HUNTING BIG BRINE

How the Oklahoma Corporation Commission is Using Historical Aerial Photographs to Protect Oklahoma Waters

The 21st International Petroleum Environmental Conference
Westchase Marriott Hotel
October 14-16, 2014
Houston, Texas

Madeline Dillner
Oil & Gas Specialist: Brownfields GIS
Oklahoma Corporation Commission

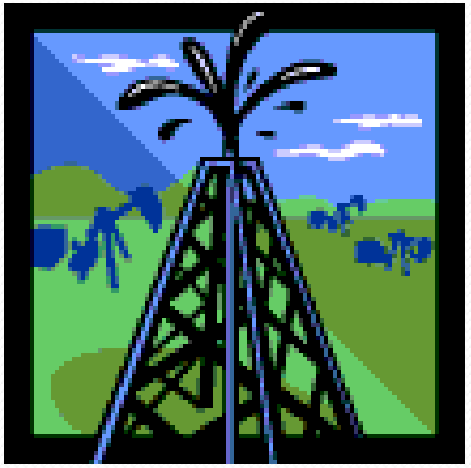
EMPOWERING OKLAHOMA
Oklahoma Corporation Commission
ENERGY • TRANSPORTATION • UTILITIES

What do you think of when you hear

"Oklahoma?"


HUGH JACKMAN
Oklahoma!


SOONERS




THUNDER
OKC

What do you think of when you hear

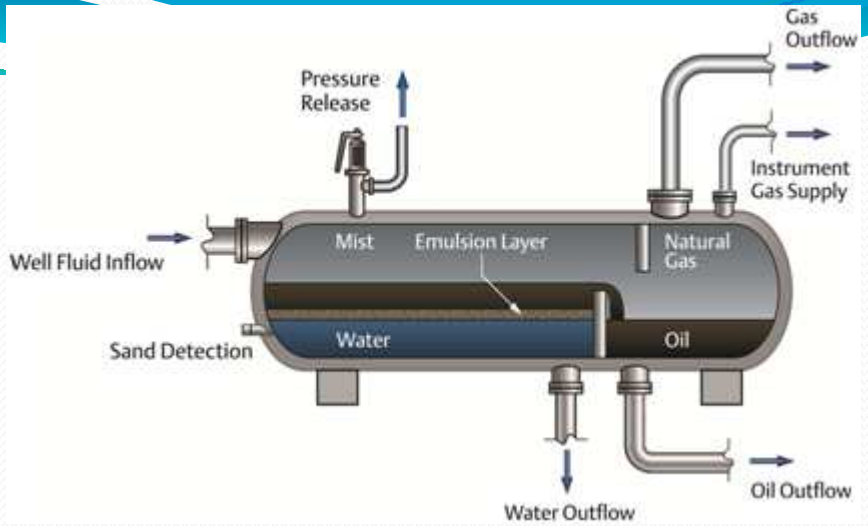
"oilfield pollution?"

Of course…

https://www.ok.gov/okhistory/store/item_images/316/196593.jpg

A 160-acre patch of land in a historical aerial photograph showing what the results of a leaking oil pipeline look like.

But also…



http://www.daveshowalter.com/images/large/Fracking-waste-ponds-aerial.jpg

http://cdn.emersonprocessxperts.com/wp-content/uploads/2014/02/Horizontal-oil-gas-separator.png

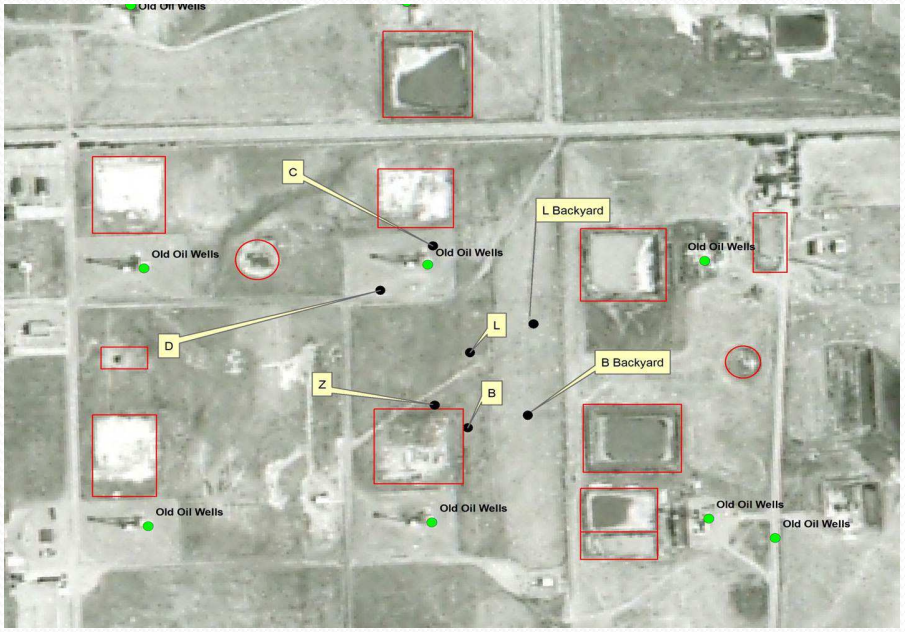
BRINE

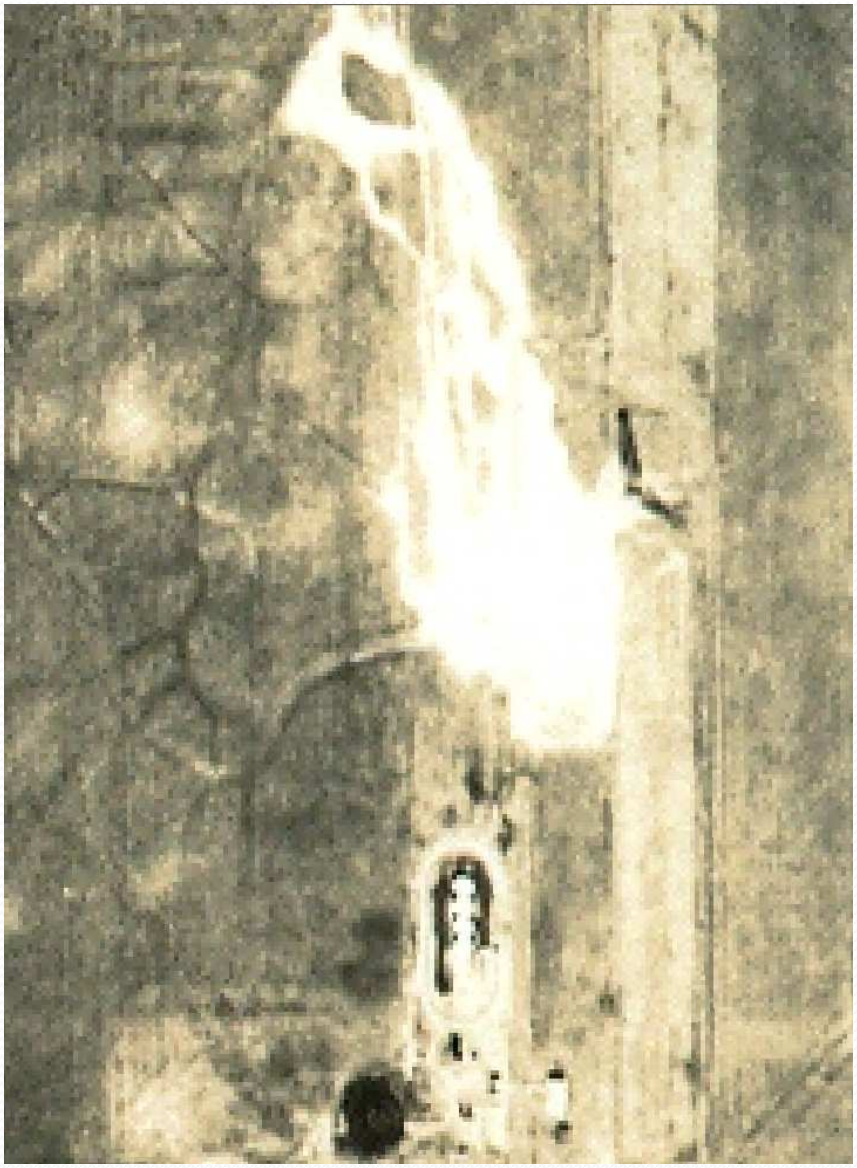
http://www.sepprosystems.com/Images/53x10x1440[1].jpg

Produced Water

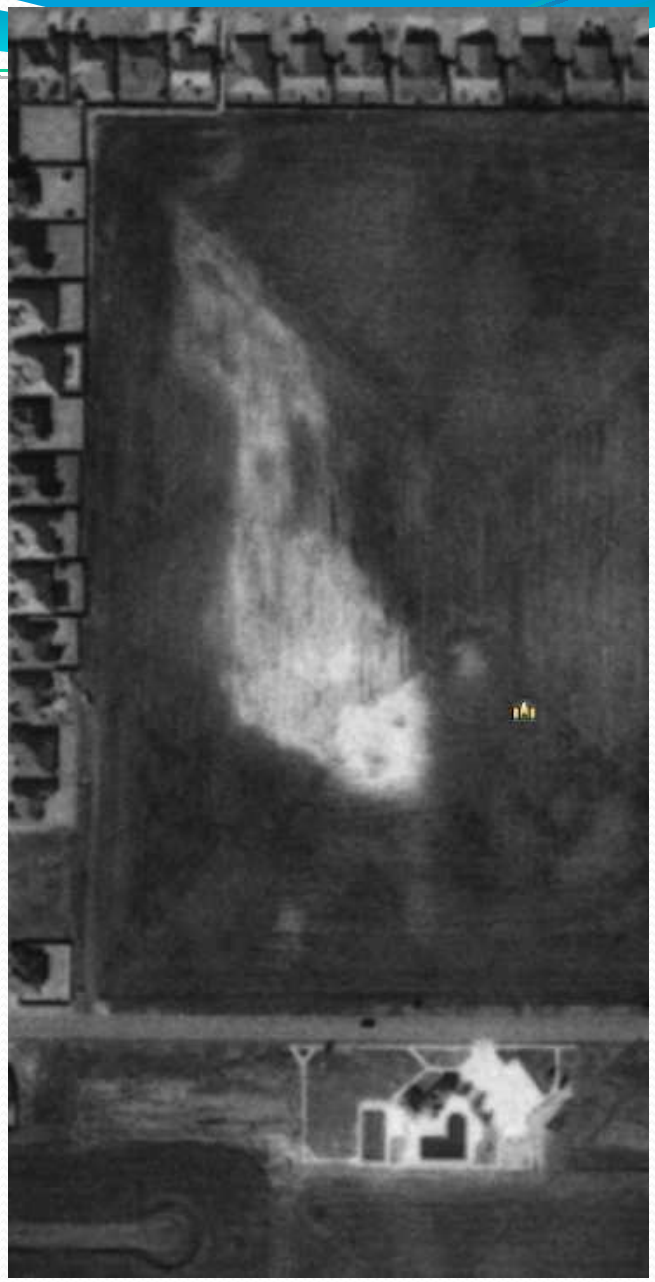
Today we collect it and inject it back into formations.

