Monitoring the Active Migration and Biodegradation of Natural Gas in the Trinity Group Aquifer at the Silverado Development in Southern Parker County, Texas*

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Abstract

The Lower Cretaceous Trinity Group aquifer contains natural gas generated by the Barnett Formation that migrated over geologic time into the aquifer from the underlying Pennsylvanian Strawn Group across an angular unconformity. Thermal gas dissolved in water samples collected from that aquifer generally is severely biodegraded except where water wells either occur above – or inadvertently penetrate – gassy Strawn strata. We describe changes in the abundance and the molecular and C isotopic composition of the natural gas dissolved in water samples collected periodically from all accessible wells in the Silverado Development between December 2010 and December 2012. Initially the gas dissolved in only six out of 22 water wells contained >20 mol% methane, and the presence of isotopically-heavy ethane (> −24 per mil) in most water samples proved that natural gas in the aquifer generally was severely biodegraded. By May 2012, the amount of dissolved methane had increased substantially at one well location from ~26 mol% to ~63 mol%. The C isotopic composition of ethane indicates dissolved natural gas was less biodegraded at two other well locations than it was in December 2010, while ethane was more biodegraded than previously measured at a different well location. We also observed changes in the amount of dissolved methane and the C isotopic composition of ethane in water samples collected from several wells in August 2012 and December 2012. During the 24–month period that we studied water samples collected from the Trinity Aquifer in the Silverado Development, the amount and/or the C isotopic composition of HC gas compounds dissolved in water changed in ~20% of the wells. At one well location, the dissolved natural gas systematically became more biodegraded every time water was collected. But at two other well locations, the data indicate that a pulse of fresh natural gas migrated into the Trinity Aquifer across the unconformity between December 2010 and May 2012, and by December 2012 subsequently was biodegraded by microbes in that aquifer. Temporal and spatial changes in the amount and composition of natural gas dissolved in water samples demonstrate that thermal gas in the Strawn Group episodically migrates vertically across an unconformity into the Trinity Aquifer. These data reinforce our prior conclusion that two nearby horizontal production wells completed in the Barnett Formation are not the source of the natural gas dissolved in the Trinity Aquifer.

Reference Cited

Pollastro, R.M., D.M. Jarvie, R.J. Hill, and C.W. Adams, 2007, Geologic framework of the Mississippian Barnett Shale, Barnett – Paleozoic total petroleum system, Bend Arch–Fort Worth Basin, Texas: AAPG Bulletin, v. 91/4, p. 405–436.

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Acknowledgments

We thank Range Production Company for giving us permission to present these results. We also thank the staff of Premier Environmental Services Inc. for efficiently collecting a large number of water well samples, and Isotech Laboratories for measuring high-quality geochemical data on the natural gas dissolved in those water samples.

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Presentation Outline

- Introduction
- Evidence for the presence of native stray gas in the Trinity Aquifer
- Results from the water-well monitoring program
- Key observations and conclusions

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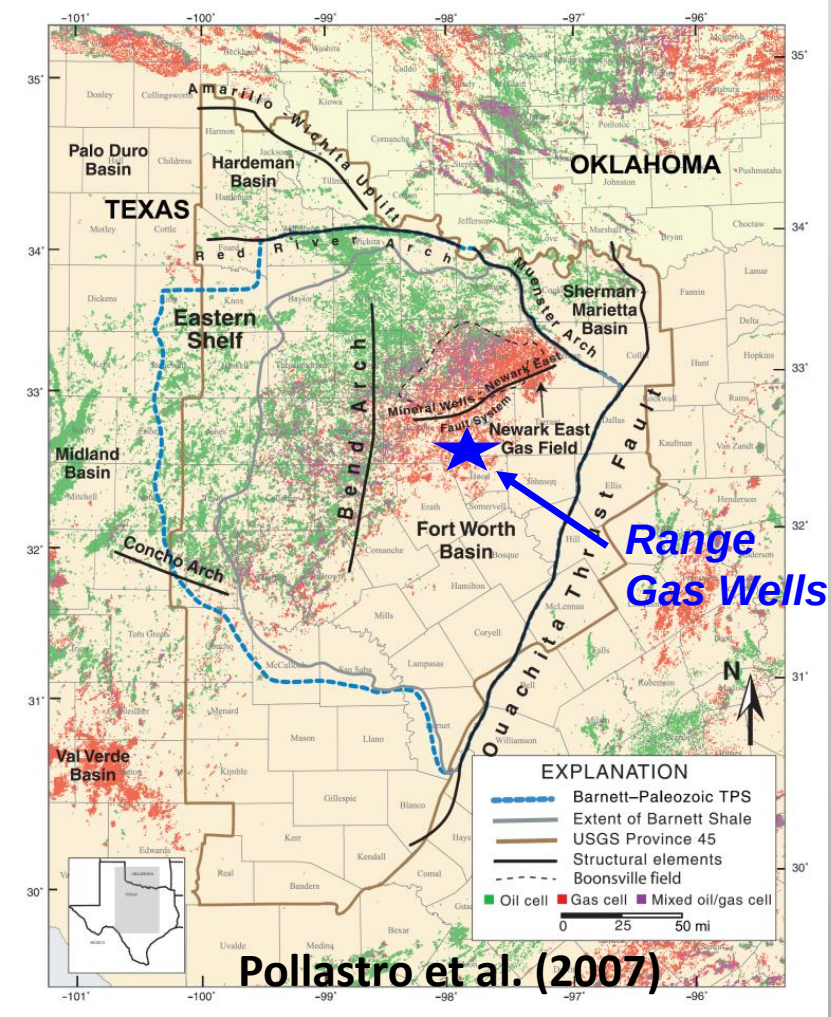
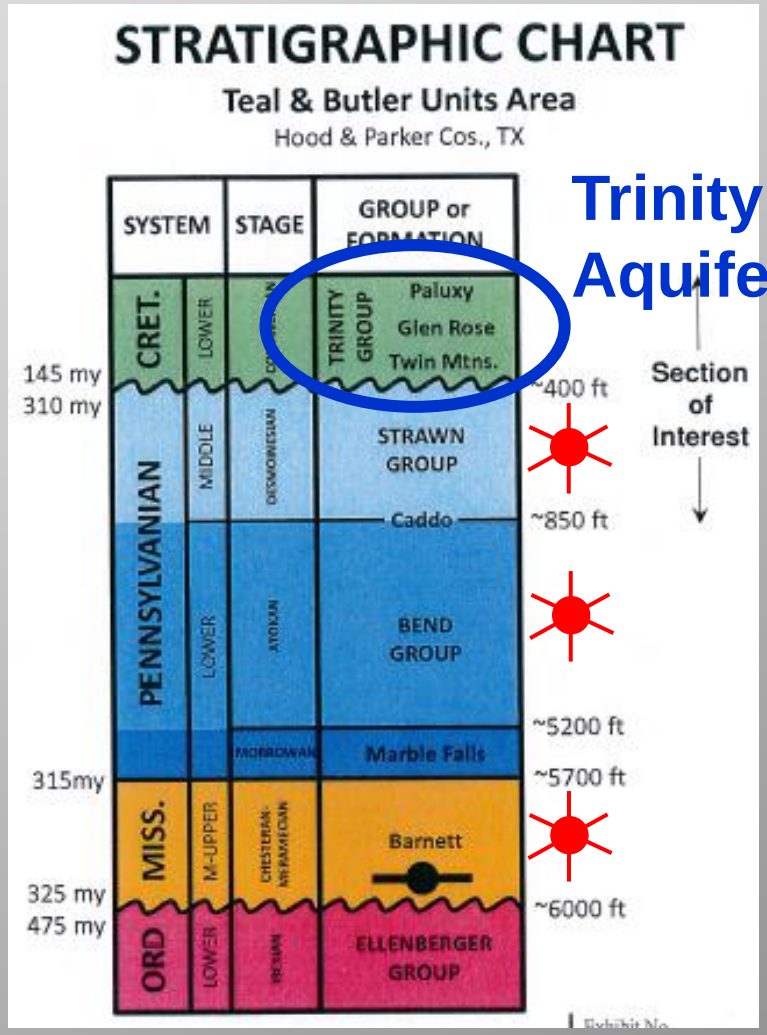
Stratigraphy and Petroleum Geology of the Ft Worth Basin





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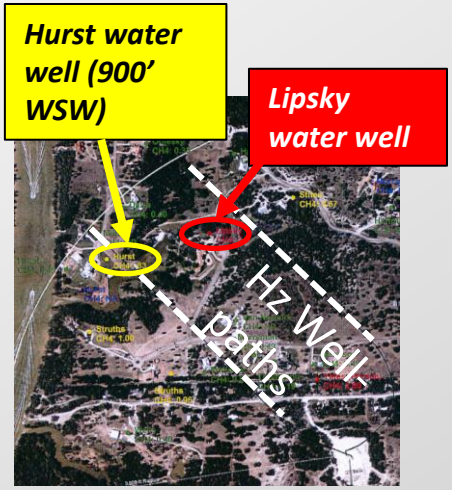
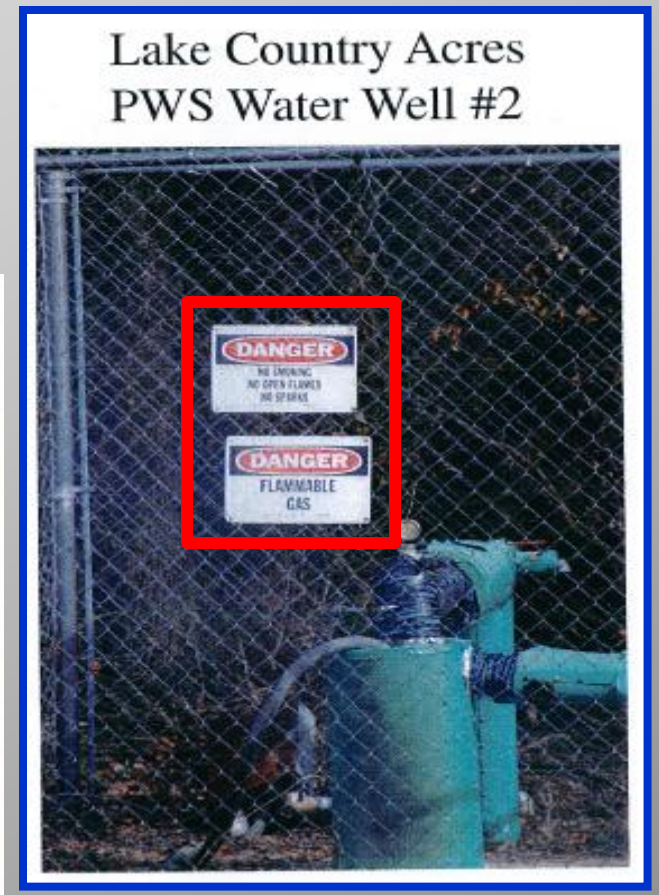
Chronology of Key Events and Outcome of the Case

