

# **Twenty Years of CBM Production and Monitoring of the Pine River Subcrop and Gas Seeps: No Depletion\***

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Search and Discovery Article #80489 (2015)

Posted November 2, 2015

\*Adapted from oral presentation given at AAPG Annual Convention & Exhibition, Denver, Colorado, May 31-June 3, 2015. Please see closely related article, "[The Story of Moving Mountain: An Historic Gas Seepage and Mass Wasting Event, Search and Discovery Article #80109.](#)"

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## **Abstract**

Starting in 1994 a ground water, surface water and gas seepage monitoring network was set up in response to observed gas seepage near the subcrop of a producing Coal Bed Methane (CBM) formation and the Pine River in the San Juan Basin, southwestern Colorado. The null hypothesis was that CBM production was releasing gas at the subcrop due to down-basin CBM water pumping. The null hypothesis was tested using downhole video, packer testing, reservoir/seepage production analysis, temperature tracing, cation water quality, water age, and potentiometric head trends. Based on the 20 years of data and analysis the CBM null hypothesis was rejected. Since there was no hydraulic connection between the subcrop and CBM production, there was no depletion from the Pine River. A new null hypothesis that gas seepage was due to long term precipitation trends was formulated in 2000 by the author. It continues to be accepted 13 years later.

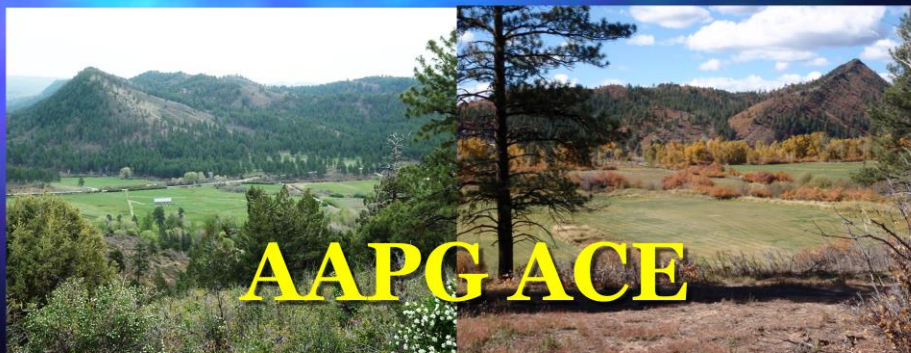
## **Selected References**

Fassett, James E., and Jim S. Hinds, 1971, Geology and fuel resources of the Fruitland Formation and Kirtland Shale of the San Juan Basin, New Mexico and Colorado: USGS Professional Paper 676, 76 p.

Sanford, W.E., and P.D. Sorek, 2003, Groundwater ages in the Northern San Juan Basin: implications for hydrogeology of the Fruitland Formation: Power Point Presentation in Pine River Ranches Monitoring by Paul Oldaker, CD-ROM by British Petroleum, March 13.

Snyder, G.T., W.C. Riese, S. Franks, U. Fehn, W.L. Pelzmann, A.W. Gorody, and J.E. Moran. 2003, Origin and history of waters associated with coal-bed methane: 129I, 36Cl, and stable isotope results from the Fruitland Formation, Colorado and New Mexico, USA: *Geochimica et Cosmochimica Acta*, v. 67/23, p. 4529-4544.

# **20 YEARS OF CBM PRODUCTION AND MONITORING THE PINE RIVER SUBCROP. NO DEPLETION**

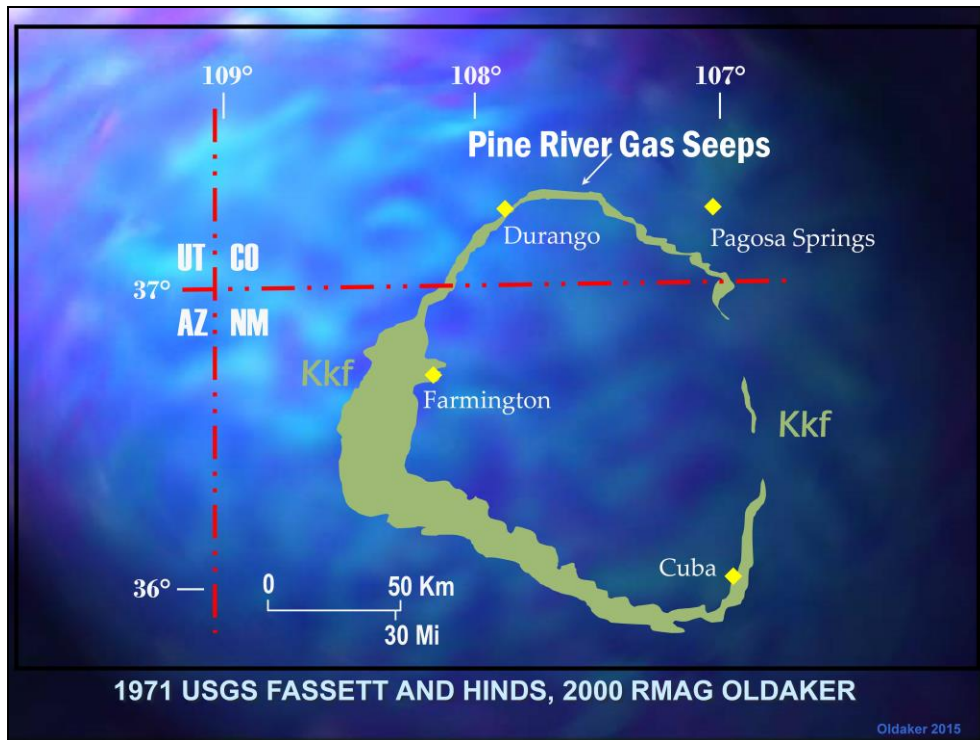


Presented by: Mr. Paul Oldaker

Graphic Arts by: Mr. Chris Chavez

2015 June 2 • Denver, CO, USA

Oldaker 2015

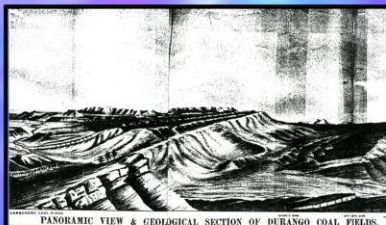


Presenter's notes: Four Corners Area.

San Juan Basin is second largest gas basin in the USA. Most of the formations produce oil, gas and/or water. Over 30 trillion CF produced so far from 1950.

Fruitland Formation is the most prolific coal bed methane formation in the world. Estimated 50 trillion CF originally in place.

Pine River Gas Seeps are on the northern edge of the basin.



1888

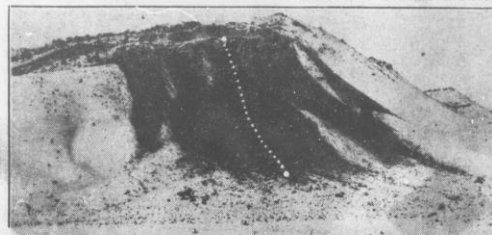


1924



1  
9  
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3

DOTTED LINE SHOWS WHERE CONWAY CAME DOWN



Between fifty and one hundred people stood spell bound Sunday afternoon as they watched Ed Conway, son of Mr. and Mrs. Tom Conway, of North Durango miraculously escape death or serious injury as he came down the north side of Carbon mountain with big rocks tumbling all around him.