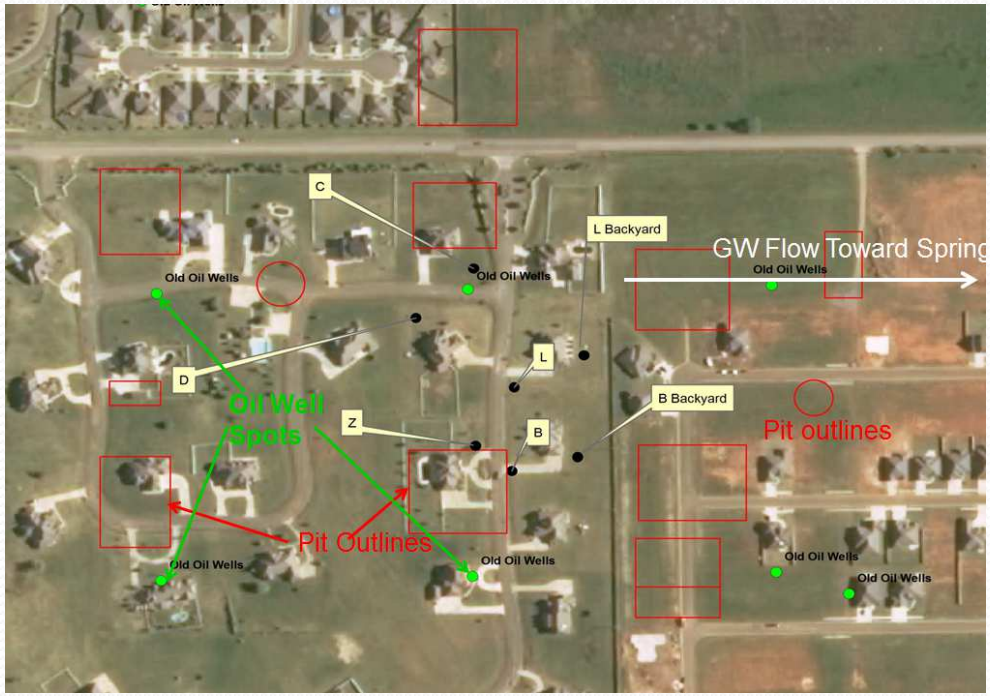
Historically, it was left to evaporate in unlined pits, or allowed to spill all over the surrounding area.





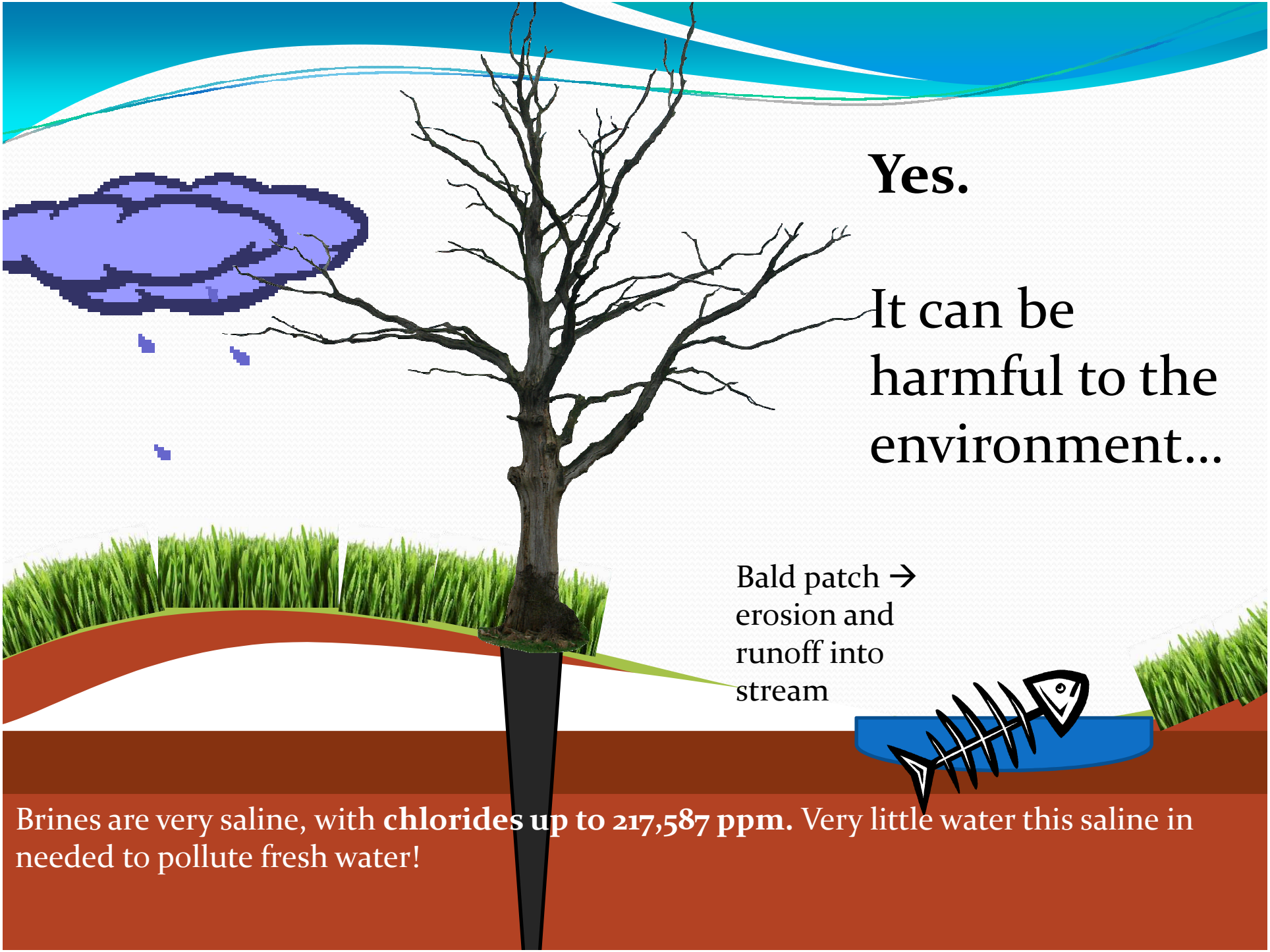
Still a Problem Today





Do we really need to be worried about

salt?


Yes.
It can be harmful to the environment…
Bald patch → erosion and runoff into stream
Brines are very saline, with **chlorides up to 217,587 ppm.** Very little water this saline in needed to pollute fresh water!

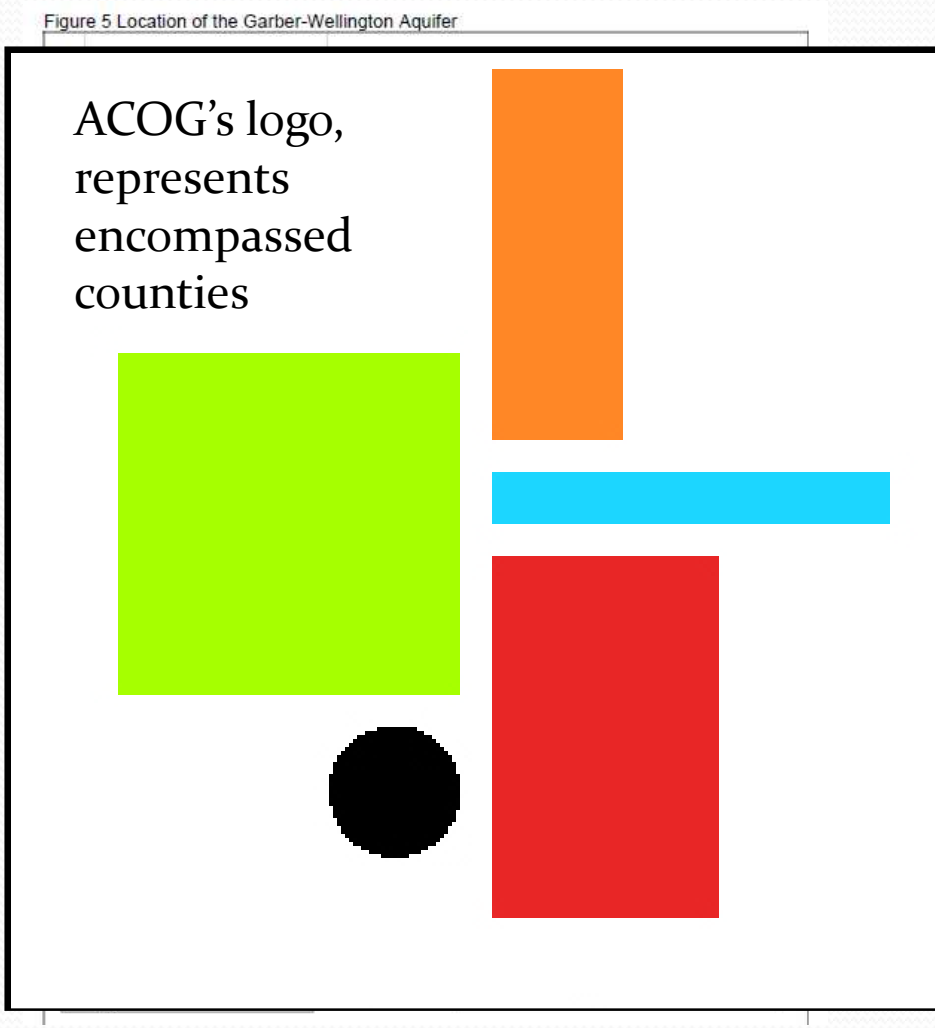
...and to humans.

