

USING OIL AND GAS DATA TO FIND GROUNDWATER SUPPLIES

**Patricia Billingsley, Brownfields Manager
Madeline Dillner, GIS specialist
Oklahoma Corporation Commission**

Background Slide #1

Groundwater :

- Supplies ~40% of all water used in Oklahoma
- Provides water to > 300 Oklahoma cities and towns
- Supplies water to 295,000 Oklahomans with domestic wells
- Supplies 73% of all Irrigation water for Agriculture - It is our food too!

Background Slide #2

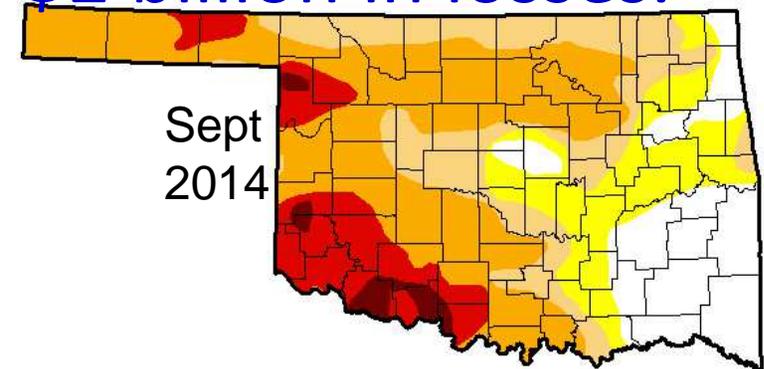
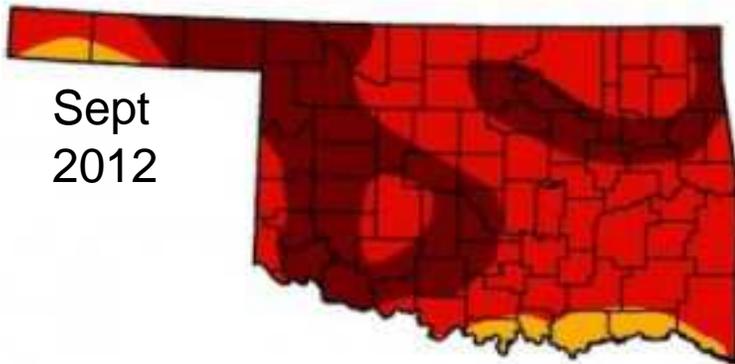
Drought Severity Classification

There are 5 stages of Drought, from D0, dry, to D4, Exceptional.

Category	Description	Possible Impacts
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures.
D1	Moderate Drought	Some damage to crops, streams, reservoirs, or wells low, voluntary water-use restrictions requested
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies

Drought Result -

- Statewide average is <36 " of rain per year
 - The 4 year (10/10-10/14) OK drought – 34 of 48 months quite dry; so far 30" below normal rain
- 2011 & 2012- 95% of state "extreme" (Red, D3) to "exceptional" (Dark red, D4) - \$2 billion in losses.



- 2013 & 2014 better, but the last 365 days is still down >7" Statewide (=80% of average); aquifers and lakes have not refilled.

Because of the Drought, OK Rural Water Districts and Towns Need Water!

At the request of The Oklahoma Rural Water Association, Corp Comm has helped out by:

- Using some of our oil and gas related well and other data, and
- Using accessible (to us, but not to RWDs with no internet connection) other water data, to
- Recommend which of a RWD's possible new water well locations might be better bets.

Or, where NOT to drill!

Oil & Gas Related Data That Can Be Useful

- Base of Treatable Water Maps
- Oil, gas, and dry hole (exploration) electric or gamma ray well Logs pulled up to near surface
- Maps of current and former oil & gas fields
- Historic Aerial Photos
- Well plugging data
- Maps of Hydrologically Sensitive Areas, including aquifer recharge areas, where we already have special mud pit rules

Base of Treatable Water - BTW

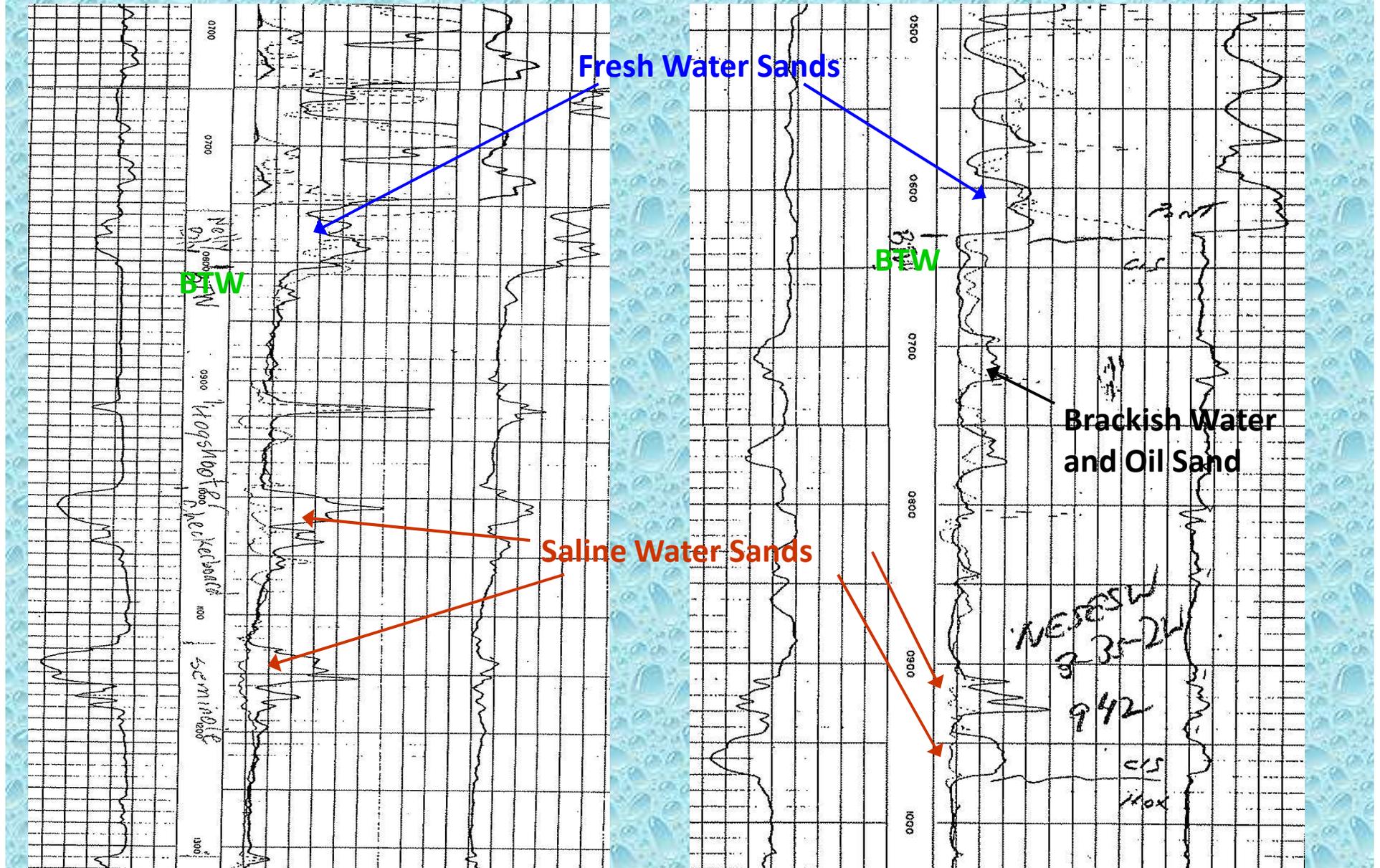
- The Commission has been mapping the Base of Treatable (fresh to brackish) water across the state. This is done to make sure that oil and gas operators put in sufficient casing, cemented into place from the surface to below all fresh water zones. This casing confines produced oil and gas within the wellbore, so that it cannot leak out to pollute fresh water.

Well Log Information; BTW

- Commission staff Use electrical and gamma ray well logs run by oil and gas companies in wells drilled over the past ~75 years.
- These logs let us differentiate between clean sands/porous limestones that can hold water, and tight shales/other rocks that cannot.
- **These logs also let us differentiate between fresh water zones and saline (salty) zones.**