1889 CSM Lakes, 1924 Bayfield Blade, 1932 Durango Herald

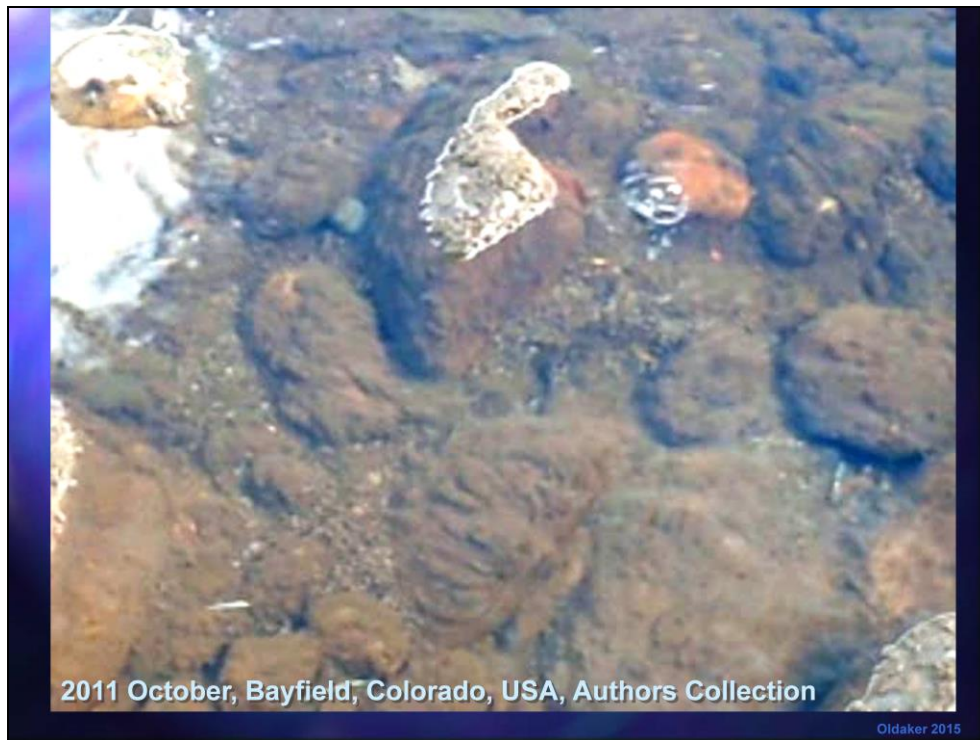
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Presenter's notes: Long history of gas seepage from the Fruitland Formation.

1888 - Animas River Carbon Junction Seep identified.

1924 - Tendick Mine blowout like an out of control gas well.

1932 and 1933 - Moving Mountain. An outcrop coal fire intersects a gas seep and causes explosions and landslides for 9 months.



2011 October, Bayfield, Colorado, USA, Authors Collection

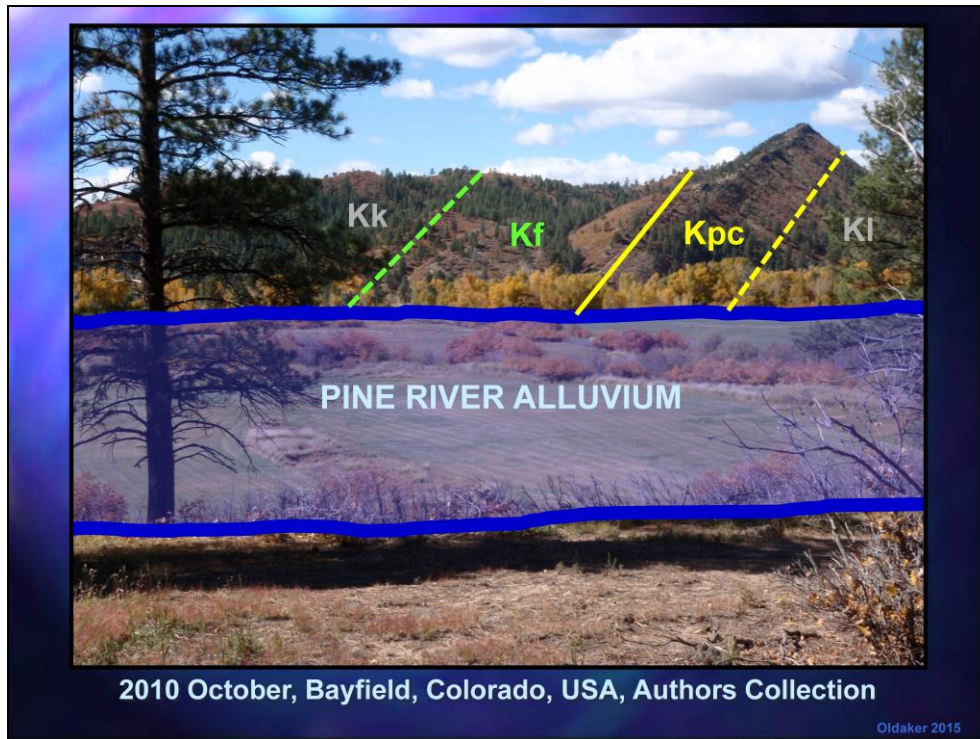
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Presenter's notes: 1993 - The Pine River began bubbling. Some accounts of this happening before.  
Gas seep and/or gas spring.

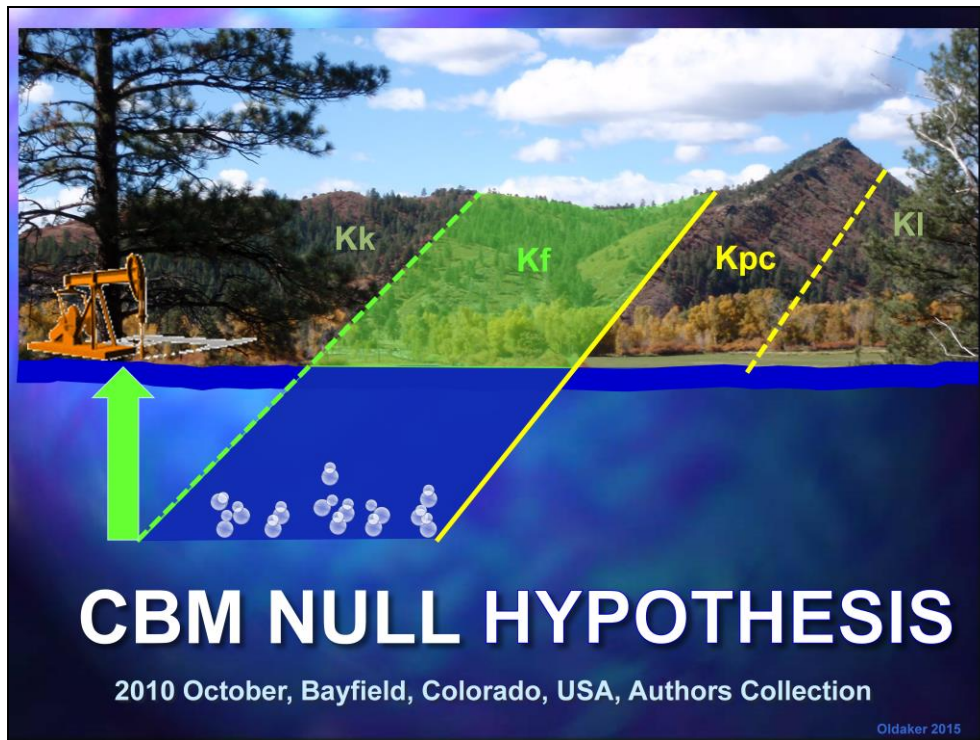




Presenter's notes: Methane seepage in high concentrations cause vegetation mortality due to oxygen deficit in the root zone. Any gas can and does do it except oxygen. Not toxic. Ponderosa pines and grasses are most sensitive. Species used to flooding such as cottonwood, willow and sedges were essentially unaffected. The trend was a swath across the river.



Presenter's notes: Pine River alluvium - unconsolidated recently deposited sediments.  
Lewis Shale (KI) - marine mud with a transitional contact with.  
Picture Cliffs Sandstone (Kpc) - marine beach sand with a distinct contact with.  
Fruitland Formation (Kf) - fresh water swamps that formed thick and thin coal seams. A transitional contact with.  
Kirtland Shale (Kk) - shale with thin coals.  
All produce natural gas, oil and/or water in the SJB. Downhole video show gas in Kk, Kf, Kpc formations.