What Does This Have to do with Protecting Groundwater?

Protecting existing water supplies is always important, but takes center stage when a region has been in a drought for years, like Oklahoma has.

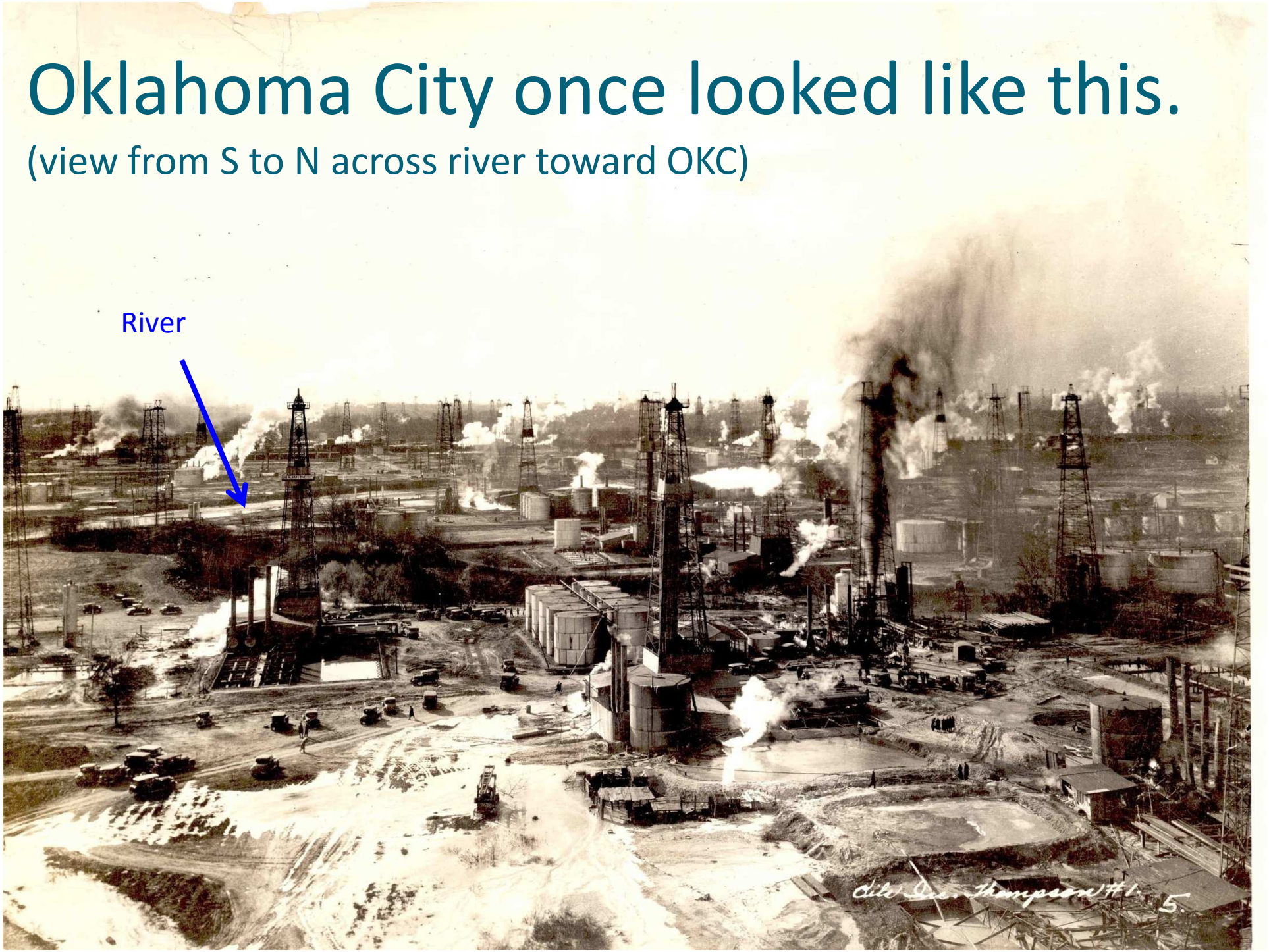
Water users:
The Association of Central Oklahoma Governments (ACOG) is located over the Garber Wellington aquifer, one of Oklahoma's largest aquifers, **and contains two of the three most populous cities in Oklahoma: Norman and Oklahoma City, both of which are growing.**

Water regulators:
The OCC is the government body responsible for regulating the oil and gas industry, which includes preventing and cleaning up soil, surface water, and **groundwater pollution**.



Oklahoma City once looked like this.

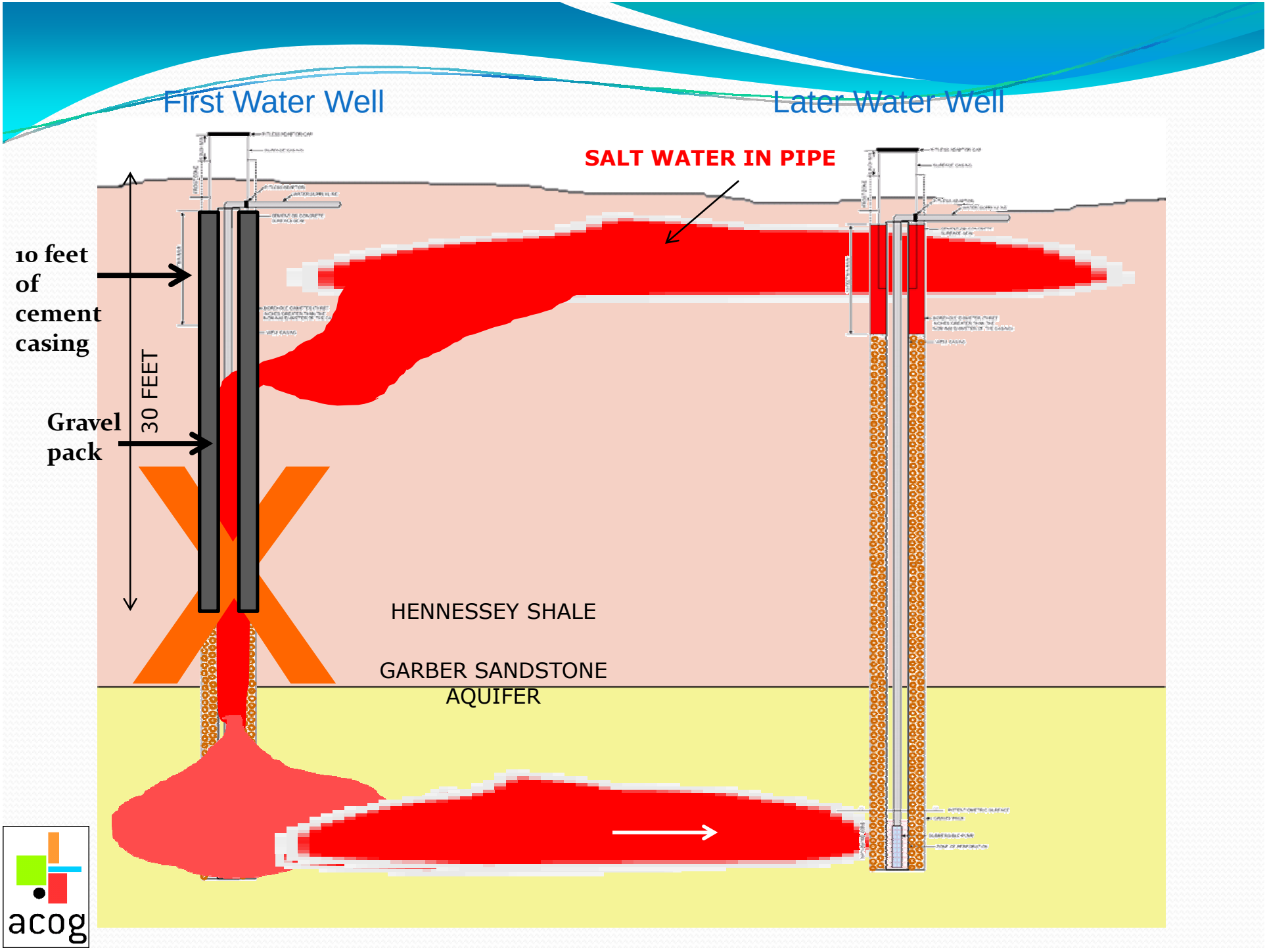
(view from S to N across river toward OKC)



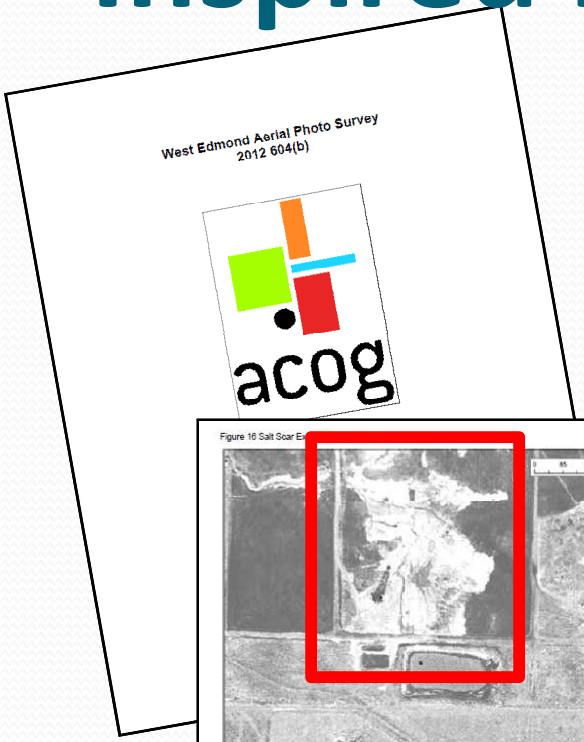
And much of small-town Oklahoma looked like this.

