

BASELINE DATA – PAVILLION, WYOMING AREA GROUNDWATER

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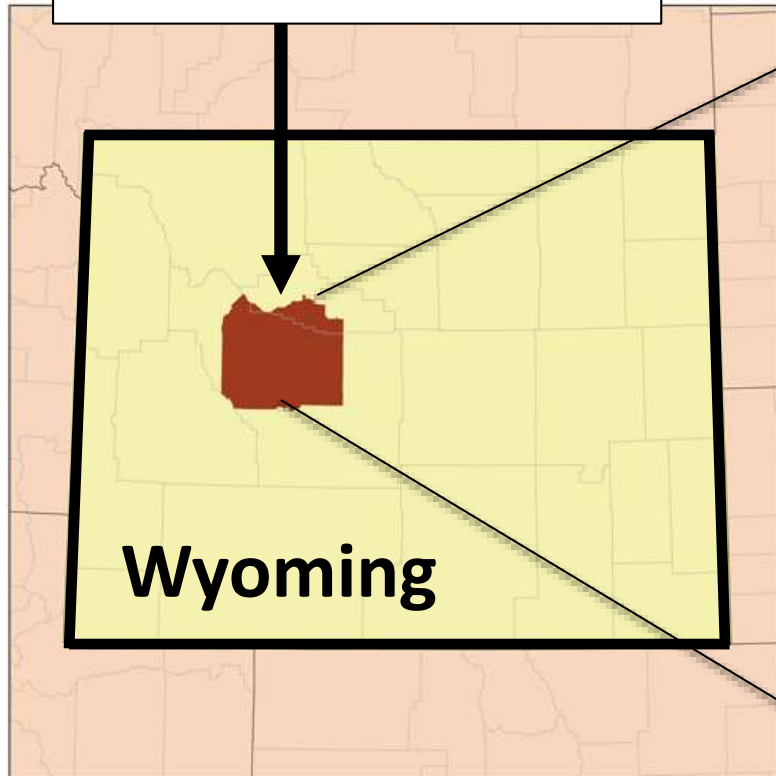
BACKGROUND

- **Near Pavillion, Wyoming, farmers complained that the quality of their well water changed after gas well fracturing nearby**
 - Gas blowout while drilling a water well (522' deep)
 - Higher pH
 - Taste, odor complaints
 - Having to haul drinking water from Riverton (30 miles)
 - Can't haul stock water economically
- **EPA Report (2011) – 2 Parts**
 - Construction of gas wellbores
 - Contamination of shallow and deep aquifers.

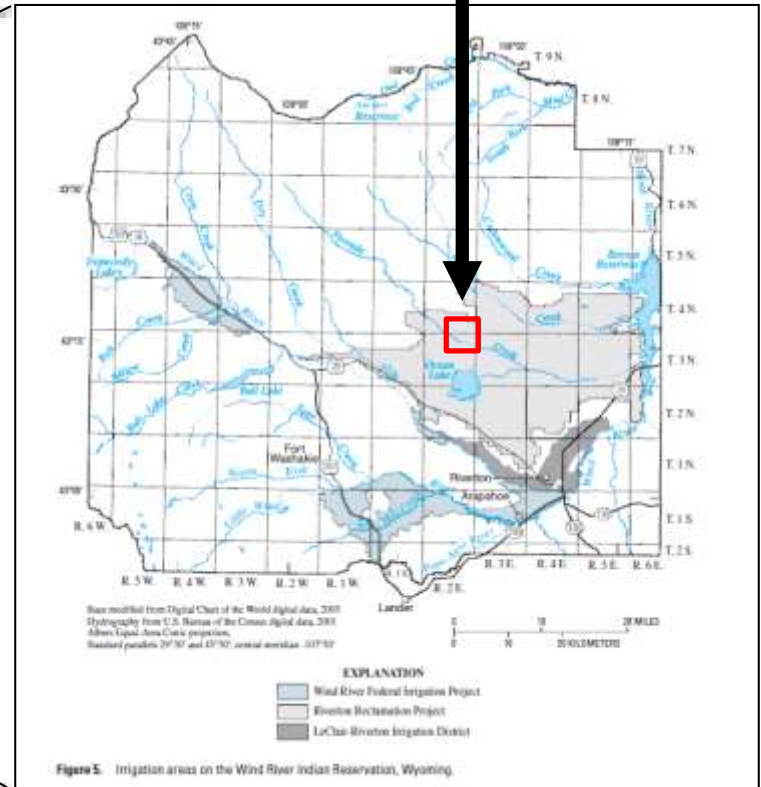


LOCATION

Wind River
Indian Reservation



Subject Area in Red



WATER WELLS

- **Two kinds:**
 - **Shallow, say, less than 100 feet**
 - “Water table” wells
 - Sulfates a problem
 - Contamination from pits on surface
 - **Deep, say, 100 feet to 750+ feet**
 - Wind River Formation
 - Better water compared to shallow wells
 - Contamination from below



