

**AAPG Webinar 10 - Pivoting 2021:
Imaging Technologies and Water
Management**
May 26, 2021
Susan Nash, Ph.D. Moderator

Stepping Up to Measuring: The Nature of Groundwater Flow Gradients & Groundwater vs. Natural Gas

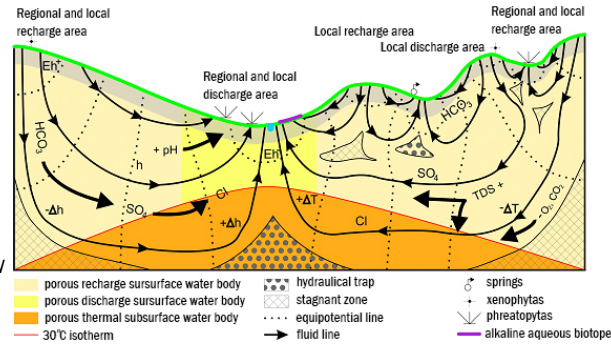
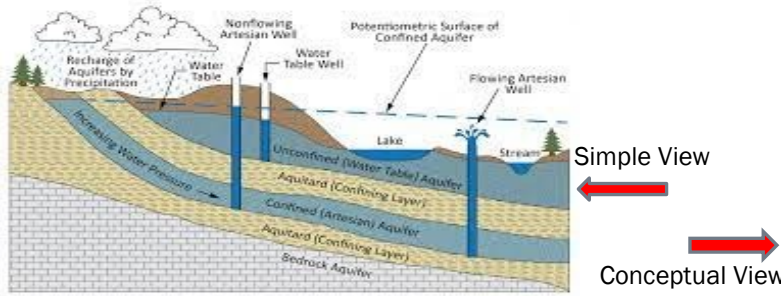
A Brief Introduction To Three Long Stories

A YouTube Version of this presentation with narration is also available ([here](#))

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For more information on Mr. Campbell,
see: ([here](#))





Jozef Toth and M. King Hubbert led the way in O&G reservoir migration investigations. They were both hydrogeologists ([more](#)).

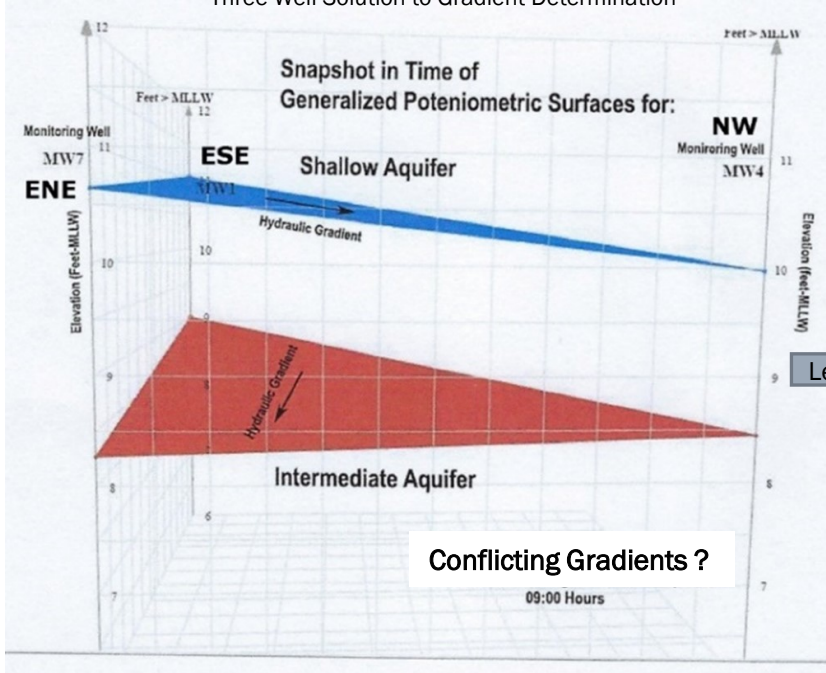
Understanding Groundwater:

- Local Shallow Groundwater Flow
- Subsurface Pressure Distribution
- Recharge-Discharge Areas
- Monitoring Wells Screened at ~Depths
- Groundwater Flow Drives Oil & Gas & Geothermal Energy & Strata-Bound Mineralization (Uranium, etc.)
- Surface water &/or Groundwater are Required in Nuclear Power for Cooling.