- August 2009: Range Production Co. begins producing Barnett gas from two horizontal wells (Butler 1H and Teal 1H) drilled >5,000 ft below the Trinity Aquifer.
- August 2010: A local homeowner (Mr. Lipsky) complains that his water well now contains gas. The Texas RRC and the US EPA launch independent investigations.
- December 2010: EPA issues Emergency Administrative Order (EAO), concluding Range caused/contributed to the presence of methane and benzene in the two water wells. EPA bases decision on C and H isotopic composition of methane.
- January 2011: TRRC holds public hearing to determine if Range gas wells caused or contributed to contamination of water wells. EPA and Mr. Lipsky do not attend.
- March 2011: TRRC rules Range gas wells have not contaminated water wells.
- March 2012: EPA withdraws EAO against Range Production Company. Range voluntarily implements a program to monitor dissolved gas in nearby water wells.
- Currently: Mr. Lipsky and several neighbors continue to allege that production from Barnett gas wells is responsible for natural gas dissolved in their water wells.

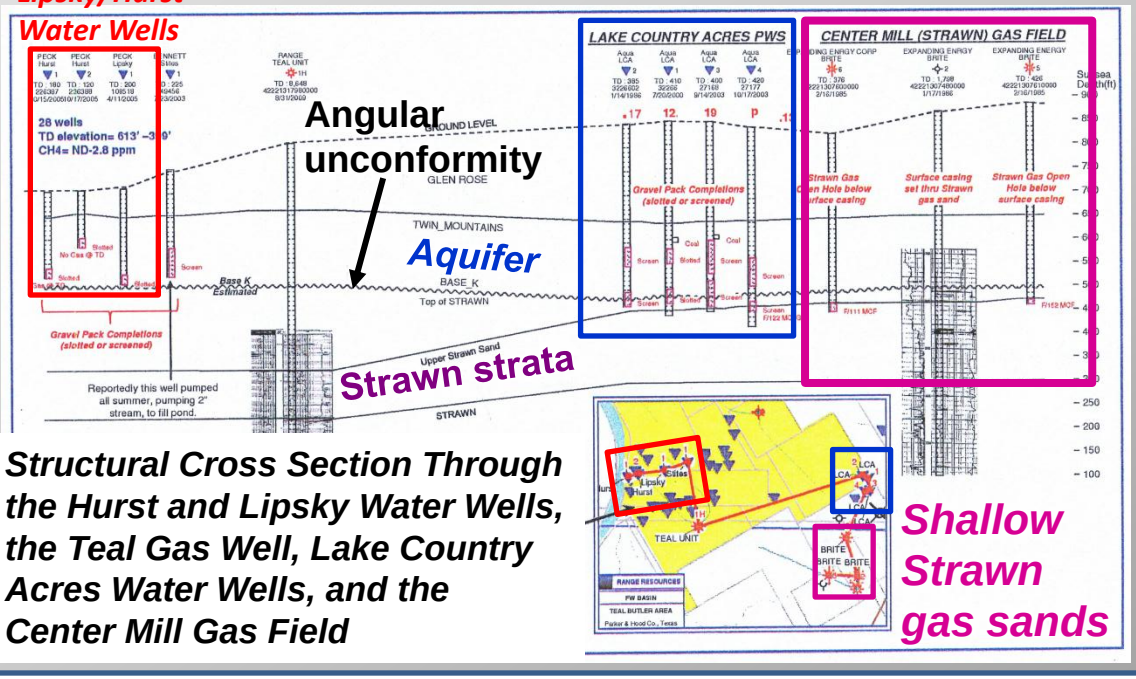
The Trinity Aquifer Contains Stray Gas That Migrated from Strawn Strata Across an Angular Unconformity



A water well inadvertently drilled into the Strawn in 2003 flowed 122,000 cf gas/day before it was P&A.



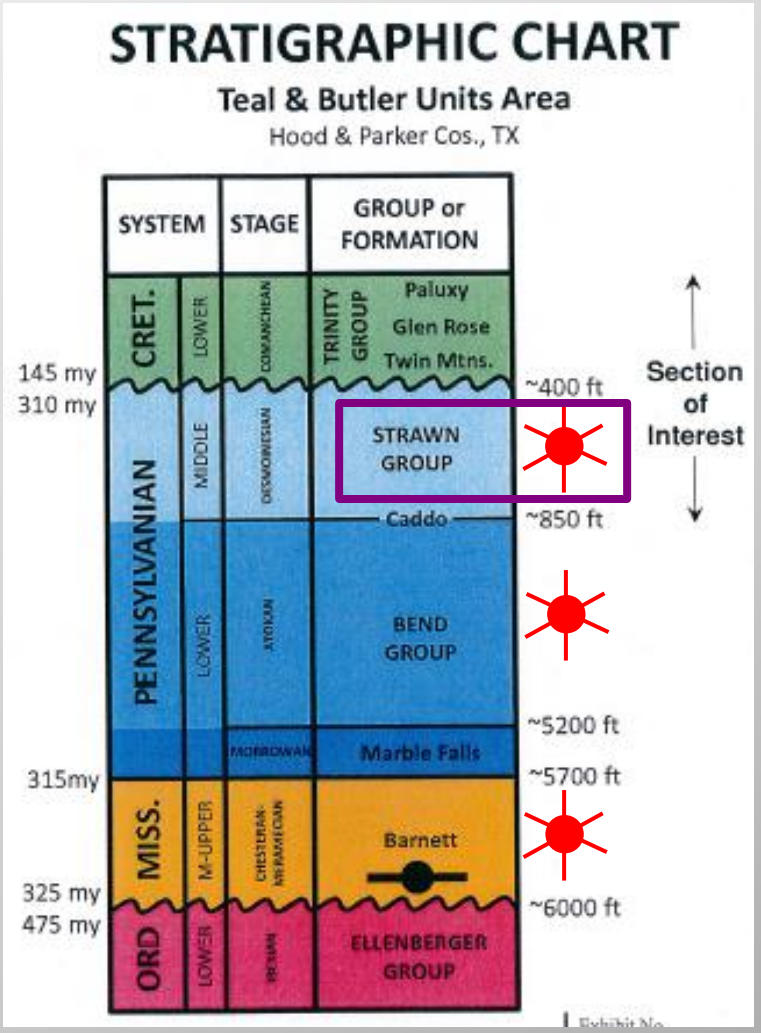
Lipsky/Hurst Water Wells

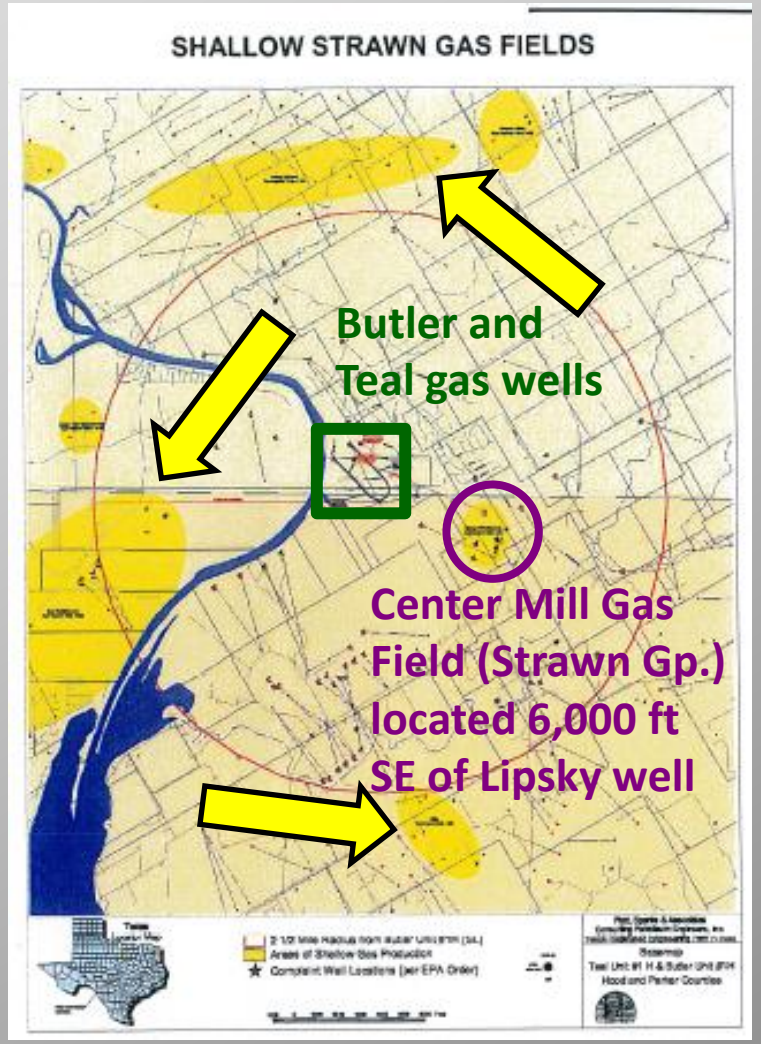


Structural Cross Section Through the Hurst and Lipsky Water Wells, the Teal Gas Well, Lake Country Acres Water Wells, and the Center Mill Gas Field

