

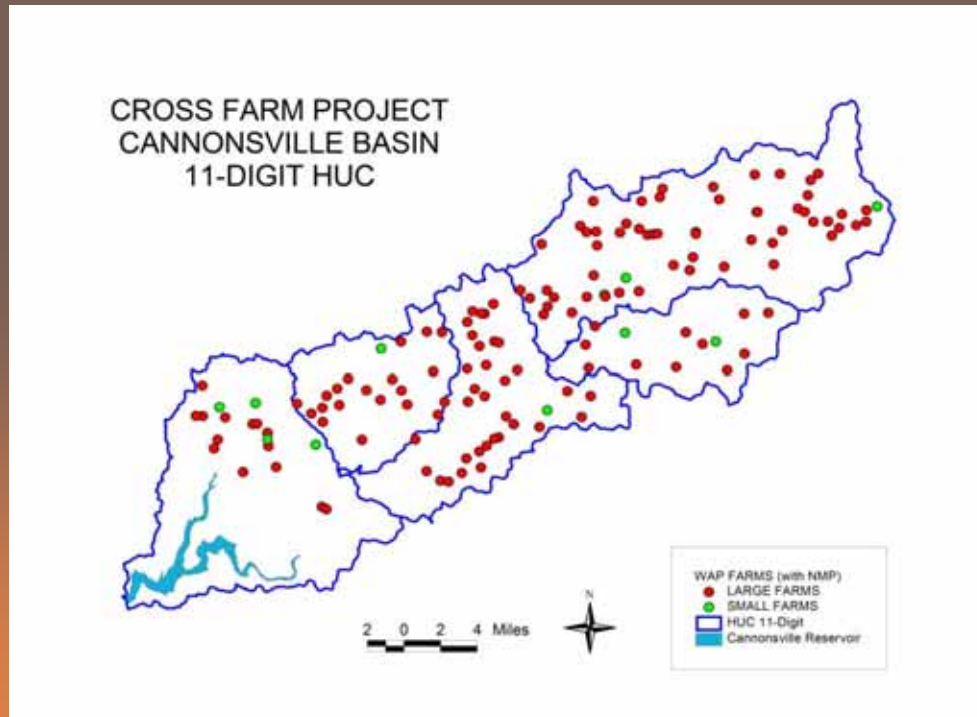
DISTRIBUTED HYDROLOGICAL MODELING OF RUNOFF GENERATION AND TOTAL DISSOLVED PHOSPHORUS TRANSPORT TO IMPROVE BMP EVALUATION IN A NEW YORK CITY SOURCE (CEAP) WATERSHED

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This project is supported by National Research Initiative Competitive Grant from the USDA Cooperative State Research, Education, and Extension Service



CAEP Study Site: Cannonsville Reservoir Watershed





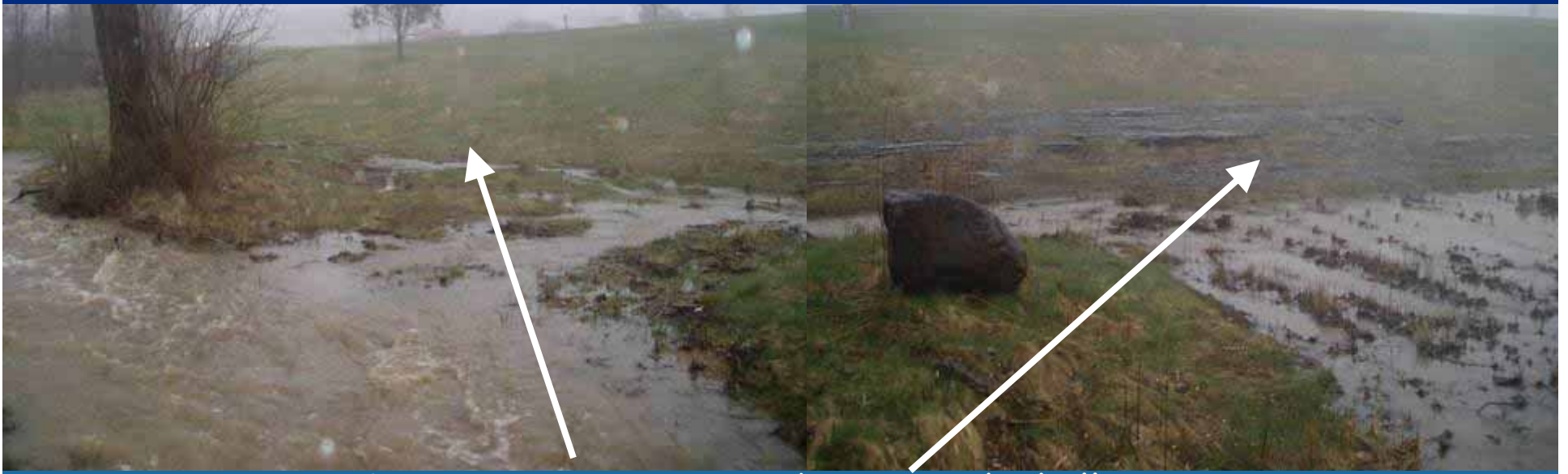
Best Management Practices were done right!



Why is that?

This is why!

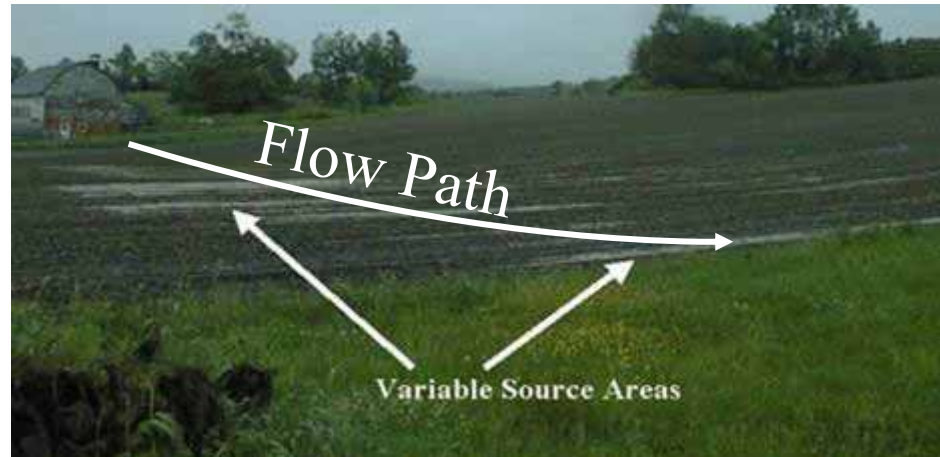
- In the temperate northeast hydrology is, to a great extent, driven by topology



Near stream areas, and areas with shallow, soils over a slowly permeable glacial till or bedrock produce the majority of runoff



Runoff location



**Variable Source Areas concept
included in BMP
installation from early on**

BMP's

BMP effectiveness is determined by the three "L's"

Location

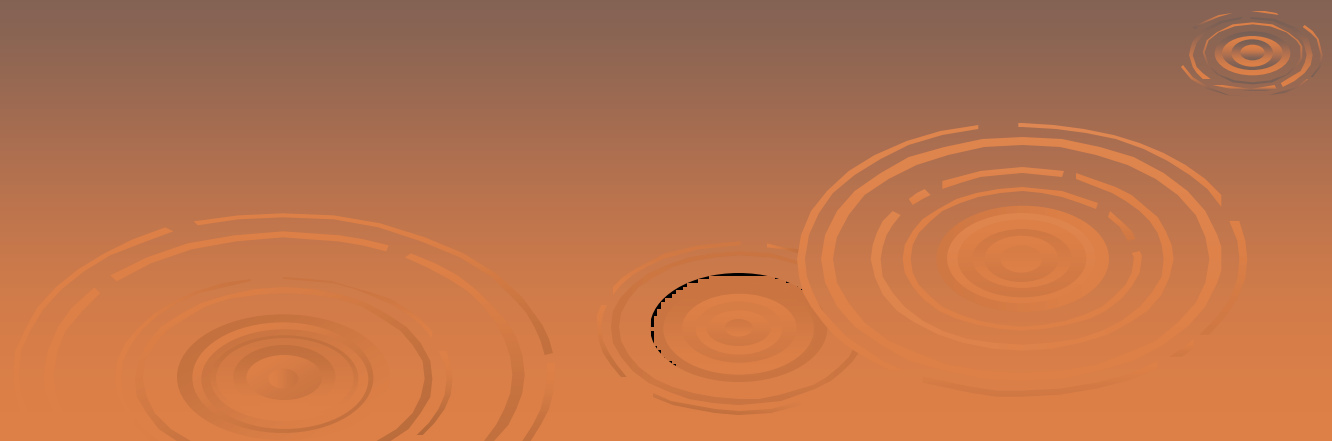
Location

Location

The Science of Reducing P


- Keep the manure out of the runoff water
 - Requires knowledge of saturated areas
- Reduce P loading
 - Reducing P in feed import
- To optimize P reductions, models are needed simulating hydrology of the region and are in agreement with farmer's perceptions

The Case of SWAT

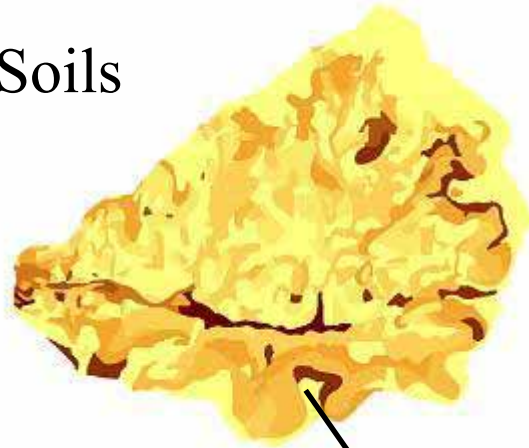




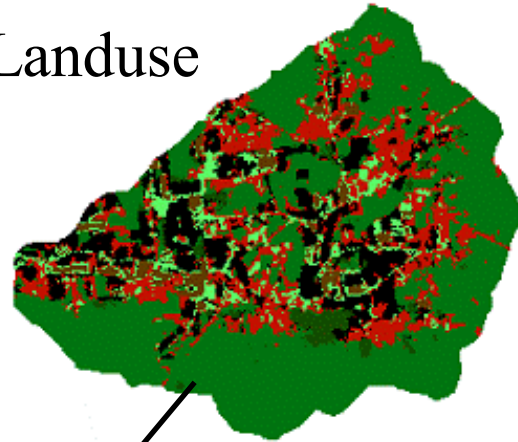
Soil Water Assessment Tool (SWAT)

- Basin scale hydrological and water quality
 - 0.06 ha  continental
- Runs on easily available data
- Process based chemistry
 - vs export coefficient type models
- Does not require much calibration for hydrology
 - More for chemistry and sediment