Regional Groundwater Aquifers:

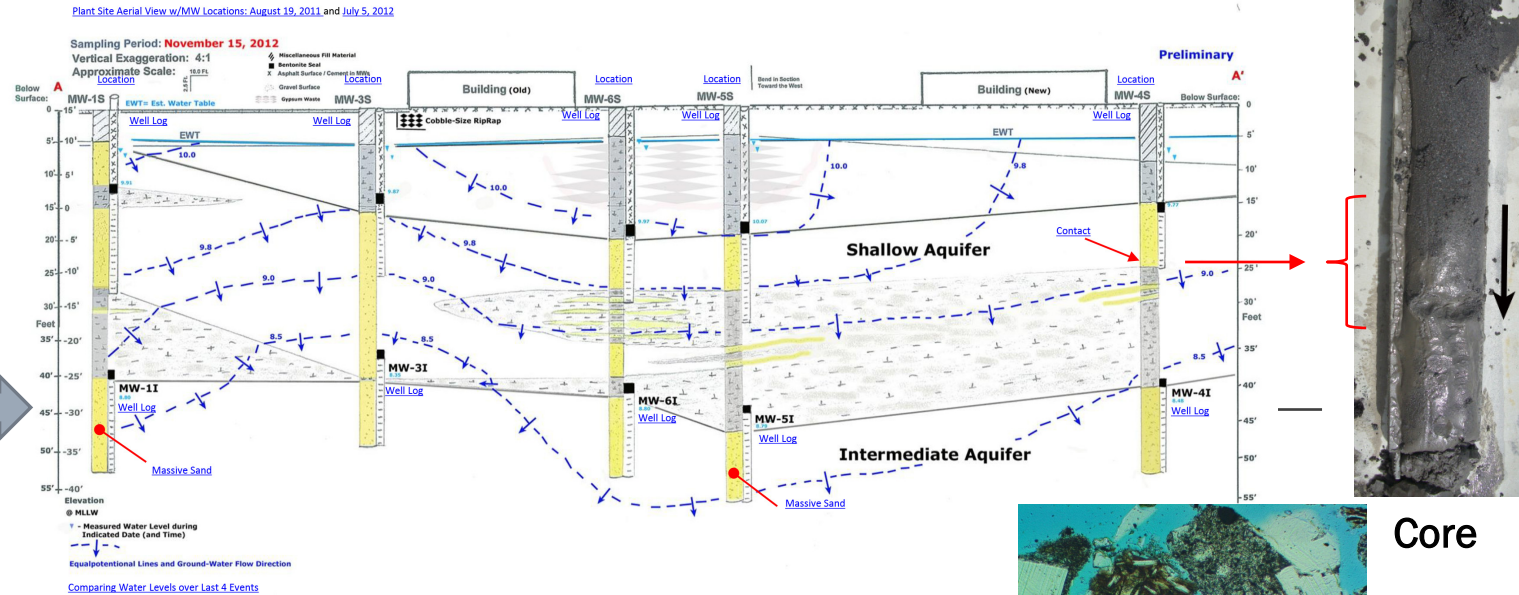
- Unconfined Aquifer
- Confined Aquifer

Three-Well Solution to Gradient Determination



Early Groundwater Monitoring

Leads to:

