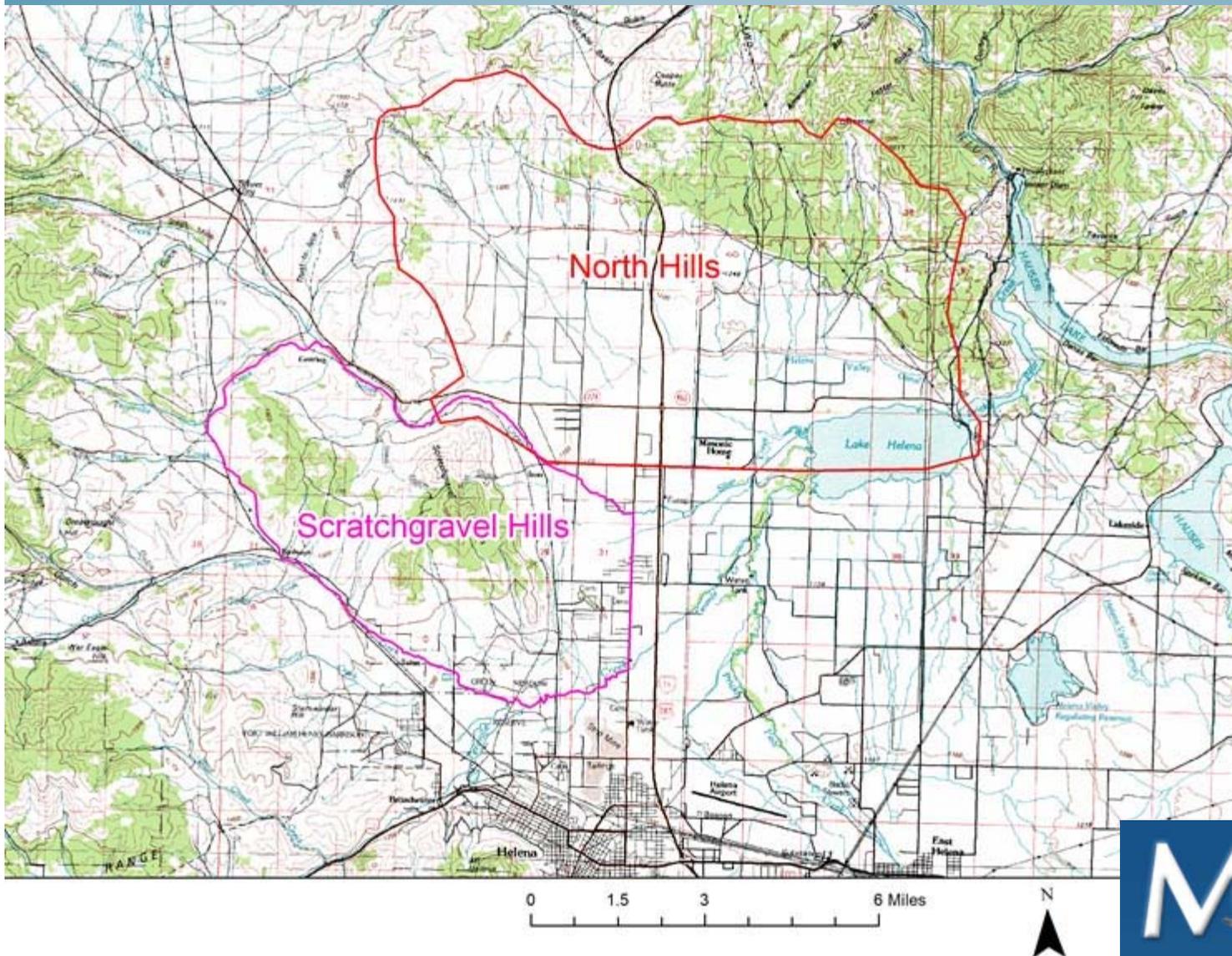
