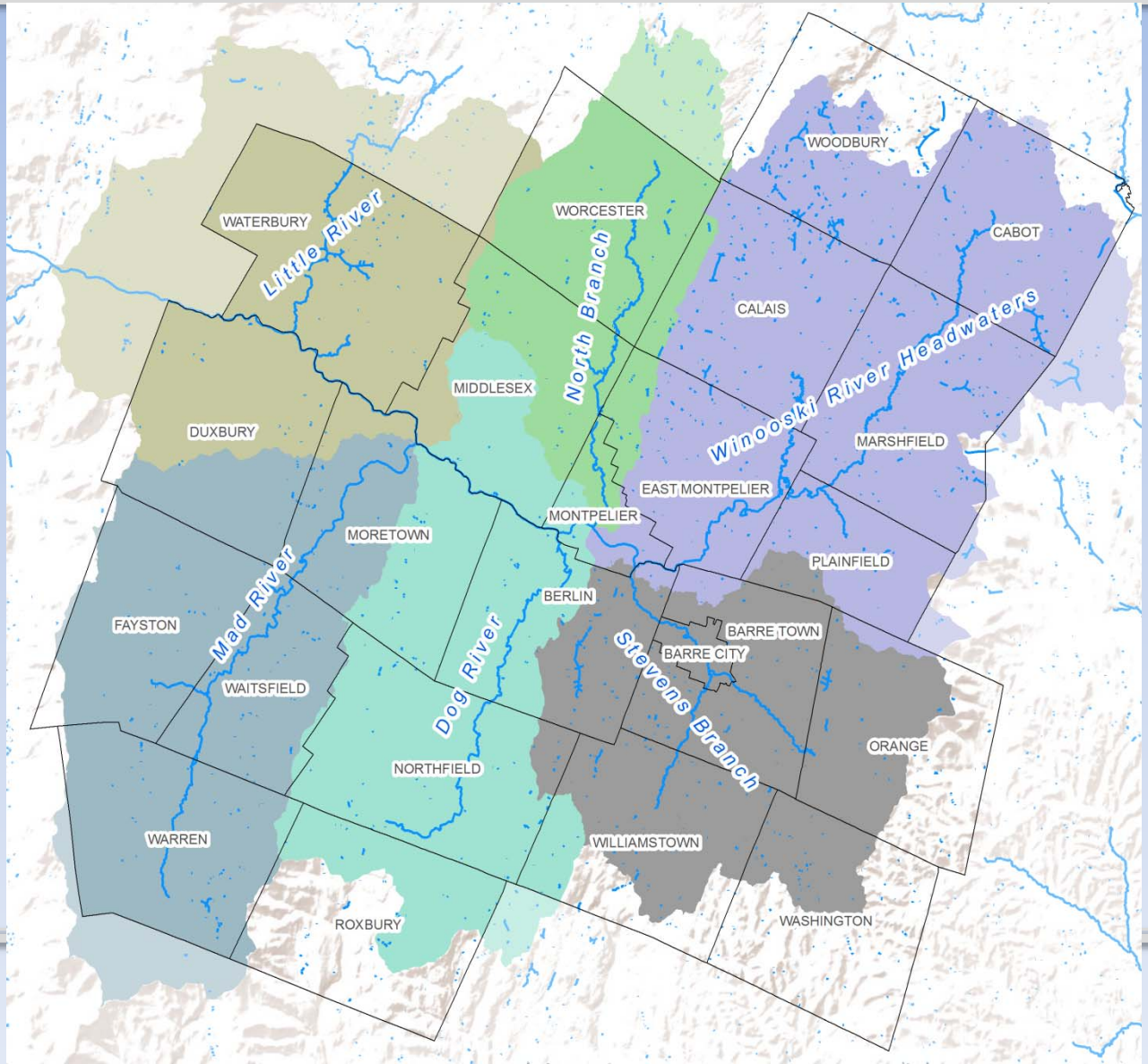
Green Infrastructure

Innovative Solutions to Stormwater Woes

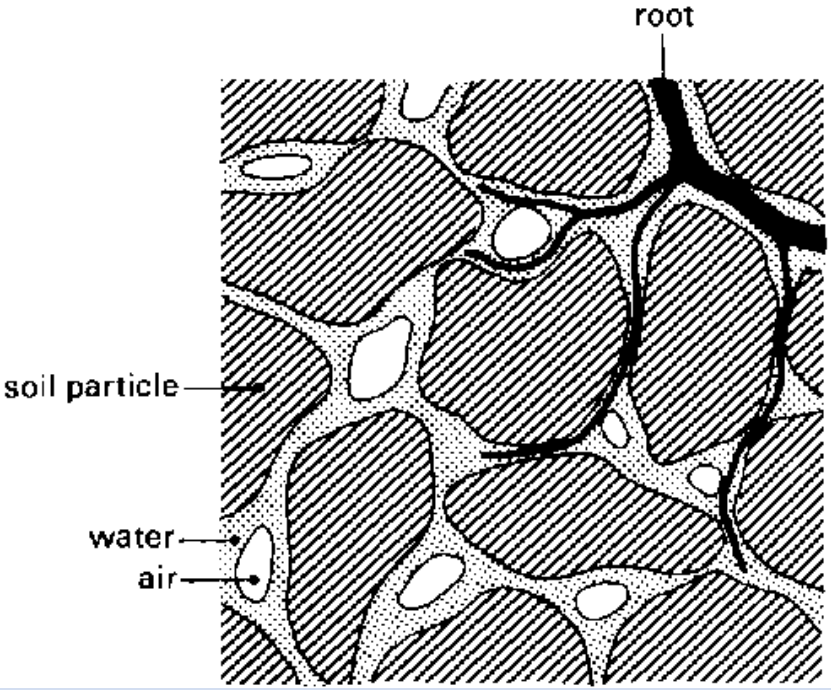
Central Vermont Watersheds



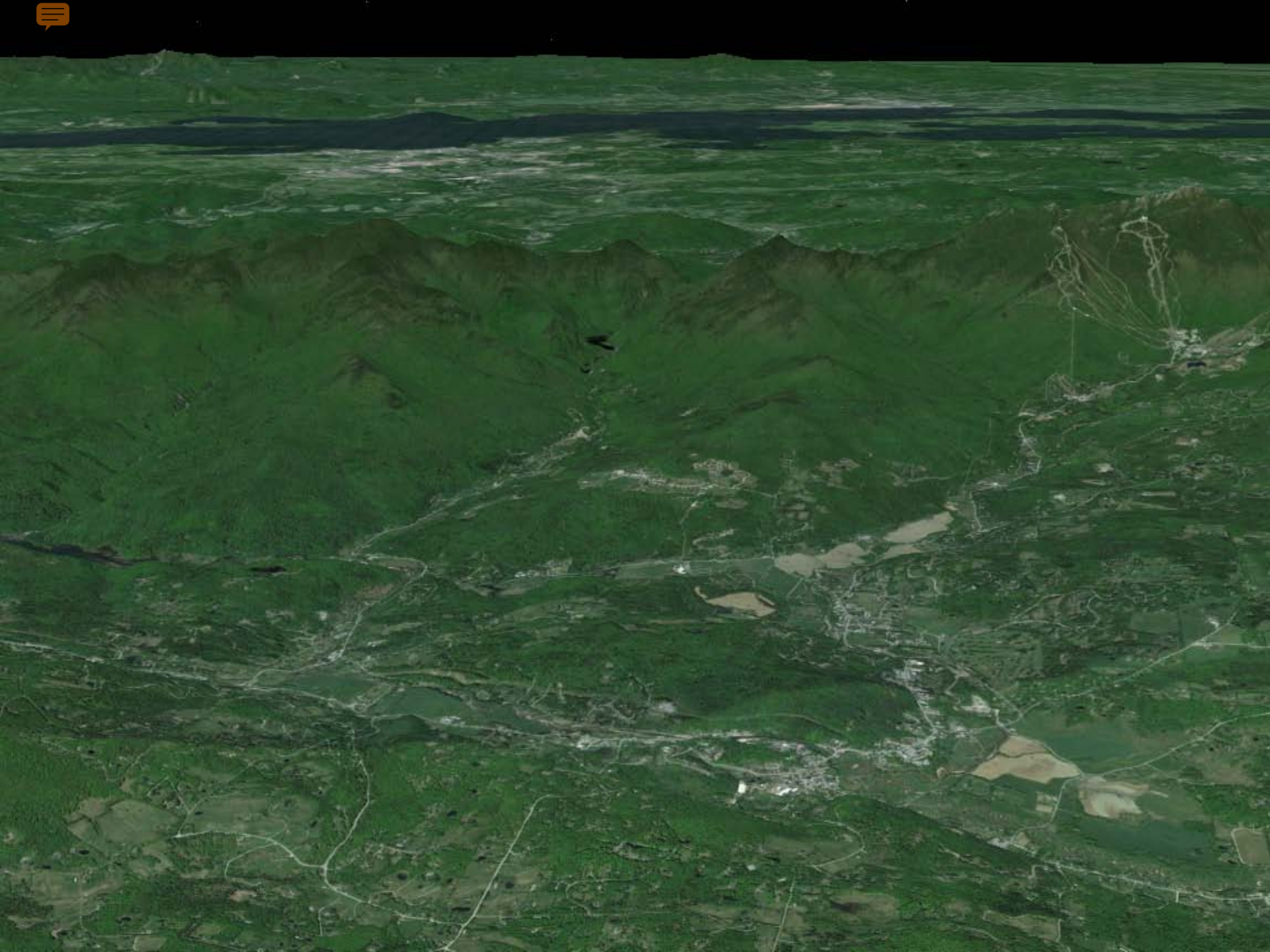
Overview

- Hydrology, Impacts of Development & Traditional Management
- Green Infrastructure Planning, Design & Techniques
  - Site Walk
- Implementing GI with Zoning, Permitting, and other Tools
  - Group Exercise

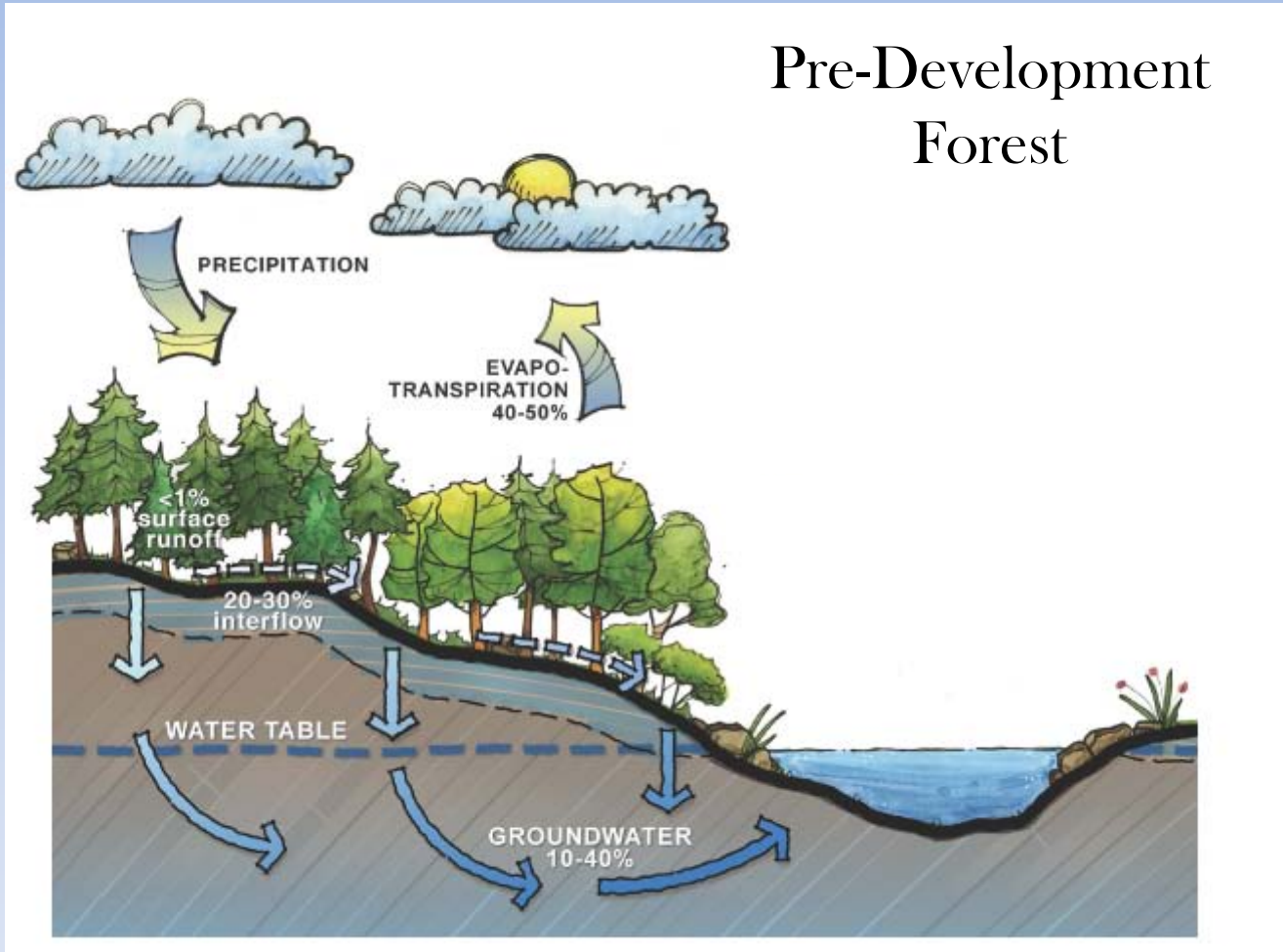
Soil & Vegetation



Evaporation + Transpiration =
EvapoTranspiration (ETo)



