

Stream Monitoring for Estimating Methane in Groundwater Discharge to Streams – *Lessons Learned From a Pilot Study in Northern Pennsylvania*



Collaboration

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Stream Measurements Locate Thermogenic Methane Fluxes in Groundwater Discharge in an Area of Shale-Gas Development

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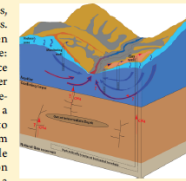
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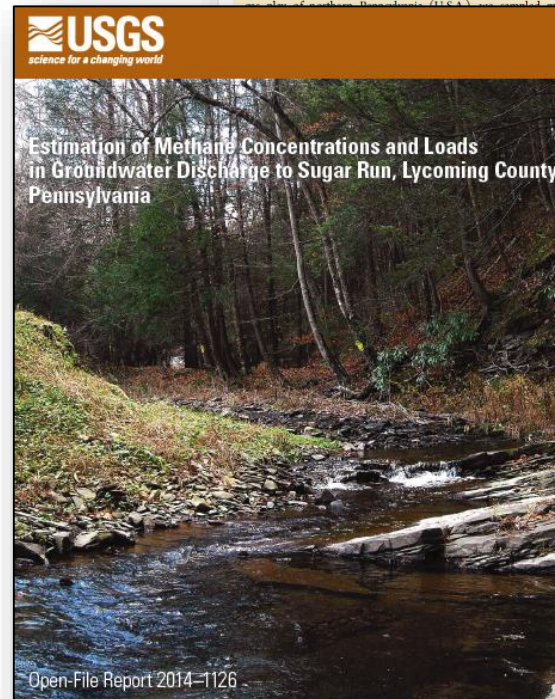
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Supporting Information

ABSTRACT: The environmental impacts of shale-gas development on water resources, including methane migration to shallow groundwater, have been difficult to assess. Monitoring around gas wells is generally limited to domestic water-supply wells, which often are not situated along predominant groundwater flow paths. A new concept is tested here: combining stream hydrocarbon and noble-gas measurements with reach mass-balance modeling to estimate thermogenic methane concentrations and fluxes in groundwater discharging to streams and to constrain methane sources. In the Marcellus Formation shale-gas development in Lycoming County, Pennsylvania (USA), we sampled methane in 15 streams as a

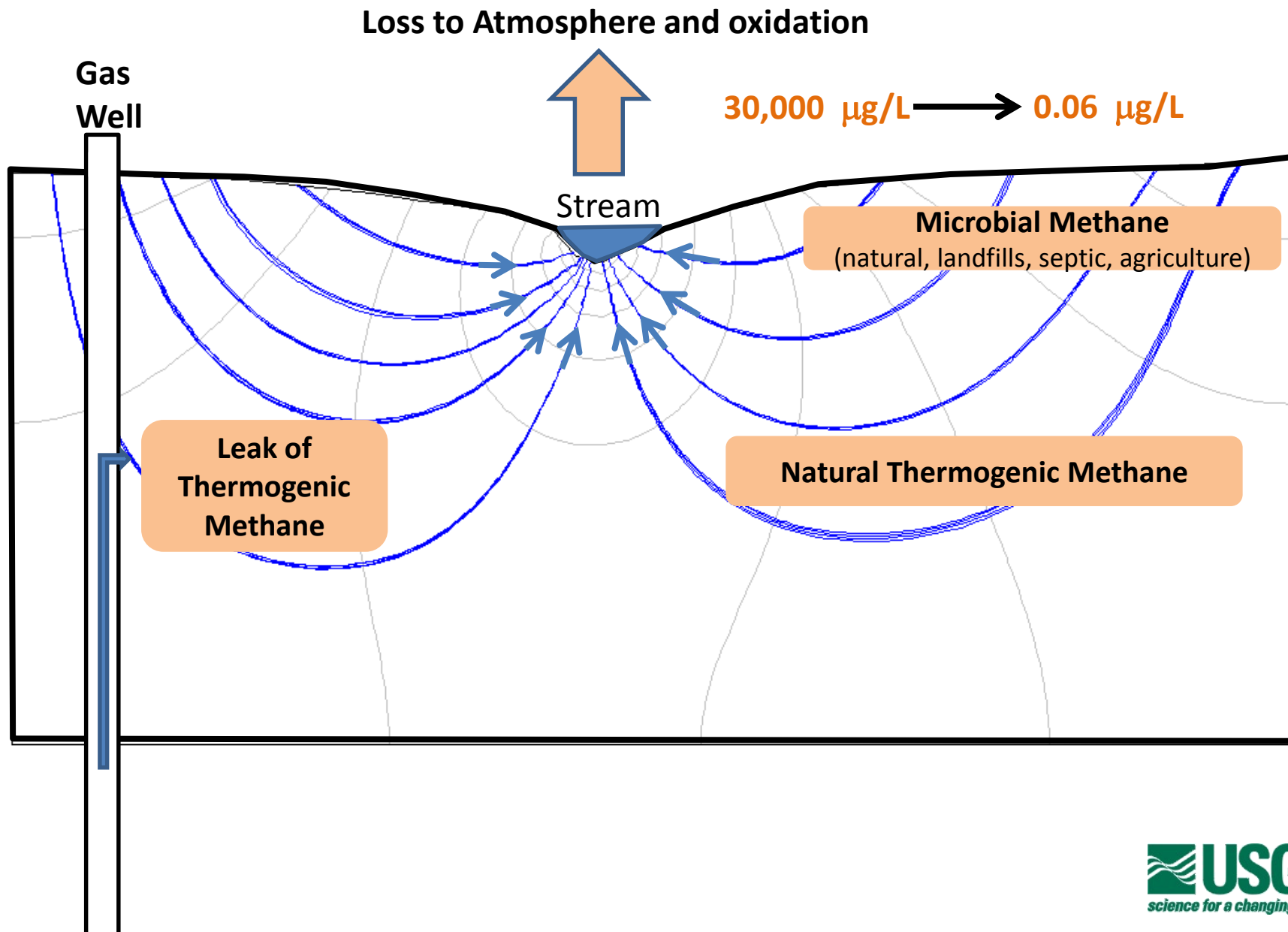


range: concentrations up to 100 ppm. Geochemical analyses of water from these streams are consistent with Middle Devonian shale-gas discharge. A regulatory investigation well, modeling indicates a discharge of methane into Sugar Run, possibly from this fugitive gas source. This study shows that stream methane monitoring provides the first watershed-scale method to