The Trinity Aquifer Contains Stray Gas That Migrated from Strawn Strata Across an Angular Unconformity

Several Shallow Strawn Gas Fields Occur in This Area

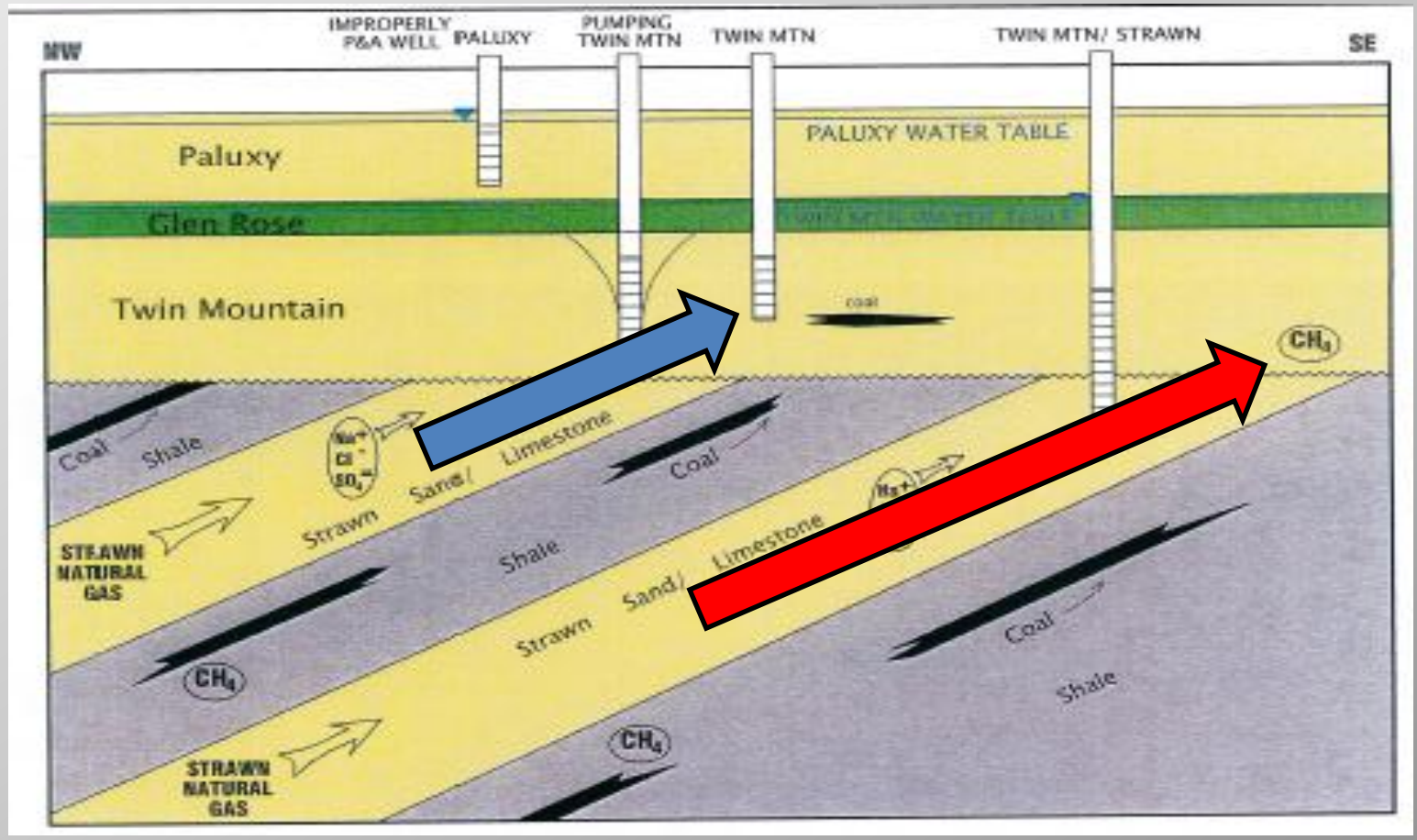




The Trinity Aquifer Contains Stray Gas That Migrated from Strawn Strata Across an Angular Unconformity

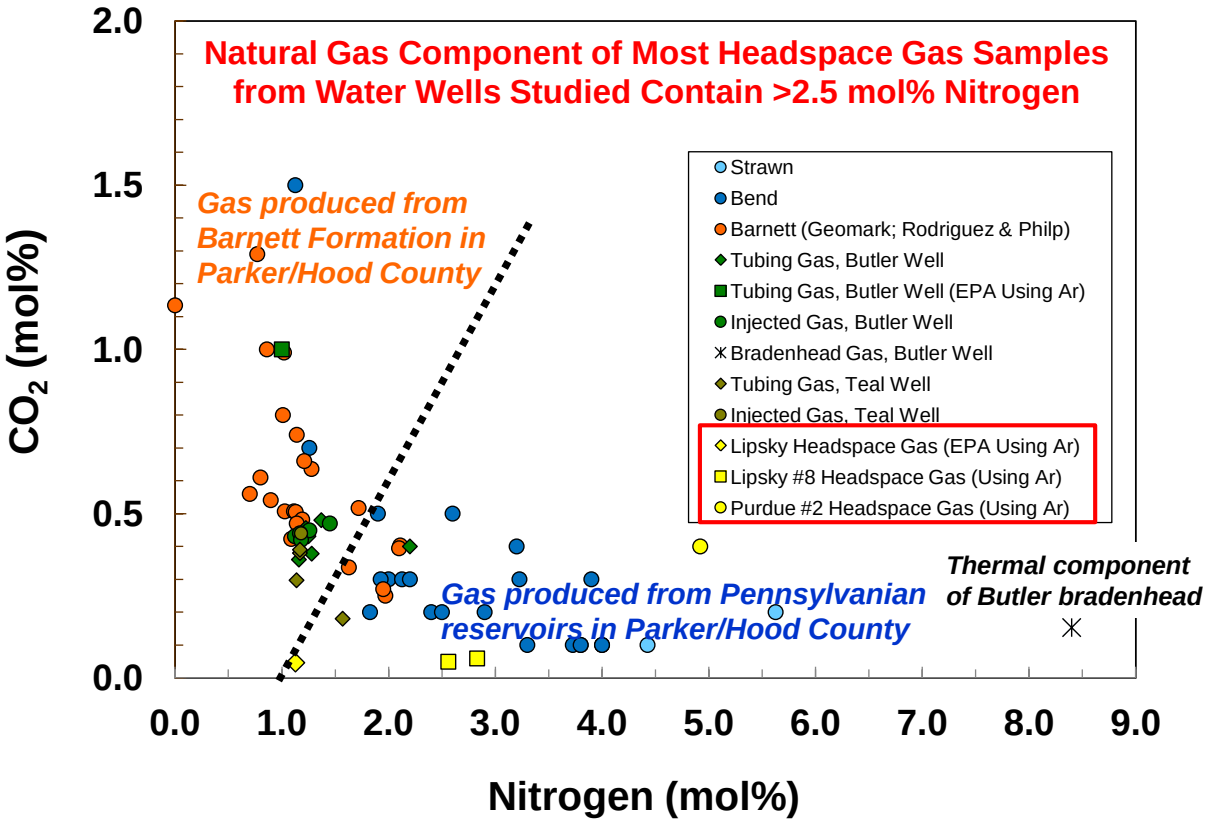
Hydrogeology of the Trinity Aquifer

Natural Gas and Brine Migrate from Strawn Sandstones into the Trinity Aquifer Across an Angular Unconformity



Geochemical Evidence That Natural Gas Collected from the Lipsky Water Well Originated in the Strawn Group

Using Gas Fingerprinting Technology to Determine the Origin of Stray Gas in the Trinity Aquifer



Biodegradation Influences the Molecular and C Isotopic Composition of Thermal Gas

- **Microbes metabolize ethane, propane, and n-butane relative to methane.**
- **Microbes metabolize HC compounds that contain isotopically-light C (^{12}C) relative to the same gas compounds that contain isotopically-heavy C (^{13}C).**
- **Compared to unaltered natural gas, thermal gas that is biodegraded:**
  - **Has higher methane/ethane and methane/propane ratios**
  - **Contains residual ethane and/or propane that are enriched in isotopically-heavy C: i.e., exhibit relatively low $\delta^{13}C$ values.**