Seminole & Carter Co. Wells

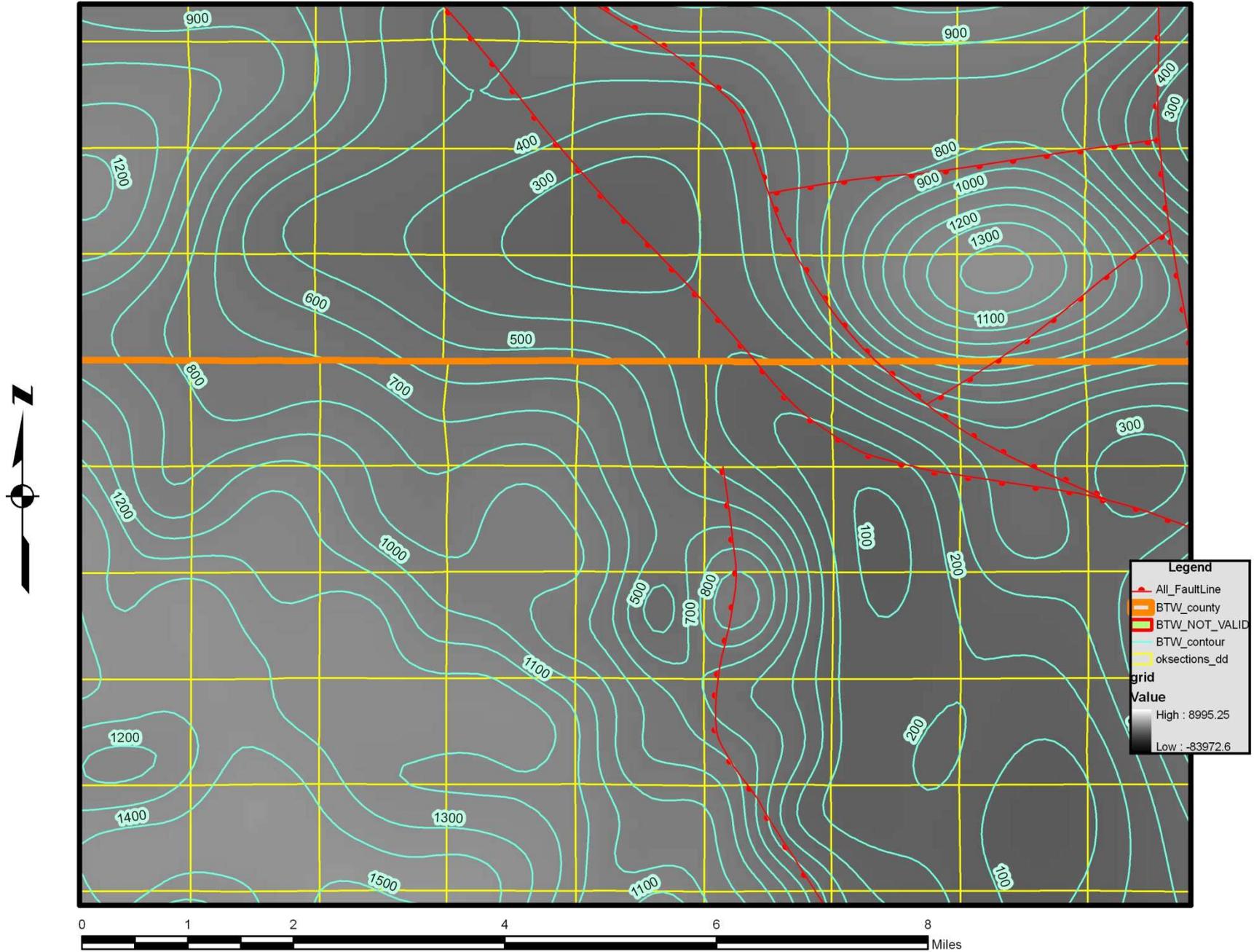
BTW is picked from electric logs run in oil & gas wells



Well Log Information; BTW

- Maps made from this data can also tell you how deep you can drill a water well with little risk of running into the deep, salty water that underlies fresh water throughout most of the state (the Arbuckle Aquifer has fresh water to basement rock – no saline water).

BTW - Feet below surface



Other uses for Electric/Gamma Ray Well Log Information

- Sometimes the aquifer zone a rural water well is completed in cannot supply all of the water needed.
- Using old electric logs in the area, we sometimes see other potential fresh water zones below their current aquifer, going down many hundreds to thousands of feet

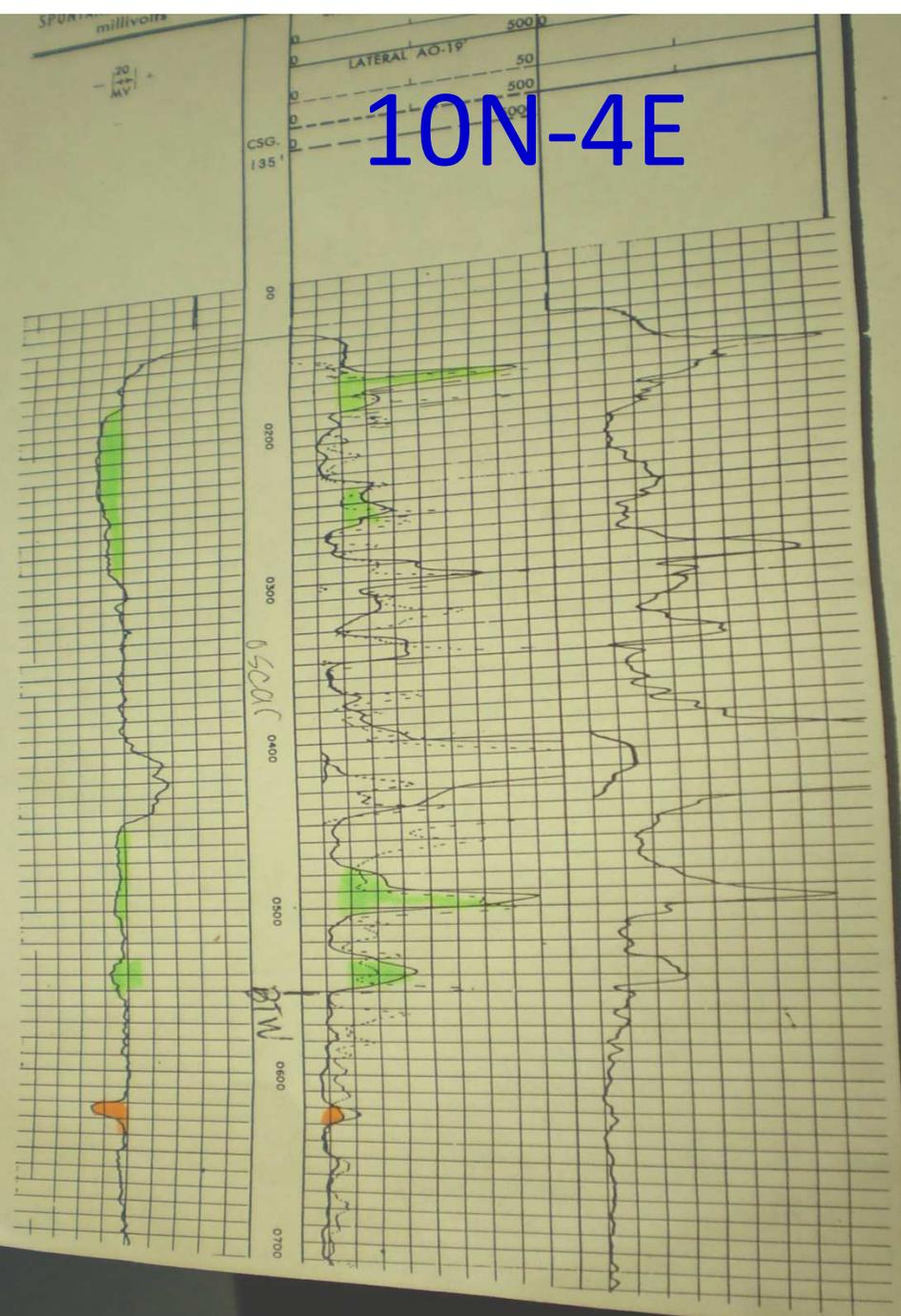
Well Log Information

- Or, if a RWD wants to drill an additional water well in a new area – perhaps their reservoir is running dry or the water table is dropping in existing wells - we may be able to tell them whether or not there are good sand zones there, and how deep, to plan a new water well.

Example: Pottawatomie-Seminole Co, 10N-4E verses 10N-5E

- In Township 10N-5E in Pottawatomie Co., just east of Shawnee, the base of fresh/treatable water is 550 feet deep.
- There are two 50-100' thick freshwater sandstone aquifers. Unfortunately, there is also some pollution in parts of the aquifer, and water demand is growing.