Understanding Hydrology

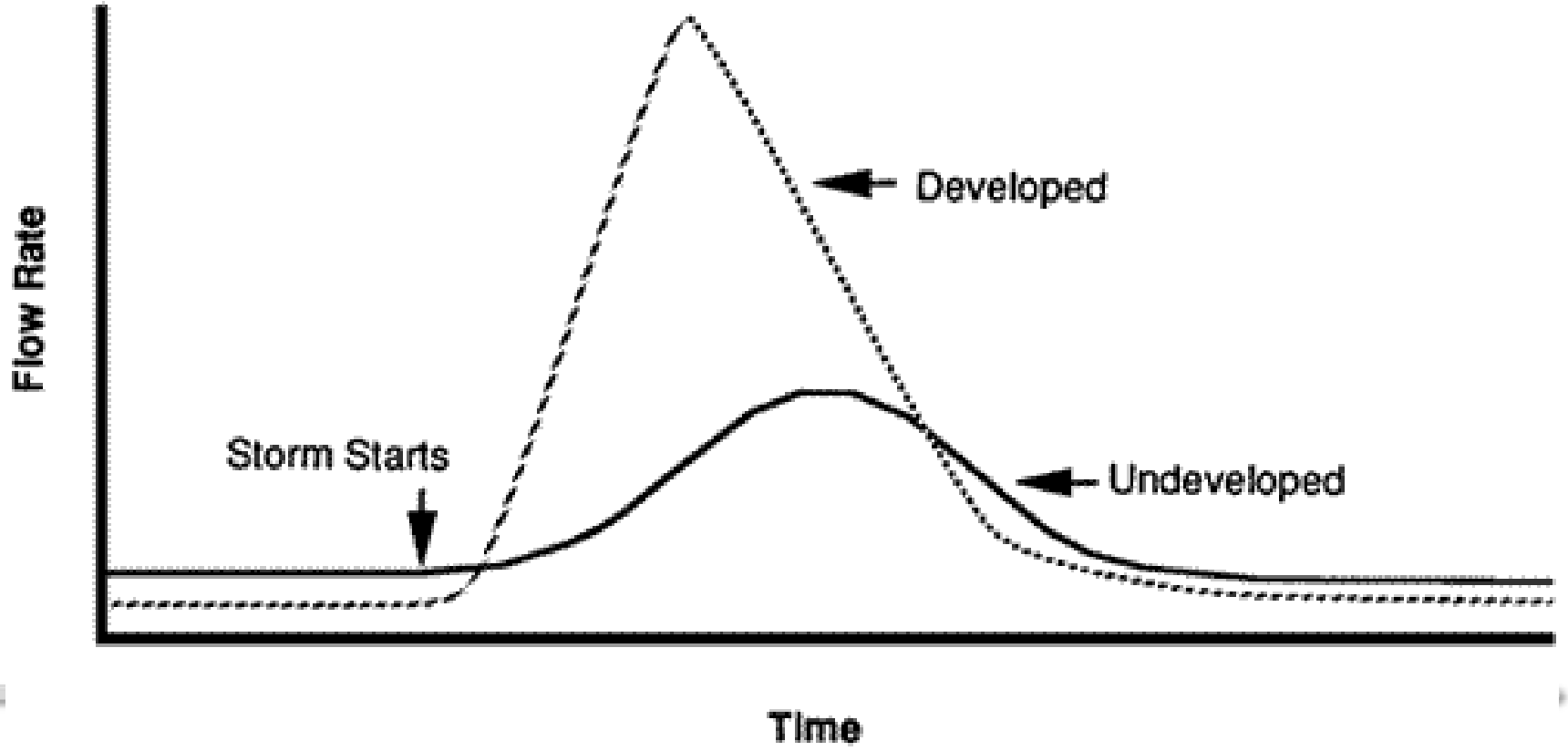


Understanding Hydrology

- While there is a lot of variability, generally under natural forested conditions:
  - 40% evapotranspiration
  - 10% runoff
  - 50% into ground
    - Half shallow infiltration, half deep infiltration

Understanding Hydrology

What happens in streams & rivers after precipitation?



Source: R.R. Horner

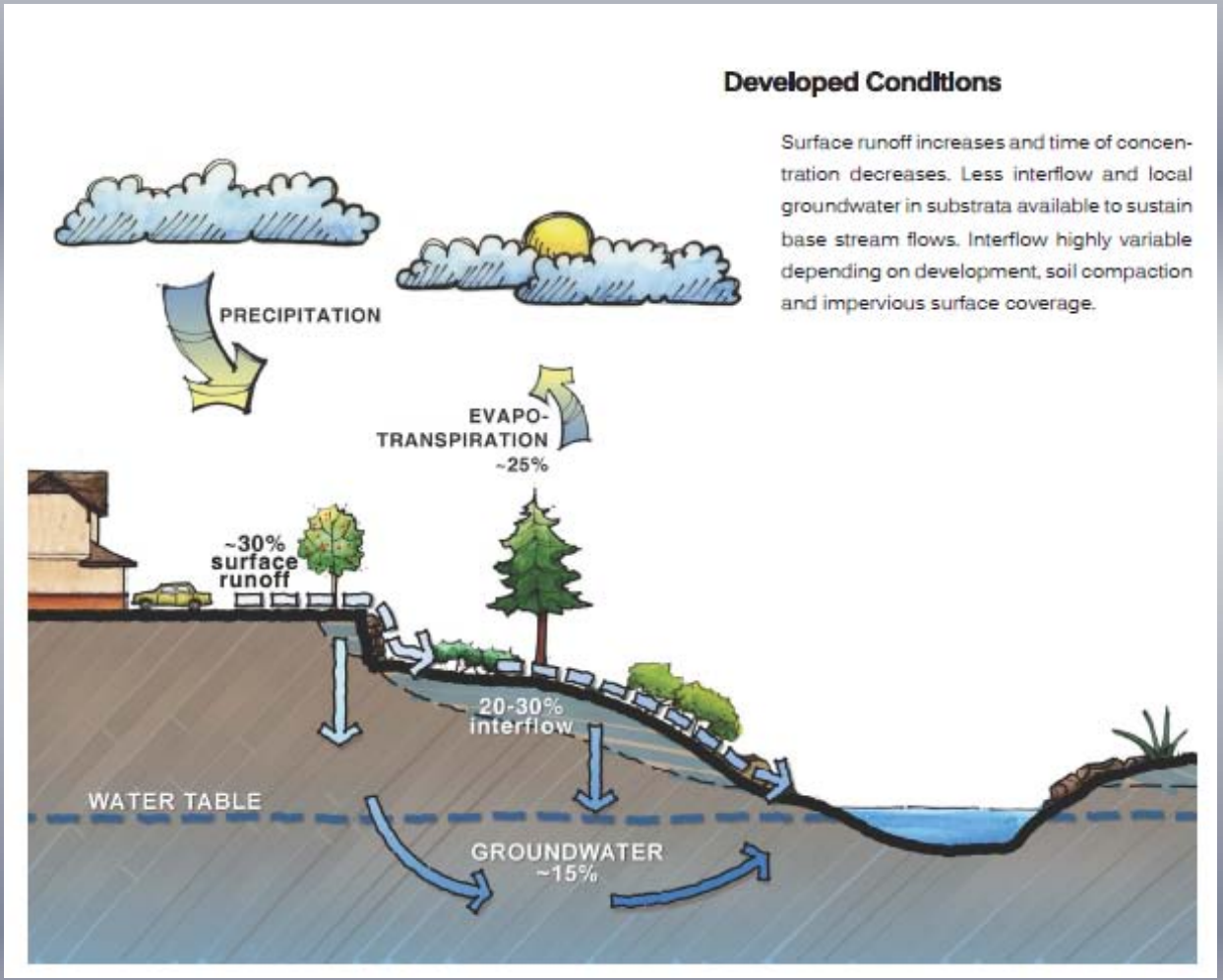
Impacts of Development

- Humans tend to alter the hydrologic cycle
  - Agriculture
  - Deforestation
  - Industry (including Dams and Water Extraction
  - And via Development
    - Roads (and ditches and culverts and ...)
    - Parking lots (and curbs and driveways and ...)
    - Buildings (and roofs and sidewalks and...)

Impacts of Development

- Those alterations lead to:
  - Increased surface runoff due to additional impervious cover
  - Reductions in water holding capacity due to the compaction and removal of top soil
  - Reductions in evaporation & transpiration due to vegetation clearing

Impacts of Development



Impacts of Development

- Generally, under urbanized conditions:
  - 30% evapotranspiration
  - 55% runoff
  - 10% shallow infiltration
  - 5% deep infiltration