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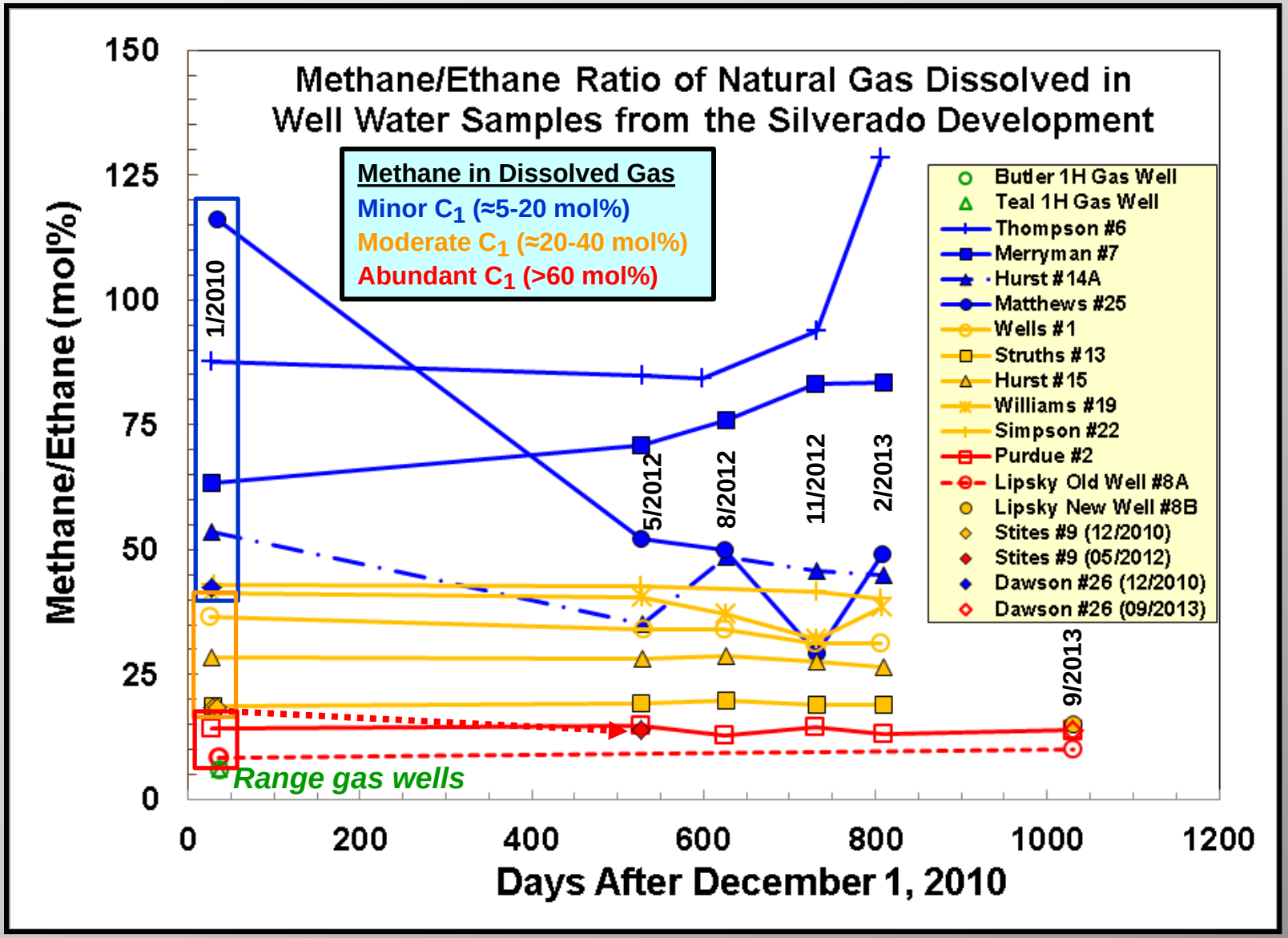

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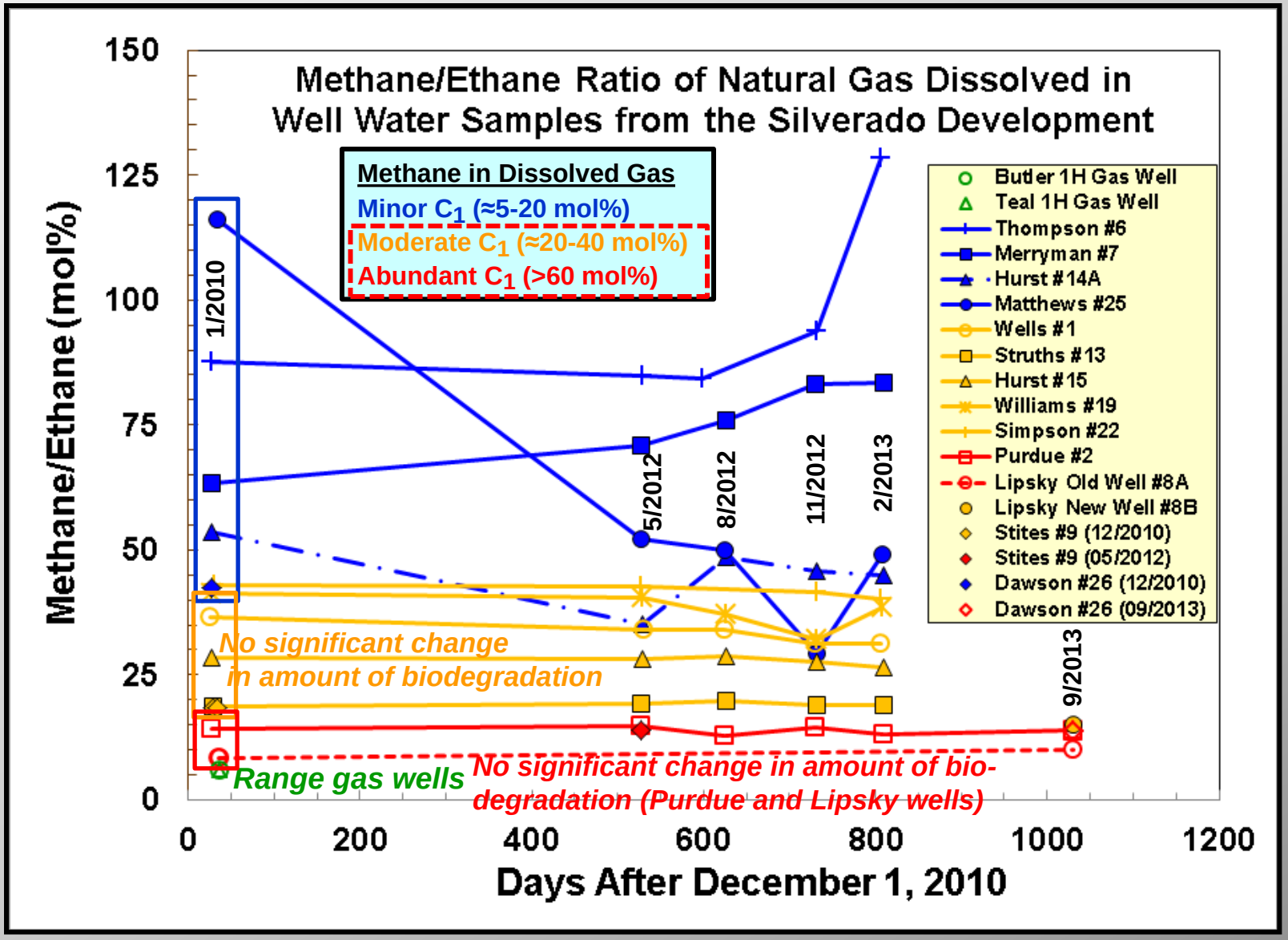

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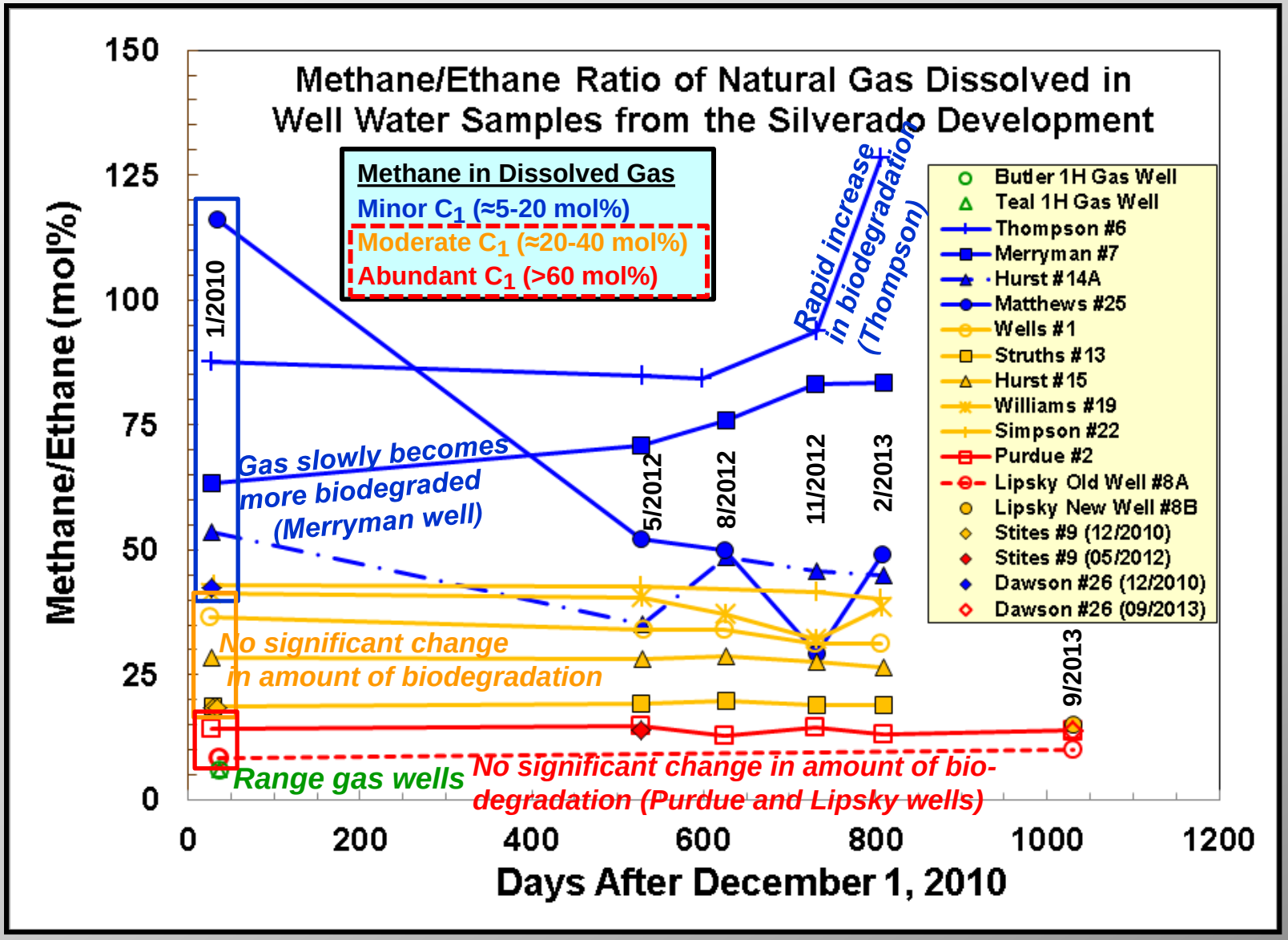