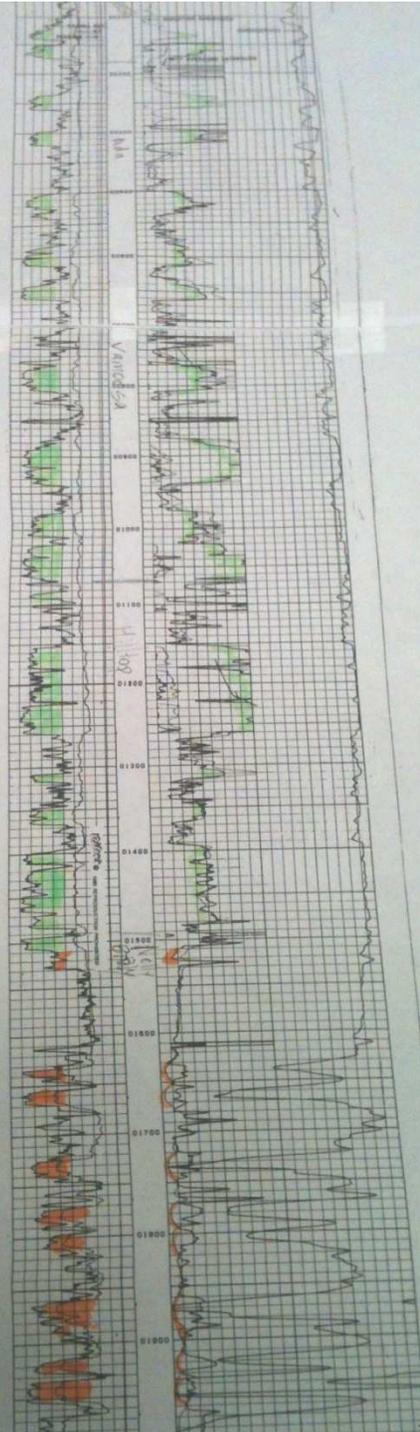
10N-4E

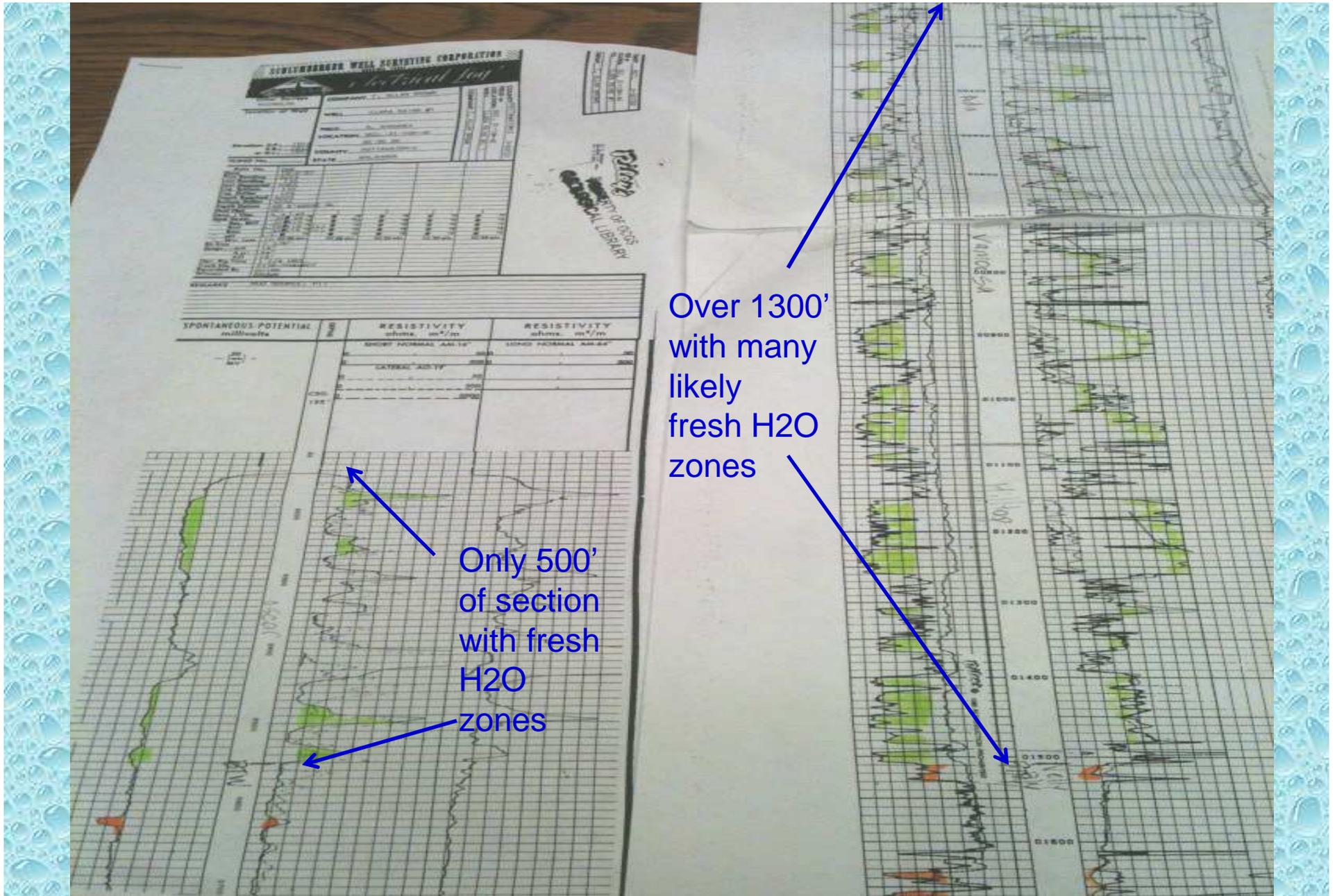


Example: Pottawatomie-Seminole Co, 10N-4E verses 10N-5E

- Yet only 5 miles to the east, in Township 10N-5E, the base of fresh/treatable water is around 1300 feet deep.
- There are five (5) potential 50-100' thick freshwater zones, and seven (7) others not as good or thick.

10N-5E





Two Example Wells (5 miles apart)

Maps Of Oil & Gas Fields

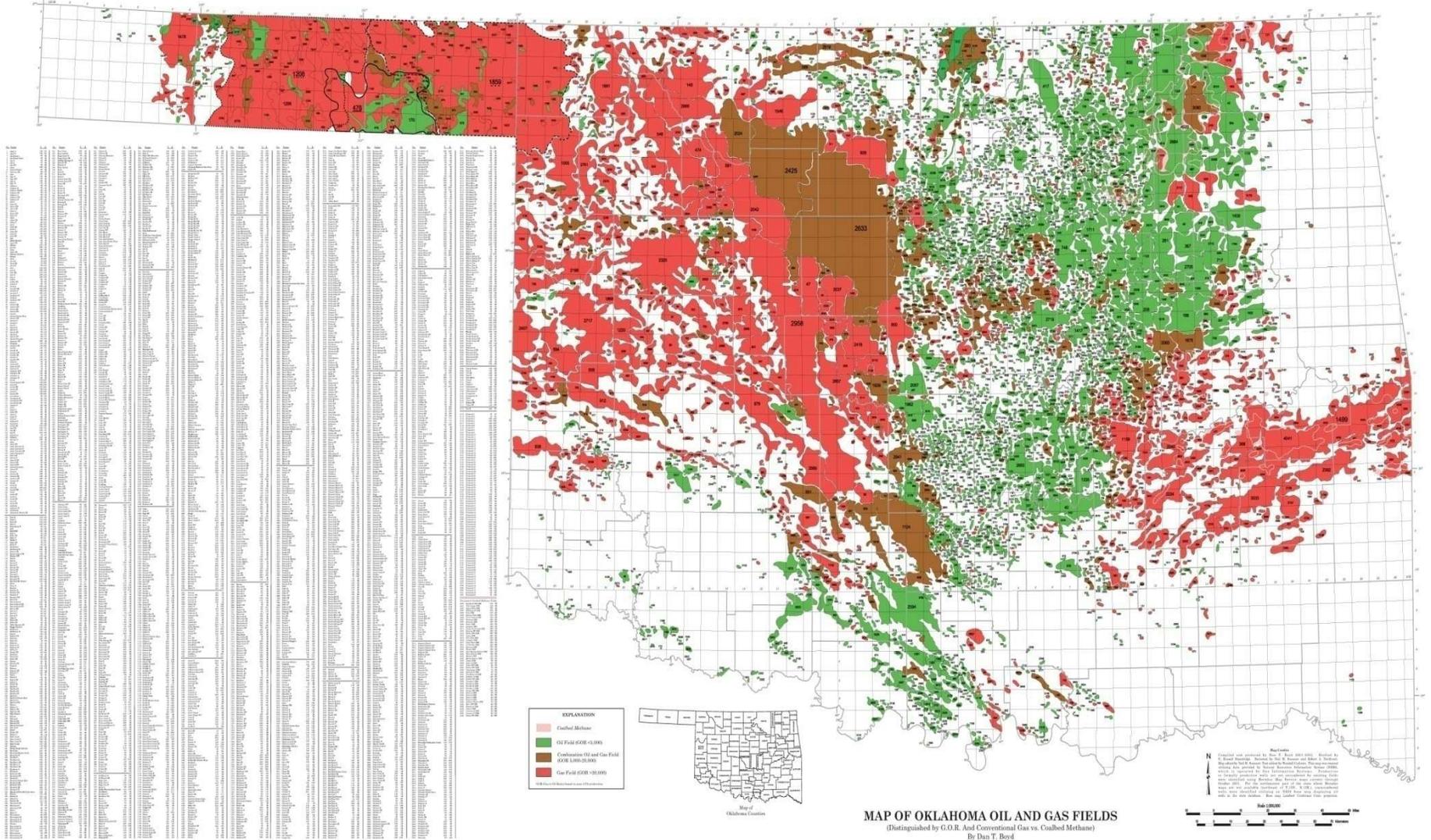
Old Fields Pose Higher Pollution Risk

- Oklahoma has had Oil Production for >100 years
- Old oilfields had spills, without required cleanup;
- Modern oilfield regulation, with better trained Field Inspectors etc., started in the 1980s;
- Corp Comm did not require Mechanical Integrity Testing of wells/casing until relatively recently – many old well casings & lines could have leaked;
- By today's standards, pre-1980 wells often poorly plugged – and could be conduits up to aquifers

