



A Review of GWPC's Stray Gas Incidence & Response Forum

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Veil Environmental, LLC

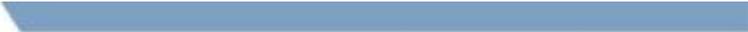
Topics for Discussion

- What is stray gas?
- The Stray Gas Forum
- Key themes and findings
- Information resources from the Forum



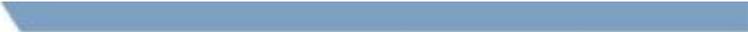
What Is Stray Gas?

- Gas that migrates from its usual geological location to places where it may pose health or safety issues
 - Particularly into homes or drinking water wells
- Stray gas can include various types of gases, but the Forum focused on methane
 - Methane is a flammable, colorless, and odorless gas.
 - Its solubility at atmospheric pressure is 33 ml/l (~28 mg/l).
 - Methane is nontoxic when ingested. It can, however, reduce the amount of oxygen in the air necessary to support life.
 - It poses an immediate fire and explosion hazard when mixed with air at concentrations 5% to 15%.
 - The LEL (lowest explosive level) is 5%



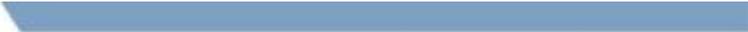
The Stray Gas Forum

- GWPC held a Stray Gas Incidence & Response Forum (the Forum) from July 24-26, 2012 in Cleveland, Ohio.
- The Forum, which attracted nearly 200 participants, focused on stray gas in areas where shale gas or other unconventional natural gas is being developed.
- The presentations included three short courses that allowed for a detailed review of specific topics and about 30 other technical talks over more than two and a half days.
 - Much of the information presented at the Forum was associated with studies conducted in the Marcellus Shale region, although a few presentations provided data from other locations.
- Special acknowledgments to the planning efforts of:
 - Ben Grunewald, GWPC
 - Scott Kell, consulting geologist
 - Fred Baldassare, Echelon Applied Geoscience Consulting



Why Was the Forum Held?

- The idea for the Forum was conceived following the GWPC's annual UIC Conference in January 2012.
- During that meeting, several presentations described stray methane gas found in water supplies in Pennsylvania.
- Initially, the methane was thought to result from new Marcellus Shale drilling and hydraulic fracturing activities.
- But upon more careful geochemical investigation using various analytical tools, the gas found in the water supplies was determined not to have the same geochemical characteristics as the gas produced from the Marcellus.
- This suggested that the gas originated from other locations.

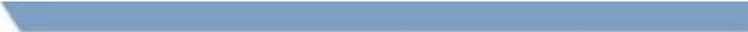


Sources of Stray Gas

- Pre-existing, shallow deposits of natural gas
 - Several presentations documented evidence of methane from the geological record and century-old reports of gas well drilling from historical records
- Leaks from abandoned, recently drilled, or operating gas wells
 - One of the short courses described the well known explosion from leaking gas in Bainbridge Township, Ohio
- Underground activities unrelated to shale gas production (e.g., coal mining, landfills)
- Leaks from natural gas pipelines or natural gas storage fields or caverns
 - One presentation described leaks of methane from a Mississippi salt dome.

Testing for Methane in Water Wells

- Many gas producers conduct pre-drill testing of local water wells to establish a baseline concentration.
- Chesapeake Energy has collected more than 31,000 water well samples in areas where shale gas drilling was planned.
 - These spanned the states of Arkansas, Colorado, Kansas, Louisiana, New York, North Dakota, Ohio, Pennsylvania, Texas, West Virginia, and Wyoming.
 - About 25% of all the samples had detectable methane concentrations.
 - The highest concentrations of dissolved methane have been found in Louisiana, Ohio, and Pennsylvania.
- Chesapeake also conducted several focused studies to evaluate variability of methane concentrations over time.
 - Several presentations described some interesting findings from those data

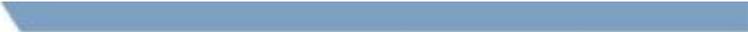


Results of Detailed Sampling Programs

- Study 1: Review of 14,000 samples taken between 2009 to 2012 at water wells in Pennsylvania, Ohio, and West Virginia
- Higher methane concentrations appear to be associated with:
 - Certain geologic units
 - Waters having higher concentrations of total dissolved solids, sodium, chloride, barium, and strontium), and
 - Water that has lower sulfate concentrations,
 - Certain water types (particularly those dominated by sodium bicarbonate and sodium chloride water)
 - Topographic position – in northeastern Pennsylvania, higher methane is found at wells in lower topographical locations (in valleys).
- Another data set collected by Cabot Oil and Gas also shows the topographic trend noted in the previous bullet

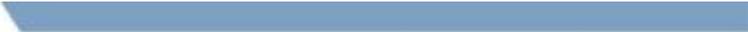
Results of Detailed Sampling Programs (2)

- Study 2: Sample 12 wells weekly or monthly for 1 year
 - Over the course of four months, dissolved methane ranged from nearly zero to more than 15 mg/L, with an “average” methane concentration of approximately 7 mg/L.
 - Methane occurs naturally and is highly variable:
 - Spatially and temporally,
 - With temperature, barometric pressure, and drought.
- Study 3: Sample 30 wells daily and/or weekly for two months
 - Dissolved methane varied significantly from day to day
 - The range for wells located close to a gas well was <0.026 – 11.8 mg/L.
 - For the other wells farther out, but within a 4,000-ft radius, the range of dissolved methane was <0.026 – 17.4 mg/L
 - Recognition of natural variability is important in interpretation of water-quality data.



