Hillslope Hydrology of Alabama's Sandmountain Pastures

Runoff Generation Mechanisms
Spatial and Temporal Distribution of Runoff Generation Areas

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Presentation Outline

- Justification
- Runoff Generation Process Concepts
- Objectives
- Methodology - Instrumentation
- Results and Discussion
  - Runoff generation mechanisms
  - Spatial and temporal variability of runoff generation areas
- Conclusions/Implications of P transport

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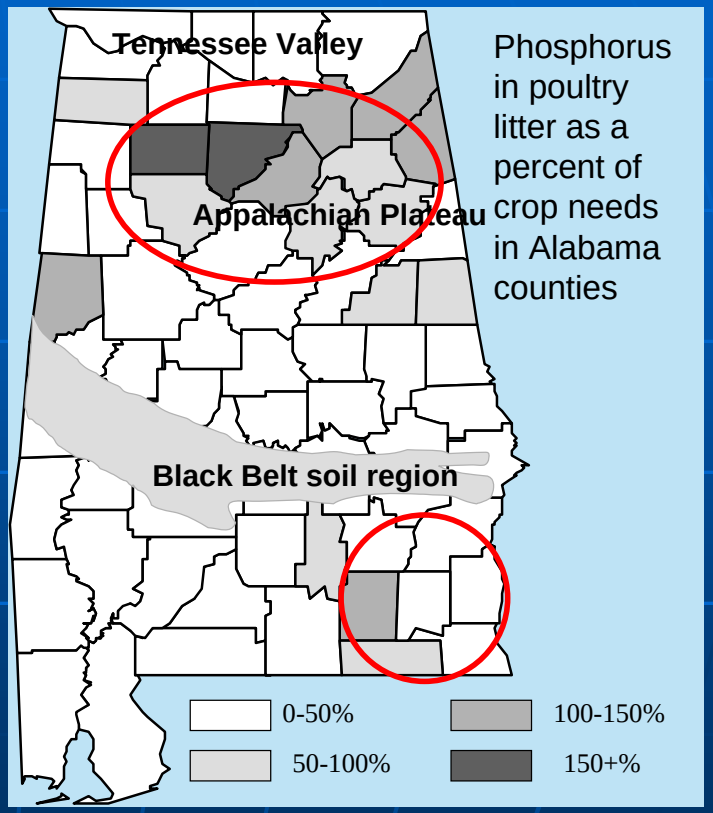
Justification

- Alabama ranks in top three in broiler production
- About 500 CAFOs and 4000 AFOs; about 12,000 chicken houses
- Broiler litter production – 1.8 million tons/year
- Most of the poultry production occurs in 5 counties in the Appalachian Plateau (Sandmountain region)
- Land application to pastures - build up and transport of P



Phosphorus in poultry litter as a percent of crop needs in Alabama counties

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Alabama P-Index

- Alabama P-Index: alleviate water quality issues related to P loss
- Based on the principle that P is transported in surface runoff
  - Agronomic soil P thresholds
  - Runoff class (hydrologic soil groups)
  - Soil erosion
  - P application distance to water
- Treats an entire field as runoff (and P) contributing area
- Recent studies indicate subsurface transport might be important
- Runoff might not occur uniformly (spatial and temporally) on the entire hillslope

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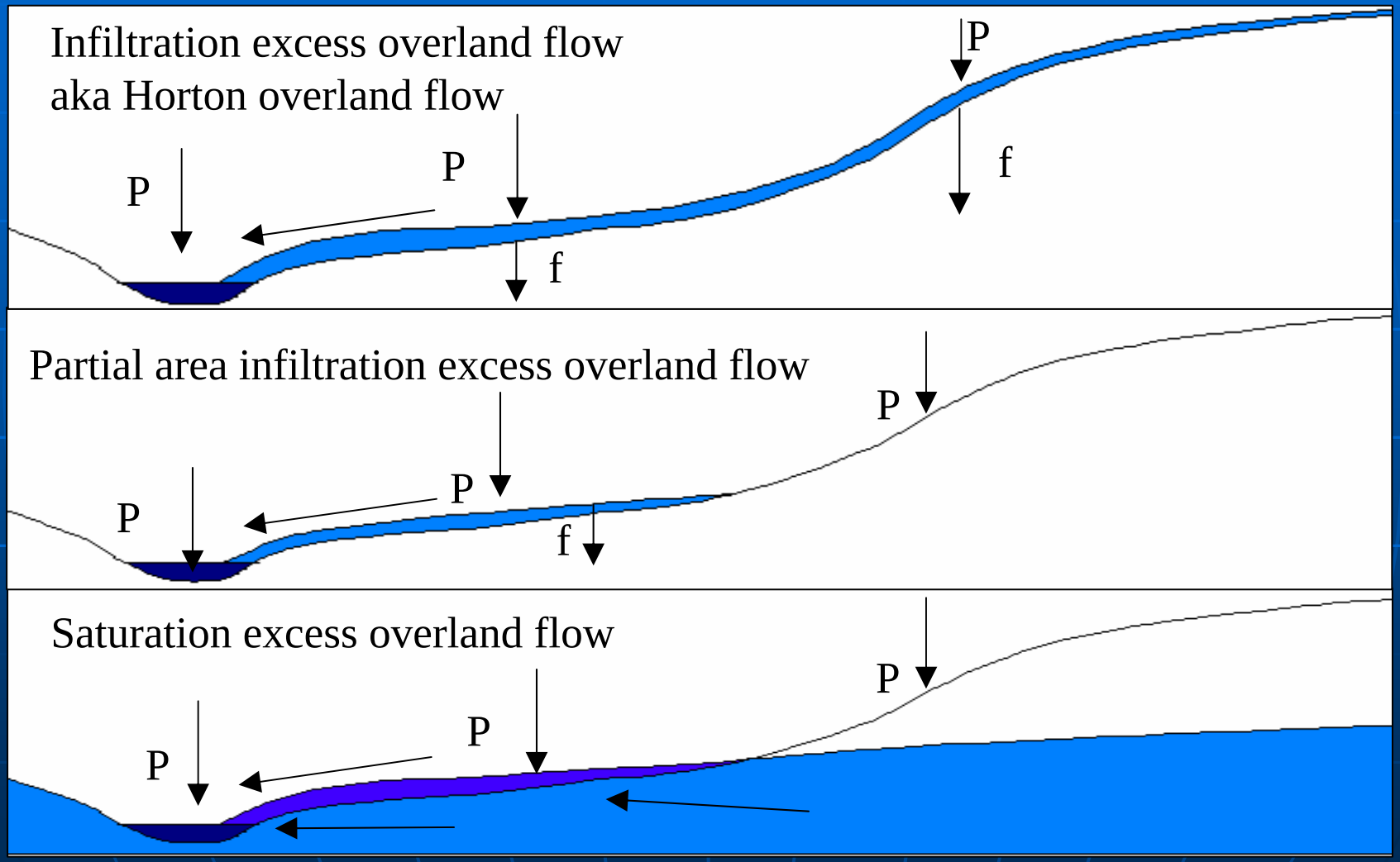
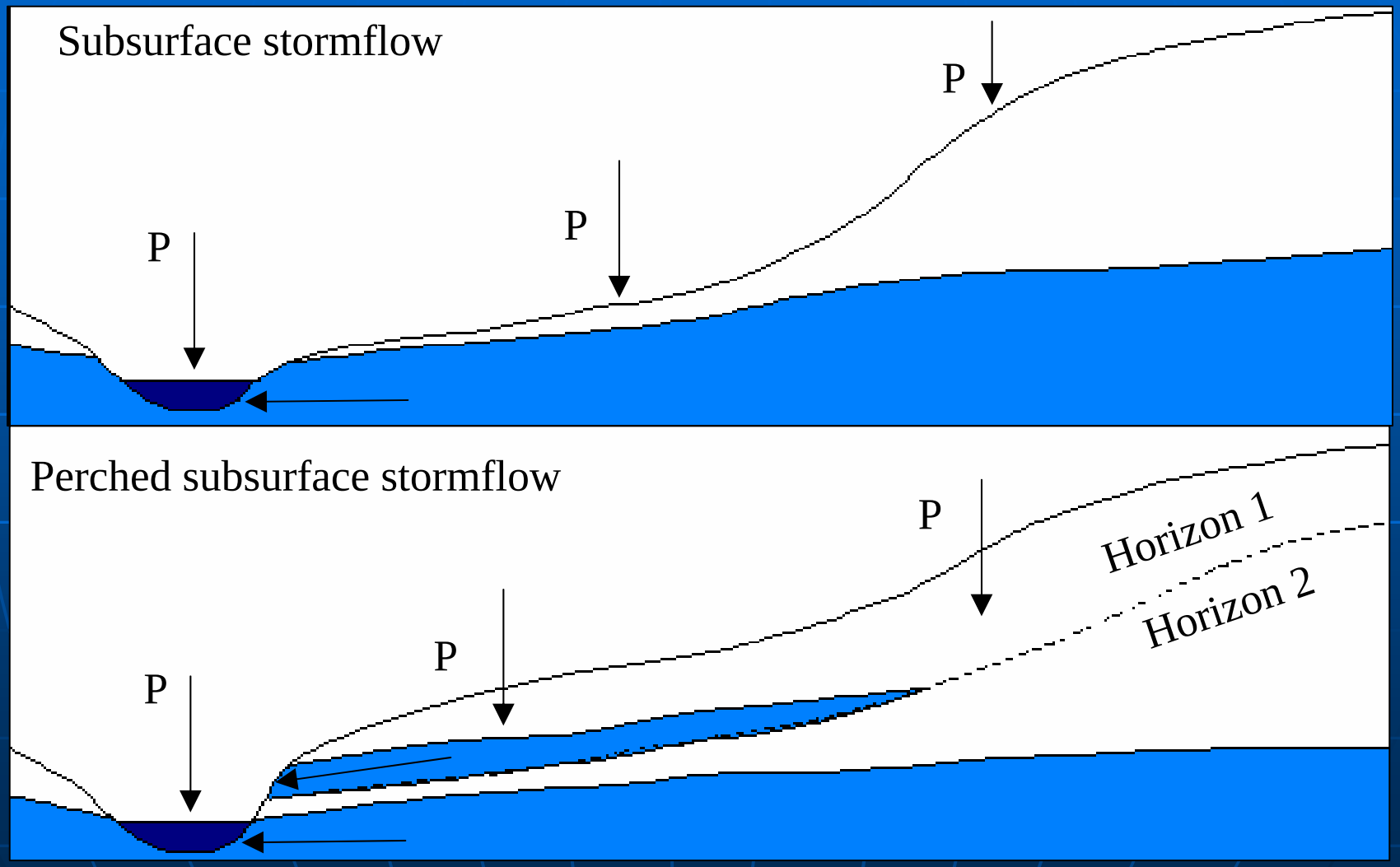
Runoff Generation Processes