**WATER CHEMISTRY, GAS WELL MECHANICAL
EPA STUDY**



EPA STUDY

- Water wells as deep as 800 feet
- Surface casing in gas wells as shallow as 361 feet
 - Does not protect the aquifer
- Fracturing as shallow as 1220 feet

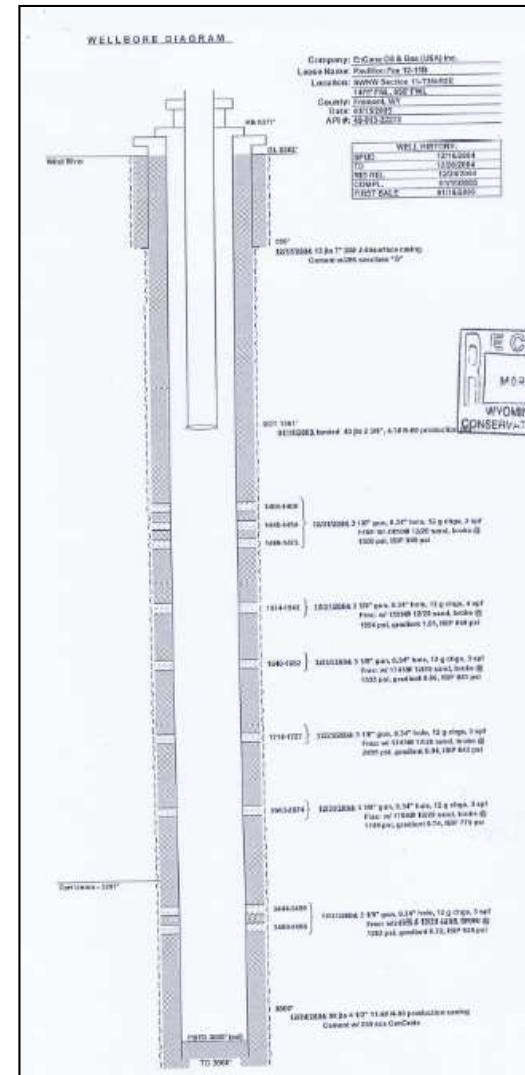


Diagram from WOGCC website



EPA STUDY

- **Initially, EPA detected in deeper farm water wells:**
 - Methane (natural gas), DRO – Diesel Range Organics
 - High pH



- **Drilled 2 water monitoring wells**
- **Tested for chemicals. Found:**
 - Hydrocarbons
 - Synthetics: not found in nature
 - Glycols (like antifreeze)
 - Alcohols (like rubbing alcohol)
- **Compared to frac fluid ingredients**
 - Same chemicals
- **Higher pH, potassium than expected**



EPA STUDY

- **Tested for inorganic ions**
- **Main ions:**
 - Calcium
 - Magnesium
 - Sodium
 - Potassium
 - Bicarbonate
 - Carbonate
 - Sulfate
 - Nitrate
 - Hydroxide (affects pH)
- **EPA identified lack of baseline data as a challenge**



**BASELINE WATER CHEMISTRY DATA,
WELLBORE MECHANICAL INTEGRITY
THIS STUDY**



EPSCoR - PAVILLION STUDY

- **Evaluate mechanical condition of gas wells**
 - Make cross section showing relationship to water wells
- **Look for baseline data for inorganic ions**
- **Assess availability of data**
- **Compare to EPA data**
 - For farmers' water wells only
 - Exclude water monitoring wells, which are slightly deeper

