Soil-The Critical Element in Stormwater Design

Robert G. Traver, Ph.D., PE, D.WRE

Villanova Urban Stormwater PartnershipVUSP
Department of Civil and Environmental Engineering

Villanova University

Mission Statement

*The mission of the Villanova Urban Stormwater Partnership is to advance **sustainable** stormwater management practices and to foster the development of public and private Partnerships through research on innovative stormwater best management practices, directed studies, technology transfer, and education.*

- *Research and directed studies emphasize sustainable stormwater management planning, implementation, and evaluation*
- *Technology transfer provides tools, guidance, and education for the professional*
- *The goal of the partnership is to promote cooperation amongst the private, public and academic sectors*

CICEET

Corporate Partners

Down To Earth Design

Baker

Philadelphia PWD Water Department

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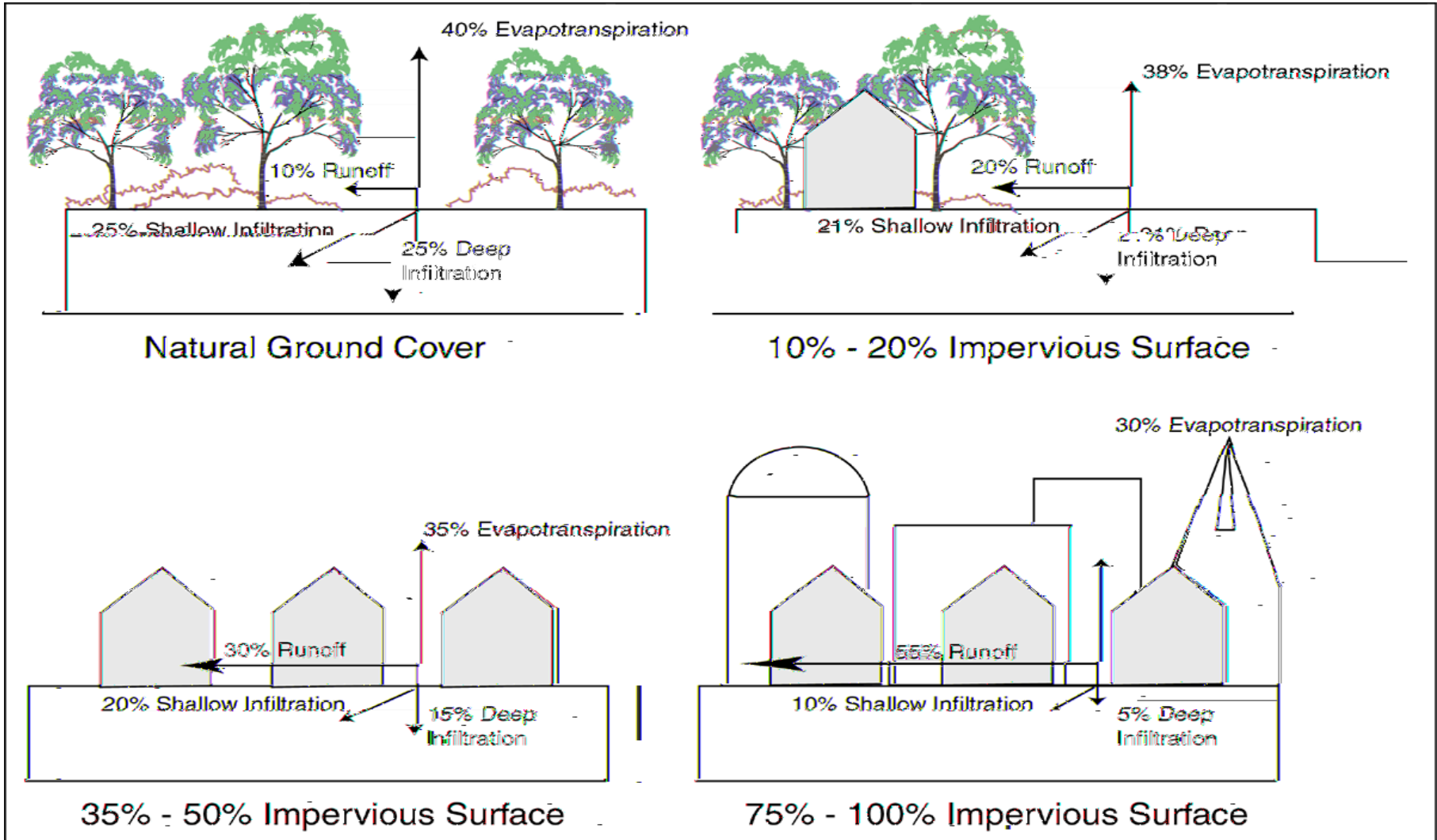
Imperviousness vs. Runoff



Changes in runoff flow resulting from increased impervious area (NC Dept. of Nat. Res. and Community Dev., in Livingston and McCarron, 1992.)

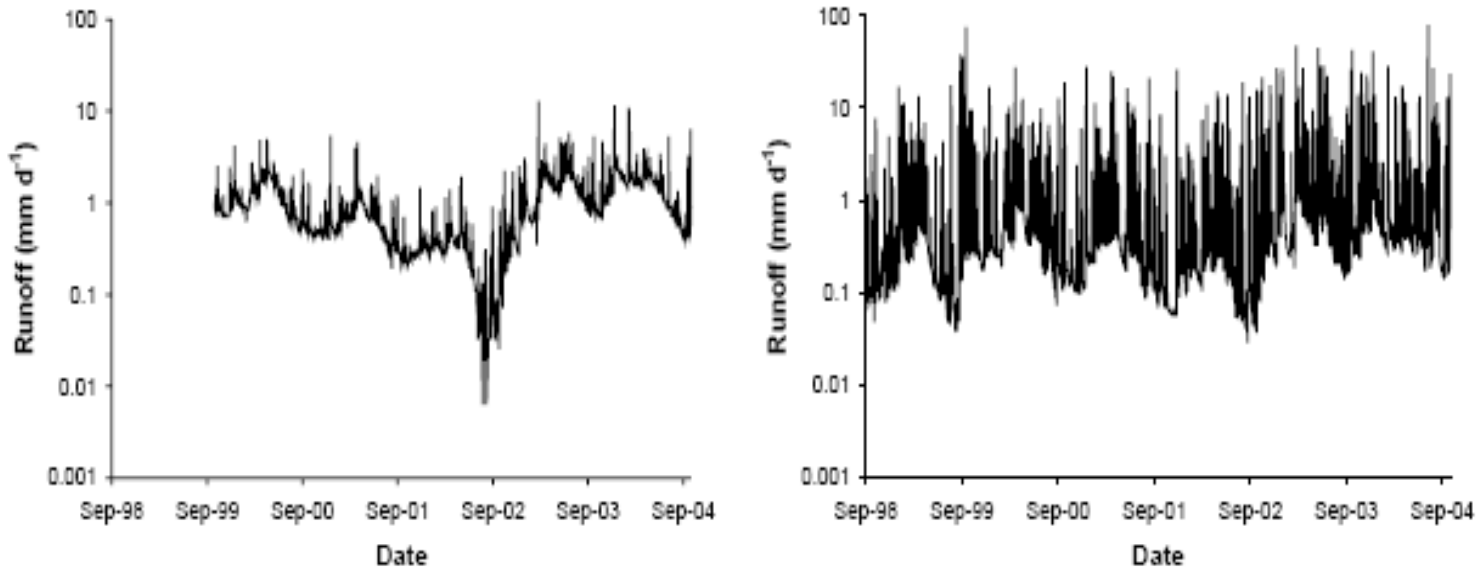
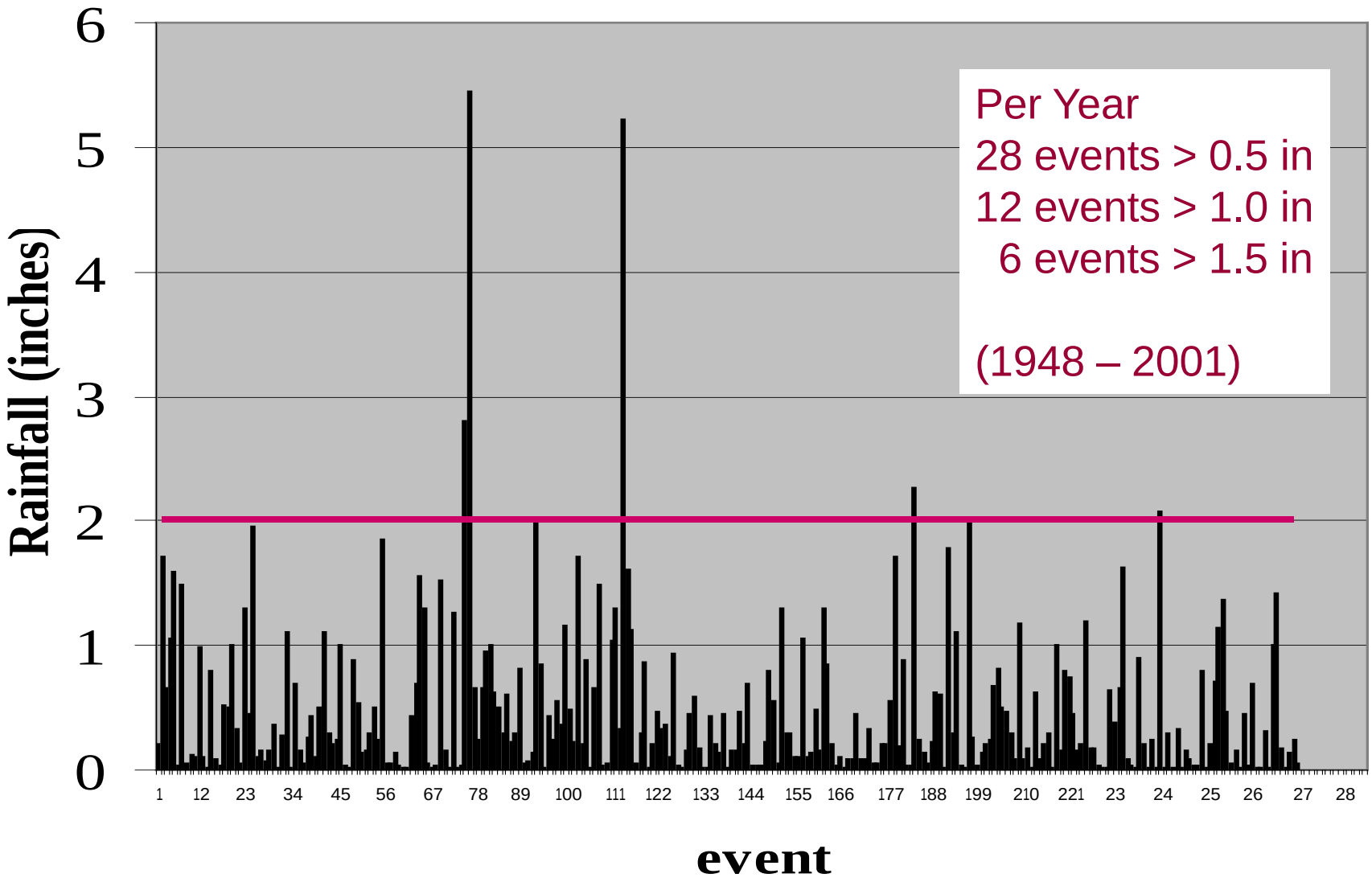
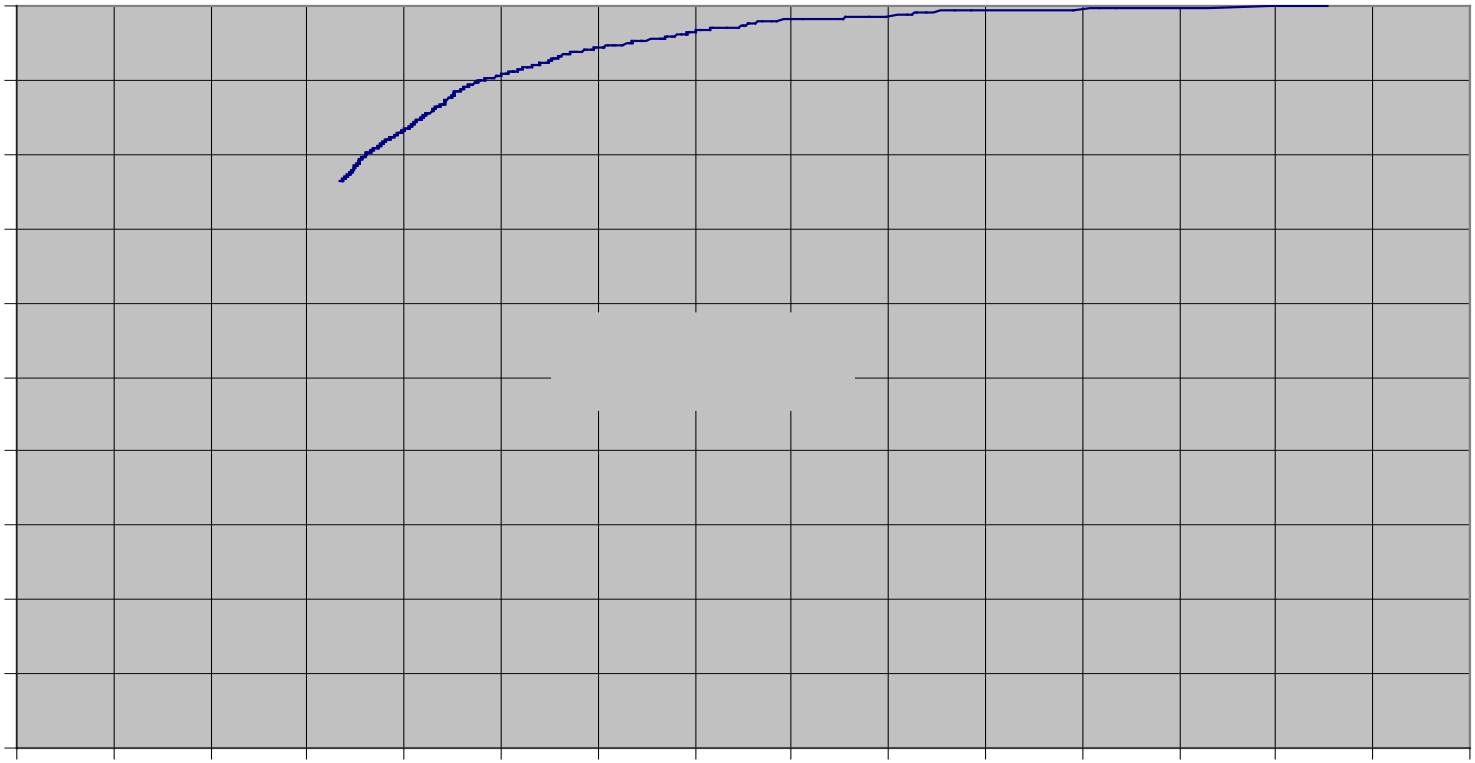