Runoff Generation Processes



Runoff Generation Processes

- Factors affecting runoff generation in watershed:
  - Rainfall characteristics
  - Soil hydraulic characteristics
  - Antecedent moisture conditions
  - Topography
  - Vegetation
  - Depth to water table
  - Presence or absence of restrictive layers (fragipans)
- Depending on the runoff generation process
  - Over or underestimation of runoff and P transport potential
  - Inappropriate application of BMPs

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Objectives

- Identify the main surface runoff generation mechanism in the Sandmountain region of Alabama
- Identify spatial and temporal distribution of hydrologically active areas (HAAs) and their connectivity to the outlet

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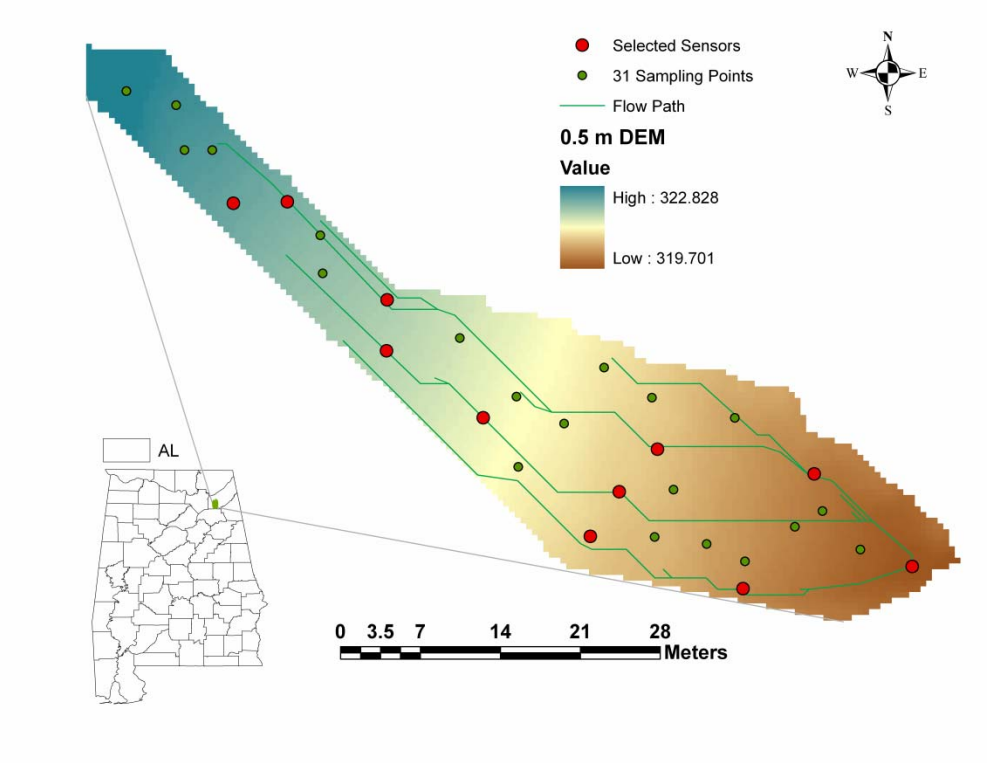
Study Site

- A pasture hillslope of 0.12 ha was instrumented at Sandmountain Research and Extension Center, Crossville, AL
- Located in DeKalb County, one of largest poultry producing counties in AL
- Detailed topography
- Surface and subsurface sensors



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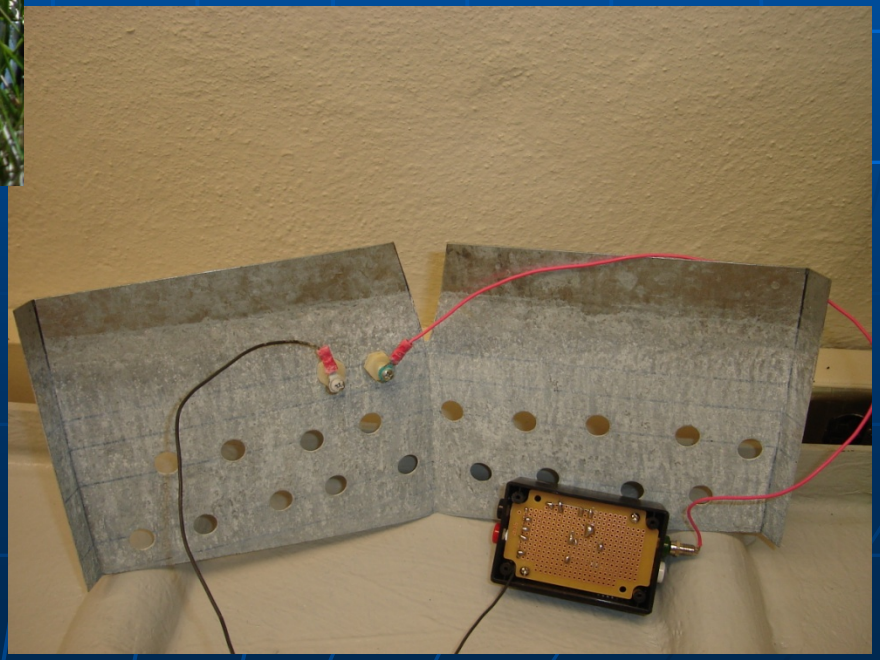
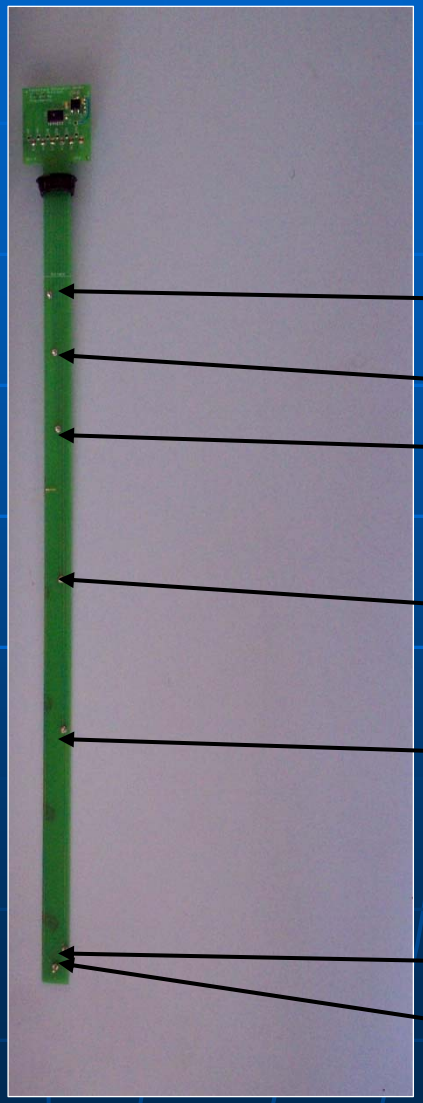
Study Site