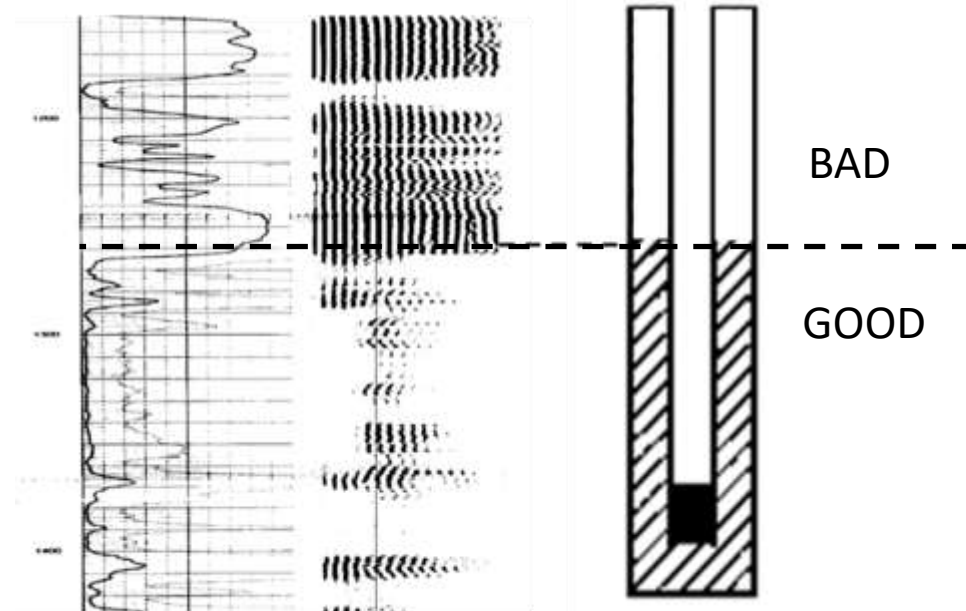


CASING (PIPE) AND CEMENT
GAS WELL MECHANICAL

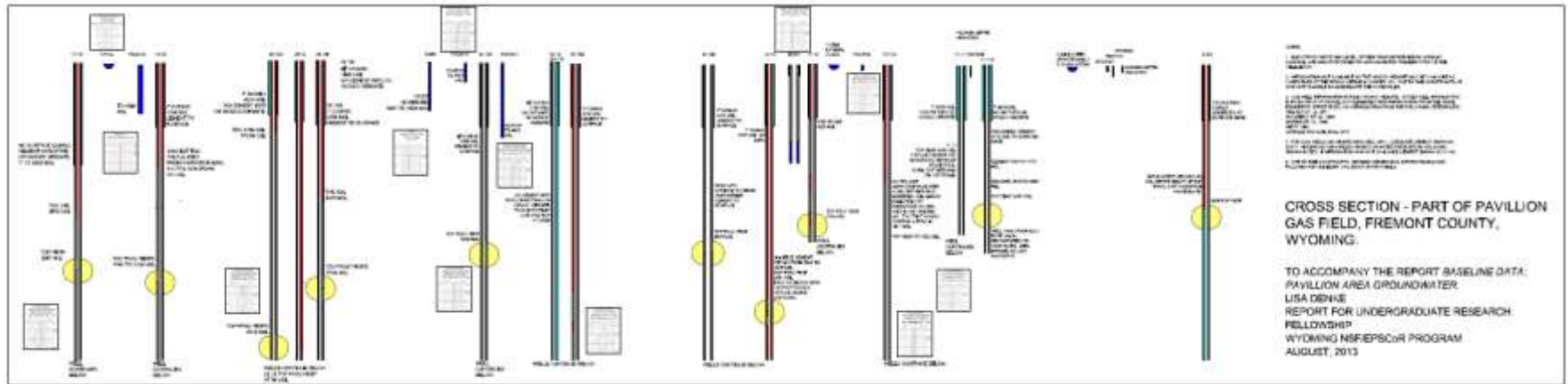


GAS WELL MECHANICAL

- Data from WOGCC website for gas wells
- Data reasonably complete
 - Casing
 - Cement
 - Fractures
- Cement narratives available
 - Were repairs done?
- Bond logs available
 - Is there cement between the pipe and the hole?



