What is the Water telling Us about the Land?
This Morning
This Morning

Rain

Land

Water
The Water

- Precipitation
- Soil Water
- Groundwater
- Streams
- Lakes
The Water

- Let’s explore how these are connected!
Hydrologic Cycle

- Lake
- Groundwater
- Stream
Elevation

- Water goes downhill

Greetings from Wisconsin...?
Elevation

• Water goes downhill
The Water

- Precipitation
- Evapotranspiration
- Streamflow
And it is a lot of water…. 

$10''/yr = \frac{23 \text{ million cubic ft/yr}}{31 \text{ million seconds/yr}} = 0.74 \text{ cfs}$
And it is a lot of water....

one square mile

Per Second!
How could we test this?

• Figure out the area that contributes water to a point
  – We’ll call this the watershed

• Measure the streamflow and convert that to a depth of water per year
  – This is some math…
  – Volume of water divided by area = depth
The Watershed

- A land area
- Remember, water flows downhill
The Watershed

- A land area
- Remember, water flows downhill
- Some clues from a map
- Topography
Really?

- USGS 05379500 TREMPEALEAU RIVER AT DODGE, WI
- DRAINAGE AREA: 643 square miles.

Average flow \(\sim 470\) cubic feet per second.
Really?

• USGS 05340500 ST. CROIX RIVER AT ST. CROIX FALLS, WI

• DRAINAGE AREA.—6,240 square miles.

Average flow ~4,432 cubic feet per second
What is the Water telling Us about the Land?

How much water is moving through the land!

(we might measure it as flow.... gallons/day or cubic feet per second..... But that is a depth/time if we know the “watershed “ area (area that contributes the water))
This is very useful!

1) How long does water spend in a lake?
2) What is the low flow in a stream?
3) How might these change if the amount of water changes?
Part 2.

- What can we learn in a single storm?
Part 2.

• *What can we learn in a single storm?*
Part 2.

• **What can we learn in a single storm?**

- **The Rain**
  - ___ Inches per Year +/-
    - ___ storms per year +/-
      - ___ hours of precipitation (>trace) per year +/-
Part 2.

- What can we learn in a single storm?

The Rain

- 32 Inches per Year +/-
- 100 storms per year +/-
- 500 hours of precipitation (>trace) per year +/-
Part 2.

• What can we learn in a single storm?

How much rain do we get in these hours?

$\frac{1}{4}$ inch/hour

Based on P8 hourly rainfall File for 36 years, Madison
Part 2.

• What can we learn in a single storm?

How much rain do we get in these hours?

Based on P8 hourly rainfall file for 36 years, Madison
Part 2.

- What can we learn in a single storm?
Part 2.

- What can we learn in a single storm?

What’s going on here?
Part 2.

• What can we learn in a single storm?

1) Raining faster than it can infiltrate
2) Raining on saturated ground
What if we could monitor some small areas and the stream!
• Let’s look at one of those projects
Edge-of-field to Stream

- Jersey Valley 5000 acre watershed
- Discovery Farms
- USGS

Rain

Runoff & Streamflow

- Avg Waterway
- Stream Flow

Date

Flow (cfs)

09-08-2016 09-09-2016 09-10-2016 09-11-2016 09-12-2016

Hourly Precip (inches)

0.0 0.1 0.2 0.3

09-08-2016 09-09-2016 09-10-2016 09-11-2016 09-12-2016
Stream Flow vs Runoff Flow

1:1 Line Stream Flow = Edge of Field Flow

Stream Flow Volume During Event (ft³/mi²)

Edge of Field Runoff Volume During Event (ft³/mi²)
What do we learn?

- 0 to 4 inches/yr of water across the surface
- 6 to 14 inches/yr of infiltration
- Streamflow combines sources of runoff
- What separates runoff from infiltration?
  - Infiltration rates are important!
### Example Infiltration Rates

#### Type of Soil

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Ponded Infiltration Rate (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>2 to 10</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>0.2 to 1</td>
</tr>
<tr>
<td>Clay</td>
<td>0.03 to 0.3</td>
</tr>
</tbody>
</table>
### Example Infiltration Rates

**Condition (compaction/structure)**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Ponded Infiltration Rate (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetated</td>
<td>3.4</td>
</tr>
<tr>
<td>Open Soil</td>
<td>0.7</td>
</tr>
<tr>
<td>Traffic</td>
<td>0.1</td>
</tr>
</tbody>
</table>

What is the Water telling Us about the Land?