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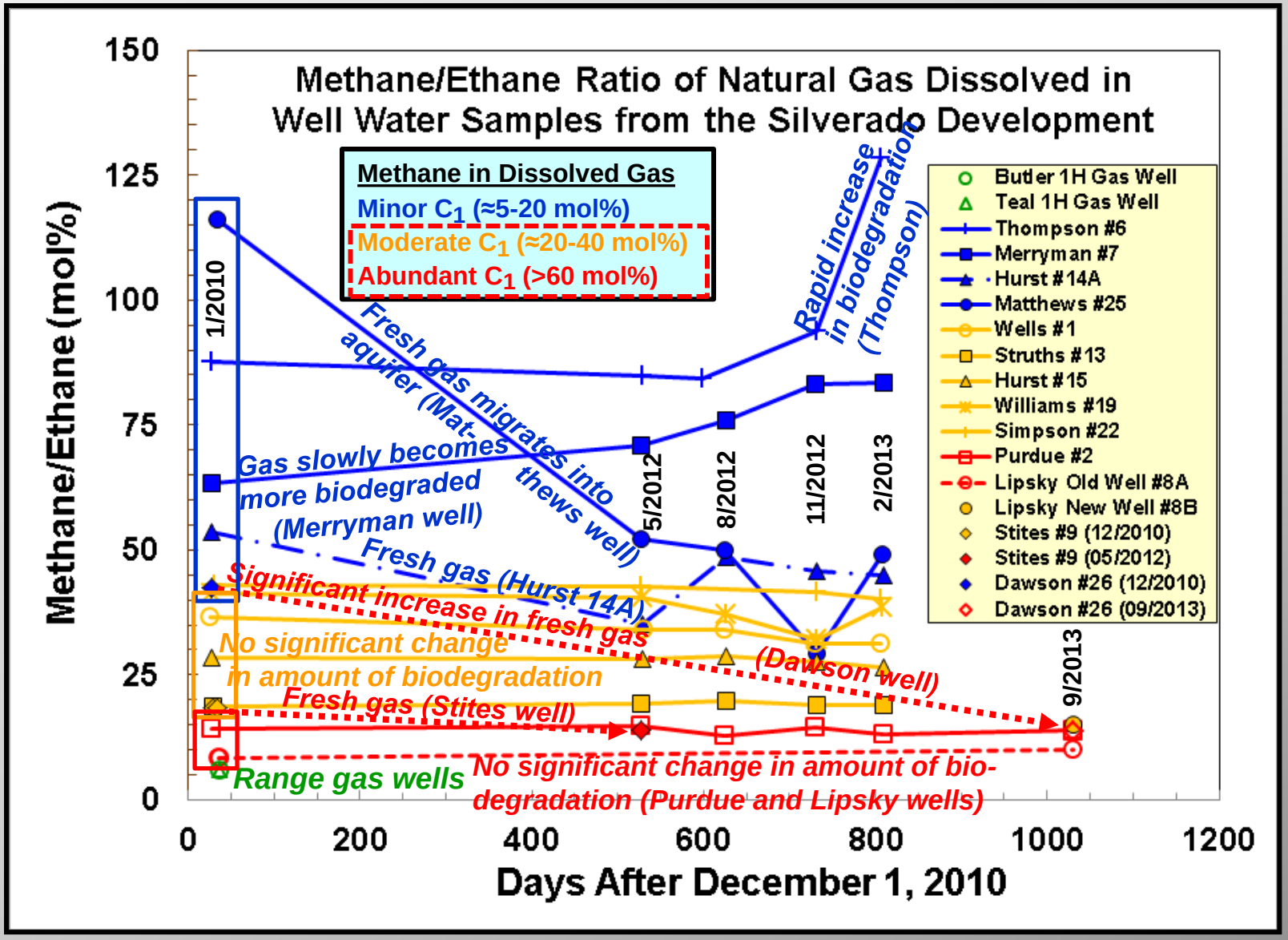

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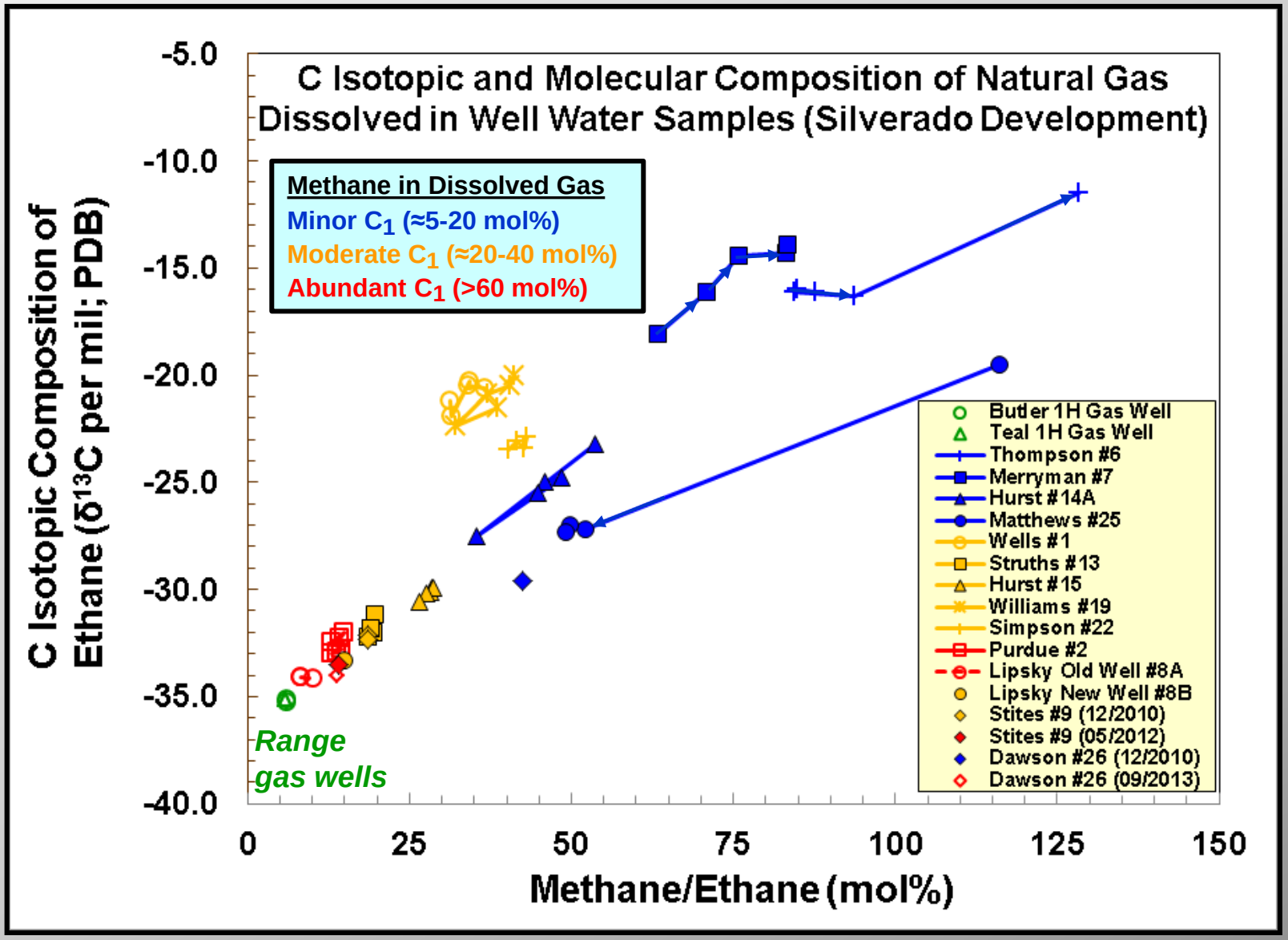

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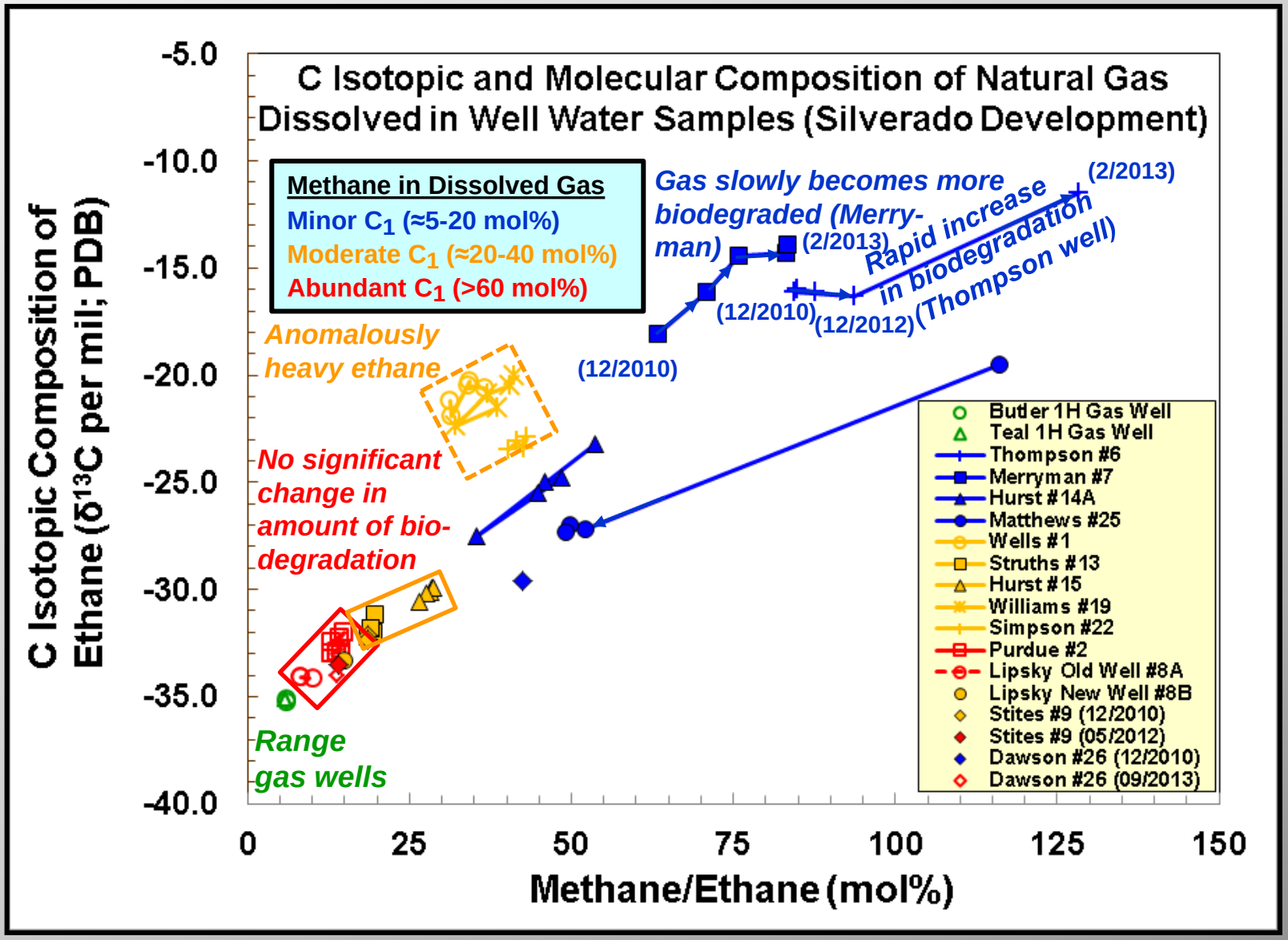