CROSS SECTION



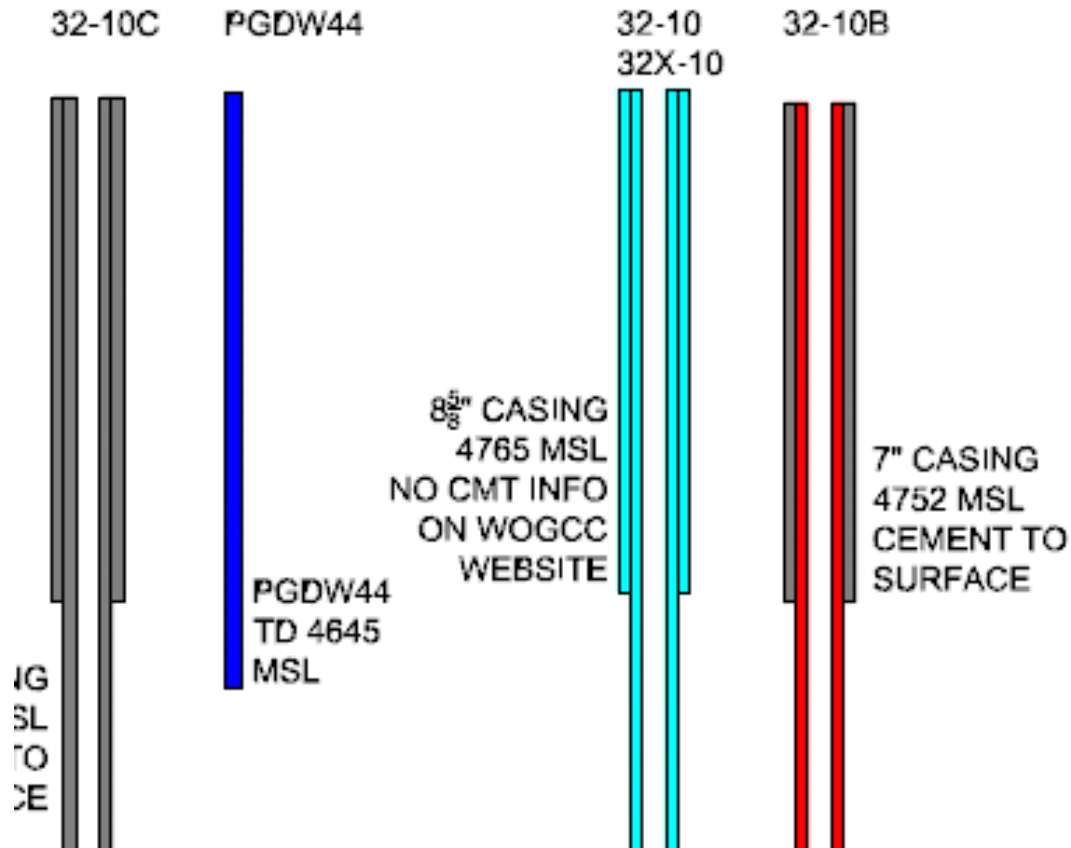
Gas wells extend deeper, shown truncated.

Only top most frac shown (yellow circle).

120' frac shown for graphical illustration only. Height is a reasonable guess.

Frac are longer from “left to right”, but are not necessarily in the plane of the paper.