How much of the precipitation is moving rapidly and how much is moving more slowly to the stream!

(Separating into “new” and “old” water may not be easy but we know that a portion of the water moves rapidly to the stream and a portion is more slowly delivered)
Part 3.

- Let’s do some chemistry
Part 3.

- Let’s do some chemistry
- Why is this important?
- Remember, it doesn’t explain everything
Part 3.

Let’s look at two important examples

• Groundwater
• Runoff (...lake and stream)

Remember, this distinction is a little tricky
Part 3.

- **Groundwater**
- **Water percolating through soil profile**
- **Rain becomes groundwater!**
Part 3.

- **Groundwater**
- **Water percolating through soil profile**
- **Rain becomes groundwater!**

http://www.exploringnature.org

\[ \text{pH} \ 5.5 \]

\[ \text{pH} \ 7.5 \]
Part 3.

- **Groundwater**
- **Water percolating through soil profile**
- **Rain becomes groundwater!**
Part 3.

- **Groundwater**
- **Water percolating through soil profile**
- **Rain becomes groundwater!**

![Diagram showing water percolating through soil profile with pH and calcium levels.](http://www.exploringnature.org)
Part 3.

- Calcium and Magnesium ("hardness") varies across Wisconsin... Why?

"Soft" Water

"Hard" Water
Part 3.

- **Groundwater**
- **Large amounts of nitrogen in the soil profile increase groundwater nitrate** (and hardness)
Part 3.

- **Groundwater Nitrate Concentrations (County Averages)**
What is the Water telling Us about the Land?

The chemistry of groundwater (pH, hardness) reflects the geology of the soil and bedrock. Additions of nitrogen increase nitrate concentrations.
Part 3.

- Chemistry... Continued
- What about “Runoff”?
Part 3.

- Chemistry... Continued
- What about “Runoff”?

A “mass balance”
Concentration = Total Mass / Total Volume

Runoff

Downstream Just After Mixing

Further Downstream

Upstream
Part 3.

• Chemistry... Continued

• What about “Runoff”?

A “mass balance”
Concentration = Total Mass / Total Volume

Groundwater / Streamflow

Runoff

Lake
Part 3.

- **Chemistry... Continued**
- **What about “Runoff”?**

The "hydrograph" & The "chemograph"
Part 3.

- **Chemistry... Continued**
- **What about “Runoff”?**
Phosphorus Concentration Increases During the Event

Nitrate Concentration Decreases During the Event
Let’s take one last look at phosphorus in different runoff studies.
10 fold concentration difference!
10000 fold runoff volume difference

Event Total
P Loss (lb/acre)

Runoff Depth (mm)

- Lawns
- Woods
- Corn
- Alfalfa

5 mg/l
0.5 mg/l
10 fold concentration difference!
10000 fold runoff volume difference
WHY?
WHY?

45,000 lb plant P
50,000 lb organic matter P
250,000 lbs soil P (top 6”)

350,000 lb P / sq mile

A Tale of Two Pathways

• 10 inches of infiltration at 0.02 mg P/liter
  = 0.05 pounds of Phosphorus from 1 acre

• 2 inches of runoff at 2 mg P / liter
  = 0.90 pounds of Phosphorus from 1 acre
Part 3.

- The concentration we see reflects the mixing of these pathways.
What is the Water telling Us about the Land?

The land has a relatively high concentration of phosphorus...
Runoff acquires this phosphorus....

*The mass that is transported reflects the runoff volume x runoff concentration*
What is the Water Telling Us About the Land?

• The water moves through land first!

• The pathways it takes
  - The **amount** of water
  - The **timing** of the water
  - The **mineralization** of our water
  - The **nutrient** content of our water

• Good Luck with your Watershed Connections!