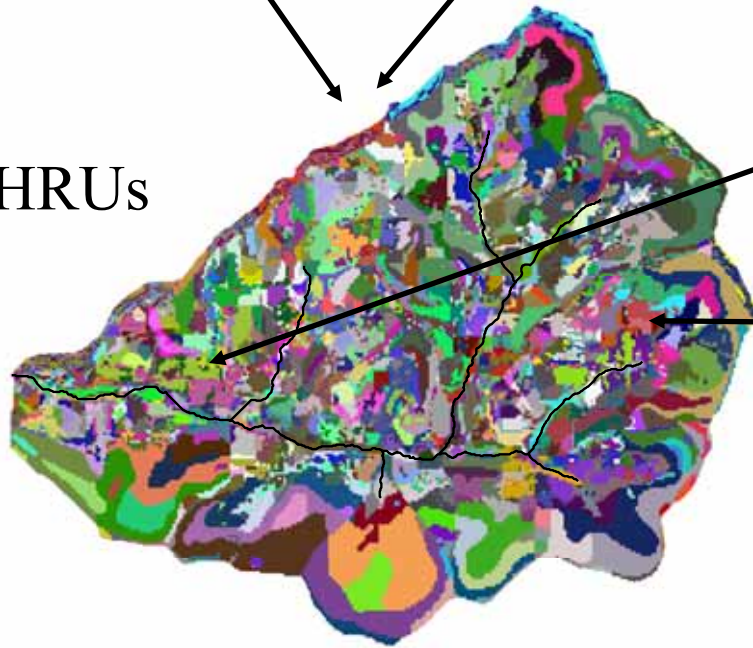
Soils



Landuse



HRUs

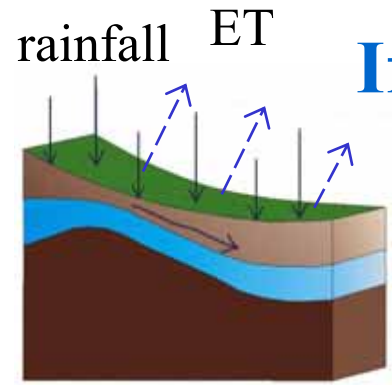


- SWAT defines HRUs as the coincidence of soil type and landuse
 - Hydrological/chemical properties are defined at the HRU
- So runoff/P loss is the same here (lowland pasture)
- As here (upland pasture)
- We know this is not the case

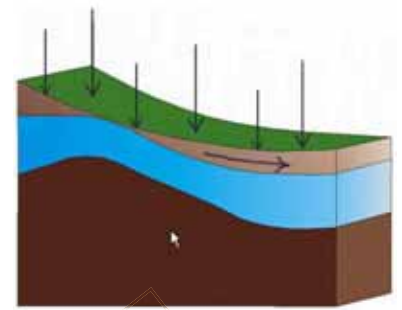
model approach

For each hydrologic response unit

hydrology



If rainfall > ET,
soil wets up



$$Q = \frac{P_e^2}{P_e + S}$$



USDA-NRCS Curve Number Model

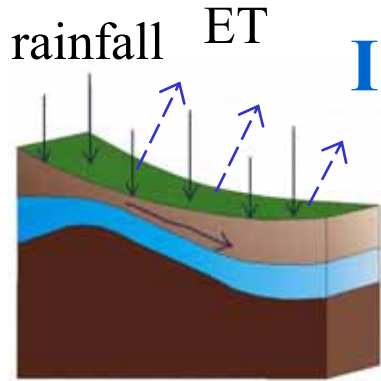
That is a big problem

**Infiltration capacity in excess of
rainfall intensity!**

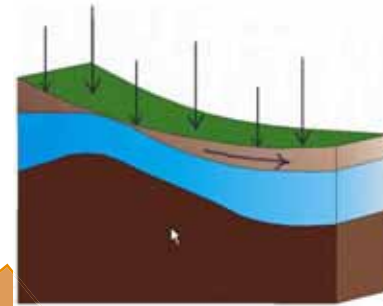
model approach

Total runoff and the saturated portion of the watershed is a function of amount of precipitation

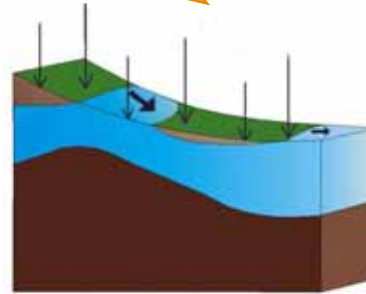
hydrology



If rainfall > ET,
soil wets up



If rainfall > soil storage,
excess overland flow



$$Q = \frac{P_e^2}{P_e + S}$$
$$A_f = 1 - \frac{S^2}{(P_e + S)^2}$$

- **Why not use a distributed storage directly in the water balance?**
- **If done wisely, it should give same overall “S” and runoff distribution**



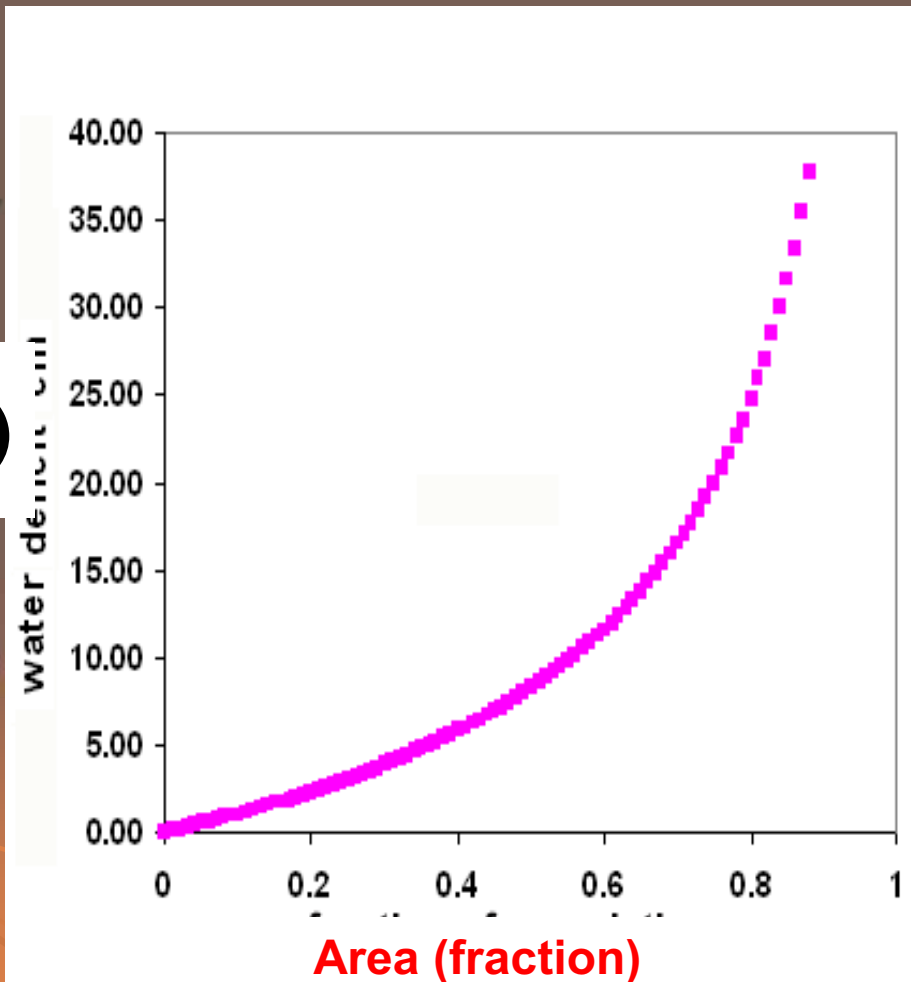
Available Storage

Defining the distribution of available storage or water deficit

The difference between saturation and field capacity is the availability storage or water deficit σ

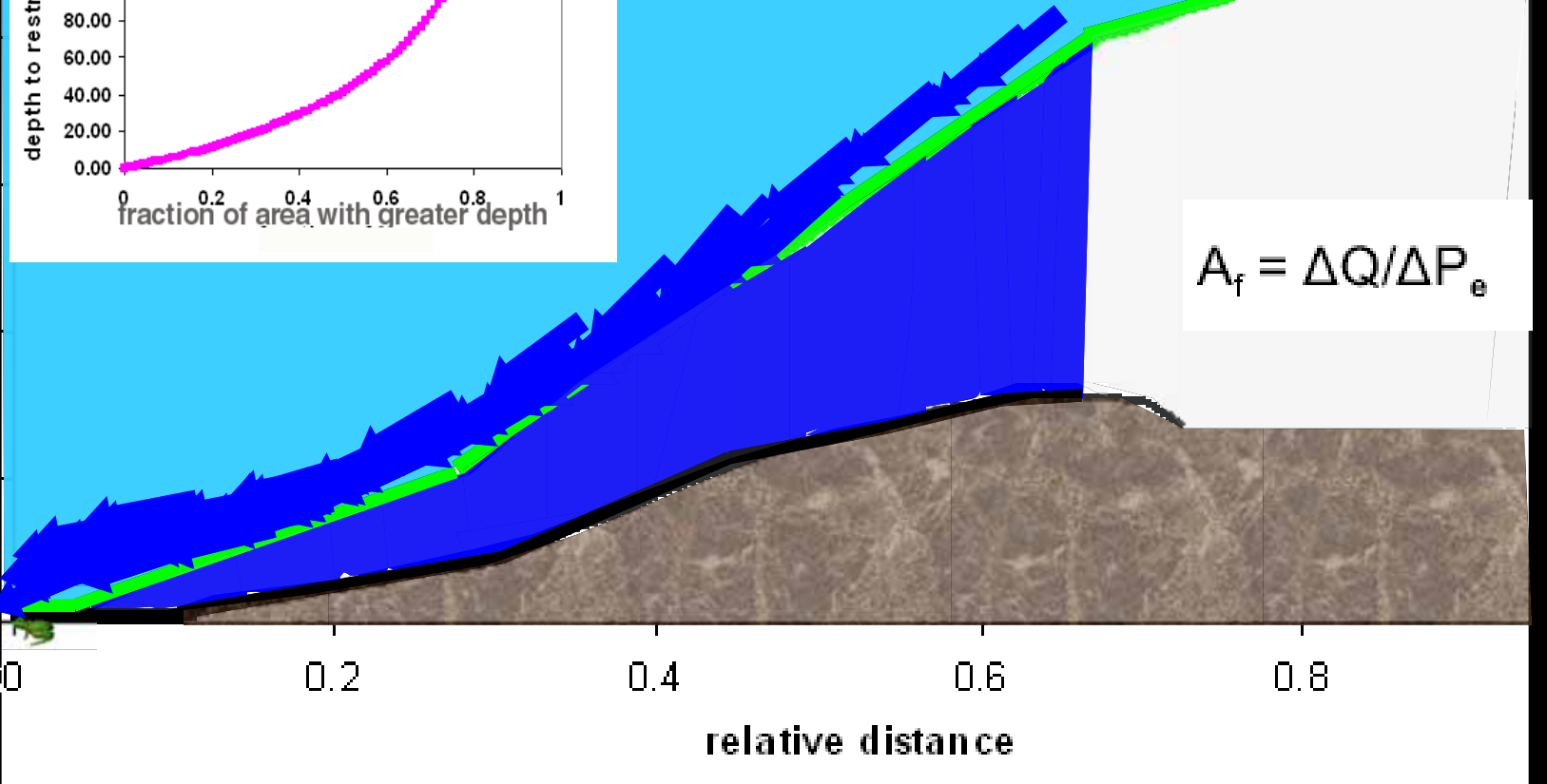
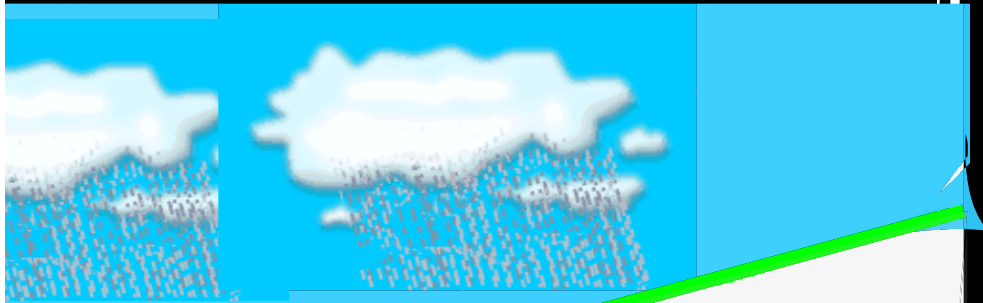
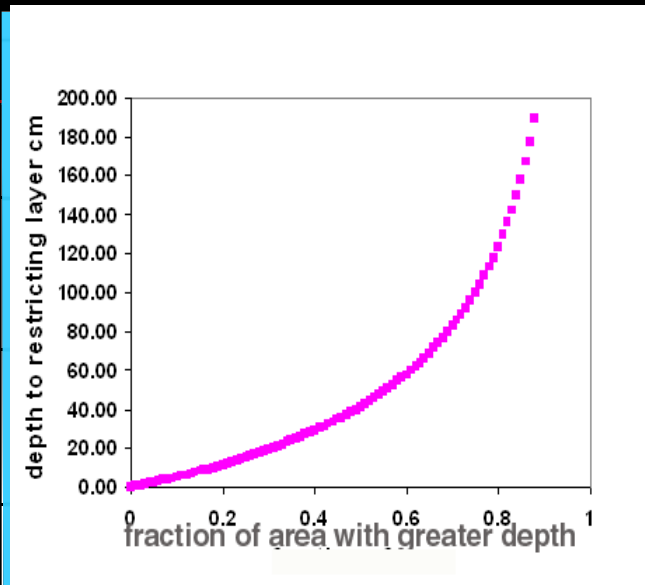
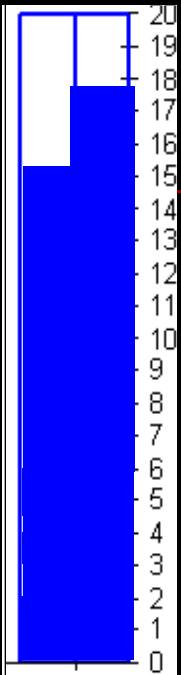
$$\sigma = S(\sqrt{1/(1 - A_s)} - 1)$$