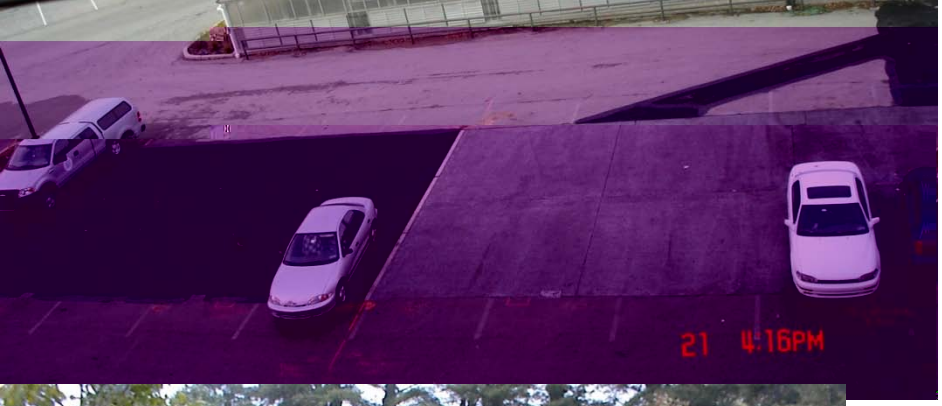
FIGURE 3-12 Daily time series of flows in (A) a low-density suburban and forested catchment (Baisman Run, http://waterdata.usgs.gov/md/nwis/uv/?site_no=01583580) and (B) a catchment dominated by medium to high-density residential land cover and land use (Read Run, http://waterdata.usgs.gov/md/nwis/uv/?site_no=01589330). Both lie within the Piedmont physiographic province.

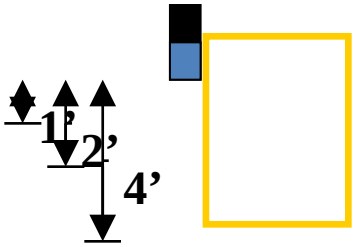
National Academies 2008

Chadds Ford 1999-2001 Depth (in.)