COLOR CODING



WATER WELLS = BLUE

GAS WELLS

GRAY = Good cement

CYAN = No information

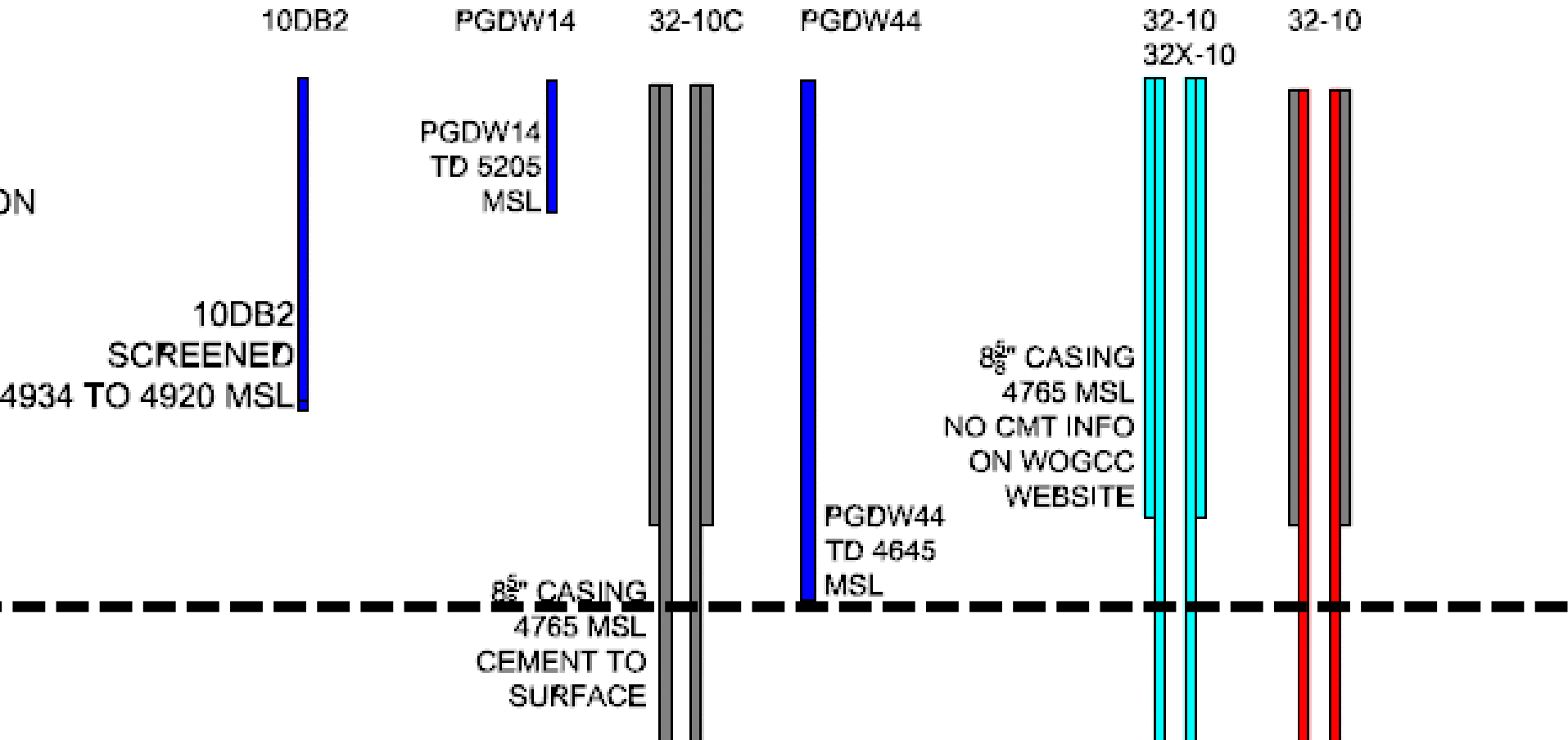
RED = No cement or
channeled cement

STEEL PIPE is likely ok, it's new

MSL – Elevation above Mean
Sea Level



CASING DEPTHS COMPARED TO AQUIFER

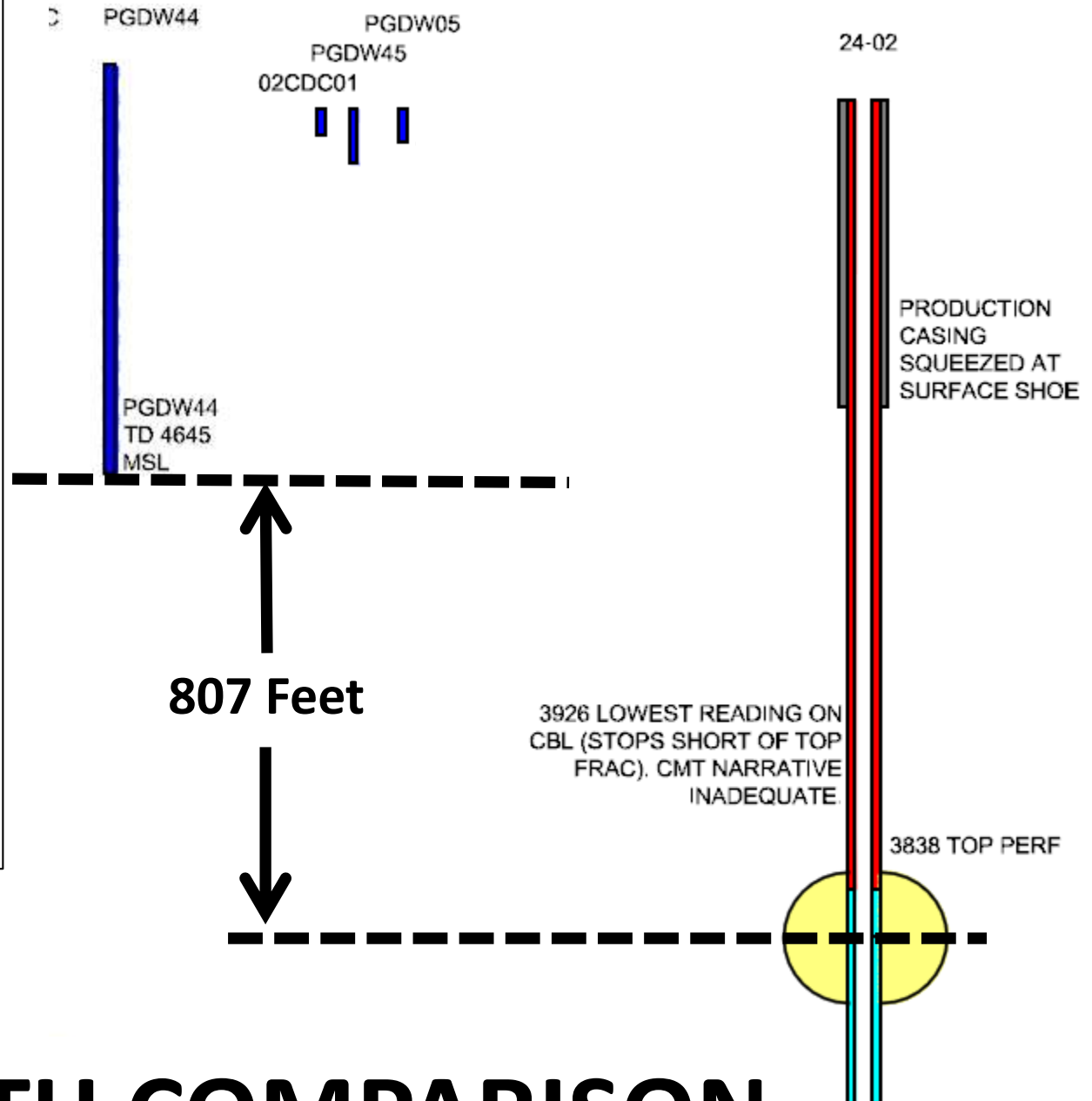


No cement behind pipe on 24-02 gas well.

PGDW 05 is near the blowout water well.

02CDC01 is an old water well, USGS tested in 1959.

PGDW 44 is a deep water well.



FRAC DEPTH COMPARISON

GAS WELL MECHANICAL

- **My analysis confirms EPA's analysis**
 - Surface casings not deep enough to protect aquifer
 - Not enough cement fill behind production casings
- **Likely that frac fluid went into the aquifer**
- **Losing gas out of the production zone**
 - Pressure lower, can't get the gas now
 - Royalties, tax income lost



pH HIGHER THAN HISTORICAL

WATER DATA COMPARISON



PAVILLION STUDY

- **Baseline data availability**
- **USGS “Water Supply Papers”** are main source
 - WSP 1375, written in 1959
 - WSP 1576I, written in 1969