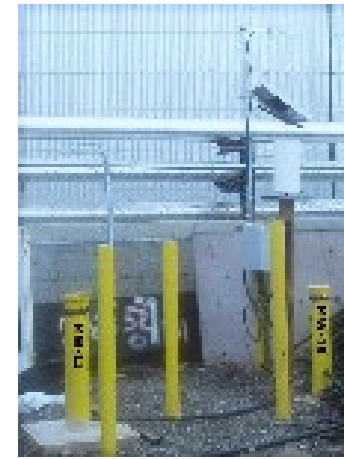
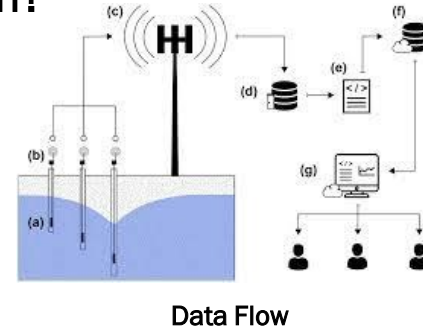
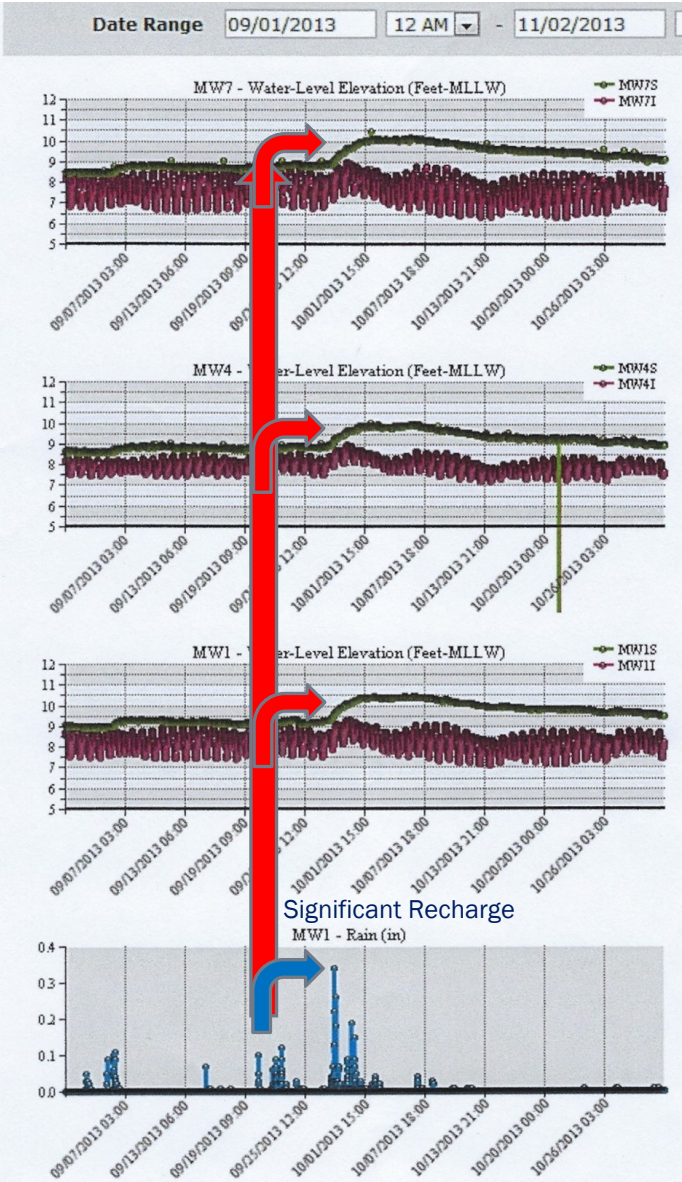


Actual View - Complex Geology in Recharge Zone:

- Flow-Net Analysis
- Slab Sections

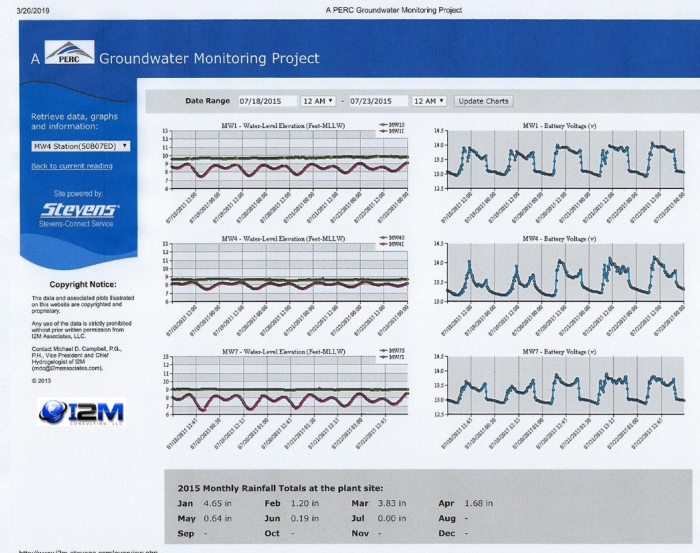
Thin-Section Analysis: All Fluvial Lahar Volcanics

Conflicting Groundwater Flow Gradients: Solution?



24/7 Remote Monitoring of Shallow & “Deep” Aquifers

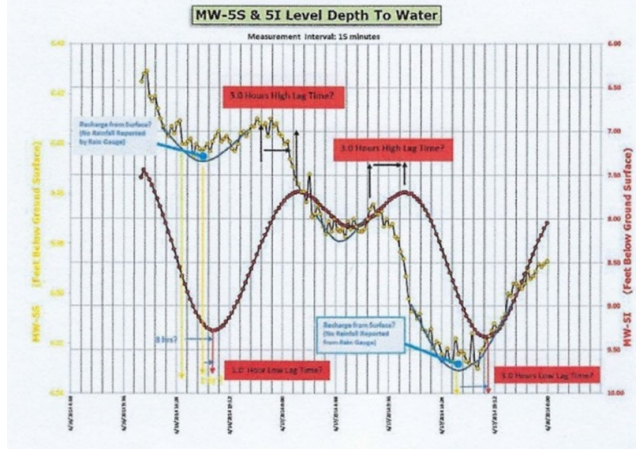
- Pressure Transducers & Remote Data Monitoring
- Precipitation Remote Monitoring
- Data Reduction from Remote Locations