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Base Flow of Gaining Stream

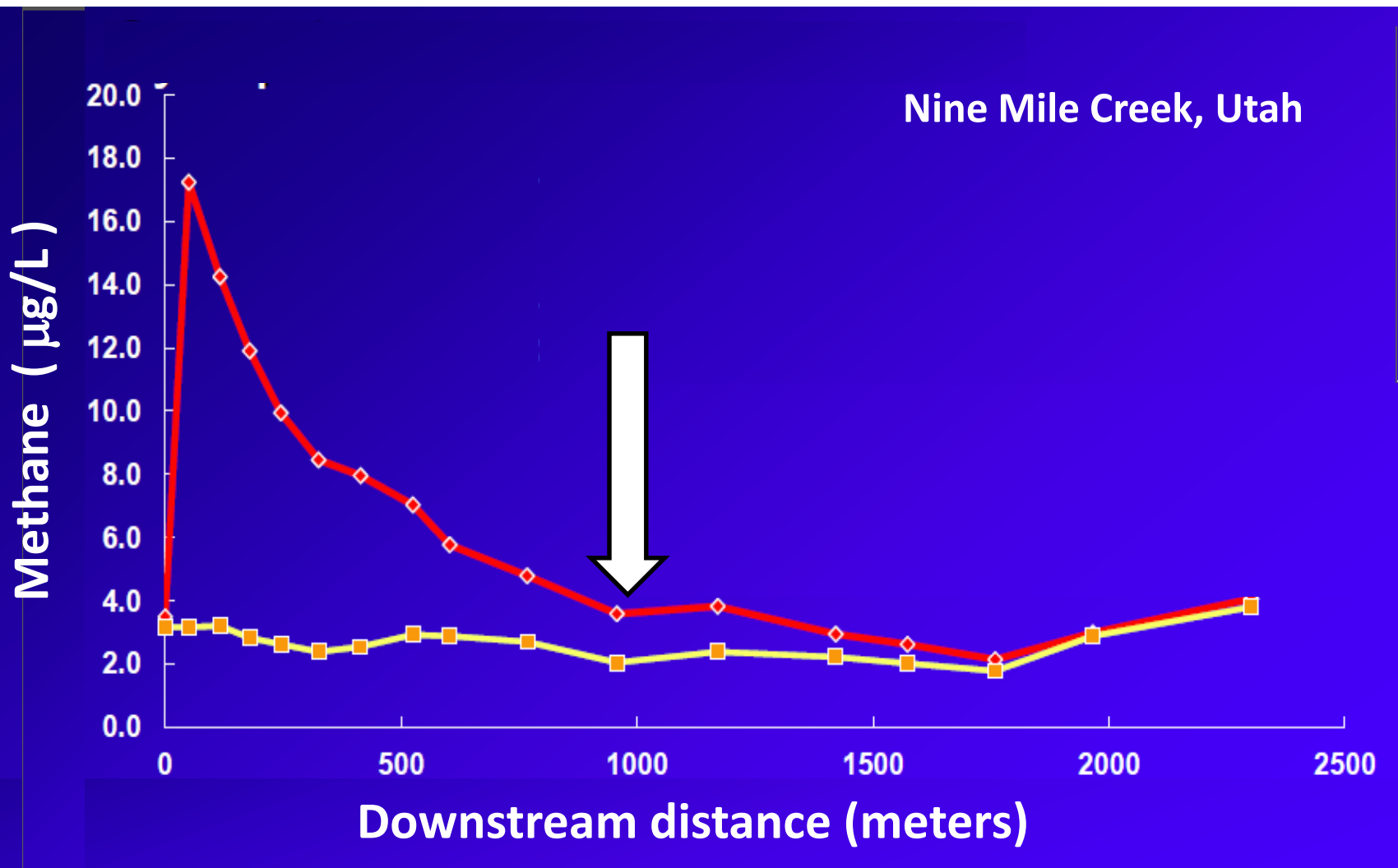


Methane Tracer Test

Nine Mile Creek, Utah

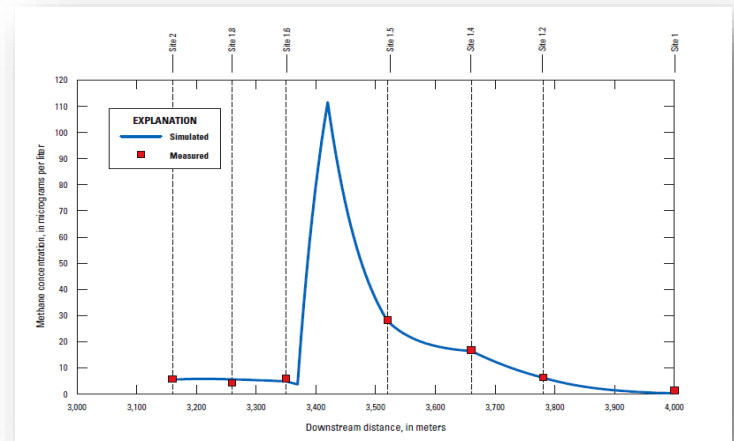


Persistence of Methane in Stream

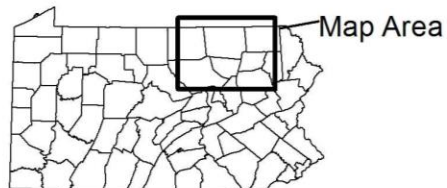
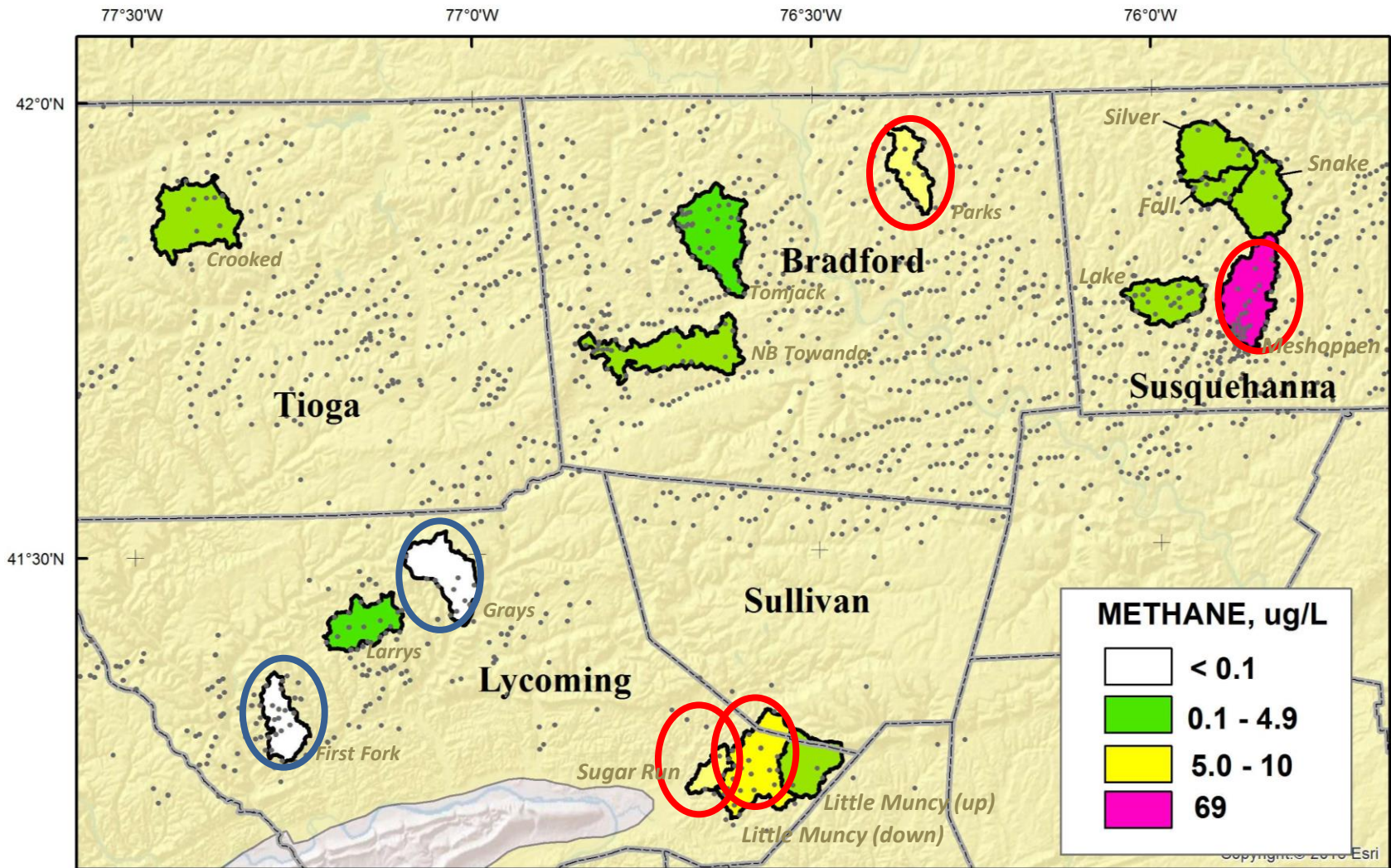


Objectives of Pilot Study in PA

- Determine range of methane concentrations in streams in northern PA.
- Estimate methane loads and concentrations with detailed monitoring and modeling

