Green Infrastructure Design
NYS -WRR

Shohreh Karimipour, P.E.
New York State Department of Environmental Conservation

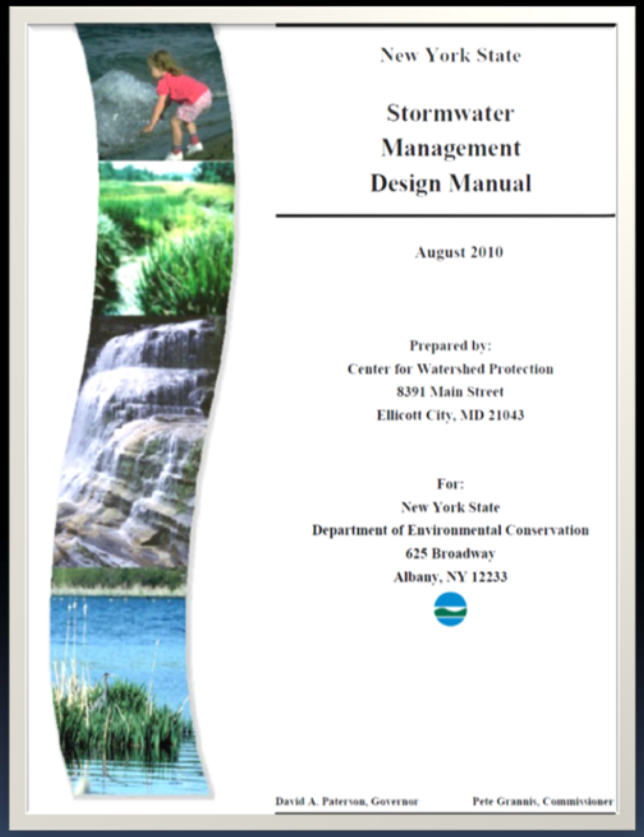
COMPUTATION METHODS

Computational Methods:

NYS Standards
NYC Watershed Rules and Regulations
Hydrology
Hydraulics
Water Quality
Modeling / Methodology

New York State Stormwater Management Design Manual

- First Release 2001
  - Volumetric Control of 90% Storm
  - Performance Criteria
    - 80% TSS & 40% P Removal
    - Accepted Treatment, Pretreatment, maintenance
  - Channel Protection and Flood Controls
- Sizing Criteria & Alternative Method
  - Water Quality Volume (WQv)*
  - Runoff Reduction Volume (RRv) for total WQv
  - Alternative method (WQv)
- Channel Protection
  - 1-yr 24 hr extended detention
- Flood Control**
  - 10 & 100 yr 24 hr peak rate
    - *small storm hydrology
    - ** TR-55, TR-20