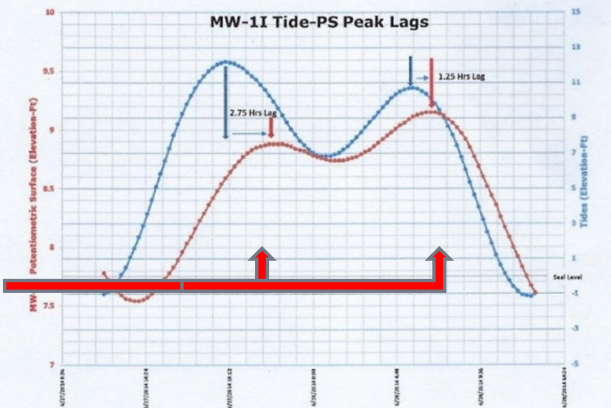
Remote Graphs

- **Results:**
 - Diurnal Tides
 - Large Impact at Depth
 - Less Impact Shallow
 - Recharge Evident in Both
 - Confirms 2 Gradients
 - Peak Arrivals Offset in Time
- **Needs:**
 - More Data
 - Remote Collection & Data Interpretation

MW-5S and I High-Low Lag- Two Day Excerpt from Two Week Program
(Click on Figure to enlarge for better viewing of data plot)



MW-1I - Two Day Excerpt for Same Period from Modeling Database
(Click on Figure to enlarge for better viewing of data plot)



Complications: Off-Set Diurnal Peaks?
Shallow Aquifer: Unconfined; Lower Aquifer: Confined

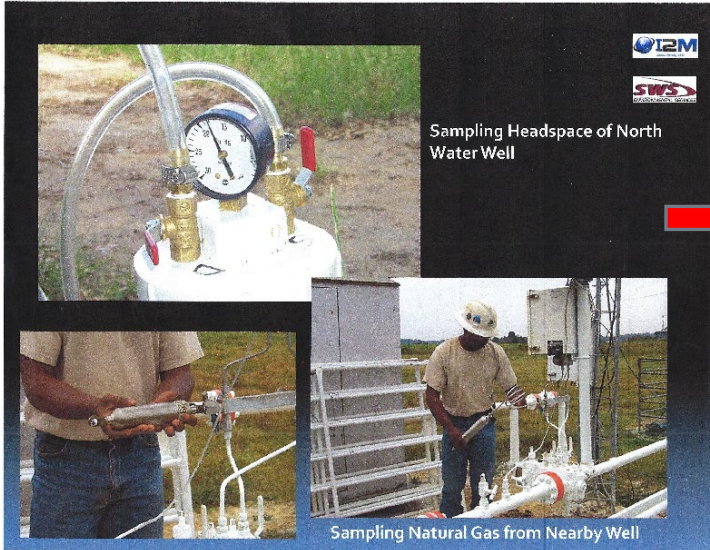
Groundwater Supplies in Trouble ?