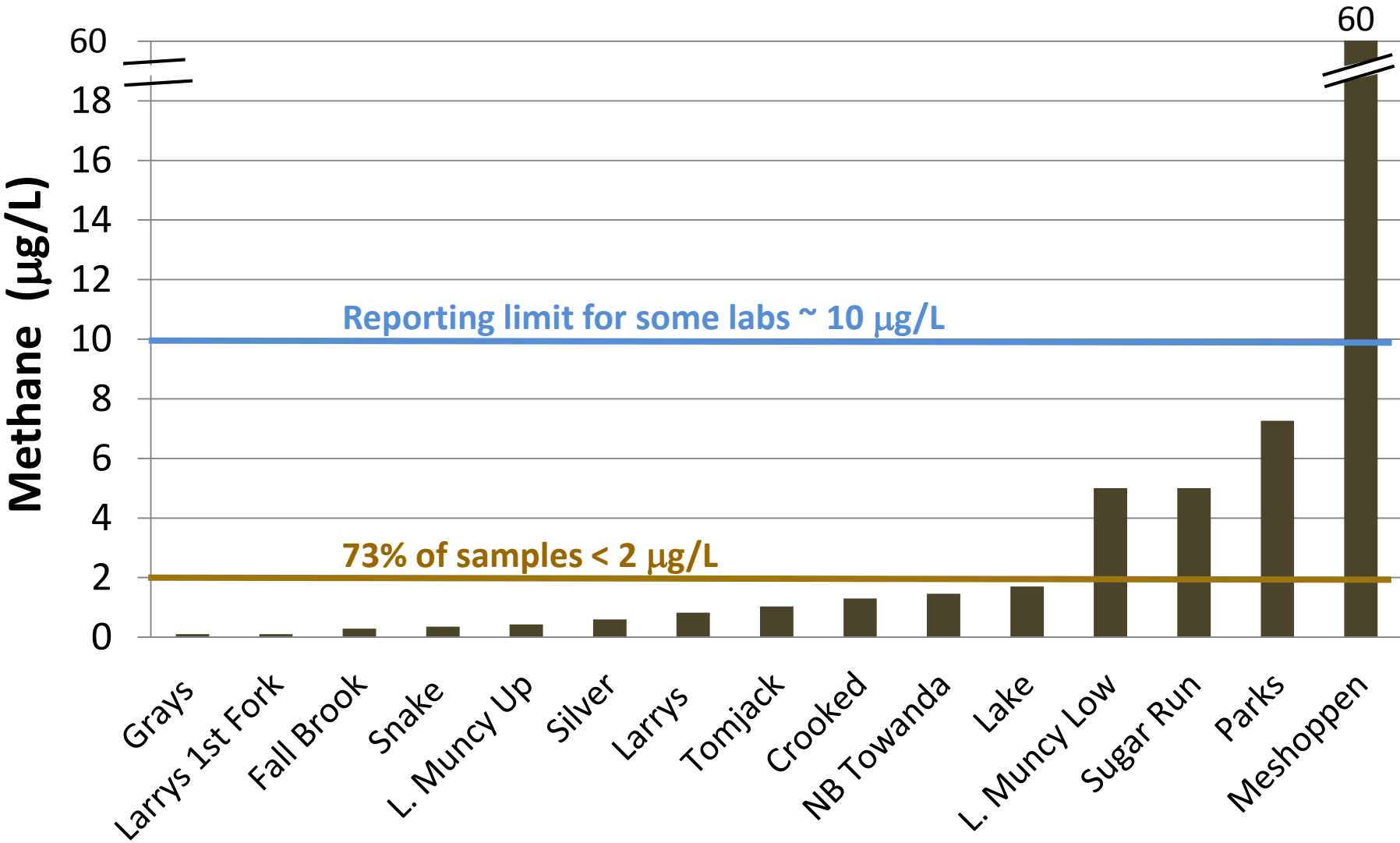


Reconnaissance of 15 Streams

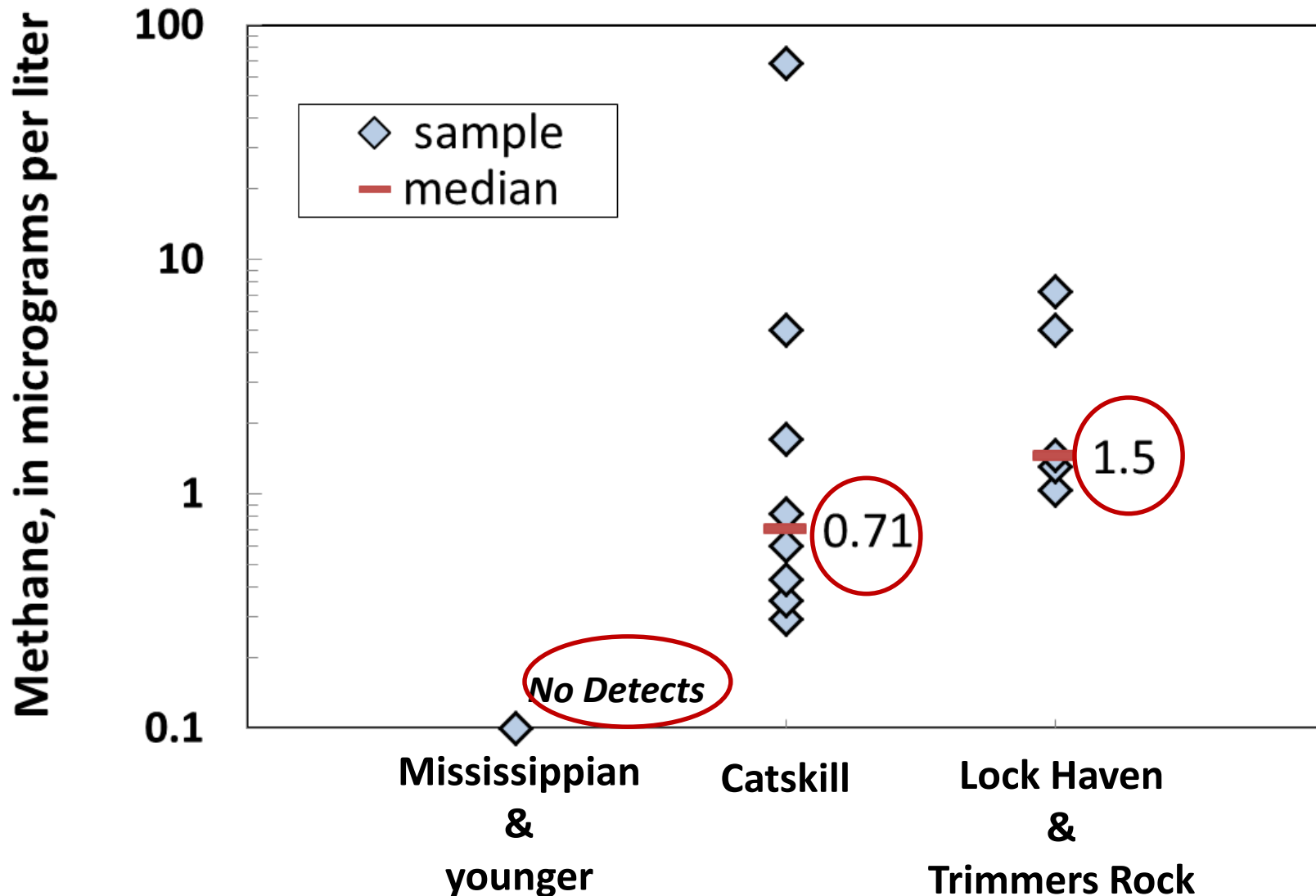


Area underlain by Marcellus Shale

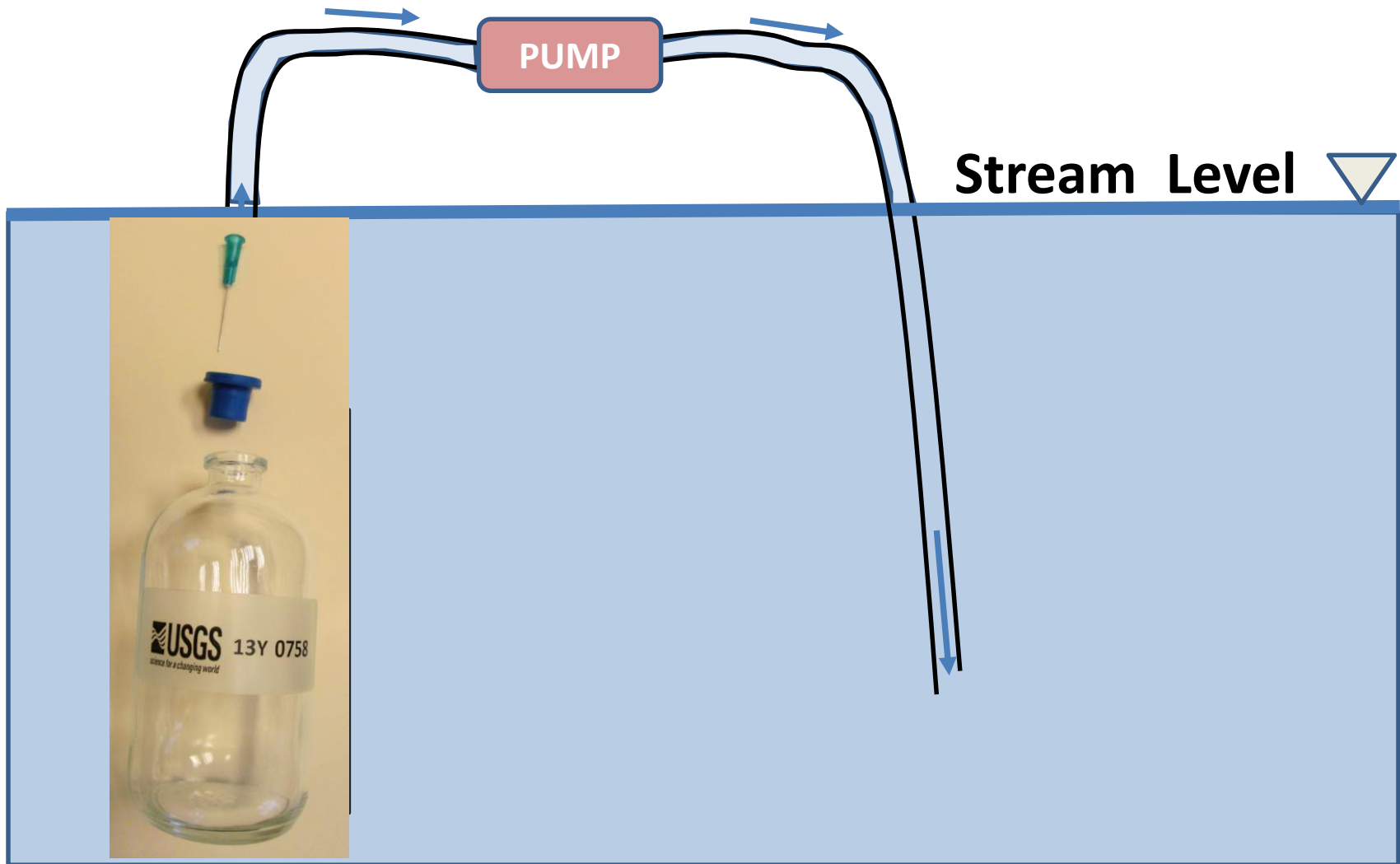
Methane Concentrations in 15 Streams



