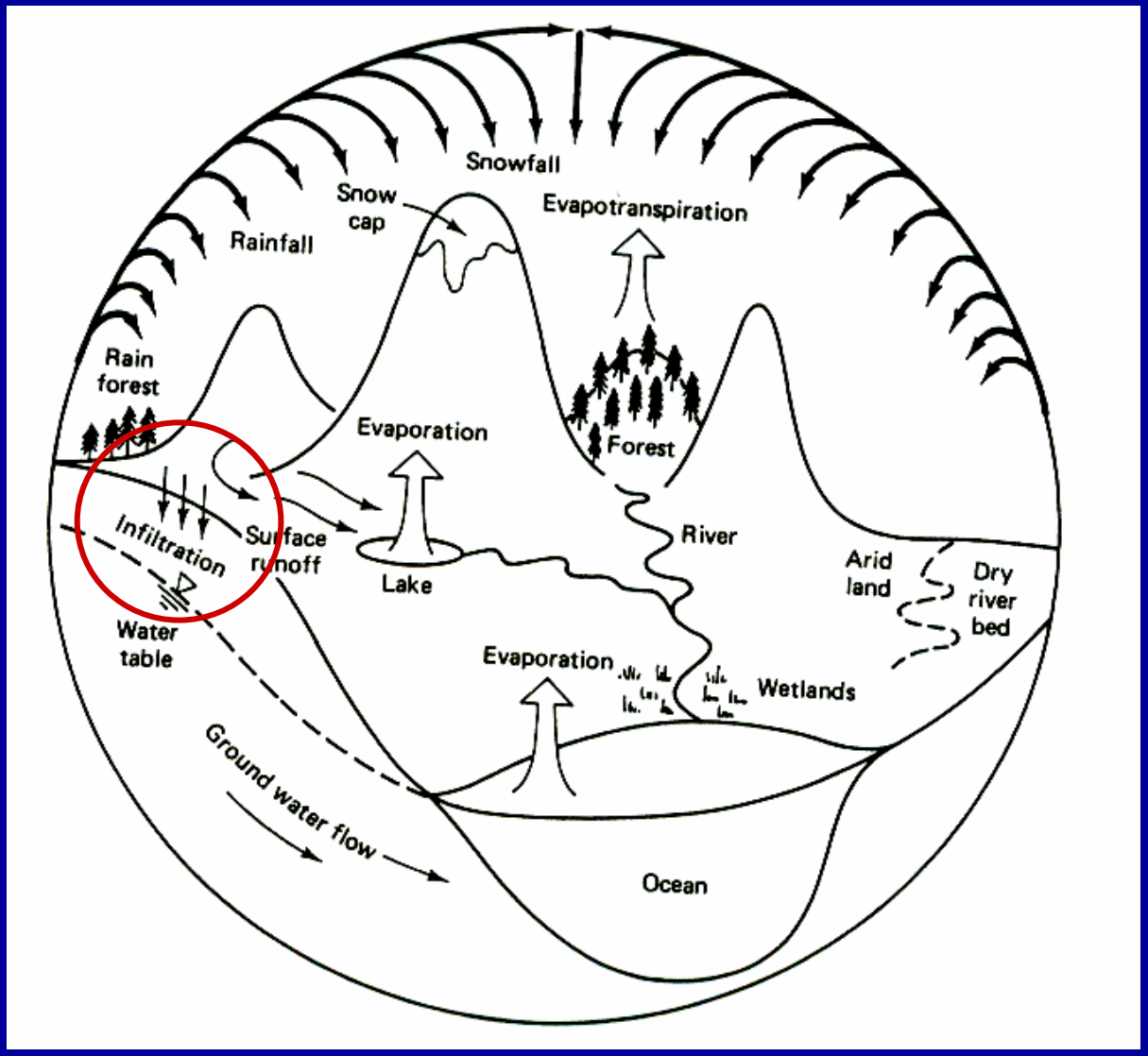
Stormwater Management Standards for Pennsylvania

Another LOOK

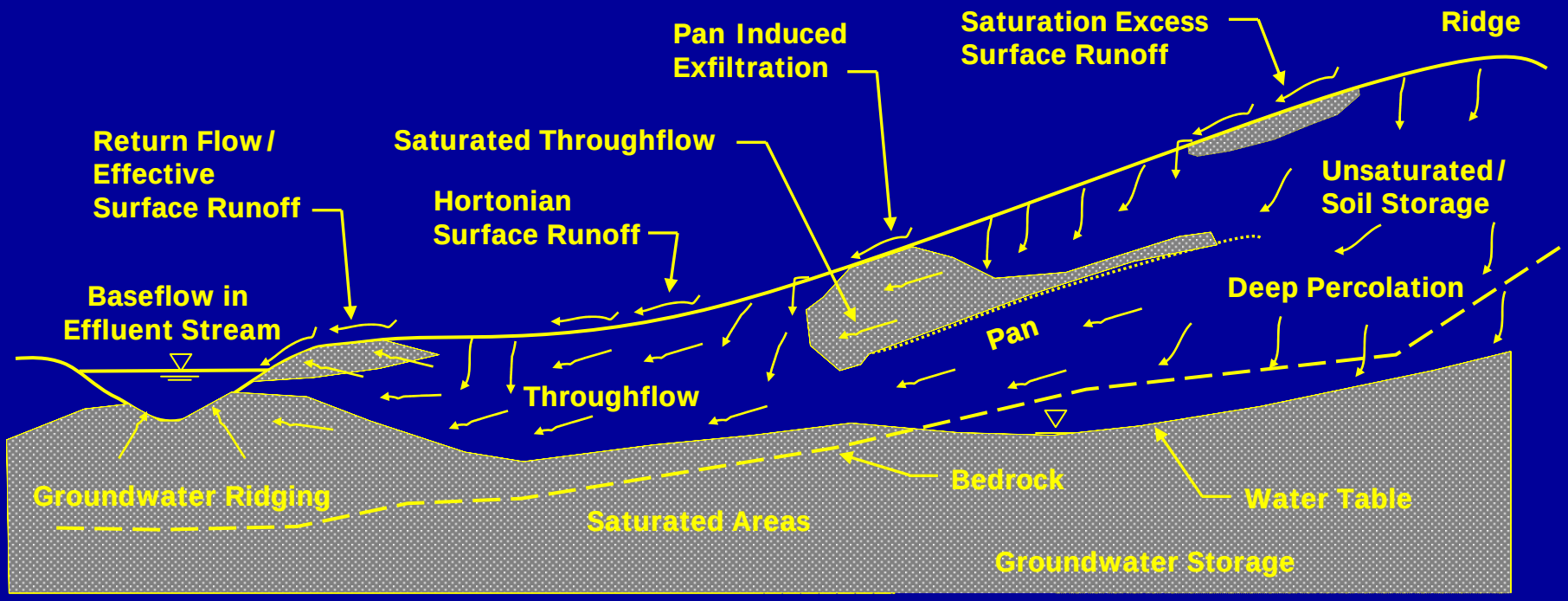
A presentation from "The Other Side of the Table"