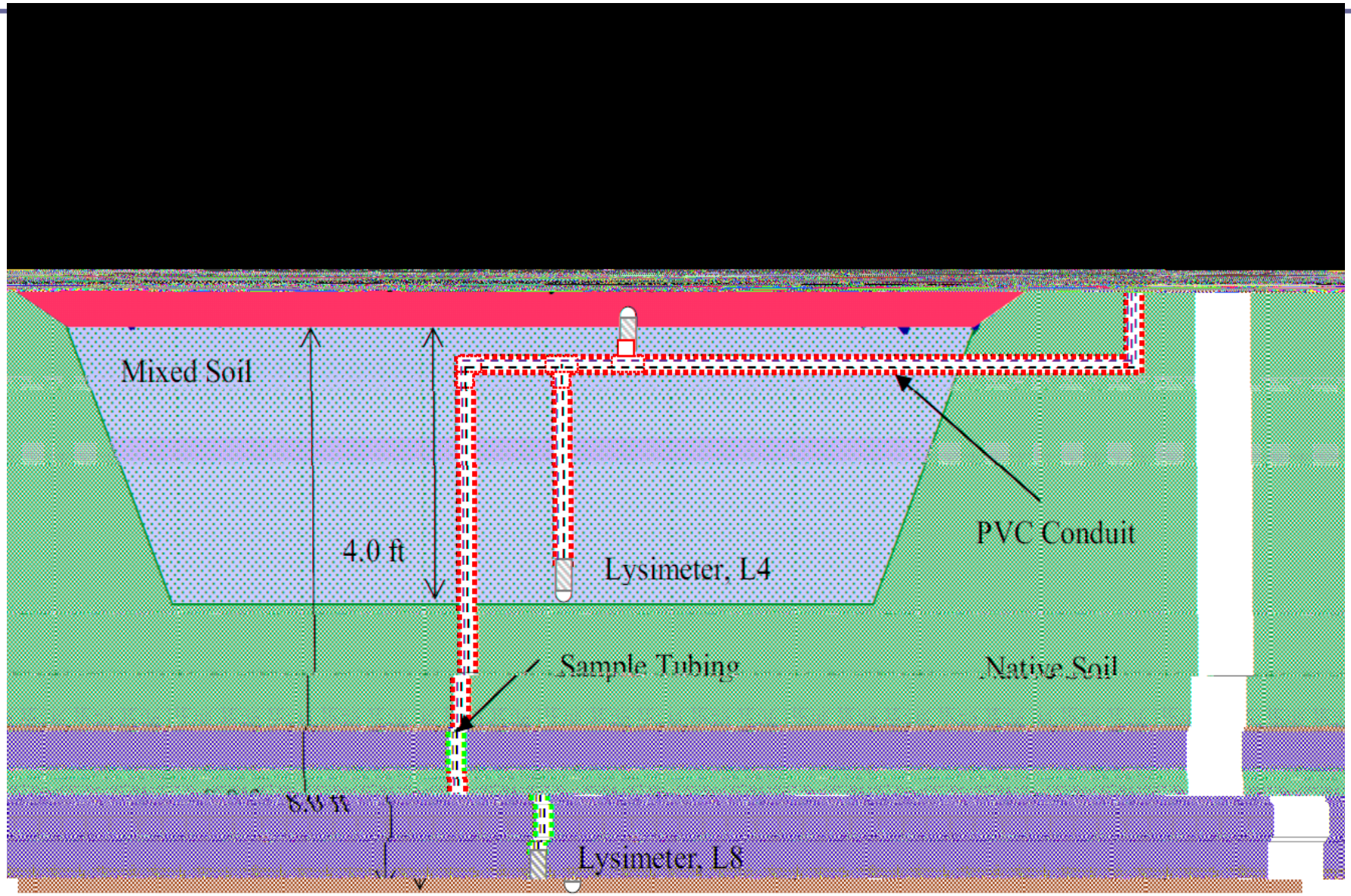


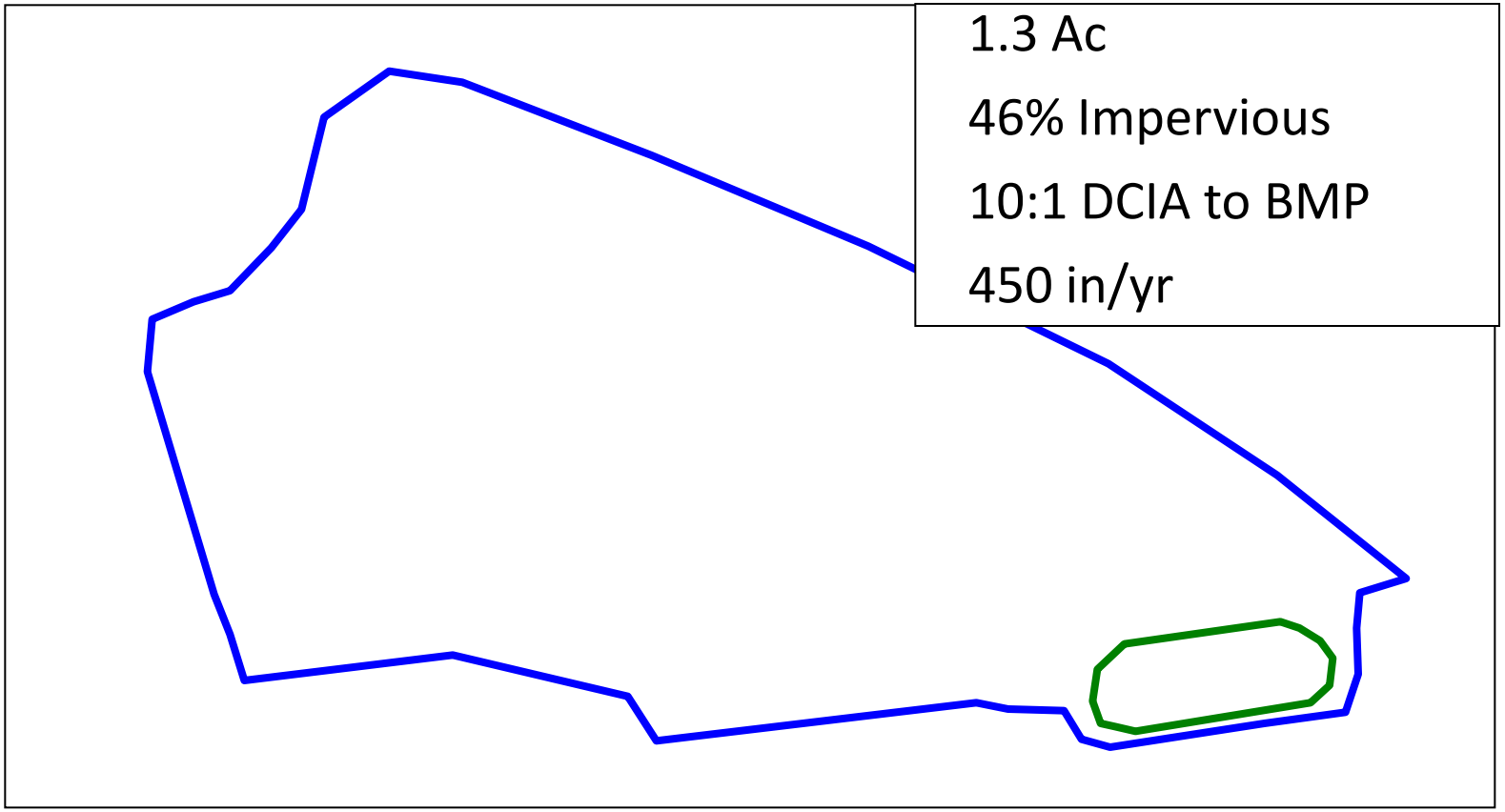

21 4:16PM


1'
2'
4'

BioInfiltration Rain Garden

Profile


Mixed Soil
4.0 ft
Lysimeter, L4
PVC Conduit
Sample Tubing
Native Soil
8.0 ft
Lysimeter, L8

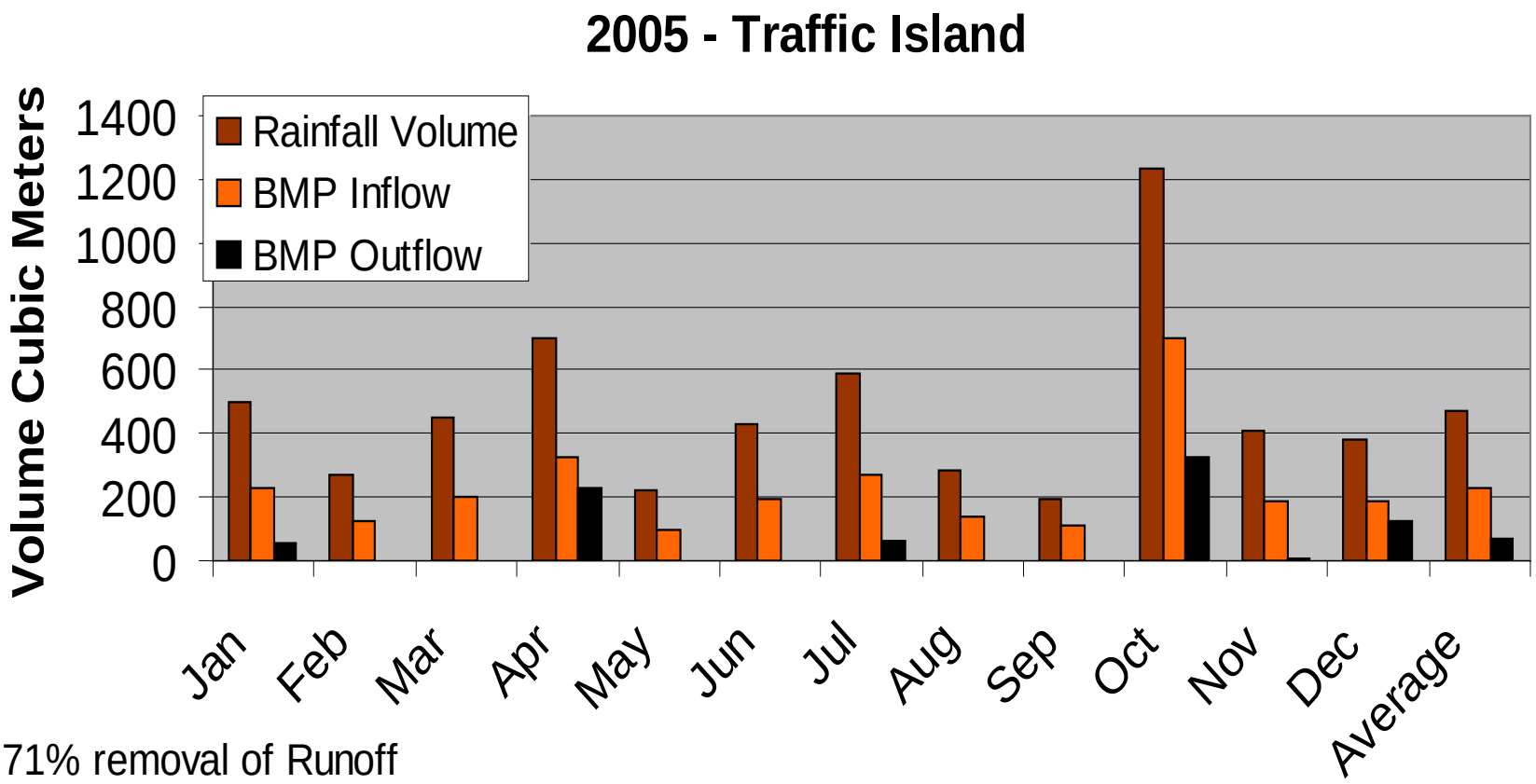

1.3 Ac
46% Impervious
10:1 DCIA to BMP
450 in/yr

Constructed in 2001

~4 ft excavation, filled with a 1:1 sand/soil mixture

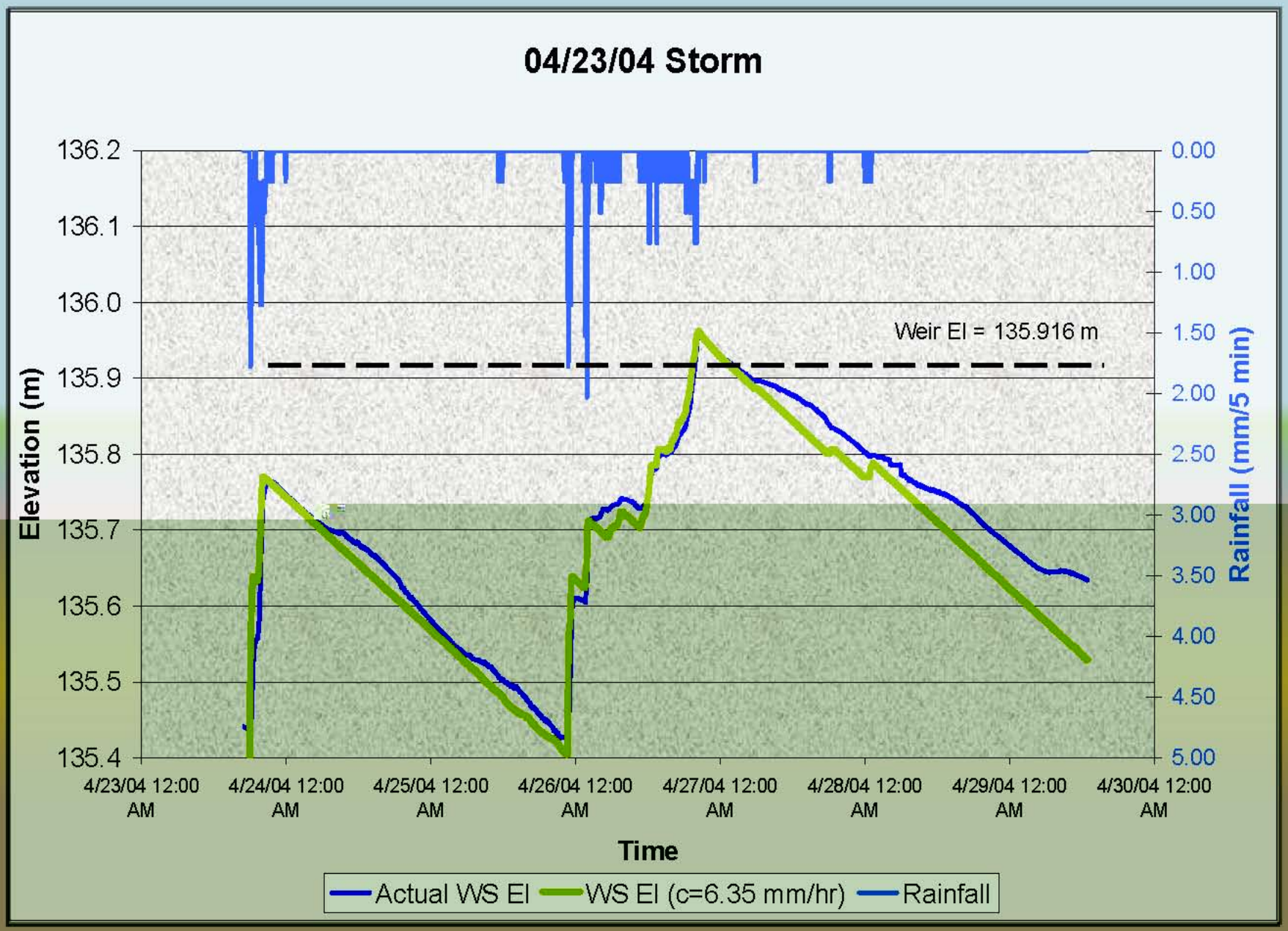
Planted with vegetation typically found along the eastern seaboard