Historic Oil & Gas Fields Affect >60% of OK Townships



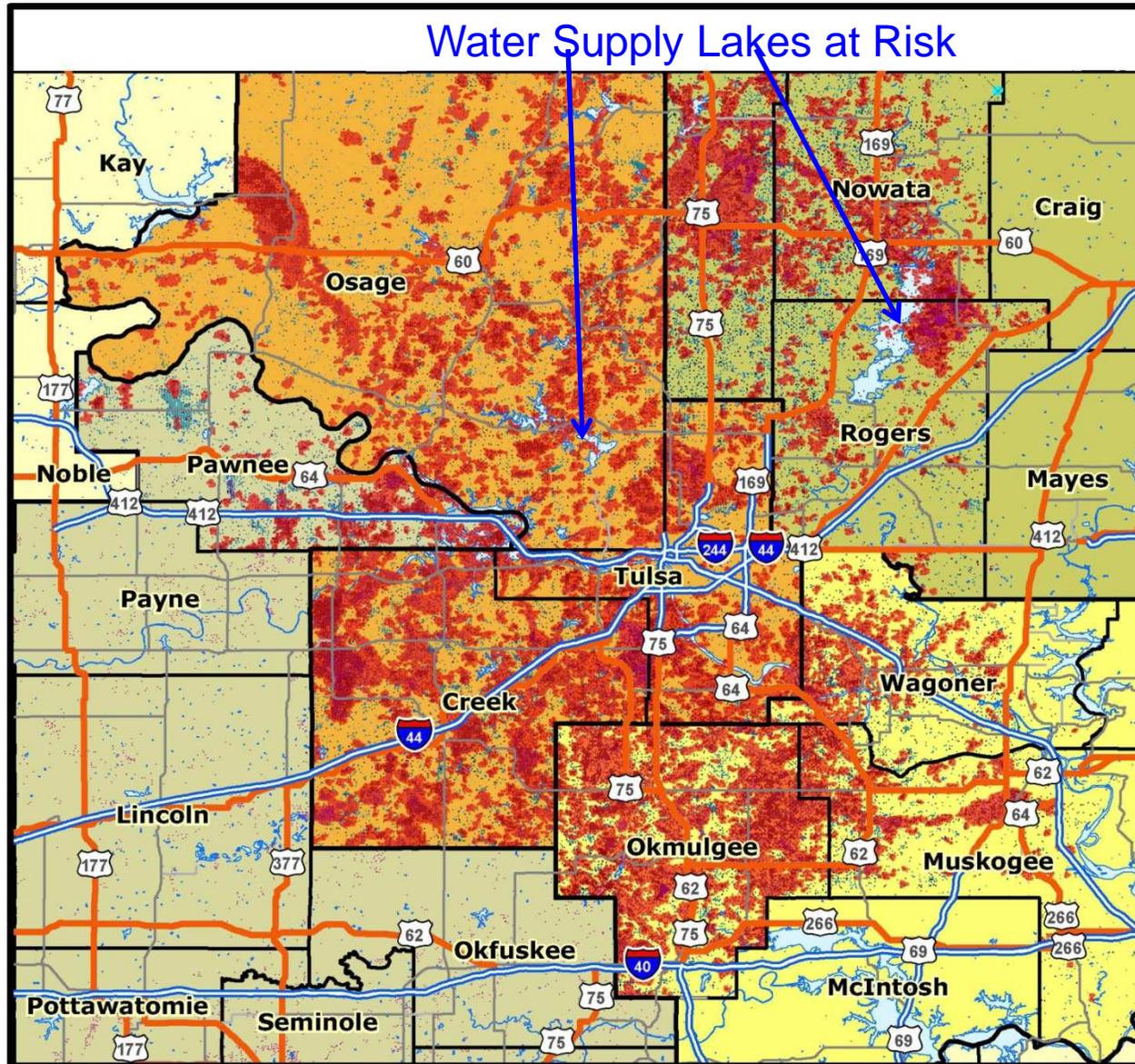
MAP OF OKLAHOMA OIL AND GAS FIELDS
 Distinguished by G.O.R. And Conventional Gas vs. Coalbed Methane
 By Dan T. Boyd
 2002