Impacts of Development

1” rain storm over 1 acre

Forest runoff = 2,715 gallons

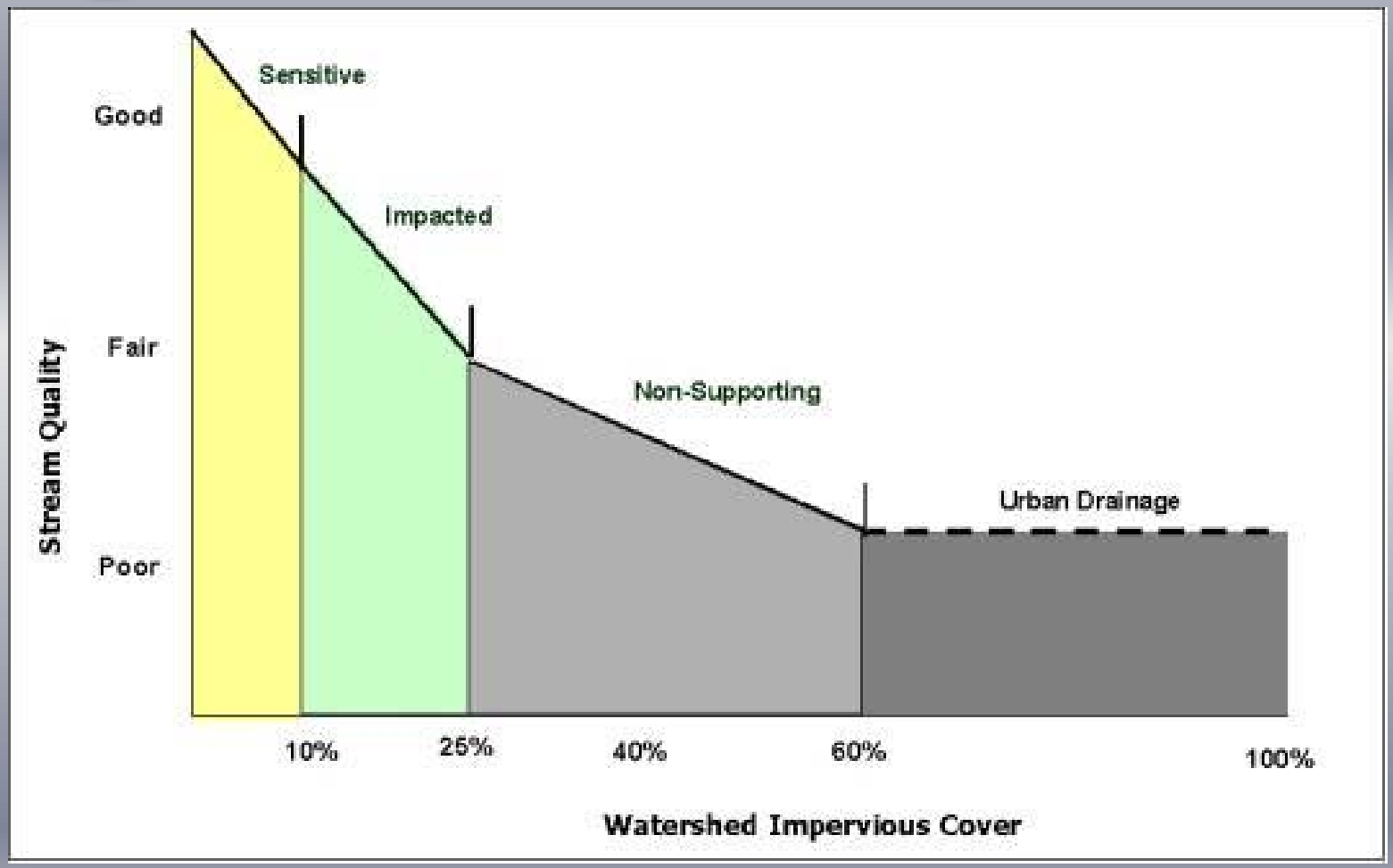
Urban runoff = 14,934 gallons +

1” storm over Burlington

148,145,280 gallons

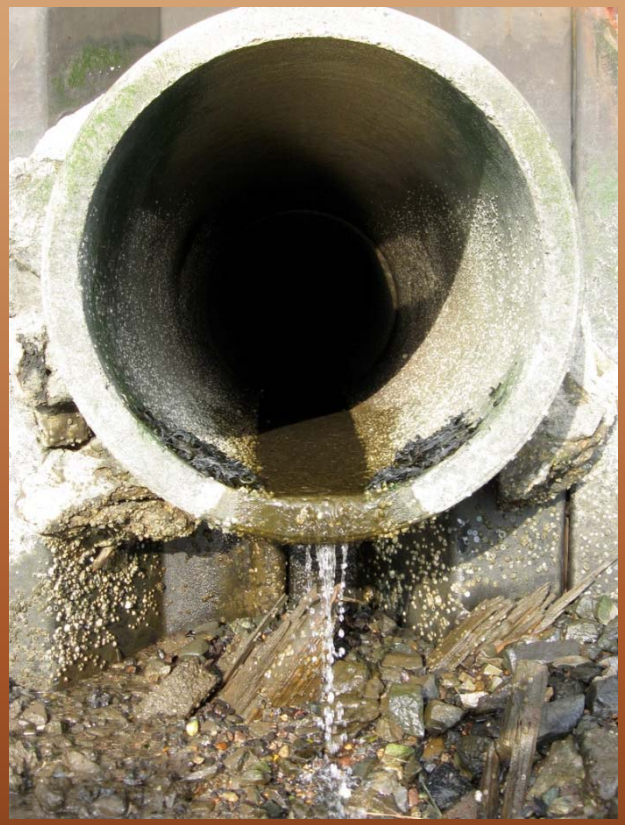
225 Olympic size swimming pools

Impacts of Development

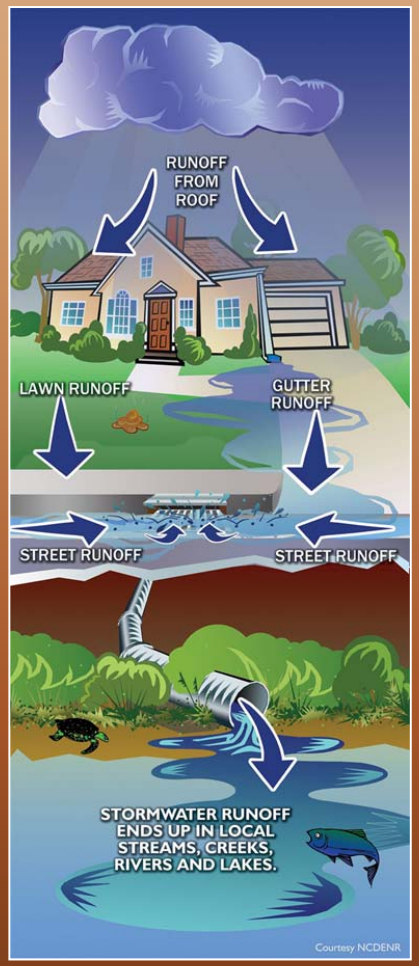



Traditional
STORMWATER
Management

Traditional Stormwater Management



Traditional Stormwater Management

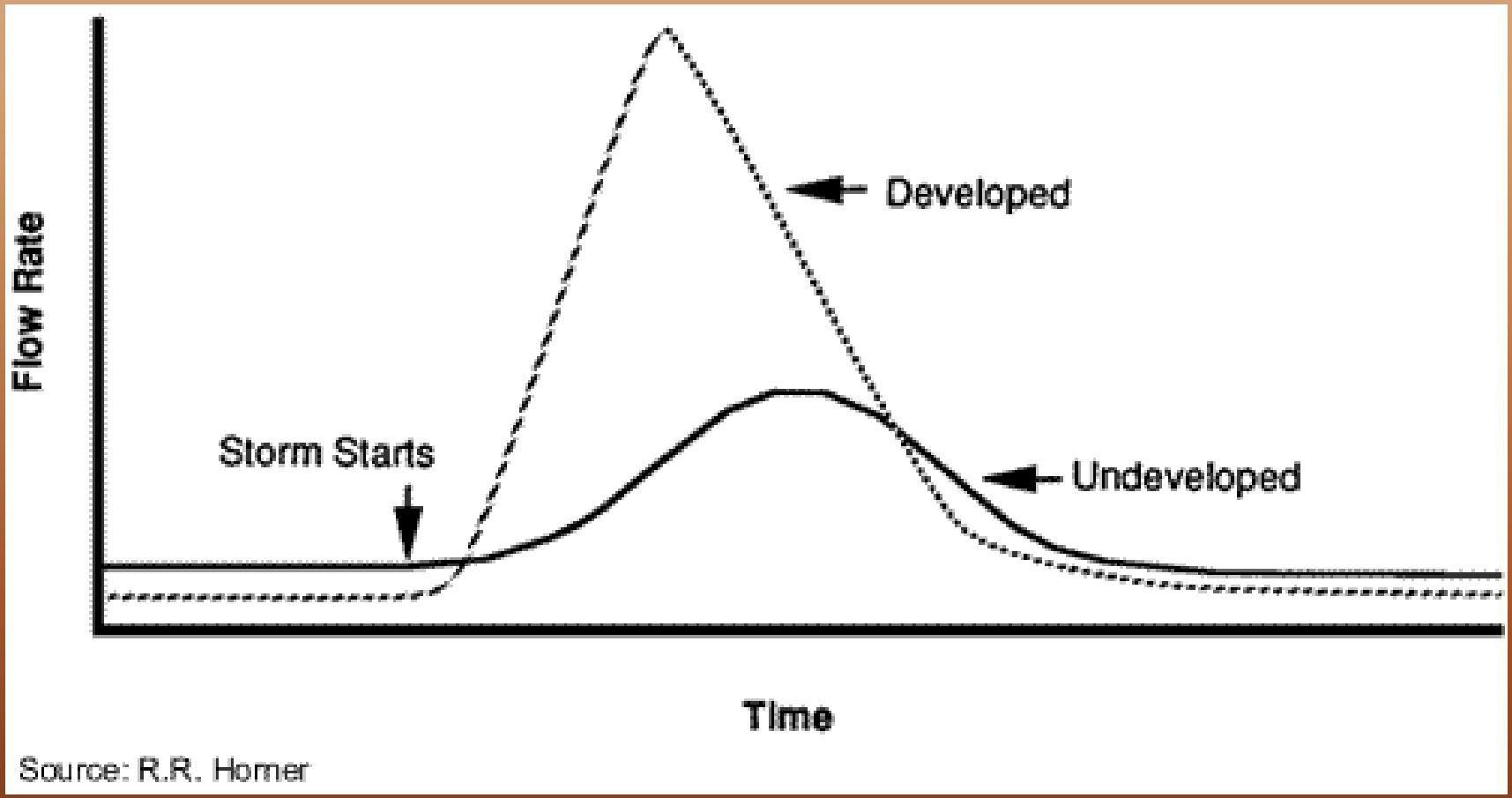


Traditional Stormwater Management

Traditional Stormwater Management

- Sedimentation and erosion
- Nutrient loading
- Bacteria
- Trash and debris
- Trace metals
- Increased runoff volume
- Reductions in groundwater base flow

Traditional Stormwater Management

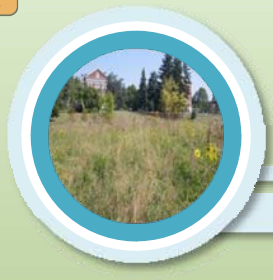


Source: R.R. Horner

Traditional Stormwater Management

- Treats stormwater as a waste, not a resource
- Considers stormwater last in the design process
- Centralized
- Looks mostly at surface runoff
- Manages peak flow
- Reliant on large infrastructure

Questions?



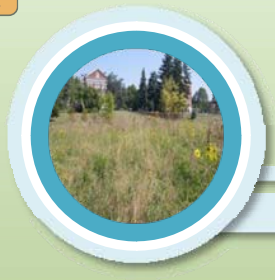
Green Infrastructure

Consists of two approaches

Planning & Design via Low Impact Development

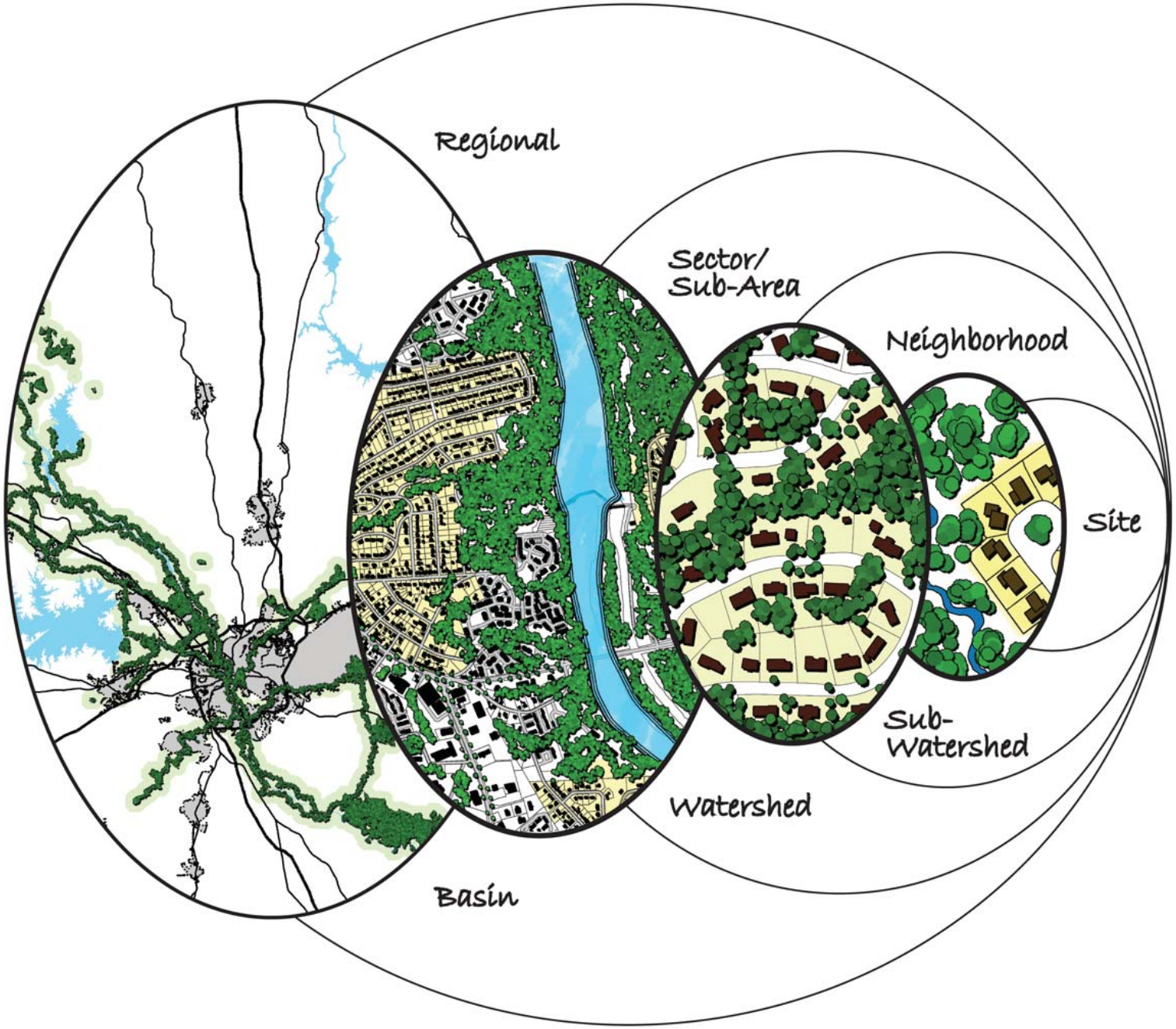
Techniques via Green Stormwater Infrastructure

LOW IMPACT DEVELOPMENT



Low Impact Development

- Began in Prince George's County, MD in 1990
- Strategic design process to create a sustainable site that mimics undeveloped hydrologic properties
- An innovative land planning and design approach which seeks to maintain a site's **pre-development ecological and hydrological function** through the protection, enhancement, or mimicry of natural processes


Regional
Sector/
Sub-Area
Neighborhood
Site
Sub-
Watershed
Watershed
Basin

Conservation Development

Minimize Total Disturbance

Minimize Soil Compaction

Reduce Impervious Surfaces

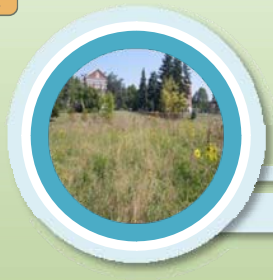
Protect Natural Flow Patterns

Protect Riparian Buffers

Protect Sensitive Areas

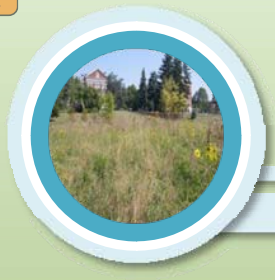
Disconnect Stormwater


AVOID



Avoid

- Steer development away from environmentally sensitive and high-value natural areas
- Maintain natural ecological and hydrologic processes



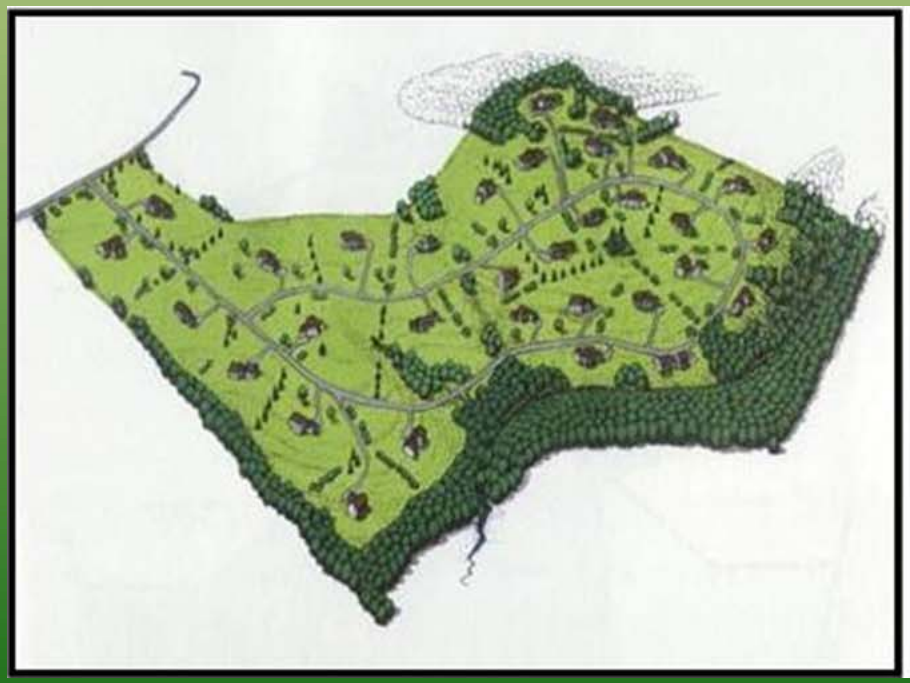
Avoid

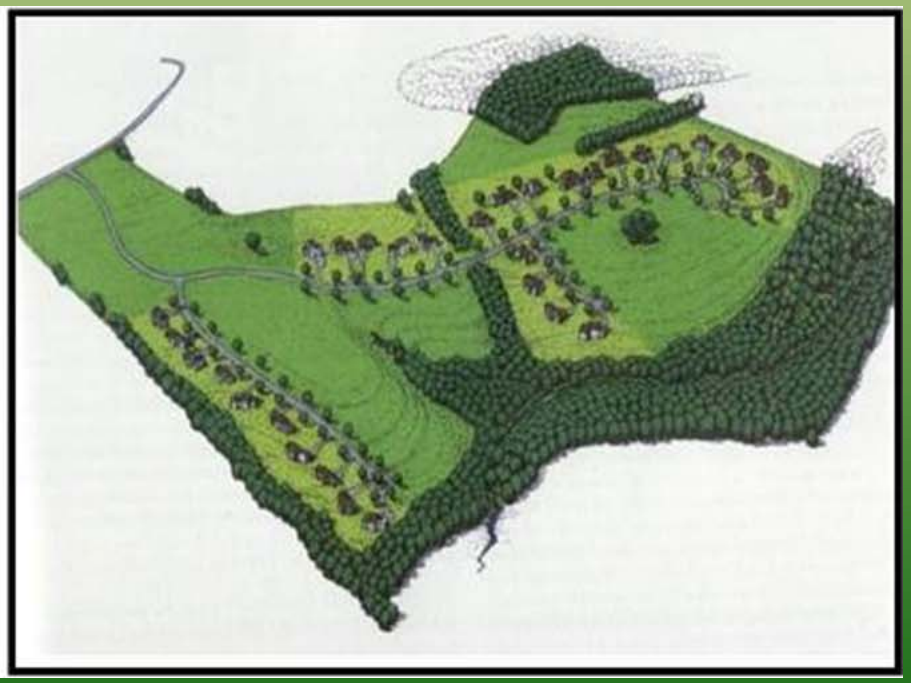
- At the watershed-scale
  - Buffer, wetland and floodplain requirements
  - Development restrictions on steep slopes, ridgetops, etc.
  - Conservation easements
- At the community-scale
  - Overlay districts
  - Cluster or open space development
  - Flexible site design incentives
- At the site-scale
  - Enhanced site plan review
  - Natural drainage protection
  - Sensitive area protection