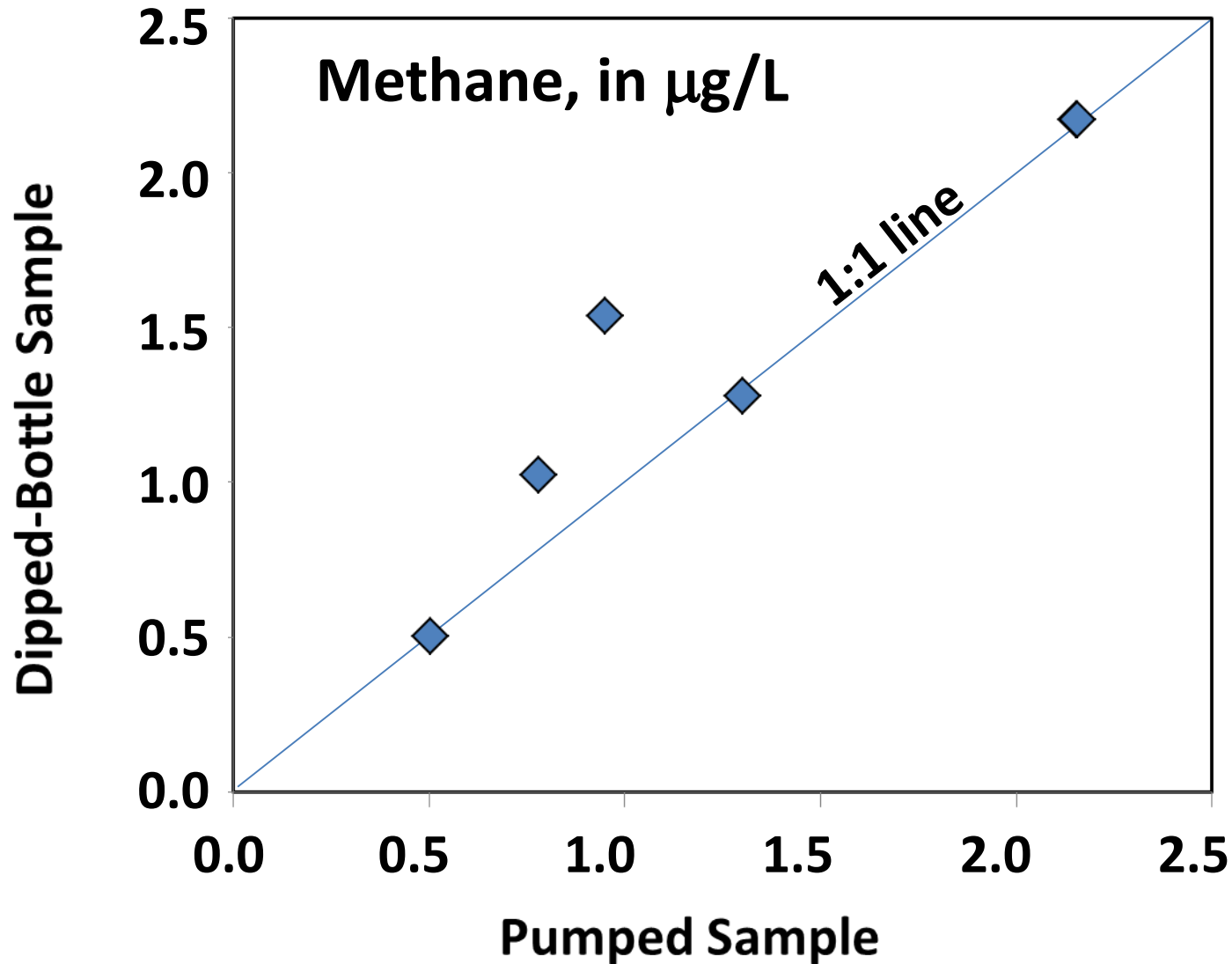
Methane and Geologic Units



Sampling

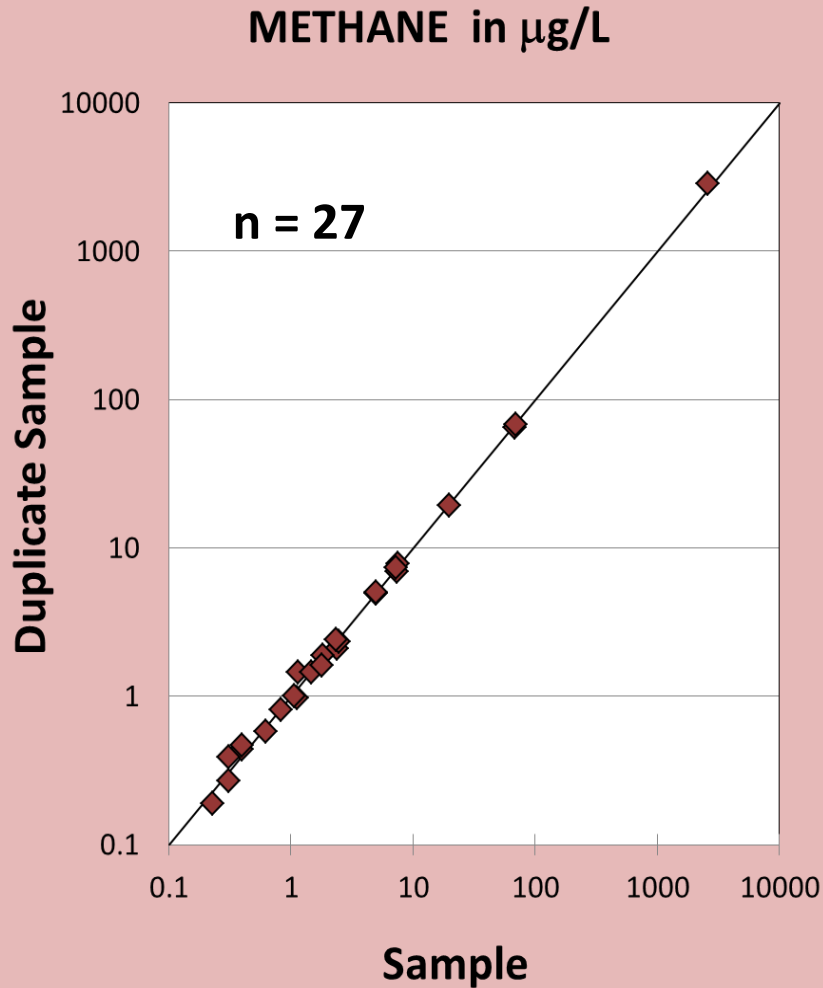


Easier Sampling Protocol?

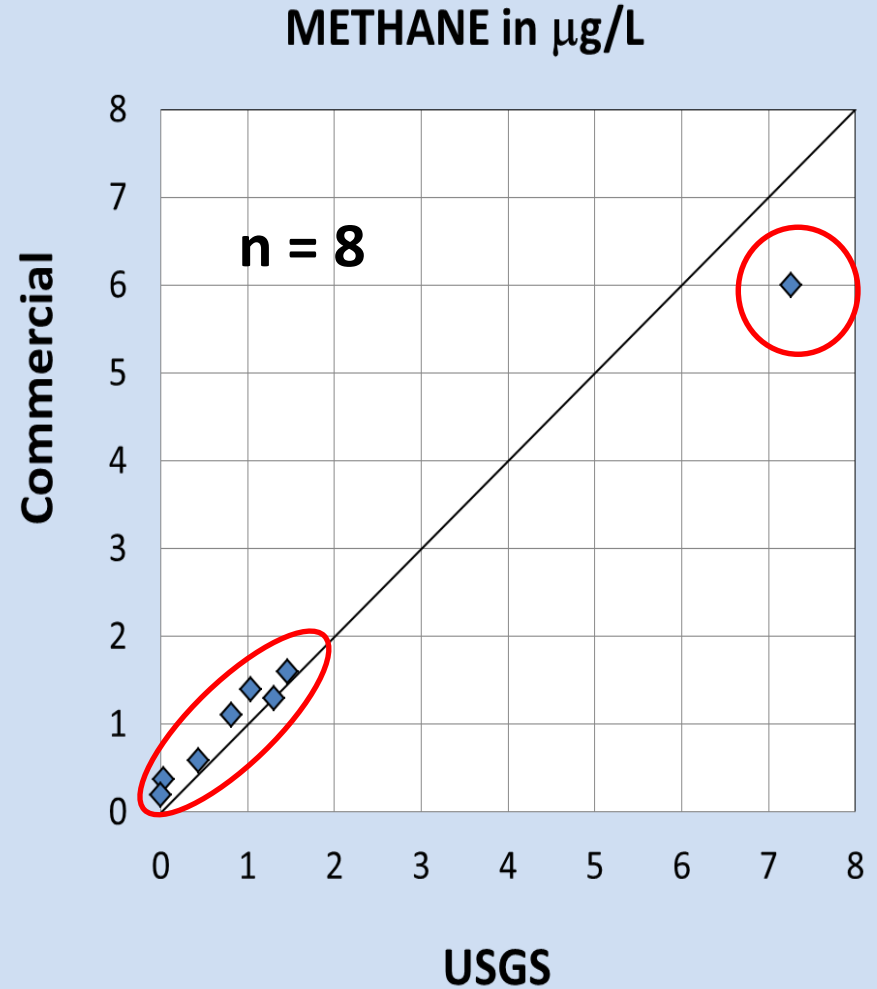