Surface Runoff Sensor

- Surface sensors work on "Yes" or "No"

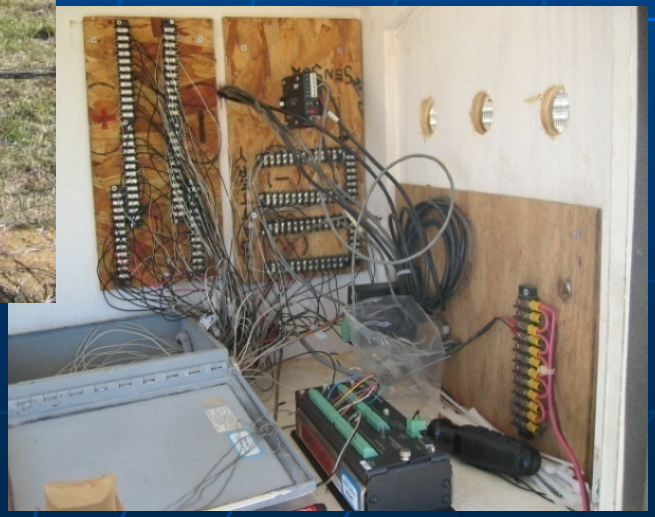


Subsurface Runoff Sensor



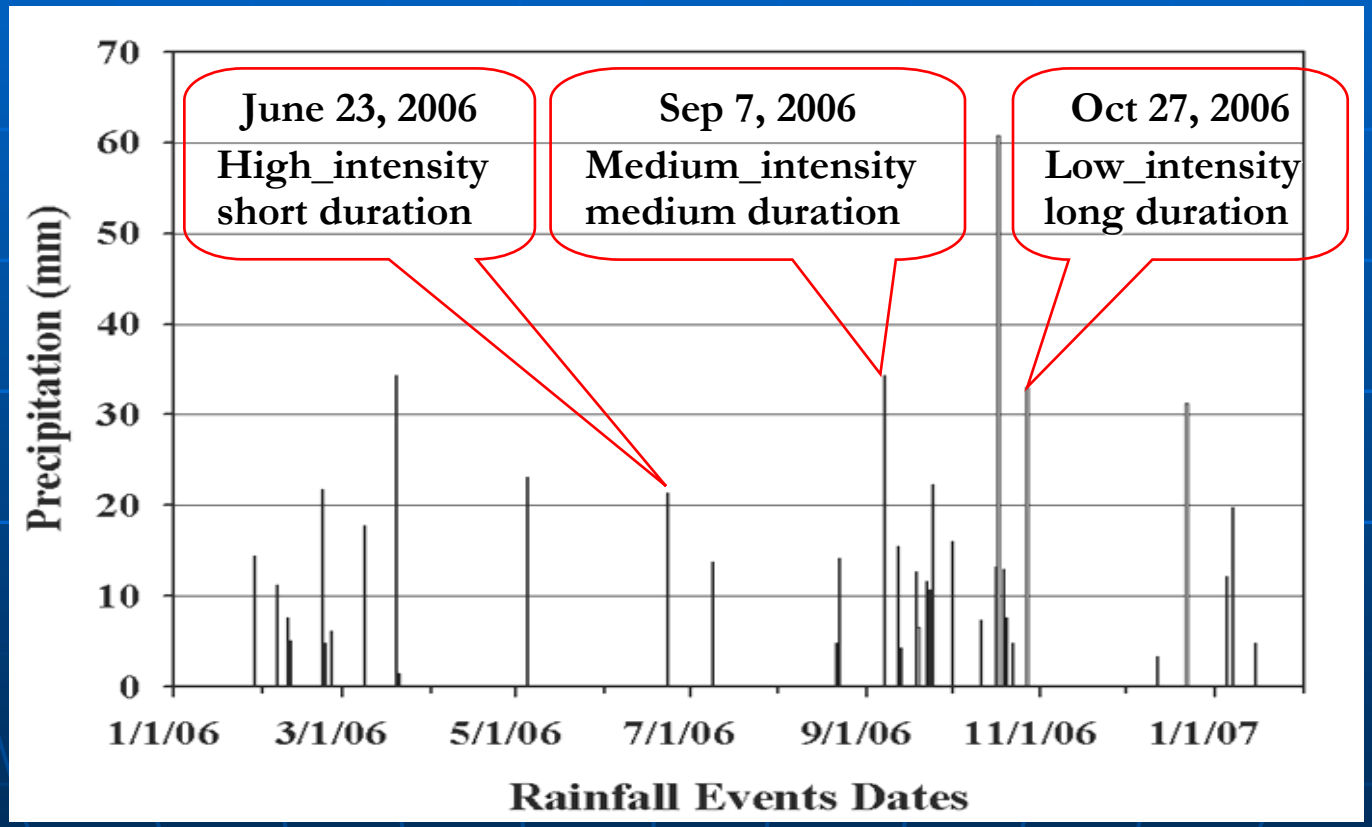
Water level in cm	Voltage (V)
0	2.25
4	2.00
9	1.70
20	1.50
27	1.00
40	0.52
Ground Pin	0