Maps of Old Oilfields

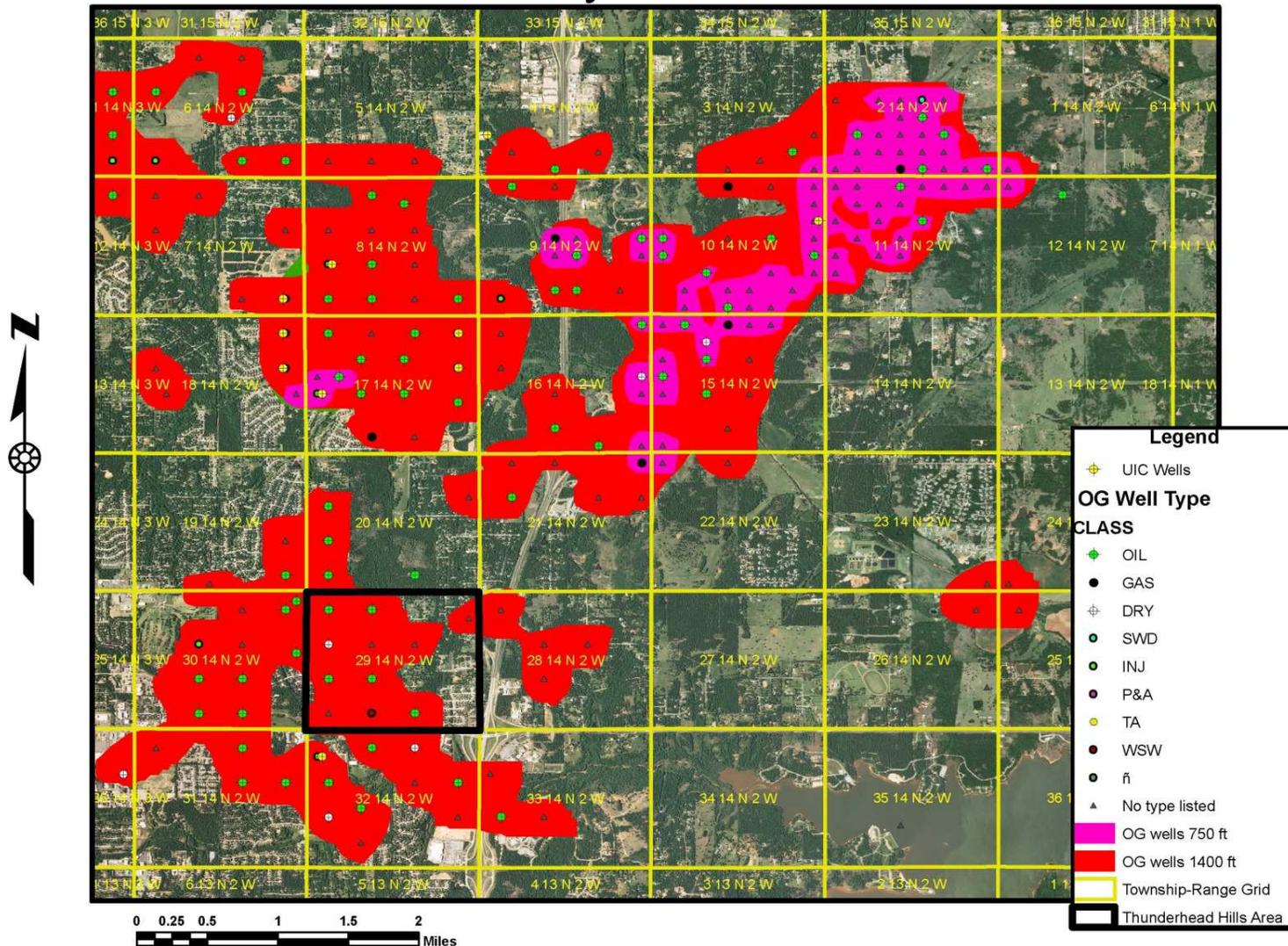
Dense OG Fields and All UIC Wells

This is
NE OK,
INCOG
area



Former Oilfield Area Where There Was Groundwater Pollution

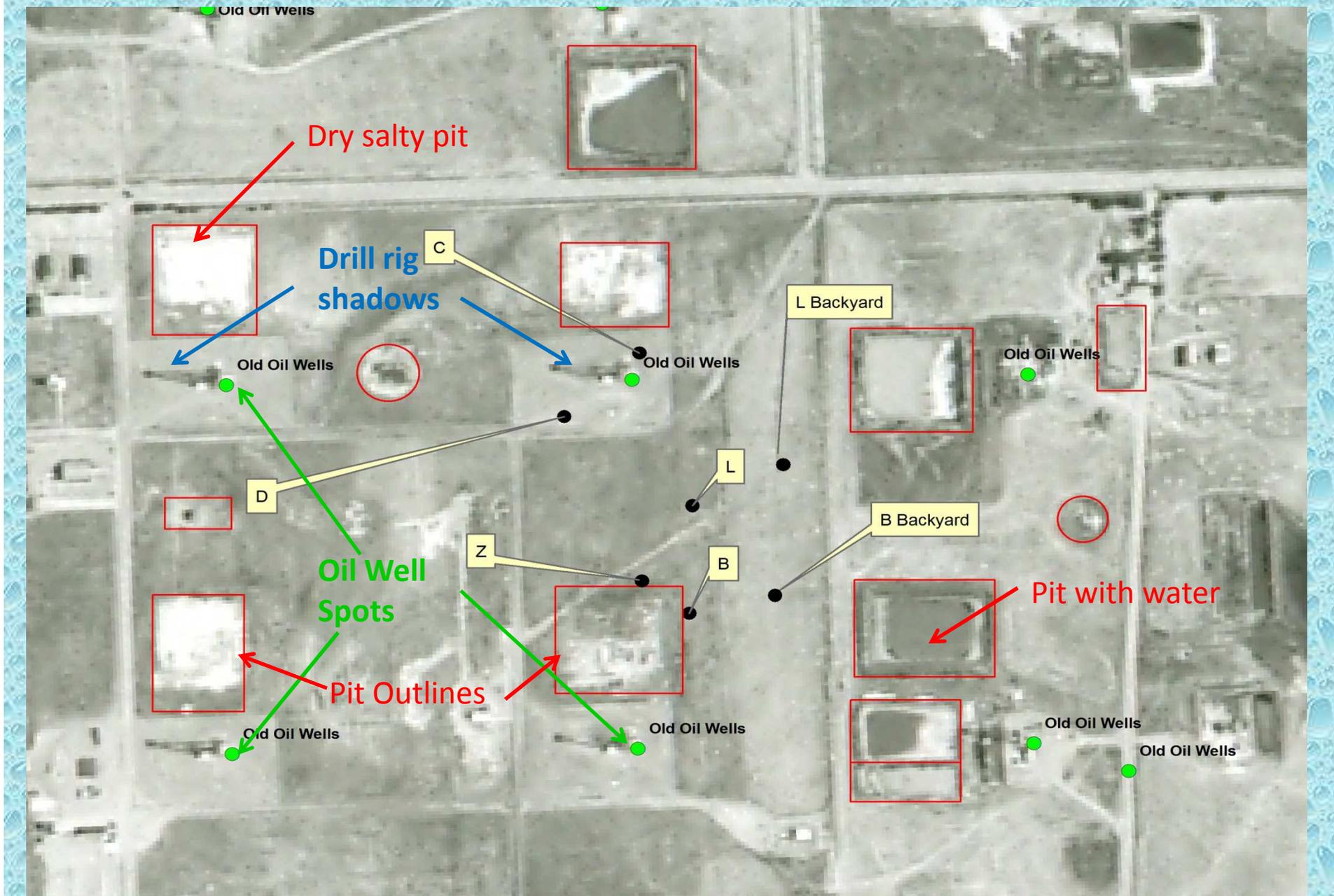
Oklahoma County 14N 2W Oilfield Wells



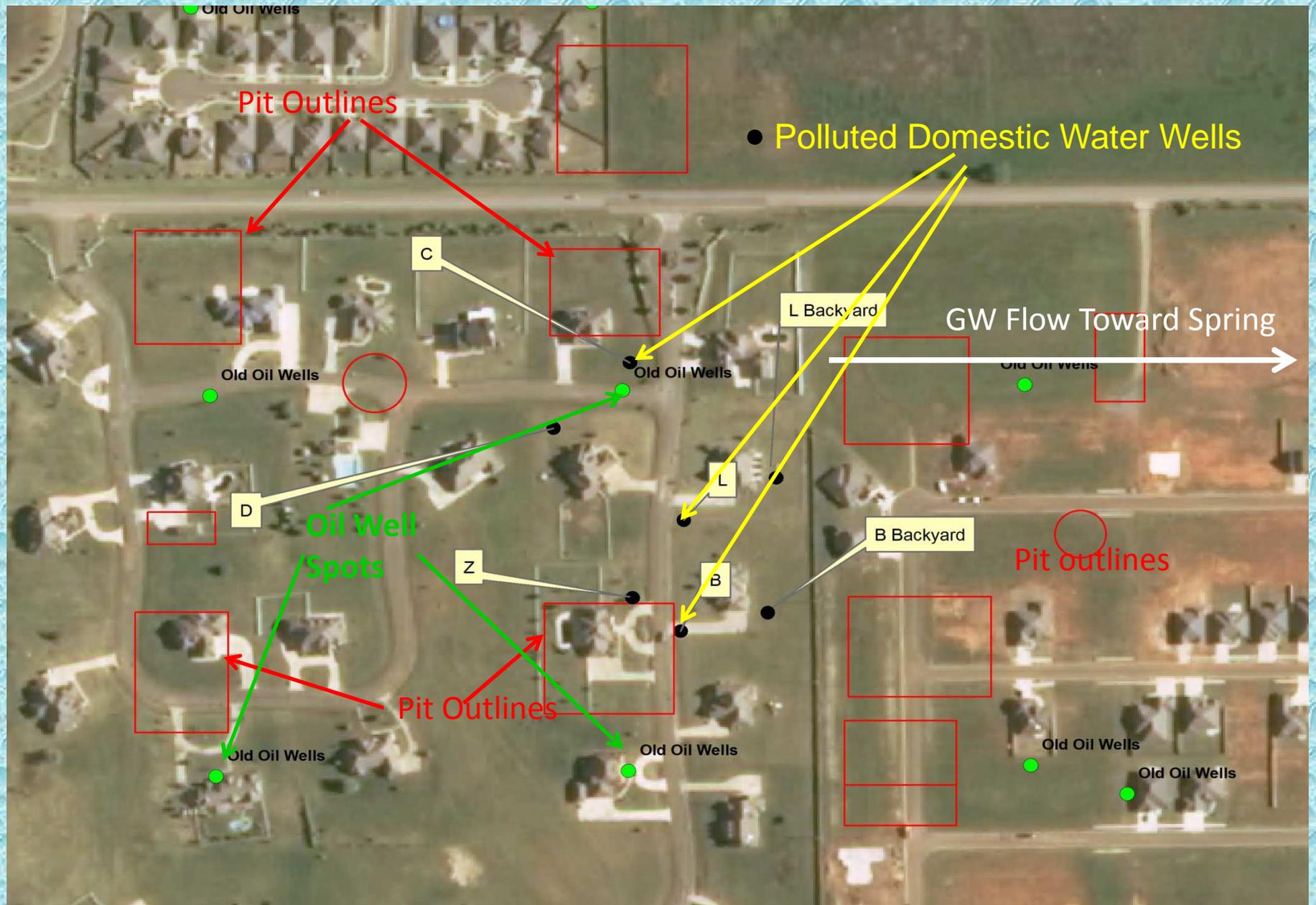
Old Aerial Photos Are Also Useful!

- Corp Comm is collecting aerial photos from 1937-present across the state
- We have scanned them, and are geo-referencing them for input into our GIS mapping software.

1941 Aerial Showing Drill Rigs, Pits



Old Pits & Wells, Modern Air Photo

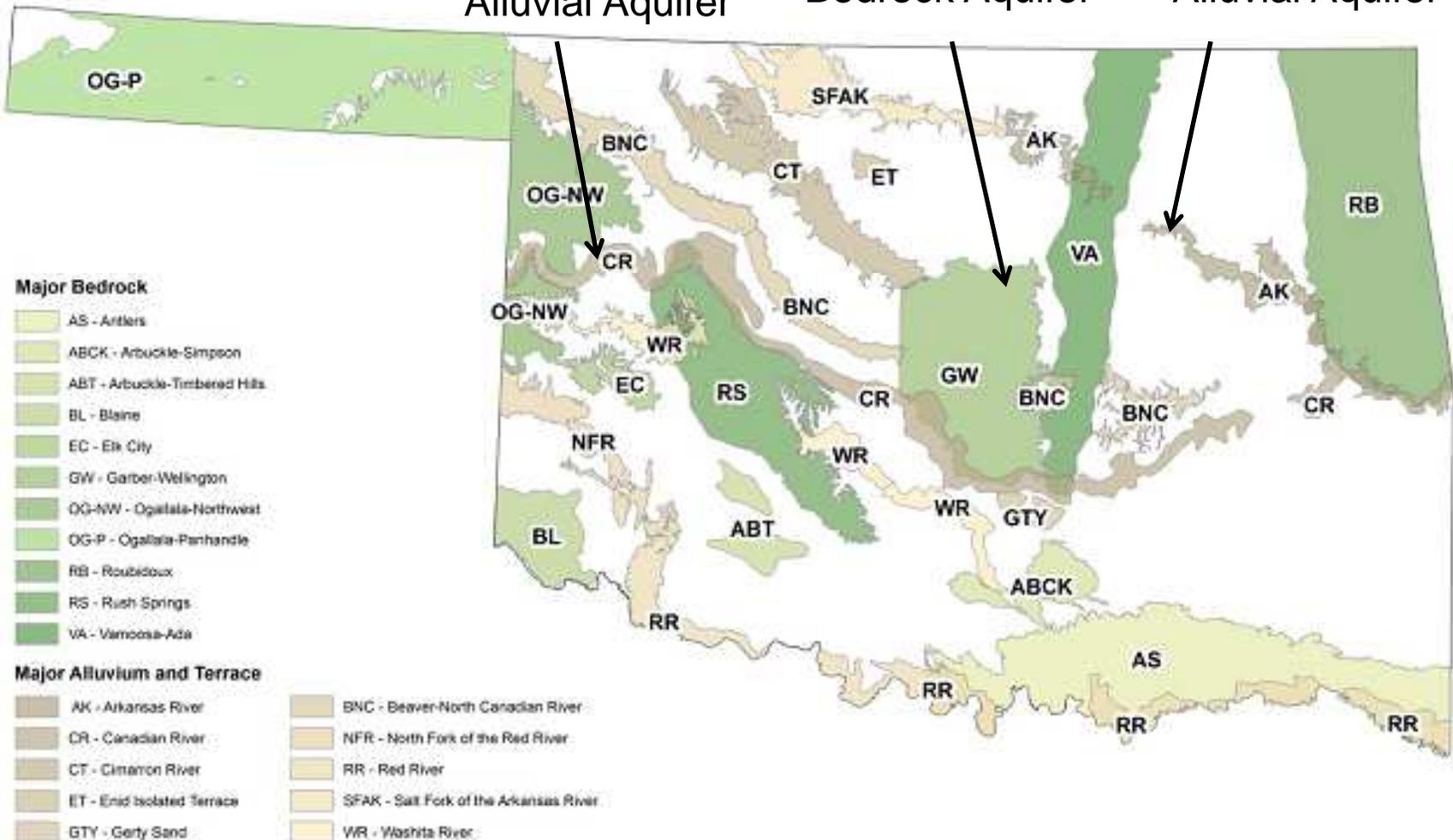


Also Check Aquifer, Water Well Data

Example #3,
Alluvial Aquifer

Example #2,
Bedrock Aquifer

Example #1,
Alluvial Aquifer



Example # 1 – Creek County

- A rural water district wanted to drill water wells into the river alluvium – blue outline
- Area had Old oil fields (Red and Black outlines) – but little evidence of this is visible today
- Many of these oil wells were not plugged to today's standards (e.g. mud plugged); a few have no plugging of record.
- Aerial Photos showed significant salt/brine scarring 1940s, 1960s.