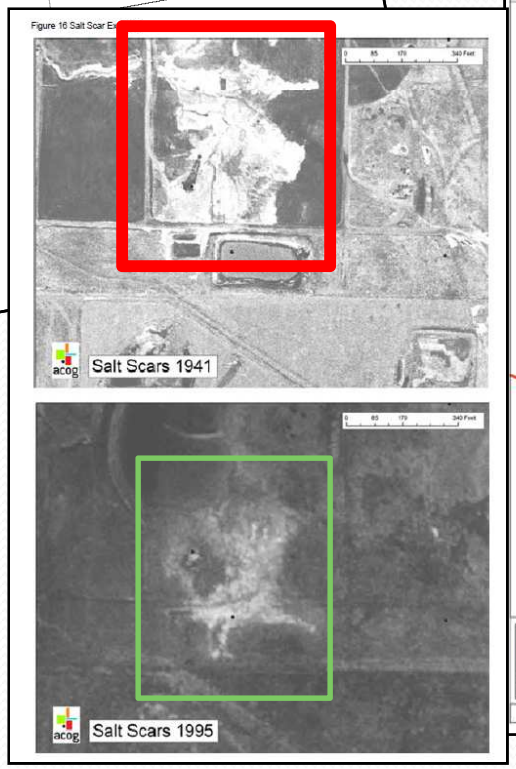
(Tonkawa, 90 years ago)

With that in mind, lets look at how historic oil and gas activity can impact groundwater.

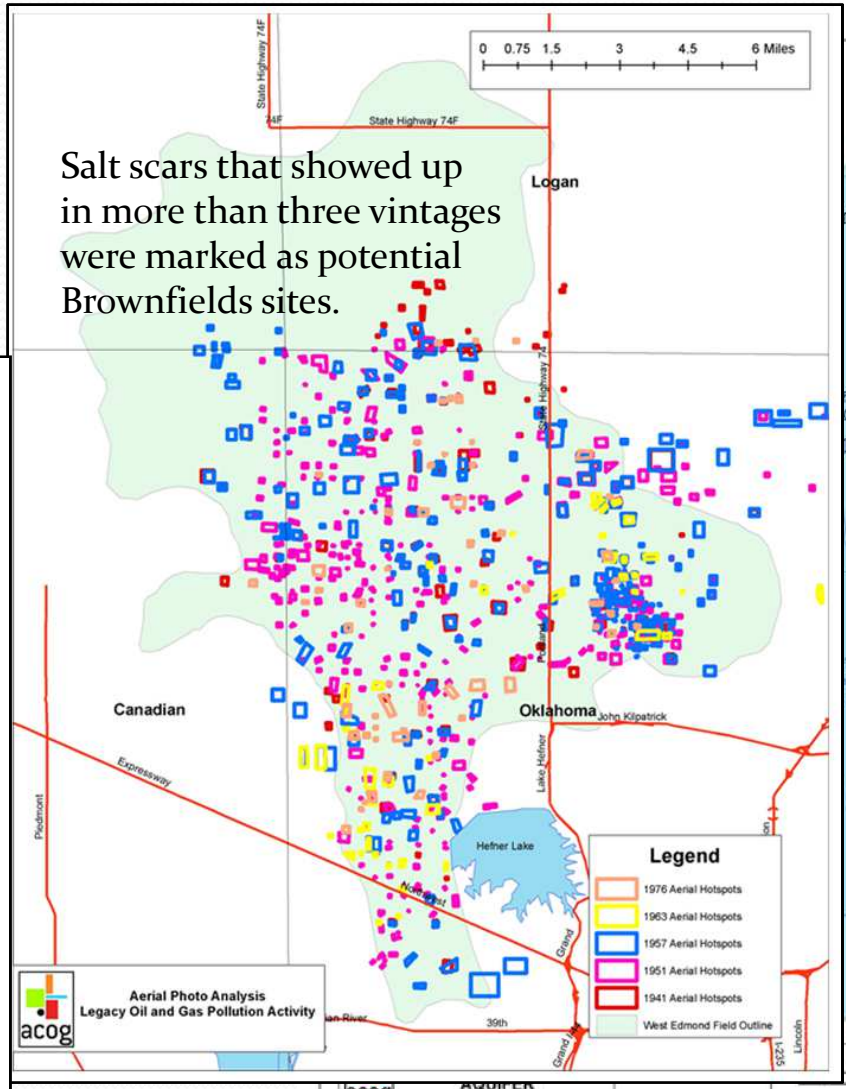

First Water Well
Later Water Well
SALT WATER IN PIPE
10 feet of cement casing
30 FEET
Gravel pack
HENNESSEY SHALE
GARBER SANDSTONE AQUIFER
acog

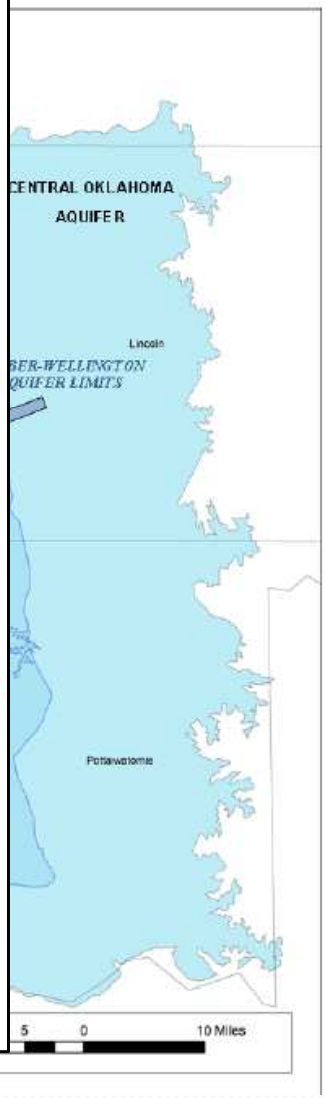
Inspired by ACOG's research…





ACOG identified and outlined salt scars in different vintages of historic aerial photographs



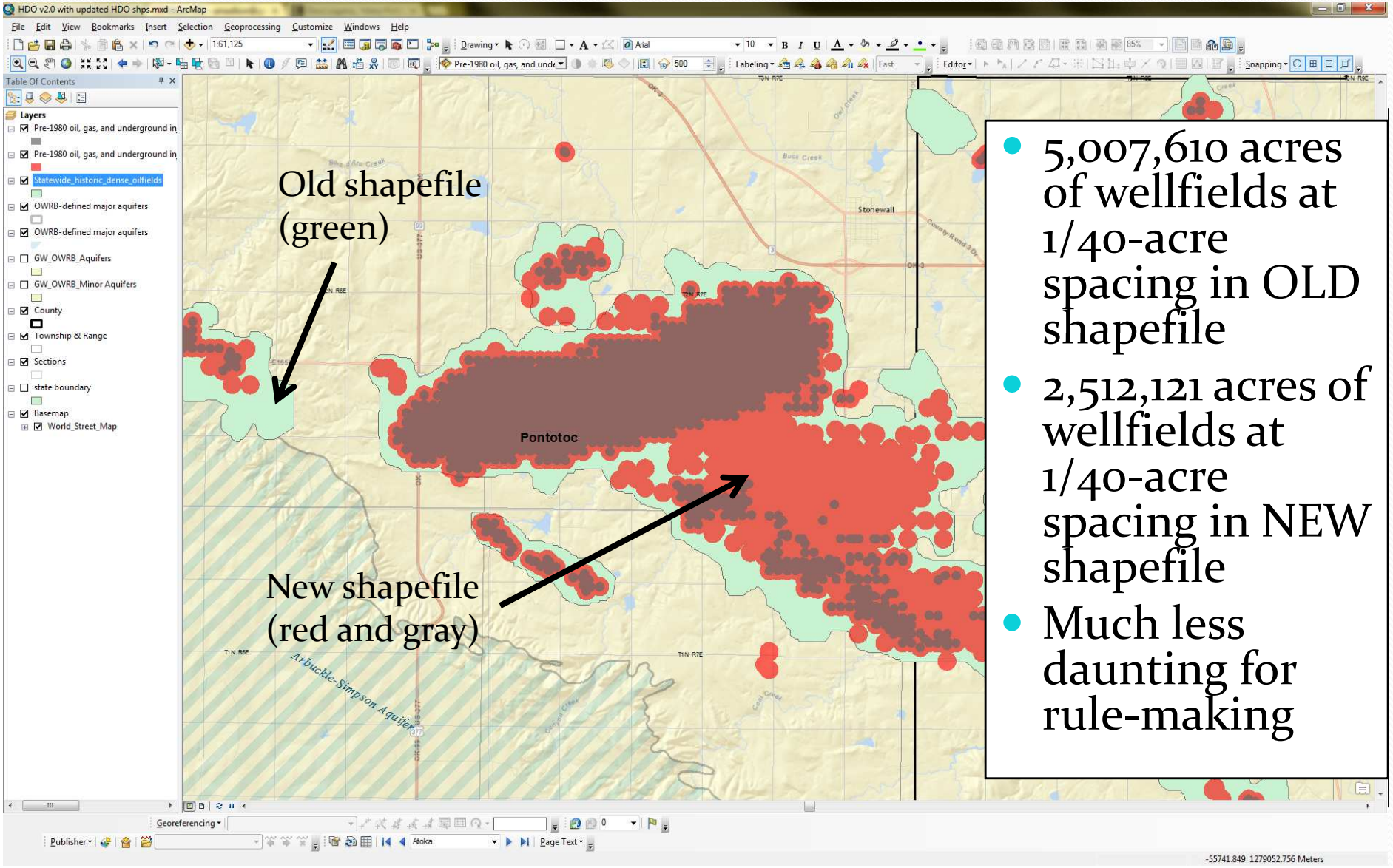


OCC Created Historic Dense Oilfield Maps for New Water Well Casing Rule

- Shortcut! As opposed to georectifying photos for the entire state
- Based on evidence that the most contamination will be found around:
  - **H**istoric
    - Pre-1980
    - OCC's environmental regulations and enforcement power both increased in 1980
  - **D**ense
    - Over 1 well/40 acres
    - Pretty standard density
  - **O**ilfields
    - Oil, gas and injection wells
    - Along with their associated separators, gathering lines, flow lines, tank batteries, reserve pits, etc.