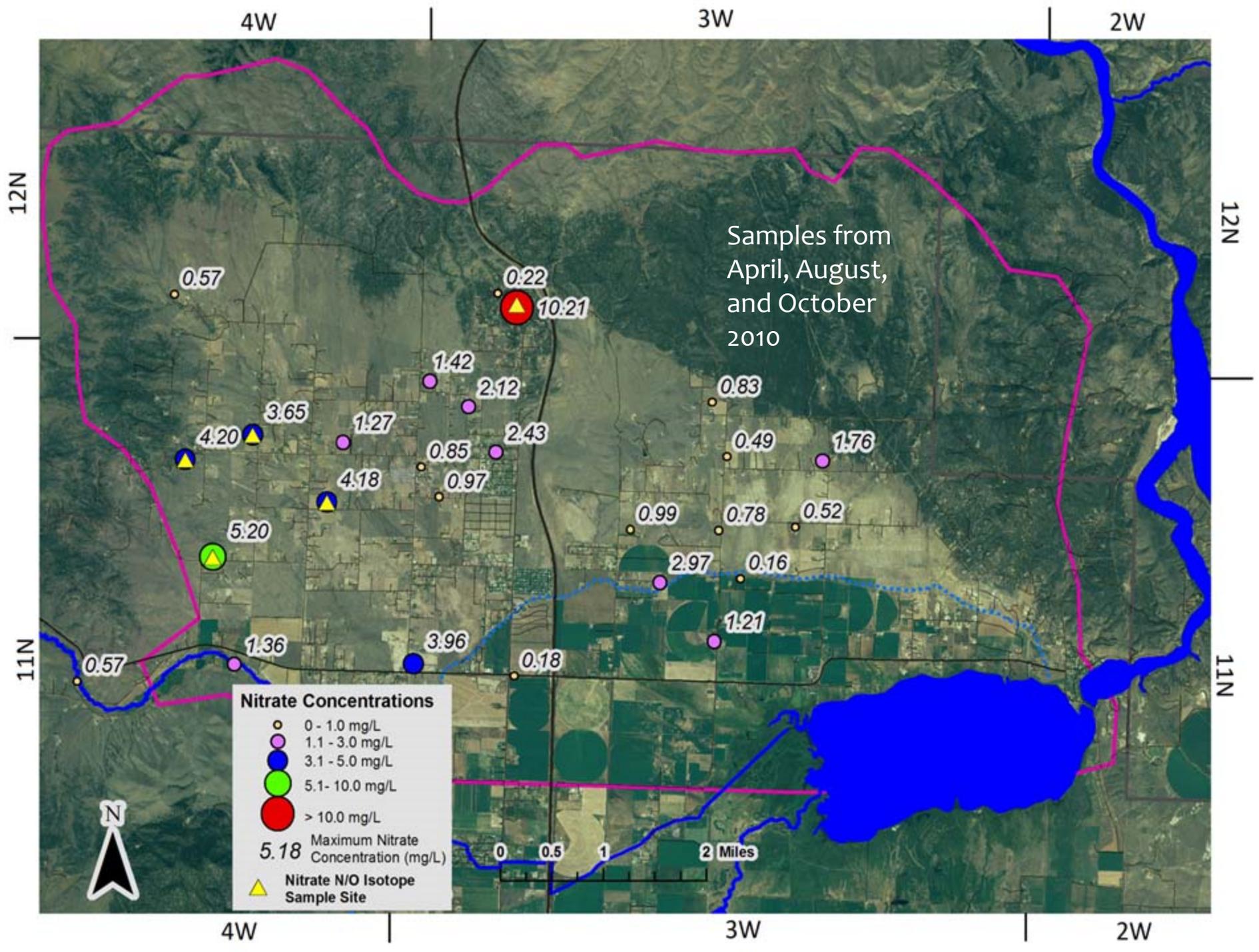