New York State

Stormwater Management Design Manual

August 2010

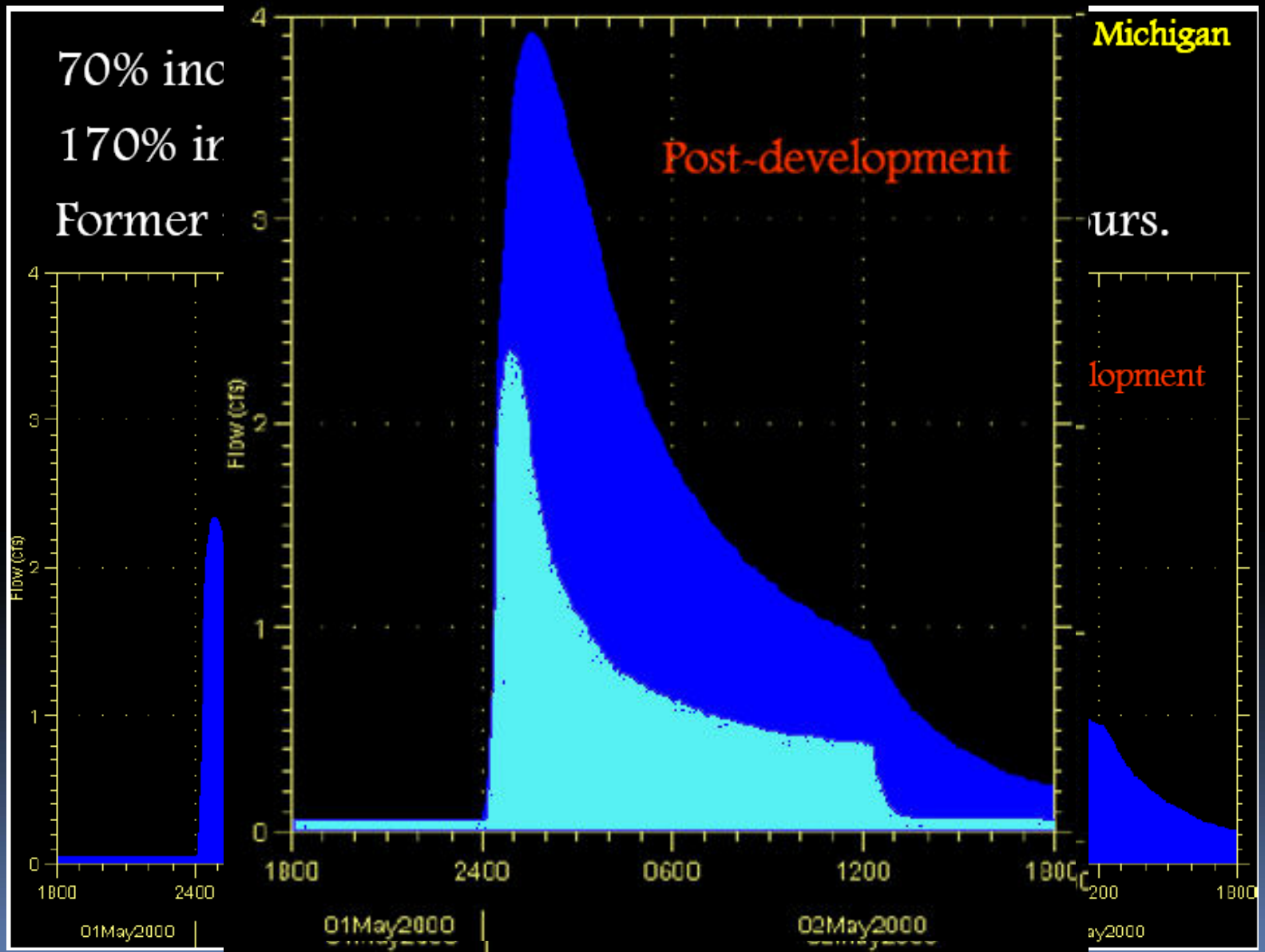
Prepared by:
Center for Watershed Protection
8391 Main Street
Ellicott City, MD 21043

For:
New York State
Department of Environmental Conservation
625 Broadway
Albany, NY 12233

David A. Paterson, Governor Pete Grannis, Commissioner

Water Quality Volume (WQv)	**90% Rule:** WQ_v(acre-feet) = [(P)(Rv)(A)] /12 Rv = 0.05+0.009(I) I = Impervious Cover (Percent) P(inch) = 90% Rainfall Event Number A = drainage area in acres
Runoff Reduction Volume(RRv)	RRv (acre-feet) = Reduction of the total WQv by application of green infrastructure techniques and SMPs to replicate pre-development hydrology . The minimum required RRv defined as the Specified Reduction Factor provided objective technical justification is documented.
Alternative Method (WQv)	Design, construct, and maintain systems sized to capture, reduce, reuse, treat, and manage rainfall on-site, and prevent the off-site discharge of the precipitation from all rainfall events less than or equal to the 95th percentile rainfall event, computed by an acceptable continuous simulation model.

Volume Control



Alternative Methods

- **Continuous simulation models**

  Utilize historical precipitation records for estimating runoff volumes, duration, and pollutant loading and examination of watershed parameters' responses to long term effects of storm events.

  - soil infiltration rate
  - storage in the porous system
  - evaporation /evapotranspiration
  - soil moisture accounting
  - subsurface flow
  - runoff formation
  - overflow control the design

Continuous Simulation Modeling Tools
SWMM (XPSWMM, PCSWMM, InfoSWMM)
HSPF
SUSTAIN
P8

Alternative Methods

- Natural hydrologic features in green roof, porous pavement, street planters, bio-retention, vegetative buffers
- The natural hydrologic processes must be correctly integrated in the model.
- Computational methods traditionally use curve numbers and coefficients.
- Variables such as storage, infiltration, evaporation, evapotranspiration, soil moisture accounting, subsurface flow, runoff and overflow are not equally captured in all methodologies.