QA of Sampling

USGS Precision

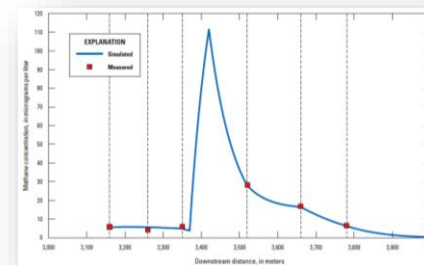
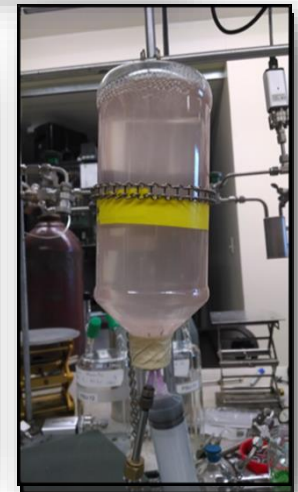


Compare Labs

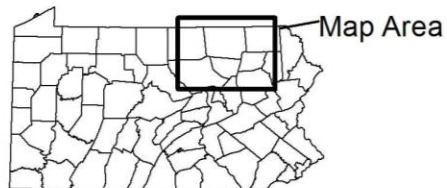
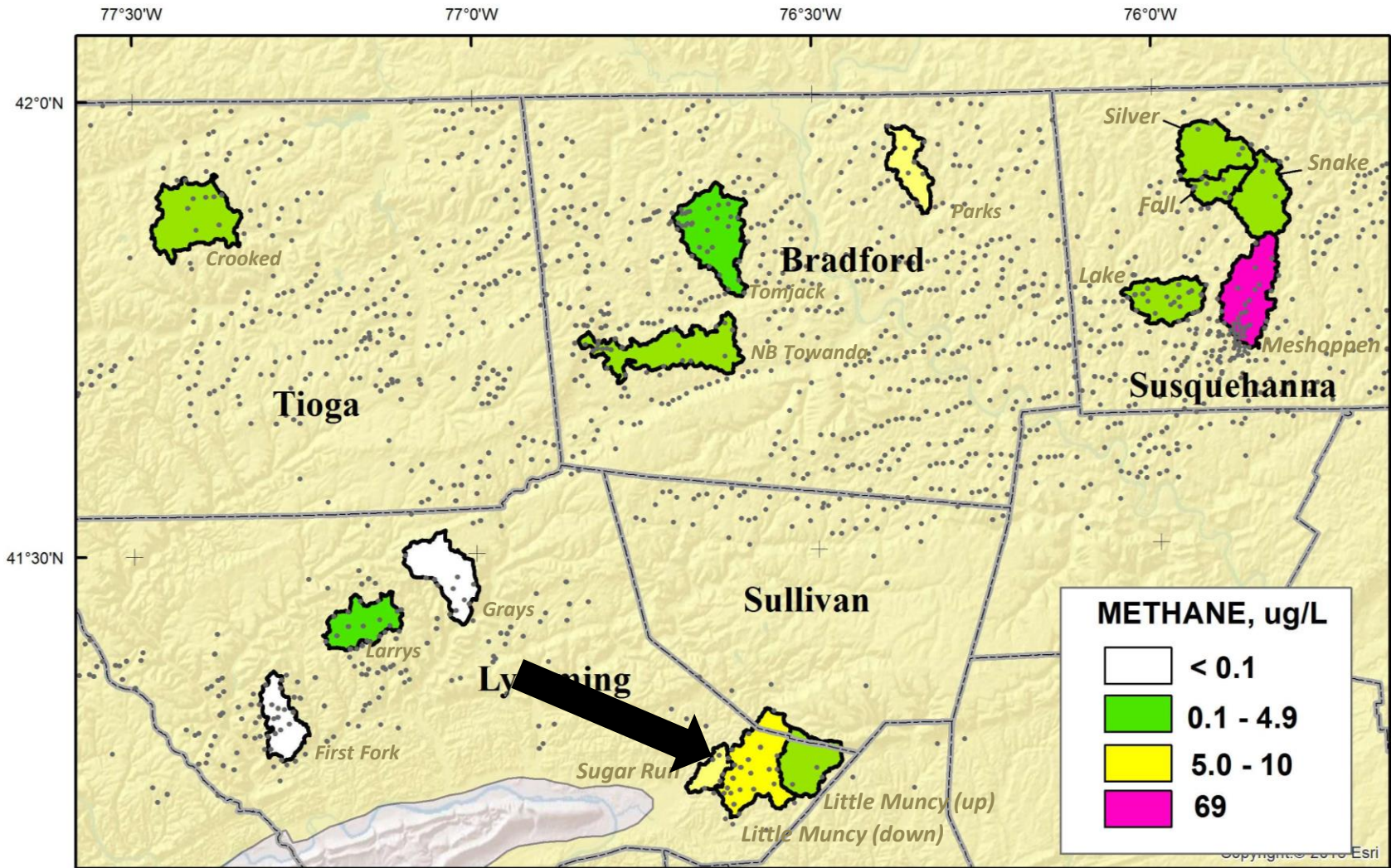