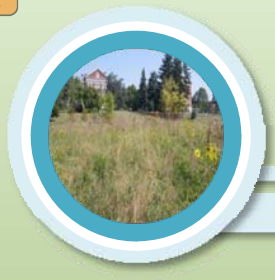

MINIMIZE

Minimize

- Lessen the amount of stormwater runoff being generated by reducing the scale and scope of **land disturbing activities** and **impervious cover**

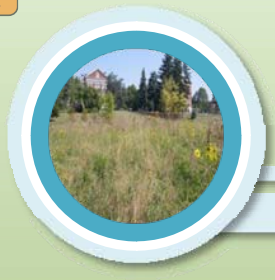






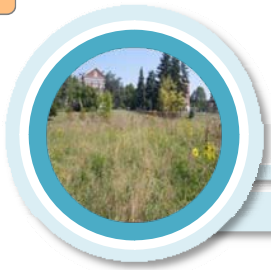
Minimize

- At the watershed-scale
  - Canopy cover goals
  - Education and outreach (Think Blue Maine, Smart Waterways)
- At the community-scale
  - Maximum road widths
  - Parking maximums
  - Revised setback requirements
  - Landscaping requirements
- At the site-scale
  - Limits of disturbance
  - Soil restoration
  - Stormwater disconnection



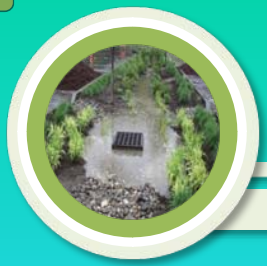
Benefits of LID

- Reduce use of “traditional (grey) infrastructure”
- Maintain a town’s unique character
- Reduce risk associated with flooding and streambank erosion
- Ensure continued provision of environmental goods and services (habitat, recreation, etc.)
- Decrease development costs
- Reduce infrastructure needs
- Reduce long-term maintenance costs
- Improve water quality
- Reduce surface flows



Questions?

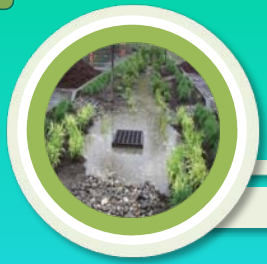

Green Stormwater Infrastructure



Green Stormwater Infrastructure

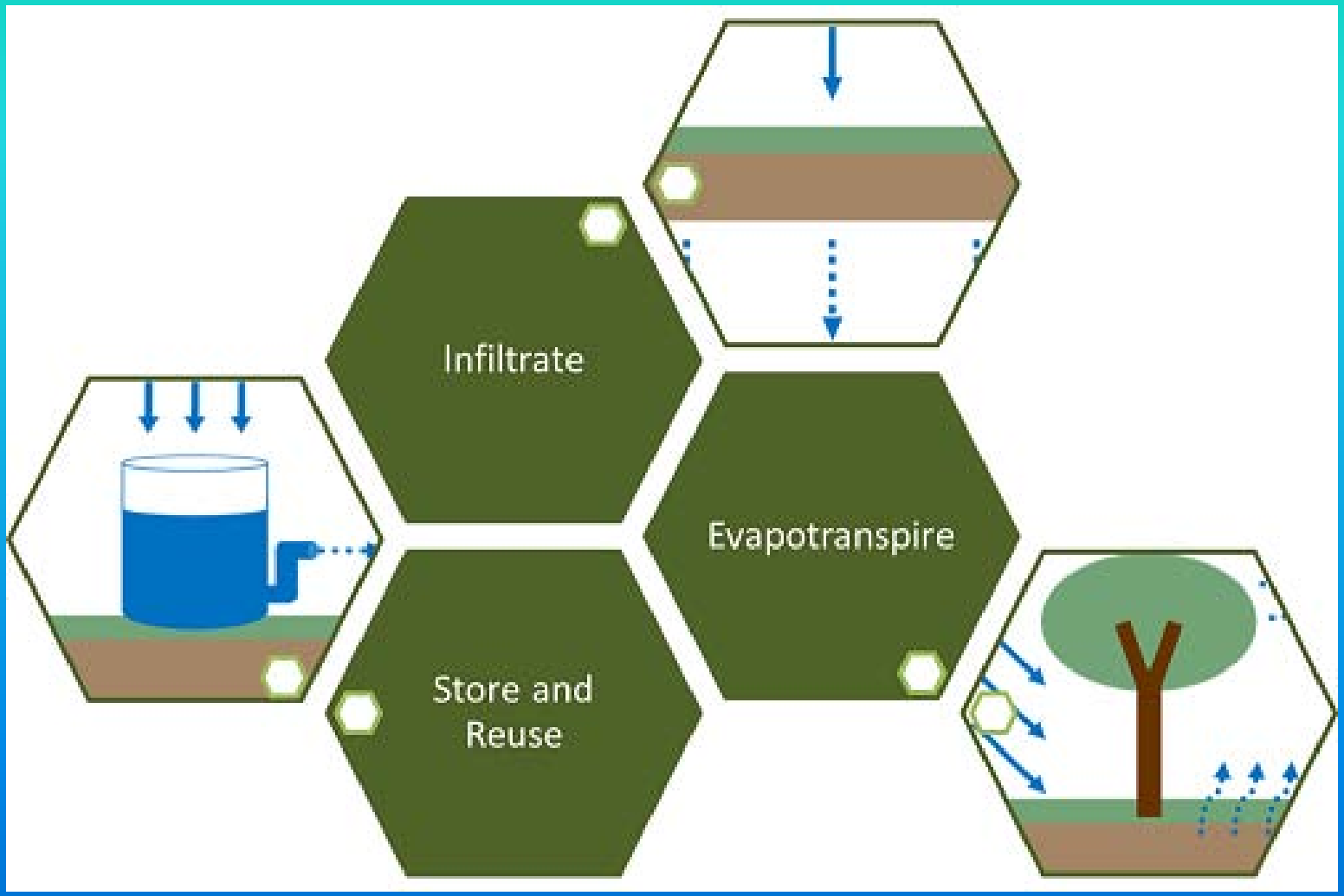
- Coined by EPA around 2007
- Systems and practices that restore and maintain natural hydrologic processes
- Reduces the volume and water quality impacts of the built environment while providing multiple societal benefits


Manage



Manage

- Use structural best management practices (BMP's) that mimic natural processes
  - Stormwater volume
  - Stormwater quality
- Interested in all aspects of the hydrologic cycle


Infiltrate
Evapotranspire
Store and
Reuse

Manage

Manage

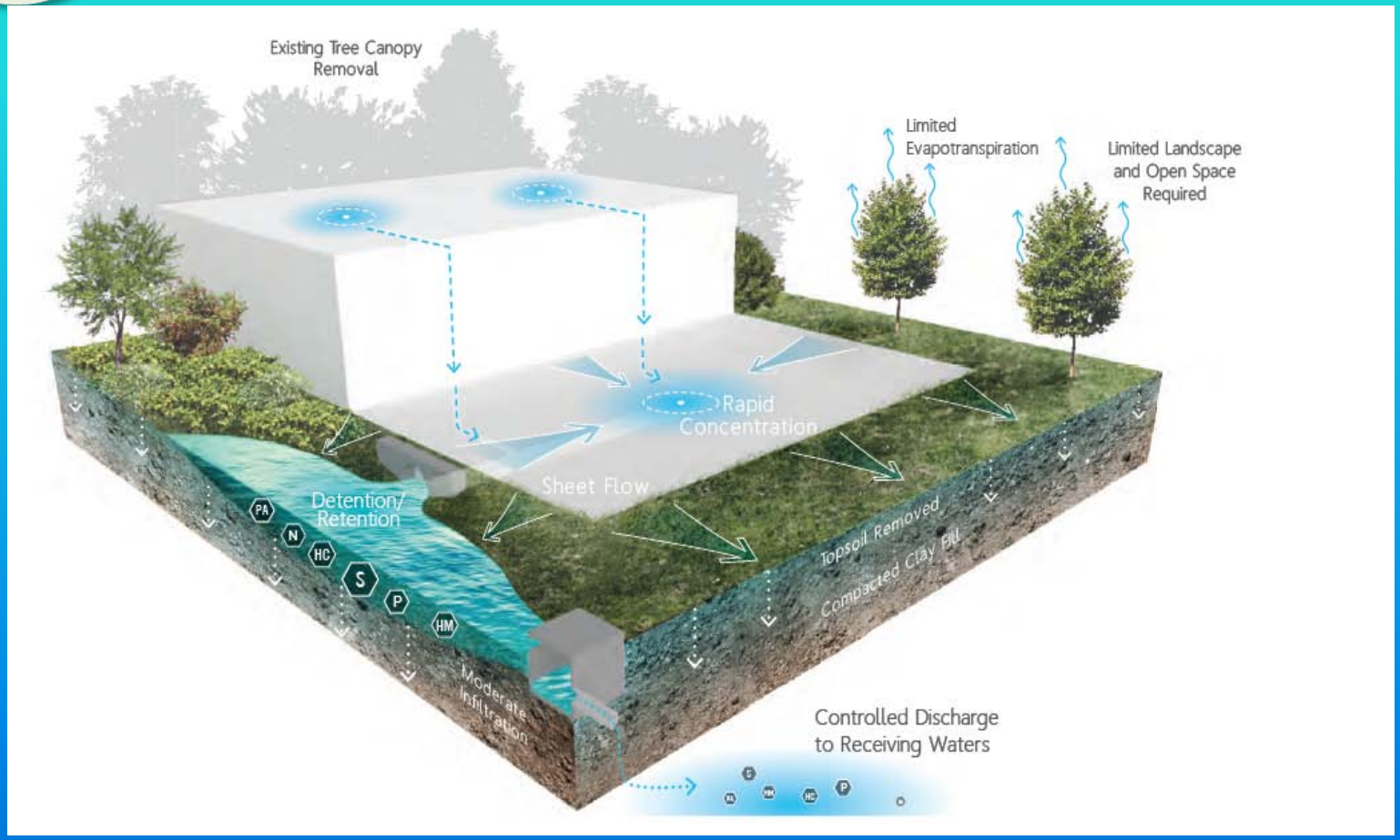
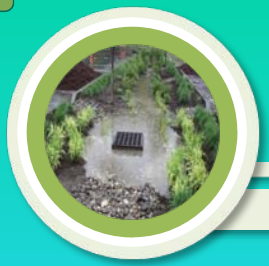
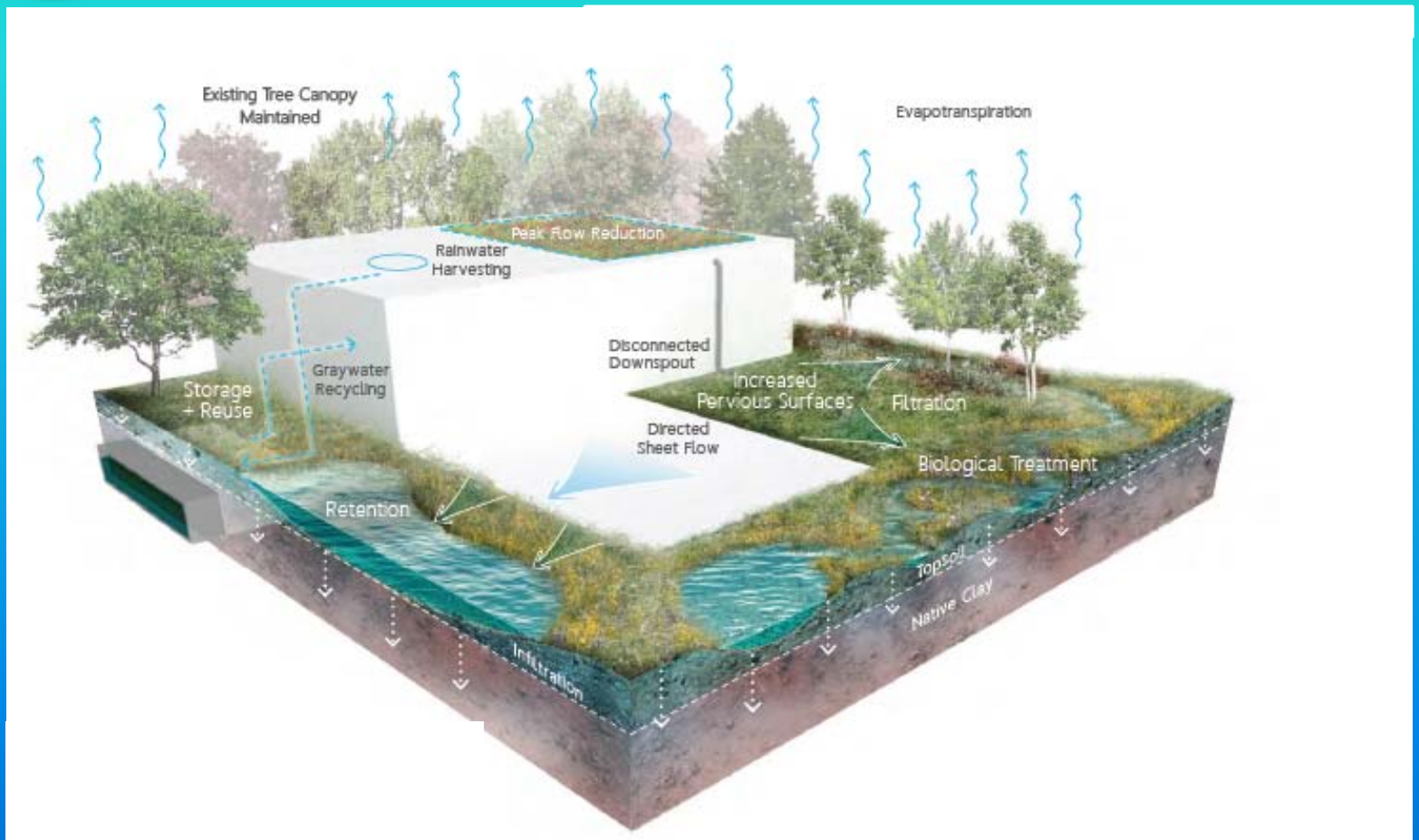


photo credit: University of Tennessee, Knoxville, Landscape Architecture Program



Manage



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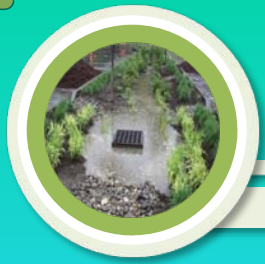