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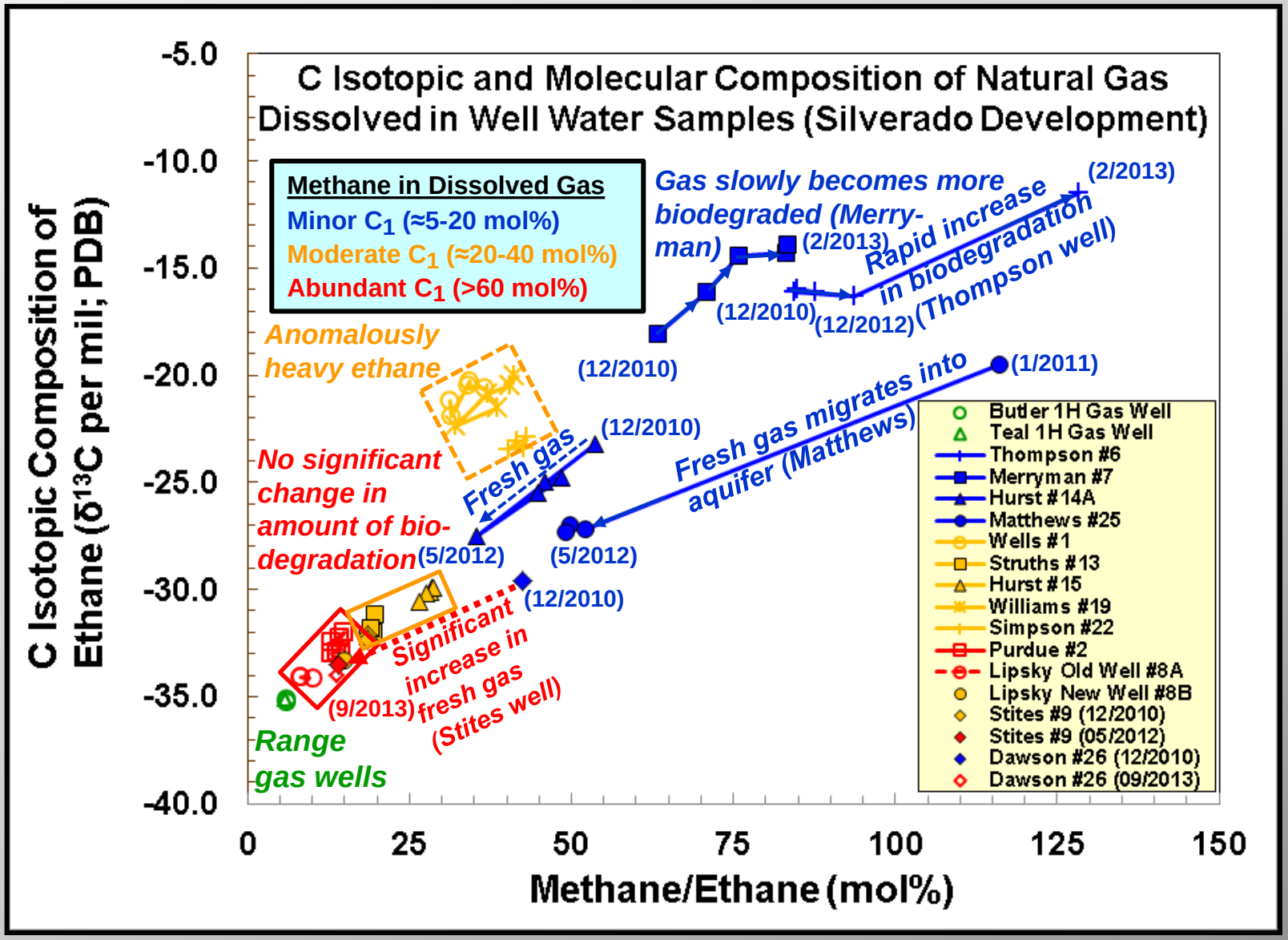
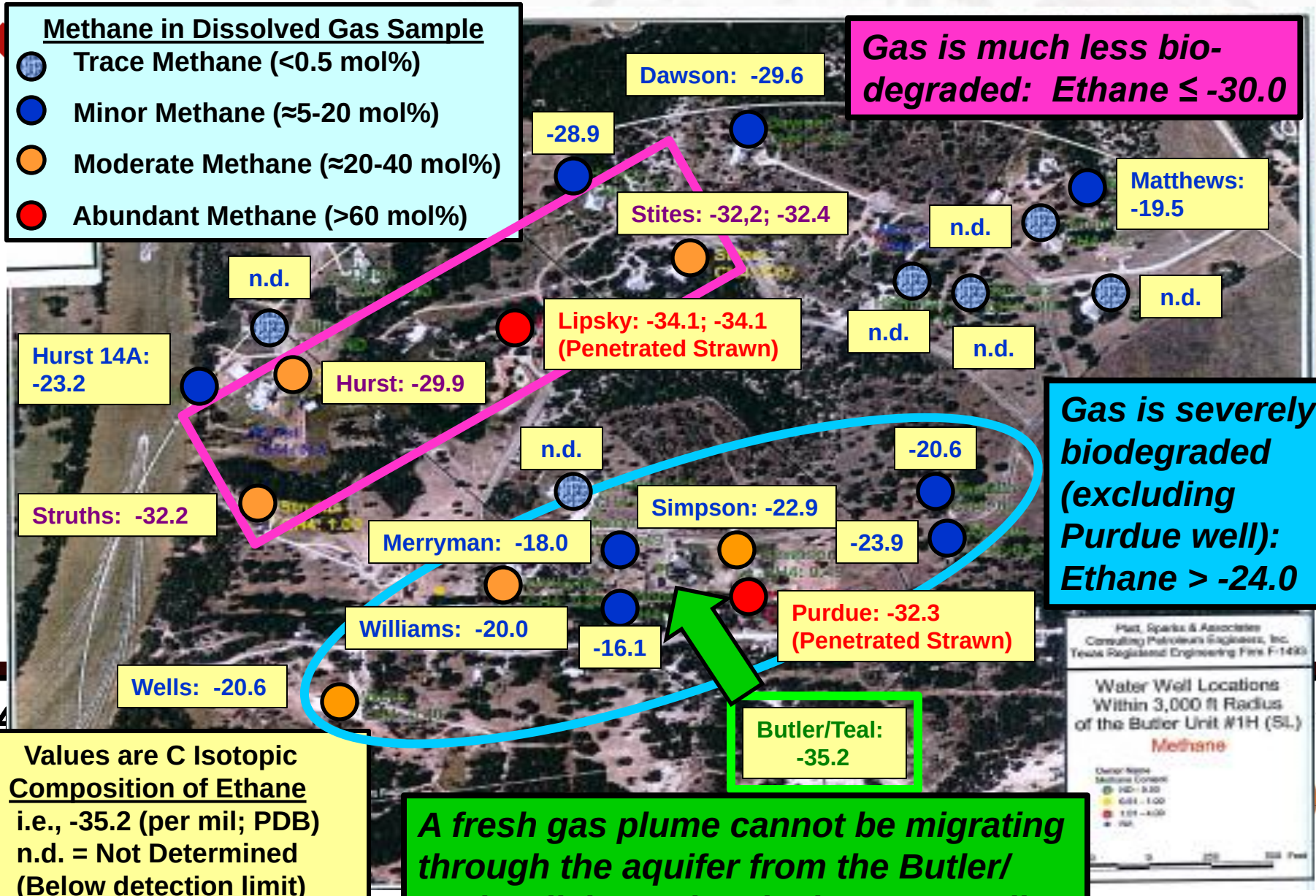
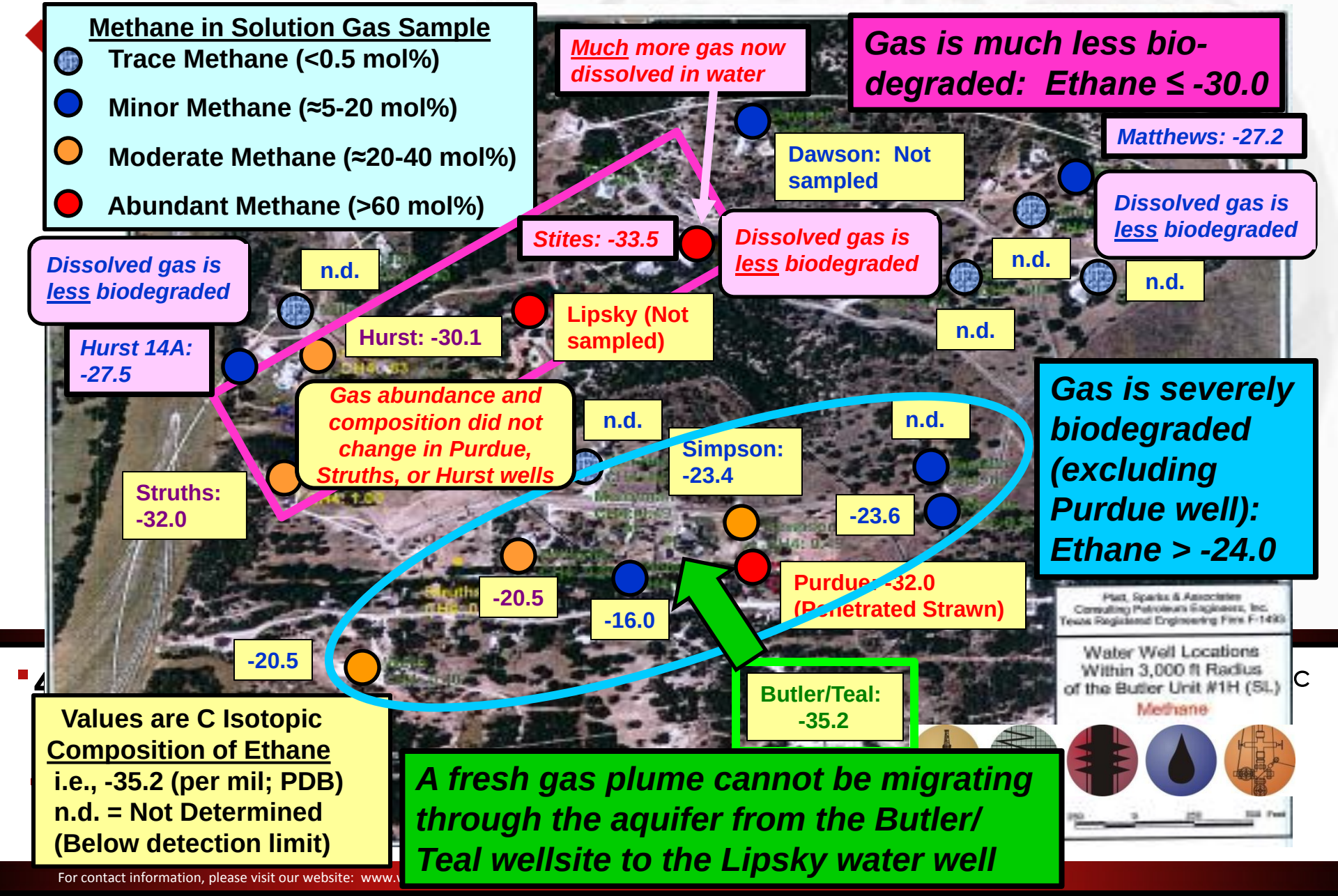