Hydrologic Performance



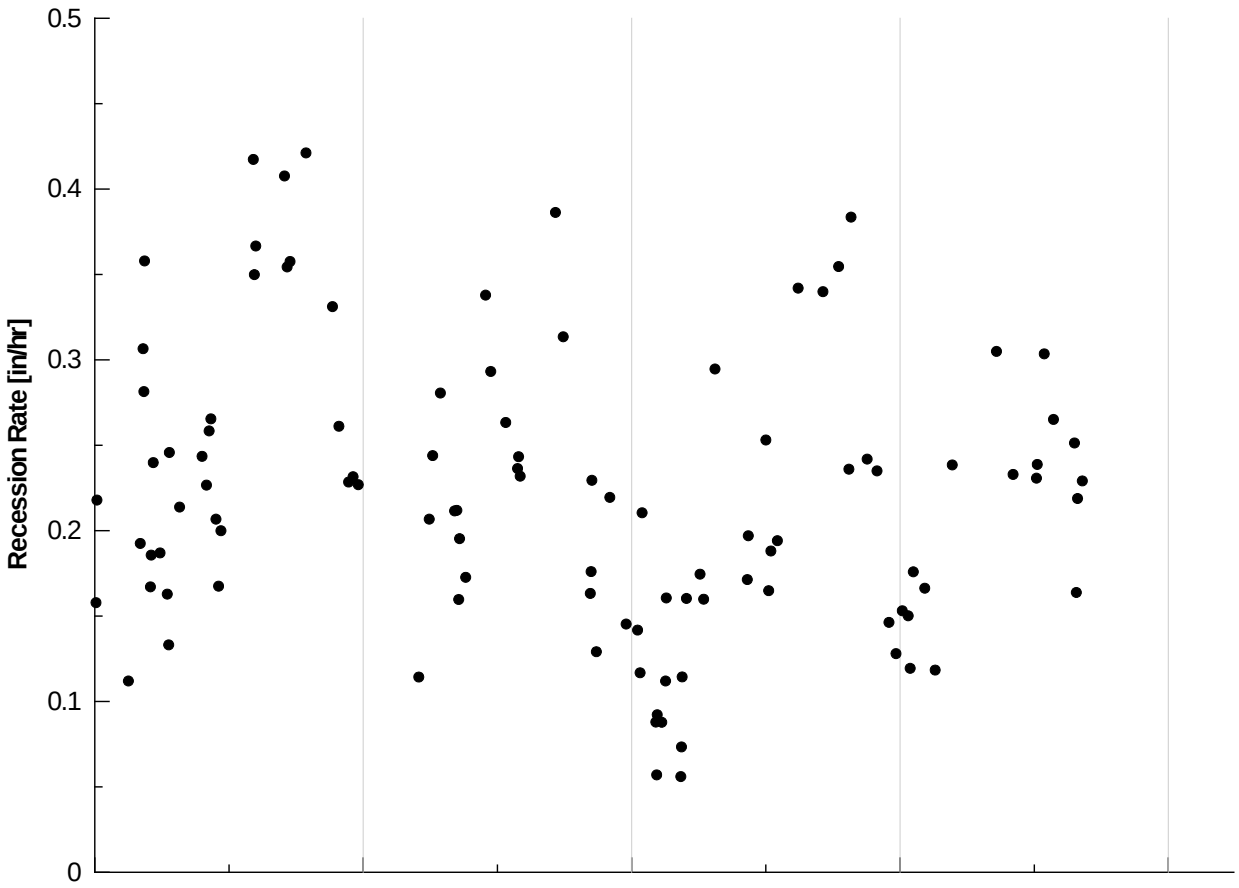
71% removal of Runoff
86% removal of Rainfall

2007 Traffic Island Surface Water Analysis				
	# of Storms	Inflow	Outflow	Removal Efficiency
Water Quantity (1/2007 - 12/2007 Total)	19	983,843 L	185,117 L	81.2%
Water Quantity (1/2007 - 12/2007 Sampled)	17	943,874 L	185,117 L	80.4%
Total Phosphorus (TP) as P	17	614.4 g	142.4 g	76.8%
NO2 as N	16	55.0 g	13.6 g	75.2%
NO3 as N	16	505.3 g	46.7 g	90.8%
Phosphate (PO4) as P	16	131.0 g	30.7 g	76.6%
Chloride (CHL)	16	325.7 kg	0.3 kg	99.9%
Total Suspended Solids (TSS)	17	187.7 kg	1.4 kg	99.3%
Total Dissolved Solids (TDS)	17	156.2 kg	7.2 kg	95.4%
Total Copper	8	21.0 g	2.3 g	89.0%
Total Lead	10	13.5 g	0.7 g	94.7%
Total Cadmium	10	1.9 g	0.1 g	97.3%
Total Chromium	12	21.8 g	0.8 g	96.1%



William Heasom

Temperature Variation



BTI (4.25 years of data)

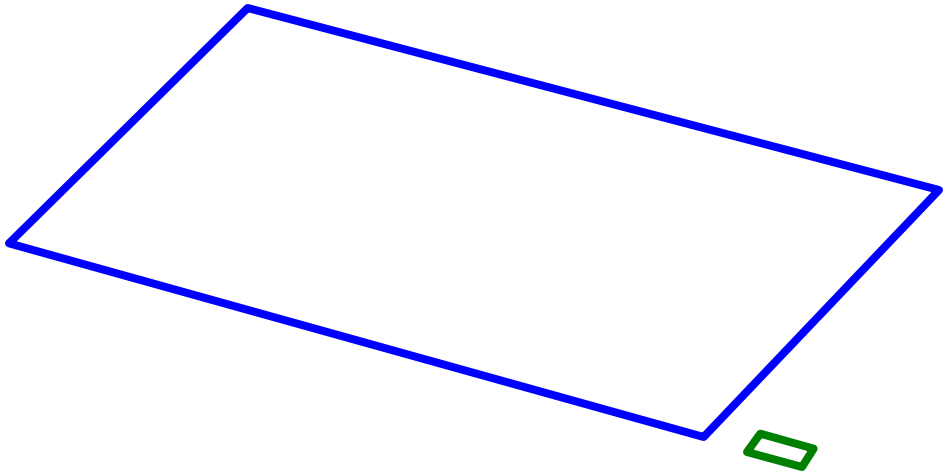
Infiltration Trench (IT)

0.47 Ac

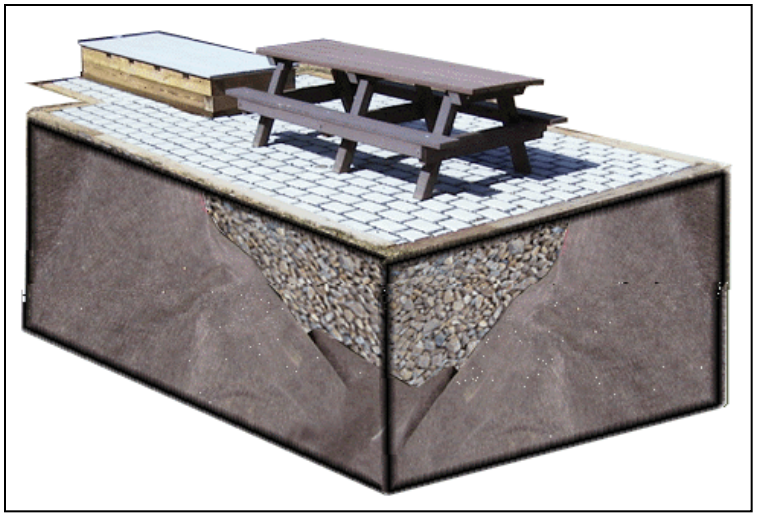
100% Impervious

130:1 DCIA to BMP

5,900 in/yr



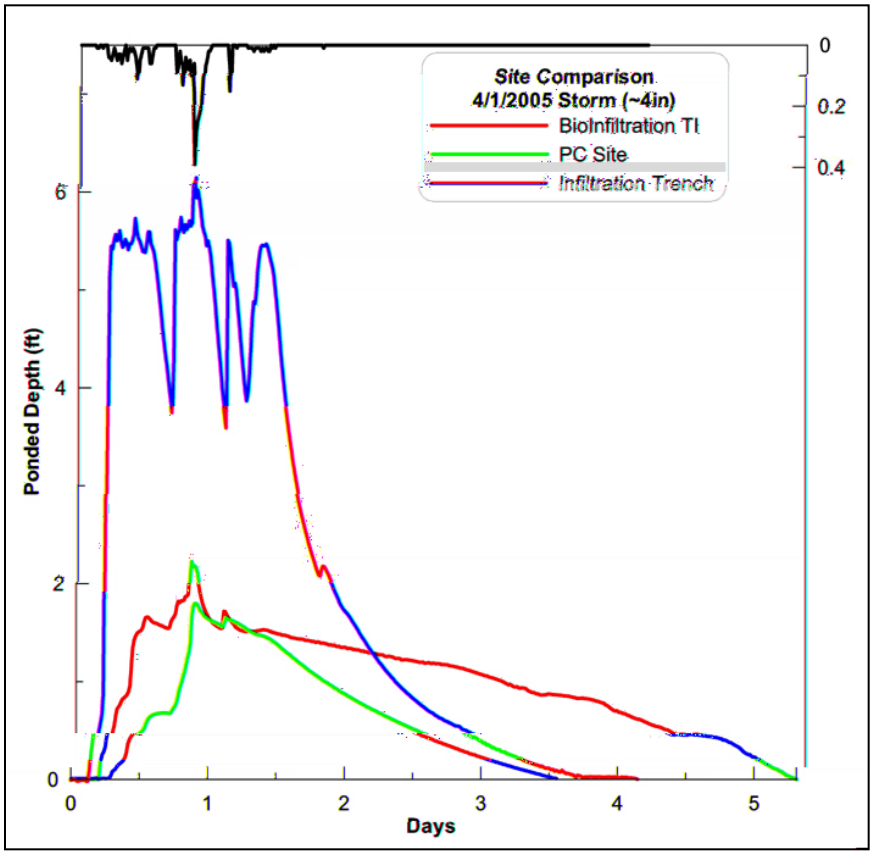
Infiltration Trench (IT)