Manage

- At the watershed-scale
  - Identify areas of stormwater generation
  - Identify areas of stormwater attenuation
  - Educate the public
- At the community-scale
  - Look for opportunities to retrofit
  - Enact local stormwater regulations
  - Train staff and volunteers
- At the site-scale
  - Promote GSI through local zoning and subdivision regulations

Manage

Modular Porous Concrete Slab

Trinity Lot,
UVM Campus

photo credit: StormCrete

Manage

Step Pool Conveyance System
Enosburg Falls Village Garage

photo credit: Stone Environmental

Manage

Subsurface Gravel Wetland

St. Albans/Exit 19 Park and Ride

photo credit: Stone Environmental

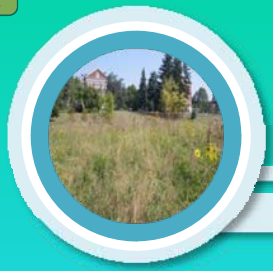
Manage

Turf Pavers
Burlington

photo credit: Stone Environmental

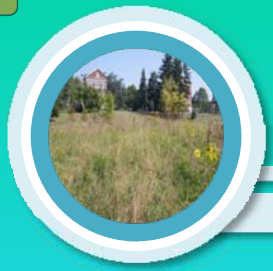
Grass Lined Ditch

Grassed Waterway



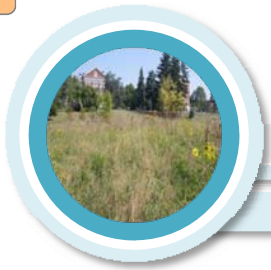
Benefits of GSI

- Distributes the stormwater burden across the landscape
- Reduces water quantity and improves water quality
- Reduces cost over the long-term
- Mimic predevelopment hydrology
- Adds value to the community



Challenges to LID and GSI

- Lack of familiarity with LID and GSI
- Lack of expertise with GSI techniques
- Using traditional SW approach is more familiar to engineers and developers
- Maintenance of GSI techniques



Questions?

Case Study


Incorporating Green
Infrastructure into
Land Use Regulations

Green Infrastructure & Long Range Planning

- Town Plan
  - Introduce topic in chapters on Natural Resources, Flood Resiliency, Future Development, etc.
- Open Space Plan
  - Where should **conservation efforts** focus
- Stormwater Master Plan
  - Detailed focus on town's **individual drainage areas**

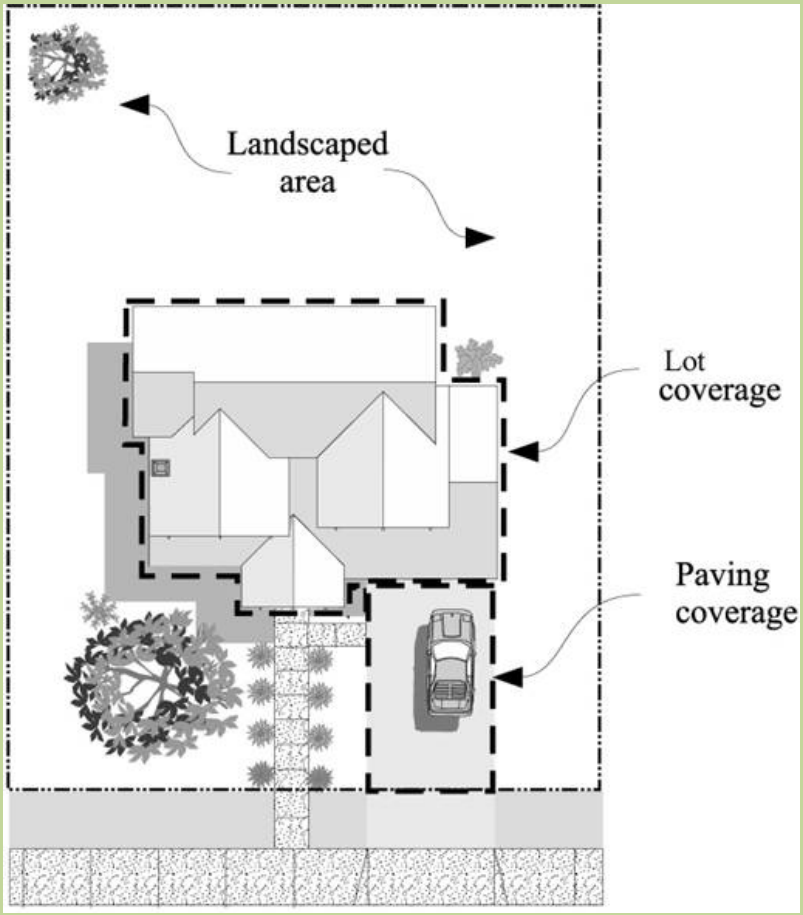
Green Infrastructure & Land Use Regulations

- Zoning bylaws
- Subdivision regulations
- Other municipal ordinances

Green Infrastructure & Land Use Regulations

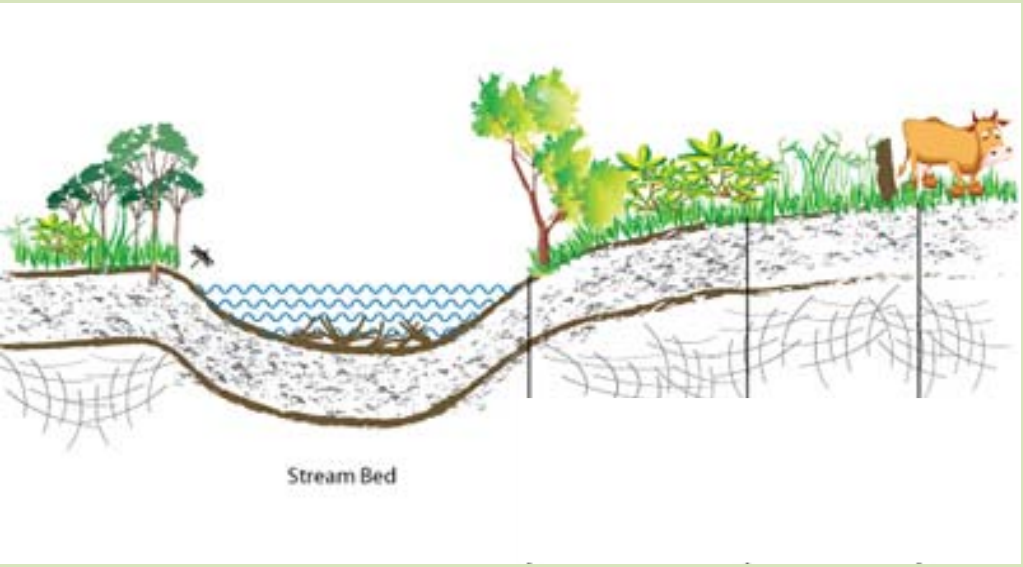
Lot Coverage-Restricts the amount which a parcel can be developed with impervious surface.

-Evaluate current limits?



Green Infrastructure & Land Use Regulations

Setback & Buffers



- Reduce front yard property setback
- Stream setback & buffer
- Wetland setback & buffer
- Floodplain
- Restrict not only structures and parking lots but also lawns

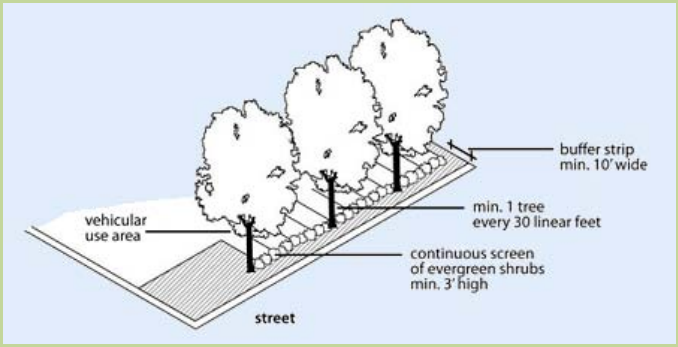
PARKING STANDARDS

- Set maximum parking requirements rather than only minimums
- Allow waivers to parking requirements
- Allow shared parking
- Lower required width and length of parking spaces
- Incentivize compact car parking

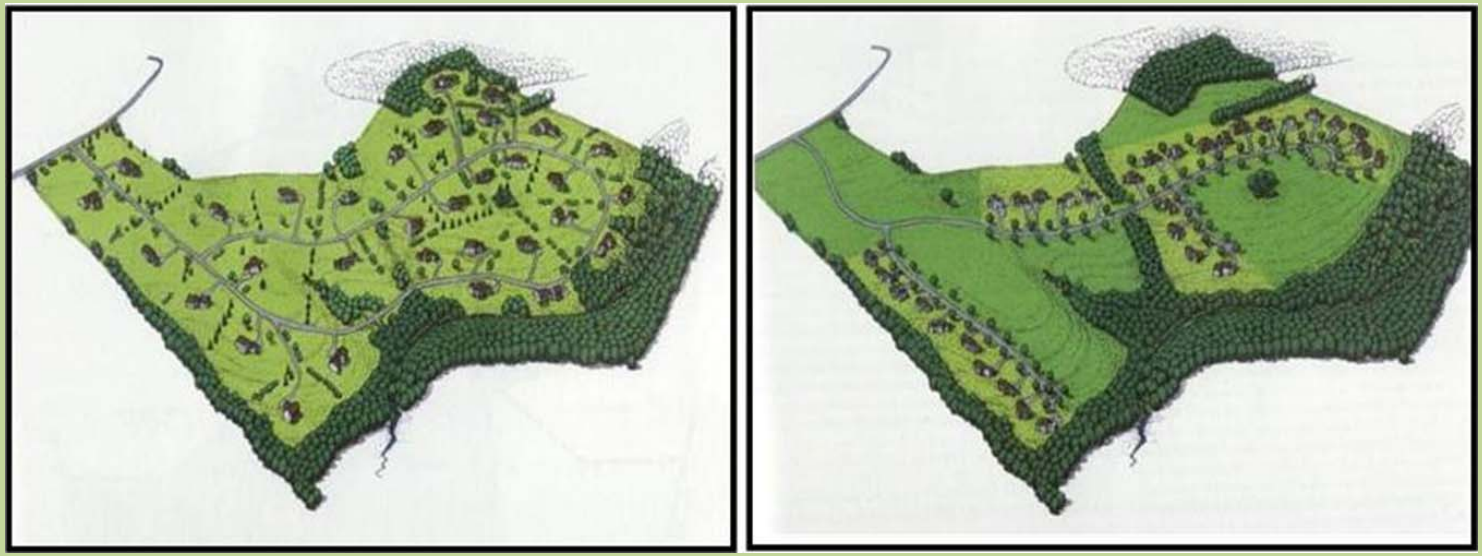
Green Infrastructure & Land Use Regulations

Parking & Landscaping Standards

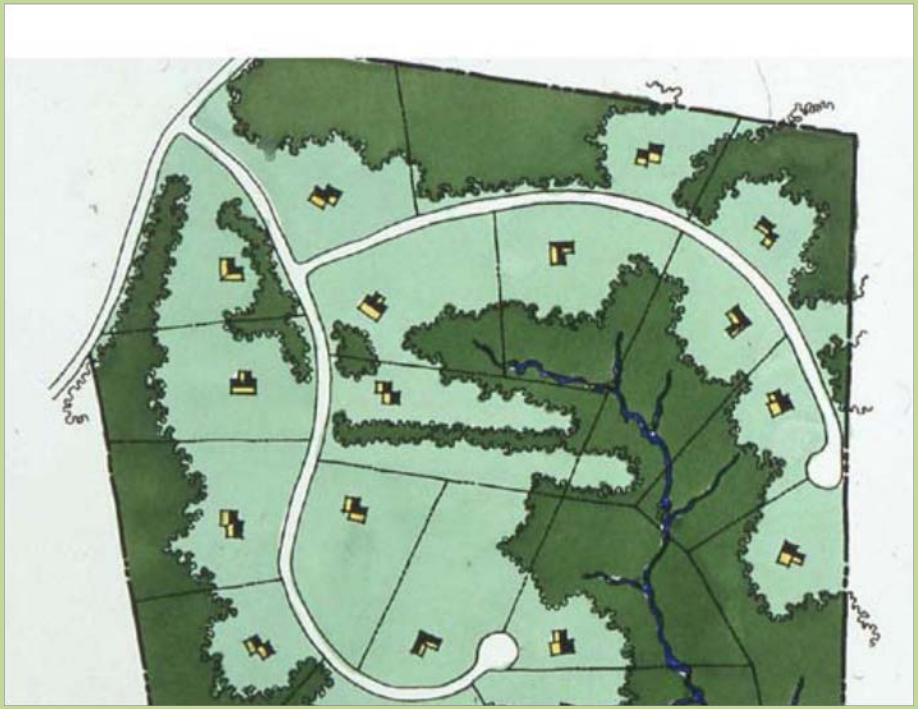
- Landscaping islands
- Encourage bio-retention ponds
- Require landscaping and trees based on # parking spaces