Presenter's notes: Null hypothesis that the water pumping in the Fruitland for CBM caused water levels/pressures in the Fruitland were reduced and caused gas to be released at the subcrop.  
Depends on the entire Fruitland being hydraulically connected.  
Does not explain historical seepage.  
Downward water flow and ascending gas flow at the same time is a problem.  
Test by several methods.



# Potentiometric Surface Map Pre-Development ( $\pm 1989$ )



1955-1994, Bayfield, CO, USA, 1955 Terry, 1987 Oldaker, 1994 Amoco

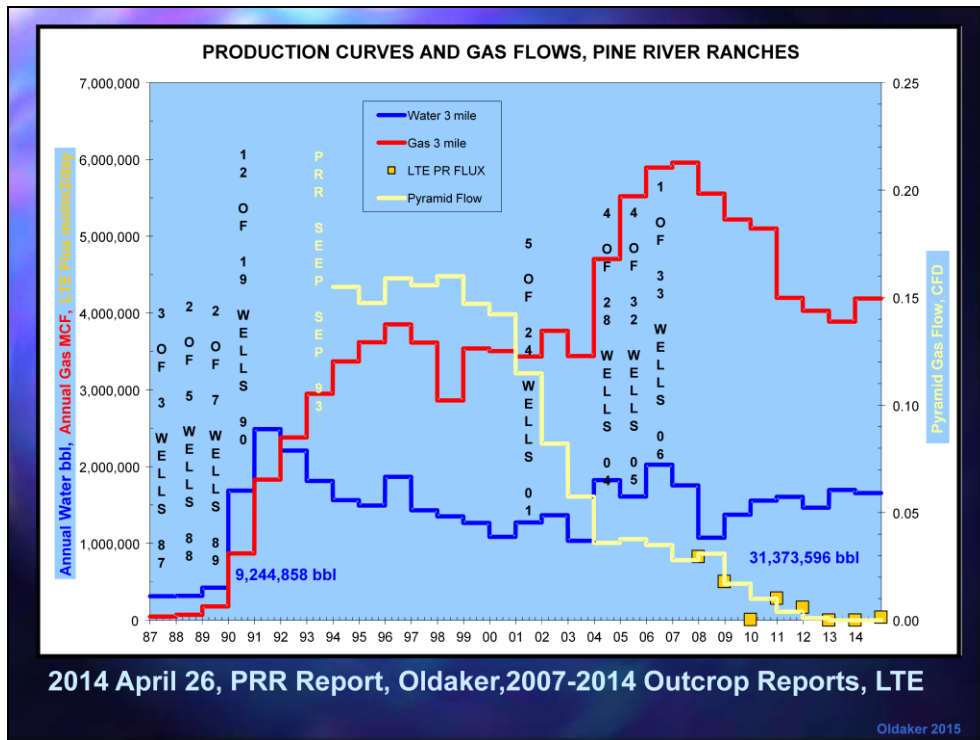
Oldaker 2015

Presenter's notes: Pre-development potentiometric surface.  
CBM wells.  
Down-basin monitor wells.  
Subcrop monitor wells.  
All should decline if all connected.

# **CBM, WATER, AND SEEP PRODUCTION**



Presenter's notes: Pyramid collectors.  
Pyramids, natural alluvium, meter flow by the minute.



Presenter's notes: Within 3 miles of seeps 19 CBM wells were drilled and produced.  
14 infill wells were then drilled.

Water production increases after new wells produced.

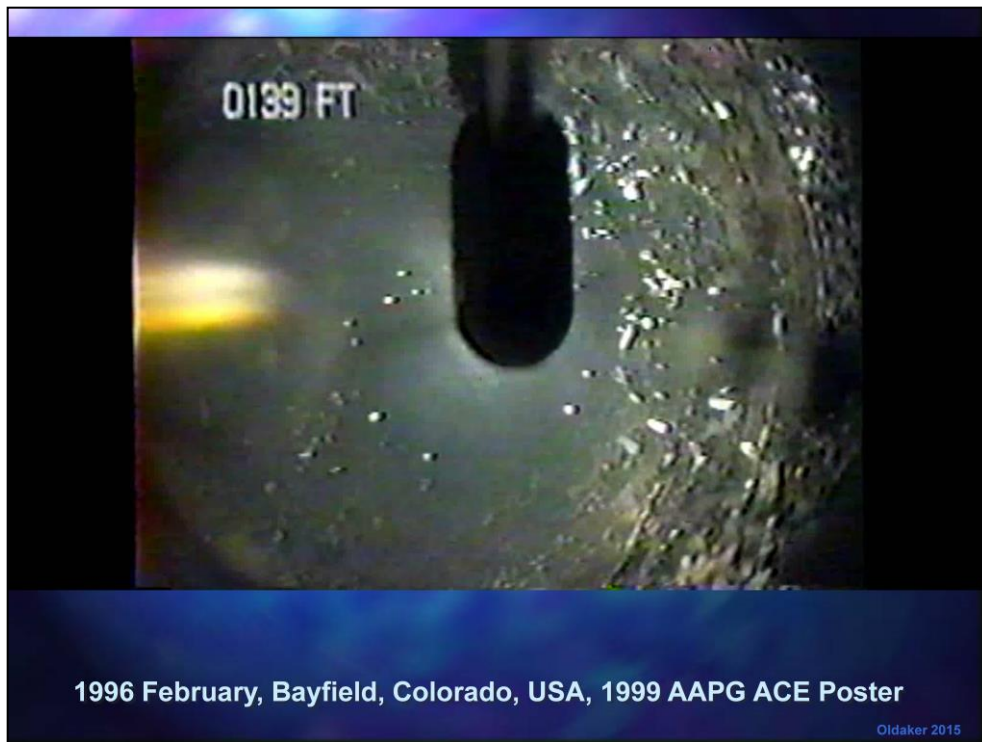
Gas production increases after new wells produced.

Seep production began 3 years after the first 19 wells were drilled. Then dropped before, during and after the infill wells were drilled. LTE data has same trend. The seep production is acting differently than the CBM reservoir.

9 million bbl to start the seeps, but over 30 million bbl produced through 2014.

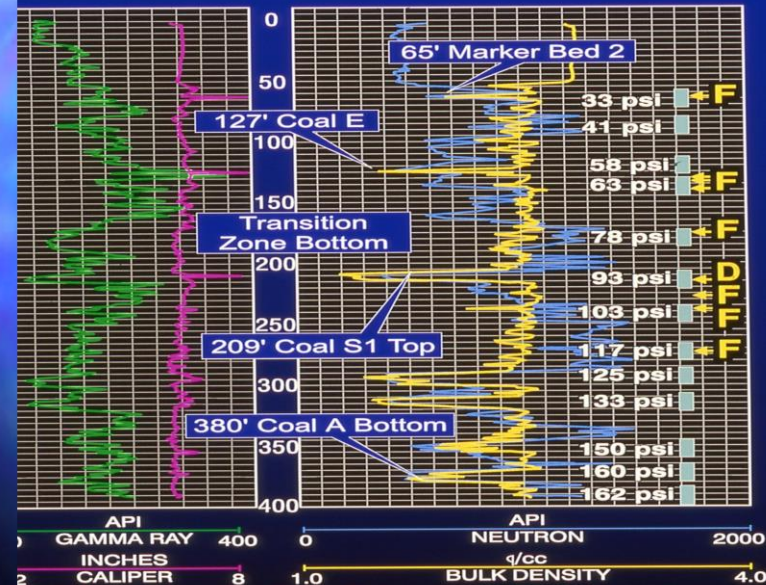


# **DOWNHOLE VIDEOS, VERTICAL PRESSURES BY PACKER TESTING**



Presenter's notes: 1996 - We directly observed the strata producing gas.  
Black oblong is light boom and yellow is the pump hose. Upward gas flow and downward water flow.  
Carbonaceous siltstone blowing gas at 139 to 140 feet in the Salmon 3 monitor well.  
No doubt, but lots of argument.