It is a function of the fractional area, A_s and the total storage, S in the watershed

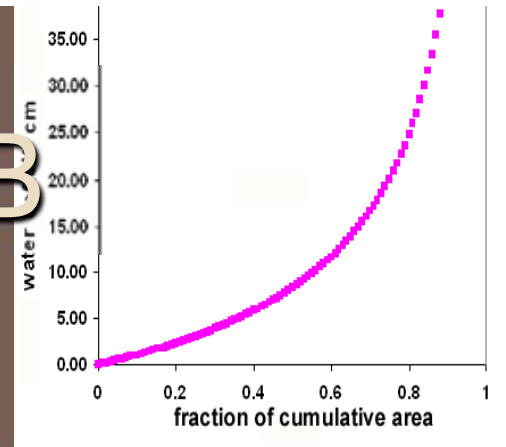


Rainfall

Effective Total



SWAT-VSA or SWAT-WB



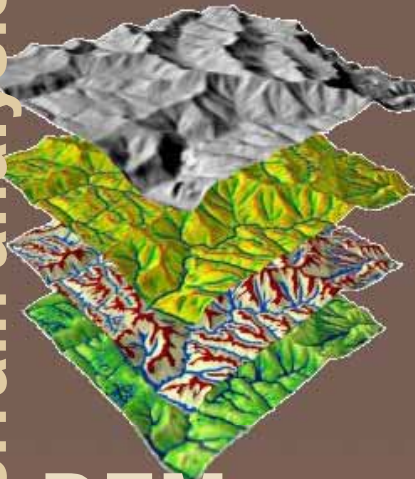
- Thus by assigning field capacities according to

$$FldCap = Saturation - S(\sqrt{1/(1 - A_s)} - 1)$$

and not according to soil type, runoff can be determined as saturation excess. Expects same hydrograph at outlet

Distribute runoff areas in the landscape

terrain analysis



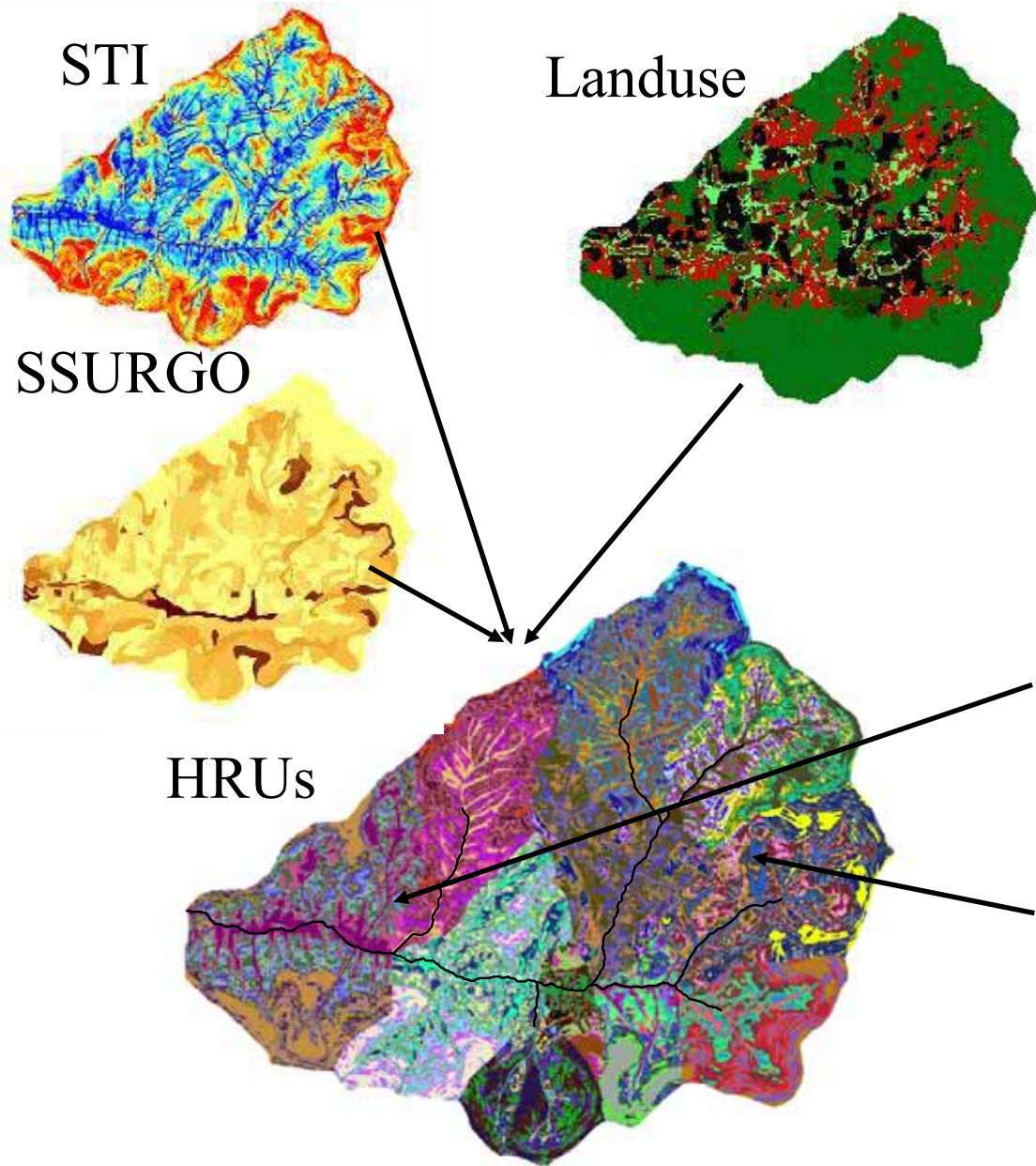
DEM

- Upstream area, A
- Slope β
- soil depth, D
- soil hydraulic conductivity K

$$\lambda = \ln \left(\frac{A}{\tan \beta \cdot K_s \cdot D} \right)$$

Soil topographic wetness index

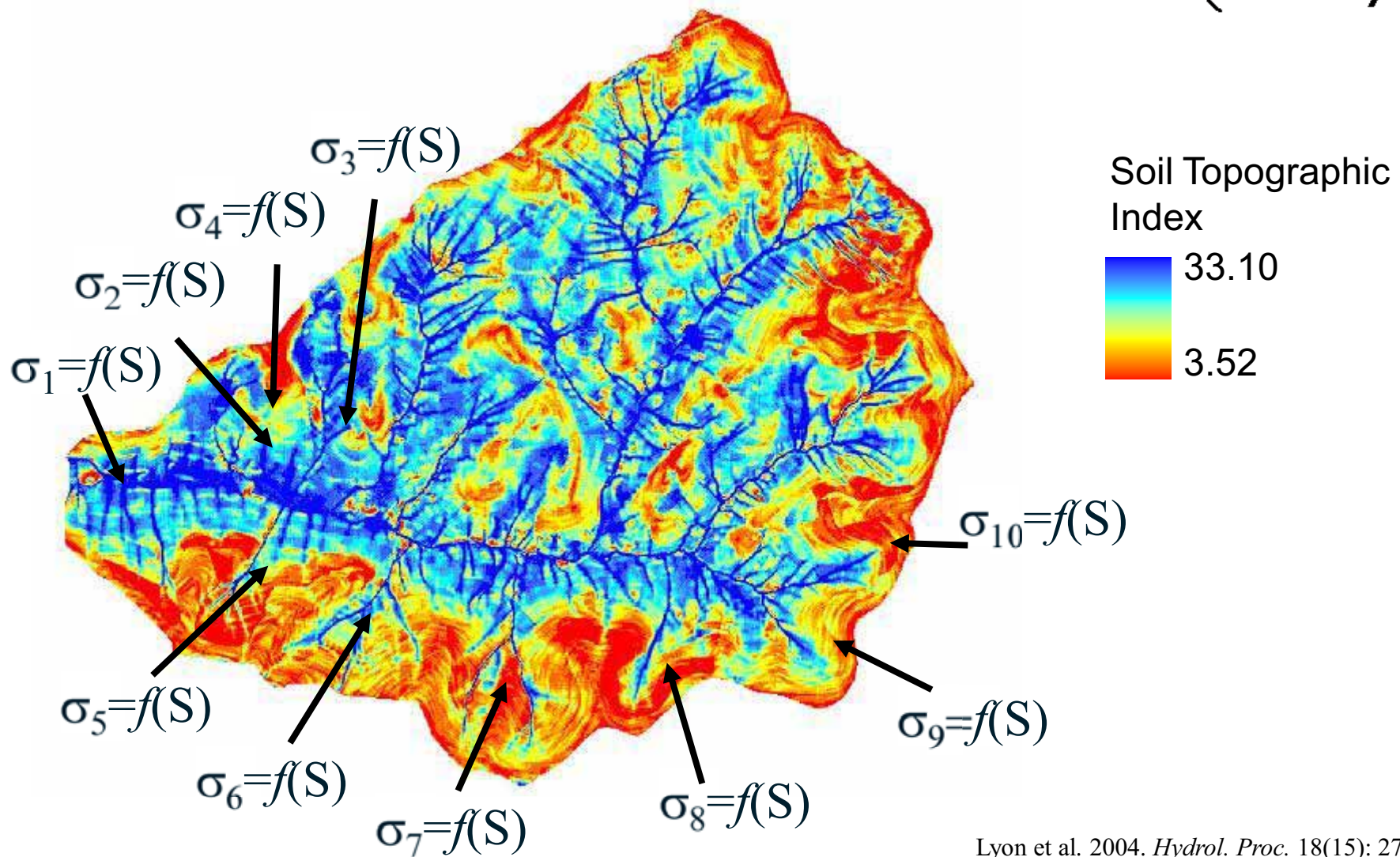
The location of the saturated areas is mainly determined by the topography




- SWAT-VSA defines HRUs as the coincidence of soil topographic index (and soil) and landuse
 - Weighted average of soil properties nested with in an area weighted index class
- So runoff/P loss is now not the same here (lowland pasture)
- As here (upland pasture)