Ground-Water Resources of Riverton Irrigation Project Area, Wyoming

By D. A. MORRIS, O. M. HACKETT, K. E. VANLIER and
E. A. MOULDER

With a section on
CHEMICAL QUALITY OF GROUND WATER

By W. H. DURUM

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1375

Ground-Water Resources of the Wind River Indian Reservation Wyoming

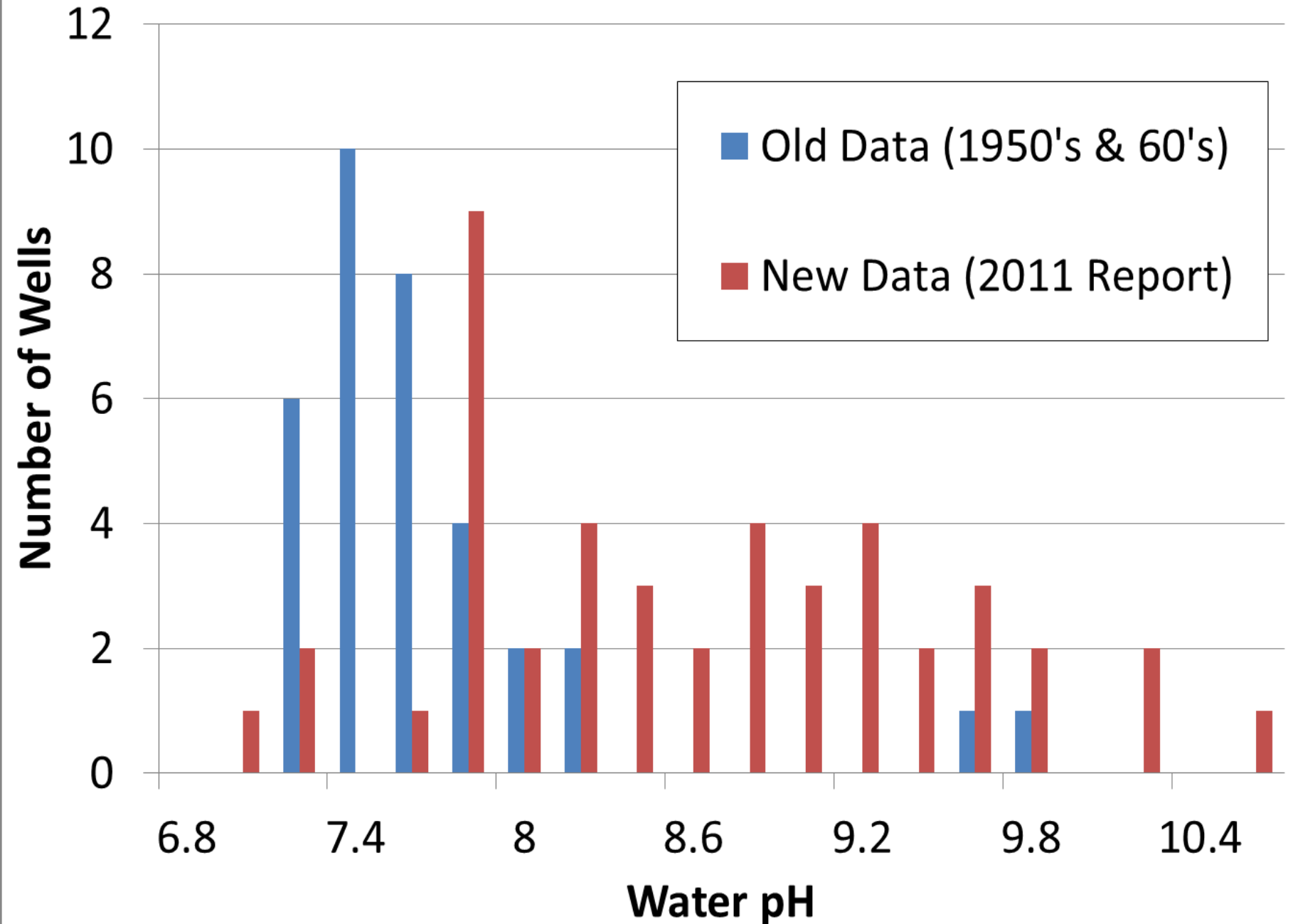
By LAURENCE J. MCGREEVY, WARREN G. HODSON, and SAMUEL J. RUCKER IV
WATER SUPPLY OF INDIAN RESERVATIONS

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1576-I

*Prepared as part of the program of
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development of the Missouri River basin*



Water Well pH Histogram



SUMMARY

- **Is the gas well mechanical integrity ok?**
 - No, surface casings are too shallow, and not enough cement on deeper production casing
- **Is baseline data available?**
 - Yes, available online from WRDS at UW
- **Is there a statistically significant change in inorganic ions in farmer's wells?**
 - Yes, pH is higher than historical (more hydroxide ions)
 - Statistical “p-value” = 0.0000004
 - A “p-value” less than 0.05 indicates statistical significance
 - pH too high to explain with just frac fluid
 - Some other ions have changed, some didn't



RECOMMENDED NEXT STEPS

- **Monitor farmers' wells for pH**
 - Cheap and easy, just supply pH strips to farmers and have them send the data. “Crowdsourcing”
 - 100 data points for \$12
 - State agency should check with more accurate equipment also
- **pH strip measurements will help constrain source:**
 - If naturally occurring, readings should stay constant
 - If a constant influx of contaminants, should stay constant near source, increase as contamination moves farther from source
 - If a one-time influx of contaminants, contaminants should drop off over time due to dilution
- **Repair cement in gas wells**
 - Check if gas in farmers' wells is reduced



THANK YOU!

- **My mentor, Dr. Patricia Colberg, for her guidance and expertise in groundwater remediation**
- **EPSCoR for funding my research**
- **WRDS for curating the data, and for helping me find it**