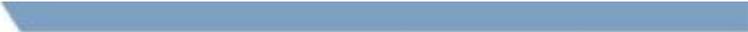
How to Identify the Source of Stray Gas

- Use various chemical measurements
 - Don't rely on a single piece of evidence
- One of the techniques is called stable isotopic analysis
 - Compares ratios of different isotopic forms of carbon, hydrogen, and other elements to “fingerprint” different types and origins of gas samples
 - Used extensively in stray gas evaluations
- This will be covered in other presentations to follow
- Several presentations gave examples of investigations from Pennsylvania, Ohio, Colorado, Texas, and Mississippi



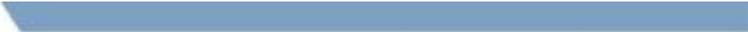
Mitigation and Remediation when Stray Gas is Observed

- When elevated methane is observed in a water well or in a building, a prompt investigation of the health and safety risks is warranted to determine the threat level:
 - First make sure public health and safety is protected
 - Define the origin of the stray gas and the extent of the stray gas plume,
 - Identify potential sources of the stray gas,
 - Monitor to confirm a remedy
 - Remediate if needed
- Depending on the concentration of the methane, various venting, plugging, and treatment methods can be used to mitigate the risk.



Wellbore Integrity

- One of the sources for stray gas is leakage from poorly constructed wells or wells that have developed leaks
- One of the short courses described issues about wellbore integrity and provided a variety of test procedures that can help determine the presence and locations of leaks.

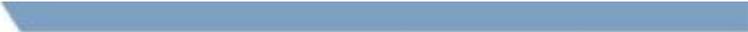


Legal Issues

- Presentations were made by two attorneys
- The first described the legal bases for filing lawsuits against gas companies.
- The second reviewed regulations in Pennsylvania, Ohio, and West Virginia relating to stray gas.

Migration of Marcellus Brine to Shallow Aquifers

- One speaker gave a controversial presentation concerning his interpretation of data suggesting a possibility of hydraulic connectivity between the Marcellus Shale and shallow aquifers in Pennsylvania
- He and his colleagues published a scientific paper on this subject in July.
- Several commenters immediately challenged that conclusion.
 - One commenter noted that the Marcellus Shale does not contain much natural moisture. Rather, it tends to imbibe water from injected fracture fluids.
 - The commenter questioned how such a dry and deep formation could contribute sufficient moisture to the shallow groundwater.
- The resulting debate was inconclusive, with neither party conceding.

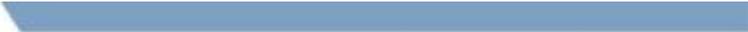


API Standards

- Two presentations were made to describe API Standards
- The first gave an overview of the program through which more than 600 standards have been set by committees
 - Three sets of standards relating to hydraulic fracturing
- The second presentation covered a standard for Isolating Potential Flow Zones during Well Construction
 - Relevant to wellbore integrity and stray gas

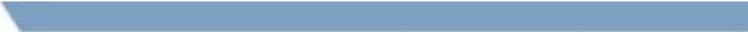
Other Federal Agency Research

- Representatives from EPA, DOE, and USGS described some of their research activities that relate to unconventional oil and gas.
 - EPA described a multi-agency research plan to address the highest priority research questions associated with safely and prudently developing unconventional shale gas and tight oil resources.
 - USGS described an integrated study plan on the effects of Marcellus Shale gas production on the environment.
 - DOE described some of the in-house research on shale gas and other oil and gas topics it was conducting,
- A presentation was made summarizing some split-sample groundwater data collected in Bradford County, Pennsylvania relating to EPA's hydraulic fracturing study.
 - The 15 groundwater sample locations they tested do not appear to be impacted by natural gas drilling or production activities.



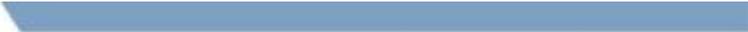
Additional Information Resources

- Most of the presentations from the Forum can be viewed and downloaded from [GWPC's website](#).
- A draft white paper, summarizing the Forum, is under review by GWPC and will be available on the GWPC website soon.



Conclusions

- Stray gas in the form of methane is prevalent in many shallow formations around the country. It is particularly prevalent in Pennsylvania.
- Methane poses little risk from ingestion, but can cause serious risks through fires or explosion.
- Large numbers of water well samples have been collected throughout the Marcellus region. Approximately $\frac{1}{4}$ of the sampled wells show some detectable methane concentration.
- There are multiple potential sources of stray gas.
 - Although the extensive gas well drilling programs in the Marcellus region have been suggested as a cause of the methane found in groundwater, detailed geochemical investigations using chemical data and isotopic analysis show strong evidence that much of the methane observed in water wells has origins in shallower geological formations.



Conclusions (2)

- A few focused data collection efforts over time on the same set of wells show a wide range of variability in dissolved methane over time (seasonal, monthly, and even daily).
 - This suggests that attempts to characterize the pre-drill baseline methane concentrations using only a single sample may not be as useful as previously thought.
- When elevated methane is observed in a water well or in a building, a prompt investigation of the health and safety risks is warranted.
- State laws and regulations continue to evolve to include more protective well construction standards and other requirements relating to water supplies.