Watershed Hydrologic Process

What we've been taught:



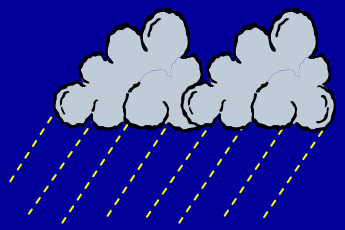
Actual infiltration and watershed runoff processes are much more complex !!

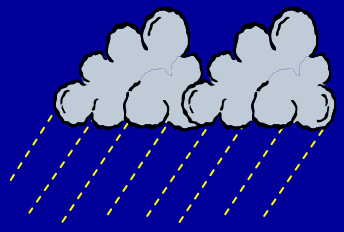


Partial Components of Hillslope Hydrology

Adapted from Chorley (1978)

Infiltration Processes

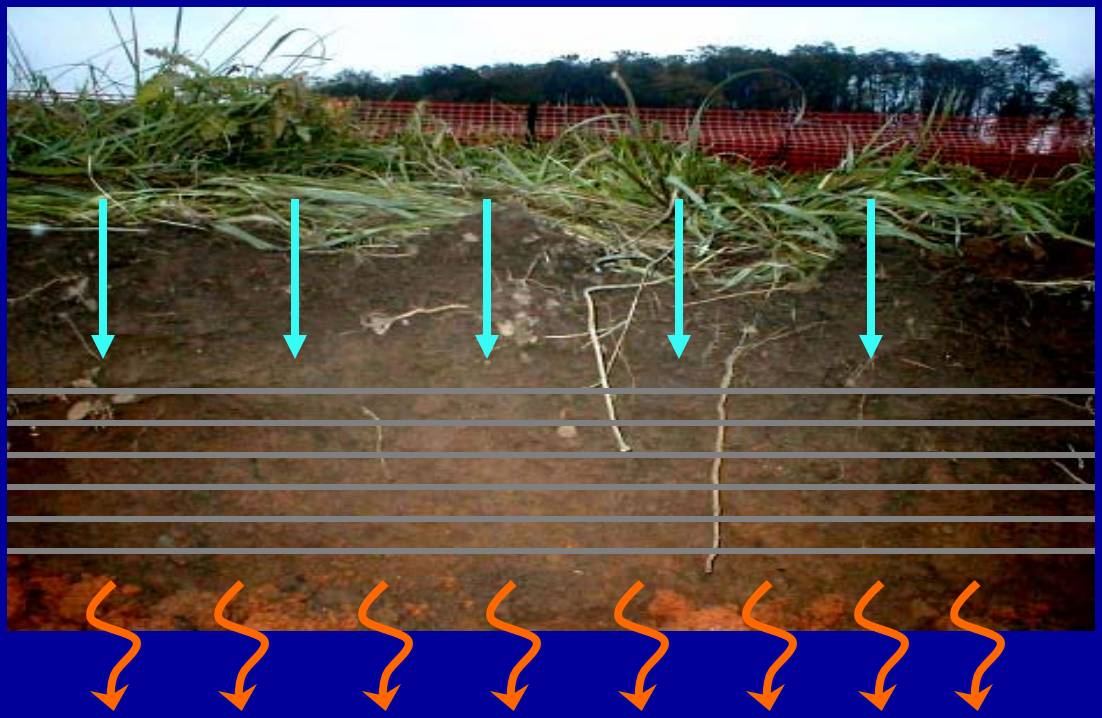




Rainfall **45”**

Infiltration **37”**

Infiltration Processes



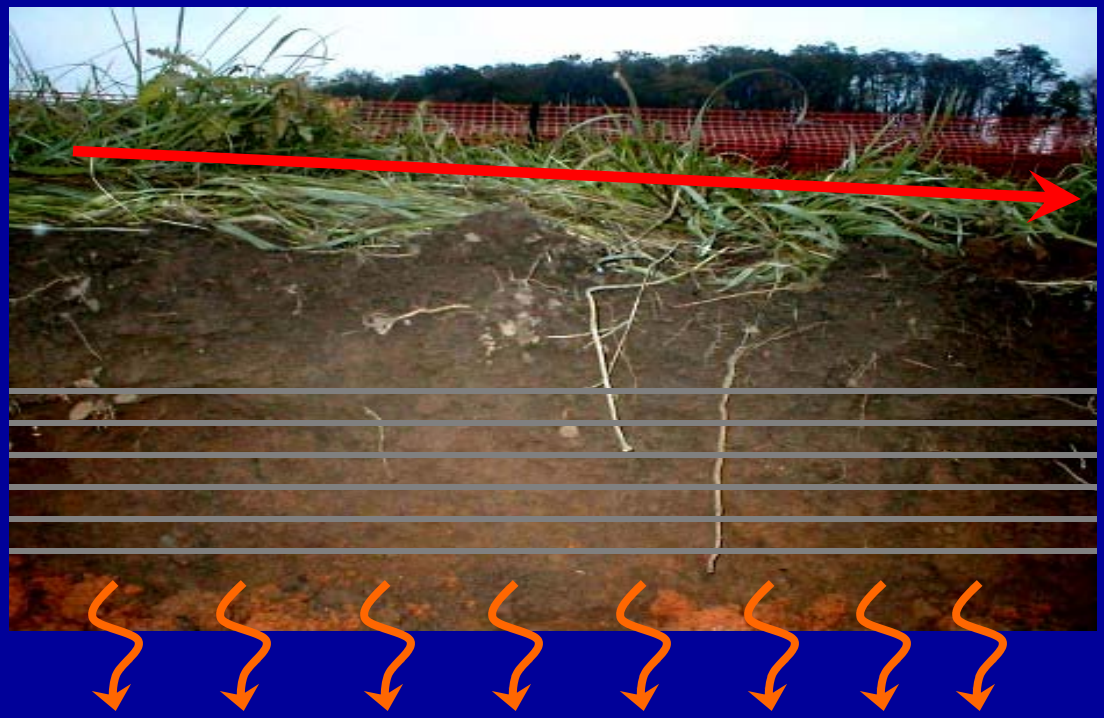
Rainfall **45”**

Infiltration **37”**

Storage **22”**

Deep Perc. (Recharge) **15”**

Infiltration Processes



Rainfall 45”

Runoff 8”

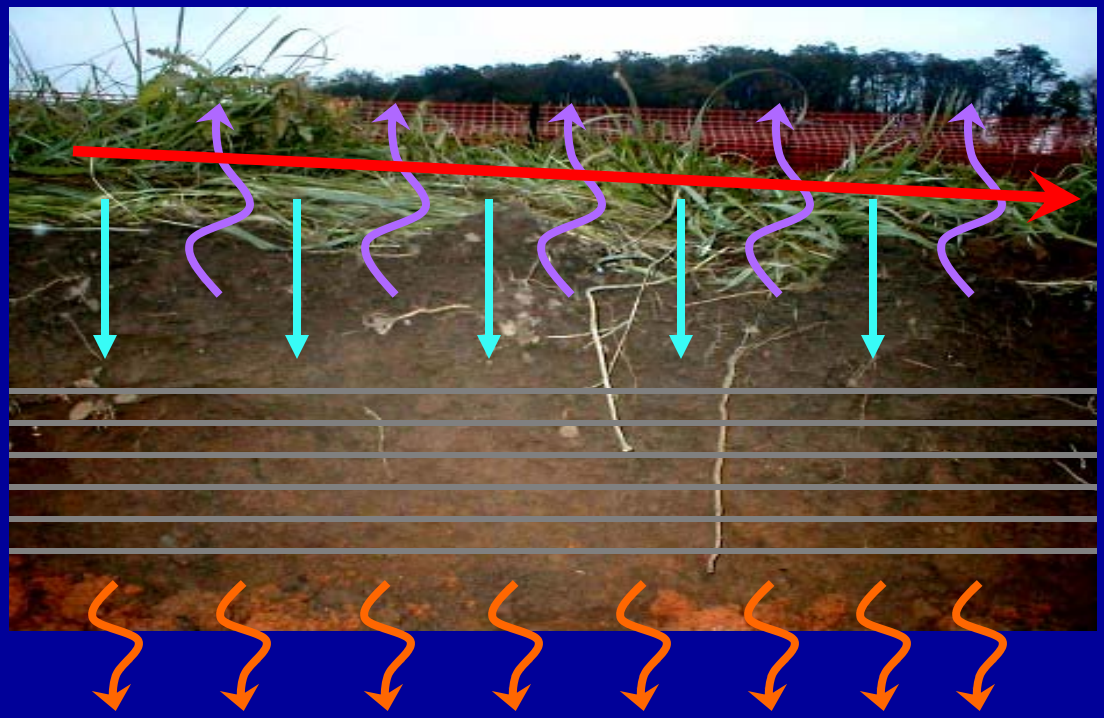
Storage 22”

Deep Perc. (Recharge) 15”

Infiltration Processes

Rainfall	45”
Evapotrans.	22”
Runoff	8”
Storage	0”
Deep Perc. (Recharge)	15”