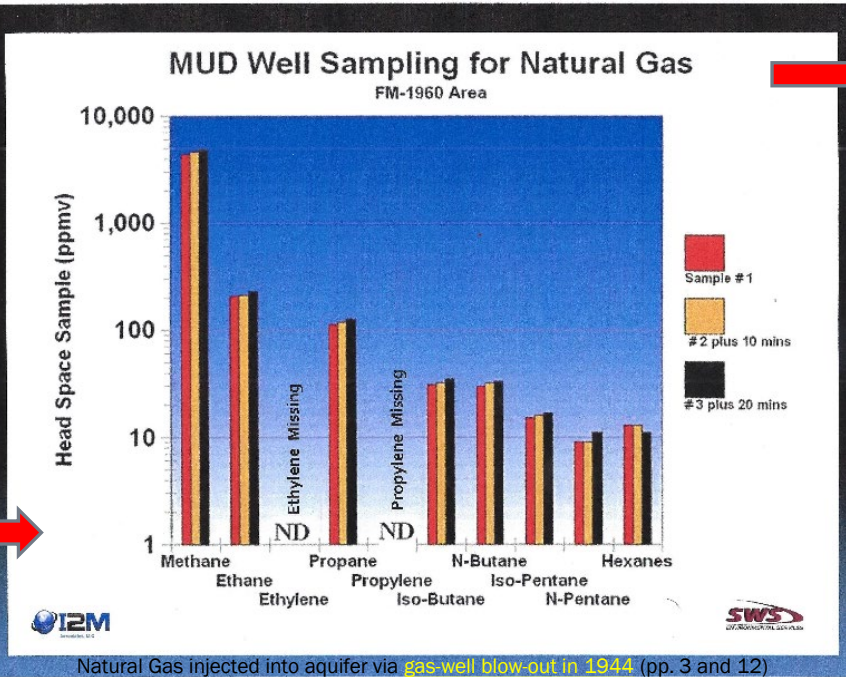
Municipal Water Well Testing

For additional information on both projects, see ([here](#), either pp. 18-27 (above project) or pp. 28-38 (below project)).

Natural Gas in Rural Groundwater ?



Natural Gas Well Sampling

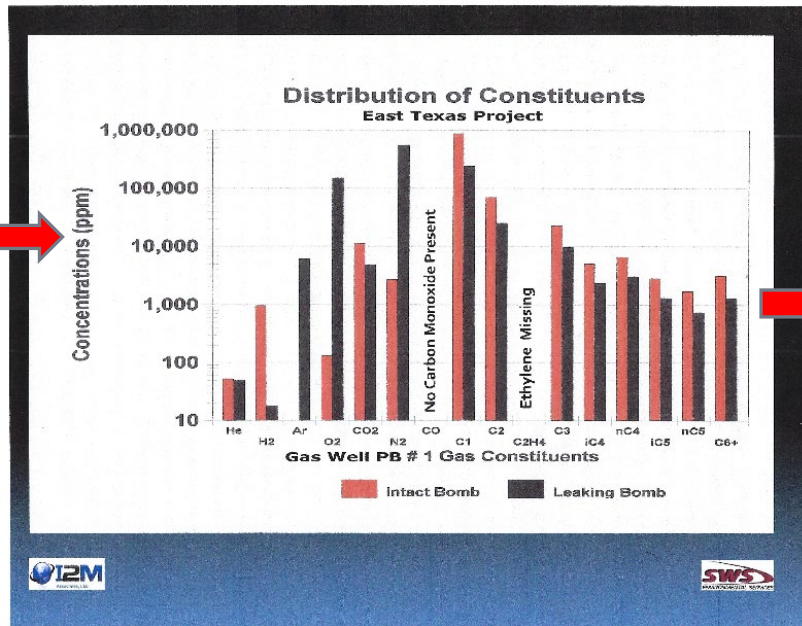
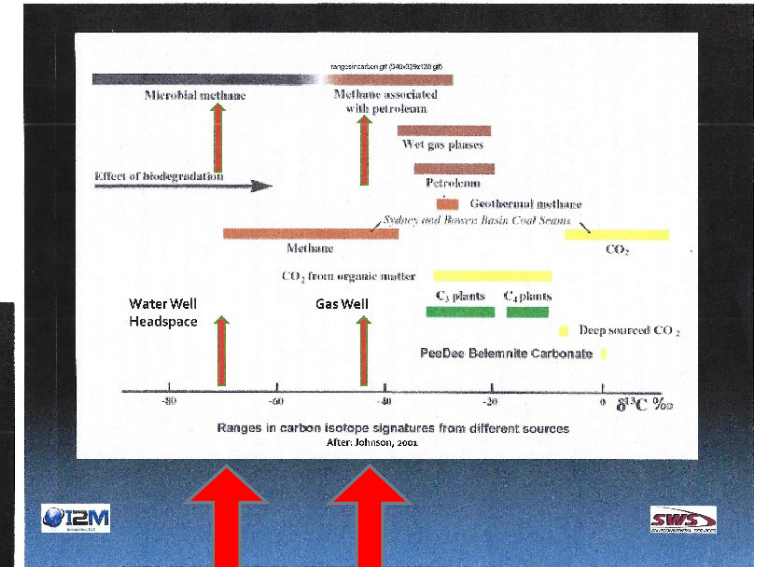


Natural Gas injected into aquifer via [gas well blow-out in 1944](#) (pp. 3 and 12)

Results: Emergency Shut-Down of MUD water supply, flush lines, and storage tanks, install explosion-proof electrics & gas removal at wellhead.

$\sigma^{13}C$ Comparison:

Head Space Water Well vs. Nearby Gas Well



Final Take- Away:

Wherever groundwater wells & gas wells co-exist, conflict can emerge: Groundwater is becoming more important than natural gas production?

For additional information, see the [I2M Web Portal](#)