Soil Topographic Index

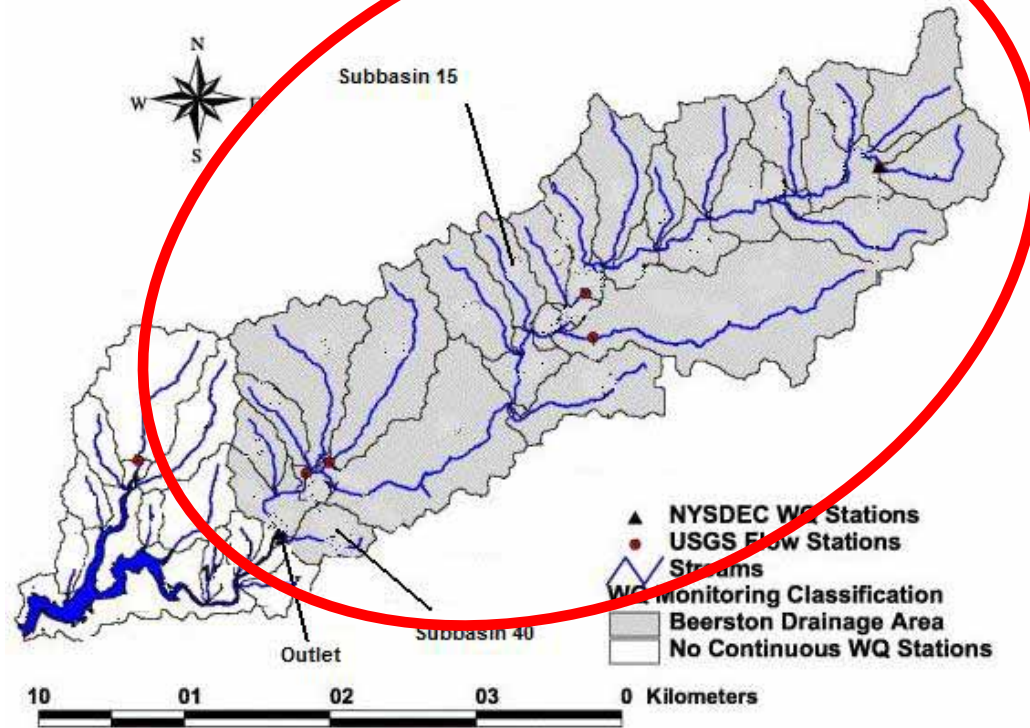
$$\lambda = \ln\left(\frac{a}{T \tan \beta}\right)$$



A scenic view of a lake surrounded by forested hills, with autumn foliage in the foreground. The foreground is dominated by branches with leaves in shades of yellow, orange, and red. In the background, a large body of water stretches across the middle ground, with rolling hills covered in dense forest in various autumn colors. The sky is bright and clear.

Application of two SWATs
to the Cannonsville watershed

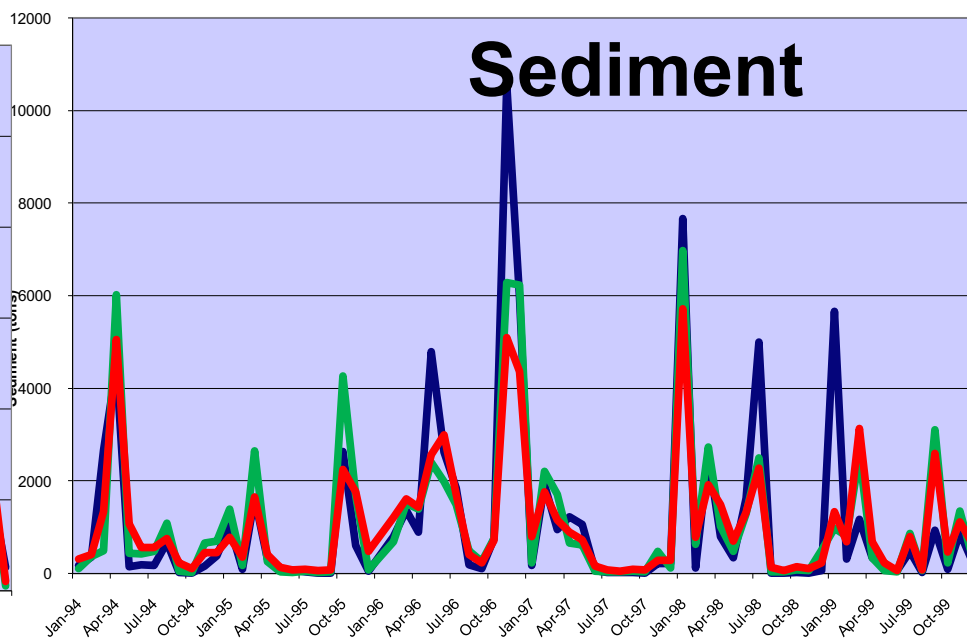
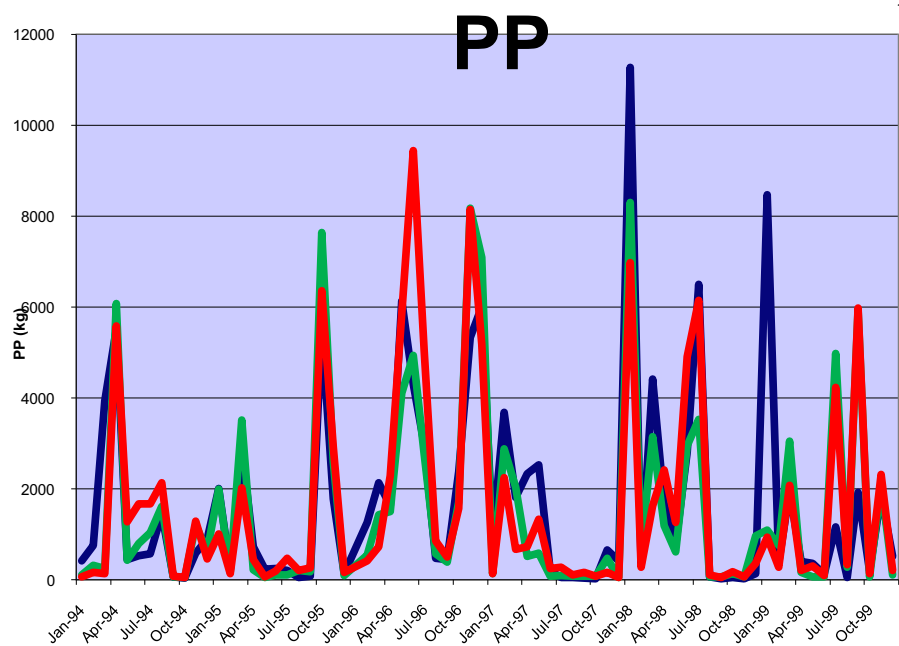
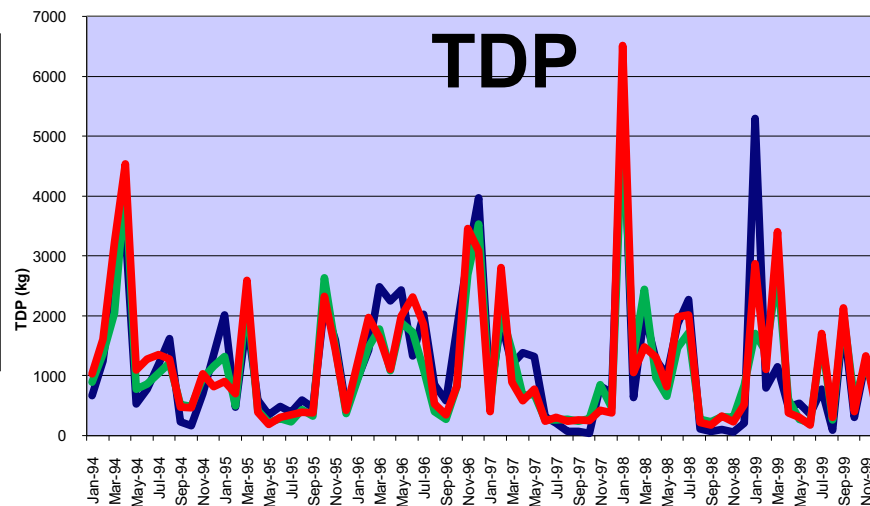
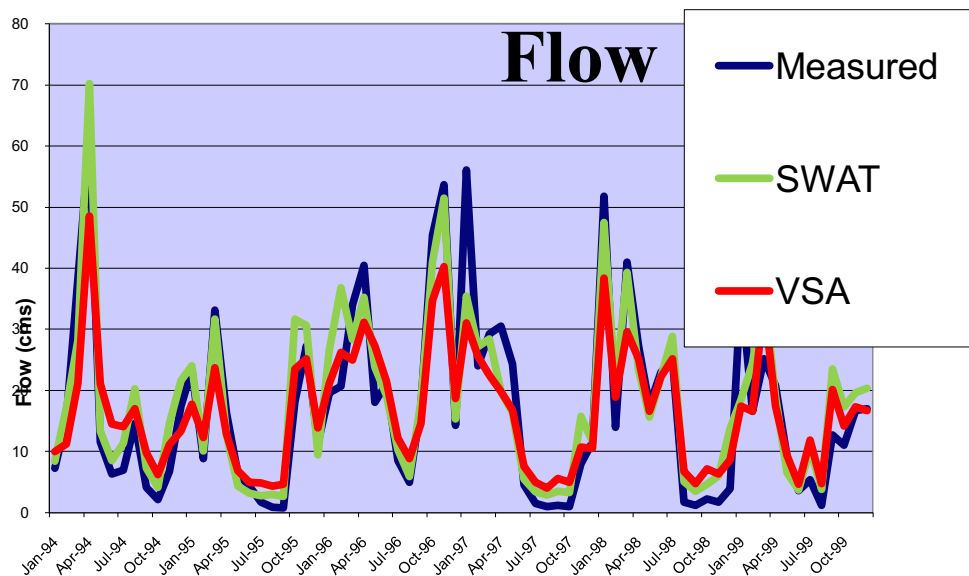
Cannonsville Watershed



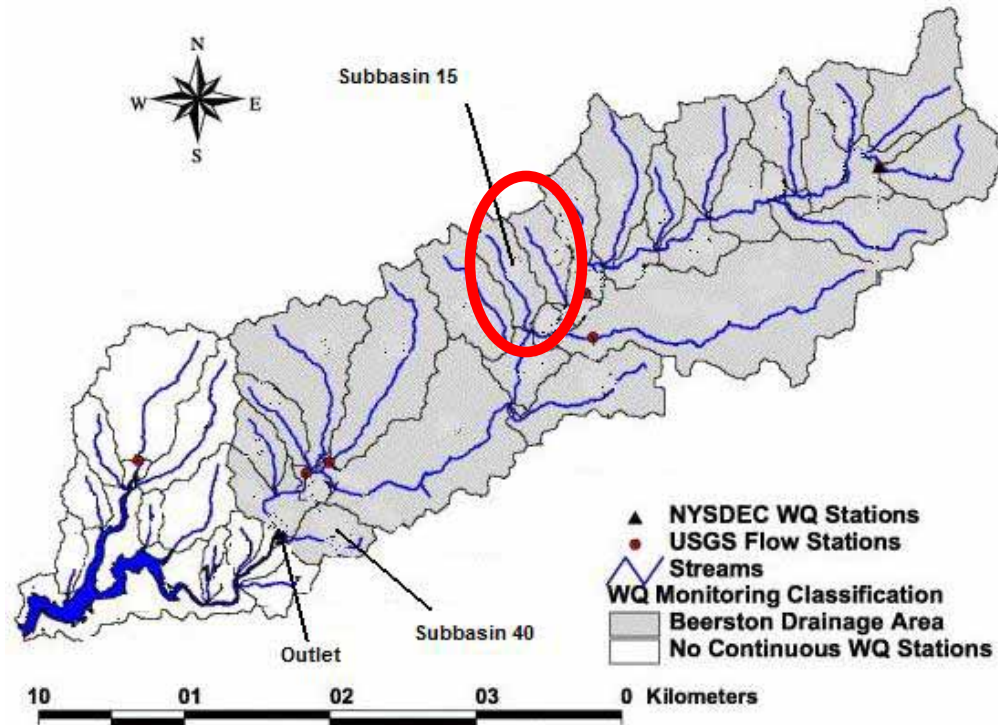
- Modeling Options

Modeling Option	SWAT	VSA
ICRK: crack flow	Turned off	Turned off
IRTE: water routing method	Variable	Variable
IDEG: channel degradation code	Turned off	Turned on
IWQ: in-stream water quality	Turned off	Turned off