Depth measured using a pressure transducer

Rainfall and temperature measurements

Intentionally under (poorly) designed…

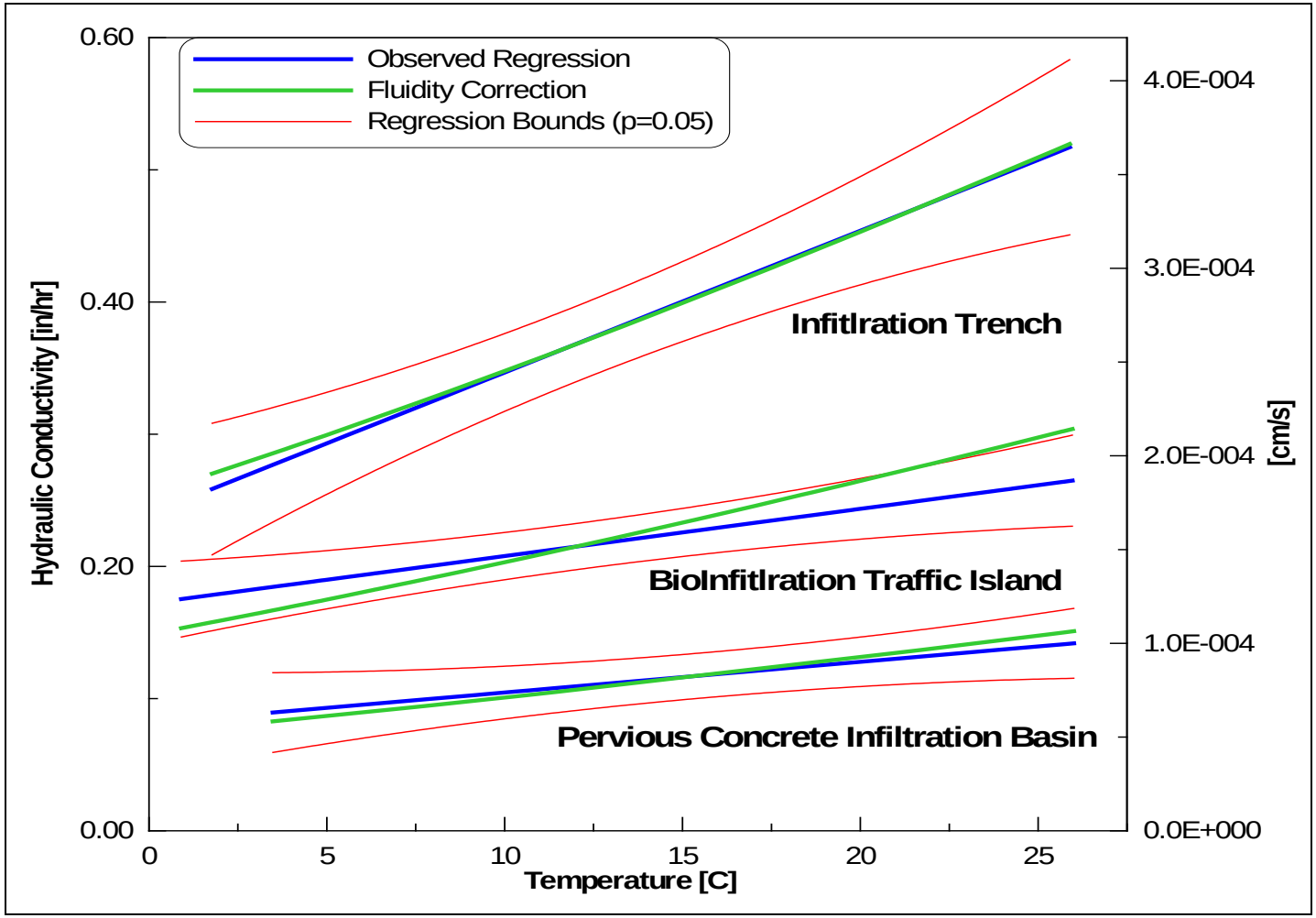


Not always constant with depth

Each BMP has its own characteristic recession limb (shape) from storm to storm

Can be compared over time (longevity)

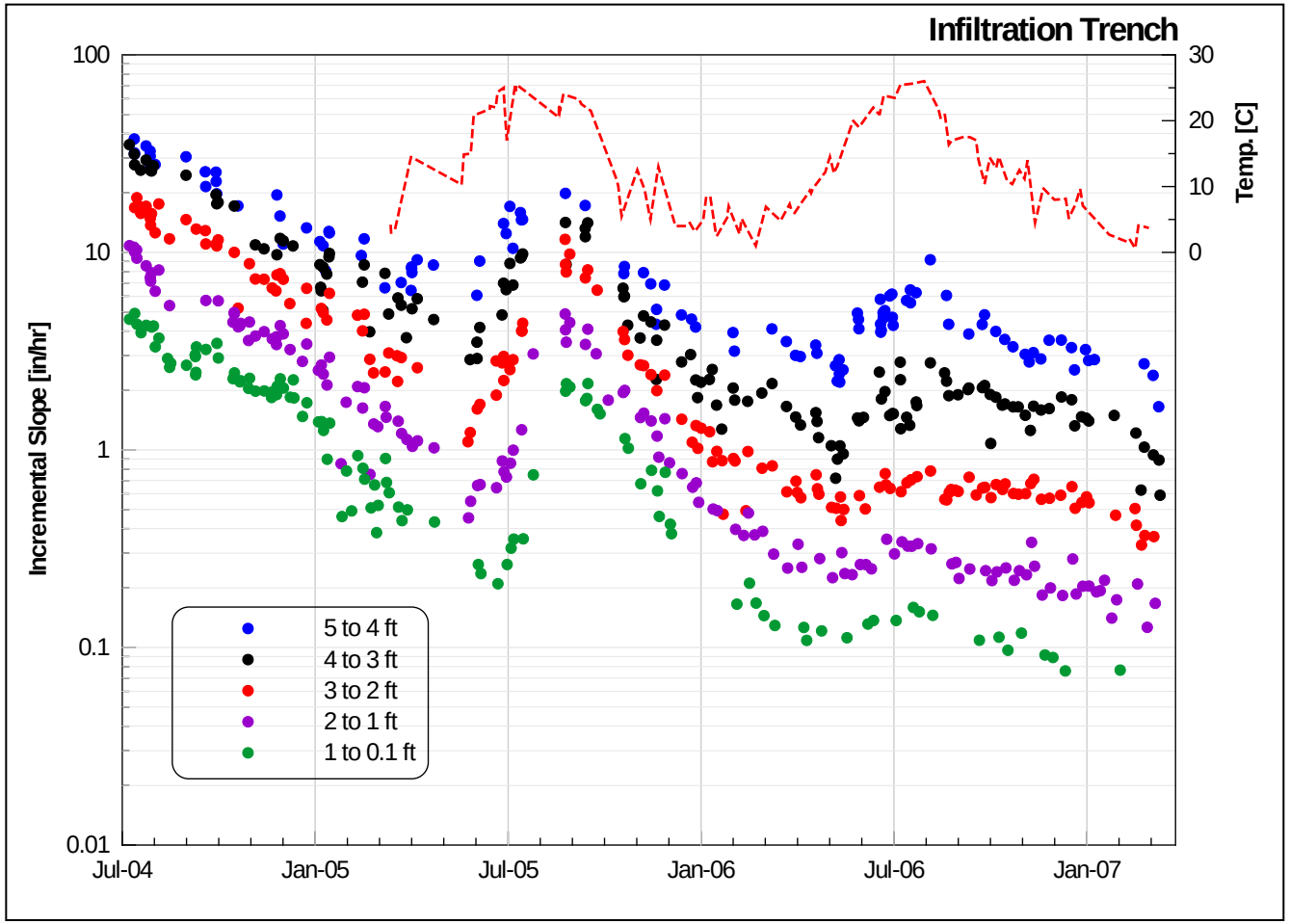
Emerson


Observed Regression
Fluidity Correction
Regression Bounds (p=0.05)
Infitlration Trench
BioInfitlration Traffic Island
Pervious Concrete Infiltration Basin
Hydraulic Conductivity [in/hr]
[cm/s]
Temperature [C]
0.60
0.40
0.20
0.00
4.0E-004
3.0E-004
2.0E-004
1.0E-004
0.0E+000
0
5
10
15
20
25

Infiltration Trench (IT)

Emerson

(log scale)



Extremely high (130:1) ratio of DCIA to BMP area

Inflow with characteristically high TSS concentrations

Closed bed, no vegetation, mulch, organic matter, or freeze-thaw

Deep and Sediments-Danger!

No Maintenance

Low (3-6:1) ratio of DCIA to BMP area

Inflow with characteristically low TSS concentrations

PC Filter

Shallow bed

Closed bed, no vegetation, mulch, organic matter, or freeze-thaw.

