Preventing New Groundwater Pollution Problems from Old Oilfield Areas

Patricia Billingsley, Brownfields Manager, Oklahoma Corporation Commission
Last year I presented a case study about subdivision water wells polluted by brine from 1940s-50s era oilfield gathering lines.

Today I am going to
1) Summarize a couple of pollution cases;
2) Briefly discuss old oilfield groundwater pollution statewide; and
3) Discuss what Oklahoma is doing via rules to minimize future groundwater pollution problems from historic oil and gas activity.
OK Once Looked Like This (View From S to N Across River Toward OKC)
Or this - Tonkawa, 90 years ago
Historic Oil & Gas Fields (>500,000 wells) Affect >60% of Oklahoma
Corp Comm Has Taken > 2000 Groundwater Samples Over 20 Years

• Both suburban and rural, most near older oilfields with activity started pre-1980, before modern regulations;

• Most collected after complaint/problem, so

• The data is biased toward the bad.

• There are also areas with Remnant soil pollution.
Methodology; Pollutants

• Water samples were taken in
  – seeps and springs;
  – shallow monitoring wells near spills;
  – domestic, public, and agricultural water wells of all depths.

• Oilfield –related pollutants include
  --Petroleum, salinity, and boron from oil & gas production & saline produced water (brine)
  --Barium is found in oilfield drilling mud

• Nitrate, is NOT oilfield – septic and agriculture
The following maps show where water quality standards were EXCEEDED in groundwater.

**Major aquifers are Blue;**

**Dense Old Oilfields are Black**

70% of exceeds appear in or within 1 mile of pre-1980 dense oilfields; rest is scattered near few-well clusters or old injection wells
Petroleum, Water Wells, all Depths

Water Well Samples That Exceed EPA Drinking Water Standards
(Includes irrigation, public supply, livestock, domestic, and unspecified water wells)

Petrochemical Exceeds
- TPH 512 > 25 mg/L
- TPH 12-20 > 25 mg/L
- TPH 21-60 > 25 mg/L
- TPH > 60 > 25 mg/L
- Benzene > 5 ug/L
- Toluene > 1,000 ug/L
- Ethylbenzene > 700 ug/L
- Xylenes > 10,000 ug/L

Historic oilfield
- Historic oilfield UIC fields outside of oilfields
- Lake
- River
- GWAP Mapped Aquifers
- County

Major aquifers are Blue; Old Oilfields are Black

OCC water sample locations are determined by public request and suspicion of contamination. As a result, SAMPLE POINTS DO NOT REPRESENT A COMPREHENSIVE SURVEY OF STATEWIDE WATER CONTAMINATION.

Current as of February 2013
Heavy Metals in Water Wells – just 10

Water Well Samples That Exceed EPA Drinking Water Standards
(Includes irrigation, public supply, livestock, domestic, and unspecified water wells)

METALS EXCEEDS

- Arsenic > 0.1 mg/L
- Lead > 0.015 mg/L
- Chromium > 0.1 mg/L

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Current as of February 2013
Salinity Exceeds, Water Wells – Ouch!

Water Well Samples That Exceed EPA Drinking Water Standards
(Includes irrigation, public supply, livestock, domestic, and unspecified water wells)

SALINITY EXCEEDS
- Sodium > 250 ppm
- Chlorides > 250 ppm
- Total Dissolved Solids > 500 ppm
- Total Soluble Salts > 500 ppm

Major aquifers are Blue; Old Oilfields are Black
Other Pollutant Exceeds, Water Wells

Water Well Samples That Exceed EPA Drinking Water Standards
(Includes irrigation, public supply, livestock, domestic, and unspecified water wells)

OTHER EXCEEDS
- Barium > 2 ppm
- Boron > 1 ppm
- Nitrates > 10 ppm
- Historic dense oilfields
- Historic dense UIC fields outside oilfields
- Lake
- River
- OWRB-Mapped Aquifers
- County

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Current as of February 2013
Madeline Dillner’s talk Wednesday Morning, in the Waste Minimization/Pollution Prevention session, will go into the water sampling results, and data problems, in much more detail
Pollutant Focus

• Today I will focus mainly on salt/salinity – the biggest soil and groundwater problem
• Oil and gas wells produce more water than oil – 252,000,000 gallons PER DAY in OK, in 2012
• The USGS database of Produced Oilfield water show Oklahoma oilfield brines contain up to 18% salt, while seawater is ~3% salt
• SALT DOES NOT DEGRADE – It just moves, soil to water
What Does It Matter, to OK’s People?

