

# The Basic Science of Ground-Water/Surface-Water Hydrology

Montana Bureau of Mines and Geology  
Montana Tech of The University of Montana



Presented to Water Policy Interim Committee  
Dillon  
July 10, 2007

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*“The science of hydrology  
would be relatively simple if  
water were unable to penetrate  
below the earth’s surface.”*

Harold E. Thomas

## Today’s Outline

- Introduction to MBMG
- Surface- / Ground-Water Basics
- Well hydraulics
- Montana Water Use

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## Montana Bureau of Mines and Geology *a department of Montana Tech*

- Established in 1919 to provide reliable and unbiased earth science information
- Non regulatory, applied research
  - Geologic Mapping
  - Earthquake Studies
  - Small Miners
  - Environmental Assessment
  - Ground Water Assessment



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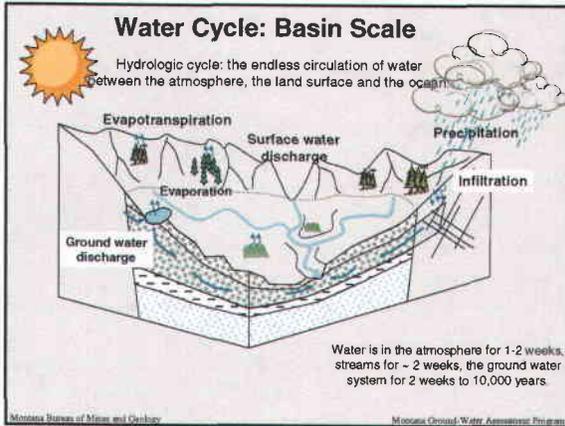
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- ### Essential Definitions / Concepts
- **Aquifer:**
    - A permeable geologic unit that can **transmit** and **store** significant quantities of water.
      - **unconfined** (water table) or **confined** (artesian)
      - **alluvial** (sand and gravel) or **bedrock** (sandstone)
  - **Recharge:**
    - Movement of water from the land surface to the aquifer
  - **Discharge:**
    - Movement of water from the aquifer to the land surface
  - **Ground water is moving... but slowly**
    - GW : 1ft/day - 1ft/yr    SW: 1ft/sec = 16 mi/day
  - **Surface water (streams) exchanges with ground water**
    - Gaining streams / losing streams
  - **Development of SW or GW water can affect the other**
    - Rate of response variable - much slower for GW than for SW
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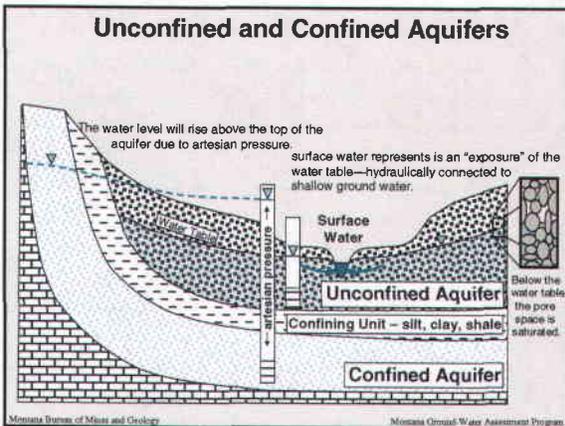
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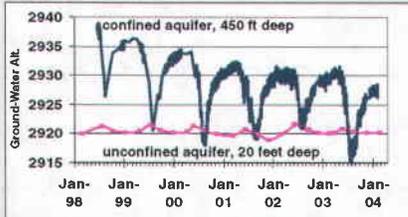
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### Ground-Water Hydrograph:

Ground-Water level measurements vs. time

- Ground water fluctuates
- Reflects changes in storage
- Scales: daily, seasonally, annually