Infiltration Processes

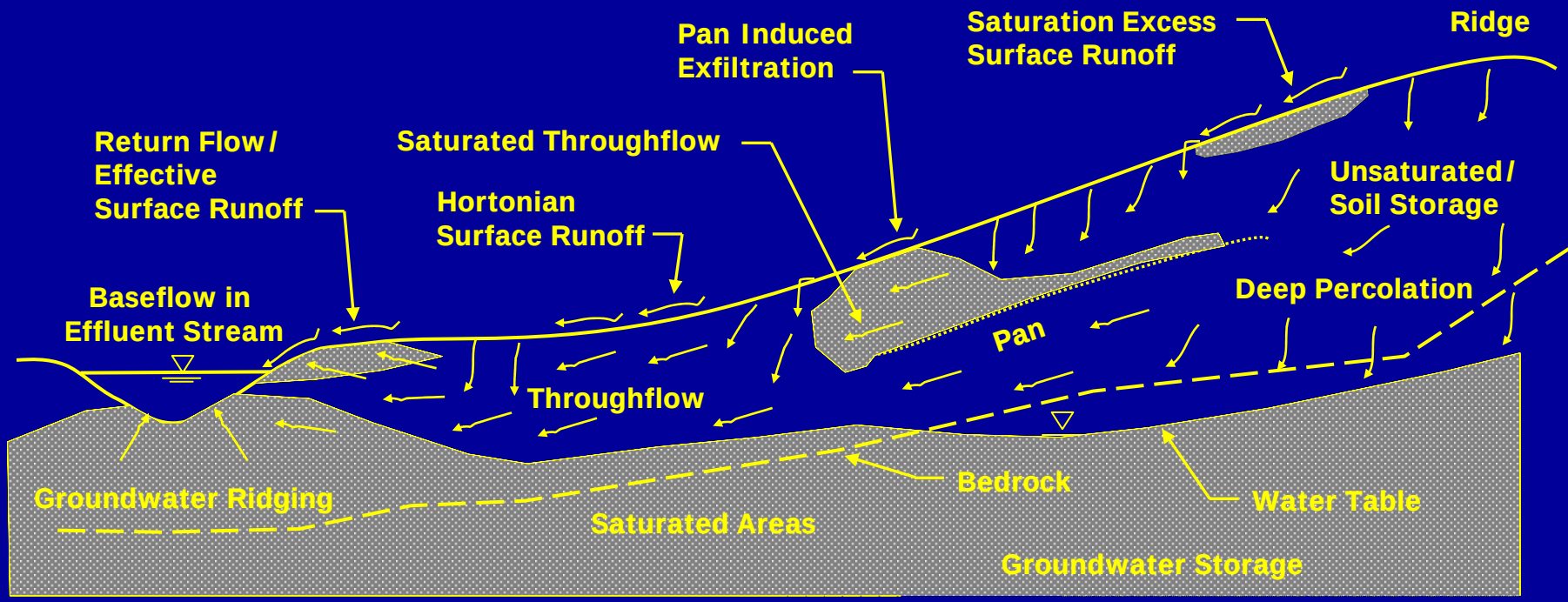


Rainfall	45”
Evapotrans.	22”
Runoff	8”
Infiltration	37”
Storage	0”
Deep Perc. (Recharge)	15”

Infiltration as Volume Control… Side-Effects:

- Over infiltration into sub-soil…Do we know what the impacts will be?
- Affect on base-flow
- Impact from a loading rate perspecitve.
- Forced infiltration in exfiltration areas.
