Stormwater Management Standards for Pennsylvania

Another

A presentation from “The Other Side of the Table”
What we’ve been taught:

Watershed Hydrologic Process
Actual infiltration and watershed runoff processes are much more complex!!

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 perspective.
• 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?
What about the affect on base-flow?

Watkinsville, Georgia ARS/SCS Research 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

Post-Development Scenario
Commercial - 70% impervious

Watershed Characteristics:

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

What about the affect on base-flow?

Infiltration standard comparison:

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

[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?
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

**Maximum Loading Rate = 0.43 in/day**
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)
- \(0.92 \times 45\) inches = 41 inches
- Annual precip. loading at 5:1
- \(5 \times 41 = 17\) feet

**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
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

Rainfall

Storm Runoff from Impervious Areas

Infiltration BMP

Groundwater level / confining layer

Wet Basement

Wet Pasture
Seeps, wet basements and foundation issues
Induced slides

Rainfall

Landslide / Slip Failure

Infiltration BMP's

Groundwater level / Confining layer

Retail
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:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Design Infiltration Volume (1)</th>
<th>Annual Capture Volume (inches)</th>
<th>Annual Loading (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acre-ft</td>
<td>inches</td>
<td>Imp area inches</td>
</tr>
<tr>
<td>Md. Std.</td>
<td>0.27</td>
<td>0.17</td>
<td>0.24</td>
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<tr>
<td>Spring Ck. (4)</td>
<td>0.57</td>
<td>0.36</td>
<td>0.50</td>
</tr>
<tr>
<td>Delta 2yr /24 hr</td>
<td>2.69</td>
<td>1.68</td>
<td>2.37</td>
</tr>
<tr>
<td>Delta 1yr /24</td>
<td>2.24</td>
<td>1.40</td>
<td>1.98</td>
</tr>
<tr>
<td>Delta 90% capture</td>
<td>1.87</td>
<td>1.17</td>
<td>1.64</td>
</tr>
<tr>
<td>Delta 75% capture</td>
<td>1.10</td>
<td>0.69</td>
<td>0.97</td>
</tr>
<tr>
<td>Typical Septic System</td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.