## Salmon No. 3



1995 November, Bayfield, Colorado, USA, Authors Collection

Oldaker 2015

Presenter's notes: 5 coals in the Fruitland nearest the seeps.

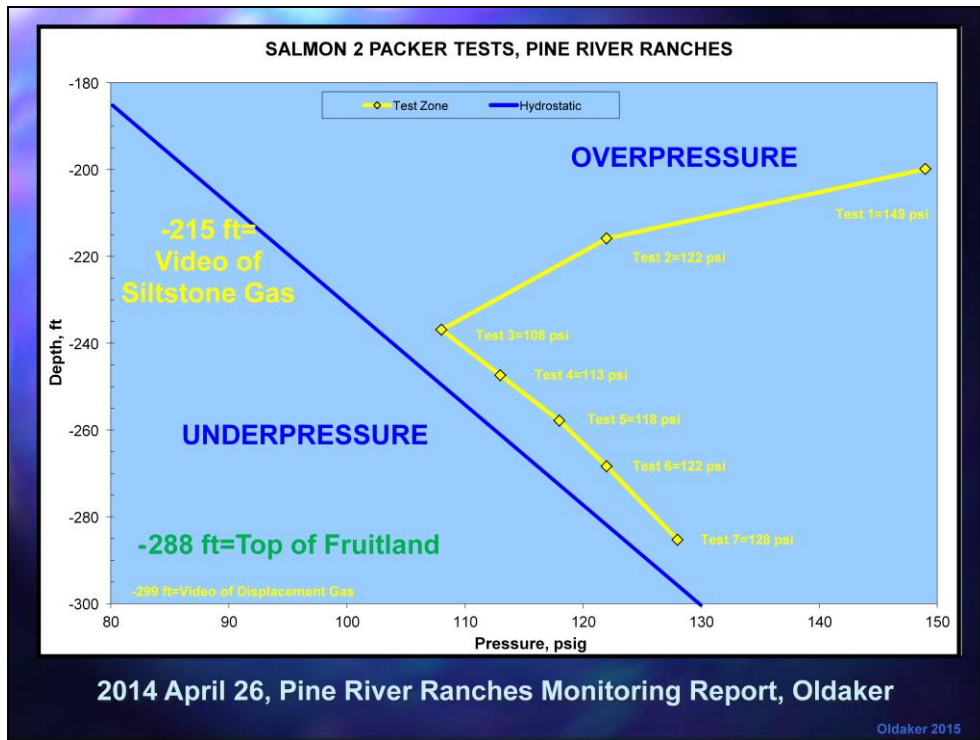
2 thin coals in the transition zone with the Kirtland.

Downhole video showed no gas in the lowest 4 coal seams. This directly contradicts the null hypothesis.

Desorbing gas in uppermost Fruitland coal seam. Location matches a secondary seep.

Six conventional gas zones in siltstones and sandstones in the Fruitland and transition zone. One matches primary seep.

All were packer tested for pressures.



Presenter's notes: Normal, over and under pressure.

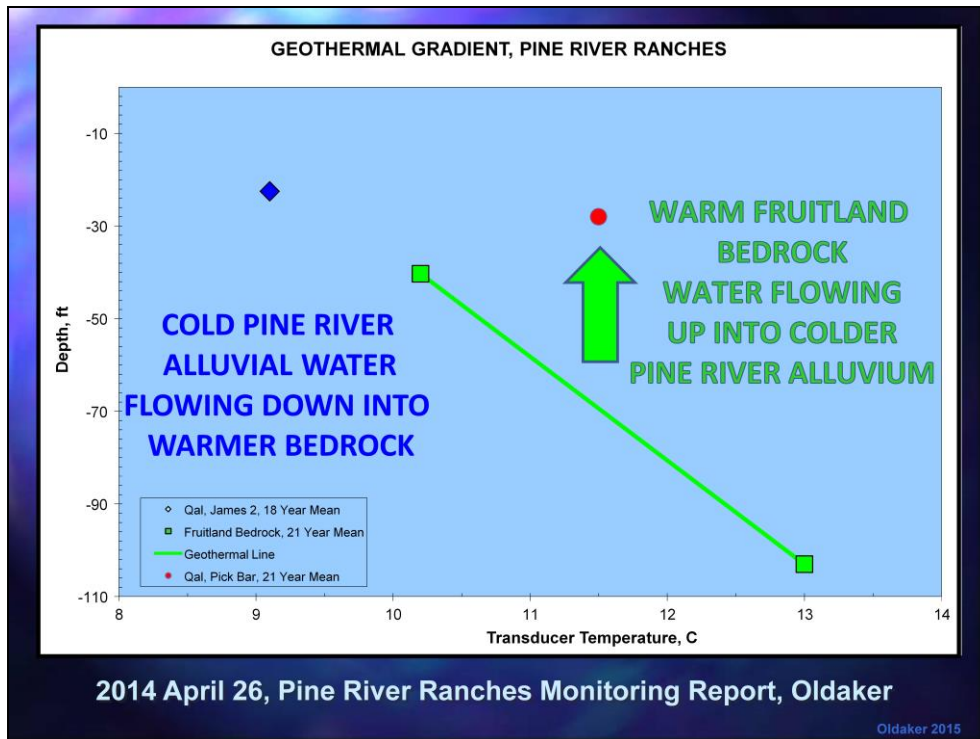
Video show gas in transition zone which matches a large overpressure area.

No under pressure due to CBM production. Direct contradiction of the null hypothesis.





# TEMPERATURE TRACER, GEOTHERMAL GRADIENT



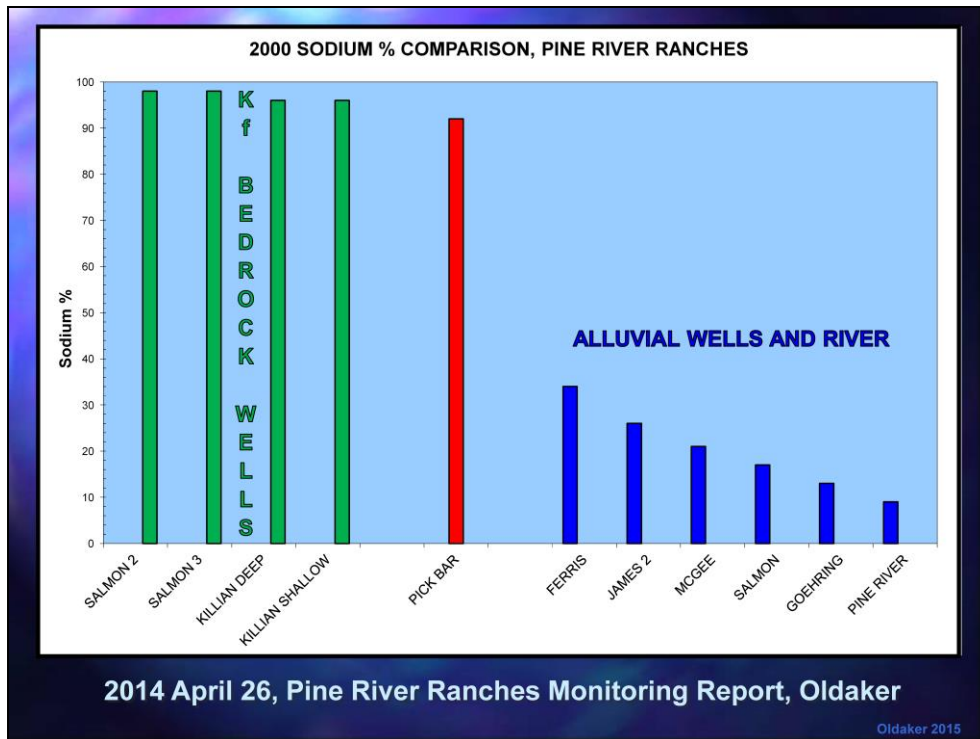
Presenter's notes: Normal geothermal gradient outside the seep.