- Seeps, wet basements, foundation issues.
- Induced slides

Over infiltration into the sub-soil…Do we know what the impact will be?

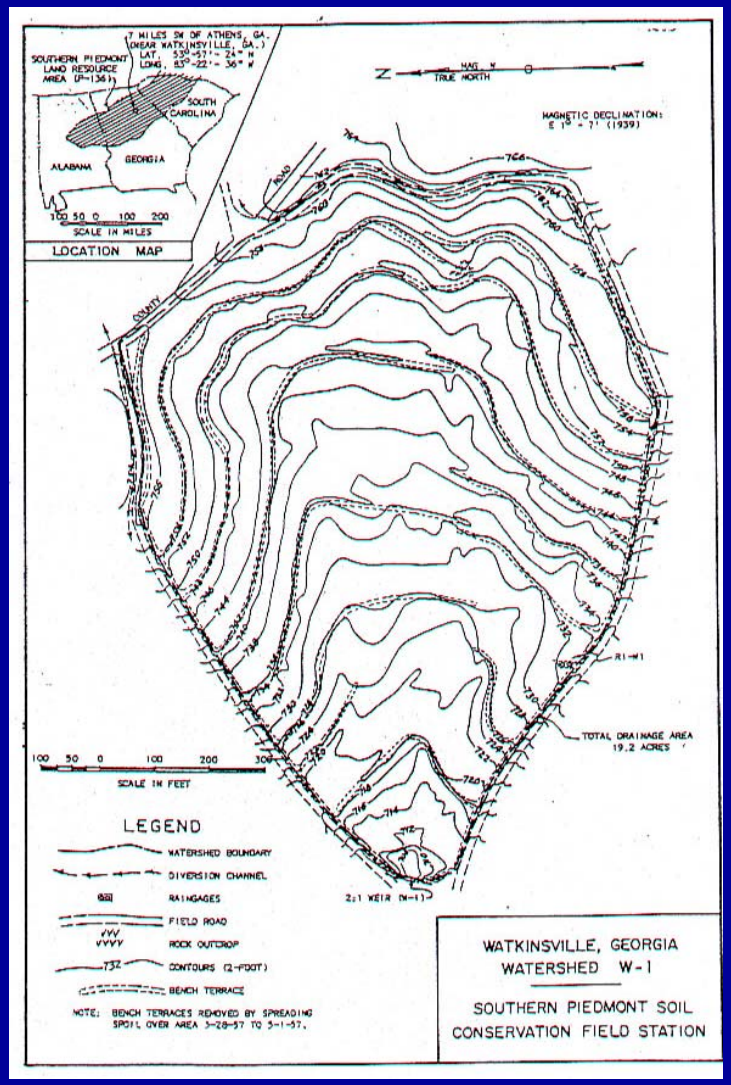


Partial Components of Hillslope Hydrology

Adapted from Chorley (1978)

What about the affect on base-flow?

Watkinsville, Georgia ARS/SCS Reseasrch Watershed



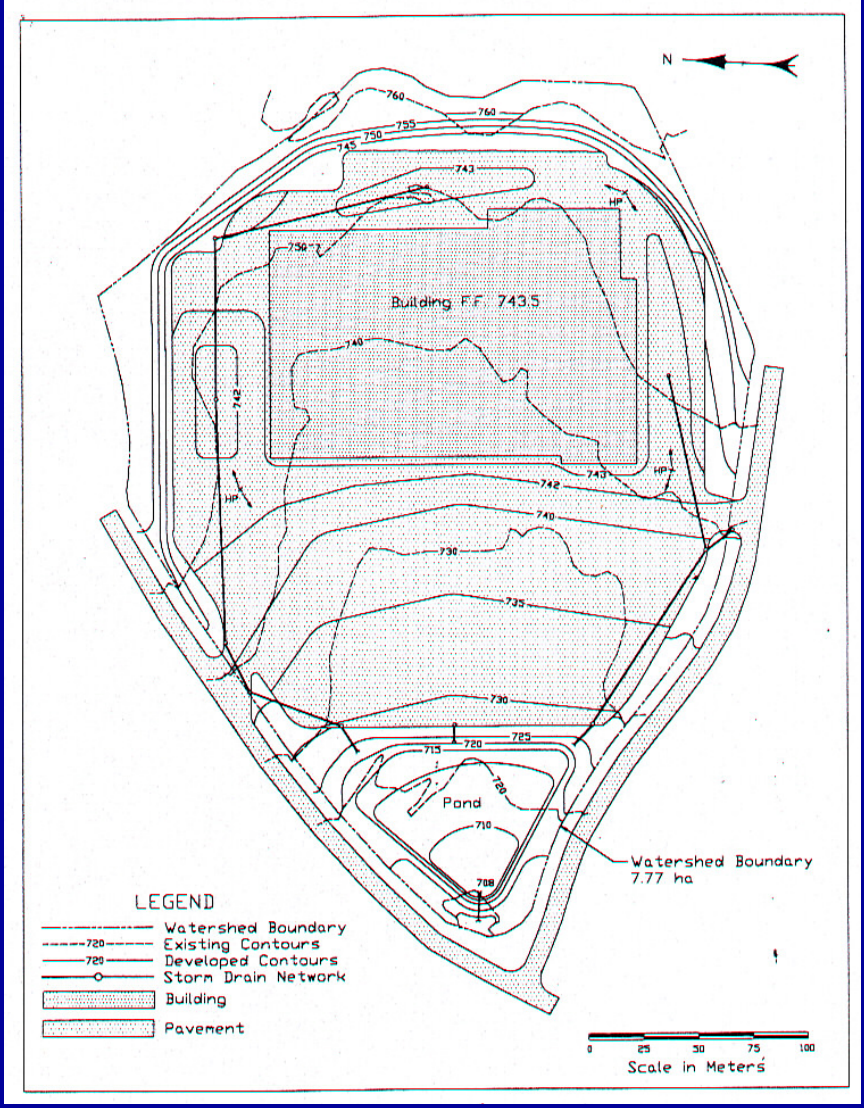
Watershed Characteristics:

Land Cover	Pasture
Area	19.2 acres
Avg. Slope	7%
Slope Range	3% - 10%
Length	366 ft
Max Width	275 ft
HSG	100% B

33 years of precipitation/ runoff data

[Fennessey, et. al., Journal of Hydrologic Engineering, 6(4):317-327, 2001]

Post-Development Scenario
Commercial - 70% impervious



Watershed Characteristics:

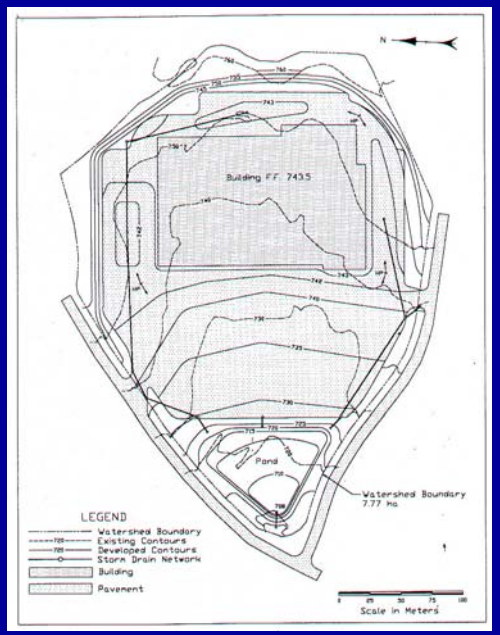
Land Use	Commercial
Area	19.2 ac
Avg. Slope	3.5%
1 Pond	

[Fennessey, et. al., Journal of Hydrologic Engineering, 6(4):317-327, 2001]

What about the affect on base-flow?

Infiltration standard comparison:

	Average Annual Runoff (in)	Total # of Runoff Events
Historic	2.83	994
Trad. Pond	21.64	2,712
Md. Std.	19.21	1,038
Spring Ck.*	15.99	622
Delta 2/24	2.56	33



[Fennessey, notes for 2002 PHRC Stormwater Workshop]

* Karst Watershed

Do we really understand the affect the reduction in the number of surface runoff events will have on headwaters hydrology ?

Impact of loading rate

Consider a residential on-lot septic system:

1 EDU = 250 gal/day

250 gal/day x 365 days = 91,250 gal/year

Assume: **1,000 sf absorption area**
Average Precip = 40 in
Deep percolation = 10 in
Direct fall precip loading = 6,250 gal/yr

Total hydrologic loading of absorption area:

91,250 + 6,250 = 97,500 gal/year = 13 ft/year

<u>Maximum Loading Rate = 0.43 in/day</u>

Impact of loading rate

Design Storm Loading Rate:

Assume: 19.2 acre site
70% impervious area (commercial)
Infiltration bed at 5:1 ratio
Precip from Region 4

Std: delta 2 yr / 24 hr (vol. = 2.69 ac-ft.)

Infiltration facility loading:

2.69 ac-ft. = 1.68 site inches = 2.37 imp. area inches

Inf. depth @ 5:1 = 2.37 X 5 = 11.9 inches

12 in. per day in 24 hours
6 in. per day in 48 hours
4 inches per day in 72 hours

Septic Field
0.43 in.

Note: Septage and stormwater loading both contain sediments and organics that can impact infiltration rates.

Impact of loading rate

Annual Loading Depth:

Assume: Annual precip. = 42 in.
19.2 acre site
70% impervious area (commercial)
Infiltration bed at 5:1 ratio
Precip Region 4
Annual Precip. 45 inches

Std: delta 2 yr / 24 hr (2.69 ac-ft.)

Analysis:

1.68 inches represents 92% depth (volume perspective)

0.92 X 45 inches = 41 inches

Annual precip. loading at 5:1

5 X 41 = <u>17 feet</u>

Septic Field
13 ft.

Note: Septage and stormwater loading both contain sediments and organics that can impact infiltration rates.

Over infiltration into the sub-soil…What experts have said:

"Injection of 5 acres of impervious area runoff into a 1 acre area and expecting this runoff to infiltrate into the soil system and to percolate through the subsoil without potentially causing other adverse effects is problematic."