Output at watershed outlet



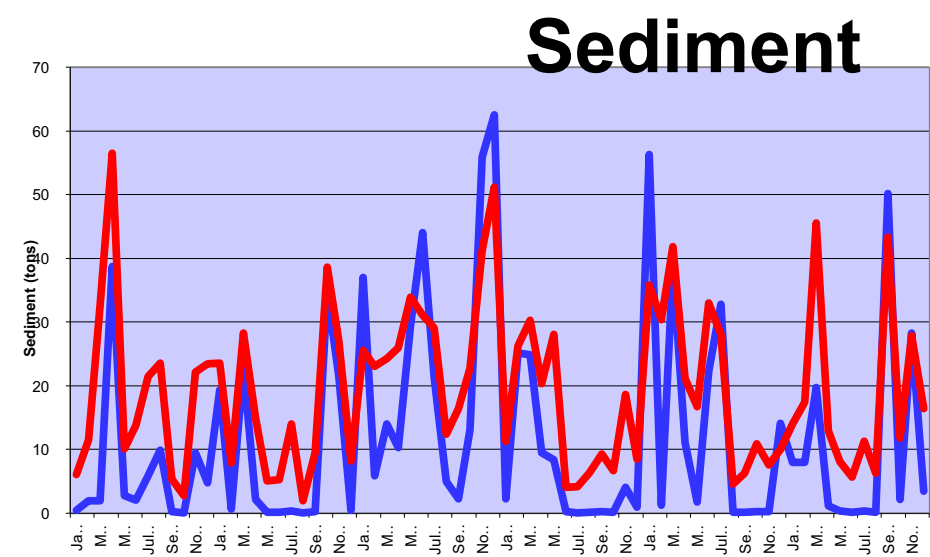
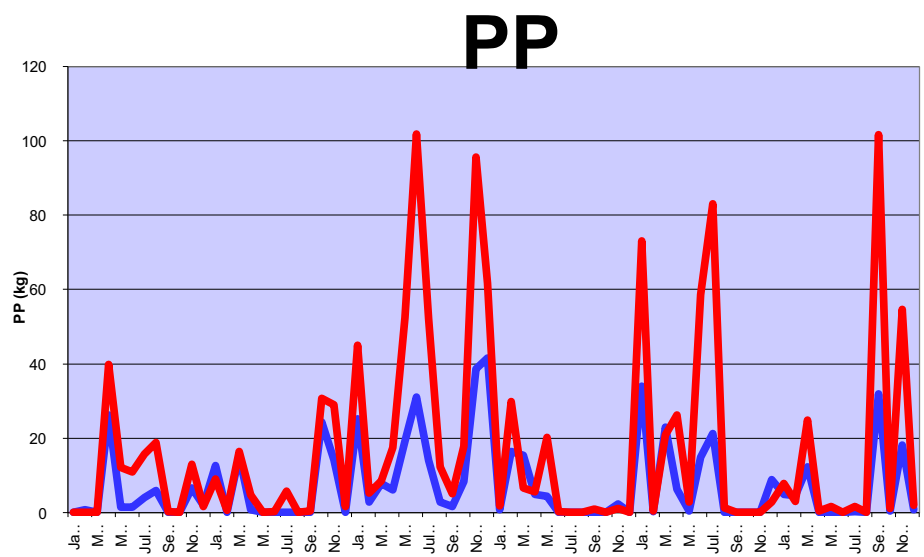
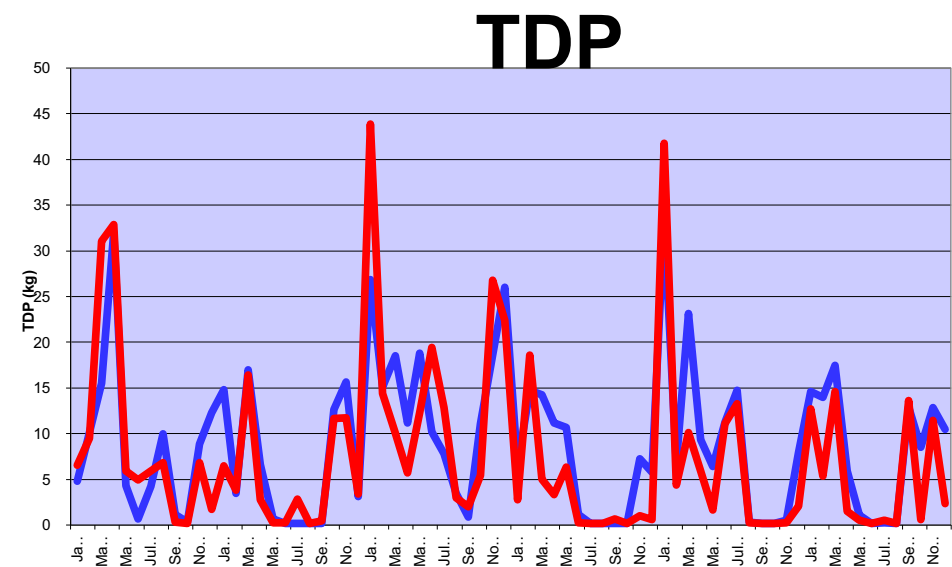
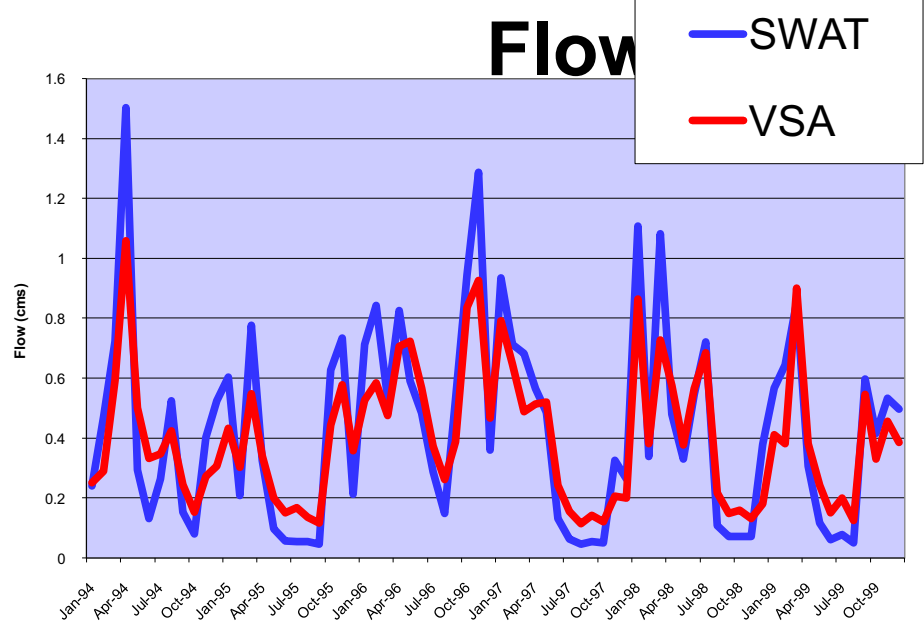
Cannonsville Watershed



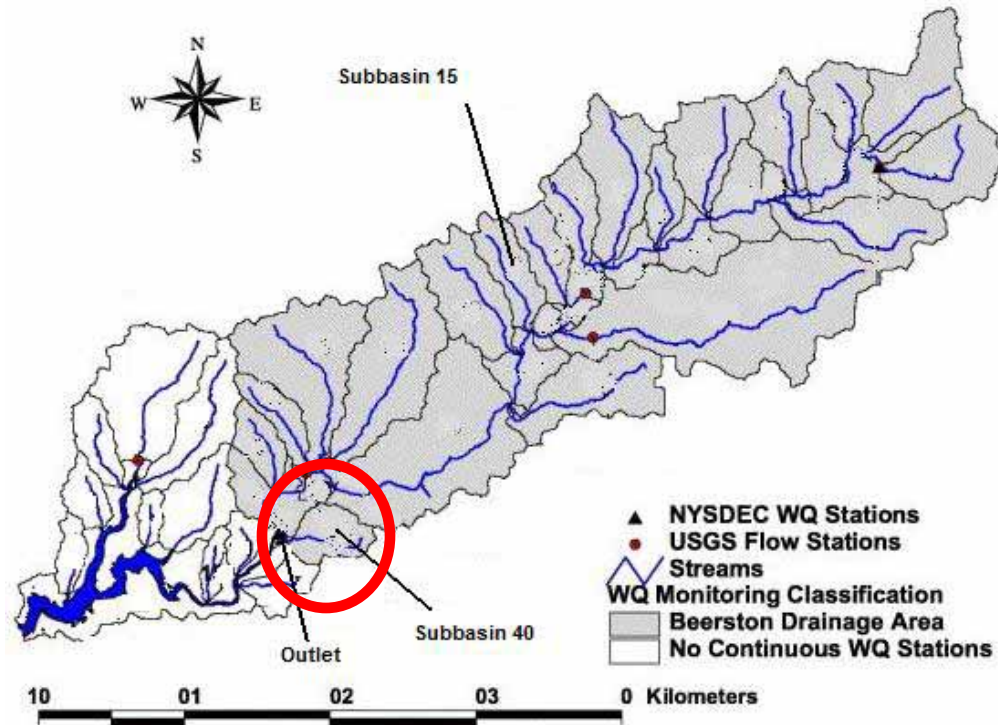
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Output at Subbasin 15



Cannonsville Watershed

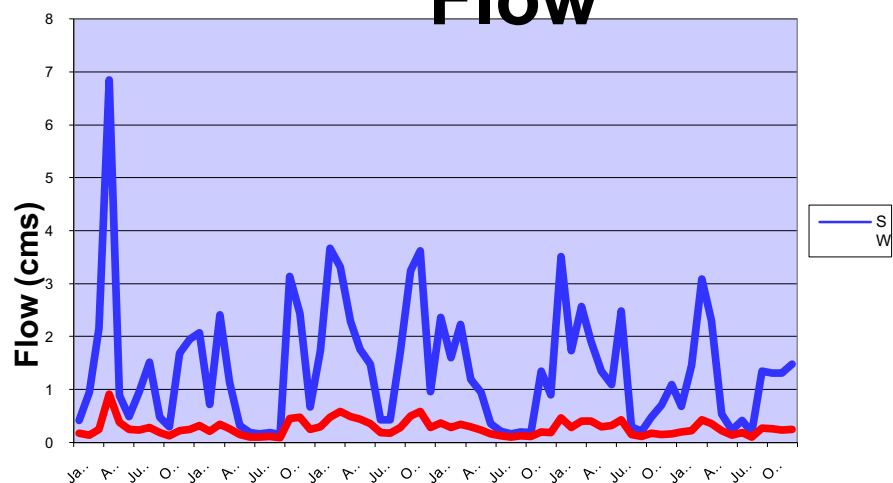


- Modeling Options

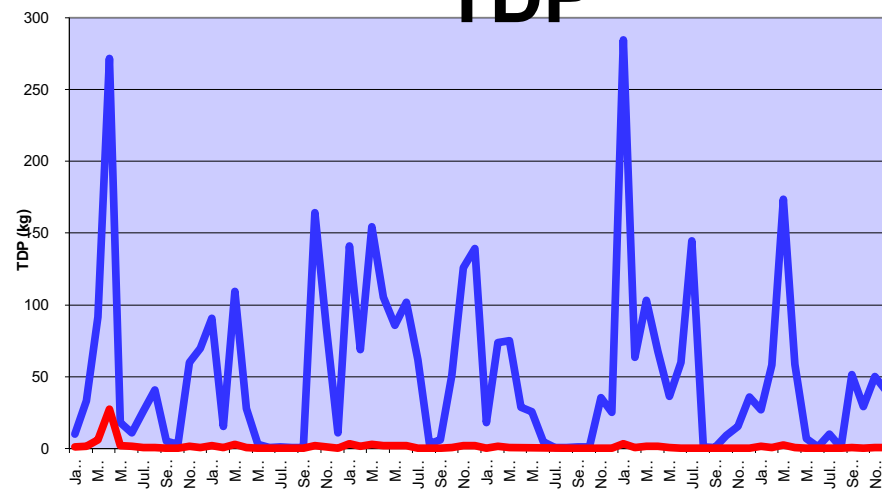
Modeling Option	SWAT	VSA
ICRK: crack flow	Turned off	Turned off
IRTE: water routing method	Variable	Variable
IDEG: channel degradation code	Turned off	Turned on
IWQ: in-stream water quality	Turned off	Turned off

