HUNTING BIG BRINE

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What do you think of when you hear

“Oklahoma?”
(too soon?)
What do you think of when you hear “oilfield pollution?”
A 160-acre patch of land in a historical aerial photograph showing what the results of a leaking oil pipeline look like.

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


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

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.

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.

ACOG’s logo, represents encompassed counties
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, let's look at how historic oil and gas activity can impact groundwater.
HENNESSEY SHALE

GARBER SANDSTONE

AQUIFER

10 feet of cement casing

30 FEET

Gravel pack

First Water Well

Later Water Well

SALT WATER IN PIPE

acog
Inspired by ACOG’s research...

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

Salt scars that showed up in more than three vintages were marked as potential Brownfields sites.
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:
  - **Historic**
    - Pre-1980
    - OCC’s environmental regulations and enforcement power both increased in 1980
  - **Dense**
    - Over 1 well/40 acres
    - Pretty standard density
  - **Oilfields**
    - 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

- More familiar with ArcToolbox
  - Created new shapefiles from a series of buffers, unions (with no gaps allowed), dissolves, spatial joins (with "sum" function), and merges
  - New shapefile was streamlined and could be used to give area of land in historic dense oilfields
  - 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

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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

- 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
Examining Data Quality

- **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.
Legal Locations and Imprecision

**PLSS Grid**

- Legal locations in Oklahoma are based on the township-range grid of the Public Land Survey.
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.
“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

<table>
<thead>
<tr>
<th>2.5-acre</th>
<th>10-acre</th>
<th>40-acre</th>
<th>160-acre</th>
<th>Section (640-acre)</th>
<th>Township</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE</td>
<td>SW</td>
<td>SE</td>
<td>NW</td>
<td>28</td>
<td>T7N</td>
<td>R3W</td>
</tr>
<tr>
<td>NW</td>
<td></td>
<td></td>
<td></td>
<td>28</td>
<td>T7N</td>
<td>R3W</td>
</tr>
</tbody>
</table>

We know that this well is somewhere in 2.5 acres.

We only know this well is somewhere in 160 acres.
How accurate are the locations of 232,237 oil and gas wells completed before Jan 1, 1980?

Because of the lack of GPS units at the time of recording, these wells' coordinates are calculated from TRS.

- 2,868, 1%
- 48,377, 21%
- 78,678, 34%
- 11,379, 5%
- 1 quarter
- 2 quarters
- 3 quarters
- 4 quarters

Better

Not good
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](http://www.occeweb.com/og/OHADP%20newsletter%202014-08%20update.pdf) (pictured on right)
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 so much gas, unfortunately)—by design. We rectify oilfield counties first.
Extending the Project’s Range with OKMaps

- 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.lincoln.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:

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