January 2011: Distribution of Biodegraded Gas in Water Samples Proves A Gas Plume Is Not Migrating Through the Aquifer from Range Wells to Lipsky Water Well



May 2012: Gas Dissolved in Stites, Hurst (14A), and Matthews Water Wells Is Less Biodegraded. Gas Dissolved in Merryman Water Well Is More Biodegraded.



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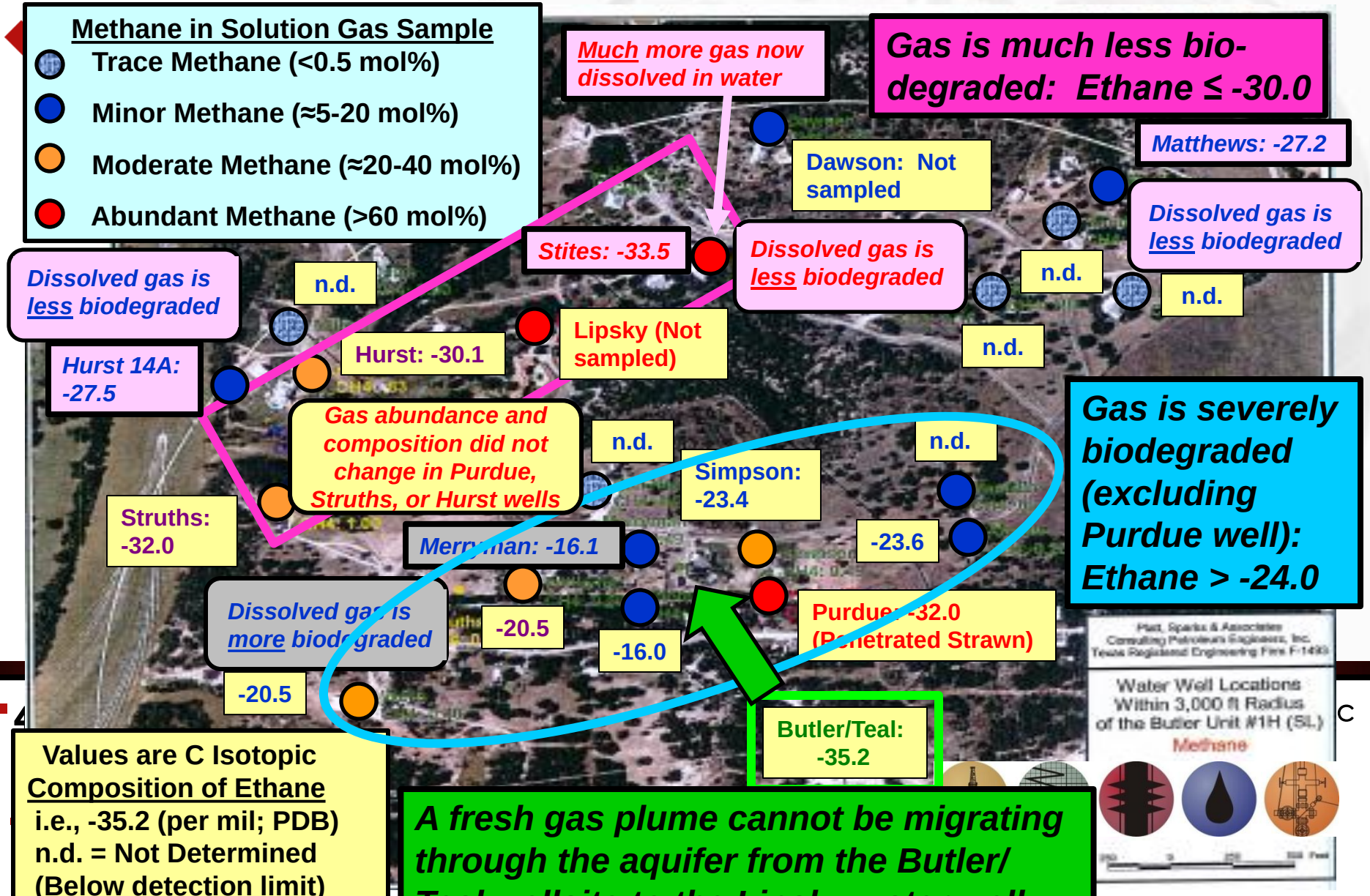
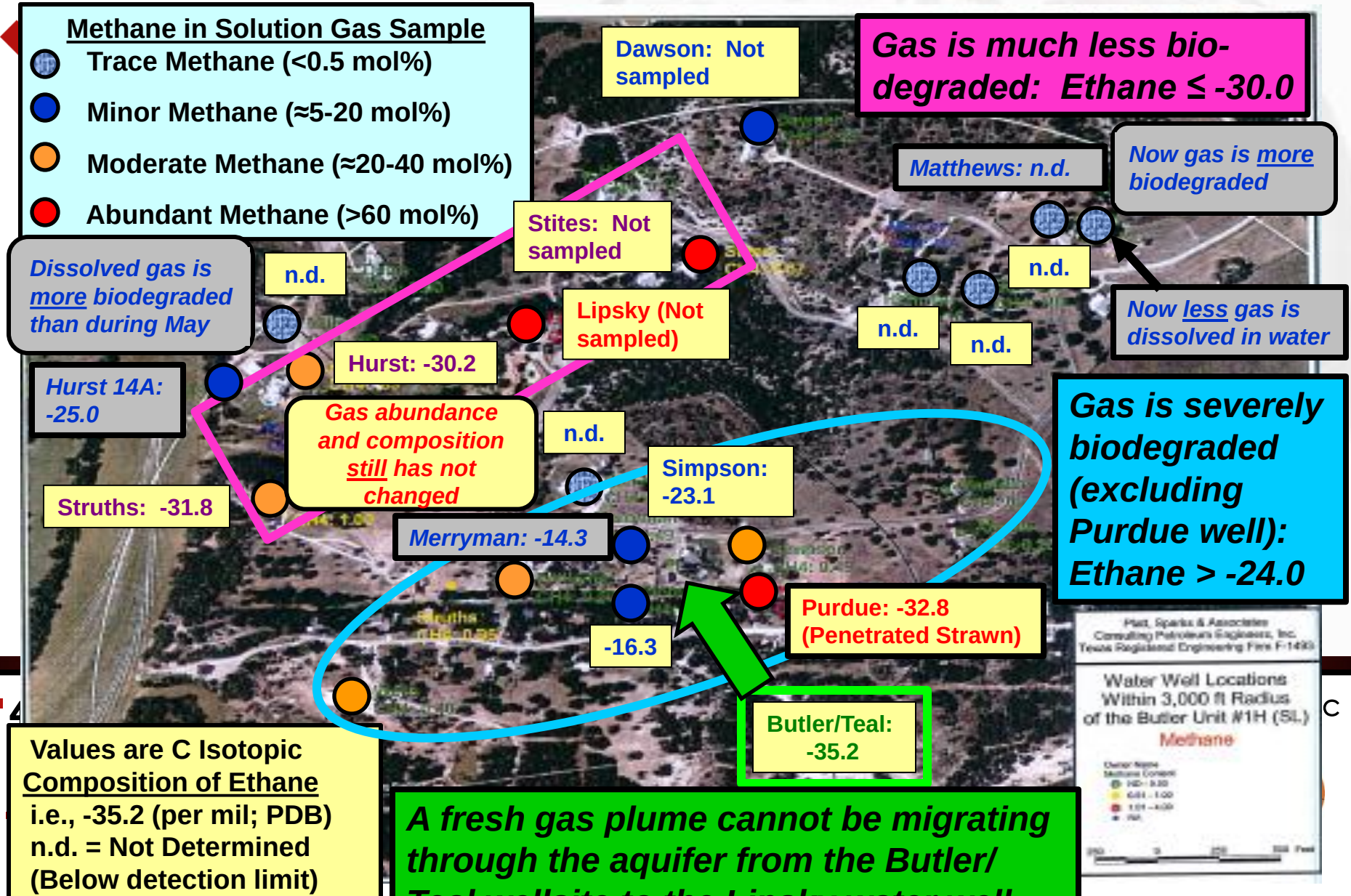


