Introduction

To

Groundwater Concepts
Important Concepts

- Hydrologic Cycle
- Aquifers
- Hydraulic Conductivity
- Head
- Gradient
- Drawdown
- Capture
Earth’s Freshwater Resources

- 97% of Earth’s water exists as salt water
- Of the remaining water (3%):
  - 69.6% glaciers, permafrost, and snow
  - 30.1% subsurface water
  - <1% rivers, lakes, swamps, wetlands, atmosphere
Earth's *liquid* fresh water resources

- Estimated 1,000,000 cubic miles of ground water
- 30,000 cubic miles in world's lakes
- 300 cubic miles in world's streams
- Michigan 500 mi³
The Hydrologic (Water) Cycle

- Precipitation on land
- Snow melt
- Surface runoff
- Infiltration
- GW Recharge
- Groundwater flow
- Surface discharge
- GW Discharge

- Moisture over land
- Evaporation from land
- Snow melt
- GW Discharge
- Precipitation to Ocean
- Evaporation from ocean
Experts' shocking revelation:

EARTH'S WATER SUPPLY CAME FROM DINOSAUR PEE

Every drop of water on Earth used to be urine — and 99.9 percent of it was once dinosaur pee-pee!

That's the fascinating finding of U.S. researcher Dr. Milton R. Grillingham, who says animals have drunk and fouled our water supply since life began.

"There's just no getting around it — every drop of water you drink has been drunk before — and that most of it has been drunk many times.

"The dinosaurs did most of the damage early on, but now humans are certainly fouling up their fair share," the Cape Town researcher stated. "The average human being produces one gallon of urine a day and with five billion people on this planet, that can really add up.

"The bottom line is that our water isn't as pure as we like to think."

But experts in the United States say the fact that all our water was once urine doesn't mean it's not safe to drink.

"People in morebackward countries might have reason to worry, but in this country our water supply is tested regularly and for the most part has been found safe — whether it was once dinosaur urine or not," said one American health official.
Water Resources

“We forget that the water cycle and the life cycle are one”

- Jacques Cousteau
The Nature of Underground Water

- **Unsaturated zone**
- **Saturated zone**
- **Water table**
- **Surface water**
- **Ground water**
- **Creviced rock**
- **Gravel**

Water (not ground water) held by molecular attraction surrounds surfaces of rock particles. The approximate level of the water table is an indicator of the depth of groundwater. All openings below the water table are full of ground water.
The Nature of Underground Water

- Unsaturated zone
- Saturated zone
- Ground water
- Water table
- Land surface
- Surface water
- Creviced rock
- Water (not ground water) held by molecular attraction surrounds surfaces of rock particles
- Approximate level of the water table
- All openings below water table full of ground water
- Gravel
The Subsurface Can Be Divided Into Two Zones

A = The Unsaturated Zone
B = The Saturated Zone
The Water Table

...the boundary between the unsaturated (aerated) and saturated zone
The Unsaturated Zone

- Zone between the land surface and the water table.
- Subsurface material has pore spaces between grains.
- In the unsaturated zone these pore spaces are occupied by both air and water.
Saturated Zone

- Zone underneath the water table
- All pore spaces are filled completely with water
- The water flows both horizontally and vertically
- This is groundwater
Groundwater
16.1 The Nature of Underground Water

- Aquifer
- Aquiclude
- Perched water table
- Springs
Groundwater

Groundwater is present in the pores and fractures in geologic formations ("Aquifers") below the land surface - NOT RIVERS. Precipitation is the source of groundwater recharge. Groundwater moves through the pores and fractures in geologic formations toward surface water, other watersheds, or pumping wells.
Underground Rivers

They Do Exist, But......
Important Concepts

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Aquifers

- **Definition:** A geological unit which can store and supply significant quantities of water.
- Depends on local geology.
GW Flow Through Pores
Michigan Aquifers

Principal aquifers in Michigan by sediment/rock type:

- **Glacial** (a.k.a. 'glacial drift')
  - Sand and Gravel

- **Bedrock** (a.k.a. 'rock')
  - Sandstone
  - Limestone and/or Dolomite
  - Igneous & Metamorphic (Western U.P.)
Aquifer Vulnerability
Michigan Bedrock Geology

Michigan Basin
Hydrogeologic Cross Section

Lake Huron
Georgian Bay
Lake Michigan
Lower Peninsula of Michigan
Wisconsin
Canada

Potable GW
Saline H₂O/Brine
Oil & Gas
Glacial Deposits

Lake Michigan

Georgian Bay
Bedrock Aquifers
Michigan Bedrock Aquifers

- **“Good”**
- **“Marginal Sedimentary”**
- **“Marginal Crystalline”**
- **“Not an Aquifer”**