In these areas, we in the Brownfields department recommend that OWRB **require water wells to have deeper cement casing** to block subsurface brine from contaminating the aquifers.

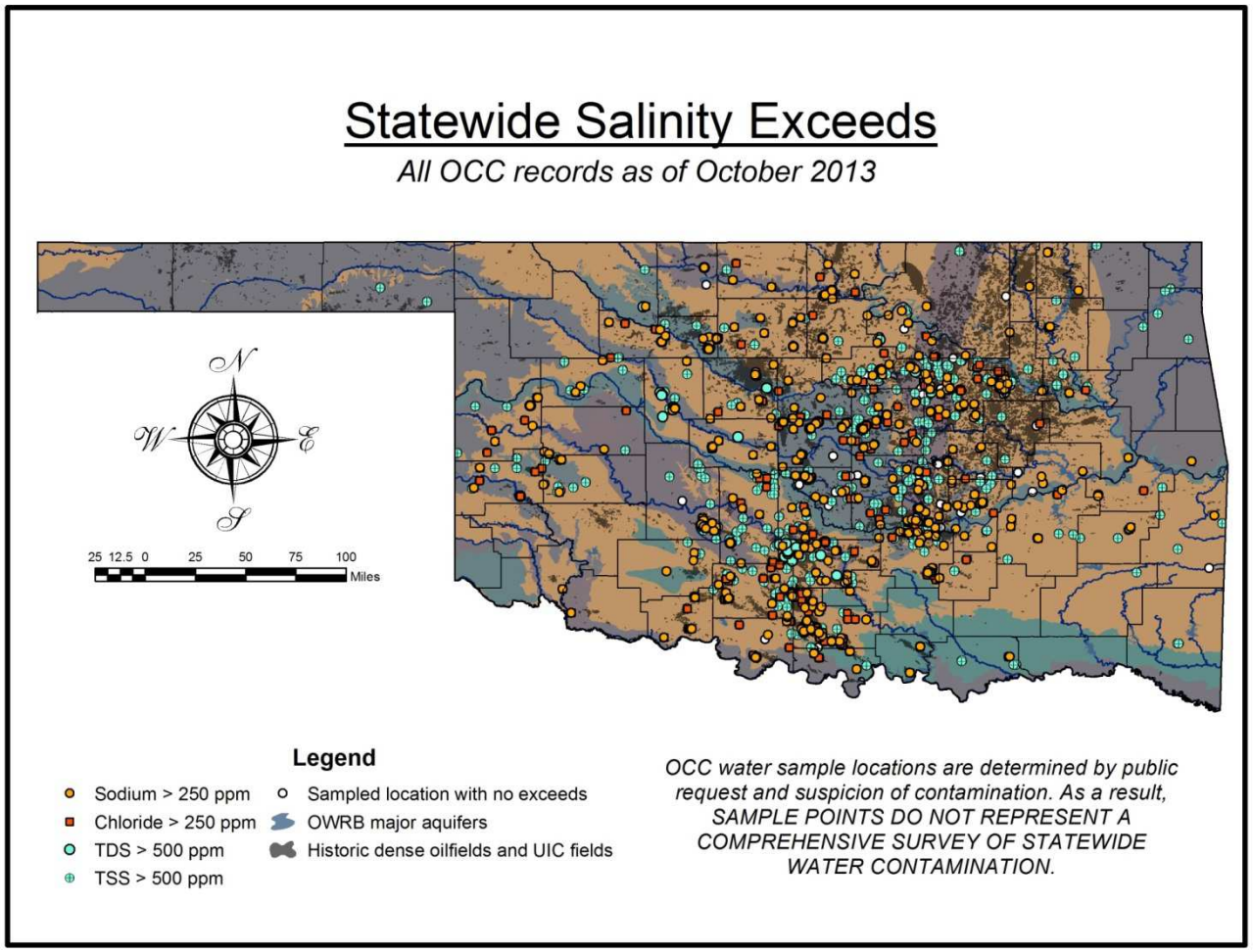
Evolution of HDO Project



- 5,007,610 acres of wellfields at 1/40-acre spacing in OLD shapefile
- 2,512,121 acres of wellfields at 1/40-acre spacing in NEW shapefile
- Much less daunting for rule-making

Examining Data Quality: How Useful are the HDO Maps for Protecting Groundwater?

- **The spatial precision and accuracy of OCC's well data** first came to my attention when I was doing a proximity analysis between points of known groundwater contamination in Oklahoma and our HDO shapefile for IPEC 2013 in San Antonio



Examining Data Quality: Accuracy and Precision

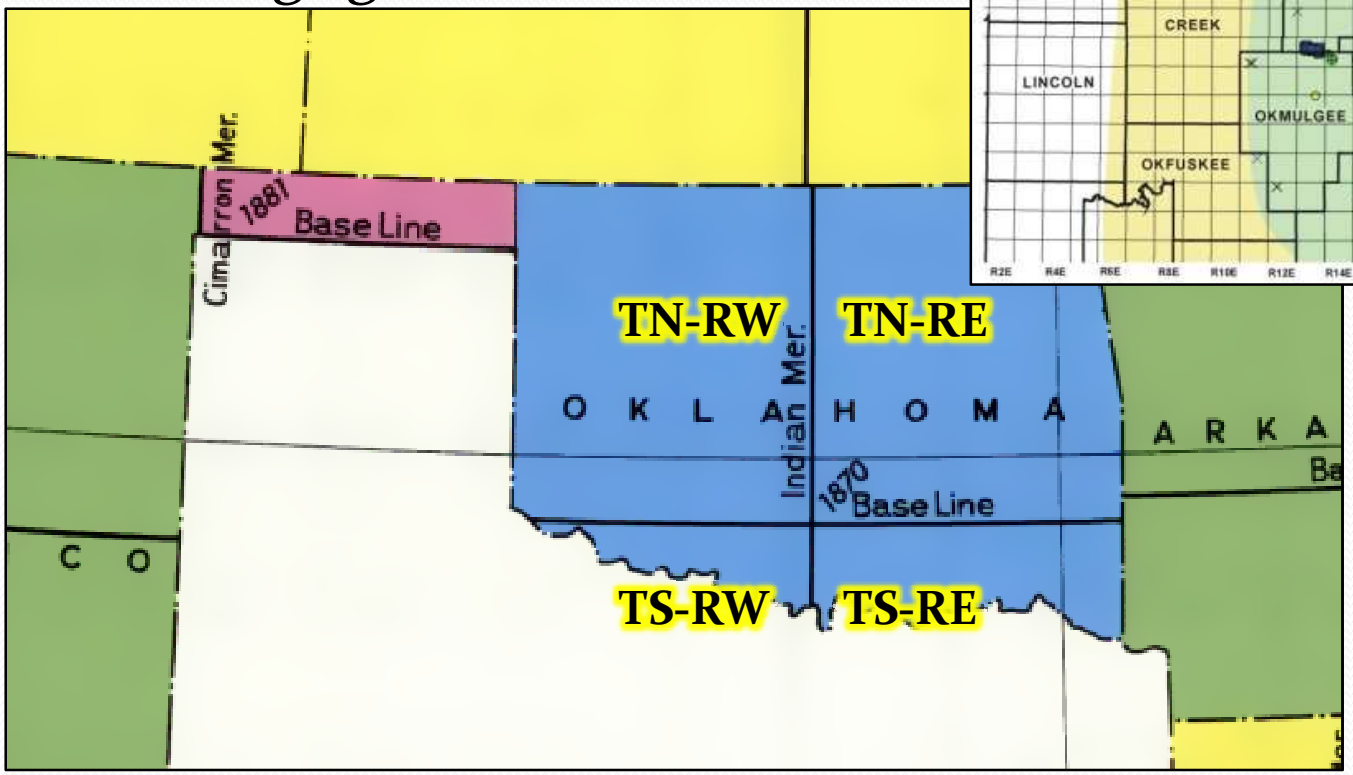
- Wells drilled before 1980 were not GPSed the way they are today; **the technology was not available**
- Locations as legal locations
  - Section
  - Township
  - Range
  - Quarter calls
- GPS locations were calculated as the centroid of the **smallest** unit of spatial location received