SOURCES OF NITRATE IN GROUNDWATER IN THE NORTH HILLS AND SCRATCHGRAVEL HILLS



Andy Bobst
and
Kirk Waren
MBMG



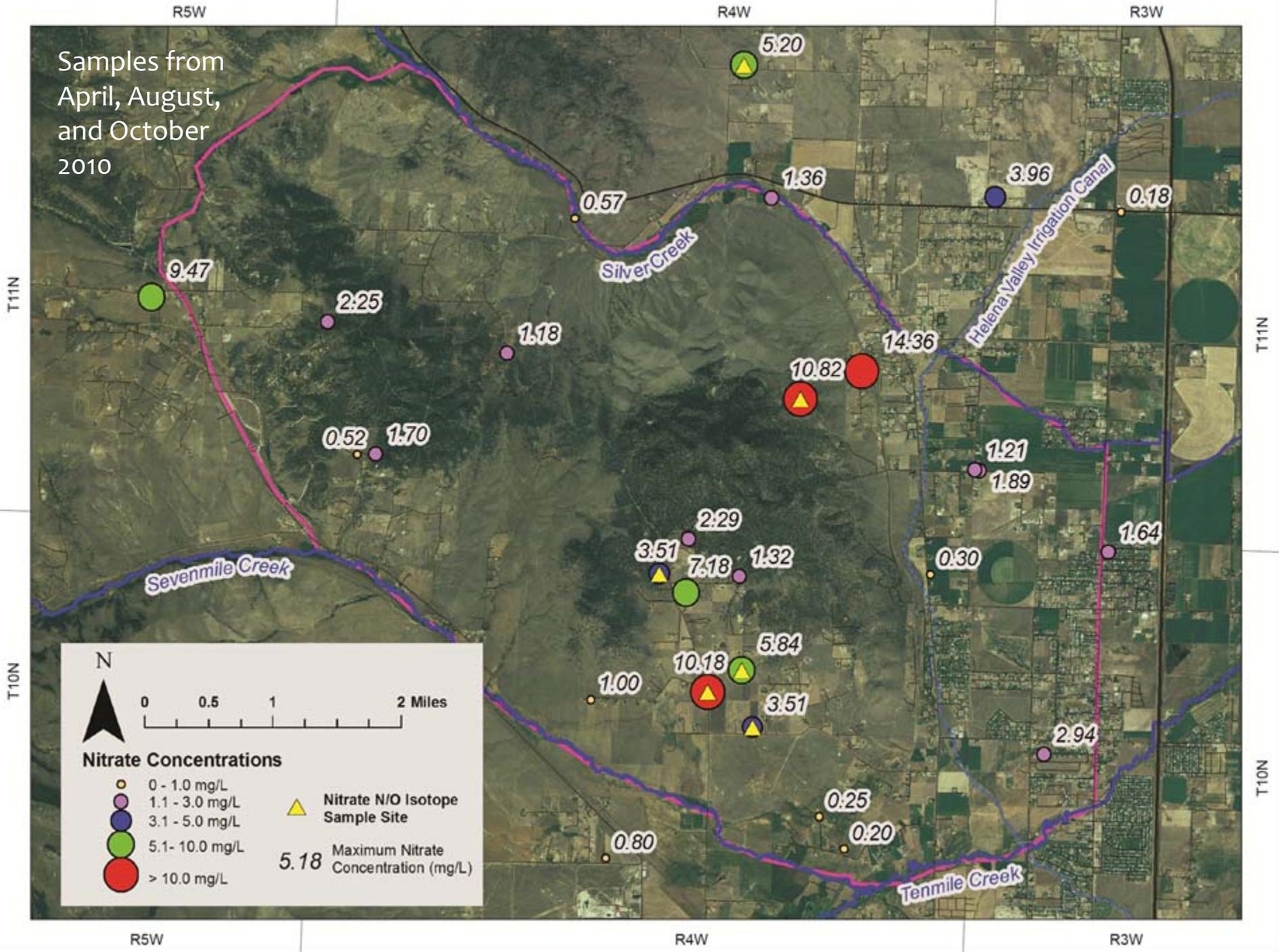


**North Hills 2010 Groundwater Samples
(ND values as ½ of DL)**

	April	August	October
Detection Limit (mg/L)	0.5	0.05	0.05
Total Samples	25	29	30
Total Detections	18	27	30
min (mg/L)	0.25*	0.025*	0.14
median (mg/L)	0.97	0.99	1.10
mean (mg/L)	1.90	1.49	1.58
max (mg/L)	10.21	4.2	4.22
%>10 mg/L	4%	0%	0%
%>2 mg/L	28%	28%	27%

* - values represent ½ of detection limit.