NYC 2010 WRR Amendments

Section 18-16(a)(112) ~ 'Stormwater Management Practices'

- *Standard* practices per Chapter 5 of the April 2008 NYS SMDM:
  - Ponds; Wetlands; Infiltration systems; Filter practices; Open Channels

- **Section 18-39(c)(3) ~ 'Design Volume'**
- The volume of runoff from the 1-yr, 24-hr storm or the WQv (90% storm), whichever is greater, from the contributory drainage area(s)
-
- **Section 18-39(c)(6) ~ '20% Rule'**
  - Two different *standard* practices in series required for all drainage areas that are at least 20% impervious; except if:
    - an infiltration system utilized, or
    - project located in specific areas

NYC 2010 WRR Amendments

- **Section 18-39(c)(5) ~ 'Runoff Reduction'**
- To the extent practicable:
  - Minimize the alteration of drainage areas
  - Maintain runoff volumes at pre-construction levels
  - Maximize the infiltration where suitable soil conditions exist
-
- **Section 18-39(b)(3) ~ 'Peak Rate Attenuation'**
  - Peak discharges for the 10-yr & 100-yr, 24-hr storms attenuated to pre-development rates
- **Section 18-39(c)(7) ~ 'Detention Time'**
  - Detention time is the time runoff is detained in a stormwater practice calculated using the center of mass or plug flow method

Computational Methods:

Hydrology

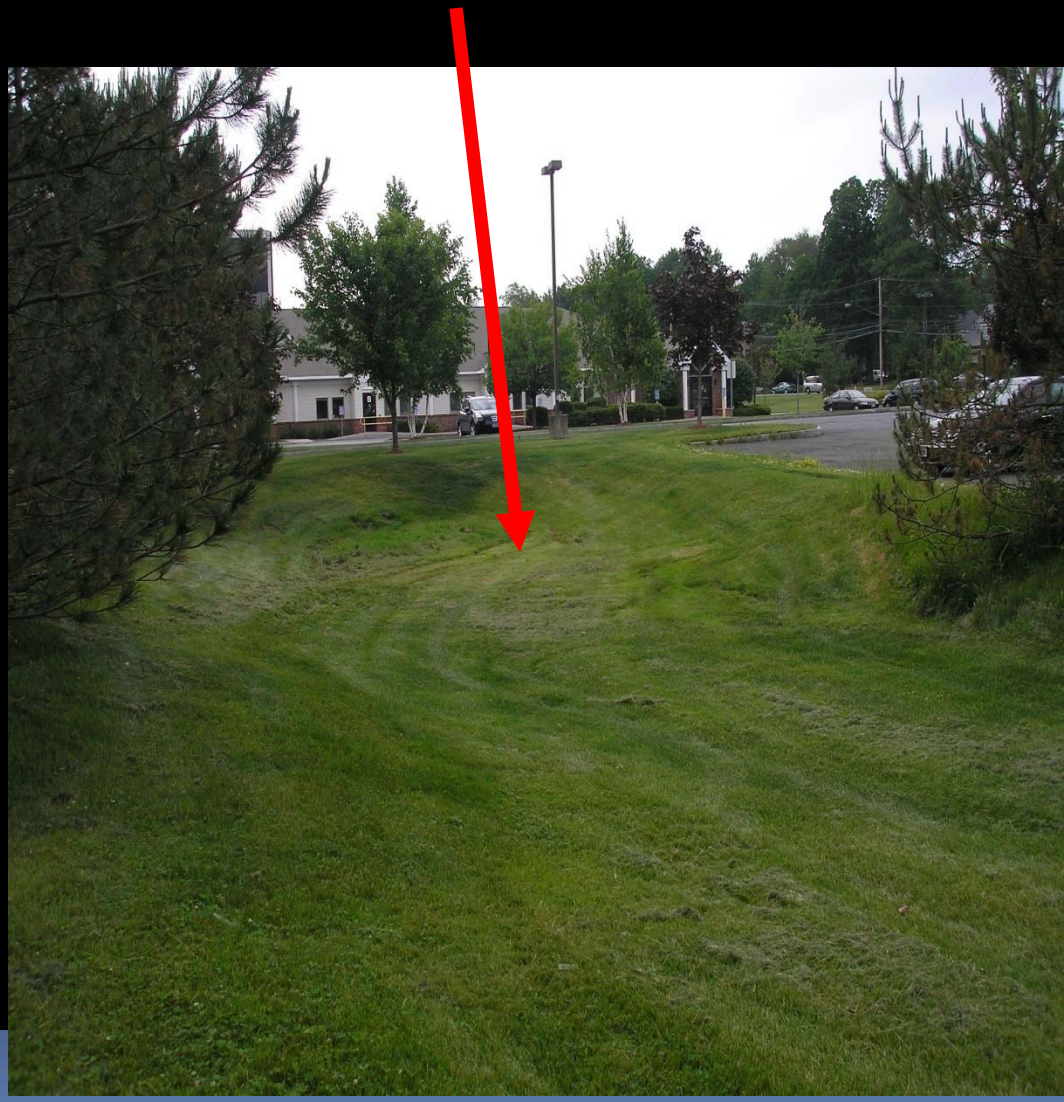
- Curve Numbers
- Travel Time/Time of Concentration
- Runoff Coefficients/Infiltration
- Evapotranspiration