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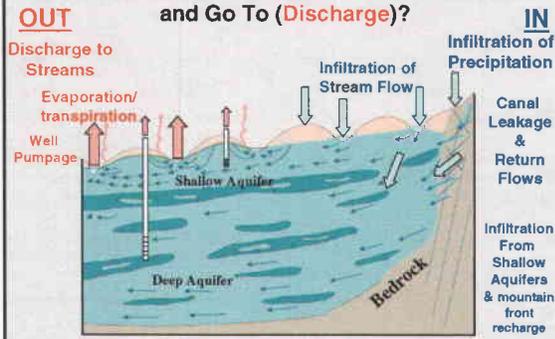
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### Ground-Water Budget

Where Does the Water Come From (Recharge) ... and Go To (Discharge)?



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### 1) Alluvial Aquifers



- WEST**
  - Basin fill
  - Stream Alluvium
- EAST**
  - Stream Alluvium
  - Benches
  - Terraces



- Shallow and deep
- Generally contain abundant water
- Shallow: hydraulically connected to streams or wetlands
- Deep: often confined or "artesian"

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## 2) Bedrock Aquifers

**West**



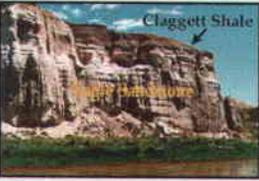
- Mountains
- Meta Sediments and volcanics
- Fracture permeability
- Low storage
- valley margins
- Seeing more development



**East**



- N. Great Plains
- Clastic Sed. Rx
- Carbonates and coals
- Primary and secondary porosity
- Main aquifers



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## The water table

**water table:**

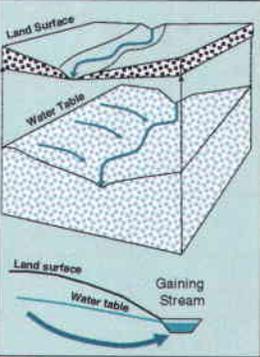
- \* subdued representation of land surface,
- \* depth to the water table variable,
- near land surface in topographically low areas (near streams).

**ground-water flows:**

down the slope of the water table surface

**gaining stream:**

- \* water table higher level than the stream,
- \* flow toward and feed the stream,
- \* discharge increases down stream.



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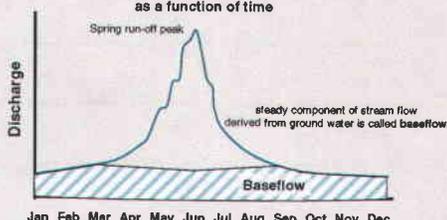
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## Seasonal Stream-Flow Hydrograph

A stream hydrograph is a measure of discharge at a given point as a function of time



Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

- **Major portion of flow ultimately derived from baseflow**
  - On average, ground water accounts for 40 - 50 % of annual flow