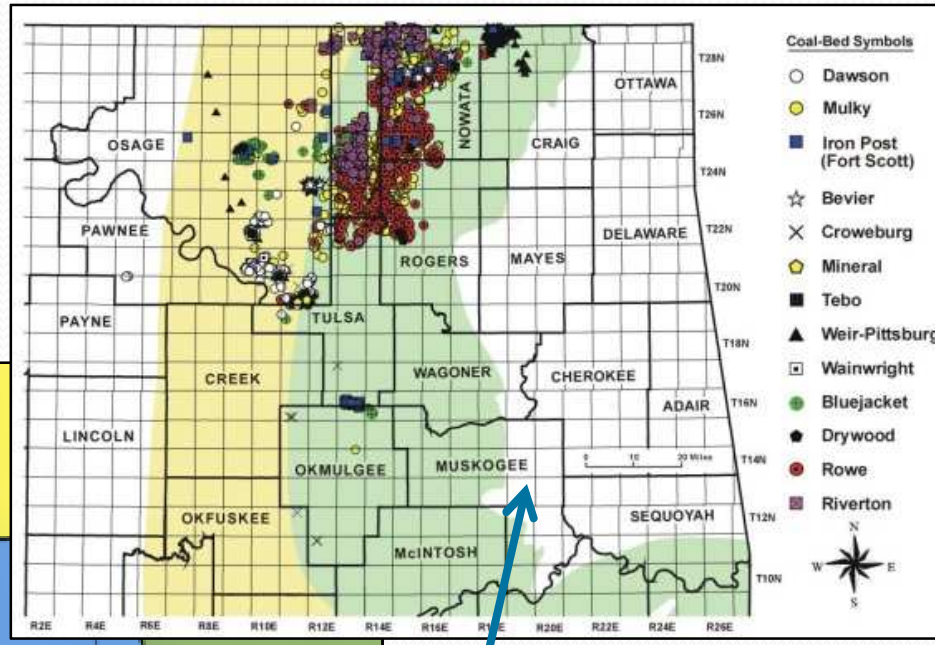
Confusing Quarter Call Format Leads to Inaccuracy

- **Potential Inaccuracy:**
  - Quarter calls are read ***right to left*** to find the location of a well – counterintuitive.
  - NE SE SW NW means
    - the NE quarter
    - of the SE quarter
    - of the SW quarter,
    - of the NW quarter…so the NW quarter has the largest area.
- If you do not understand the system, you will put the quarter calls in *backwards, thinking the largest quarter division is first*.
- The GPS location is calculated from whatever was put into the system, and if that is incorrect, our GPS location is inaccurate.

Receiving Only Legal Locations Leads to Imprecision

- PLSS Grid – Legal locations in Oklahoma are based on the township-range grid of the Public



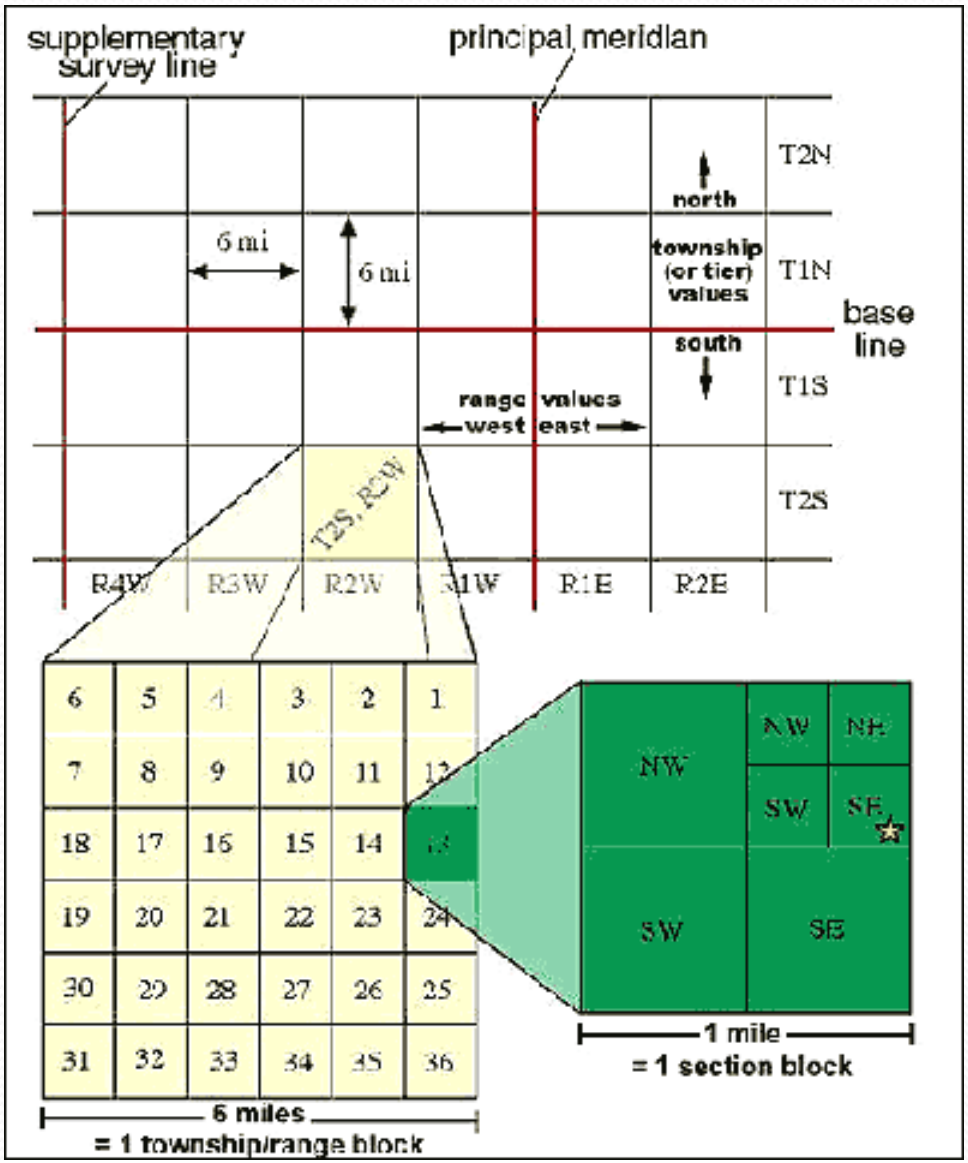


Each square block is a township/range

Legal Locations and Imprecision

Townships/Ranges and Sections

- Each township/range block is 6 miles x 6 miles, and contains 36 Sections
- Each Section is 1 mile x 1 mile (640 acres)
- Each Section is divided into quarters (160 acres), which can also be split into quarters (40 acres), which can be split again into 10-acre and 2.5-acre quarters.

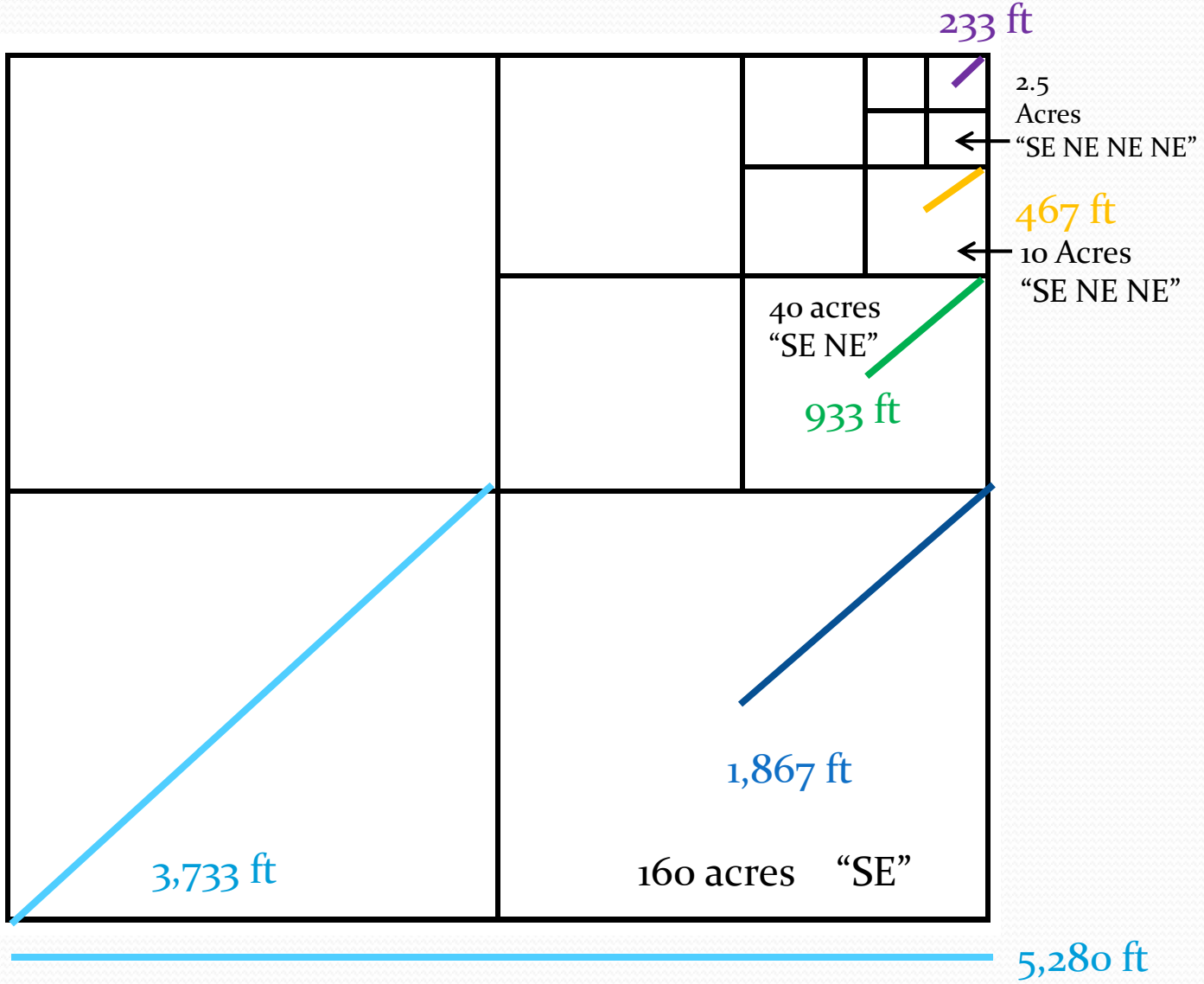


How Much Error are We Talking About?

