Shale oil and gas and surface waters: identifying potential contamination pathways through evaluation of state notice of violation and spill reports

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Issue: Shale Plays are Common

Lower 48 states shale plays

Source: U.S. Energy Information Administration based on data from various published studies. Updated April 13, 2015

Issue: Natural Gas from Shale Forecasted to Increase Over Next 30 Years

Figure MT-44. U.S. natural gas production by source in the Reference case, 1990-2040 (trillion cubic feet)
Extraction of Shale Gas and Oil

- Site Identification
- Site Prep./Infrast.
- Drilling
- Hydraulic Fracturing
- Gas Production
- Long-term
Issue: Potential to Affect Headwater Streams

Infrastructure

Sediments

Spills/Leaks

Water Withdrawal
Issue: Spills/Leaks – Not Much Known

- PA - Violations related to spills and erosion most common (Rahm et al. 2015).
- CO – Spills mostly occur during production phase of development and equipment failure and human error are leading causes (CODNR – OGCC 2014).
Spills/Leaks

- Data are needed on pathways, materials, volumes and rates.
- State notice of violation and spills databases.
- Focus on Colorado and Pennsylvania.
- **Colorado:**
  - long history of HF with vertical and directional wells.
  - Denver, Greater Green River and Piceance Basins.
  - Spills database.
- **Pennsylvania:**
  - largely horizontal.
  - NOV database.
Spills/Leaks - Methods

- Download NOV and spill data from each state for 1995-2014 (April 2014 for CO).
- QA/QC’d each record for duplicates, pathways, materials and volumes.
- Downloaded well data from the IHS database.
  - API number, well direction and spud date.
  - Formation, Play and HF information.
- Used the IHS data to identify well direction and if unconventional (combination of direction and play).
UOG Well Locations

Colorado

Pennsylvania

Well Direction
- DIRECTIONAL (15718)
- HORIZONTAL (3551)
- VERTICAL (17796)
UOG Well Locations

Colorado

Pennsylvania

Well Direction
- DIRECTIONAL (15718)
- HORIZONTAL (3551)
- VERTICAL (17796)
UOG Spill Locations

Colorado

Pennsylvania
UOG Wells by Year

Colorado

Pennsylvania

Number of Wells

Year

USGS
UOG Spills by Year

Colorado  Pennsylvania

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Spills</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
</tr>
<tr>
<td></td>
<td>Directional</td>
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<tr>
<td></td>
<td>Horizontal</td>
</tr>
</tbody>
</table>

Number of Spills: 0, 50, 100, 150, 200

Graph showing the number of spills by year for Colorado and Pennsylvania.
Major Pathways – Horizontal Wells

Colorado

Pennsylvania

Pathway

Number

Drilling
Flowline
Pit
Pump
Tank
Transport
Wellhead
Other

Pathway

Number

Blowout
Drilling
Erosion Control
Flare
Flowline
Generator
Improperly Stored
Pit
Pit or Tank
Pump
Storage Container
Tank
Transport
Unknown
Wellhead
Other
Materials Spilled – Horizontal Wells

Colorado

Pennsylvania

Material

Number

Condensate
Crude Oil
Diesel Fuel
Drilling Waste
Freshwater
HF Solution
Unknown
Wastewater

Material

Number

Chemicals
Crude Oil
Diesel Fuel
Drilling Waste
Equipment Oil
HF Solution
Oil & Saltwater
Sediment
Unknown
Wastewater
Other

USGS
Well Age & Spills – Horizontal Wells

**Colorado**

Drilling Waste

- 50% 8.0 days
- 75% 16.0 days
- 90% 27.9 days

n:48 m:0

**Pennsylvania**

Drilling Waste

- 50% 88.0 days
- 75% 181.0 days
- 90% 316.3 days

n:232 m:0
Well Age & Spills – Horizontal Wells

Colorado

Pennsylvania

Wastewater

- 50% 108.5 days
- 75% 198.8 days
- 90% 402.5 days

Wastewater

- 50% 288.0 days
- 75% 500.5 days
- 90% 918.8 days
Colorado – Horizontal Wells

Surface Waterways

1 Horizontal Well
Equipment failure at wellhead
Condensate
Estimated well age: 87 days
Distance to Stream– Horizontal Wells

Pennsylvania

Non-Waterway Incident

Waterway Incident

50% 224 m
75% 412 m
90% 518 m

50% 211 m
75% 361 m
90% 487 m

Distance (m)

Proportion <= x

Distance (m)

Proportion <= x

n:220 m:0

n:339 m:0

USGS
Summary

- Results are preliminary but highlight potential to identify pathways and materials spilled.
- Data from CO and PA varied in level of detail.
- Horizontal wells and associated spills increased in both states.
- Tanks, pits, flowlines and transport were major pathways.
- Drilling fluids and wastewater most often material spilled (crude oil also in CO).
- Temporal variation in material spilled.
Future Plans

- Investigate more detailed pathway and material spilled (if possible).
- Analyze spill data from ND and NM in similar fashion.
- Estimate rates of spills for each material by state.
- Evaluate spills at injection and disposal wells?
- Incorporate findings into biological vulnerability analysis.
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