Hydraulics

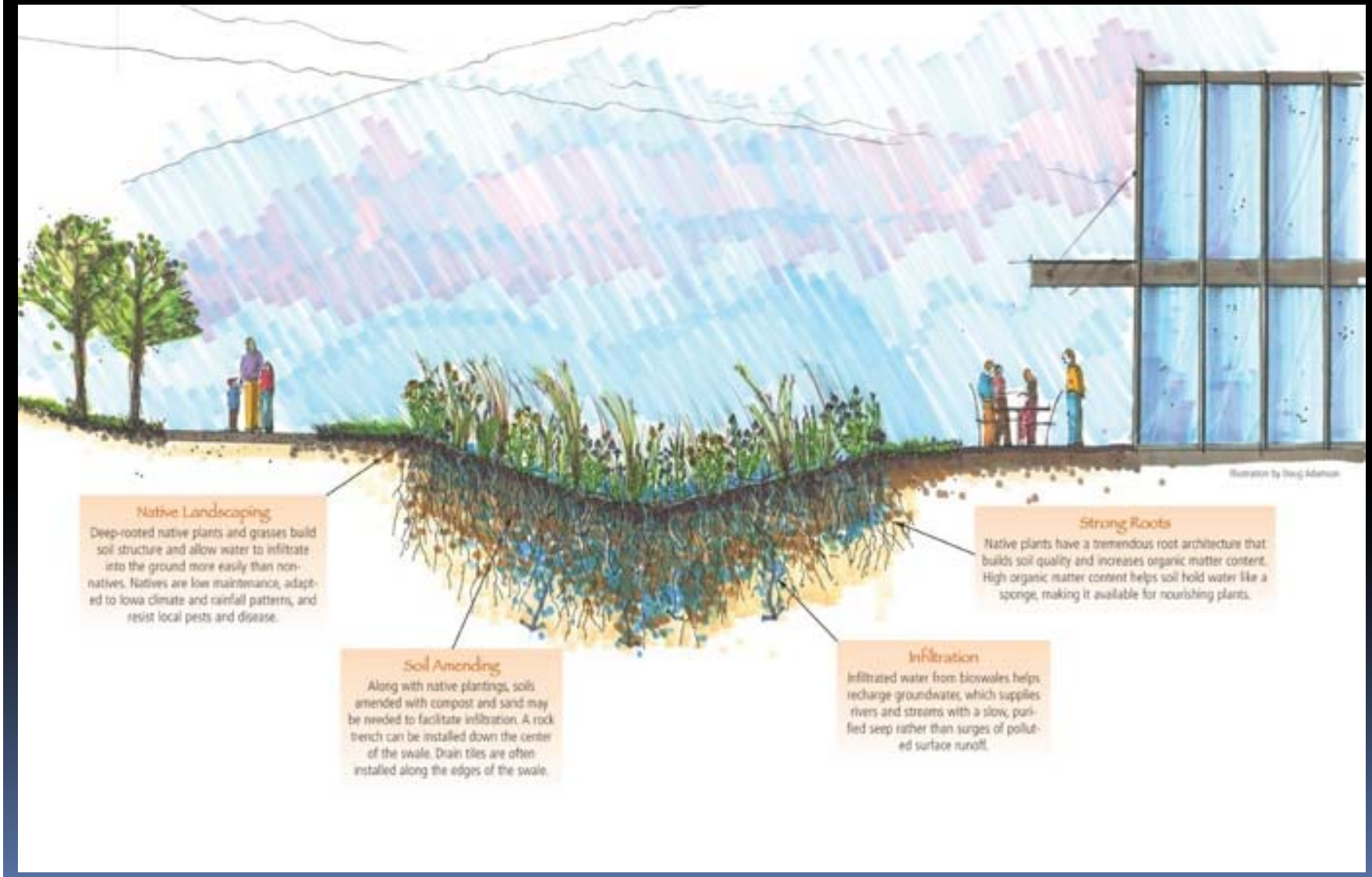
- Storage Routing
- Effective Capacity
- Drawdown Time
- Outlet Design/Underdrain pipe

Open Vegetated Channels

- Convey & treat runoff with:
  - Natural drainage paths
  - Properly designed & constructed channels
- On right-of-way
- Slopes, velocity, depth, travel time Manning's Equation



Bioswale


Native Landscaping
Deep-rooted native plants and grasses build soil structure and allow water to infiltrate into the ground more easily than non-natives. Natives are low maintenance, adapted to Iowa climate and rainfall patterns, and resist local pests and disease.
Soil Amending
Along with native plantings, soils amended with compost and sand may be needed to facilitate infiltration. A rock trench can be installed down the center of the swale. Drain tiles are often installed along the edges of the swale.
Infiltration
Infiltrated water from bioswales helps recharge groundwater, which supplies rivers and streams with a slow, purified seep rather than surges of polluted surface runoff.
Strong Roots
Native plants have a tremendous root architecture that builds soil quality and increases organic matter content. High organic matter content helps soil hold water like a sponge, making it available for nourishing plants.