* Saline GW/Brine at depth
SW Michigan Bedrock Wells
GLACIAL DRIFT THICKNESS

Figure 30: The thickness of surficial deposits in the four-state area ranges from zero in the Driftless Area to about 1,000 feet in the northwestern Lower Peninsula of Michigan. The thickness of most deposits ranges from 50 to 400 feet.
GLACIAL DRIFT THICKNESS
SE Michigan

Glacial Thickness (feet)

- Exposed bedrock
- 0 - 25
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 400
- 400 - 600
- 600 - 800
- 800 - 1,000
- 1,000 - 1,200

Monroe
Lenaewee
Wayne
Washtenaw
Oakland
Macomb
St. Clair
Michigan Glacial Drift Aquifers

- "Good"
- "Unconfined aquifer overlying bedrock - limited data"
- "Thin overlying bedrock"
- "Not an Aquifer"
SE Michigan Glacial Drift Aquifers
Wells

Lassie, go get help!
Groundwater Utilization

- **Wells**
  - Artificial openings dug or drilled below the water table to extract water
  - drawdown of water table
  - cone of depression
DRILLED WELL COMPONENTS

- WELL CAP or SEAL
- BOREHOLE
- CASING
- GROUT
- OPEN HOLE IN BEDROCK AQUIFER
- BEDROCK WELL
- NO CASING IN ROCK BOREHOLE
DRILLED WELL COMPONENTS

WELL CAP or SEAL
BOREHOLE
CASING
GROUT
SCREEN

SCREENED WELL
TYPICAL SCREENED WATER WELL CROSS SECTION

- Vented Cap
- Grade
- To Pressure Tank and House
- Pitless Adaptor
- Water Level
- Drop Pipe
- Submersible Pump
- Casing
- Packer
- Screen
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Hydraulic Conductivity

- a.k.a. “Permeability”
- Measure of rate at which water can move through aquifer material
- Wide range in values due to number and size of pores and fractures and how well they are connected
HYDRAULIC CONDUCTIVITY RANGE

Unfractured Rock

Silty Sand-Sandy Clay

Clay-Shale

Low

Fine Sand

Coarse Sand

Gravel

Fractured Rock

High
Sources of Hydraulic Conductivity (K) Data

- Site specific aquifer tests
- Estimated from well capacity data in WELLOGIC
- Use estimates based on sediment descriptions from well log records
K from Capacity Tests

- Static water level
- Pumping water level
- Length of test
- Estimated pumping rate
- Estimated K may be good if data good
K from Lithologic Descriptions

- Description of sediment or rock
- Thickness
- GWIM - Each material (sand, clay, etc) is assigned a unique K.
- Estimated K appears to be reasonable.
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GW Flow Direction

- GW wants to move from a point of high hydraulic head (elevation) to low hydraulic head (elevation) in the direction of steepest hydraulic gradient...

IMPORTANT CONCEPT

- Hydraulic Head ("GW Elevation")

- Hydraulic Gradient ("Slope")
Hydraulic Head

Land Surface Elevation (LSE)

Depth to water (a.k.a. static water level or “SWL”)

Hydraulic Head = LSE - SWL

900 ft - 20 ft = 880 ft
Where does the head information come from?
Ground Surface Elevation and Location

Well ID: 230000000102

Elevation: 929 ft
Latitude: 42.62482
Longitude: -85.02656
### Static Water Level (SWL)

<table>
<thead>
<tr>
<th>Static Water Level: 85.00 ft. Below Grade (Not Flowing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Test Method: Unknown</td>
</tr>
<tr>
<td>Measurement Taken During Pump Test:</td>
</tr>
</tbody>
</table>

Ground Surface - SWL = Head ft AMSL

Example: 929 - 85 = 844 ft AMSL
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Heads and Hydraulic Gradient

Well 1

Land Surface

Well 2

Hydraulic Head\(_1\) > Hydraulic Head\(_2\)

GW Flow

Hydraulic Head\(_1\)

Hydraulic Head\(_2\)

Elevation Datum - Sea Level
Gradient

Well 1 - Well 2

Land Surface

Hydraulic Head

Elevation Datum - Sea Level

Hydraulic Head₁ - Hydraulic Head₂

Distance
Groundwater Movement
Land Surface - Gradients and Divides

Topographic Contours
GW Elevation Surface - Gradients and Divides

Remove Land Surface to Expose Water Table
Important Concepts

✓ Hydrologic Cycle
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  ✓ Capture
Drawdown from pumping
Important Concepts

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Capture

- Capture - GW within Aquifer that flows toward and is removed by pumping well.

- Extent of Capture **NOT THE SAME** as Extent of Drawdown.

*ANOTHER IMPORTANT CONCEPT*
Extent of Capture vs Drawdown Cone

Extent of Capture

Drawdown Cone
Wellhead Protection Area
= WHPA = Area of Captured GW
Wellhead Protection

HELPING TO PROTECT YOUR DRINKING WATER

You Are Now Entering WELLHEAD PROTECTION AREA
Questions ???