CCAC
Abandoned and Orphan Oil and Gas Wells in Pennsylvania

Bureau of Oil and Gas Planning and Program Management
Division of Subsurface Activities
October 27, 2020
Presentation Outline

• Plugging Program Status Update
  - Funding
  - Emergency Procurement
  - Estimated Unfunded Liability

• Emerging Environmental/Safety Issues
  - Plugging Effectiveness
  - Short-term Environmental and Safety Risks
  - Emissions/Cornplanter State Forest

• Summary
Plugging Program Status Update

DEP Abandoned, Orphan, and Plugged Wells
DEP Plugging Program Funding

- Since 1985, DEP has received $150-$250 surcharges for every drilling permit.
Recent Emergency Procurement Trends

- Antaki Well: $14,000 for stray gas mitigation system
Recent Emergency Procurement Trends

• Antaki Well: $14,000 for stray gas mitigation system
Recent Emergency Procurement Trends

- Antaki Well: Approximately $350,000 for plugging
Recent Emergency Procurement Trends

- John Barron Well: $179,000 for flaring and plugging
Recent Emergency Procurement Trends

• John Barron Well: $179,000 for flaring and plugging
Recent Emergency Procurement Trends

• John Barron Well: $179,000 for flaring and plugging
Recent Emergency Procurement Trends

- Monahan Well: $160,000 for plugging
Recent Emergency Procurement Trends

- Monahan Well: $160,000 for plugging
Recent Emergency Procurement Trends

• DEP’s emergency procurement trends also suggest expenditures have the potential to exceed fund growth.
Mass Abandonment

• In 2018 two operators with major holdings have abandoned approximately 2,750 wells

• Tens of thousands of conventional oil and gas wells will eventually need to be plugged but they may not have a viable owner that can afford to plug them

• Bonding levels do not equate to actual plugging costs
  • $2,500 single conventional well bond
  • $25,000 blanket bond (unlimited number of conventional wells)

  • Thousands of wells are under a single blanket bond or have no bonds at all (Pre-Act wells)
Crunching the Numbers

• There are more than 8,000 wells in DEP’s Abandoned and Orphan Well database – DEP has the statutory authority to plug these wells

• Over the last four years, DEP has added 345 wells to its Abandoned and Orphan Well database

• Mass abandonment is likely to continue increasing DEP’s plugging liability

• Since 1989, DEP has plugged a little over 3,000 wells
Crunching the Numbers

• Dilmore et al. (2015) and Engelder (2017) have estimated that somewhere between 330,000 and 350,000 wells were likely drilled in the commonwealth between 1859 and 2016 – Kang et al.’s (2016) estimate more than doubles the upper end of this range

• DEP and the industry have plugged 65,000 wells between 1910 and 2016, but many of these wells have not been decommissioned in accordance with current standards

• Approximately 100,000 conventional wells are “active” and around 40,000 of these have never reported production – it is possible that the 40,000 wells will become future liabilities for the commonwealth

• Conservatively, these studies and data suggest that there are likely at least 200,000 additional legacy wells, many of which will require plugging as they are discovered
Cost Modeling/Liability Forecasting

- A conservative estimate of $33,000 per well has been derived from reviewing contract costs.
- Liability forecasting changes significantly based on per-well cost assumptions.
  - At $33,000 per well, DEP’s plugging liability ranges somewhere between $280 million (8,500 wells) and $6.6 billion (200,000 wells).
Emerging Environmental/Safety Issues

Plugging Effectiveness: Field Investigation and Statistical Analysis

- Conduct well site investigations utilizing high sensitivity gas monitoring equipment to determine if plugs are leaking
- Analyze field data and compare to other leaking plugged wells and non-leaking plugged wells to determine variables that may be influencing rate of plug failure
Statistical Testing

• Compared leaking well (n = 41) to confirmed non-leaking well data from BOGPPM Legacy Well Integrity and Emissions Study (n = 52) (GSA, 2017)
• Removed 2 Marcellus wells from leaking well data
• SPSS: One-Way ANOVA, Comparison of Medians, Mann-Whitney U, Kruskal-Wallis
Emerging Environmental/Safety Issues

