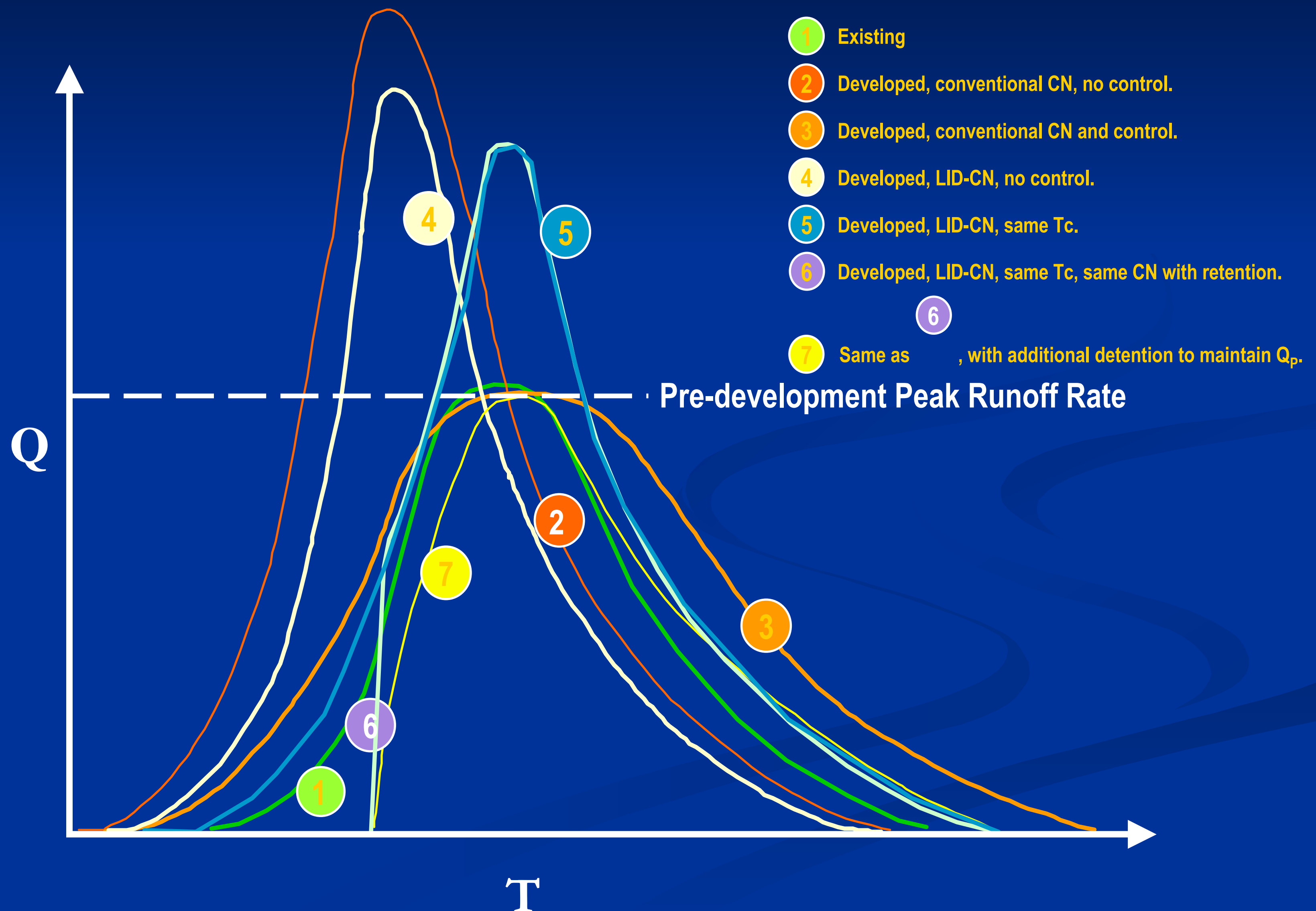
# Low-Impact Development Hydrologic Analysis and Design

- Based on NRCS technology, can be applied nationally
- Analysis components use same methods as NRCS
- Designed to meet both storm water quality and quantity requirements

# Hydrograpgh Pre/ Post Development



# Hydrographs Summary



# LID Techniques and Objectives

Low-Impact Development Technique

| Low Impact Development Objective | Flatten Slope | Increase Flow Path | Increase Sheet Flow | Increase Roughness | Minimize Disturbance | Larger Swales | Flatten Slopes on Swales | Infiltration Swales | Vegetative Filter Strips | Constricted Pipes | Disconnected Impervious Areas | Reduce Curb and Gutter | Rain Barrels | Rooftop Storage | Bioretention | Re-Vegetation | Vegetation Preservation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Increase Time of Concentration** | X | X | X | X | | | | | X | X | X | X | X | X | X | | |
| **Increase Detention Time** | | | | | | | X | | | X | | | X | X | | | |
| **Increase Storage** | | | | | | X | | X | X | | | | | | X | X | X |
| **Lower Post Development CN** | | | | | X | | | | | | X | | | | X | X | X |

# Summary of LID Techniques

(1) Recalculate Postdevelopment CN based on LID land use and impervious surface disconnection.

(2) Increase Travel Time (TT) using LID techniques to achieve the same Tc as Existing conditions.

(3) Retention: Provide permanent storage (Infiltration/Retention) using LID techniques to maintain the CN and runoff volume of existing conditions.

(4) Detention: Provide additional detention storage to maintain the same peak discharge as existing conditions.