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!
• I am going to summarize 2 typical case studies in Central OK.
• Where I also have geophysical data, so
• We can show where the pollution originated, and
• How it is moving through the subsurface.
Example 1 - Recent Case, 2011

• 15 year old gated community in NW OKC
• Homeowner complaints of salty water, 2011.
• Was a historic, until 1980s, oilfield area, so
• Our Field Inspector sampled their water wells.
• We later learned that two original homeowners had had bad wells in their backyard, with later new wells in the front yards. **Red Flag!**
Area was once an oilfield—green dots
WEST EDMOND OIL FIELD CIRCA 1945
Sampling Results
Wells ~300’ deep; only reached ~150’ backyard

<table>
<thead>
<tr>
<th>Who</th>
<th>Na ppm</th>
<th>Cl ppm</th>
<th>SO4 ppm</th>
<th>TDS or TotlSolSalts</th>
<th>Na/Cl</th>
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<tbody>
<tr>
<td>Z</td>
<td>1314</td>
<td>3323</td>
<td>798</td>
<td>7597</td>
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<td>L</td>
<td>665</td>
<td>2171</td>
<td>370</td>
<td>4996</td>
<td>0.306</td>
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<td>C</td>
<td>438</td>
<td>1047</td>
<td>722</td>
<td>3247</td>
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<tr>
<td>D</td>
<td>210</td>
<td>460</td>
<td>357</td>
<td>1756</td>
<td>0.457</td>
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<tr>
<td>N</td>
<td>184</td>
<td>139</td>
<td>302</td>
<td>1095</td>
<td>0.662</td>
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<tr>
<td>B Front yard</td>
<td>92</td>
<td>417</td>
<td>79</td>
<td>1327</td>
<td>0.441</td>
</tr>
<tr>
<td>B Backyard</td>
<td></td>
<td></td>
<td></td>
<td>1600</td>
<td></td>
</tr>
</tbody>
</table>

Exceeds **Chloride** secondary drinking water standards

**Na/Cl Ratio <0.6** indicates oilfield source

**Sulfate SO4** – from **natural** BaSO4, which makes Rose Rocks
Where there were Oilfield Tank, now we have New Homes

Tank group @
end of
gathering
system
1941 Aerial Showing Drill Rigs, Pits

- Dry salty pit
- Drill rig shadows
- Oil Well Spots
- Pit Outlines
- Pit with water
Geophysics – 3D, both saline plumes

Backyard Plume

larger Plume

UNPLUGGED WELLS

EXISTING
DOMESTIC WELLS

NORTH
Geophysics – Linear Saline Plume, Backyard

STAKE LOCATIONS

SALT WATER PLUME

GW Flow Direction

Geophysical Array CF03
Resistivity Values <= 1 ohm-meter
Depth ~ 20 Feet
Geophysics, IP – METAL! Was A Gathering Line – With a Hole

Geophysical Array CF03 IP
Induced Potential Values > 100 ms
Depth ~ 20 Feet
1951 Aerial – Linear Scars Were Gathering Line System?

