Understanding Hydrologic Process for Better Stormwater Management

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GOAL ... to project an understanding of...

- how surface cover characteristics, topography / landscape position, soils and geology all play a key role in how water moves over and under the surface of a site;

- the difference between surface runoff response from a natural watershed and that from a small land area or hypothetical watershed; and

- the limitations of available stormwater modeling tools when applied to hypothetical watersheds.
Hydrologic Process... a lay perspective

[Diagram showing hydrologic processes including condensation, evaporations from rivers, soils, and lakes, transpiration, interception, runoff, infiltration, soil moisture, throughflow, groundwater, and seepage.]
Surface and Subsurface Hydrologic Process:

Increased Peak Rate, Volume, and Frequency of Runoff.

Modified From: Controlling Urban runoff, Schueler, 1987
Hillslope hydrologic Processes

- Unsatuated/Soil Storage
- Baseflow in Effluent Stream
- Saturation Excess Surface Runoff
- Hortonian Surface Runoff
- Ridge
- Bedrock
- Water Table
- Saturated Areas
- Pan Induced Exfiltration
- Saturated Throughflow
- Throughflow
- Deep Percolation
- Return Flow/Effective Surface Runoff
- Groundwater Storage
Factors Affecting the Movement of Gravitational Water Through Soil

1. Texture
2. Structure
3. Layering
4. Preferential Flow Paths
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2. Structure

Round  Blocky  Angular  Platy
Factors Affecting the Movement of Gravitational Water Through Soil

2. Structure

Round / Angular

Platy
Factors Affecting the Movement of Gravitational Water Through Soil

3. Soil Layering
Factors Affecting the Movement of Gravitational Water Through Soil

3. Soil Layering – Restrictive Soil Layers

Fragipan
Factors Affecting the Movement of Gravitational Water Through Soil

4. *Preferential Flow Paths – in the soil*

![Diagram showing preferential flow paths in soil](image.png)
Factors Affecting the Movement of Gravitational Water Through Soil

4. Preferential Flow Paths – in shallow bedrock
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4. *Preferential Flow Paths – in shallow bedrock*
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4. Preferential Flow Paths – in shallow bedrock
The Net Affect…. 

1) Subsurface seepage through macropore networks in subsoils

2) Lateral flow through the interface between A and B horizons

3) Return flow at footslope and toeslope during snow melts or large storms

4) Flow at the soil-bedrock interface

Shale Hills Watershed
Huntingdon Co., PA

Stream

Hilltop
(Dry Site)

Backslope
(Moderately Wet or Moderately Dry Site)

Valley Floor or Swale Bottom
(Wet Site)
Watershed Response Processes

- Surface Runoff
- Unsaturated
- Saturated Area
- Stream
- Saturated Areas
- Bedrock
An example of saturated watershed areas at the beginning of a storm in a humid region.
Watershed Response Processes – Partial (Variable) source Area

An example of saturated watershed areas near the end of a storm in a humid region
Watershed Response Processes – Partial (Variable) source Area

An example of saturated watershed areas during a major storm in a humid region.
Watershed Response ... the standard of engineering practice

Hortonian Overland Flow Model
Watershed Response … what really happens.

Process is complex…understand site specific hydrologic response

Partial Components of Hillslope Hydrology

Adapted from Chorley (1978)
Also:

- Hydrologic response is not uniform and some areas of a watershed will produce more runoff than others.
Hydrologic models in common use today are simplistic representations of average watershed response and will over predict runoff in some areas, and under predict runoff in others.
So what does all this mean
Consider a development centered in upland ridge areas.
Pre-Post Hydrologic Analysis

- Modeled /actual post-development runoff
- Modeled pre-development runoff
- Actual pre-development runoff

Flow (cfs) vs. Time (hours)
Hydrologic Process And The Placement Of Infiltration Facilities

- Unsaturated/Soil Storage
- Baseflow in Effluent Stream
- Ridge
- Unsaturated/Soil Storage
- Deep Percolation
- Groundwater Storage

Partial Components of Hillslope Hydrology

Adapted from Chorley (1978)
Remember to consider ...........

Down – gradient impacts from concentrated infiltration practices

Natural Meadow Soils have high infiltration characteristics......
Remember to consider ..........

Down – gradient impacts from concentrated infiltration practices

..... Removing these deep soils and vegetation and replacing them with a structural feature concentrating infiltration can cause adverse down-gradient impacts.
And what about impacts in Karst Areas?
Concluding Statements

1. Surface and subsurface flow characteristics at a watershed and land development scale are defined by a complex interaction of a surface and subsurface physical characteristics.

2. Available computational tools for assessing runoff response are based on simplified conceptual models that don’t adequately simulate development scale runoff response;

3. **Responsible** design of stormwater mitigation measures requires an understanding of hydrologic process, and consideration of site specific characteristics driving the runoff response mechanisms. It can not rely on blind application of available hydrologic models.