Output at Subbasin 40

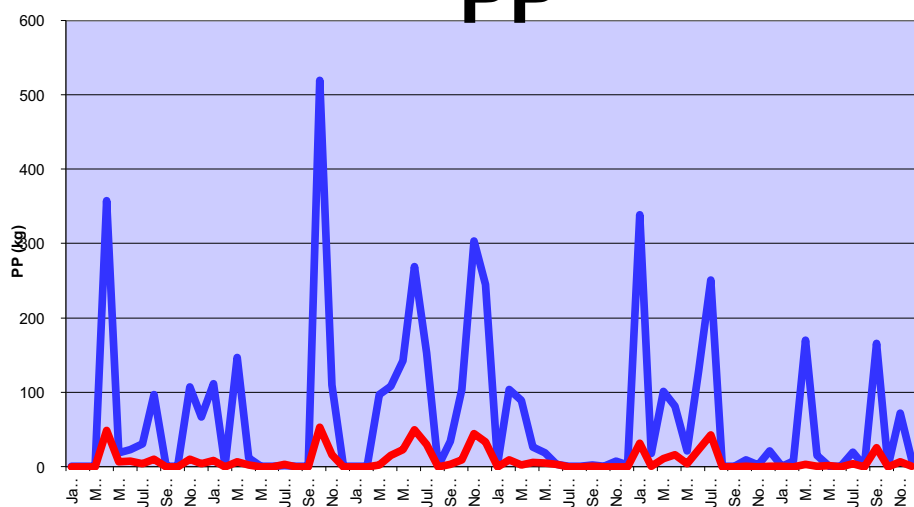
Flow



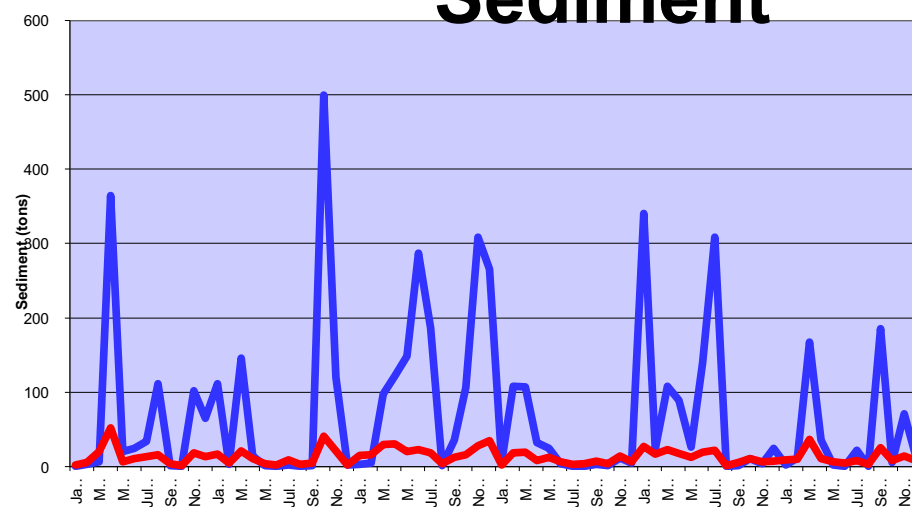
TDP



PP



Sediment



Average Values

- Values at subbasin 15

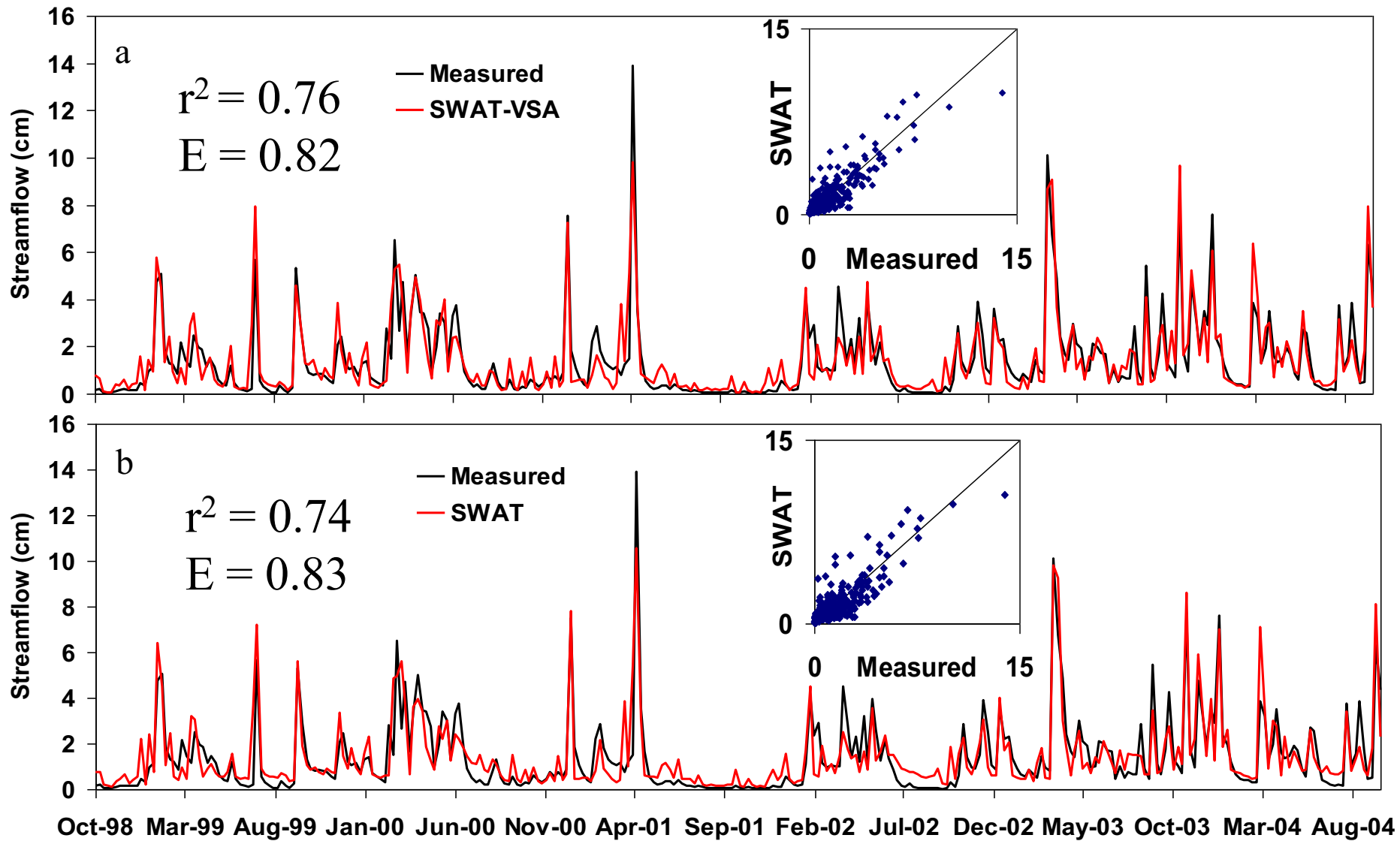
	Flow	PP	TDP	Sediment
SWAT	0.431462	7.597742	8.775495	11.92149
VSA	0.404872	16.99449	7.576776	19.34477

- Values at subbasin 40

	Flow	PP	TDP	Sediment
SWAT	1.389932	66.03428	52.83943	70.62377
VSA	0.273268	8.373887	1.23619	13.51877



Application to Townbrook.

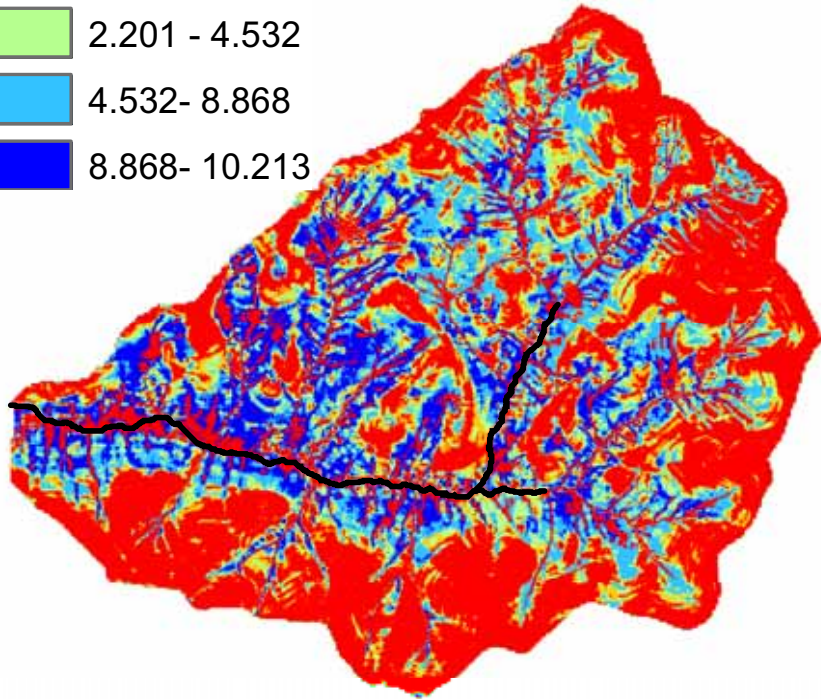
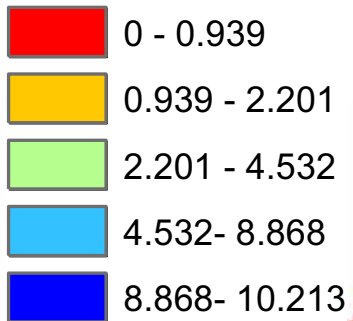


Runoff

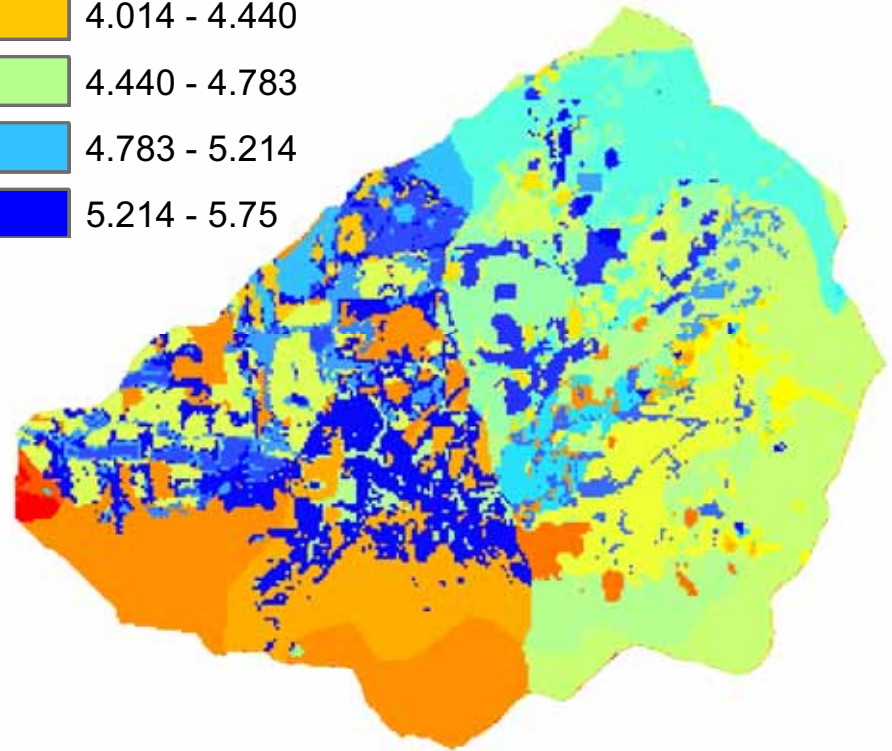
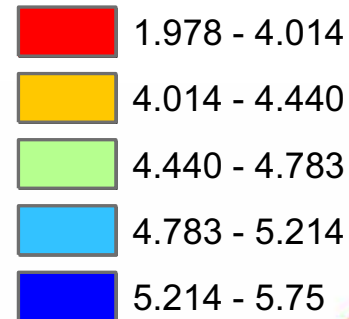
SWAT-VSA