Heavily vegetated, Protective mulch layer, High organic matter content in surficial soil

Shallow bed

Freeze-thaw action

Can be maintained

Moderate (~10:1) DCIA to BMP ratio

Emerson

Performance Mis? Perceptions

- PGC Md, Galli 1993
  - > 60 Infiltration (mostly trenches)
  - Most not working as designed
  - Listed sediment in pre treatment, location, construction and
  - (
- Subu
  1992
  - 1
- > ½ f

Washington State Hilding 1996

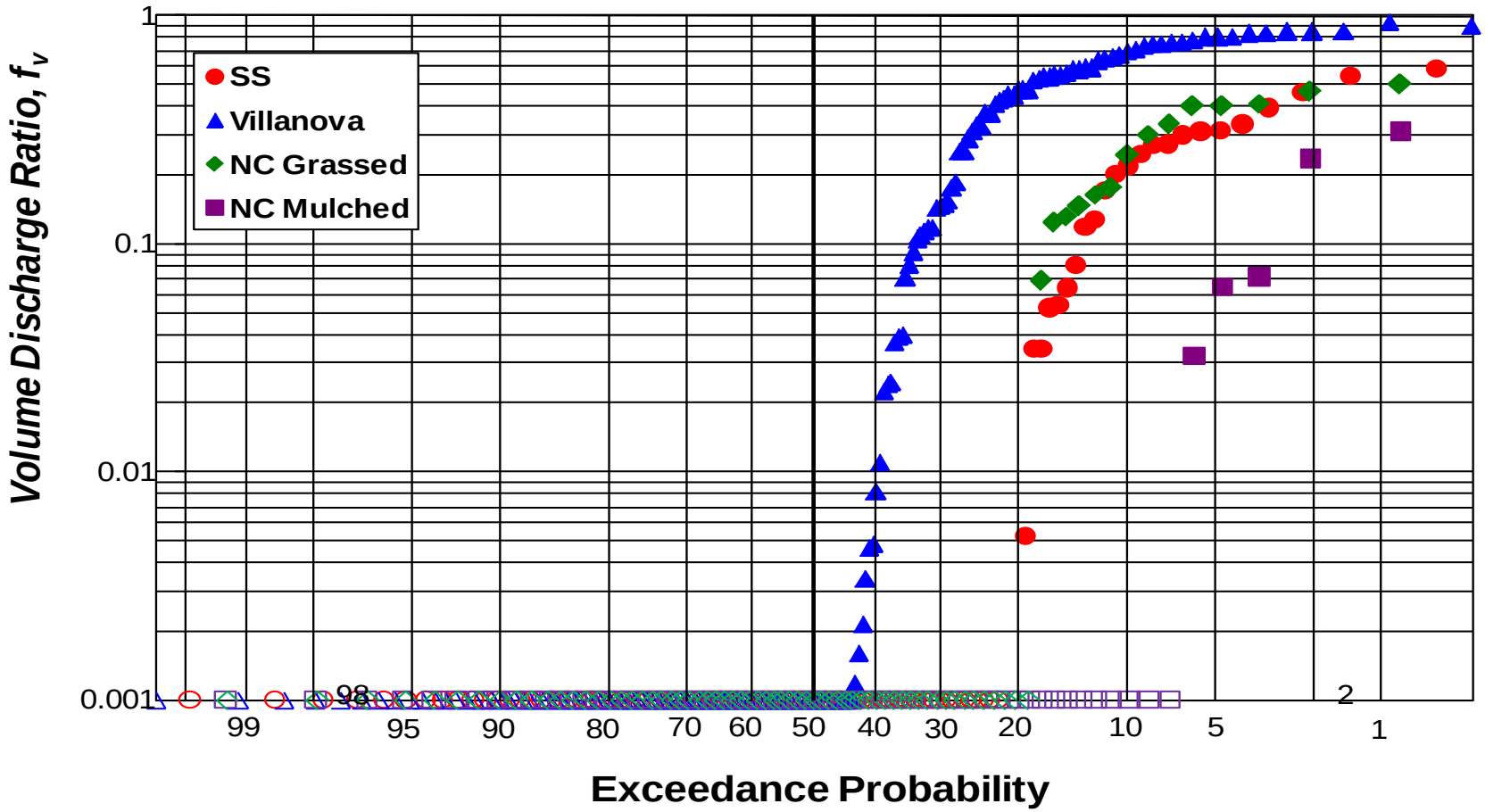
- Majority working
- 1/3 had sediment buildup

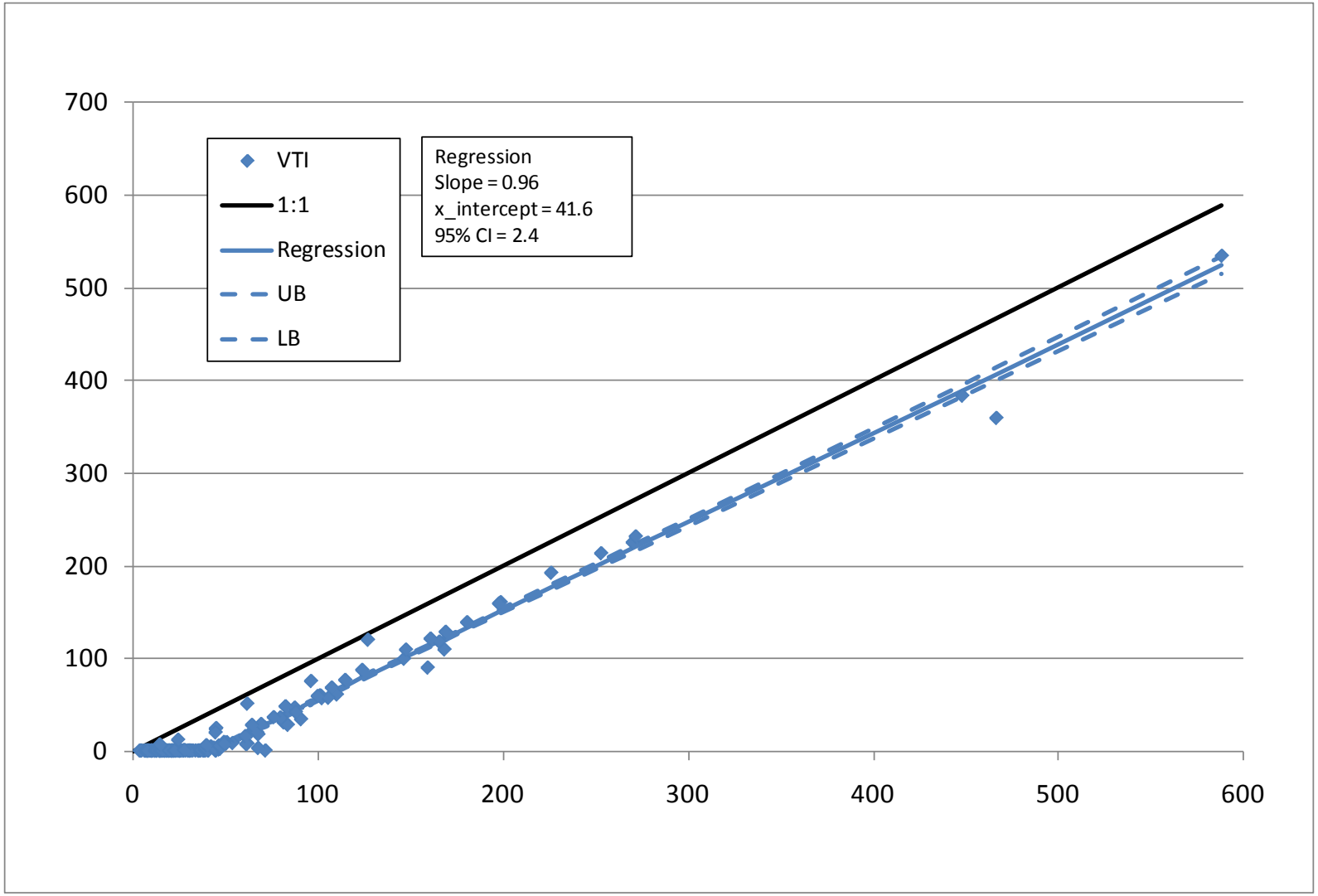
NJ Pine Barrens Princeton Hydro, LLC 2005

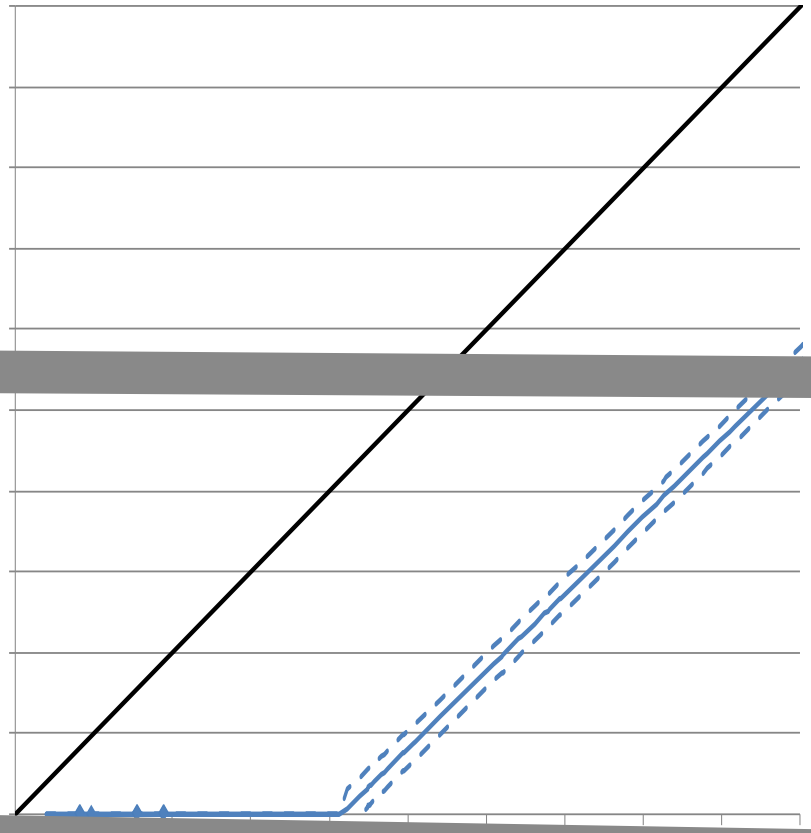
So, if you locate, design, construct, and maintain poorly.....

It will WORK 50% of the time.....