Detailed Stepwise Monitoring at One Stream

1. Sample at kilometer-scale downstream intervals to locate reaches with elevated methane.
2. Monitor at smaller spacing to better define anomalies and analyze isotopes -- thermogenic or microbial.
3. Estimate the concentration and load of methane from groundwater -- mass-balance modeling.

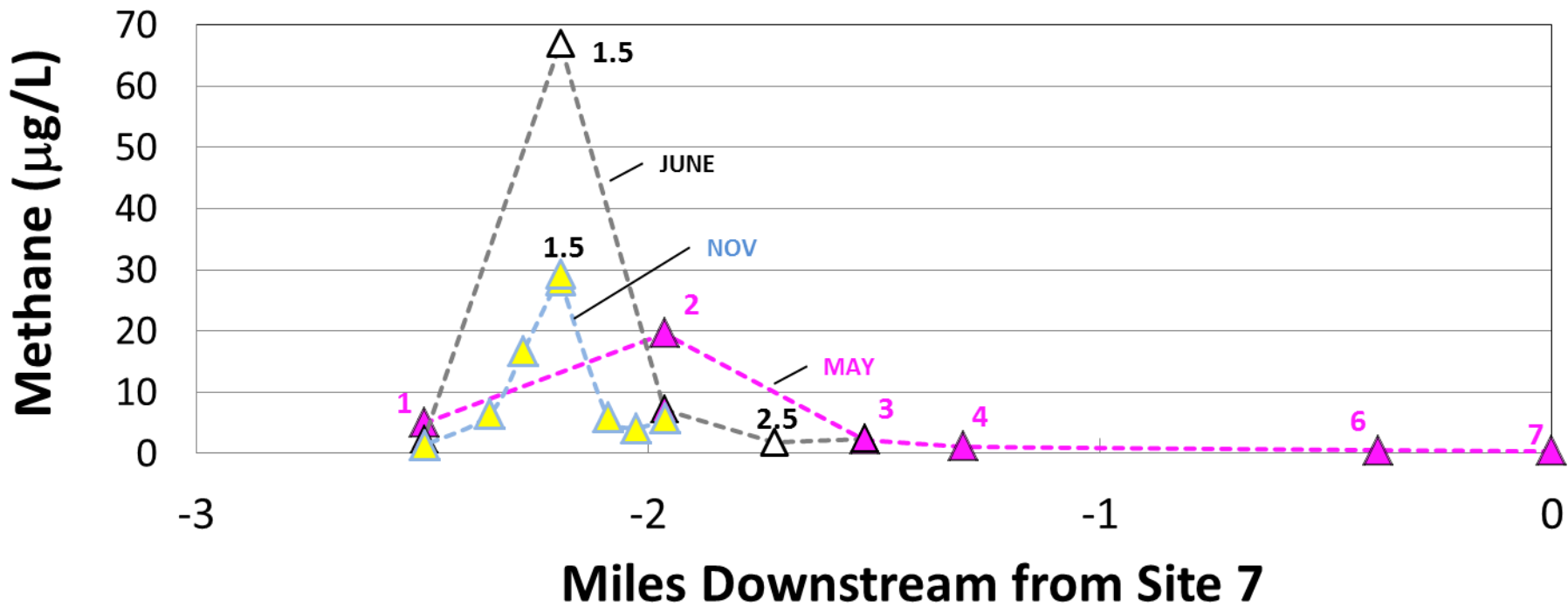


Detailed Survey in Sugar Run



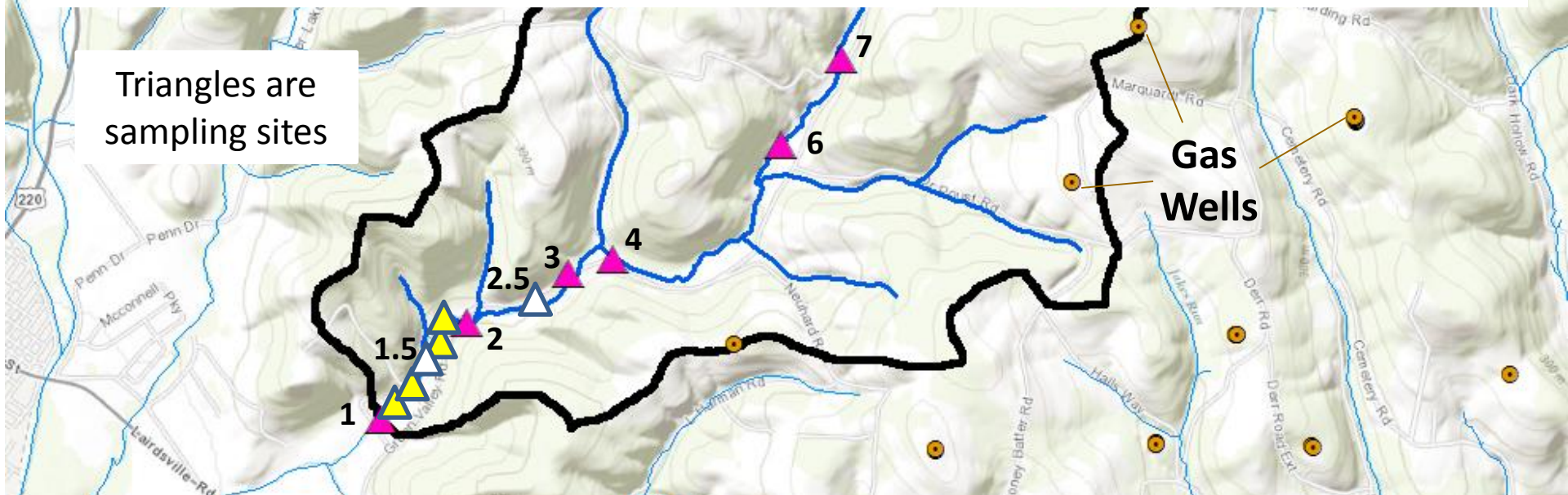