Samples from
April, August,
and October
2010

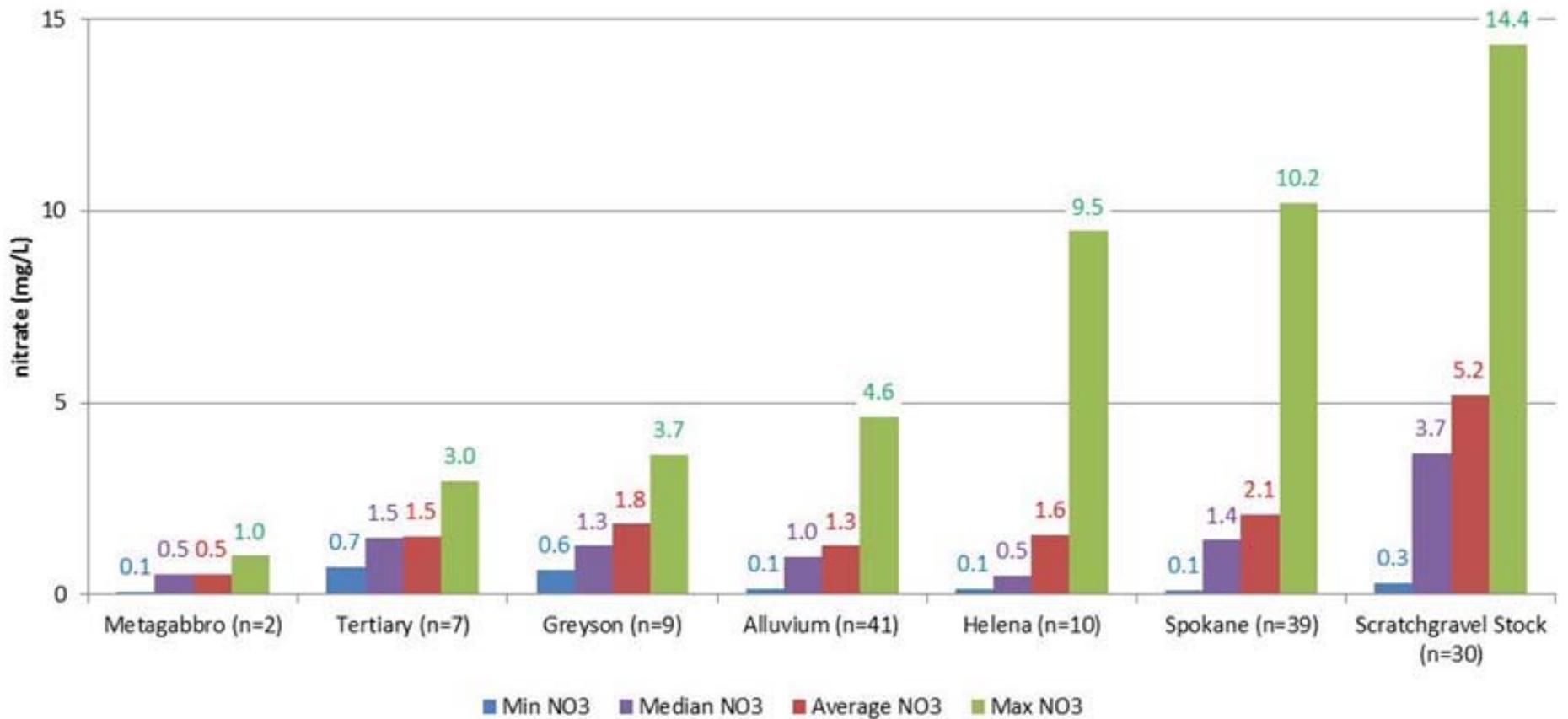


**Scratchgravel Hills 2010 Groundwater Samples
(ND values as 1/2 of DL)**

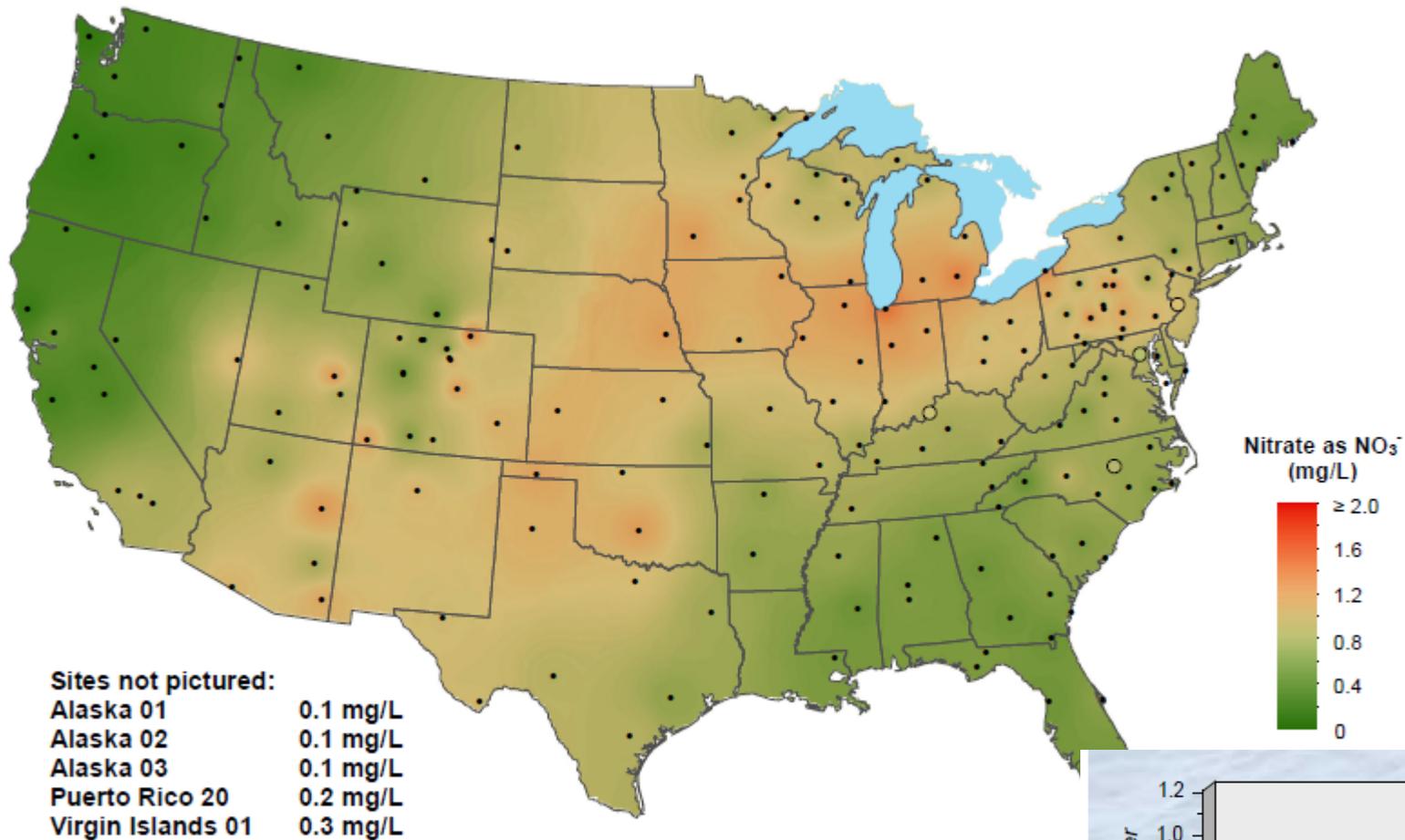
	April	August	October
Detection Limit (mg/L)	0.5	0.05	0.05
Total Samples	21	22	24
Total Detections	18	18	22
min (mg/L)	0.25*	0.025*	0.025*
median (mg/L)	1.58	1.13	1.05
mean (mg/L)	3.09	2.61	2.63
max (mg/L)	12.96	13.53	14.36
%>10 mg/L	5%	14%	8%
%>2 mg/L	38%	27%	29%

* - values represent ½ of detection limit.