Subdivision Regulations



Standard Subdivision Design

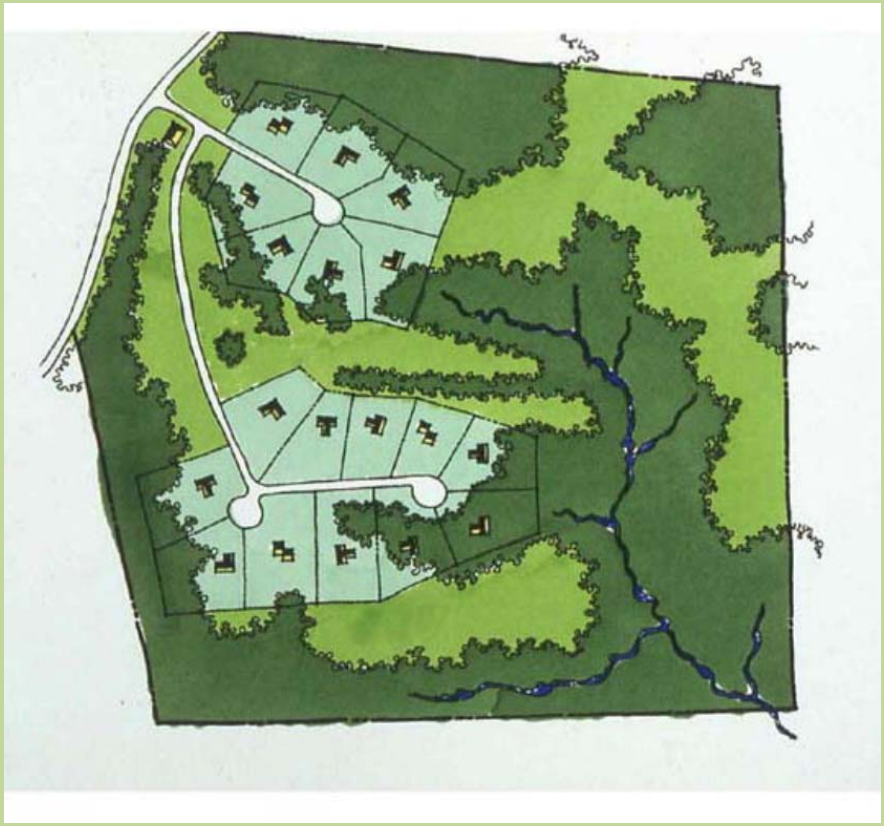


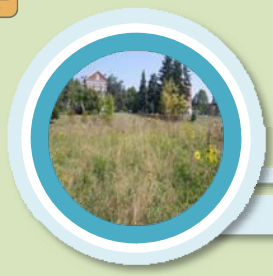
- Minimum Lot Size
- Frontage
- No provisions for sensitive area setbacks (i.e. wetlands, streams, etc.)
- Large infrastructure cost

Flexible Subdivision Design

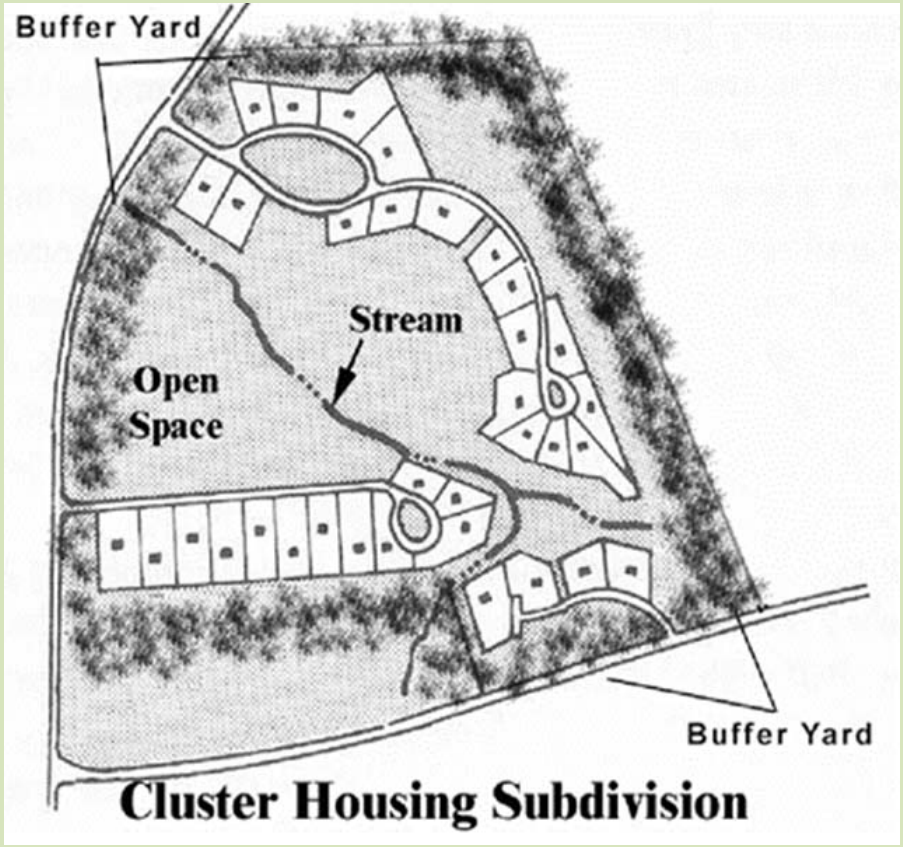
Conservation, Cluster, PUD Subdivisions

- Waiver(s) for Dimensional Requirements
- Limit Clearing
- Open & Common Space
- Protection of Natural Areas
- Shared Driveways
- Designated Building Envelopes
- Flexibility in Design
- Incentives- Density Bonuses

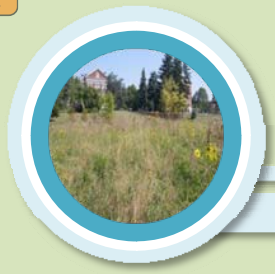




Benefits



- Preservation of working landscape, agricultural and forest lands
- Preserved wildlife habitat
- Reduced stormwater/impervious surfaces
- Access to open space
- Maintain rural character
- Reduced infrastructure cost



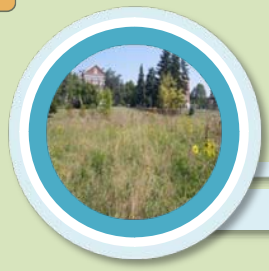
Challenges

- Perceived additional density
- Current zoning regulations and bylaws
- Lack of familiarity with LID and GSI
- Reluctance to make “new” regulations

Other Municipal Ordinances

Road & Driveway Ordinance

- Reduce impervious surfaces
  - Incentivize low impervious
  - Reduce driveway widths, incentivize shared driveways
  - Evaluate road and driveway widths. Consider reducing based on traffic patterns and use.



VLCT Model LID Bylaw

Scope and Applicability

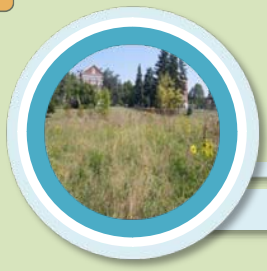
- The requirements of this regulation shall apply to land disturbance, development and any construction activities requiring a municipal land use permit.

- Allows for exemptions

"Any activity that will disturb an area less than [ ] square feet or less than [ ]% of contiguous property, whichever is less."

"Any activity that will increase an impervious area or contiguous impervious area less than [ ] square feet."

Focus on minimizing Land Disturbance and Preservation of Natural Areas



VLCT Model LID Bylaw

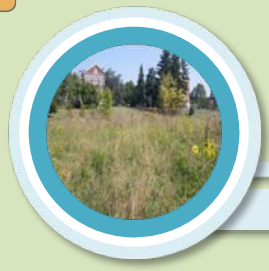
Standards & Guidelines

Standard 1: Vegetation and Landscaping

Standard 2: Development on Steep Slopes

Standard 3: Reduce Impervious Surfaces

Standard 4: Integrate Low-Impact Management Practices.



VLCT Model LID Bylaw

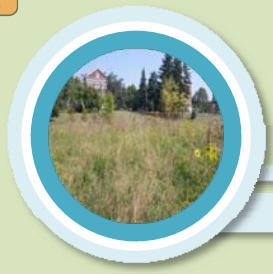
VLCT Model LID Bylaw

- Independent Technical Review

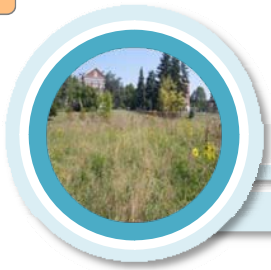
"The legislative body may establish procedures and standards for requiring an applicant to pay for reasonable costs of an independent technical review of the application." [24 VSA 4440(d)]

VLCT Webinar- "Green Stormwater Infrastructure Simplified Sizing Tool for Small Projects"-

Tues. November 10th 2-3 PM.



Group Exercise



Meeting Regulatory Requirements

- US EPA requires Vermont to change Water Quality Plan
- Lake Champlain Phosphorus Standards
- Municipal Roads Stormwater General Permit
- Vermont Stormwater Management Manual

Purpose of the Roads Permit

- Bring “connected” road drainage systems up to basic maintenance standards

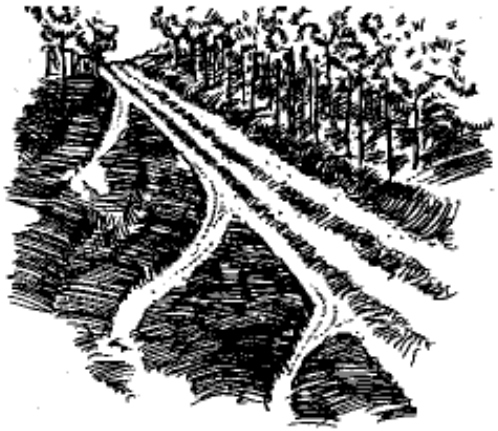


Figure 1. Water turn-out

- Implement additional corrective measures necessary to reduce erosion to meet water quality standards

MRGP Timeline

- Fall & Winter 2015

Begin outreach to towns

- Spring 2016

Develop permit and standards

- Summer 2016

Continue stakeholder process

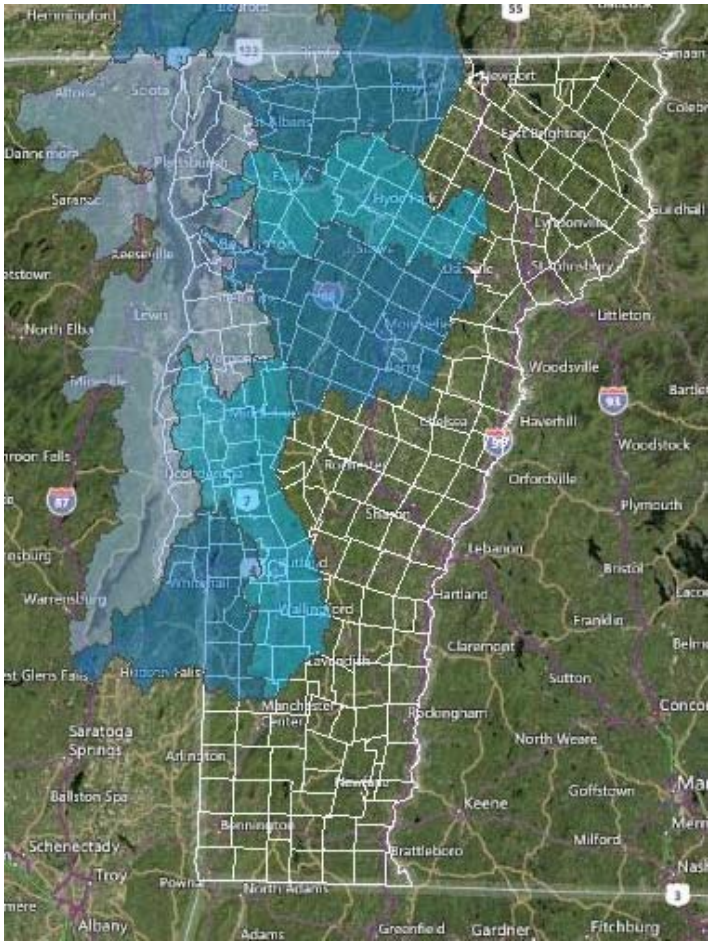
- Fall & Winter 2016

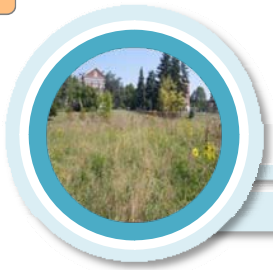
Develop draft General Permit

- Fall & Winter 2017

Issue Final General Permit

- Phase in permit coverage 2018-2021

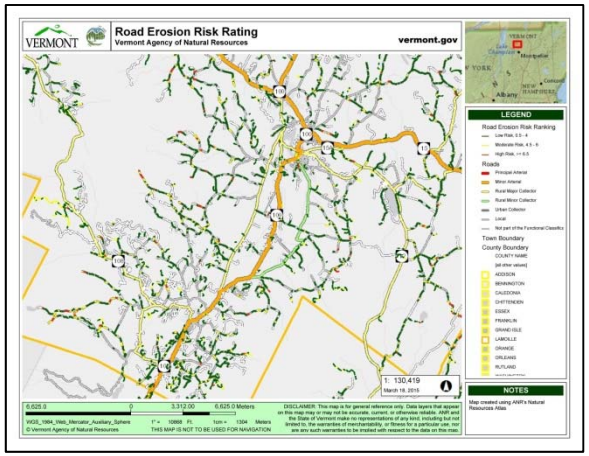




Permit Framework

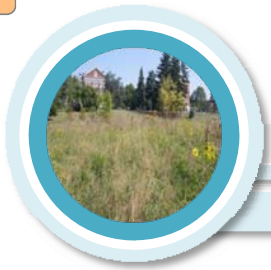
- Municipalities develop Road Stormwater Management Plan