Instrumentation



Results and Discussion

Runoff Generation Mechanism



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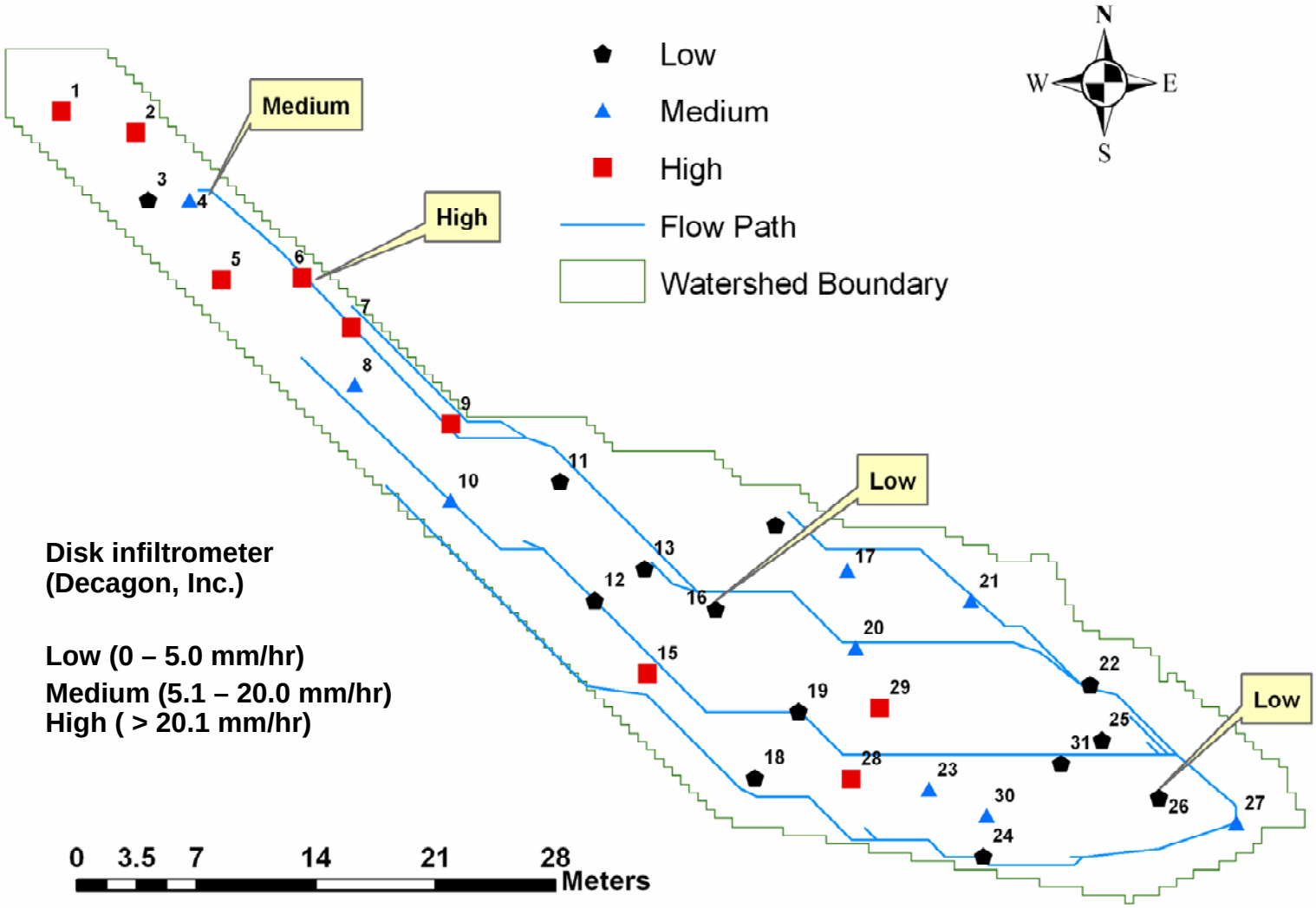

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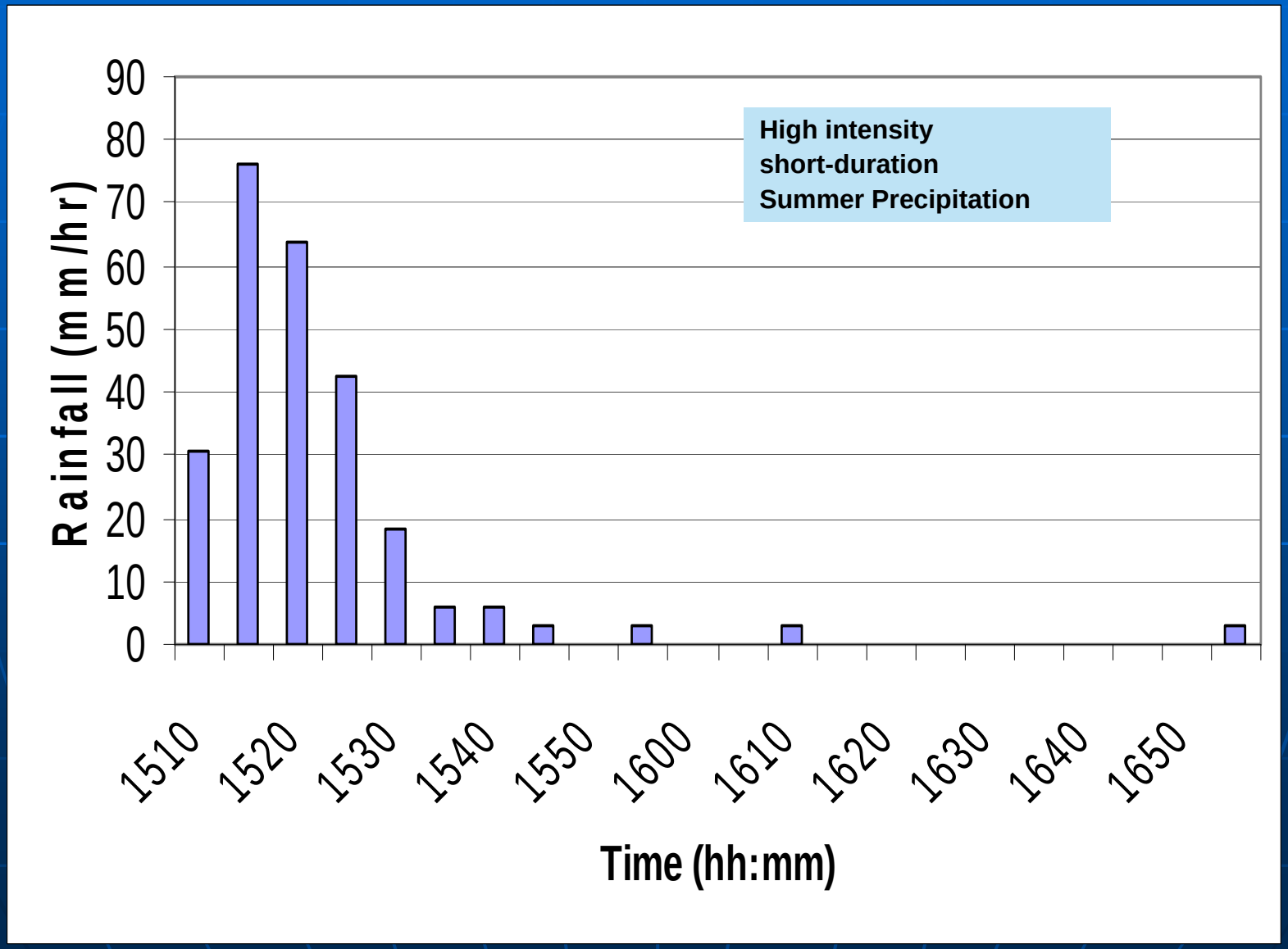

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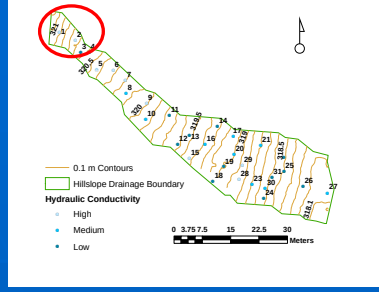
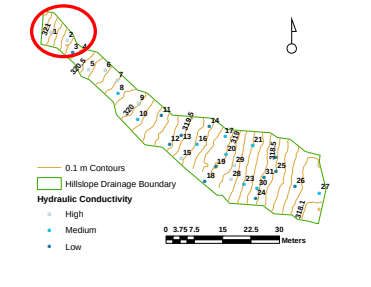


- Location 4 (measured soil hydraulic conductivity 11.1 mm/hr)

Time (hhmm)	Incremental Rainfall (mm)	Rainfall Intensity (mm/hr)	Subsurface Sensor - Depth to water table (cm)	Surface Sensor - Runoff Occurrence (yes/no)	Interpretation
1510	2.54	30.5	42	Yes	Infiltration excess runoff
1520	5.33	64.0	40	Yes	Infiltration excess runoff
1530	1.52	18.3	40	Yes	Infiltration excess runoff
1540	0.508	6.1	27	Yes	Infiltration excess runoff
1550	0.00	0.0	40	Yes	Infiltration excess runoff