If colder water at depth then alluvial water is going down into the Fruitland as predicted by the null hypothesis.

If hotter water at surface then warmer Fruitland water is going up into the alluvium.

The winner is warmer water going up. Strong measurements that the stream is not being depleted. Directly contradicts the null hypothesis.

# CATION WATER QUALITY



Presenter's notes: Bedrock wells are high in sodium.

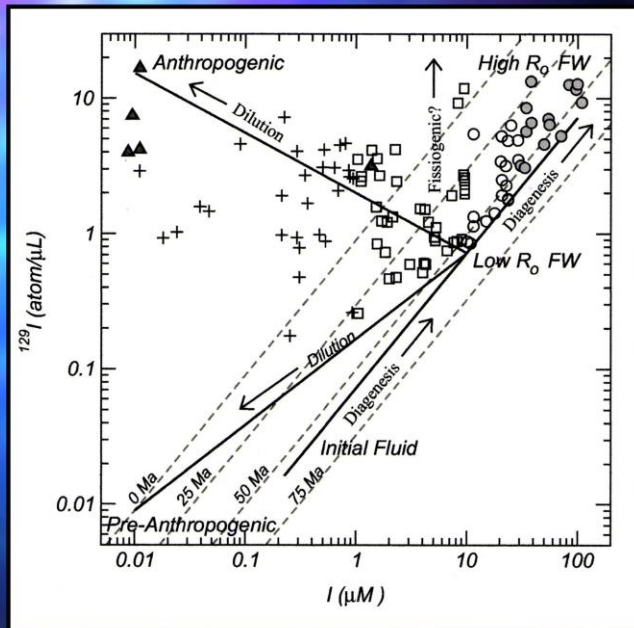
Alluvium and river are low in sodium.

No bedrock wells with low sodium. No flow from alluvium to bedrock.

One alluvial well with high sodium. Flow was from bedrock to alluvium.

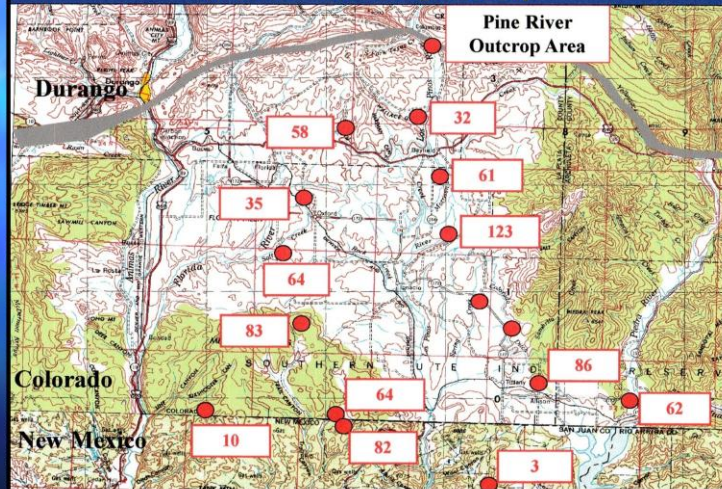


# WATER AGE



2003 Snyder et al. Figure 16

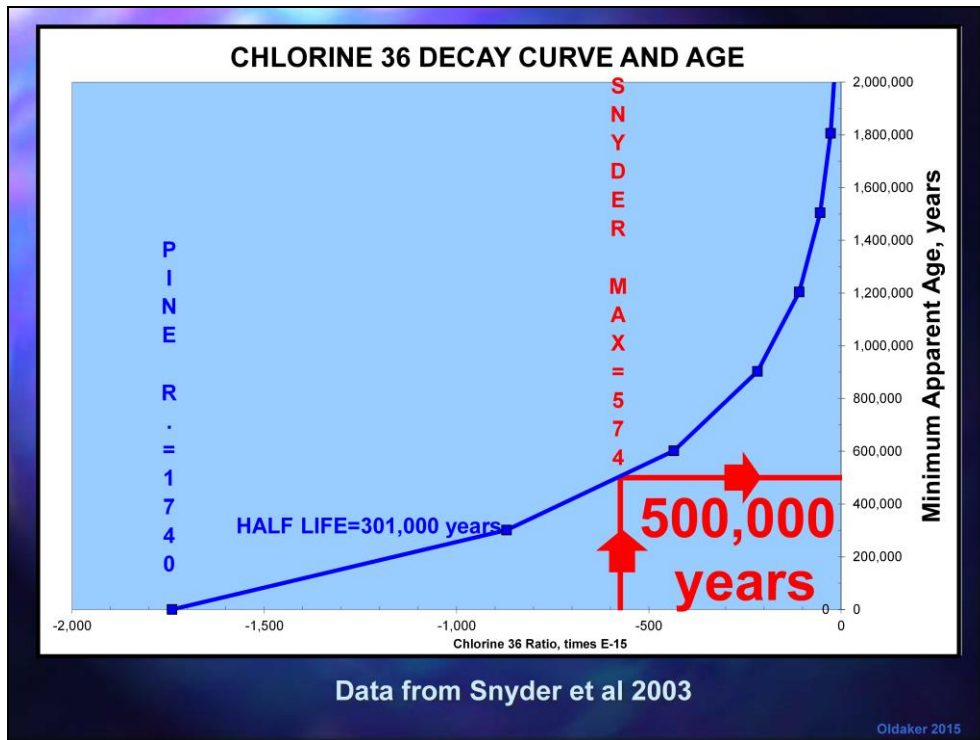
# Apparent Residence Times (millions of years)



2003 Sanford and Sorek

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Presenter's notes: Sanford and Sorek (CSU) used helium 4 to age very old Fruitland waters.



Presenter's notes: Snyder et al. also took chlorine 36 a true radioisotope. The youngest water was a well about 1.5 mile from the Pine River seeps. The result was half million year old water. Indicates a very closed system. Null hypothesis depends on an open system.

# AREAL POTENTIOMETRIC HEAD TRENDS



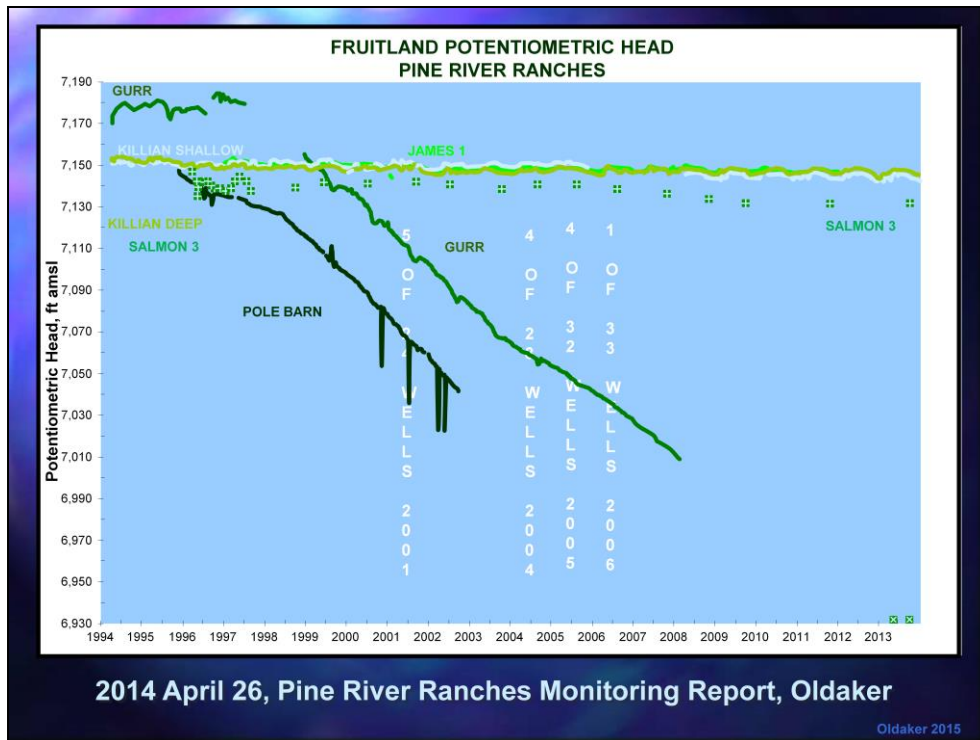
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Oldaker 2015