"…such an additional injection into the subsurface might exaggerate lateral seepage and elevate water tables that exist in many urban/suburban areas…"

Dr. James M. Hamlett, Ph.D., P.E.
Associate Professor of Agricultural and Bio Engineering
The Pennsylvania State University

Over infiltration into the sub-soil…What experts have said:

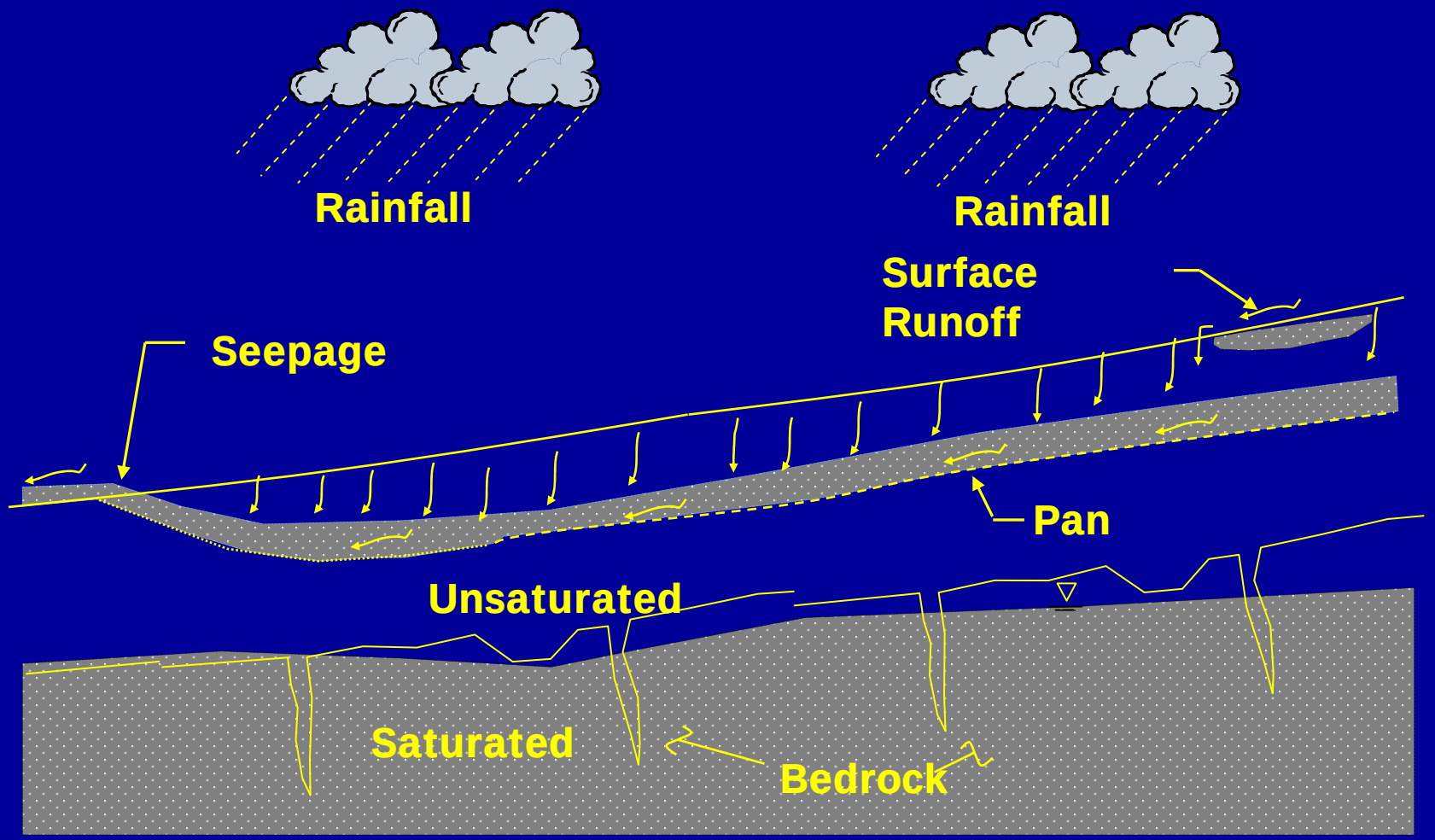
After being asked to comment on statements suggesting that the difference between the 2 year pre- and post-development runoff volumes can be infiltrated into the B or C soil horizons in Pennsylvania at a 5:1 ratio:

"I would disagree with these general statements about Pennsylvania subsoil infiltration capacities."

" …generally, not in the ridge and valley regions and any glaciated regions of Pennsylvania. The only region where this type of general statement may be applicable would be in portions of South Eastern Pennsylvania."

Dr. Gary Peterson, Ph.D.
Distinguished Professor of Soils and Land Resources
The Pennsylvania State University

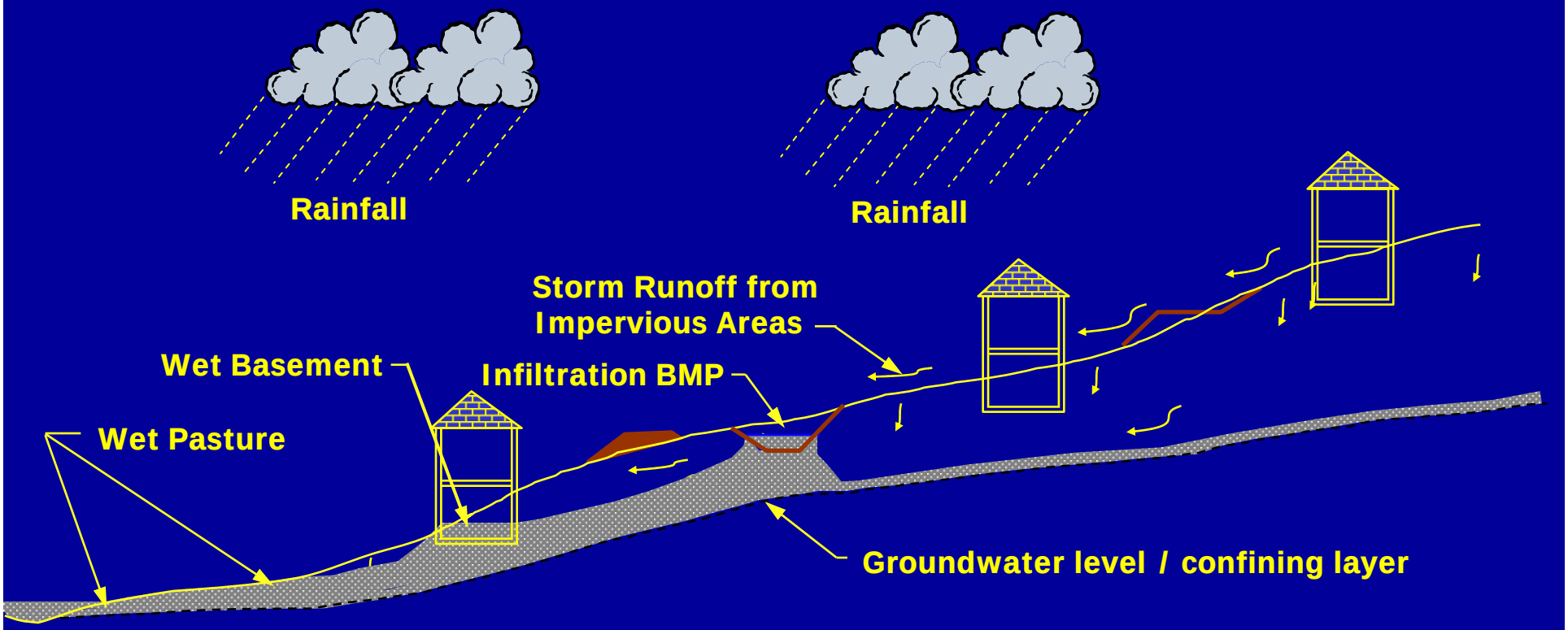
Forced infiltration in exfiltration areas