December 2012: Gas in Merryman, Matthews, and Hurst (14A) Water Wells Is More Biodegraded; Gas in Williams and Wells Water Wells Is Less Biodegraded



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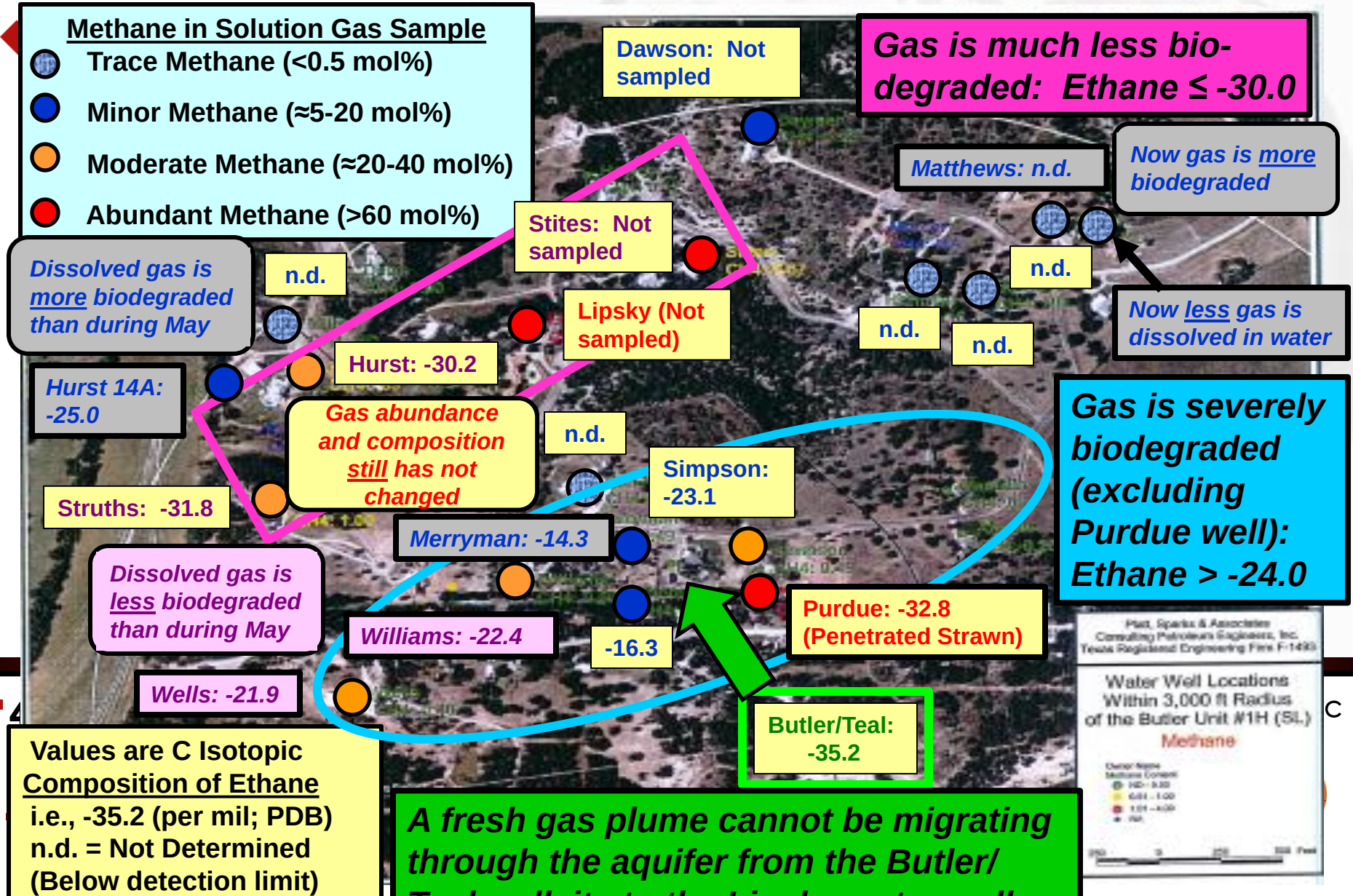
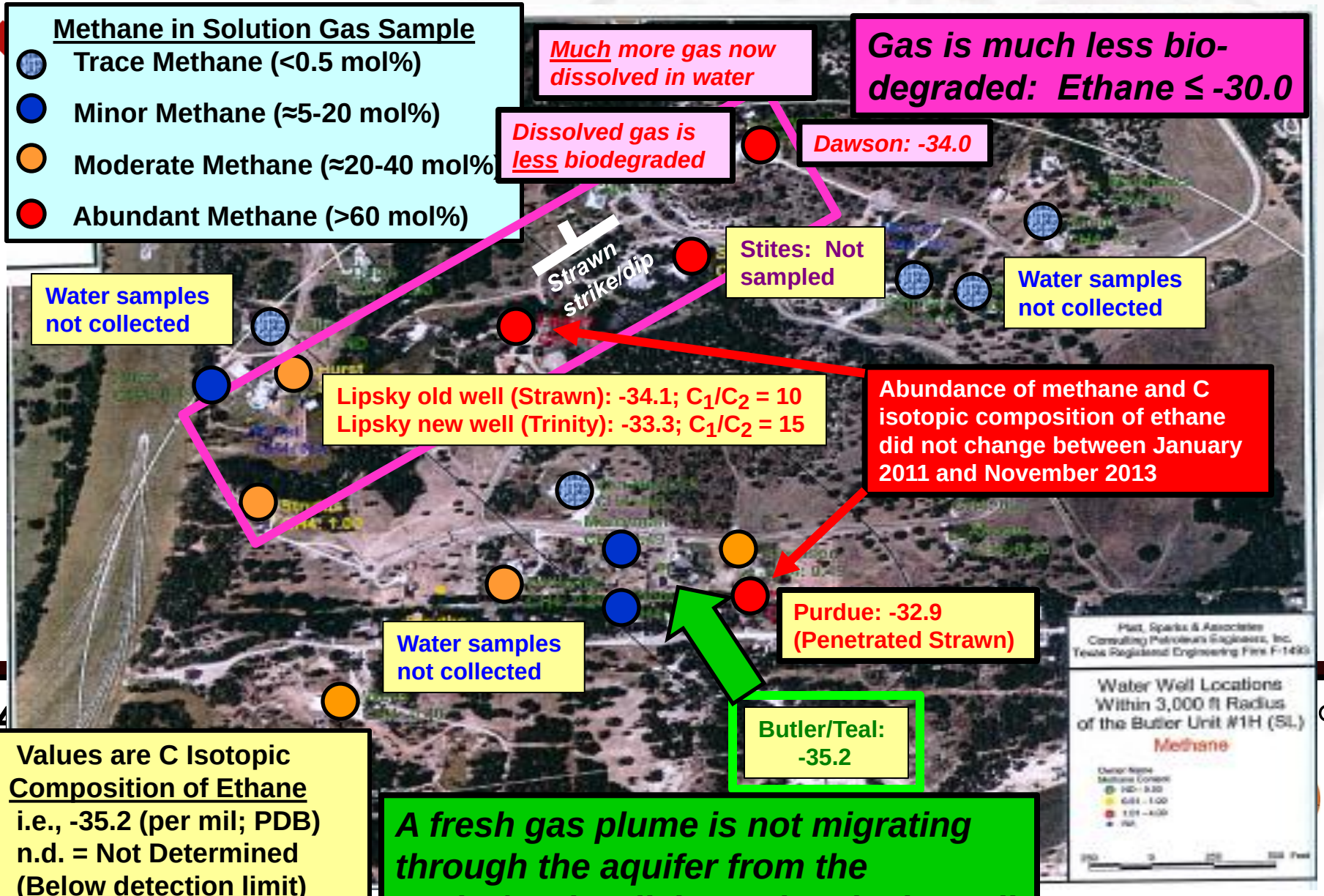


November 2013: The Dawson Well Now Contains Much More Dissolved Gas That Is Less Biodegraded Than During January 2011.



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Key Observations and Conclusions

- **Moderate to high concentrations of dissolved methane and isotopically-light ethane present in water wells NE and SW of Lipsky residence. Thermal gas in those wells significantly less biodegraded than gas in most water wells between them and Butler/Teal wellpad.**
- **The gassy water wells form a linear array parallel to the strike of Strawn strata below the unconformity. Fresh gas that migrates periodically from Strawn into the Trinity Aquifer becomes biodegraded.**
- **Purdue water well drilled into Strawn strata also contains fresh thermal gas.**
- **Carefully monitor aquifers that contain stray gas to understand its origin and fate.**