Area underlain by Marcellus Shale

Detailed Stepwise Monitoring



Triangles are sampling sites

Gas Wells



Methane Seep at Site 1.5 in Sugar Run



Drive-Point Piezometers in Stream Bed



Data from streambed piezometers are useful

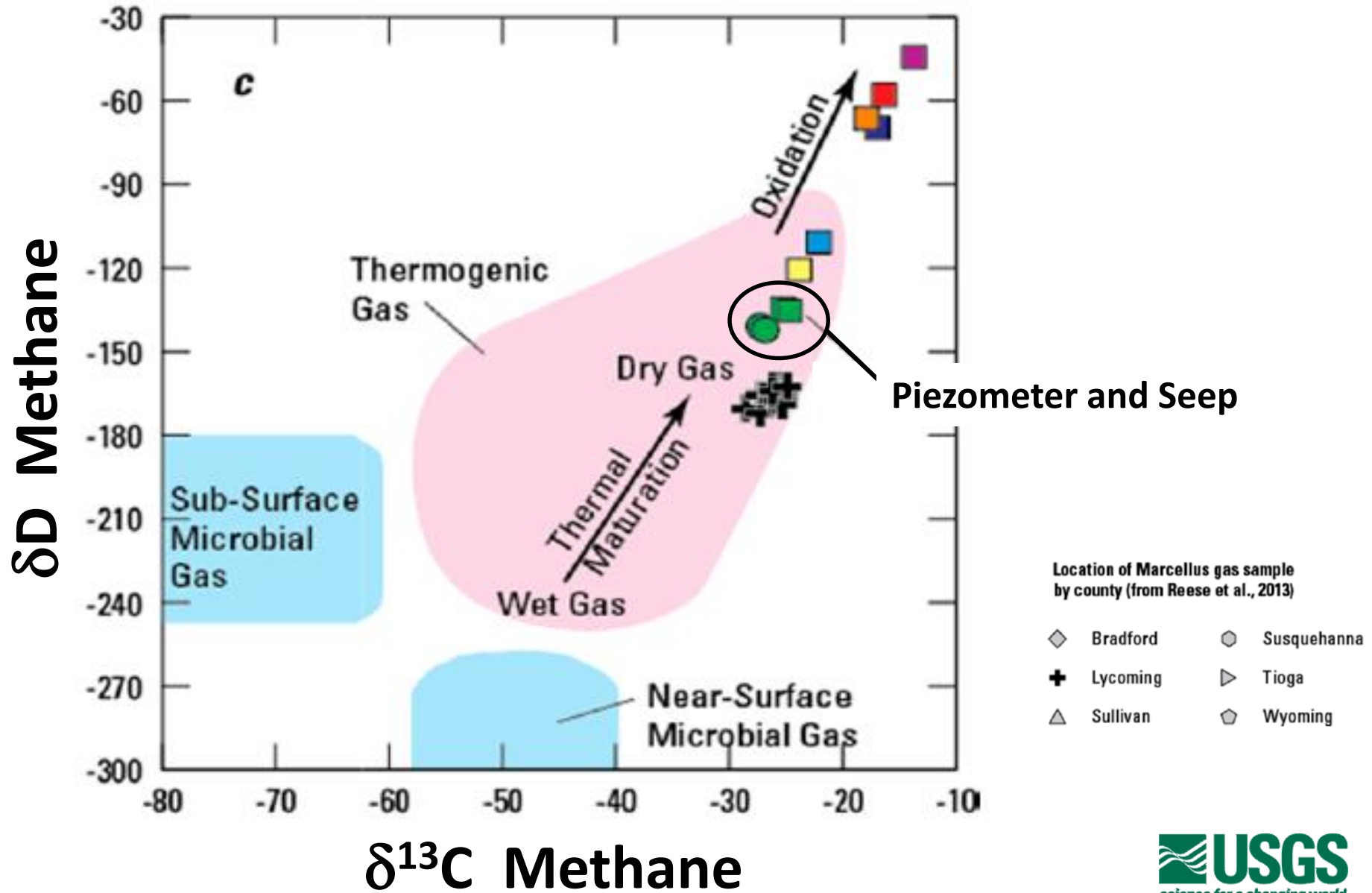


...and remove

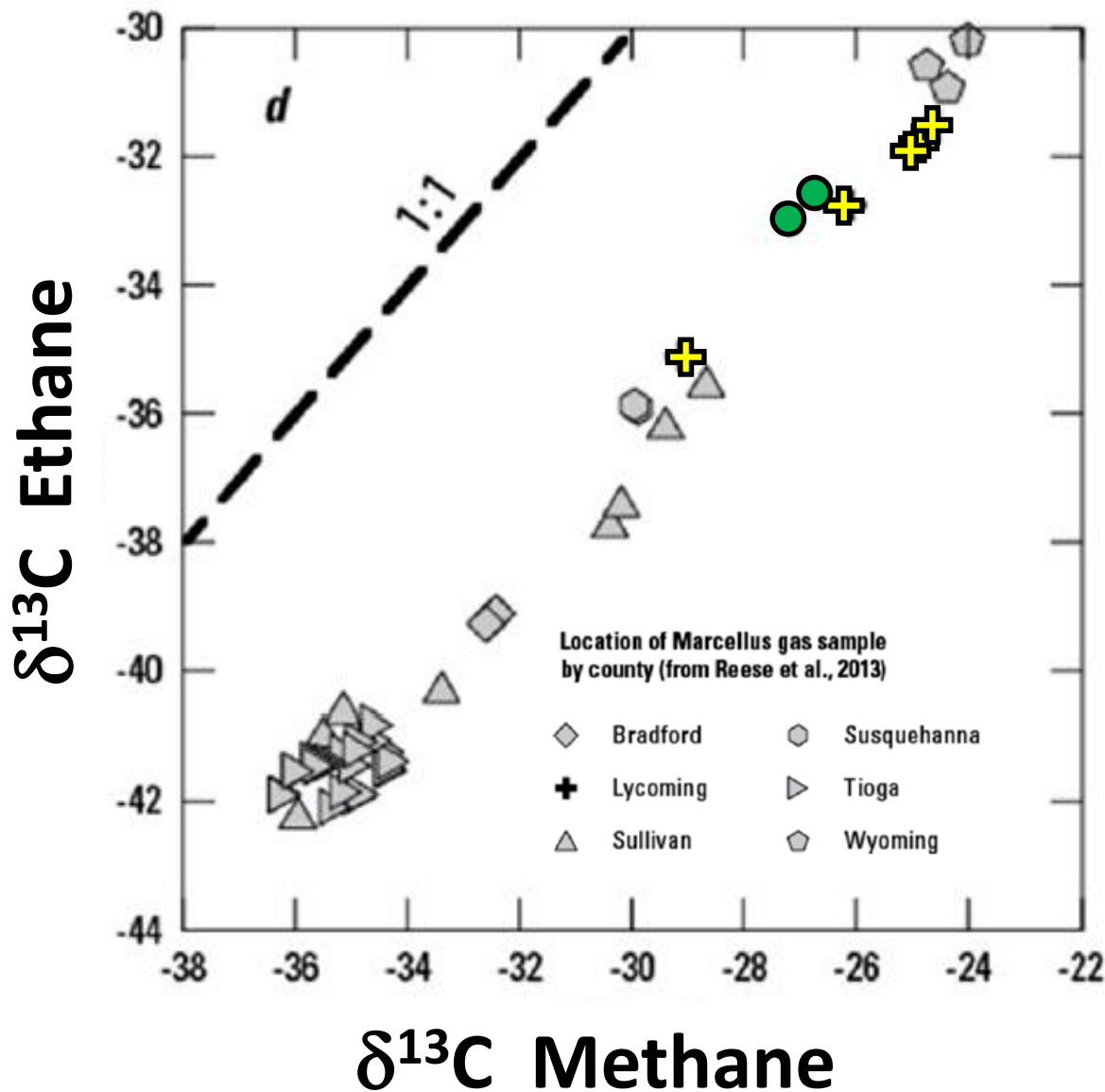
May be difficult to install



Carbon and Hydrogen Isotopes of Methane



Carbon Isotopes – Methane and Ethane