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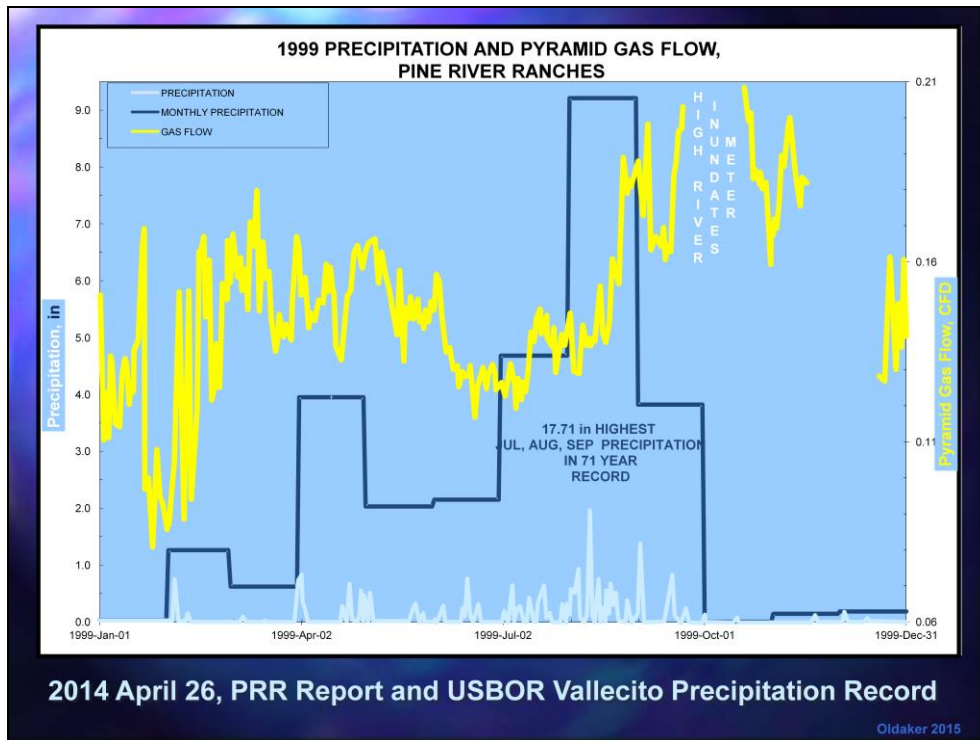
Presenter's notes: Nearest down-basin monitor wells declined, but 2-3 years after seep.  
 Subcrop monitor wells did not decline and show seasonality.  
 Neither sets of monitor wells reacted to the 14 infill wells.  
 There is a hydraulic boundary between the CBM production and the subcrop.

# CBM NULL HYPOTHESIS

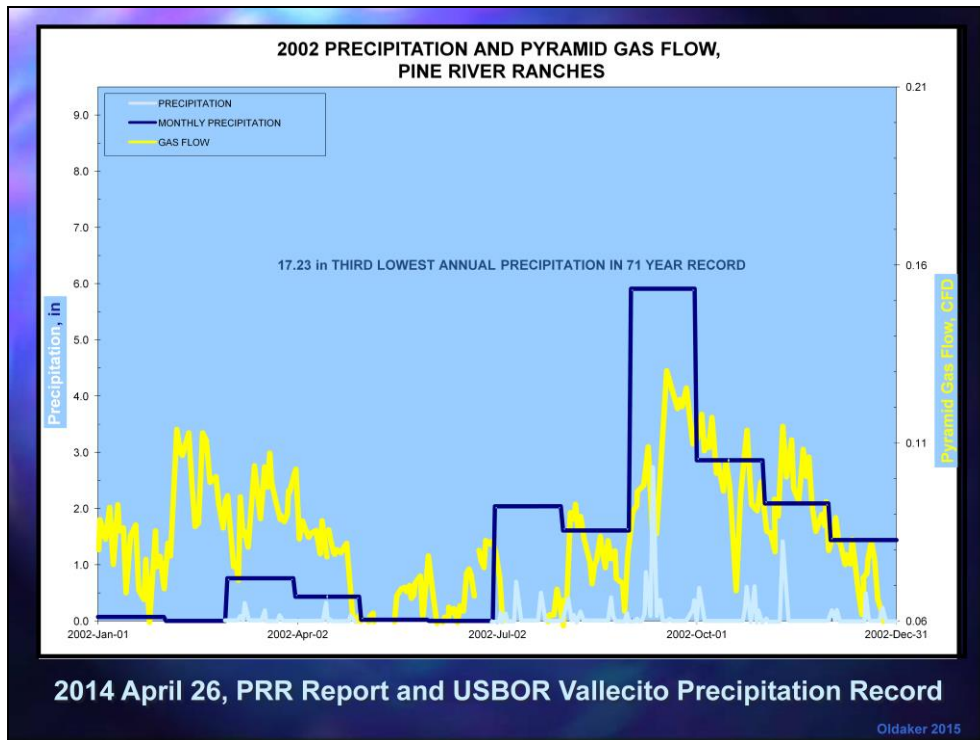
- ◆ DOES NOT EXPLAIN HISTORICAL SEEPAGE,
- ◆ SEEP PRODUCTION DIFFERENT THAN CBM,  
SEEP PRODUCTION DOES NOT REACT TO INFILL
- ◆ VIDEO- SEEP DIFFERENT ZONES THAN CBM,
- ◆ OVERPRESSURED NOT UNDERPRESSURED,
- ◆ TEMPERATURE- FLOW FROM BEDROCK TO Qal,
- ◆ WATER WAS TOO OLD BY AGE ISOTOPES,
- ◆ BOUNDARY BETWEEN CBM AND SUBCROP,
- ◆ I REJECT THE NULL CBM HYPOTHESIS,
- ◆ NO DEPLETION.

**2014 April 26, Pine River Ranches Monitoring Report, Oldaker**

Oldaker 2015



Presenter's notes: 1999 - July, August, September precipitation was over 17 inches.  
 With continued precipitation the gas flow rate went up.  
 When precipitation ended in October, November and December the gas flow rate went down.  
 March gas flow peak was due to low altitude snowmelt.  
 Also a new seep, the Tertiary seep trend was identified.