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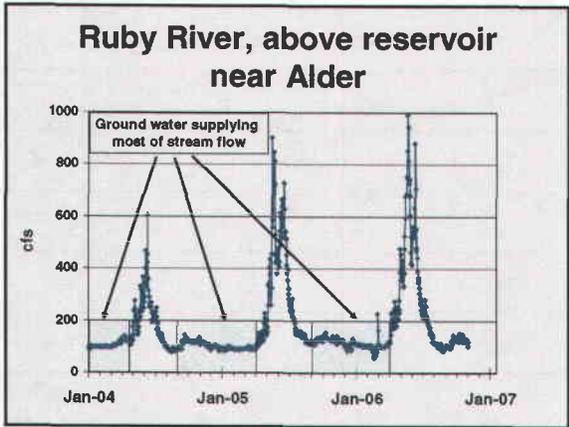
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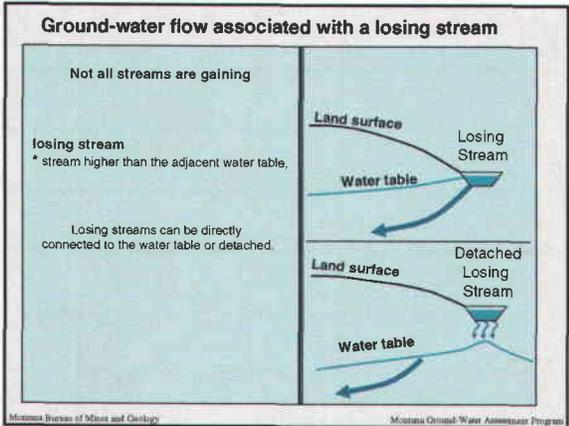
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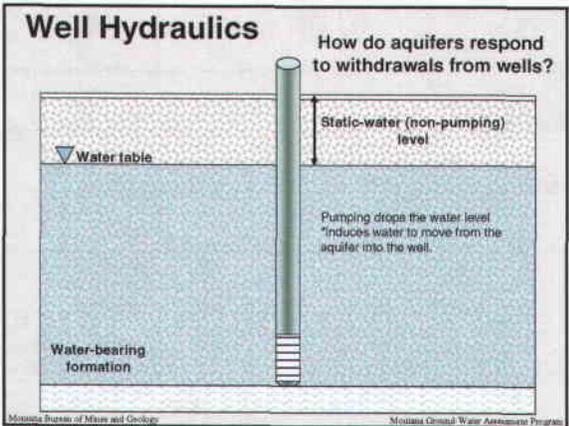
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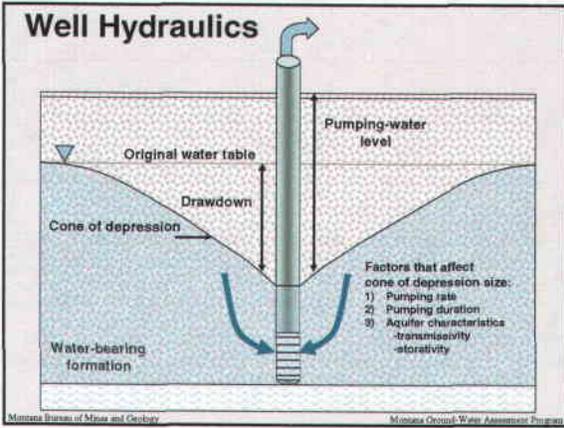
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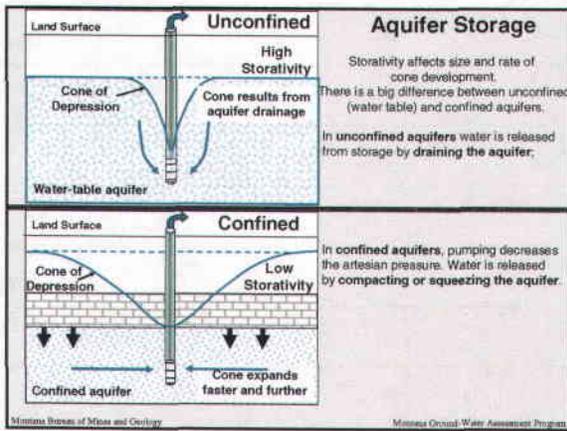
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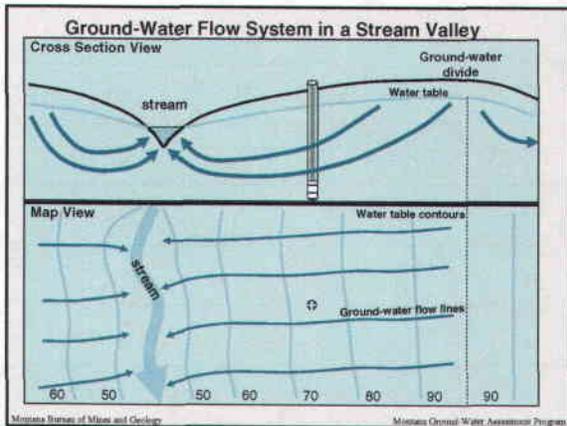
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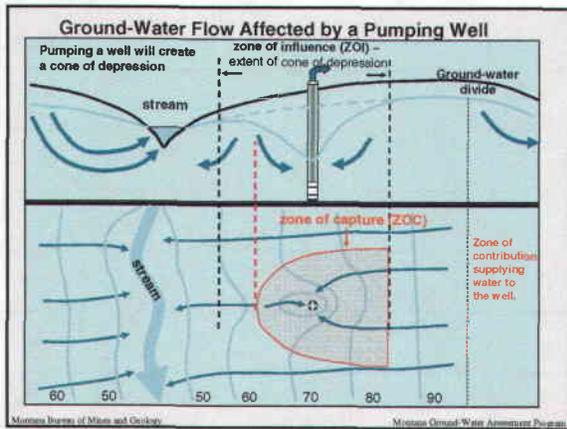
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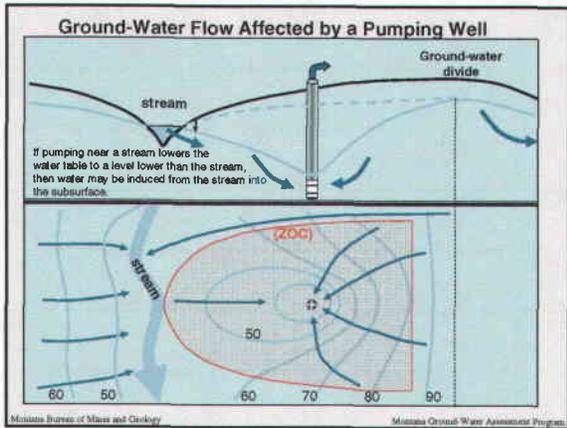
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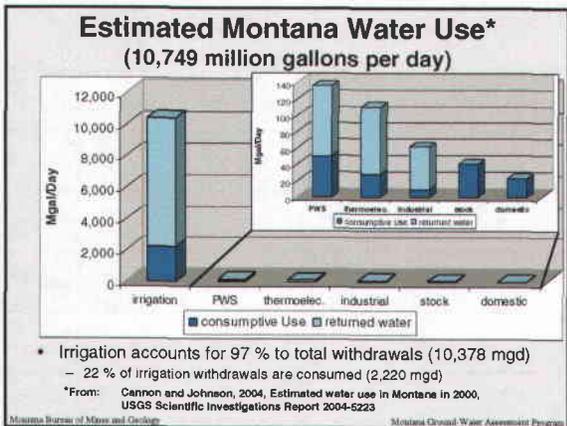
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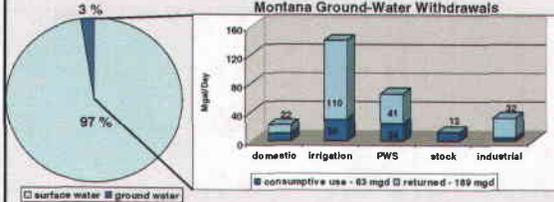
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### Estimated Montana Water Use\* (SW: 10,478 mgd GW: 272 mgd)



\*From: Cannon and Johnson, 2004, Estimated water use in Montana In 2000, USGS Scientific Investigations Report 2004-5223

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### Summary

- Ground-water resources vary
  - across the state, and within the closed basins
- Ground-water and surface water are connected
  - In varying degrees
  - Rate of water movement and system response variable
- To understand the relationship between GW and SW
  - hydrogeologic framework
  - ground-water level information
    - spatial and temporal
  - stream-flow data
  - climate data
- Water use dominated by surface water and irrigation withdrawals

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### Contact Information:

**Ground-Water Information Center:**

<http://mbmgwic.mtech.edu/>

**Montana Bureau of Mines and Geology:**

<http://www.mbmgs.mtech.edu/>

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