Green Roofs Sizing

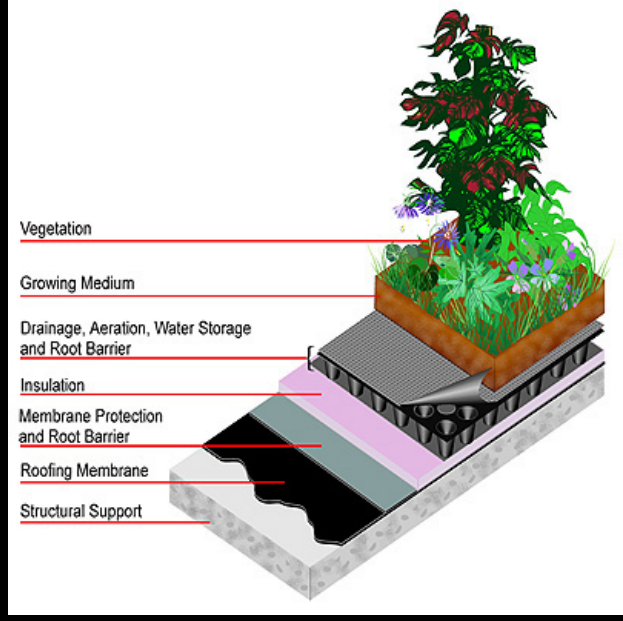
$WQ_v \leq V_{SM} + V_{DL} + (D_P \times A_{GR})$

V_{SM} = Volume stored in Soil media

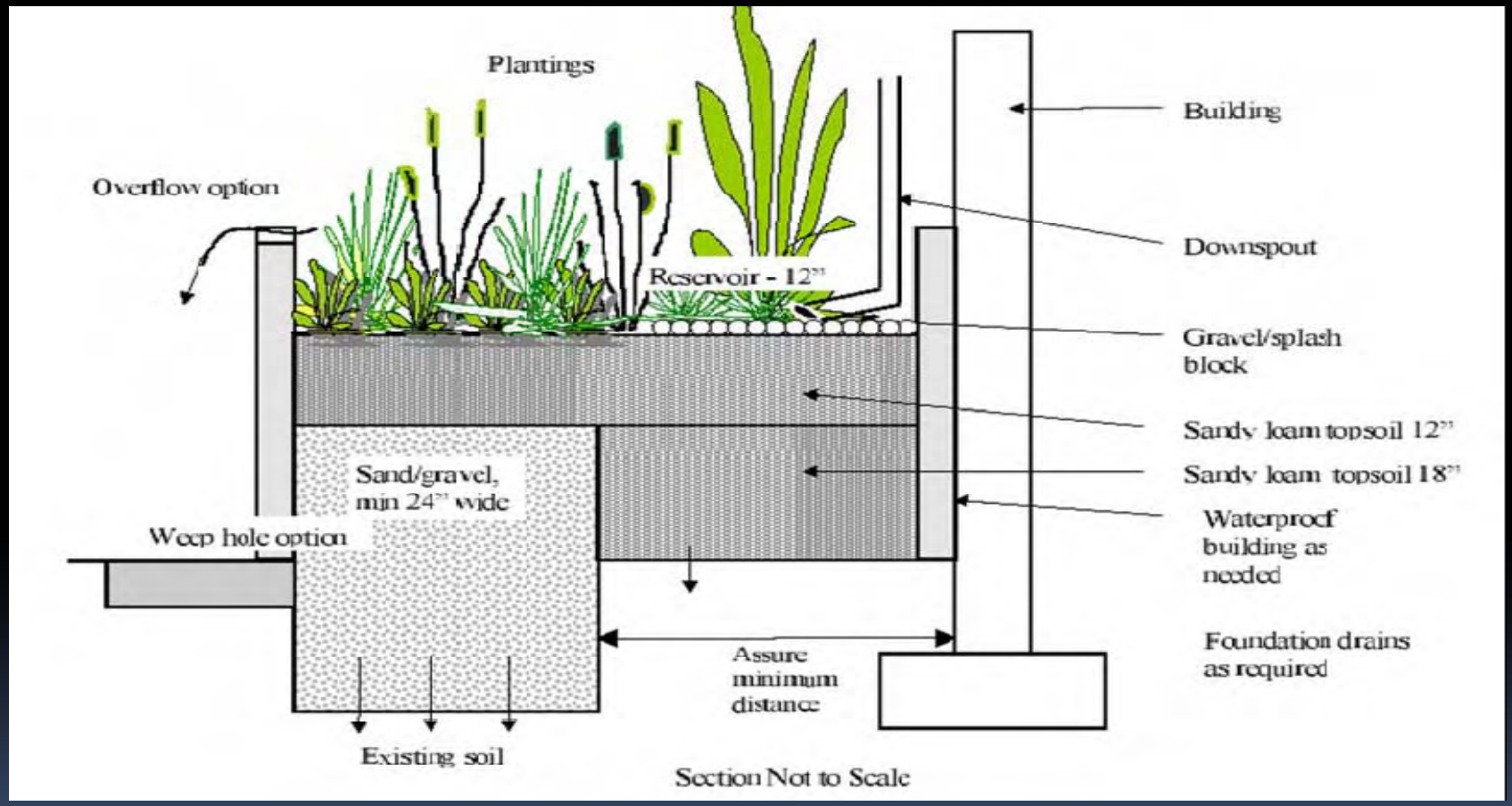
V_{DL} = Volume stored in drainage layer