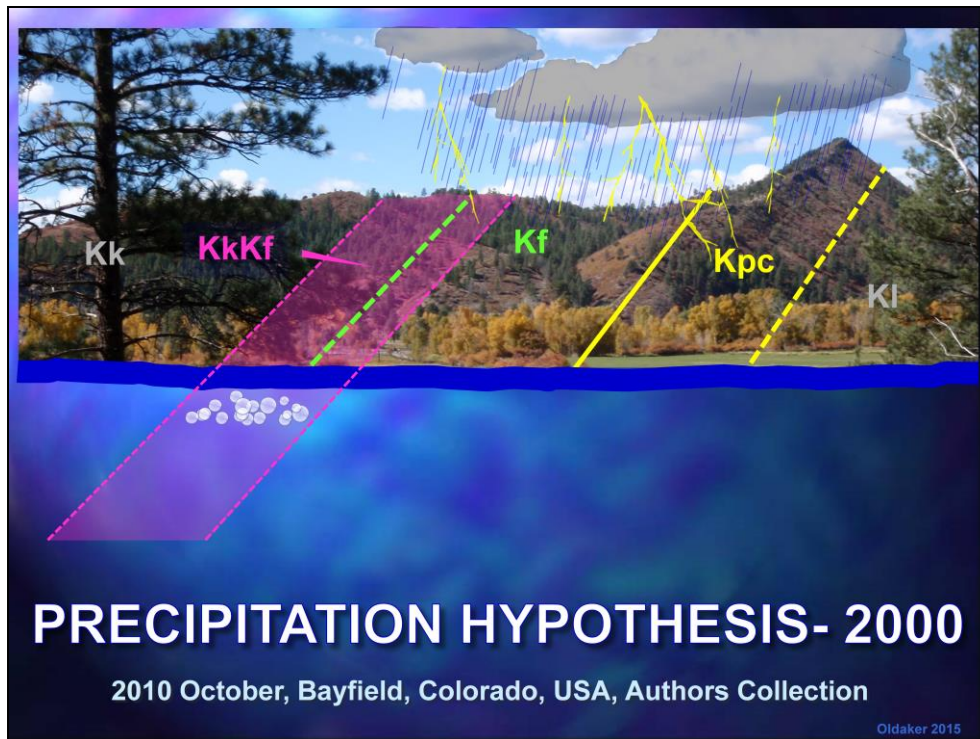
Presenter's notes: 2002 - Same scale as previous graph. Just over 17 inches of precipitation in entire year. A real drought.

Gas flow rate for entire year was much reduced.

Again July, August and September had rain and gas flow rate increased with it.

Another February gas flow peak due to low altitude snowmelt.



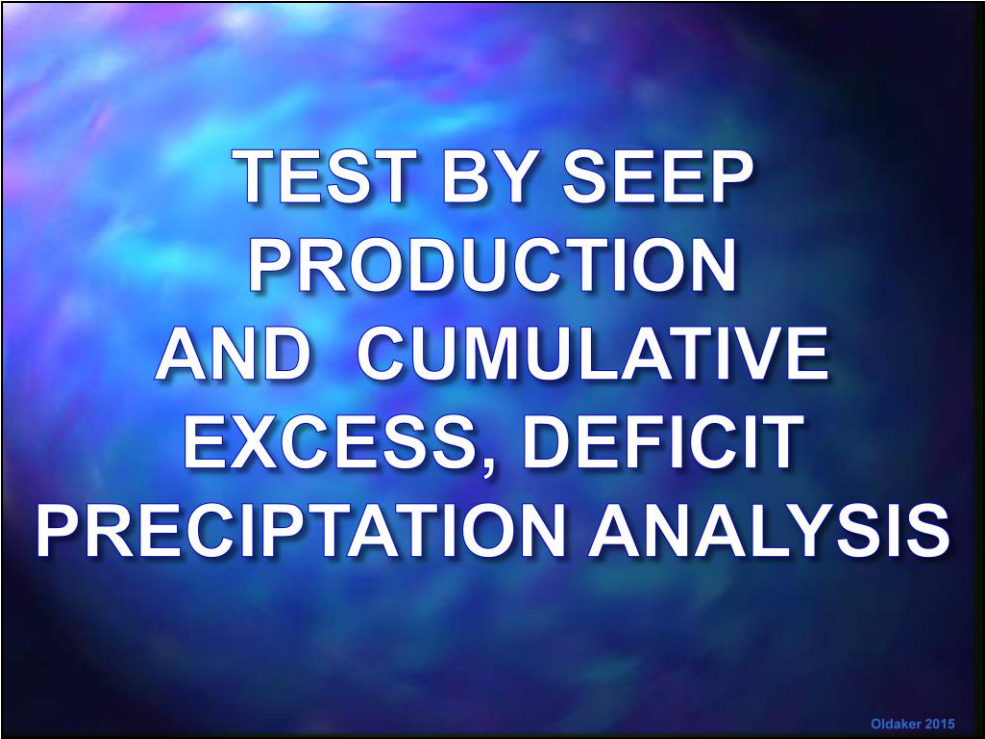


Presenter's notes: In 2000 I formed the precipitation null hypothesis.

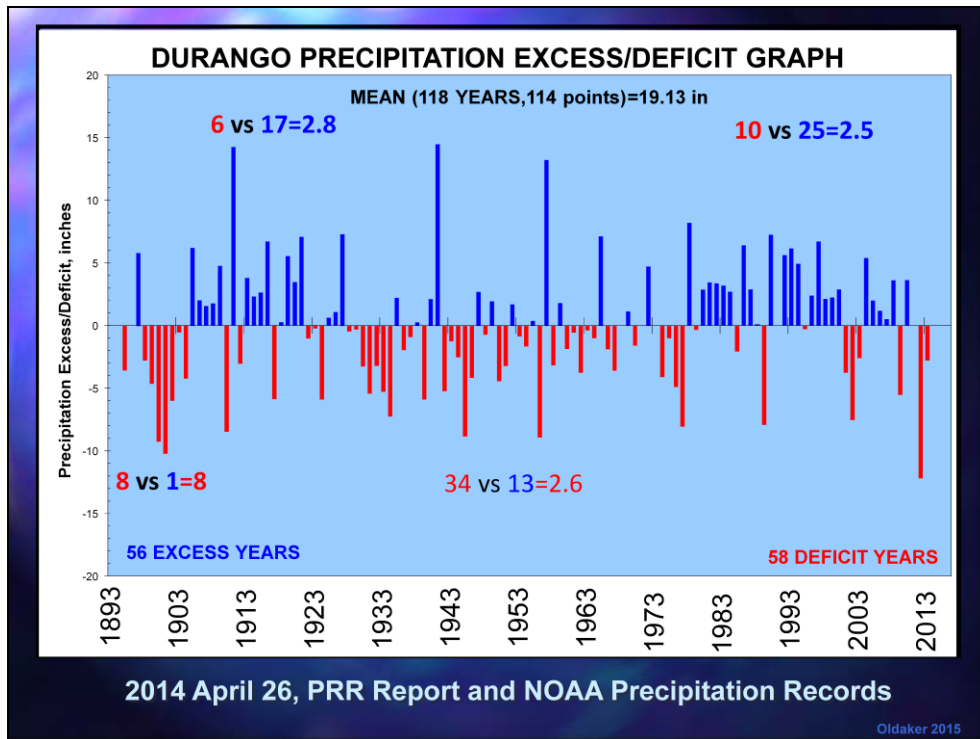
An overpressured Transition zone.

As rain continues, water levels and formation pressure in the transition zone rise and push out more gas. So water storage increasing.

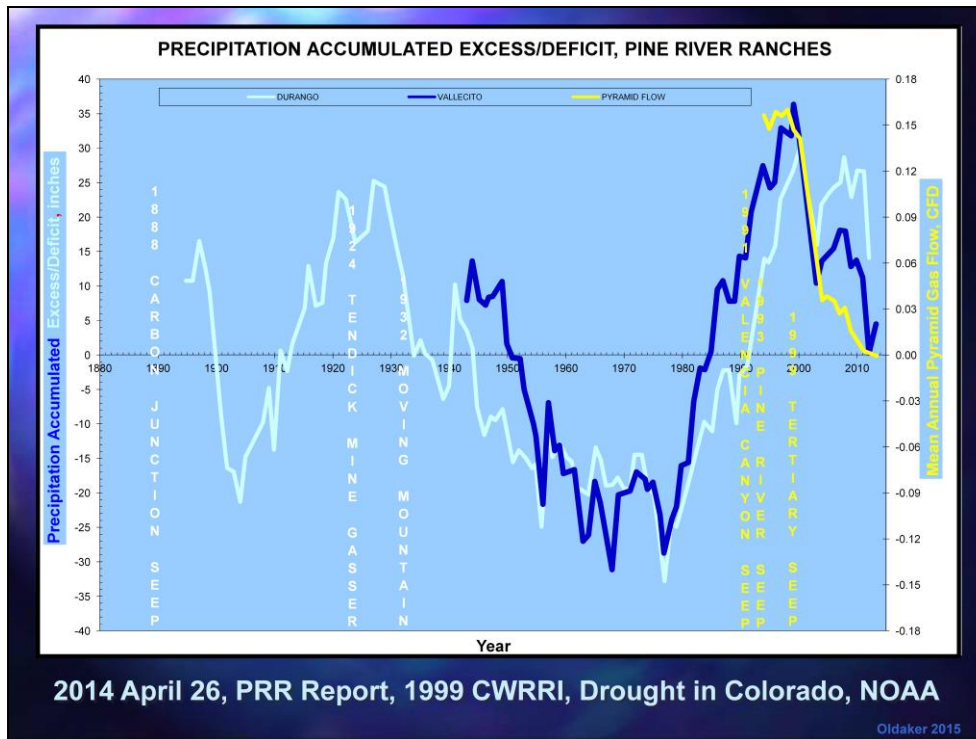
Like a water spring, so gas spring was appropriate.