SWAT-Standard

SWAT_VSA
Runoff (mm)



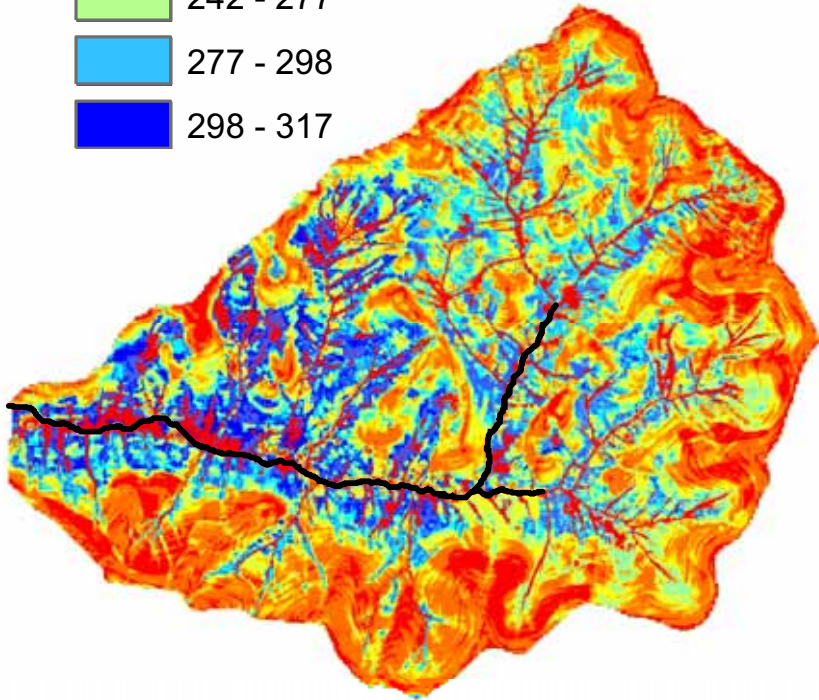
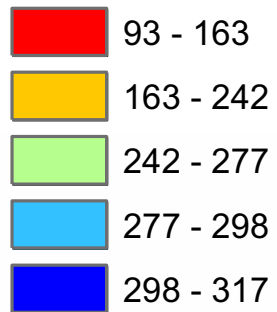
SWAT_Standard
Runoff (mm)



Soil Water

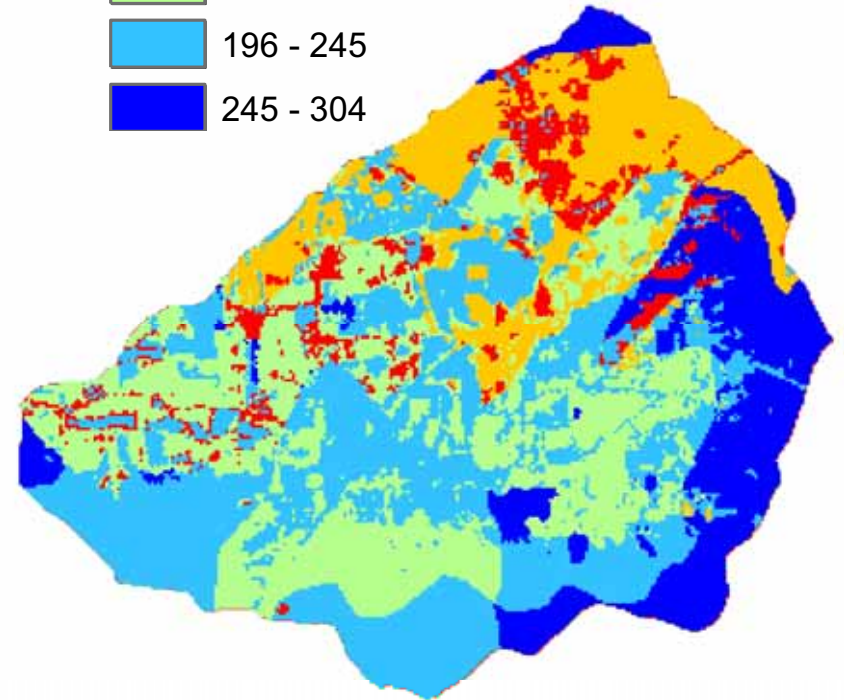
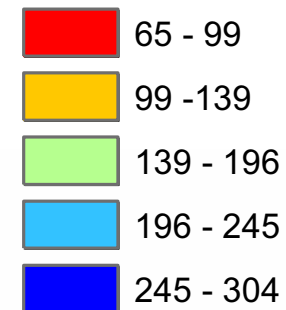
SWAT-VSA

SWAT_VSA
Soil Water (mm)

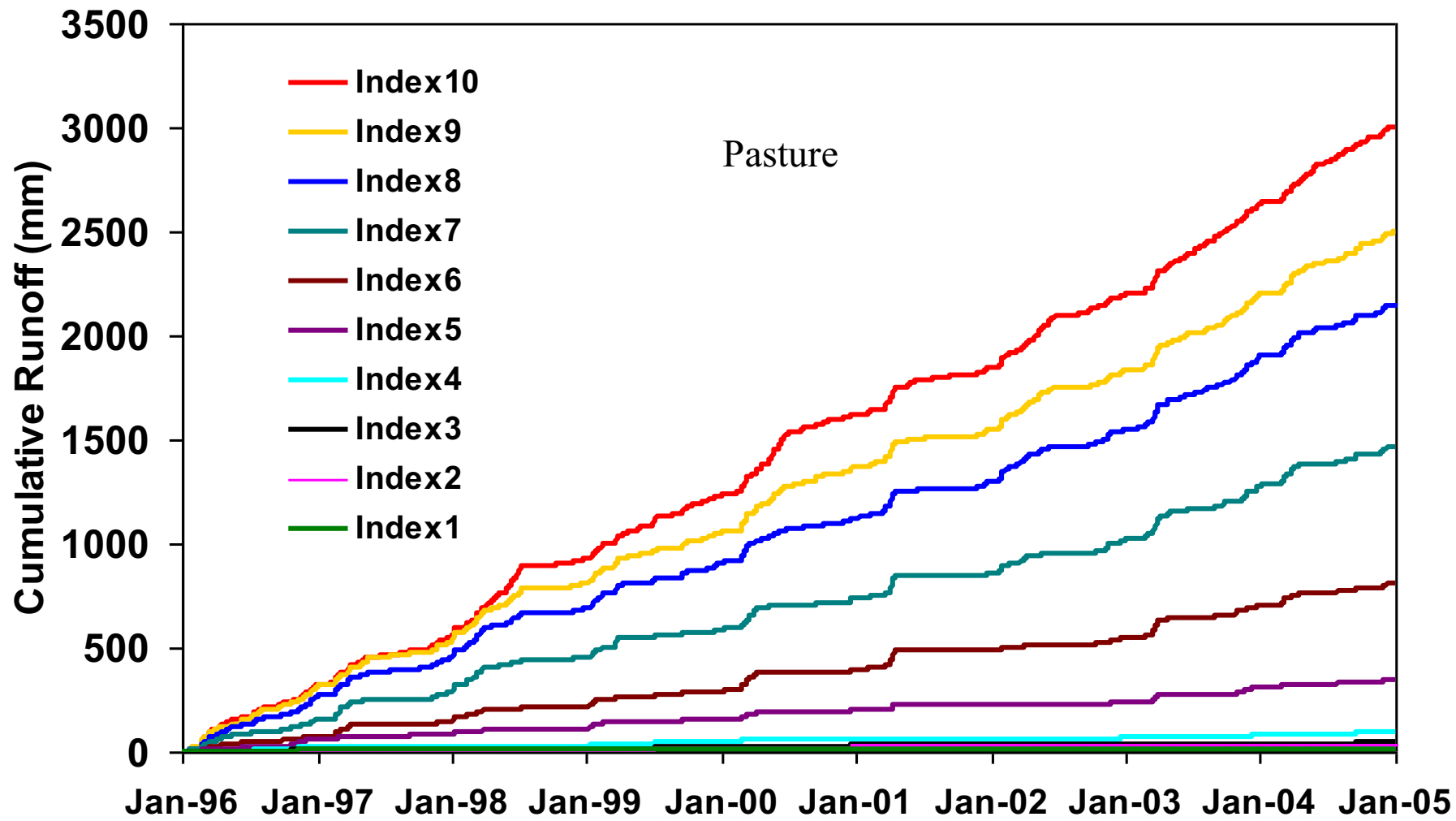


SWAT-Standard

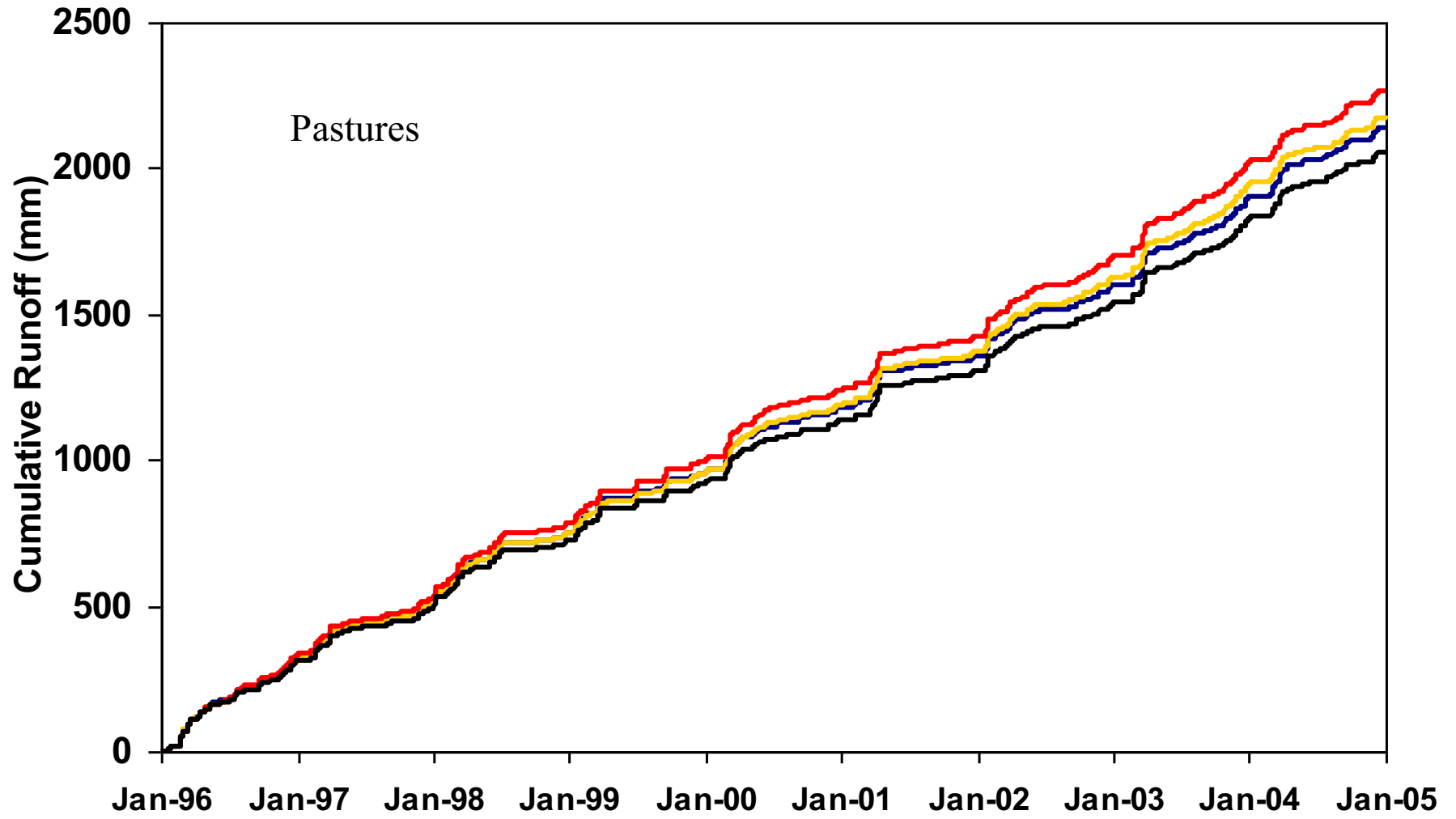
SWAT_Standard
Soil Water (mm)