Box Plots Suggest:
• Leaking wells have substantially more production or intermediate casing left in the ground than non-leaking wells – differences are statistically significant (p<0.05)

Bar Charts Suggest:
• Leaking wells have a greater ratio of cement & gel plugs
Emerging Environmental/Safety Issues

Shallow Charged Zones Possibly Attributable to Legacy Activities
Risks associated with Abandoned, Orphan, and improperly plugged wells can be compounded by mine-influenced water in areas of coal mining
Encroachment

- High population density areas/regions of active development may introduce intersections between legacy wells and occupied enclosed spaces

- During Phase I/Phase II site assessments, a thorough review of legacy development is critical for mitigating client liability
  - PA Geologic Survey Farmline Maps
  - PASDA
  - DEP Oil and Gas Mapping Tool
  - Local Government Resources

- The Good Samaritan Law affords liability relief for third parties who volunteer to decommission legacy wells for which there is no responsible party
Emerging Environmental/Safety Issues

Encroachment
Improperly Decommissioned Gathering Systems

• Stubbed off segments of gathering lines have the potential to introduce stray gas into the subsurface if not properly decommissioned during well plugging

• Recent DEP field work has identified elevated soil gas concentrations in association with such systems
Emerging Environmental/Safety Issues

Improperly Decommissioned Gathering Systems

<table>
<thead>
<tr>
<th>Observation Point</th>
<th>Date</th>
<th>Time</th>
<th>Gas Concentration</th>
<th>Volume ft³/day</th>
<th>Barometric Pressure (inHg)</th>
<th>Ambient Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4</td>
<td></td>
<td></td>
<td></td>
<td>6620 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#5</td>
<td></td>
<td></td>
<td></td>
<td>7840 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#6</td>
<td></td>
<td></td>
<td></td>
<td>500 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#7</td>
<td></td>
<td></td>
<td></td>
<td>360 ppm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Emissions

• McGill University
  - Kang et al. (2016) found a high occurrence of leaking abandoned and plugged wells
  - Isotopic signatures support deep, oil-associated origin
  - In some cases, gas was found to be flowing through the soil beyond the footprint of the outermost well casing
  - DEP is currently working to understand if Kang et al.’s (2016) emission regression model can be used as a risk-management tool
Emerging Environmental/Safety Issues

Cornplanter State Forest
Emerging Environmental/Safety Issues

Cornplanter State Forest

- DCNR Capitol Project
  - $1.9 million budget
  - Earmarked for use in Cornplanter State Forest
  - Project scope includes decommissioning 64 shallow oil wells on state land
  - 500-1,000 feet deep
  - Spudded in 1920s – 1980s
  - Root cause: mass abandonment by Pennsylvania Operator

- Environmental improvement synergies: surficial oil contamination and hazards tied to infrastructure, and leaking wells
Emerging Environmental/Safety Issues

Cornplanter State Forest

• Preliminary leak rate information
  - 11 of 62 wells (18%) were determined to have measurable leaks
  - Methane flux estimates are cumulatively on tenths of cubic feet per day scale (hundredths of MTCO2e/year)
Summary

• Pennsylvania has a significant history of legacy oil and gas development and the potential for hundreds of thousands of wells with no associated responsible party.

• Unfunded plugging liability is currently estimated at $280 million, but could be much higher – it is forecasted to grow.

• An analysis of failed plugs suggests that further improvements may be necessary to ensure long-term plug integrity.

• Legacy wells are contributing to environmental and public safety risks.
Thank You!

Questions?

Seth Pelepko, P.G.
Program Manager
Division of Subsurface Activities
mipelepko@pa.gov

Bureau of Oil & Gas Planning & Program Mgmt
717.772.2199

Many thanks to my co-authors: Serena Oldhouser, Liz Cushman, Harry Wise, Rick Swank, and Jim Braunns!

Rewriting Pennsylvania’s Legacy (dep.pa.gov/legacy wells)