# **TEST BY SEEP PRODUCTION AND CUMULATIVE EXCESS, DEFICIT PRECIPTATION ANALYSIS**



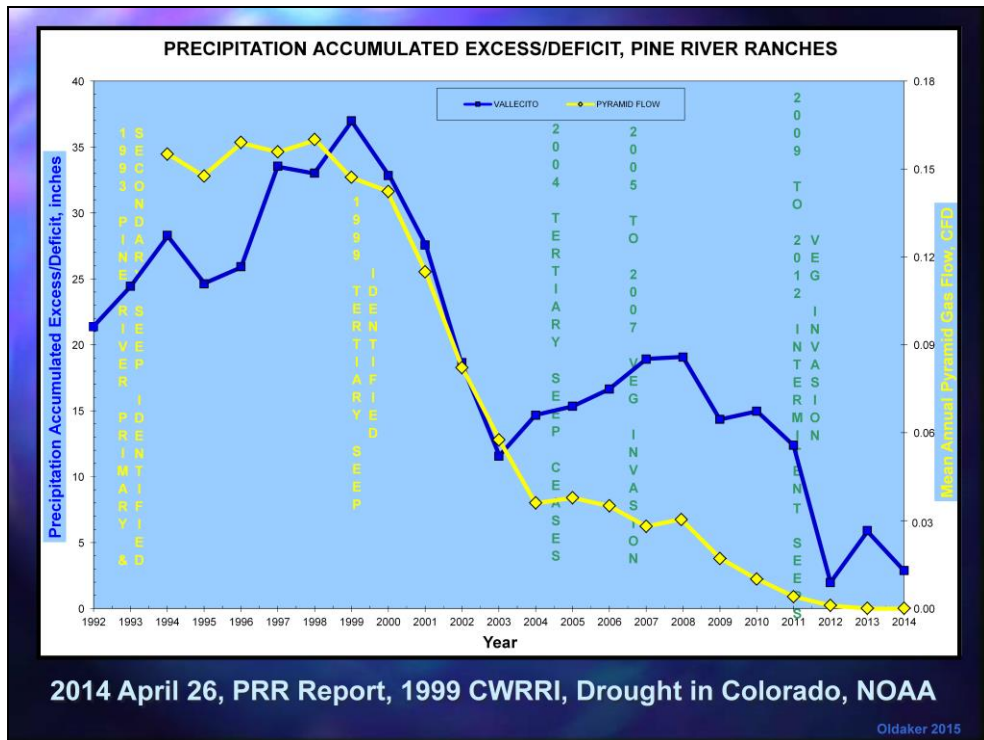
Presenter's notes: Durango record was longest in area, about 20 miles from site.  
Oscillates between periods of excess and deficit.  
Semi-arid with a strong excess and deficit oscillation.



Presenter's notes: Durango record was longest in area, about 20 miles from site. Vallecito record was closest to site at 6 miles north. Periods of excess and deficit. Gas seep observations match excess periods. 1930's, 1940's (uranium prospectors), 1950's (sandstone gas boom, FCGEO, Fort Lewis College), 1960's, 1970's (coal mine boom) have no seep observations except Carbon Junction.

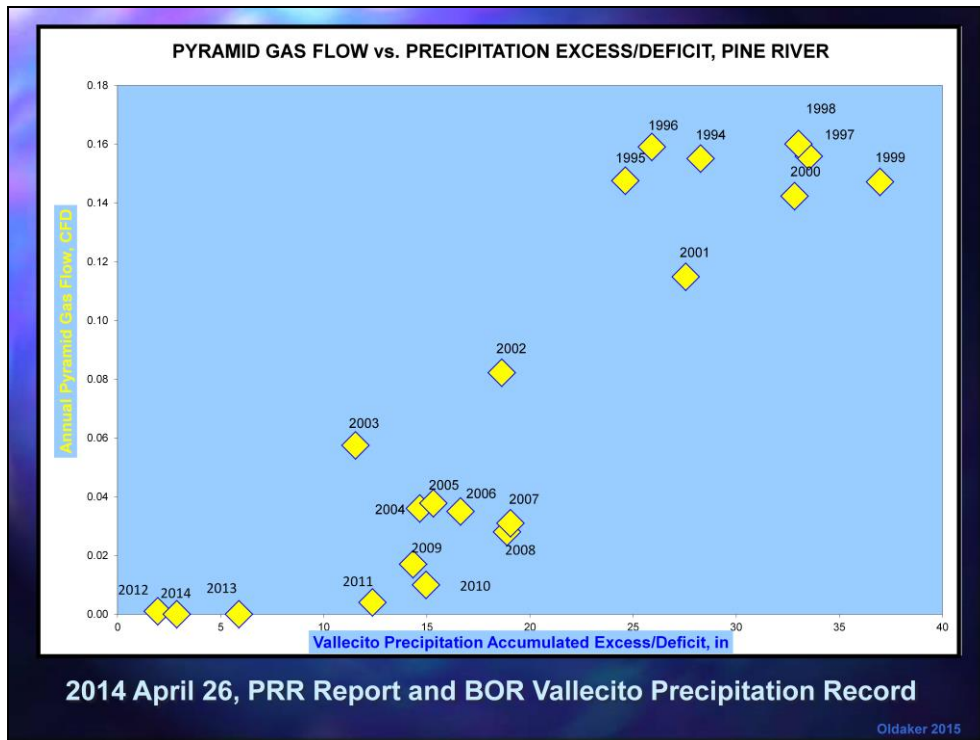
1999 Highest excess in record.

Gas Flow matches blue Vallecito line.



Presenter's notes: Similar lines.  
 Seep observations match.  
 1993 Primary and secondary seep trends identified.  
 1999 Tertiary seep trend identified.  
 2002 Drought year  
 2004 Tertiary seep ceases.  
 2005 Vegetation invasion began.  
 2009 Primary and Secondary seeps go intermittent.





Presenter's notes: Cross plot is direct relation.

About 10 inches of cumulated excess needed to start.

Gas flow rate caps, probably due to either maximum head/pressure or low permeability.

## PRECIP. NULL HYPOTHESIS-OLDAKER 2000

- ◆ CUMULATIVE EXCESS PRECIPITATION EXPLAINS EPISODIC HISTORICAL SEEPS OVER 120 YEARS,
- ◆ CUMULATIVE EXCESS PRECIPITATION DIRECTLY RELATED TO CURRENT SEEP PRODUCTION FOR 20 YEARS,
- ◆ I CONTINUE TO ACCEPT THE NULL PRECIPITATION HYPOTHESIS AFTER 15 YEARS AND COUNTING.

2014 April 26, Pine River Ranches Monitoring Report, Oldaker

THANKS TO Bp and PETER FALK

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