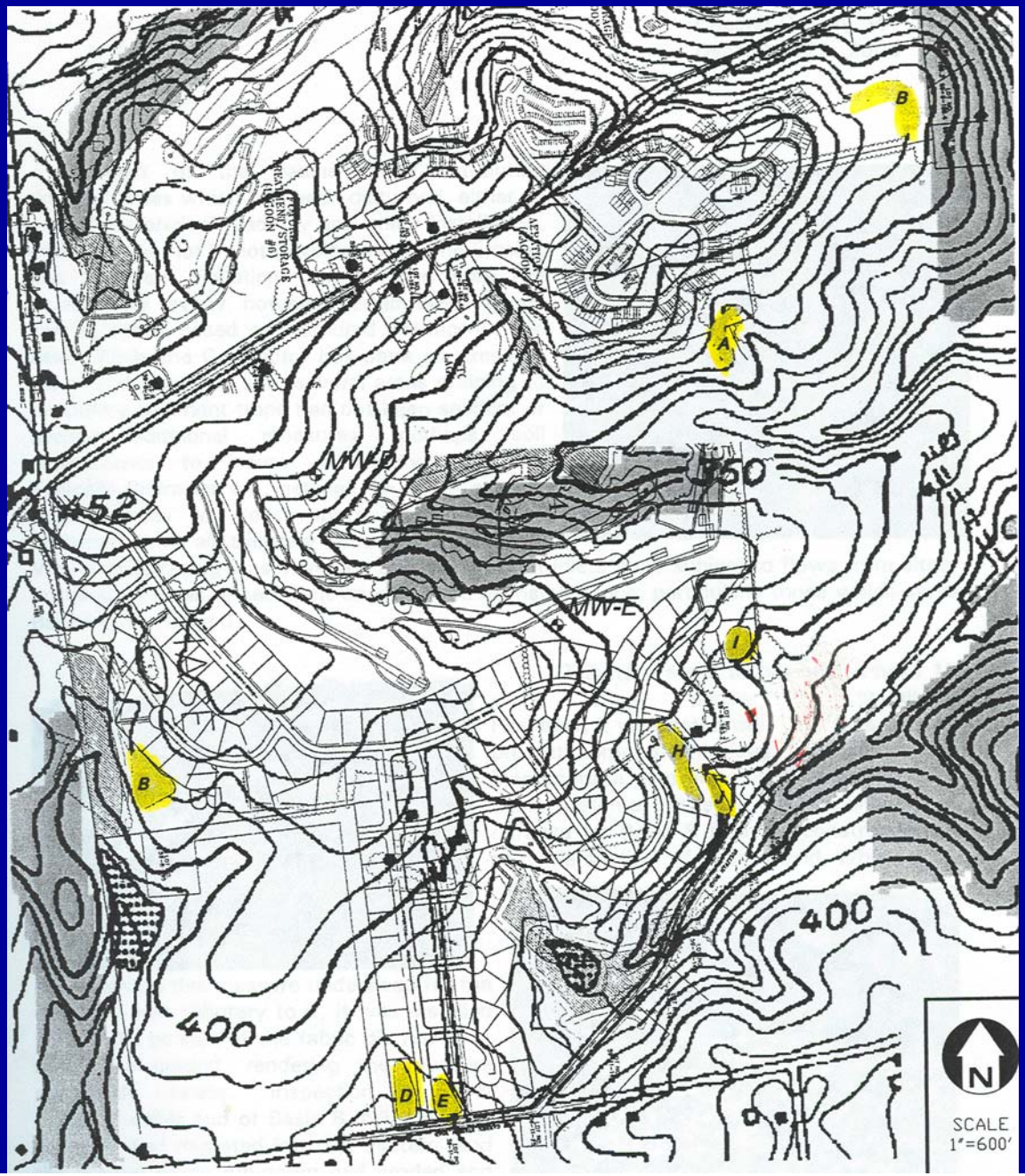
In areas underlain with impermeable layers, soil-water will move laterally to a lower potential…generally downhill.