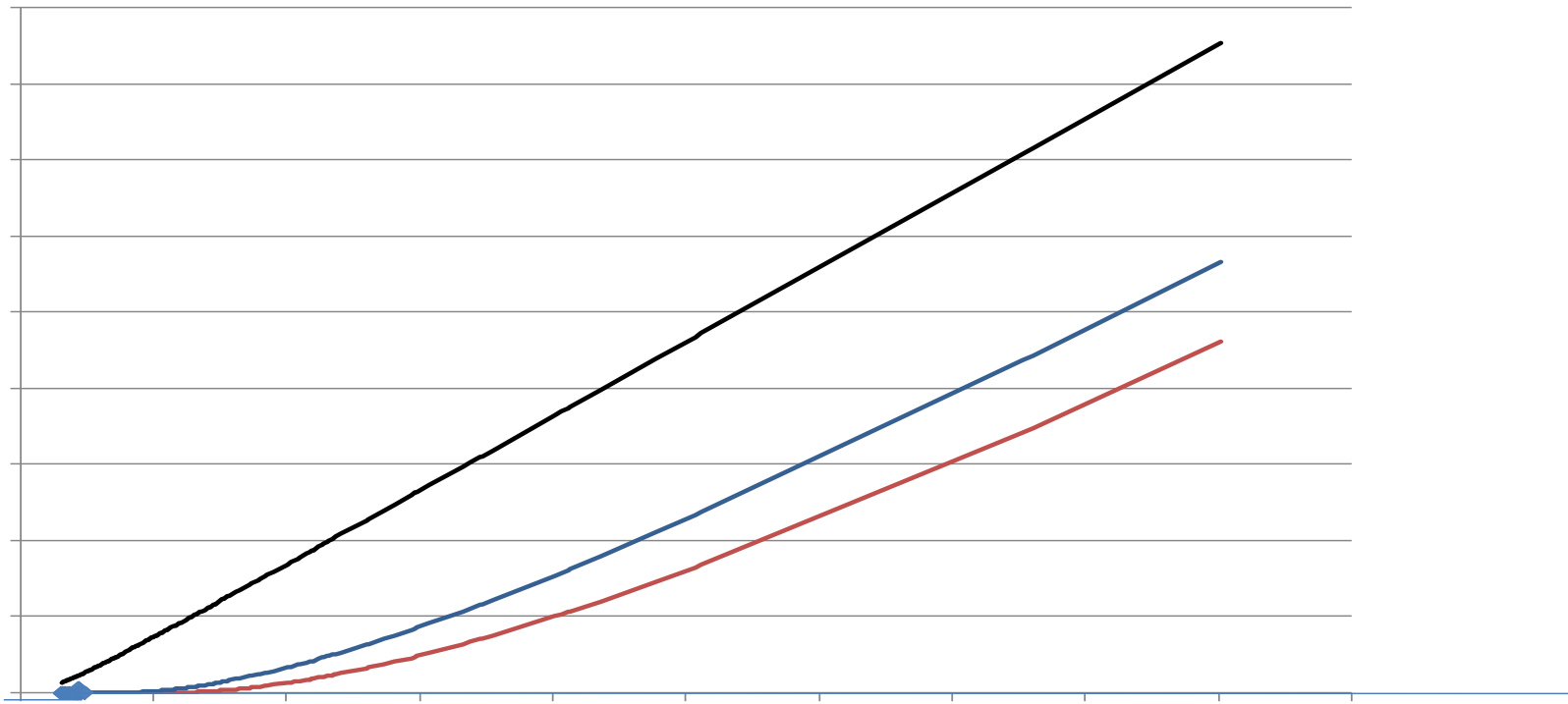
Villanova Seepage Pit


SS
Villanova
NC Grassed
NC Mulched
Volume Discharge Ratio, f_v
1
0.1
0.01
0.001
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
Exceedance Probability


700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
VTI
1:1
Regression
UB
LB
Regression
Slope = 0.96
x_intercept = 41.6
95% CI = 2.4



http://www3.villanova.edu/VUSP/
30



The Model Brocca CFM

- Brocca et al, 2008

$$e(t) = ET_P(t)\frac{W(t)}{W_{\max}}$$

$$ET_p(t) = a + b\left[\xi\left(0.018T_a(t) + 0.32\right)\right]$$

$$DP(t) = K_s\left[\frac{W(t)}{W_{\max}}\right]^{3+2/\lambda}$$

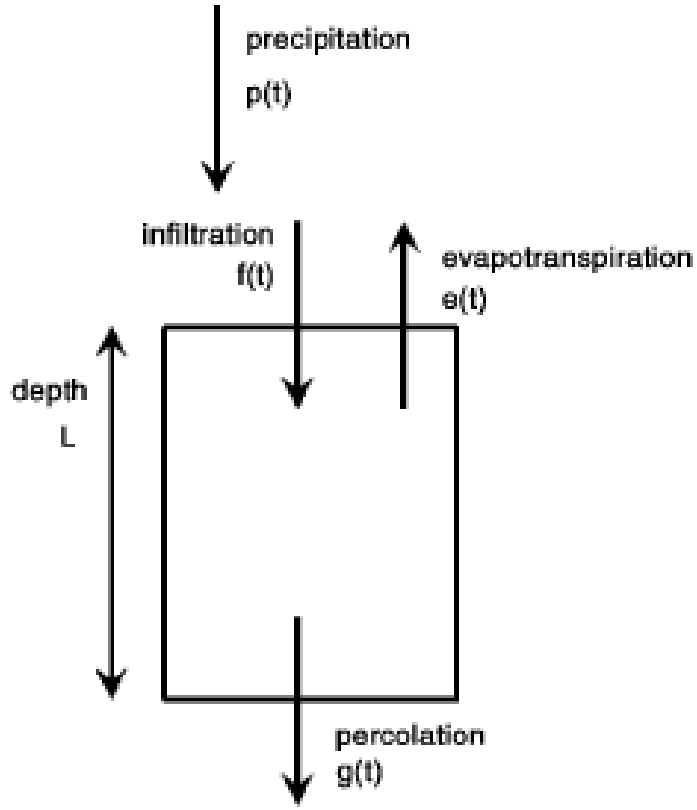
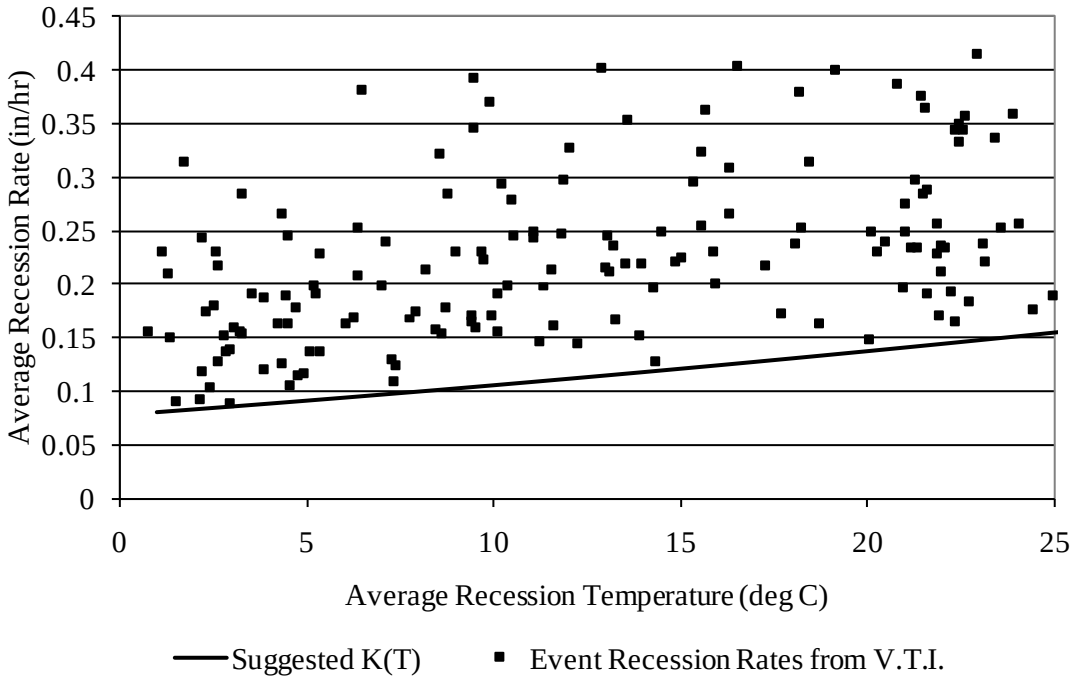


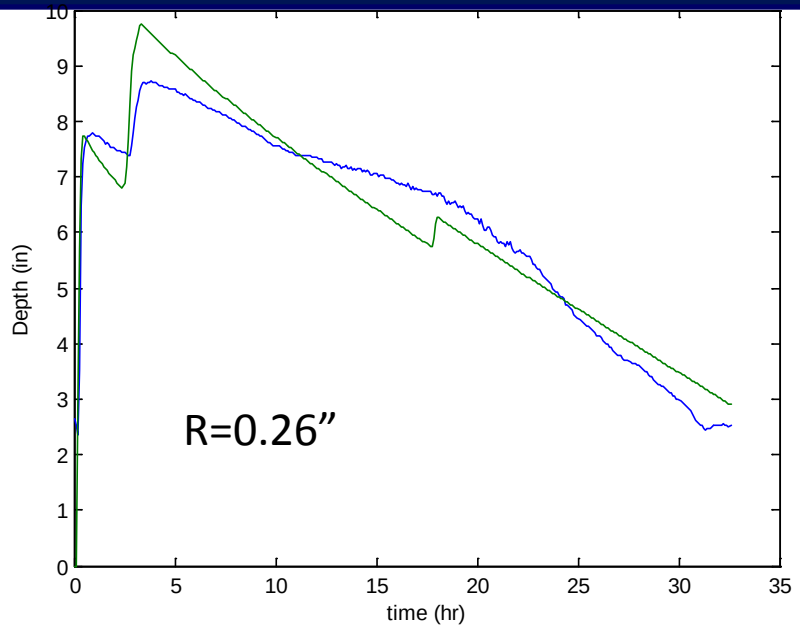
Figure 1. The root zone as a lumped hydrological system