Inventory



Prioritize

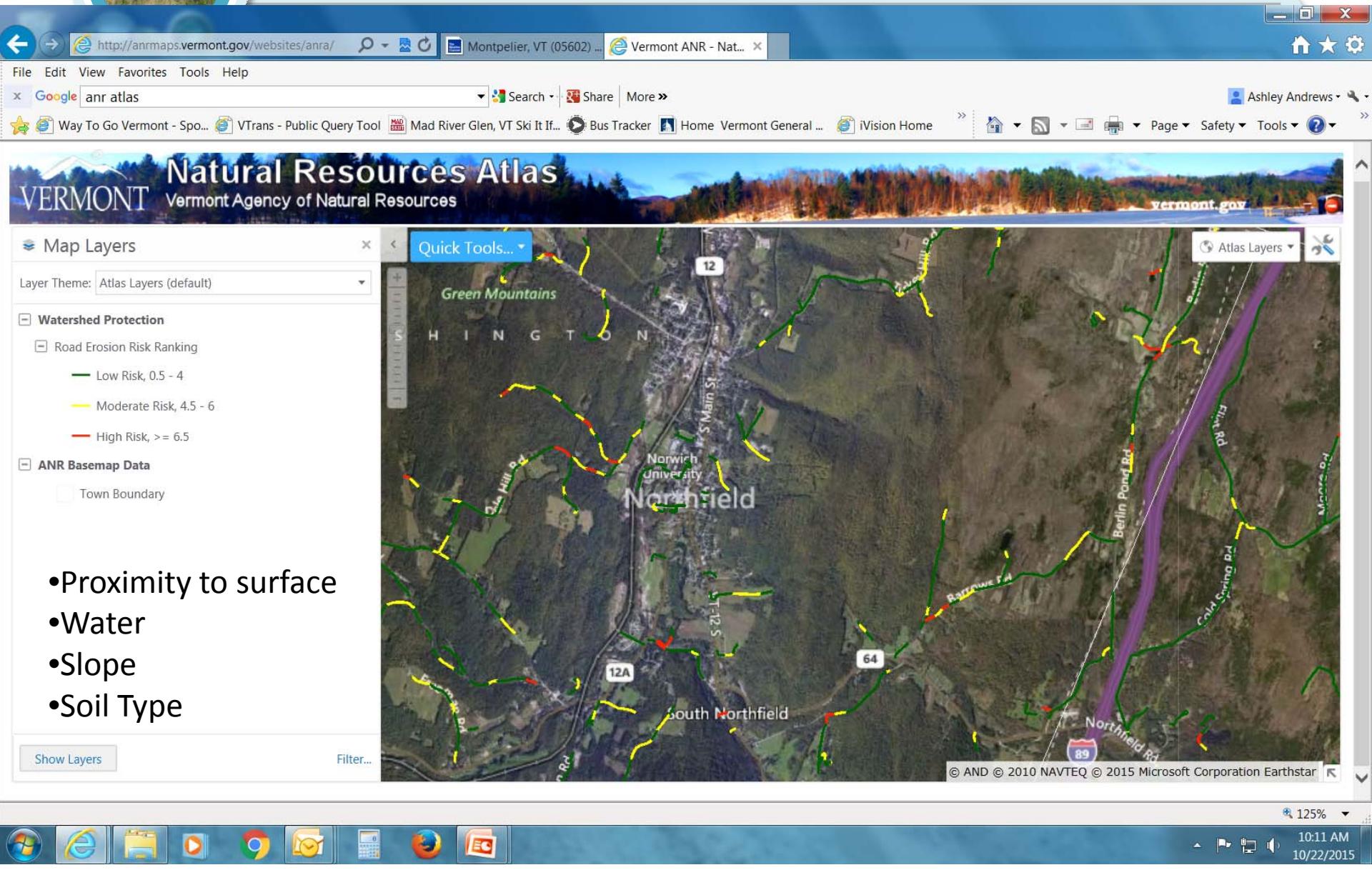
Implement



Road Erosion Workflow

- Road Erosion Inventory
- Town Gravel Roads (Class 2 – 4)
- Consult Road Erosion Risk Analysis Segments
- Consult with Town Staff
- Perform Windshield Survey
- Perform Detailed Assessment
- Prioritize Assessed Sites
- Select Treatment
- Develop Cost Estimates
- Schedule Treatments in Capital Programming

Hydrologic connection



- Proximity to surface
- Water
- Slope
- Soil Type

Road Erosion Assessment Form

Road Segment ID Code:		Date / Time Assessed:	
Town:		Road Name:	

Make an **X** to the right of your choice for each criteria

Windshield Assessment

Erosion Present :	Yes :		No :		Water Quality Issue?	Yes :		No :	
Problem Fixed?:	Yes :		No :		River/Road Conflict?	Yes :		No :	

Notes:

NOTE: If Marking No to Water Quality Issue - STOP. Do not conduct Detailed Assessment

Detailed Assessment

Erosion Location - NOTE: Please mark all locations where erosion is present

Roadway		Road Shoulder		Ditch		Road Bank	
Culvert Headwall		Culvert Outlet		Culvert Inlet		Fill Slope	
Off Road ROW		Ditched Stream					

Erosion Type - mark any type of erosion observed

Rill		Incision		Slump		Ditch Scour	

Water Quality Risk Assessment Criteria

Road/Ditch Material in Waterbody - the potential for road/ditch material to reach water body under normal precipitation

Slight		Moderate		Severe	

Runoff Volume - relative amount of runoff water to and through the erosion point or area, based on drainage area size

Low		Medium		High	

Slope to Waterbody - the slope of the conveyance from the road to the water body

Low (0 - 10%)		Medium (10-30%)		High (>30%)	

Ground Cover to Waterbody - ground cover of the conveyance - only vegetation below knee-height is considered.

>50% Vegetation		<50% Vegetation		Bare Channel	

Road Characteristics Criteria

Road Slope - average of the slope within the erosion issue drainage area

Low (<5%)		Medium (5-10%)		High (>10%)	

Road Shape - road surface's ability to shed water

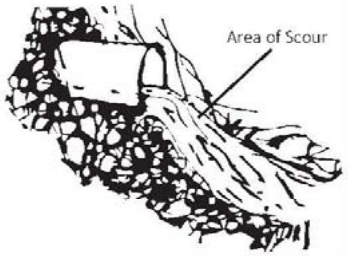
ual

Erosion Type: There are four main types of erosion. Rill and Incision erosion can occur at any location on a roadway. Slump erosion is usually limited to road shoulders or road banks, while Scour erosion typically occurs in ditches or at culvert outlets. **Sites can have more than one type!**

Rill:
Small, shallow, braided channels that do not cut much below the upper road surface.

Incision Erosion:
Erosion that is actively downcutting through the road surface and sometimes into the road sub-base.

Scour:
Erosion where the velocity of runoff has eaten away at either the bank or the bed surface. Commonly found at culvert outlets.



Slump:
Usually a point, not a linear, feature. Slumps occur when either water undercuts the soil or runoff water saturates a steep bank, leading to a collapse in a certain location.

Erosion type does not necessarily influence the severity of the water quality problem. Instead, Type serves as a descriptor which will inform how a solution to the issue is ultimately chosen.

Detailed Assessment:

If you have determined that a Detailed Assessment is necessary, proceed by recording the following information:

Town and Road Name: | Segment ID Code: | Date/Time Assessed:

Notes Section: Please use this section to record basic measurements of any erosion features (length of ditch eroded, length/width of road surface erosion, etc), as well as the presence of seeps or blocked culverts.

Erosion Location:

Road erosion can be located in several distinct spots on a road. Use the diagram on page 12 when evaluating erosion location. You can mark multiple locations for each distinct erosion point or area.

Erosion Type:

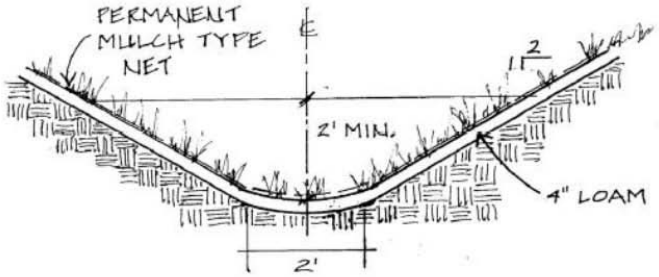
There are several types of road erosion illustrated on page 13. It is important to distinguish between them, as this will help assist in capital budget planning for repair. Erosion types include rill, incision, scour, and slump. It is possible that multiple types will occur for any erosion point or area. Mark all that apply. (Scores shown in parenthesis)

Water Quality Risk Assessment Criteria:

1. **Road or Ditch Material in Water Body**: The opportunity for, or presence of, road-based material in the water body.
    a. None (X0.0) - no road/ditch material in water body, site is buffered, no connection possible. **This site should not be evaluated using the Detailed Assessment as there is no water quality risk**.
    b. Slight (X1.1) - some road or ditch material tracking near edge of water body, connection possible or likely.
    c. Moderate (X1.2) - ditches or other channels drain to water body, obvious tracking near water body, some road-based material visible in water body.
    d. Severe (X1.3) - large channel or multiple channels drain to water body, significant tracking near water body, evidence of significant amount of road-based material in water body.
2. **Runoff Volume:** The volume of water from runoff to and through the erosion point or area - this measurement is directly related to the size of the drainage area contributing to the erosion.
    a. Low (8) - erosion point is in the top 30% of the road's drainage area. This contributing area will generate the smallest volume of runoff water.
    b. Medium (15) - erosion point is in the middle 30% of the road's drainage area. This contributing area will generate a moderate volume of runoff water.
    c. High (25) - erosion point is in the lowest 30% of the road's drainage area. This contributing area will generate the largest volume of runoff water.
3. **Slope to Water Body**: Average slope from erosion point or area to the water body - not the road slope.
    a. Low (8) - 0-10% slope average from road to water body below point of erosion.

Road Erosion Solutions - BBR

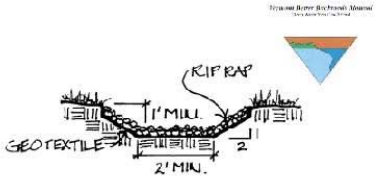
Ditch Stabilization Solutions – Better Backroads Manual

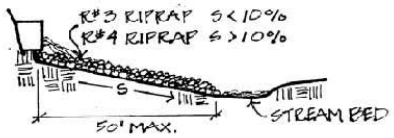


GRASS LINED DITCH
(BBR Manual – pg. 12)

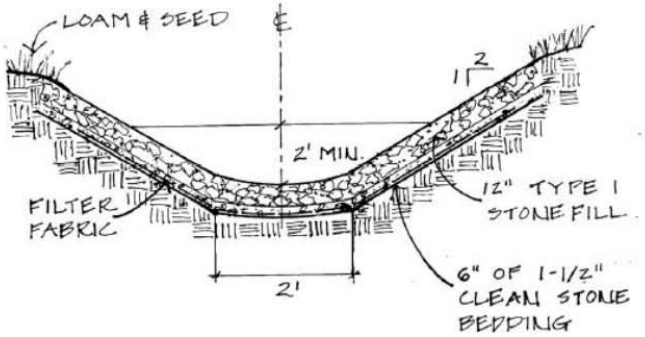
TABLE 1: DITCH LININGS		
Channel Slope	**Lining**	**Thickness**
0-5%	grass	
5-10%	R#3 (2 - 6 inch) diameter rock	7.5"
> 10%	R#4 (3-12 inch) diameter rock	12"

(BBR Manual – pg. 14)





RIPRAP CONVEYANCE CHANNEL
(BBR Manual – pg. 30)



STONE LINED DITCH
(BBR Manual – pg. 13)

MRGP Practices and Standards

- Will be simple, cost-effective, and easy to maintain whenever possible

What types of practices will be included in the MRGP?

Practices *will likely* include:

- Stone-lined ditches and check dams
- Turn outs
- Road crowning
- Culvert headers
- Culvert outlet stabilization
- Possible new techniques and Green Stormwater Infrastructure Practices

What about river-road conflict sites?

Towns will identify top river-road conflict sites as part of the Roads SWMP

Are all road classes covered by the GP?

- Yes, All road classes will be covered by the permit (Classes 1-4)
- Paved Roads will likely follow Town Standards and Best Management Practices
- Requirements for Class 4 roads will likely be less stringent

MRGP and VTrans Road and Bridge Standards Compatibility?

- DEC and VTrans Standards and BBR Manual Practices will be compatible, as they are revised
- Different will apply to different conditions

Vermont's Stormwater Management Manual – Current Manual and Draft Updates

Green Infrastructure Workshop: Alternative Techniques for Managing Stormwater

Amy Macrellis, Stone Environmental

October 28-29, 2015

VERMONT

STONE ENVIRONMENTAL INC

Horsley Witten Group
Sustainable Environmental Solutions

Adamant Accord
Meeting Facilitation and Mediation Services

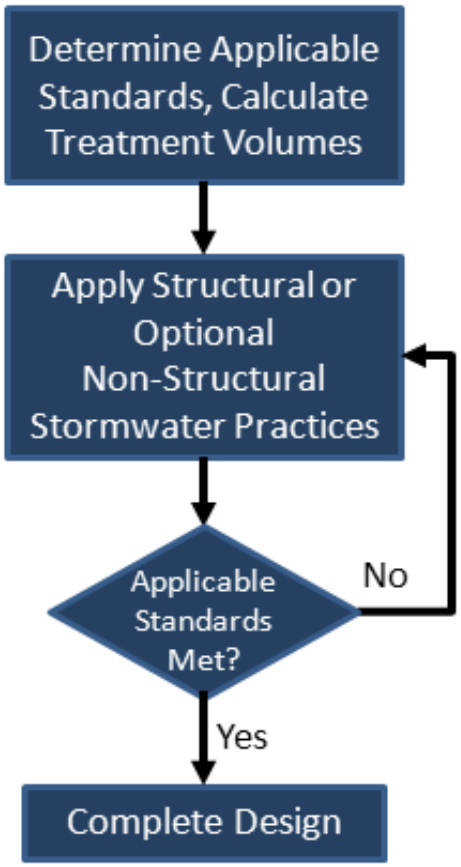
Current Vermont Stormwater Management Manual in Practice

- Stormwater construction permits are administered through an NOI process for any project creating one acre or more of disturbance
  - Approved separately from permits for post-construction stormwater management
- State stormwater discharge permit required for:
  - New impervious surfaces greater than 1 acre;
  - Redevelopment of existing impervious, where the redeveloped portion is greater than 1 acre;
  - Expansions greater than 5,000 sf, if the total resulting impervious surface is greater than 1 acre.