Results and Discussion

Runoff Generation Mechanism

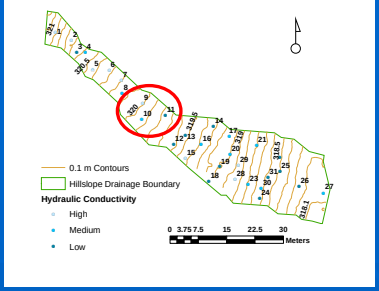


- Location 6 (measured soil hydraulic conductivity 51.2 cm/hr)

Time (hhmm)	Incremental Rainfall (mm)	Rainfall Intensity (mm/hr)	Subsurface Sensor - Depth to water table (cm)	Surface Sensor - Runoff Occurrence (yes/no)	Interpretation
1510	2.54	30.5	42	Yes	Infiltration excess runoff
1520	5.33	64.0	4	Yes	Infiltration excess runoff
1530	1.52	18.3	4	Yes	Infiltration excess runoff
1540	0.508	6.1	4	Yes	Infiltration excess runoff
1550	0.00	0.0	4	Yes	Infiltration excess runoff

Results and Discussion

Runoff Generation Mechanism

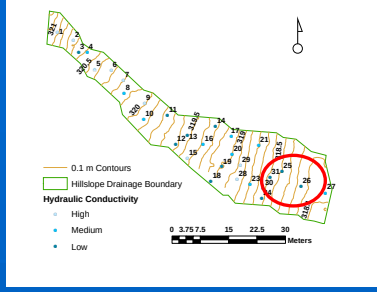


- Location 16 (measured soil hydraulic conductivity 3.5 mm/hr)

Time (hhmm)	Incremental Rainfall (mm)	Rainfall Intensity (mm/hr)	Subsurface Sensor - Depth to water table (cm)	Surface Sensor - Runoff Occurrence (yes/no)	Interpretation
1510	2.54	30.5	42	Yes	Infiltration excess runoff
1520	5.33	64.0	4	Yes	Infiltration excess runoff
1530	1.52	18.3	4	Yes	Infiltration excess runoff
1540	0.508	6.1	4	Yes	Infiltration excess runoff
1550	0.00	0.0	4	Yes	Infiltration excess runoff

Results and Discussion

Runoff Generation Mechanism

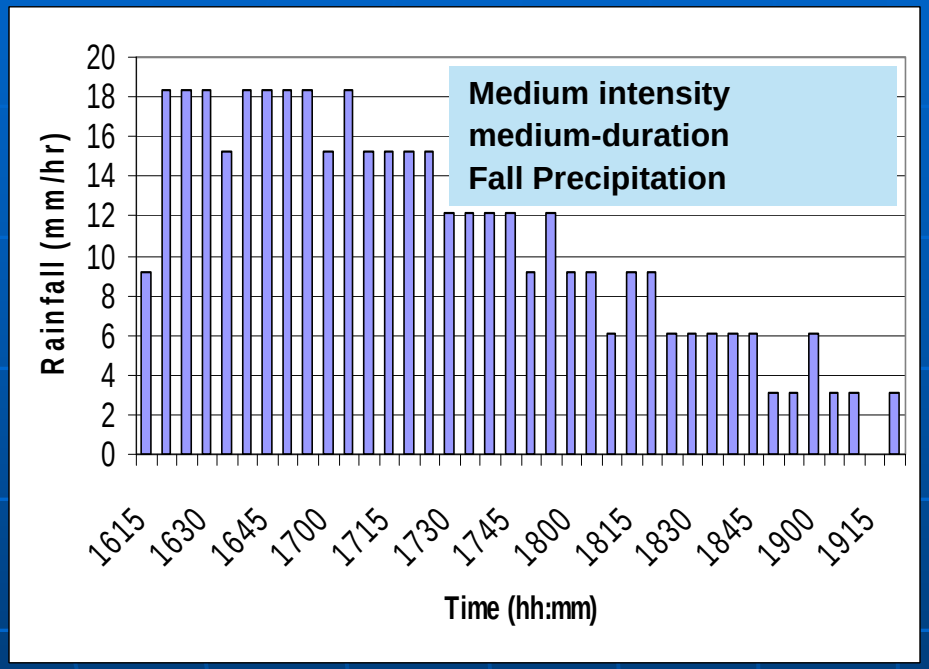


- Location 26 (measured soil hydraulic conductivity 0.7 mm/hr)

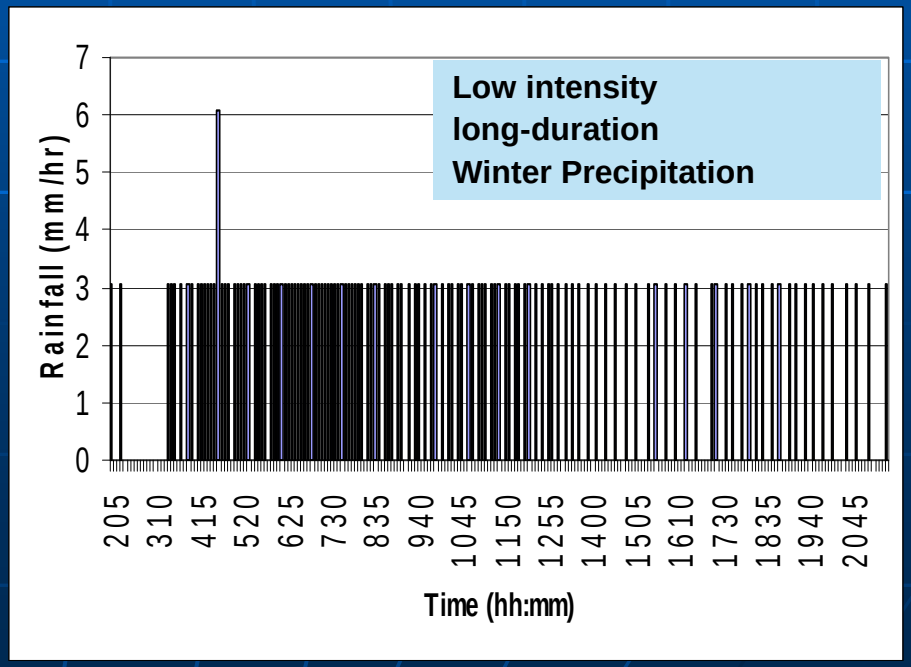
Time (hhmm)	Incremental Rainfall (mm)	Rainfall Intensity (mm/hr)	Subsurface Sensor - Depth to water table (cm)	Surface Sensor - Runoff Occurrence (yes/no)	Interpretation
1510	2.54	30.5	42	Yes	Infiltration excess runoff
1520	5.33	64.0	27	Yes	Infiltration excess runoff
1530	1.52	18.3	27	Yes	Infiltration excess runoff
1540	0.508	6.1	40	Yes	Infiltration excess runoff
1550	0.00	0.0	40	Yes	Infiltration excess runoff

Results and Discussion

Runoff Generation Mechanism



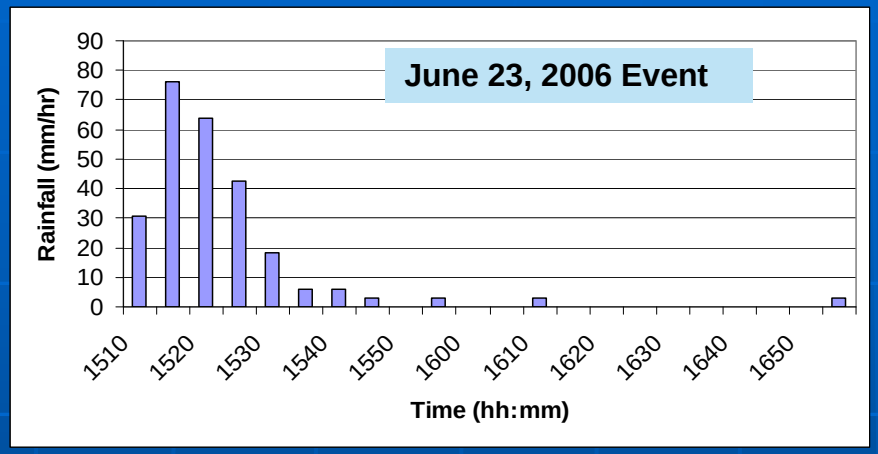
Similar analyses for Sep 7, 2006 (medium intensity, medium-duration) and October 22, 2006 (low intensity, long-duration)