SWAT-VSA Runoff



SWAT-Standard Runoff

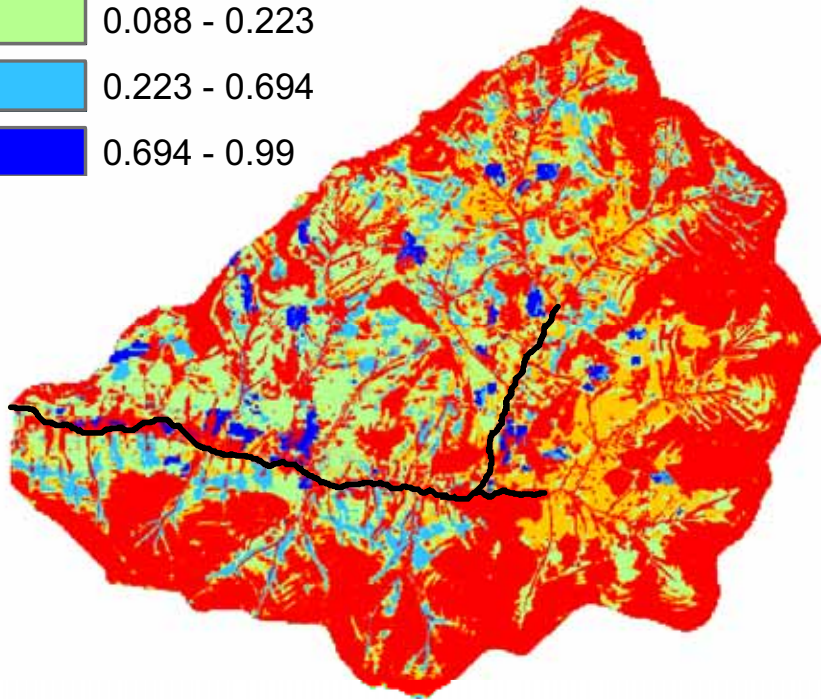
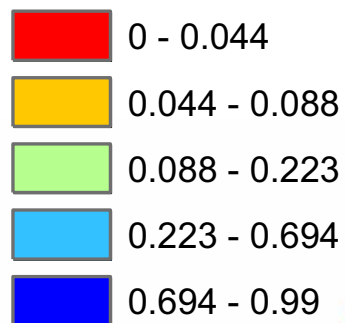


Phosphorus

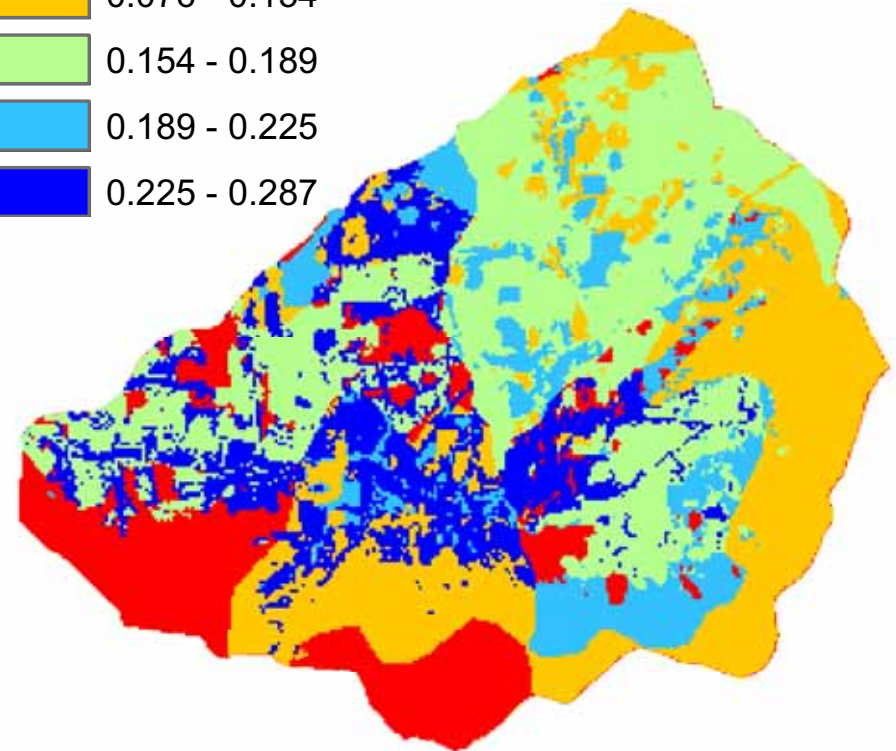
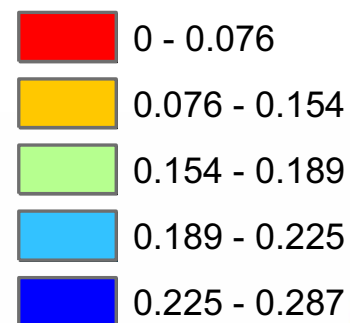
SWAT-VSA

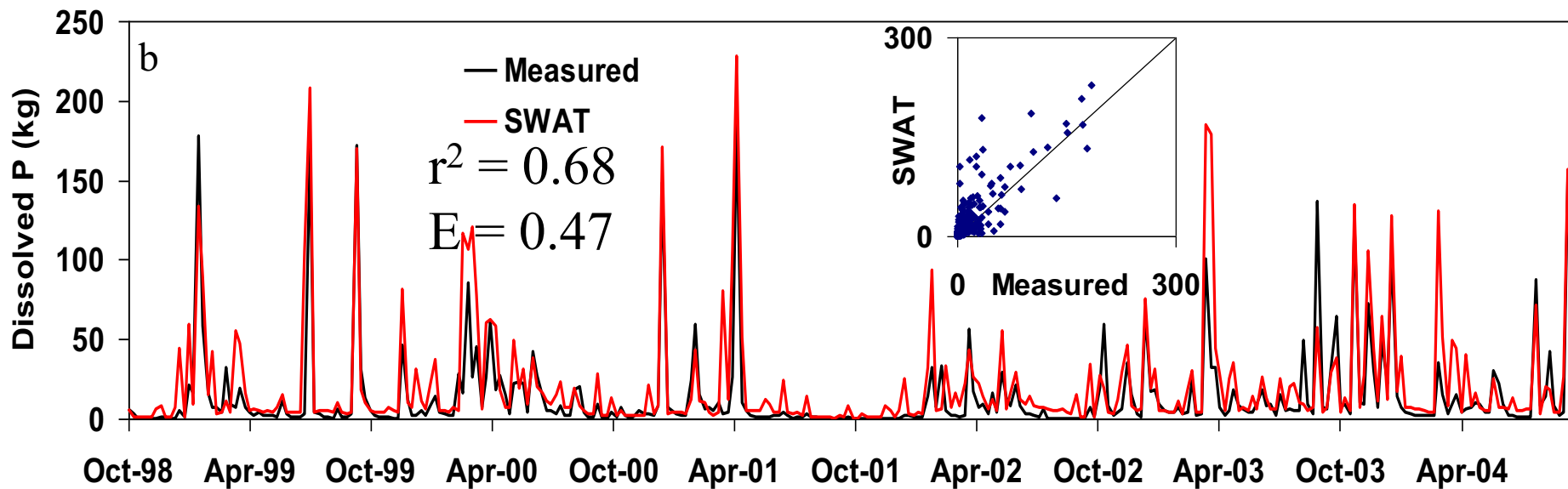
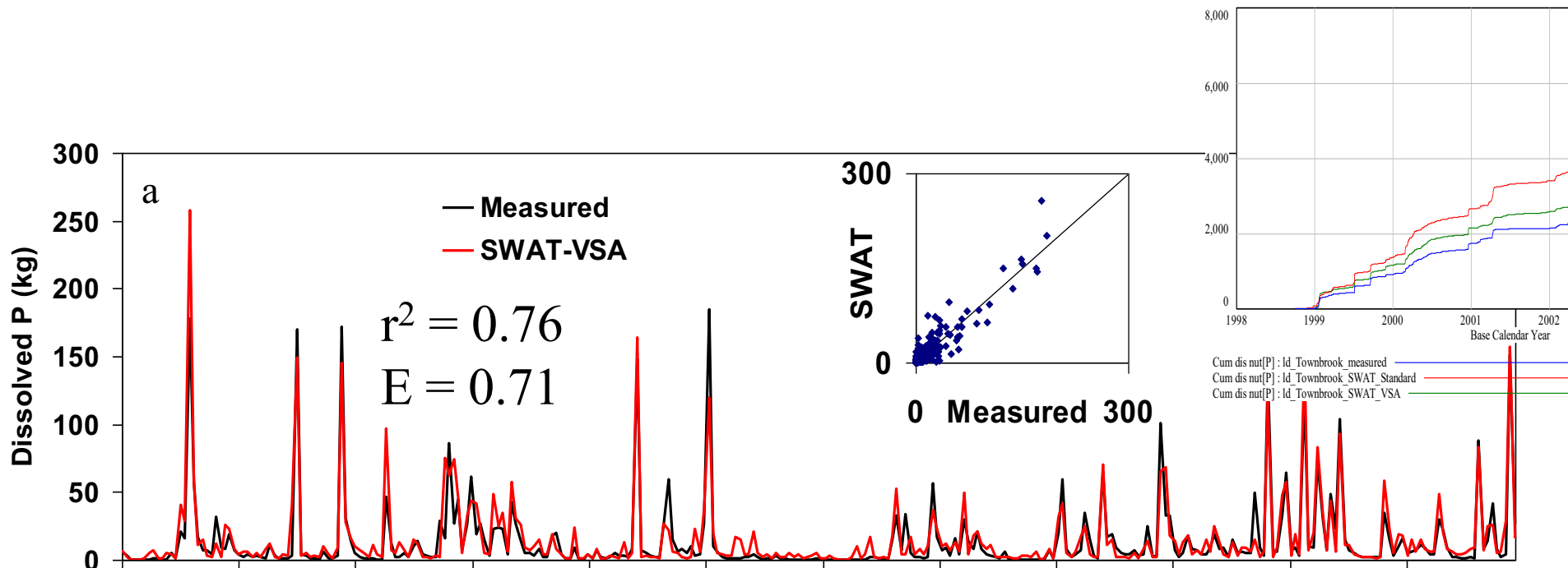
SWAT-Standard

SWAT_VSA
Dissolved P (kg ha⁻¹)



SWAT_Standard
Dissolved P (kg ha⁻¹)





Conclusions

- Both SWAT models give similar watershed outlet predictions
- For effective BMP implementation, hotspots should be identified correctly
- Validating distributed output is difficult