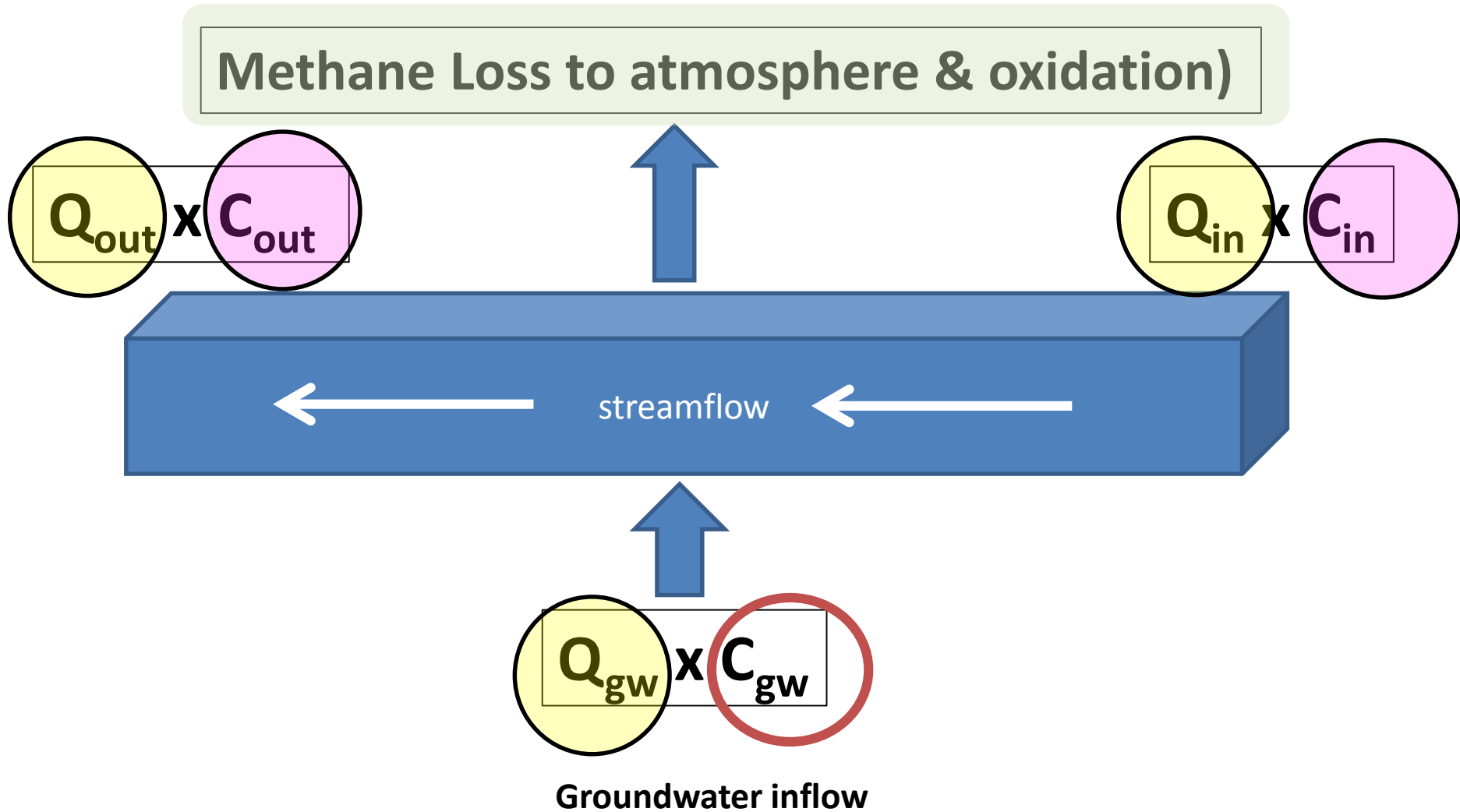
Gas in Water from:

- Sugar Run Piez 1.5
- Sugar Run Seep 1.5

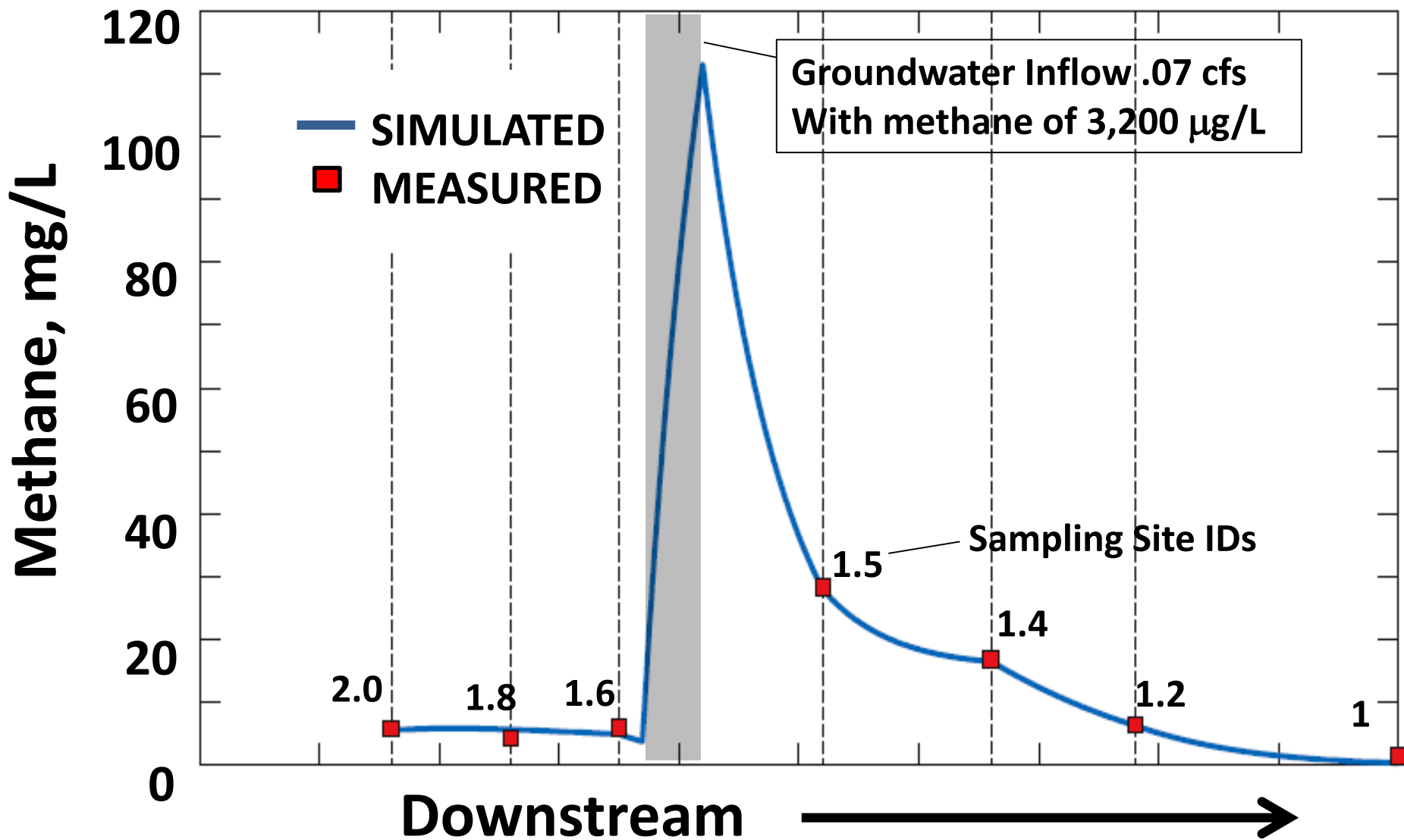
Gas Samples from:

- + Gas Wells in Lycoming County

1-D Mass Balance Modeling



Modeling Methane in Sugar Run (Nov 2013)



Sparsely Populated Areas

Gas-well buildout
In Loyalsock State Forest



Thanks for your interest.....

Measuring base flow in Sugar Run, Lycoming County