Current Vermont Stormwater Management Manual Practice

- Treatment standards include:
  - Water Quality Treatment Standard (WQv): Capture 90% of annual storm events, remove 80% of TSS and 40% of TP
  - Channel Protection (CPv): Extended detention of the one-yr, 24-hr event for 12-24 hours
  - Groundwater Recharge (Rev): Maintain average annual recharge rate for the prevailing hydrologic soil group on the project site
  - Overbank Flood Protection (Qp10)
  - Extreme Flood Protection (Qp100)
- Optional stormwater credits can be used to reduce the required WQv and Rev (mostly non-structural practices)

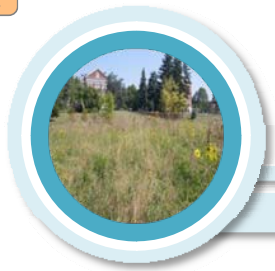
2002 Stormwater Manual Framework



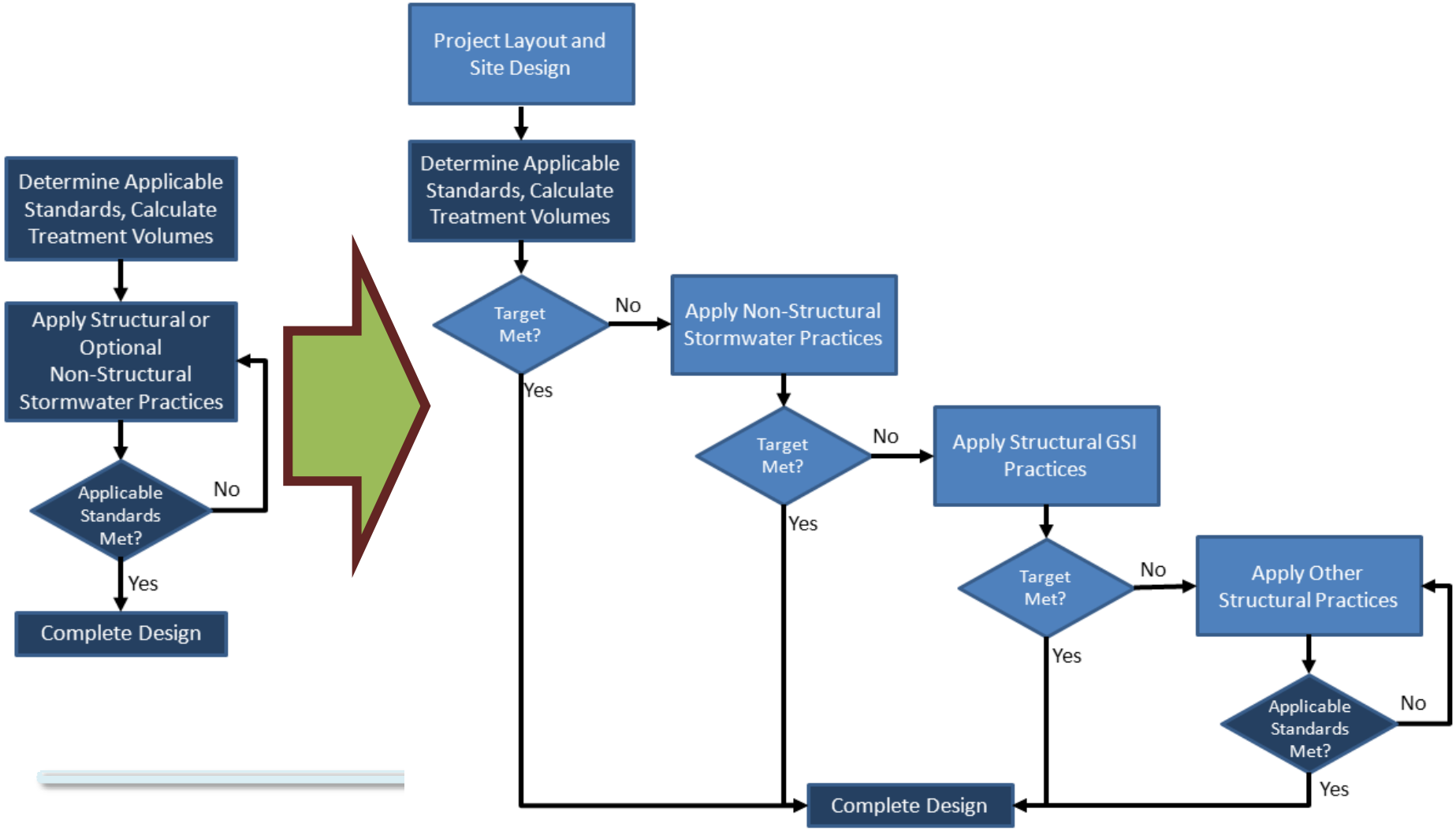
- Determine the Stormwater Treatment Standards your project is expected to meet,
- Calculate required treatment and/or storage volumes, and
- Choose and size acceptable structural stormwater treatment practices (or optional non-structural practices) to detain and treat runoff from impervious surfaces.

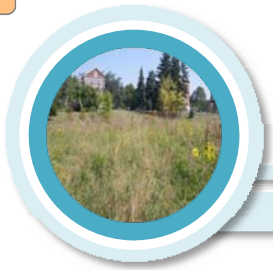
DEC and Stakeholder Goals for Updated Manual's Proposed Standards

- Mimic predevelopment hydrology
- Maximize the use of non-structural practices
- Promote infiltration and evapotranspiration
- Practical and economical to apply and administer



2015(?) DRAFT Stormwater Manual Framework





DRAFT Stormwater Manual Revisions – Treatment Standards

- Site Planning and Design: New Post-Construction Soil Quality and Depth Standard. Soils disturbed during construction, AND not covered by impervious surface, stormwater practice, or engineered fill/slope, meet organic matter and other key standards in the top 12" at close-out
- Water Quality Treatment Standard: rainfall depth increasing to 1 inch, required to be managed using non-structural and structural GSI practices
- Channel Protection Treatment Standard becomes a "Hydrologic Conditions Standard" - satisfied by using non-structural and structural GSI practices to match a project's post-development runoff curve number (RCN) to that of pre-development woods/meadow in "good condition"

DRAFT Stormwater Manual Revisions – Stormwater Treatment Practices

- New Post-Construction Soil Quality and Depth Std.
- New stand-alone section for common pre-treatment practices with improved guidance for sizing
  - Grass Channel / Pre-Treatment Swale
  - Filter Strip
  - Sediment Forebay
  - Deep Sump Catch Basins
  - Proprietary Devices – allowed if performance can be independently verified

DRAFT Stormwater Manual Revisions – Stormwater Treatment Practices

- Non-structural practices move from optional credits to "acceptable non-structural stormwater treatment practices", with expanded guidance
  - Reforestation (new)
  - Simple (Rooftop) Disconnection
  - Disconnection to Filter Strips and Vegetated Buffers
  - Watershed Hydrology Protection (high-elevation projects)

DRAFT Stormwater Manual Revisions – Stormwater Treatment Practices

- Acceptable Structural Treatment Practices revised and expanded to include more GSI practices
  - Green Roofs (new)
  - Permeable Pavement and Reinforced Turf (new)
  - Rainwater Harvesting (new)
  - Bioretention Areas and Rain Gardens (expanded)
  - Wet Swales and Dry Swales
  - Infiltration Trenches and Basins
  - Filtering Systems
  - Treatment Wetlands
  - Wet Ponds

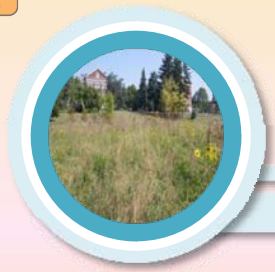
Timeline for Stormwater Manual Revisions

- DEC Stormwater Program staff are currently developing supporting information
- Draft manual anticipated to begin formal rulemaking process before 2016 Legislative session begins

Questions?

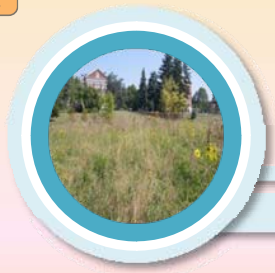
http://www.vtwaterquality.org/stormwater/htm/sw_manualrevision.htm

amacrellis@stone-env.com



Green Infrastructure: Partnerships

- Winooski Natural Resource Conservation District
- Friends of the Winooski
- Friends of the Mad River
- Mad River Valley Planning District
- CVRPC
- Vermont Agency of Natural Resources

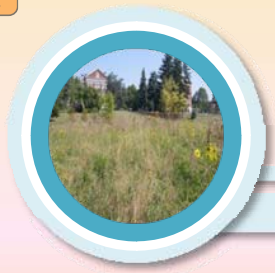


Green Infrastructure: getting your town started

- Town Offices as demonstration site
  - Rain barrel, rain gardens, vegetated swales, pervious concrete/asphalt pavers,
- Town lands for stormwater treatment
  - Constructed wetlands, large rain gardens
  - Be strategic in use of open space funds

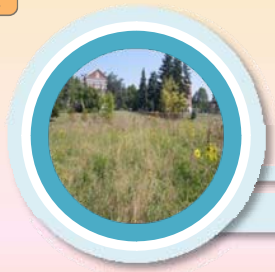
Green Infrastructure: getting your town started

- School Programming
- Green Up Day
- Workshops
  - Re-engineering your driveway
  - Installing a rain barrel and/or rain garden
  - Creating a rain-friendly property



Green Infrastructure: getting your town started

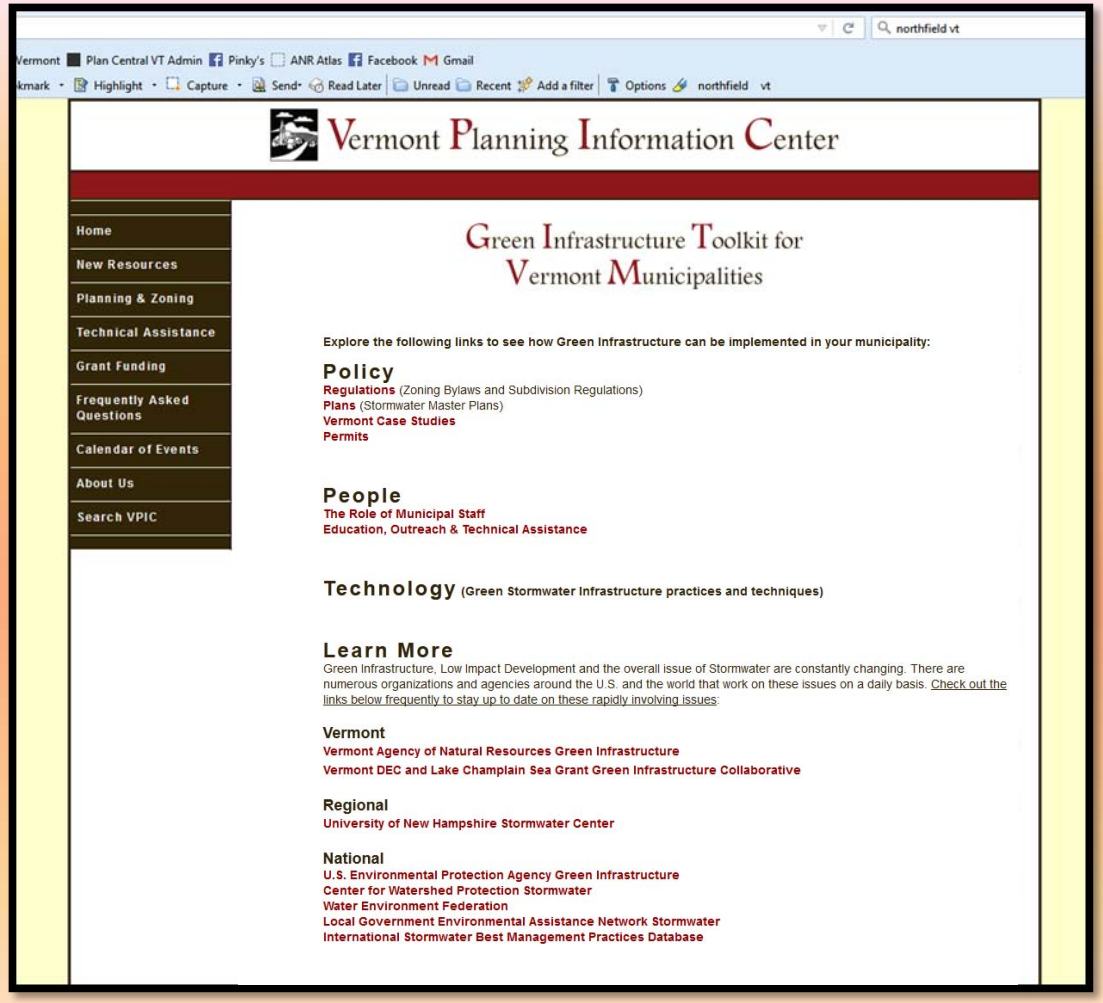
- Self-assessment checklists
- Review by RPC
- Work into town plan update
- Work into zoning bylaw update

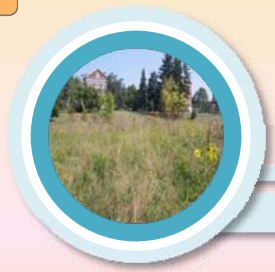


Green Infrastructure Toolkit

Vermont Planning Information Center (VPIC) website

http://www.vpic.info/GreenInfrastructureToolkit.html





Additional Resources

- Vermont DEC – Ecosystem Restoration Program
- Vermont DEC – Stormwater Program
- Vermont FPR – Urban and Community Forestry
- Vermont League of Cities and Towns
- VTrans - Better Backroads
- VTrans - Transportation Alternatives

Contact

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