D_P = Depth of ponding above surface

A_{GR} = Green Roof Surface Area



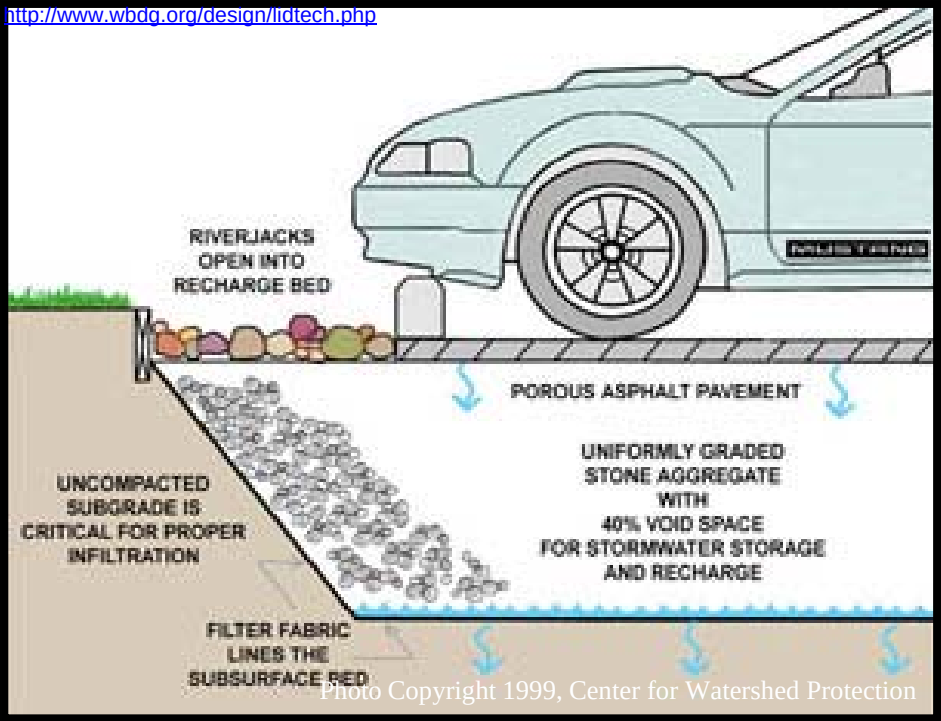
Stormwater Planters



Infiltration Stormwater Planter

Porous Pavement - Sizing

http://www.wbdg.org/design/lidtech.php