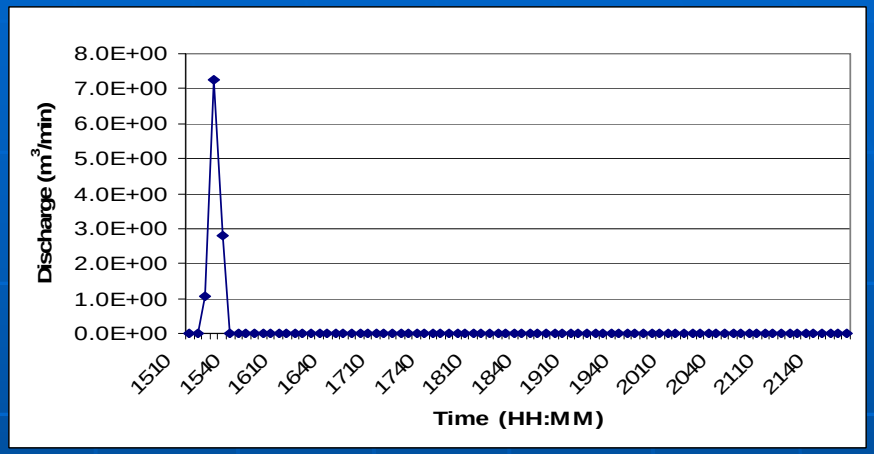


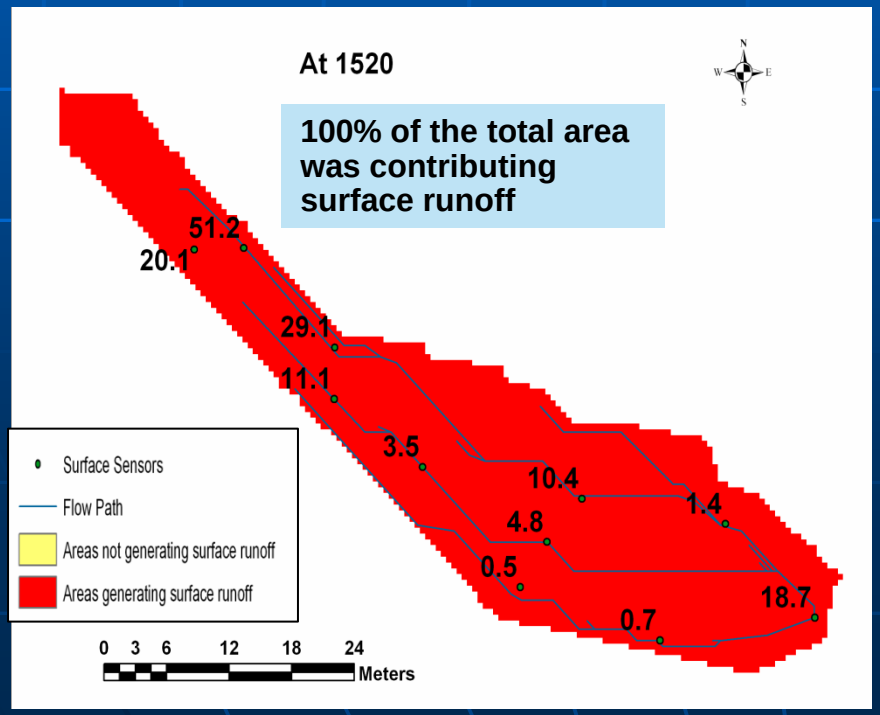
Sen, S., P. Srivastava, K. Yoo, J. Dane, J. Shaw, and M.S. Kang. 2008. RUNOFF GENERATION MECHANISMS IN PASTURES OF THE SAND MOUNTAIN REGION OF ALABAMA – A FIELD INVESTIGATION. Hydrological Processes (In Press)

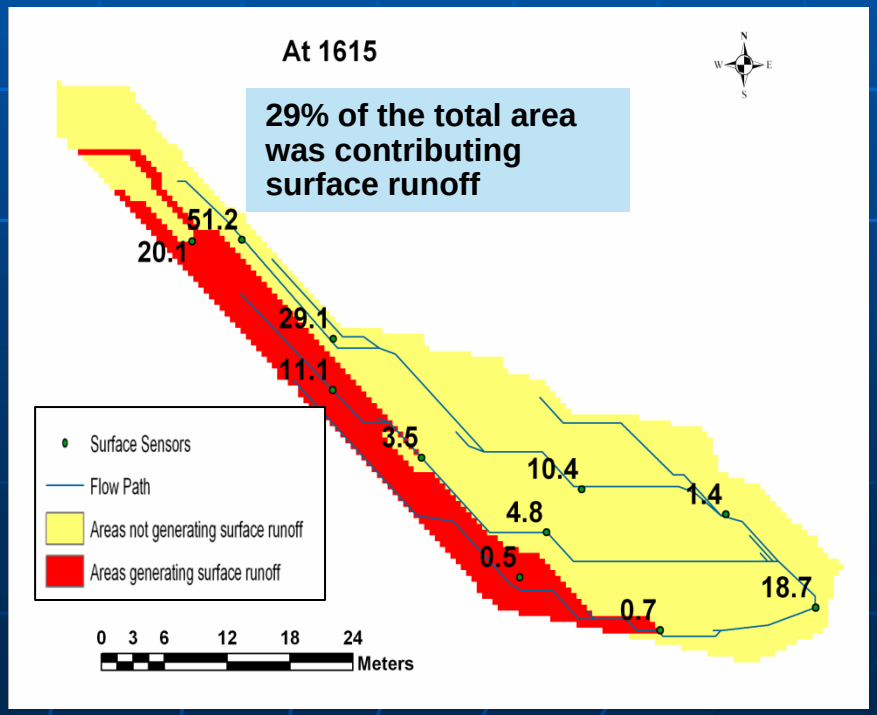
Results and Discussion

Spatial and Temporal Distribution and Connectivity









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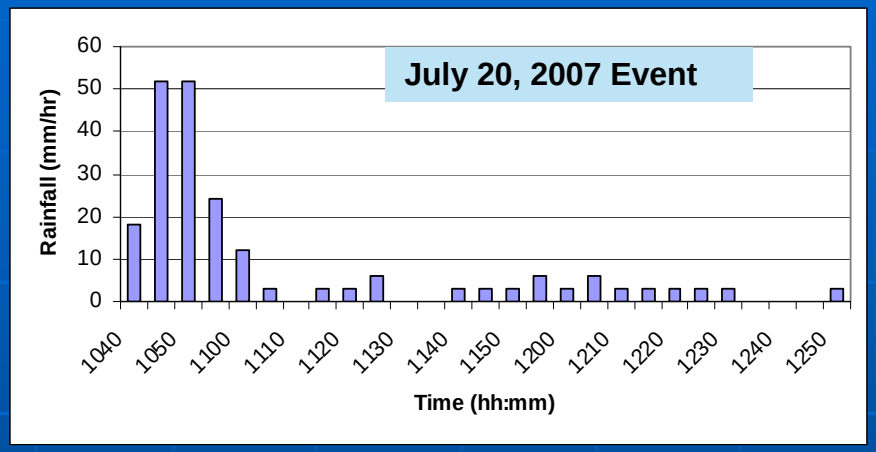