Typical Good Alluvium Water Well

Well ID: 13128

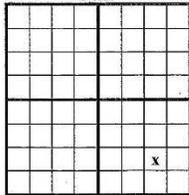
Page 1 of 2



MULTI-PURPOSE WELL COMPLETION & PLUGGING REPORT

Oklahoma Water Resources Board
3800 North Classen Boulevard
Oklahoma City, OK 73118
Telephone (405) 530-8800

Legal Location
North



One Mile
Each square is 10-acres

WELL ID NUMBER: 13128

Quarters NW-SE-SE Section 04 Township 19N Range 10E1

Latitude 36.151036 Longitude -96.247046

Date collected (latitude and longitude), if different from date the well was drilled:
01/08/1998

Method latitude and longitude was collected: Interpolation from PLSS

County Tulsa

Variance Request No. (if applicable) n/a

WELL OWNER - NAME AND ADDRESS

Well Owner Keystone Powerhouse, Corps of
Address/City/State Rt 1 Box 100 Sand Springs OK
Finding Location _____
Well Name _____

Phone (918) 865-2919
Zip 74063

Water Rights #: _____

TYPE OF WORK: Groundwater Well

USE OF WELL: Public Water Supply

NEW WELL CONSTRUCTION DATA

Date Well or Boring Was Completed 09/27/1985
Number of wells or borings represented by this log 1
* (Borings are within the same 10 acre-tract and with the same general depths and lithologies)
Hole Diameter 11 inches to a depth of 65 ft.

CASING INFORMATION *Note: If surface casing is used please indicate that on the appropriate well casing information line.

Surface Pipe Material: _____ Surface Pipe Diameter _____ inches Surface Pipe From _____ ft to _____ ft
1) Well Casing Material PVC Casing Diameter 5 inches Casing From _____ ft to 65 ft

SCREEN OR PERFORATION INFORMATION

Type of Screen: PVC Type of Slots or Openings: Other From 40 ft to 45 ft.
Type of Screen: PVC Type of Slots or Openings: Other From 57 ft to 62 ft.

Well ID: 13128

Page 2 of 2

FILTER PACK INFORMATION

Filter Pack Material: _____

WELL SEAL INFORMATION

Type of Surface Seal Cement Grout

Type of Annular Seal n/a

Filter Pack Seal Material n/a

Surface Seal Interval: From n/a ft to 10 ft

Annular Seal Interval: From n/a ft to n/a ft

Filter Pack Seal Interval: From n/a ft to n/a ft

TYPE OF COMPLETION: _____

HYDROLOGIC INFORMATION

Depth to water at time of drilling _____ ft

Estimated yield of well 30 gpm

First water zone 40 ft

LITHOLOGY DESCRIPTION

MATERIAL	ENCOUNTERED		SATURATED
	FROM (ft.)	TO (ft.)	
Top soil	0	1	N
Sandy clay	1	5	N
Cement	5	6	N
Sandy clay	6	20	N
Fine sand	20	30	N
Coarse sand	30	38	N
Gravel coarse	28	43	N
Gravel bed	43	45	Y
Limestone	45	50	N
Sand rock	50	52	N
Gray shale	52	65	N

SD &
Gravel
30-45'
30 GPM

WELL LOCATION TO POTENTIAL SOURCES OF POLLUTION

Has this well been disinfected after completion of work? n/a

Are there any potential sources of pollution or wastewater lagoons within 300 ft. of the well? n/a

Distance of Well is n/a from possible source. Type of possible source: n/a

PLUGGING INFORMATION

Date Well or Boring Was Plugged n/a

Total Depth of well being plugged _____ ft.

Was the well contaminated or was it plugged as though it was contaminated? n/a

If the well or boring was plugged as if it was contaminated, was the casing removed or perforated? n/a

Was the grout tremied? n/a

Backfilled with n/a

Backfilled from _____ ft. to _____ ft.

Grouted with n/a

Grouted from _____ ft. to _____ ft.

Grouted with Cement

Grouted from _____ ft. to _____ ft.