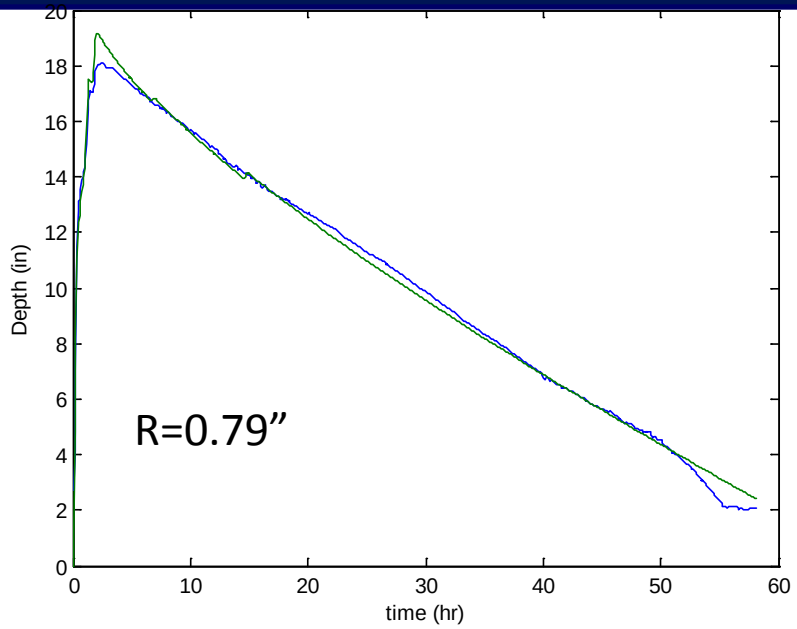
Ryan Lee

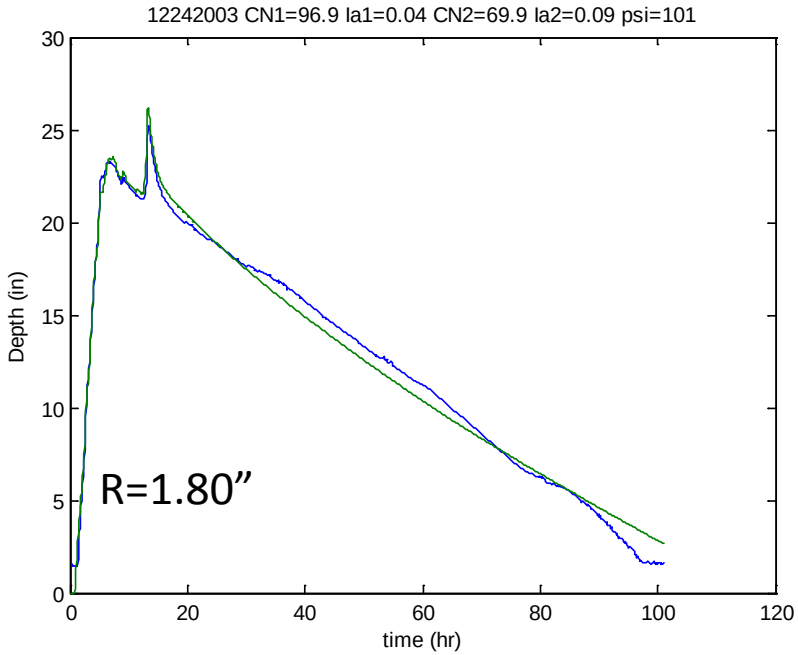
Determining K(T) from data

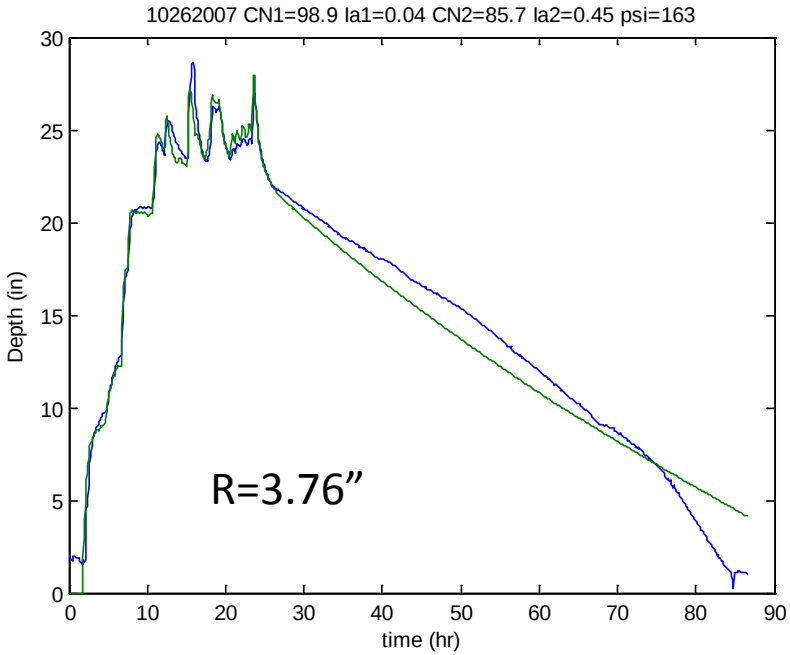
- Look at the infiltration eqn… dD/dt is <u>always</u> greater than K. This recession rate will approach K for low values of (high moisture content).



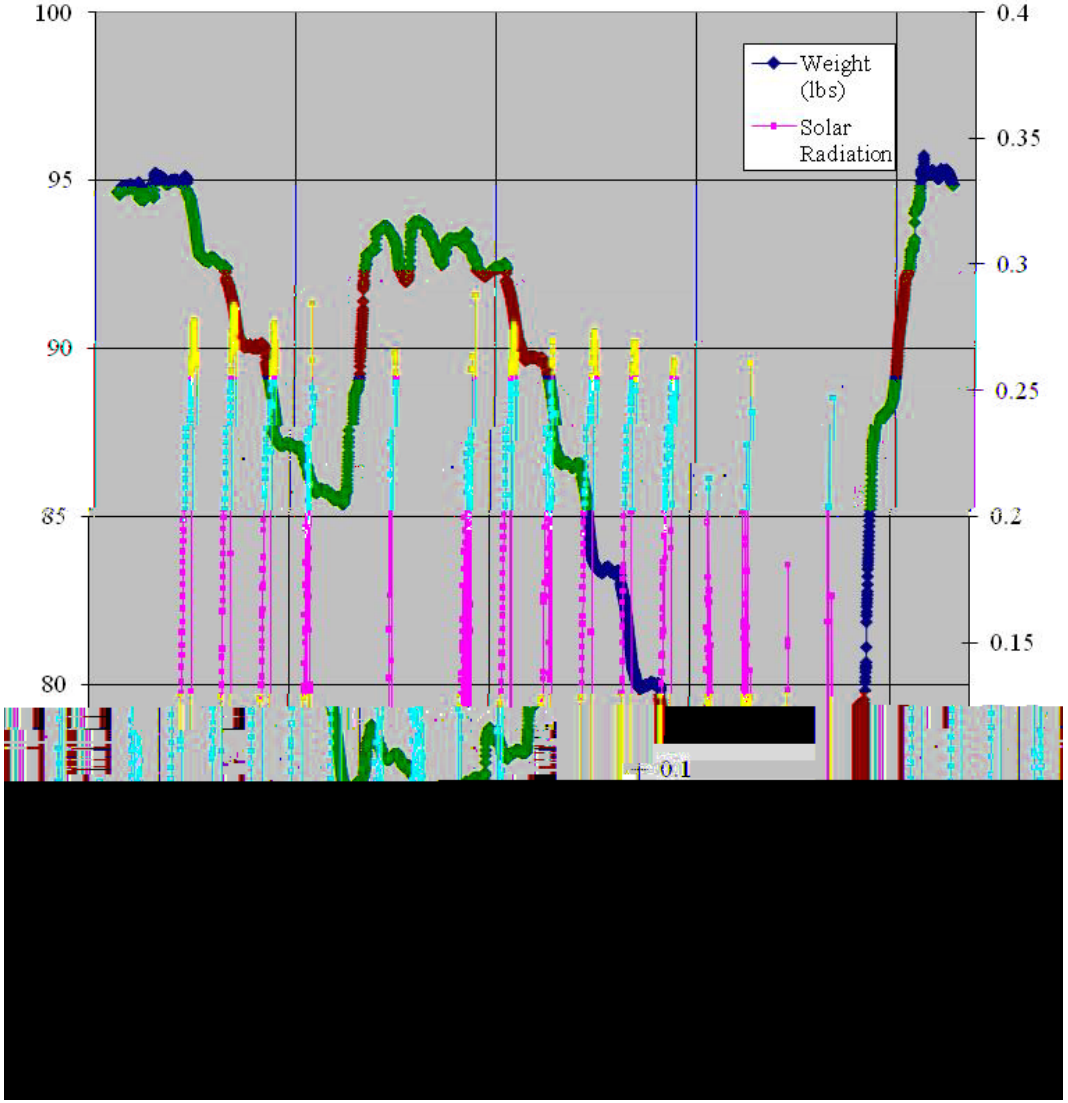

7182006 CN1=99.1 Ia1=0.04 CN2=90.2 Ia2=0.50 psi=15
Depth (in)
time (hr)
R=0.26”


7232004 CN1=97.9 Ia1=0.04 CN2=85.0 Ia2=0.44 psi=47
Depth (in)
time (hr)
R=0.79”

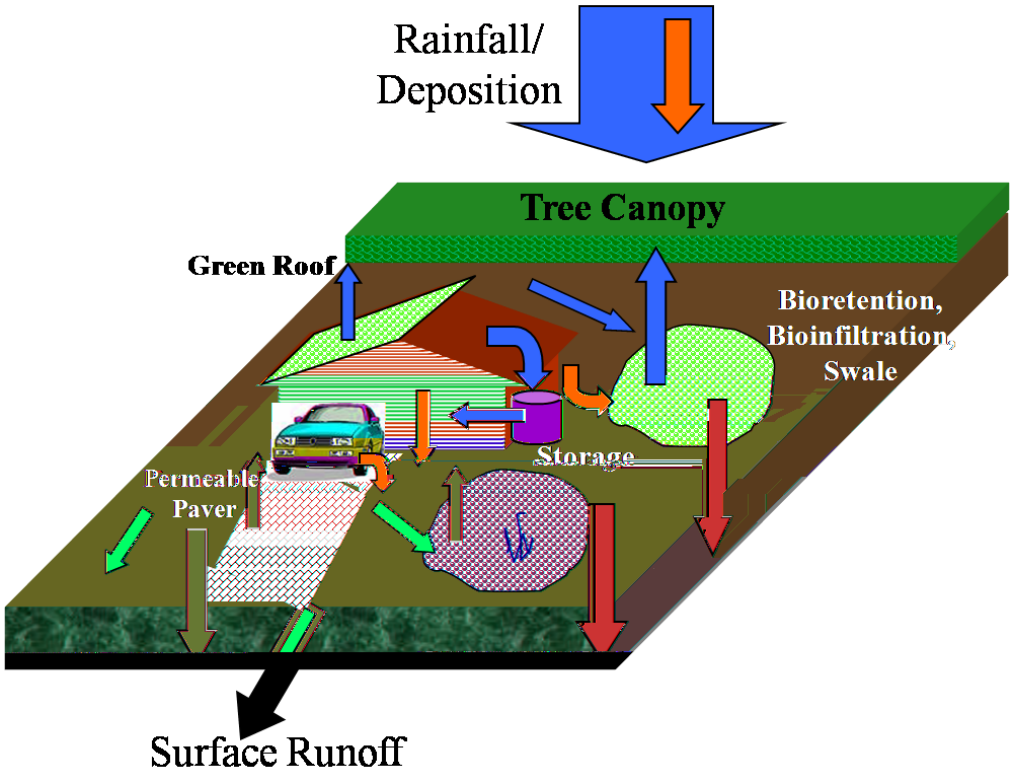

12242003 CN1=96.9 Ia1=0.04 CN2=69.9 Ia2=0.09 psi=101
Depth (in)
time (hr)
R=1.80”


10262007 CN1=98.9 Ia1=0.04 CN2=85.7 Ia2=0.45 psi=163
Depth (in)
time (hr)
R=3.76”

Other Studies - ET



Hydrology



Thanks to Allen Davis U Md.