"Maximum error" values (in color) are based on assumption that the well in question had its GPS location calculated as center of block, but is actually located in the corner.

Each additional quarter-call given cuts our potential maximum error for that well's location **in half.**

1 section = 640 acres "Sec. 27"



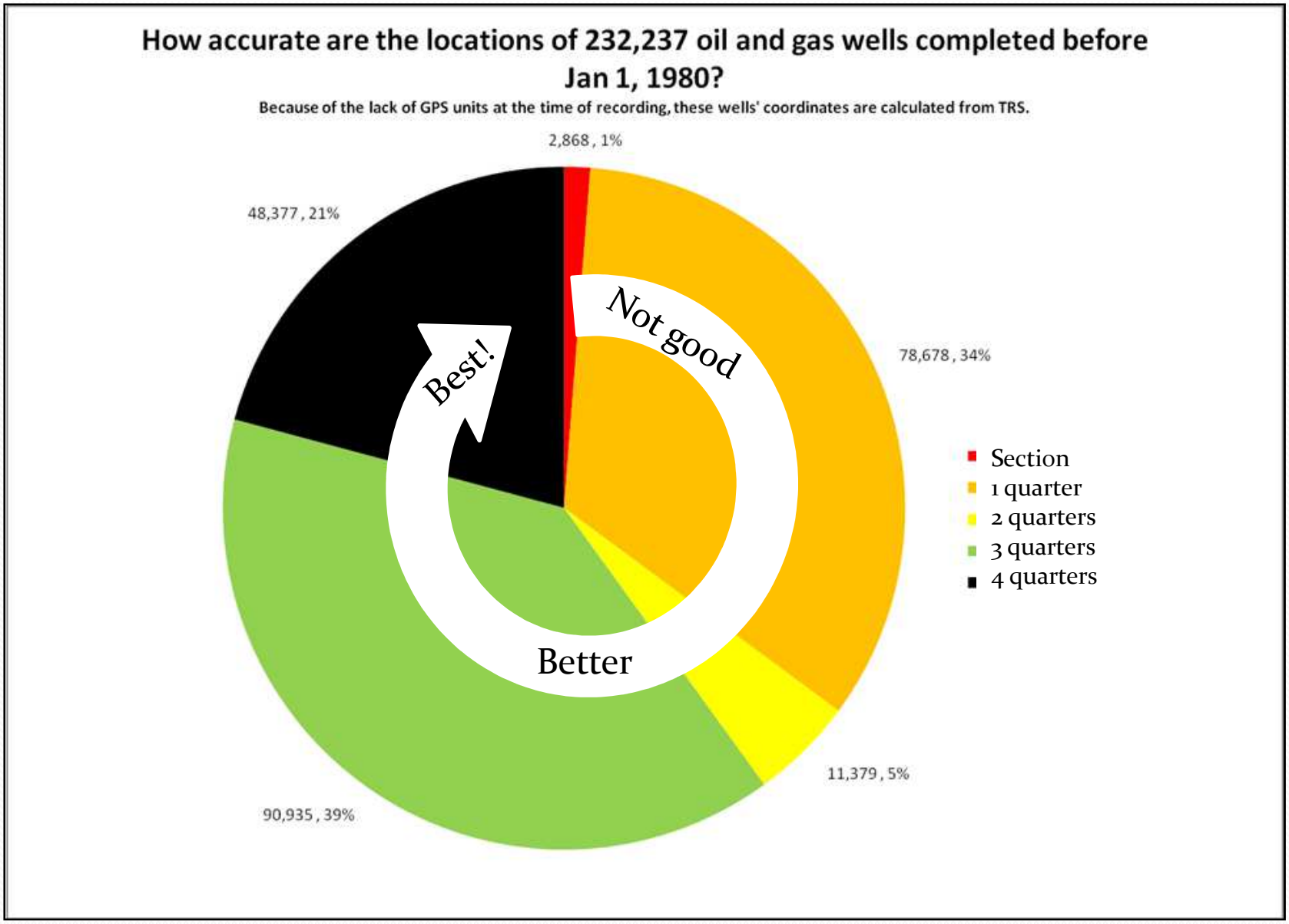
Examining Data Quality

2.5-acre	10-acre	40-acre	160-acre	Section (640-acre)	Township	Range
NE	SW	SE	NW	28	T7N	R3W
			NW	28	T7N	R3W

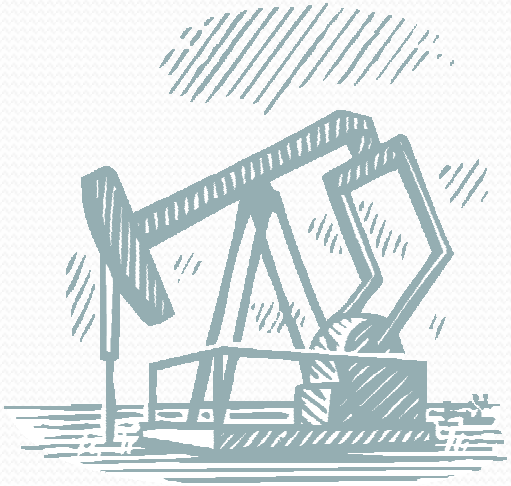
We know that this well is somewhere in 2.5 acres.

We only know this well is somewhere in 160 acres.

How Does Our Data Look?



We want the most accurate maps possible when suggesting people place extra casing in water wells in those areas. **We don't want** to cause people to spend money they don't have to, or miss areas that need protection!

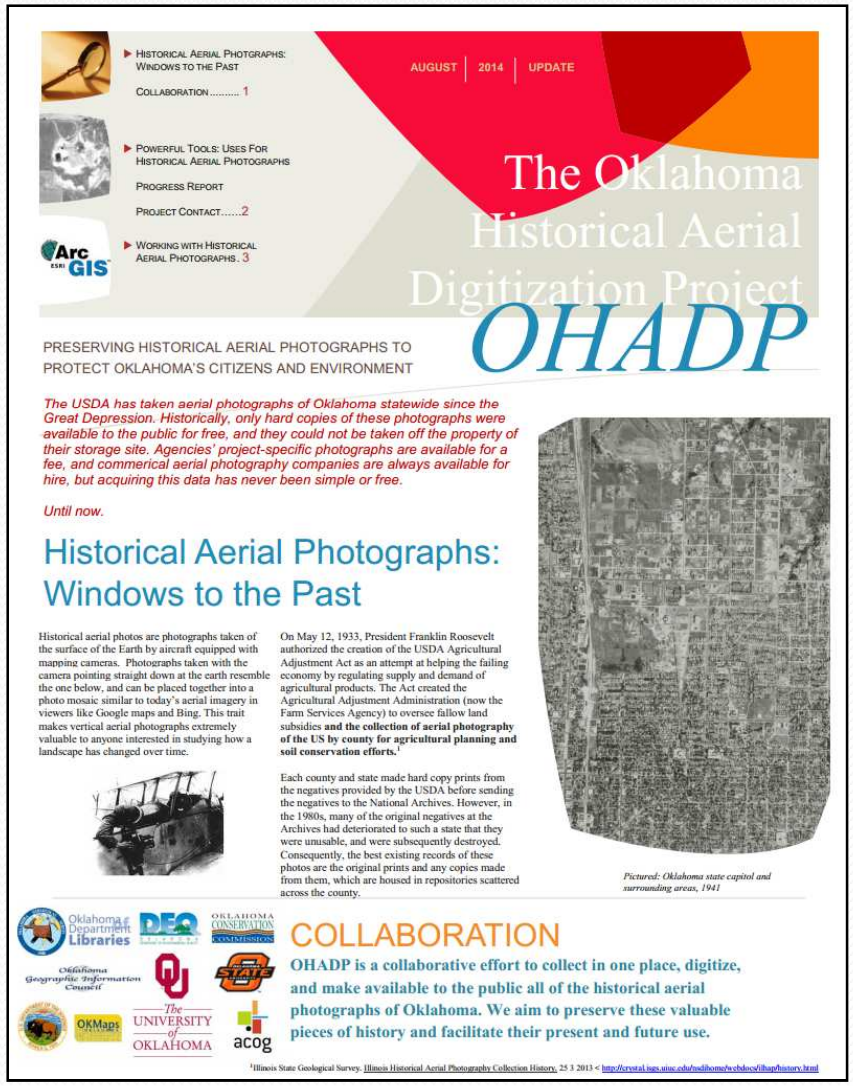


The data is as good as it can be, given the technology at the time the wells were drilled, and the number of well records that exist (which makes ground-truthing them all impractical).

Now that we have completed the "shortcut," it's time to look at the more time-consuming way of protecting groundwater.

Beyond the HDO Project

- **We can improve the accuracy of maps of groundwater cautionary zones by hunting big brine in historical aerial photographs, the way ACOG did.**
- Since 2007, OCC has been collecting, digitizing, and georectifying historical aerial photographs from around the state.
- We currently have over 100,000 photographs
- For more information on the Oklahoma Historical Aerial Digitization Project, please visit the page below: http://www.occeweb.com/og/OHADP%20newsletter%202014-08%20update.pdf (pictured on right)



HISTORICAL AERIAL PHOTGRAPHS: WINDOWS TO THE PAST
COLLABORATION..... 1
POWERFUL TOOLS: USES FOR HISTORICAL AERIAL PHOTOGRAPHS
PROGRESS REPORT
PROJECT CONTACT.....2
WORKING WITH HISTORICAL AERIAL PHOTOGRAPHS. 3

AUGUST | 2014 | UPDATE

The Oklahoma Historical Aerial Digitization Project

OHADP

PRESERVING HISTORICAL AERIAL PHOTOGRAPHS TO PROTECT OKLAHOMA'S CITIZENS AND ENVIRONMENT

The USDA has taken aerial photographs of Oklahoma statewide since the Great Depression. Historically, only hard copies of these photographs were available to the public for free, and they could not be taken off the property of their storage site. Agencies' project-specific photographs are available for a fee, and commerical aerial photography companies are always available for hire, but acquiring this data has never been simple or free.