If straight line surface scars, 1951, = Pipelines
What Happened

First Water Well

Later Water Well

30 FEET

HENNESSEY SHALE

GARBER SANDSTONE

AQUIFER

SALT WATER IN PIPE
Conclusions

• Old (1940’s-80s) Oilfield Activity Caused problem – highly saline brine leaks;
• Open, surface to 300’ deep gravel pack water well construction channeled shallow pollutants down into the Garber Aquifer.
• In effect, the water wells, by their standard design, polluted themselves - and the aquifer.
• Especially the unplugged backyard wells.
• All wells are now plugged.
Another Example – started late 1990’s

Water Well Samples, T Hills Edmond

<table>
<thead>
<tr>
<th>Address</th>
<th>Sodium ppm</th>
<th>Chloride ppm</th>
<th>Total Soluble Salts</th>
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<tbody>
<tr>
<td>3101 Sherrywood</td>
<td>153</td>
<td>577</td>
<td>1518</td>
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<tr>
<td>3009 Timothy</td>
<td>308</td>
<td>928</td>
<td>2066</td>
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<td>200 Stony Trail</td>
<td>377</td>
<td>1001</td>
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<tr>
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<td>2373</td>
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<tr>
<td>2901 Sherrywood</td>
<td></td>
<td>1237</td>
<td>2402</td>
</tr>
<tr>
<td>3001 Timothy Way</td>
<td>575</td>
<td>1258</td>
<td>2924</td>
</tr>
<tr>
<td>Produced Water,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darwin #1 T Hills Oil Well</td>
<td>79,830</td>
<td>123,947</td>
<td>222,996</td>
</tr>
</tbody>
</table>
Another Example
Saline Plume Moving S in Subdivision
Old Pits on the Garber Sandstone Leaked, Wells helped move salt deeper into aquifer

Processed Data Showing Inferred Groundwater Conditions
Edmond – A Bonus!

T Hills homes: groundwater pollution plume moving SOUTH since 1990s 90’ per year, dozens of water wells being ruined

Apparent Source: Old pits

Special “Bonus” – stream and reservoir

Lake Arcadia
Because of problems in old oilfields and cases like the above, Corp Comm is has mapped old (pre 1980) well fields, especially on Oklahoma’s aquifers.

• Before 1980, pit design, well plugging oversite, field inspection etc. not as “rigorous” as after; For example, no regular Mechanical Integrity testing of injection wells was done then, is done now.
More Wells/Oilfields, More Pollution

Rush Springs Aquifer, Old Oilwells, Oilfields & Pollutants (inorganic)

Legend
- As > 0.1
- Ba >= 2000
- Cr >= 0.1
- Pb >= 0.015
- Cl >= 250 ppm
- Na >= 250 ppm
- SO4 >= 250 mg/L
- TSS >= 1000
- pH > 8.5 or < 6.5
- Boron > 1

Red is Dense Oilfields
More Wells/Oilfields, More Pollution

Central OK and Vamoosa Aquifers

Pre-1980 Oil Wells and Dense Wellfields and Sample Exceeds
Unfortunately, many of these old pre-1980 oilfields are just open fields today.

So Pollution Risks are often NOT obvious to developers or well drillers.

So

All of our Old Oilfield maps are being loaded onto OWRB’s map viewer, for viewing by anyone on the internet.
New Rules Request Made to OWRB

• To help prevent shallow pollutants from traveling down water well gravel packs into aquifer(s) -
• In the higher risk areas Corp Comm has mapped (old oil wells, pits etc <1400’ apart, >16 per square mile),
• Corp Comm has requested a New Rule requiring future water wells to be cased and cemented from the surface to at least 30’ deep, gravel pack only BELOW 30’

• RULEMAKING THIS FALL
• These GIS maps can be made by aquifer, county, town, or Water District
• Regional planners (COGS) & town building permit departments can also use them???
• So far, 2COGs - ACOG and INCOG - have our map coverages and have agreed to make old oilfield maps for any city/town that wants them, for planning purposes; working on the rest
Indian Nations Council of Governments Area

Dense OG Fields and All UIC Wells

Red is Dense Oilfields

Water Supply Lakes
City permit Dept - Pre-test for salt here BEFORE buildings get permitted?

Or want groundwater pre-testing before home water wells are installed here – or require city/RWD water.
Questions?