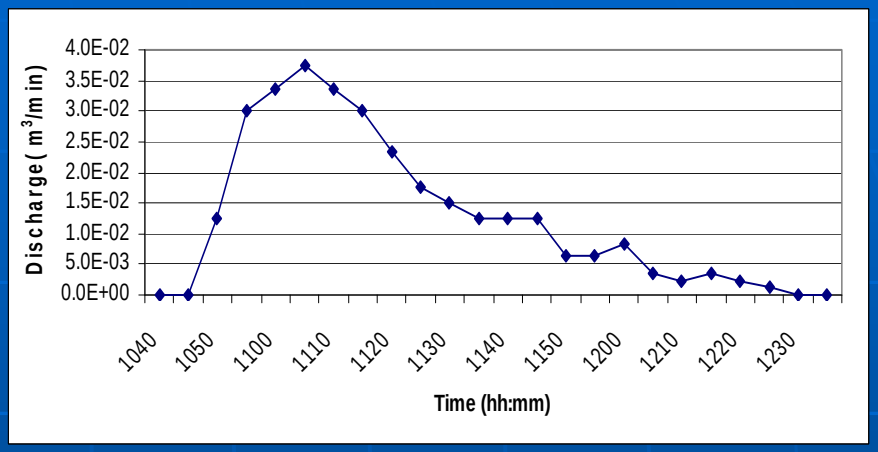

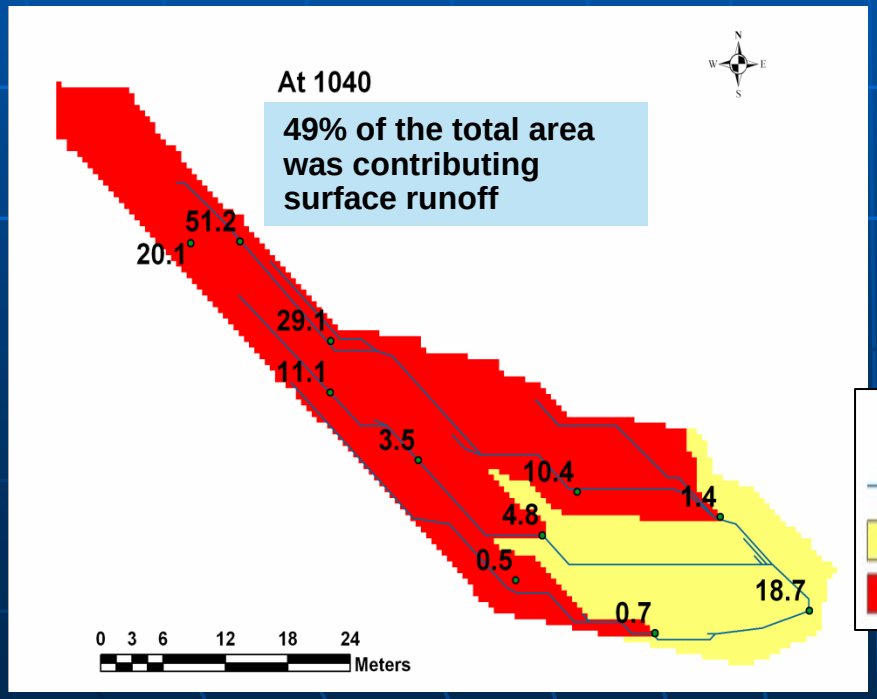

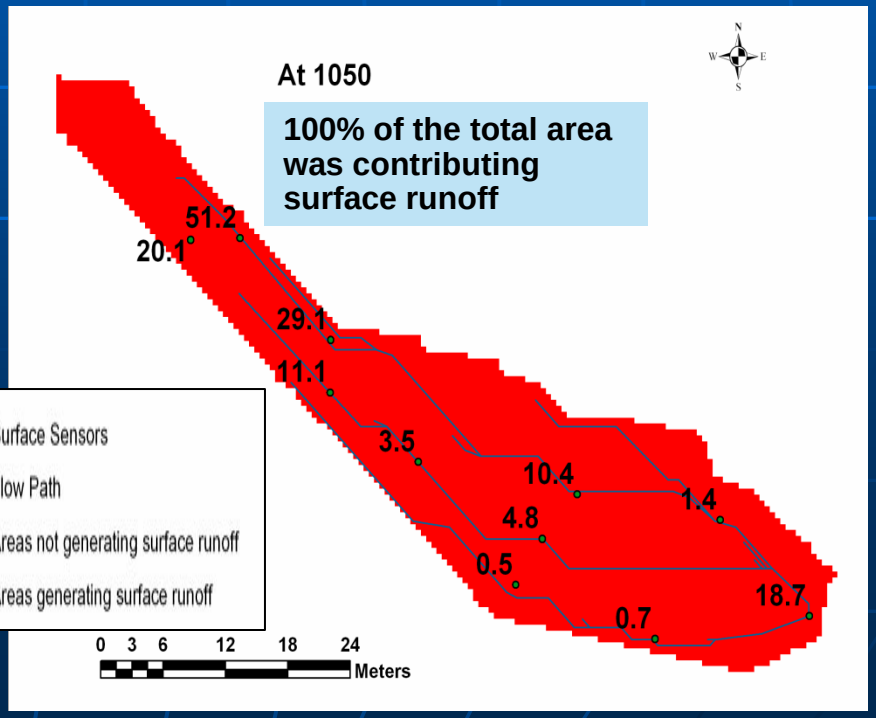

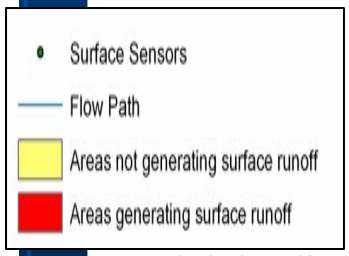

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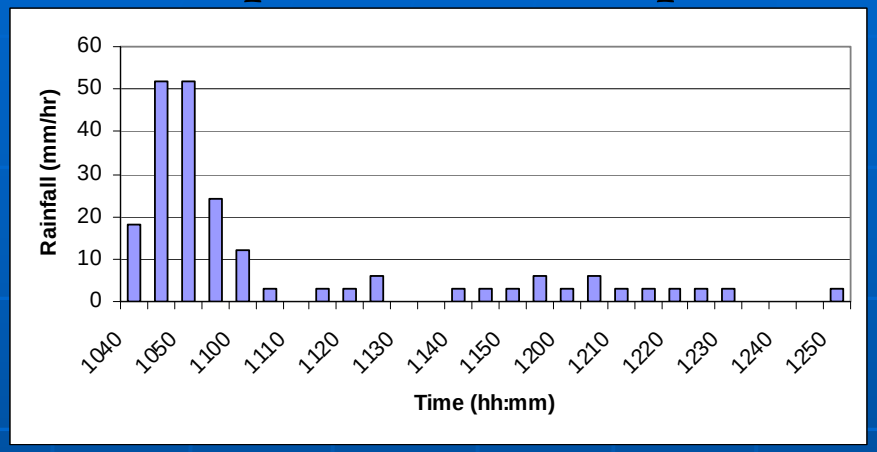