Firm Name KNOTT

D/PC No. _____

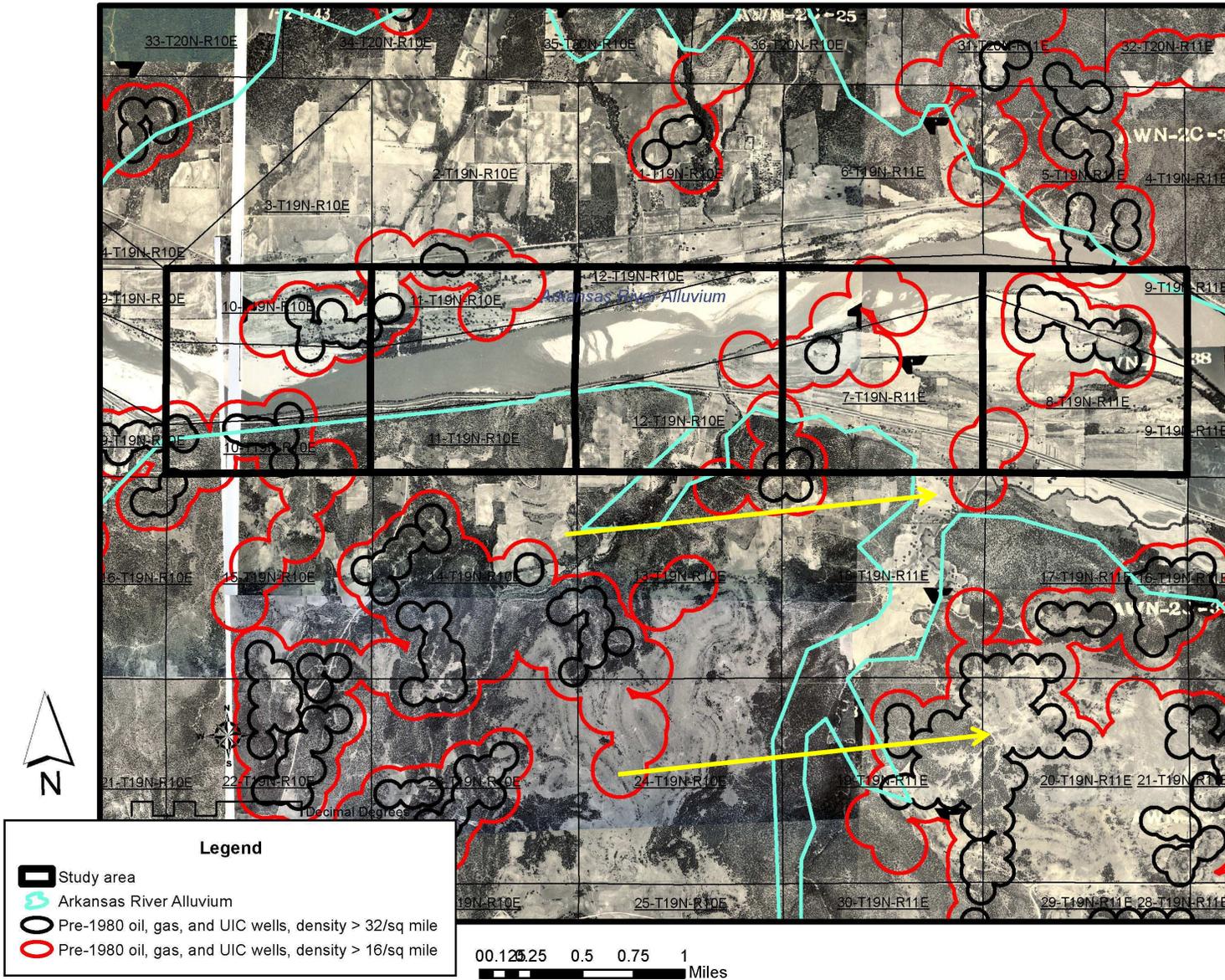
Operator Name _____

OP No. _____

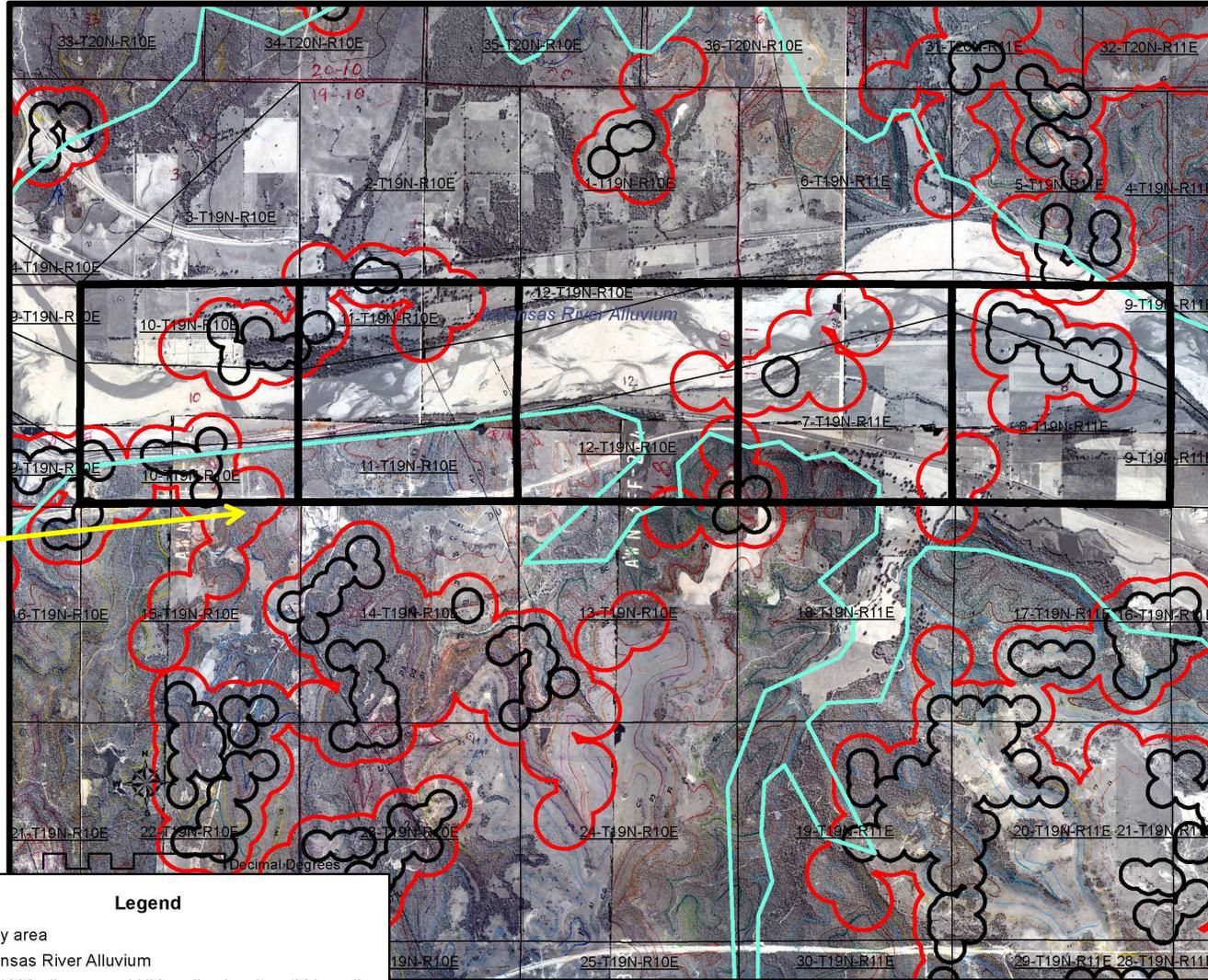
Date n/a

Comments: n/a

Creek Co RWD 1 Water Well Assistance - 1943 Aerial



Creek Co RWD 1 Water Well Assistance - 1964 Aerial

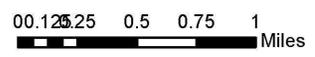


2011
Domestic
Well
Crude &
H2O mix



Legend

- Study area
- Arkansas River Alluvium
- Pre-1980 oil, gas, and UIC wells, density > 32/sq mile
- Pre-1980 oil, gas, and UIC wells, density > 16/sq mile



Conclusion:

We encouraged the RWD to look elsewhere.

They found another block of acreage where they could get water rights a few miles to the southwest that looked much better.

Example #2 – Lincoln Co

- RWD (that also served a town) had preliminary agreements for water rights on two different acreage blocks
- Asked us for recommendations

BTW Map, Water Wells, Oilfields, Logs

Lincoln County



Depth to Base of Fresh Water
Sections: 33 and 34 in T17N-R4E

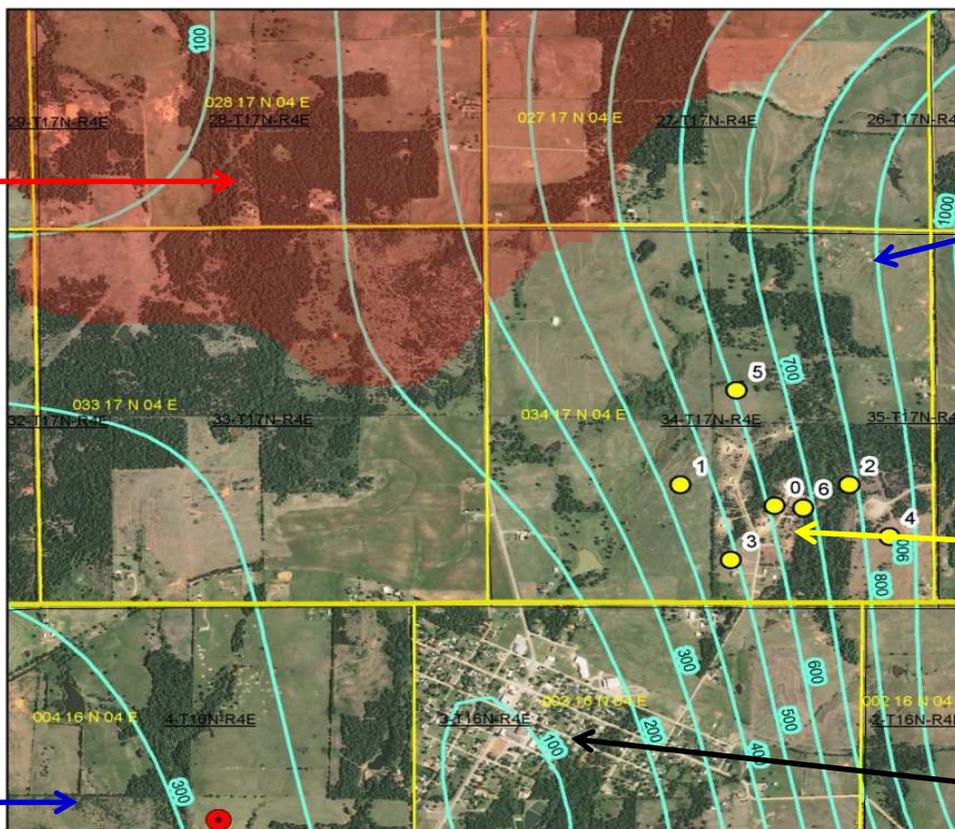
Red area is old oilfield, skip or drill with special precautions

More than 800' down to salt water @ Arrow; possible new well location

More than 300' down to salt water, and nearest old E&P well (RED DOT) shows sands

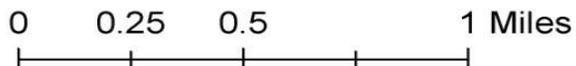
Existing Water wells where BTW > 300'

Less than 100' to saline water; no water wells



Legend

- Available Electric Log Data for Fresh Water
- Historic_dense_oilfields
- Water Wells (data below)



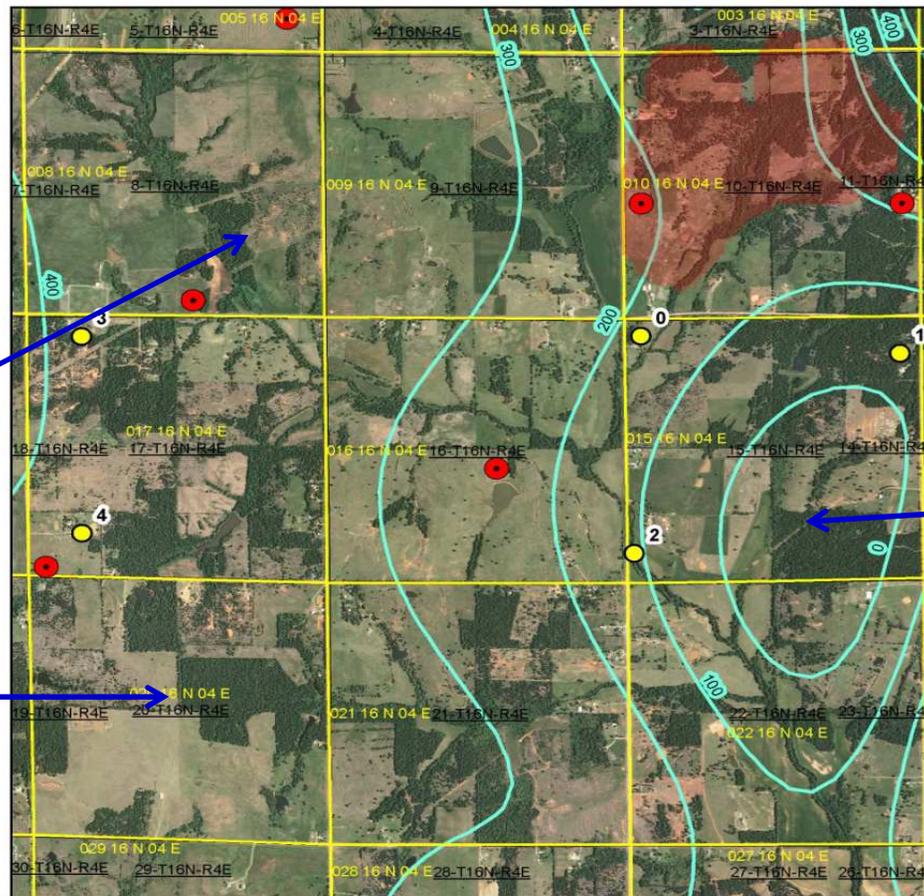
FID	Shape *	Well_ID	Qtrs	SEC_TWP_R	LATITUDE	LONGITUDE	Use	TD_ft_	Static_WL	Est_Yld	First_Zone
0	Point	93233	SENE	34-17N-04E	35.90235	-96.862383	Domestic	100	33	12	57
1	Point	91871	SENE	34-17N-04E	35.90317	-96.866121	Domestic	80	15	25	15
2	Point	113019	SWNE	34-17N-04E	35.90317	-96.859428	Commercial	140	40	10	40
3	Point	136796	SWS	34-17N-04E	35.900283	-96.864133	Domestic	100	65	15	65
4	Point	136806	NESE	34-17N-04E	35.901167	-96.857833	Domestic	130	112	20	112
5	Point	108448	SWS	34-17N-04E	35.906784	-96.86389	Commercial	140	40	10	40
6	Point	120496	SENE	34-17N-04E	35.902283	-96.86125	Domestic	130	109	12	110