$$A_p = WQv/n \times d_t$$

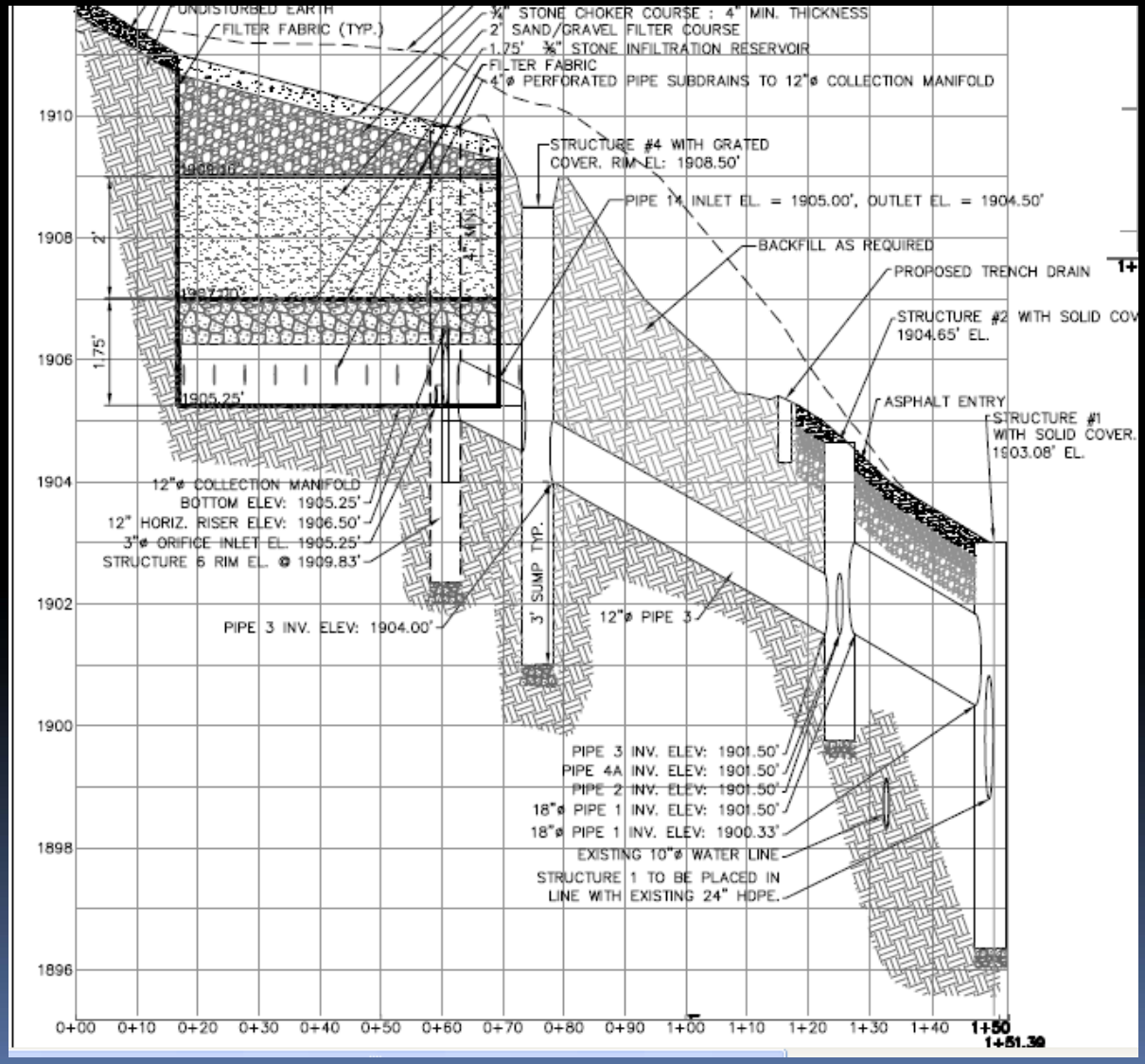
Ap = Porous Pavement Surface Area

WQv = Design Volume (cubic feet)

n = porosity of gravel bed/reservoir (0.4)

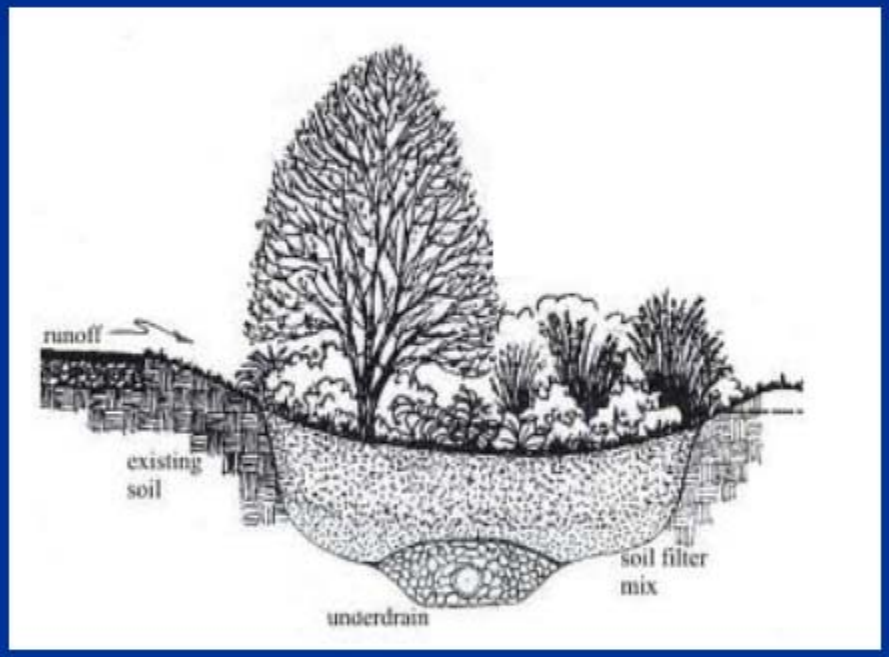
dt = depth of gravel bed (maximum 4 feet)