In Frankstown Township, fragipans create an exfiltration front at the toe of slope hundreds of acres in size

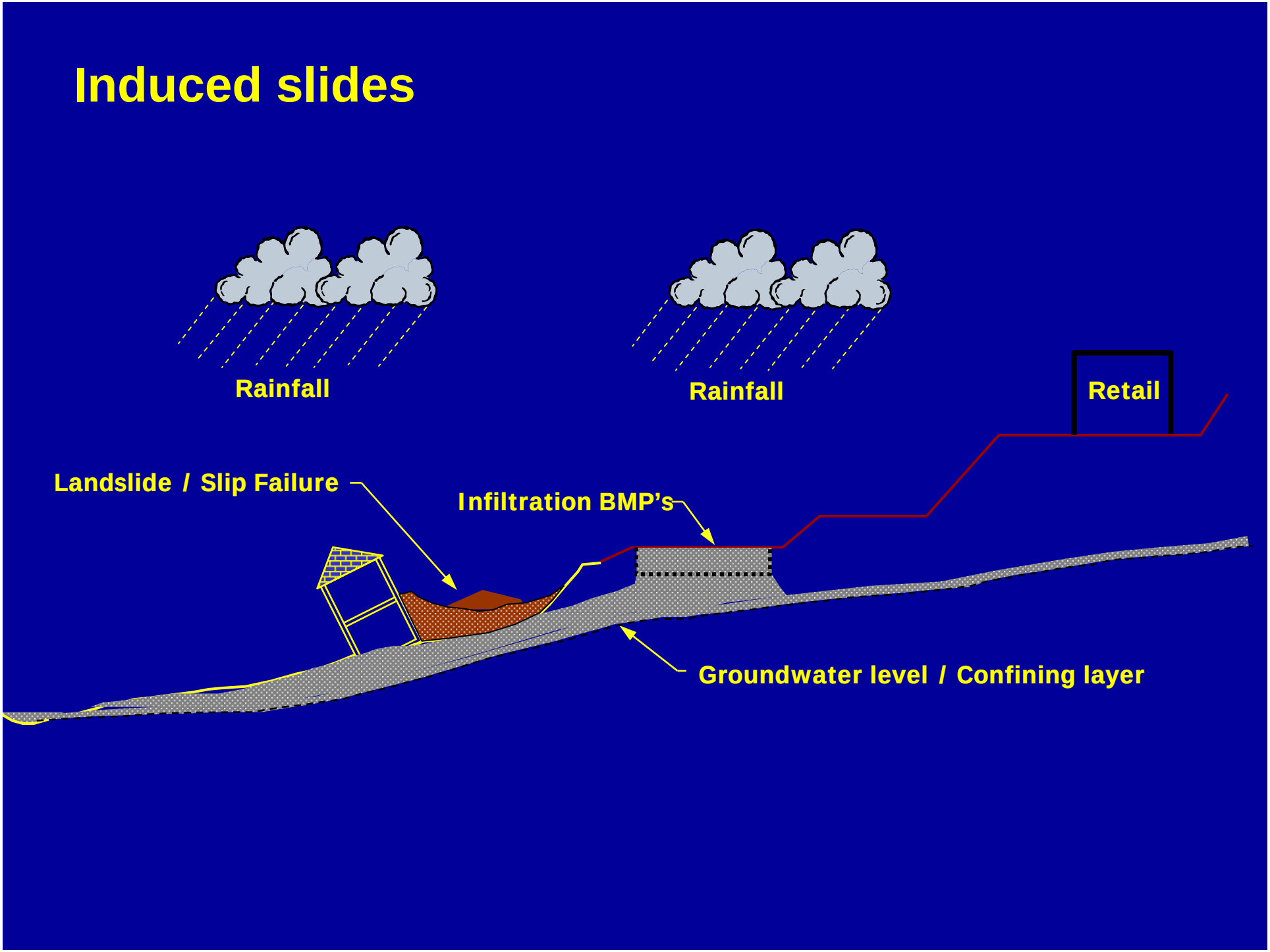
Seeps, wet basements and foundation issues



Seeps, wet basements and foundation issues



Induced slides



Side Effects…Summary:

Over infiltration into the subsoil…

How much is too much? … And do we really understand the impact?

Proposed Standards:

1. Should we even be proposing standards?
   - maybe

2. How high should the standards be set?
   - probably a moderate level.

Proposed Standards:

So, what is a reasonable standard for volume control ?

- 2 yr / 24 hr
- 1 yr / 24 hr
- 90% capture
- 75% capture

Comparison of infiltration volumes and annual loading rates for various standards:

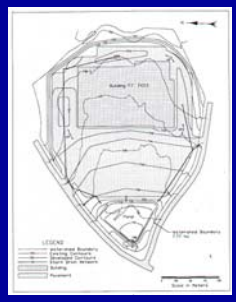
Standard	Design Infiltration Volume (1)			Annual Capture	Annual Loading (3)	
	acre-ft	Site inches	Imp area inches	(inches) (2)	Volume (feet)	72 hr (in/day)
Md. Std.	0.27	0.17	0.24	11	4.6	0.40
Spring Ck. (4)	0.57	0.36	0.50	17	7.1	0.83
Delta 2yr /24 hr	2.69	1.68	2.37	41	17.1	4.0
Delta 1yr /24	2.24	1.40	1.98	31	12.9	3.3
Delta 90% capture	1.87	1.17	1.64	35	14.5	2.7
Delta 75% capture	1.10	0.69	0.97	28	11.7	1.6
Typical Septic System					13	0.43

(1) Volumes based on Region 4 precipitation and development of 19.2 acre commercial site at 70% imperviousness.

(2) Annual rainfall volume captured in total precipitation inches. (out of 45 inches). Compare to 15 inches of deep percolation…the average for the Piedmont region.

(3) Based on 5:1 loading ratio for engineered infiltration beds.

(4) Karst watershed



Proposed Standards:

Volume Control

Suggested Std:

- Infiltrate 33% of the difference between the pre- and post-development 2 year 24 hour storm.
- Manage the remainder
  - ✓ Additional infiltration where possible
  - ✓ Reuse technologies
  - ✓ Green roofs and other ET technologies
  - ✓ Credits for conservation design practices (plant a tree… direct sheet flow to natural areas, etc.)
  - ✓ Capture and extended release

Proposed Standards:

Rate Control

Suggested Standard:

No increase in the peak runoff for the 1 – 25 year events (demonstrated through analysis of the 1, 2, 10, and 25 year event). Provide safe conveyance for the 100 year event.

Proposed Standards:

Water Quality Control

Suggested Standard:

Present the standard as a performance standard. Outline procedures for meeting performance standard.