BTW Map, Water Wells, Oilfields, Logs

Lincoln County



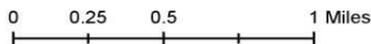
Depth to Base of Fresh Water
Sections: 15,16, and 17 in T16N-R4E



Red area is old oilfield, skip or drill with special precautions

Less than 50' to saline water; no water wells

More than 300' down to salt water, and old E&P wells (RED DOTs) show sands – possible water well locations



Legend

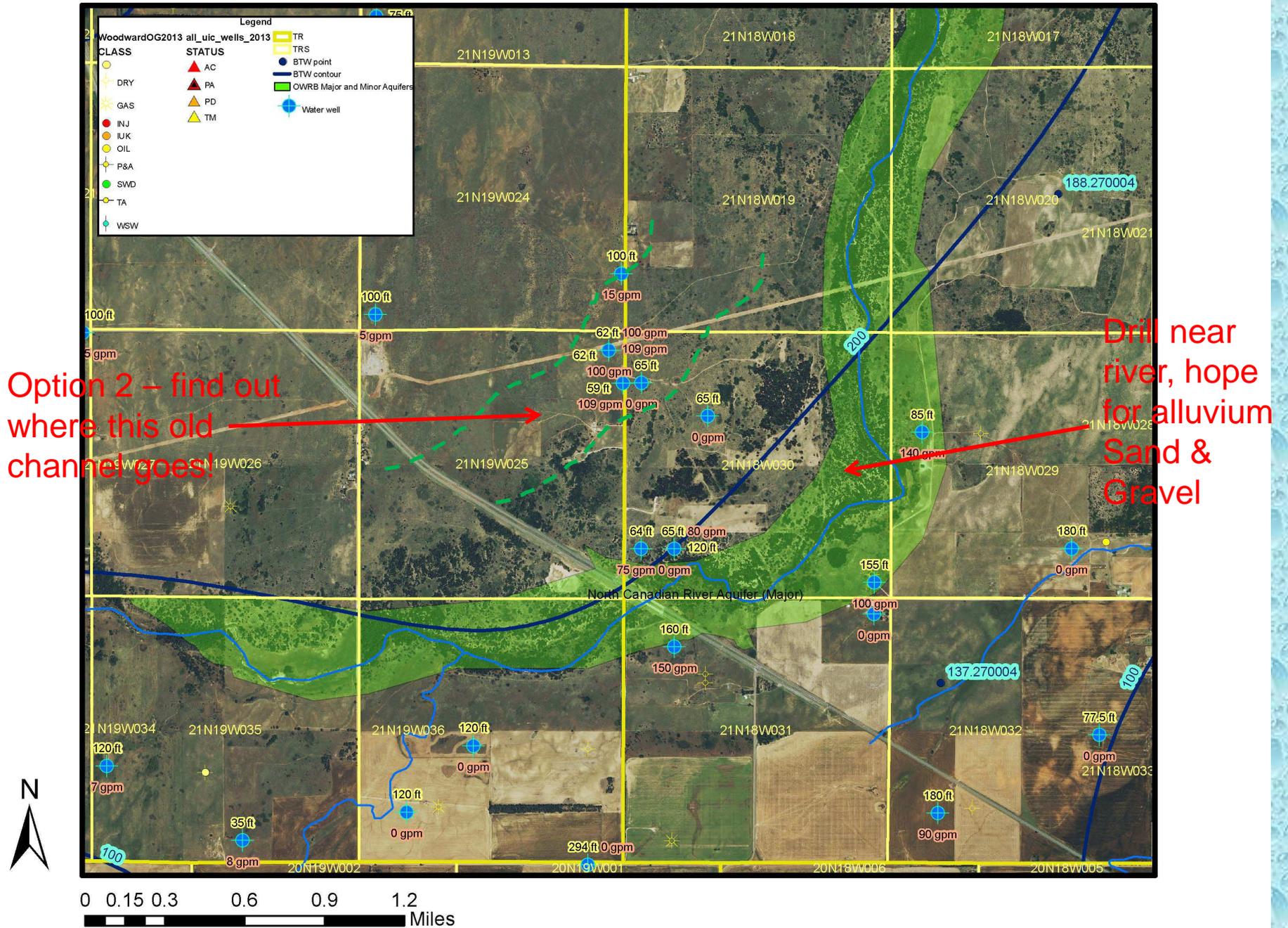
- Available Electric Log Data for Fresh Water
- Historic_dense_oilfields
- Water Wells (data below)

FID	Shape *	Well_ID	Qtrs	SEC.TWP.R	LATITUDE	LONGITUDE	Date_Const	Use	TD_ft	Static_WL	Est_Yld
0	Point	29823	NWN	15-16N-04E	35.868379	-96.875646	7/23/1993	Domestic	80	n/a	12
1	Point	94201	SENE	15-16N-04E	35.867417	-96.8603	4/4/2005	Domestic	192	79	6
2	Point	112925	SWS	15-16N-04E	35.856433	-96.876083	8/30/2007	Domestic	200	64	25
3	Point	31849	NENW	17-16N-04E	35.868432	-96.908787	2/8/1995	Domestic	110	n/a	15
4	Point	23160	NESW	17-16N-04E	35.857589	-96.908787	8/3/1989	Domestic	180	n/a	12

Example 3

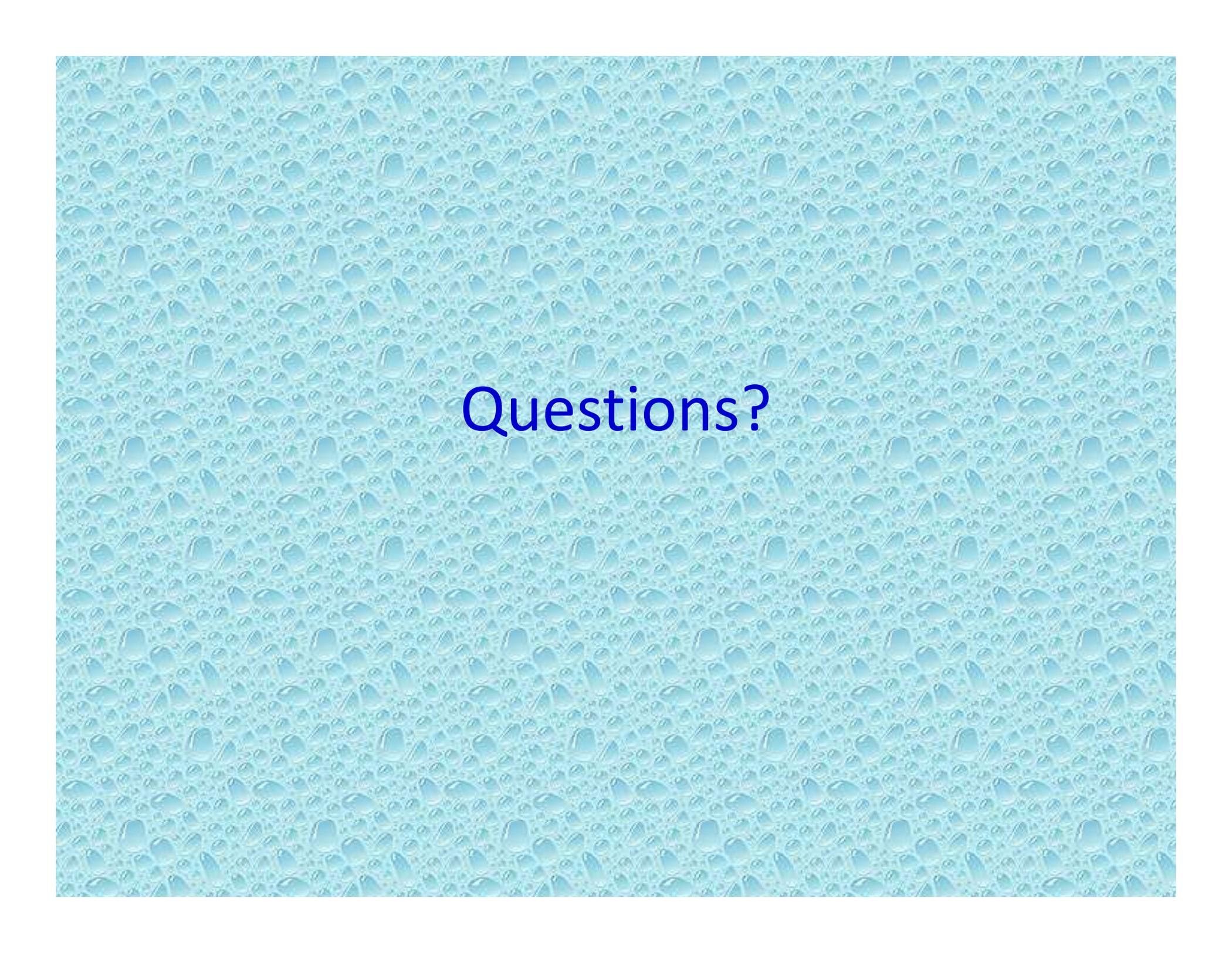
- Mutual RWD, Dewey County
- Asked us to look at 2 sections where they thought they could get water rights. We looked at a 12 section block to get an idea of the area

Mutual, OK - Water Well Assistance



What We Found

- Good wells in the alluvium near the stream channel hit sand and gravel, 100-150 GPM.
- There was also a cluster of wells WEST of the channel in sand and gravel just like it – making ~100 GPM - probably an old, abandoned channel. Wells in between had no good sand/gravel, poor.
- Suggested they get some geophysics (e.g. resistivity), see where this channel went, drill there.



Questions?