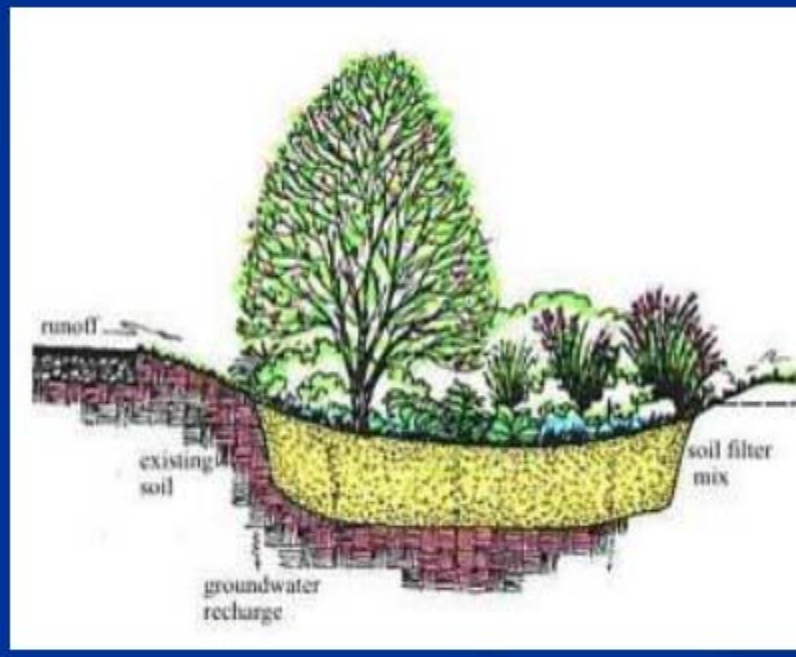
Outlet Structures



Outlet Structures

Filtration vs Infiltration





Underdrain Overflow/Diversion

Underdrained systems are flow-through systems, an
discharge water from even small 'design storms'.

Modeling Assumptions

- Modeling GI practices as ponding features and back calculation of a curve number seem reasonable.
- NRCS is the lead agency for the development of hydrologic methods to address modifications to some of the existing computational tools.
- Software tools such as HydroCAD may be consistent with a particular method (not defining regulatory requirements).
- TR-55 and TR-20 are not used for small storm hydrology for water quality calculations. Although use of GI is encouraged for CPv, reduced runoff and peak may not be as significant in larger storms.

Modeling Assumptions

- SMP modeling: Based on storage volume in the GI practices, provided the overflow is properly modeled.
- Large storms: Depending on the design, practices may wash out in higher intensity storms.
- Disconnection: Utilize the conventional method of disconnected areas in TR-55 to account for several green practices.

Modeling Assumptions
Runoff Reduction Coefficients

- Porous Pavement

Runoff Coefficient of Pavement Surface	
Aggregate	0.3 to 0.7
Turf > 50%	0.05 to 0.53
Open joint blocks	0.30 to 0.50
Porous asphalt	0.12 to 0.40

-Fergeson (2005)

- Green Roof

Roof type	**Runoff (percent)**
Standard	81
Standards with 2" gravel	77
Green roof with 2" substrate	50
Green roof with 4" substrate	45
Green roof with 6" substrate	40

– Montens et al. (2003)

Modeling Assumptions Time of…

- Travel time
- Time of concentration
  - Variables in Tc calculation can be utilized to model a longer travel time.
  - Reach length, slope, velocity….
- Dewatering Time
  - Infiltration dependent

Modeling Methods

UNH Stormwater Center

- Calculated CNs by three methods:
  - Depth of runoff
  - Reduction in peak flow
  - Lag (L)

LID Center

- An area-weighted CN is used for the drainage area
- A CN value of 98-100 for bioretention surface

Maryland Curve Number Reduction

- Using RCN to estimate precipitation for alternative surfaces areas
- A composite value using the effective RCNs
- Reduced RCNs for each HSG for rainfall below target

Virginia Method

- Spreadsheet calculation
- Adjusted Volume, Rv and CN

Summary

Computational methods for hydrologic analysis, hydraulic function, and treatment performance of green infrastructure vary depending on the complexity of the design and modification to existing methods and development of new tools advance as green infrastructure becomes mainstream.

Thank You!

Questions