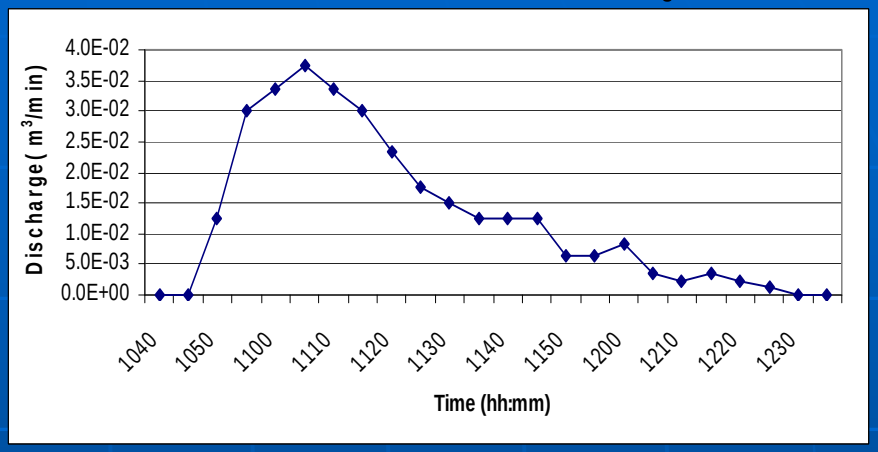

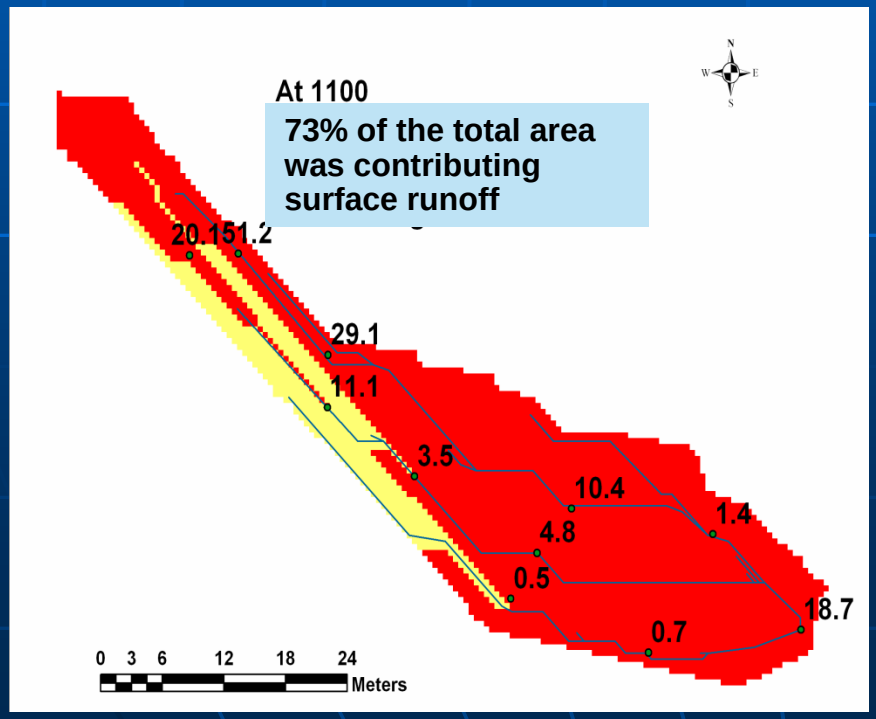

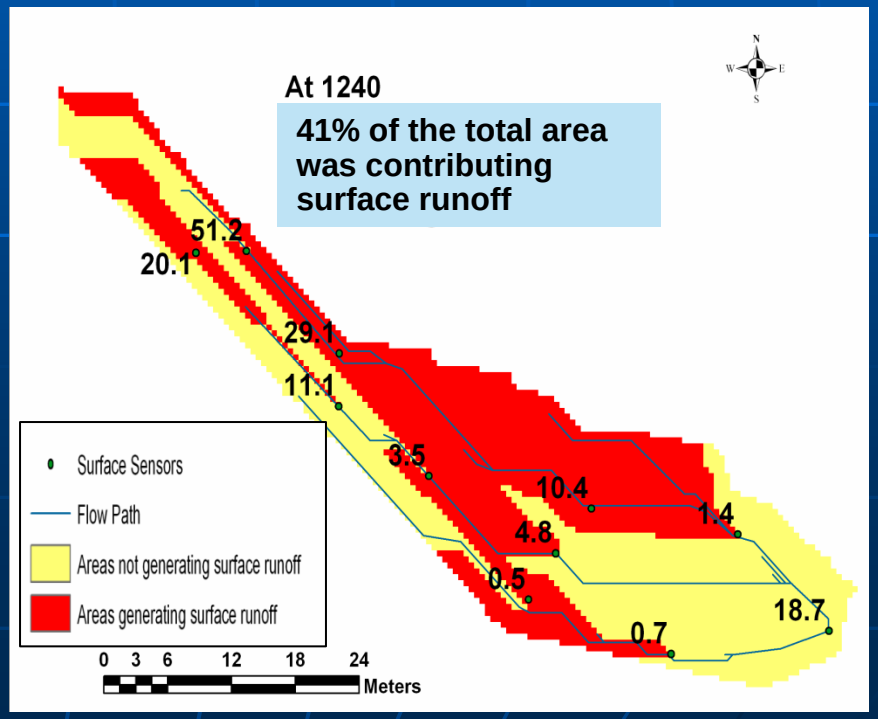

Results and Discussion

Spatial and Temporal Distribution and Connectivity

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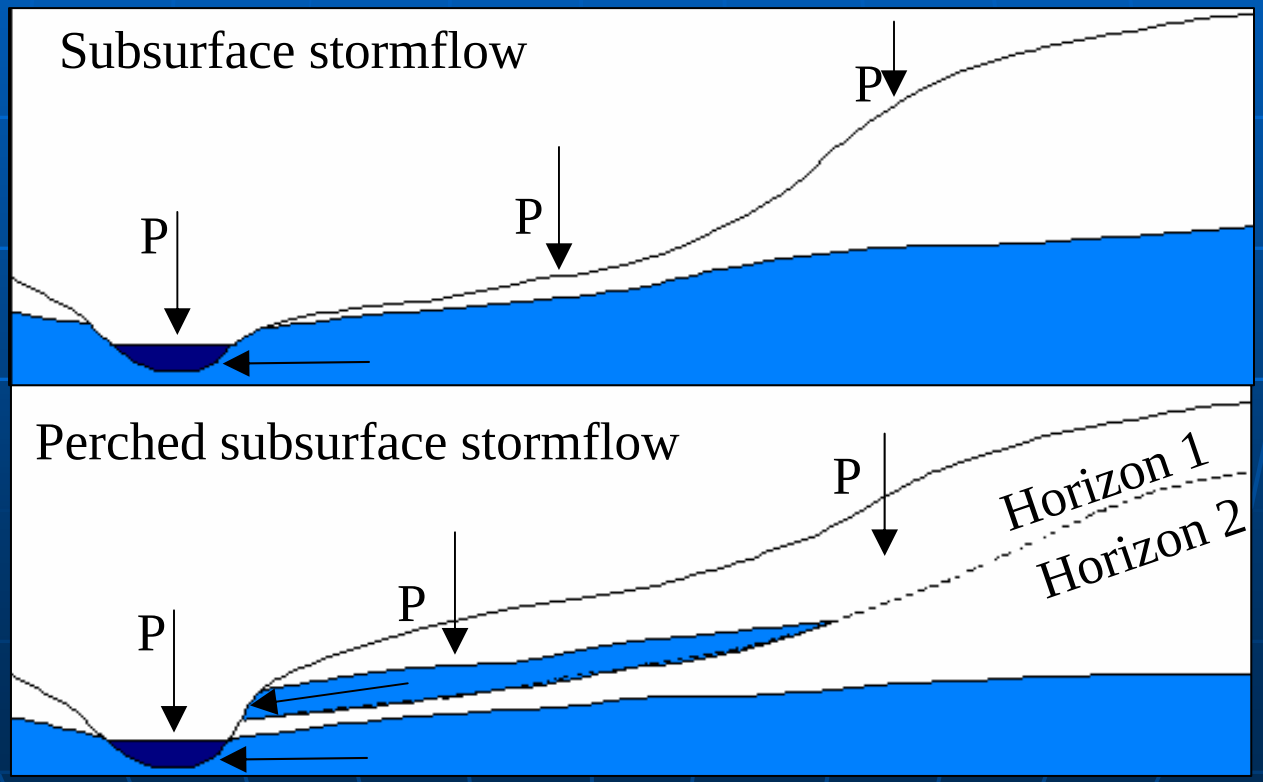
Conclusions

- Surface runoff generation mechanism was mostly infiltration excess in the Sandmountain pasture of Alabama.
- Rainfall intensity and soil hydraulic conductivity control surface runoff generation.
- At times (when the rainfall intensity is high), surface runoff can be generated from the entire hillslope.
- Connected areas of low soil hydraulic conductivity contribute most of the surface runoff at the outlet.
- Overall, preliminary analysis shows that during high-intensity short and medium duration rainfalls no more than 10% of the rainfall results in surface runoff at the outlet.
- For medium-intensity, long duration rainfalls no more than 5% of the rainfall results in surface runoff

Implications and Future Work

- Since surface runoff contributions to the outlet is small – significant infiltration occurs, highlighting the importance of understanding subsurface flows and subsurface transport.



Implications and Future Work

- Quantification of surface and subsurface flows through 2-D modeling
- Quantification of leaching of P from surface and subsurface applied broiler litter – Field investigation
- New and improved BMPs that take into account the major P transport pathway is needed.
- Alabama P-index might need to be revised.