Until now.

Historical Aerial Photographs: Windows to the Past

Historical aerial photos are photographs taken of the surface of the Earth by aircraft equipped with mapping cameras. Photographs taken with the camera pointing straight down at the earth resemble the one below, and can be placed together into a photo mosaic similar to today's aerial imagery in viewers like Google maps and Bing. This trait makes vertical aerial photographs extremely valuable to anyone interested in studying how a landscape has changed over time.

On May 12, 1933, President Franklin Roosevelt authorized the creation of the USDA Agricultural Adjustment Act as an attempt at helping the failing economy by regulating supply and demand of agricultural products. The Act created the Agricultural Adjustment Administration (now the Farm Services Agency) to oversee fallow land subsidies **and the collection of aerial photography of the US by county for agricultural planning and soil conservation efforts.**[1]

Each county and state made hard copy prints from the negatives provided by the USDA before sending the negatives to the National Archives. However, in the 1980s, many of the original negatives at the Archives had deteriorated to such a state that they were unusable, and were subsequently destroyed. Consequently, the best existing records of these photos are the original prints and any copies made from them, which are housed in repositories scattered across the county.

Pictured: Oklahoma state capitol and surrounding areas, 1941

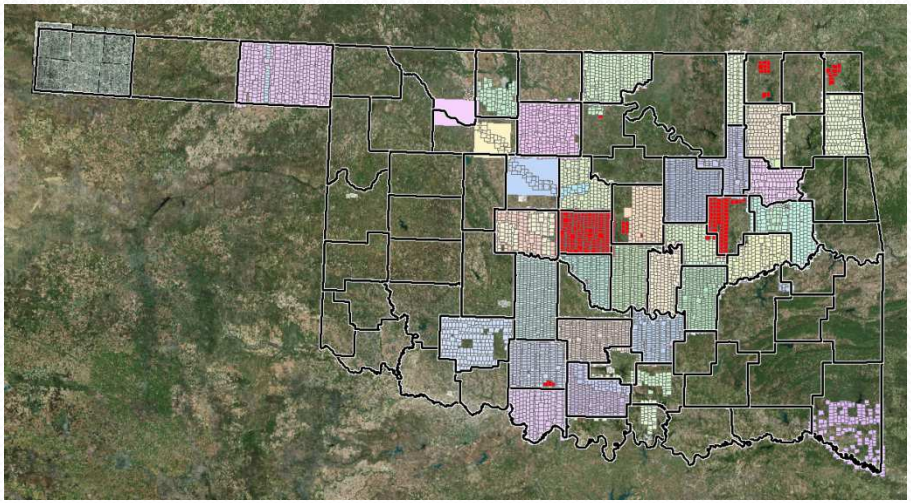
COLLABORATION

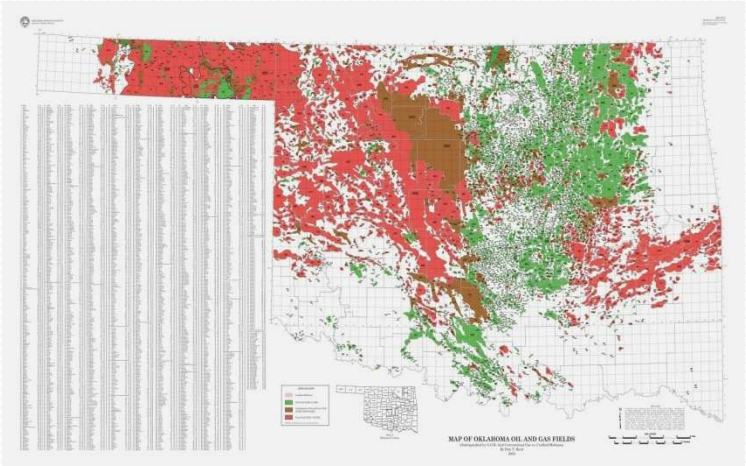
OHADP is a collaborative effort to collect in one place, digitize, and make available to the public all of the historical aerial photographs of Oklahoma. We aim to preserve these valuable pieces of history and facilitate their present and future use.

[1]Illinois State Geological Survey. Illinois Historical Aerial Photography Collection History. 25 3 2013 < http://crystal.isgs.uiuc.edu/nsdihome/webdocs/ilhap/history.html

Limited Project Range

- We can only outline brine patches in areas for which we have historical aerial coverage.
- Our aerial coverage matches up fairly well to old oilfields (not gas, unfortunately)—by design. We rectify oilfield counties first.





Oil Gas
Combination

Extending the Project's Range with OKMaps

http://ogi.state.ok.us/ogi/search.aspx

- OCC has given all of our 100,000 historical aerial photographs to the Office of Geographic Information at the Oklahoma Conservation Commission
  - Hosting on FTP site
  - Hosting on data viewer, OKMAPS
  - ***WILL BE AVAILABLE FOR FREE PUBLIC DOWNLOAD***

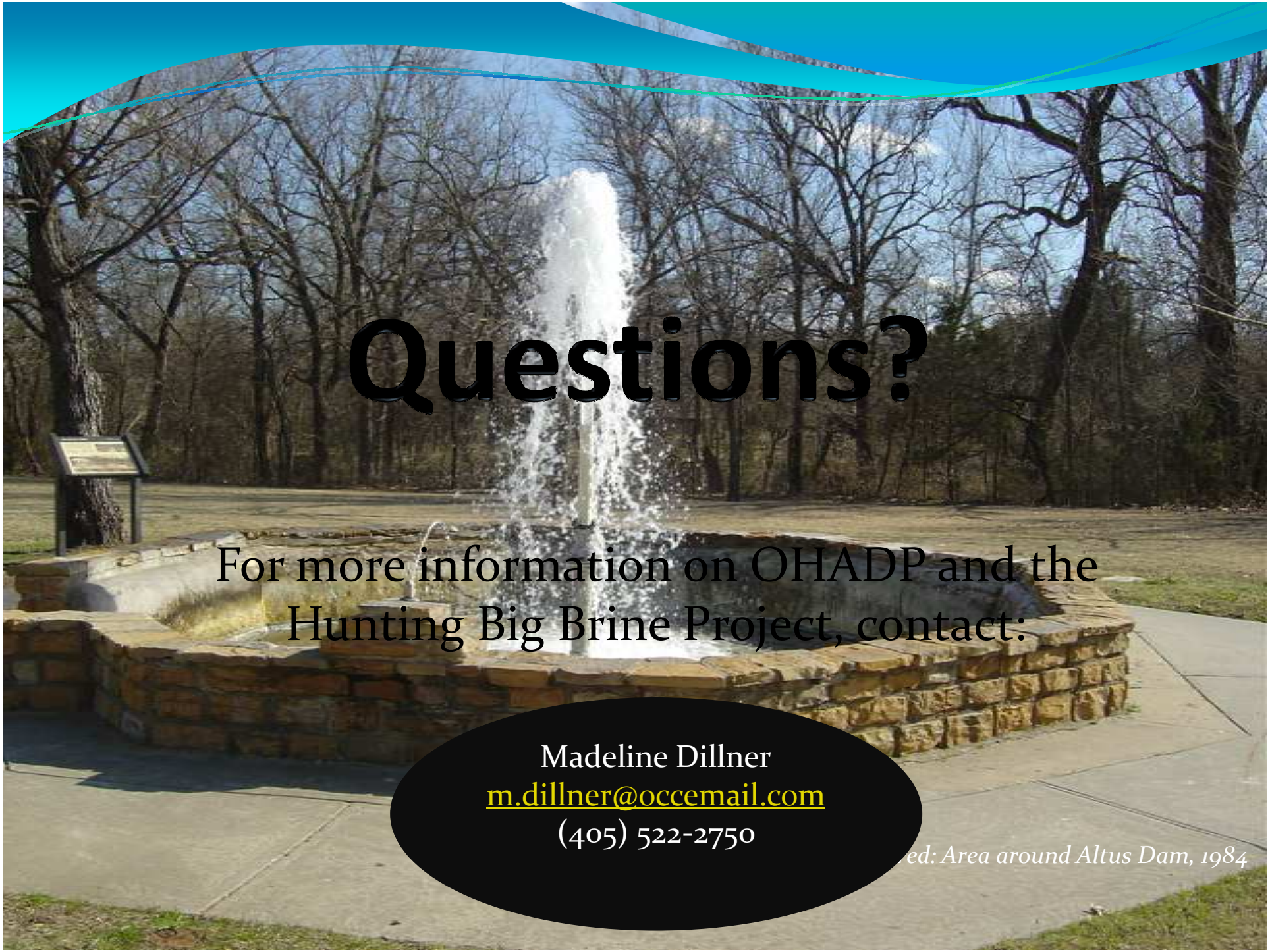
University GIS classes could be powerful crowdsourcing partners.

Photo from www.lincolnu.edu

Hope: Crowdsourced georectification of the historical aerial photographs

In Conclusion…

1. Oilfield brine is a common and persistent problem in oilfield states due to extensive historic oil and gas exploration and production activity.
2. Brine patches can be identified in historical aerial photographs as asymmetrical white smears—brine pits will be rectangular.
3. It is possible to make shapefile of where contamination is more likely to occur. This method is fast and gives people a general idea of where they need to be careful when drilling water wells—or at least gives them the idea that they **should** be careful. It also gives governmental bodies a better idea of what areas in their jurisdiction may be most in need of environmental cleanup.
4. Crowdsourcing the georectification of the state's historical aerial photographs will allow the more accurate method of outlining brine patches on aerial photographs used in ACOG's West Edmond Oilfield Study to be applied across the state.
5. Knowing where brine contamination is and examining water well casing requirements in those areas can help protect valuable groundwater resources from being contaminated with oilfield brine via the gravel-pack of water wells.



Questions?

For more information on OHADP and the Hunting Big Brine Project, contact:

Madeline Dillner
m.dillner@occemail.com
(405) 522-2750

ed: Area around Altus Dam, 1984