Nitrate Concentrations in Aquifers of the Scratchgravel and North Hills

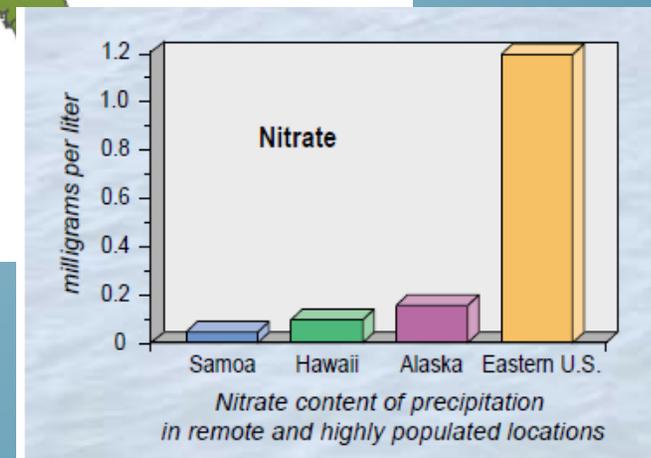


Nitrate ion concentration, 2012



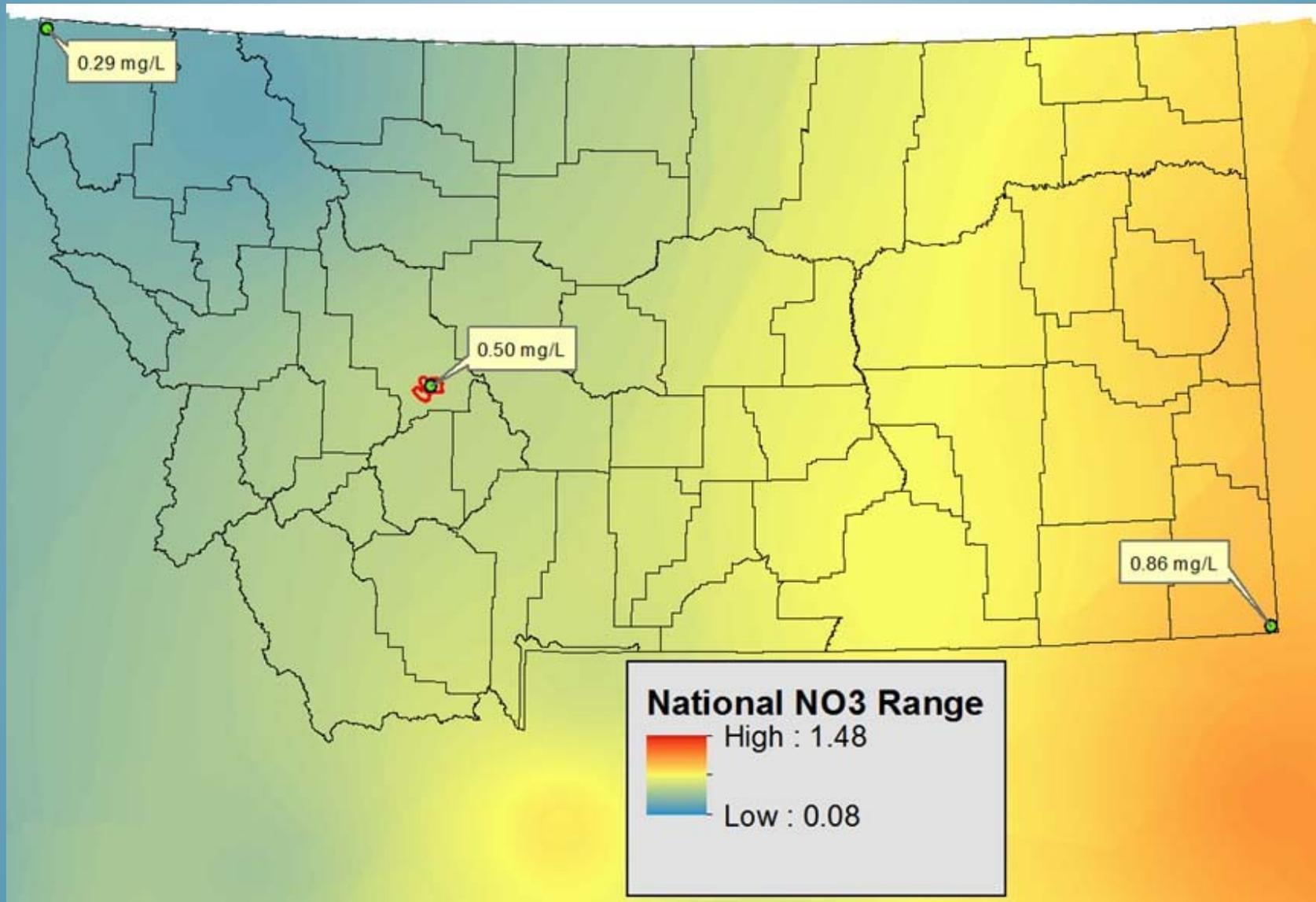
National Atmospheric Deposition Program/National Trends Network
<http://nadp.isws.illinois.edu>

Nitrate from Precipitation
-There is also dry deposition

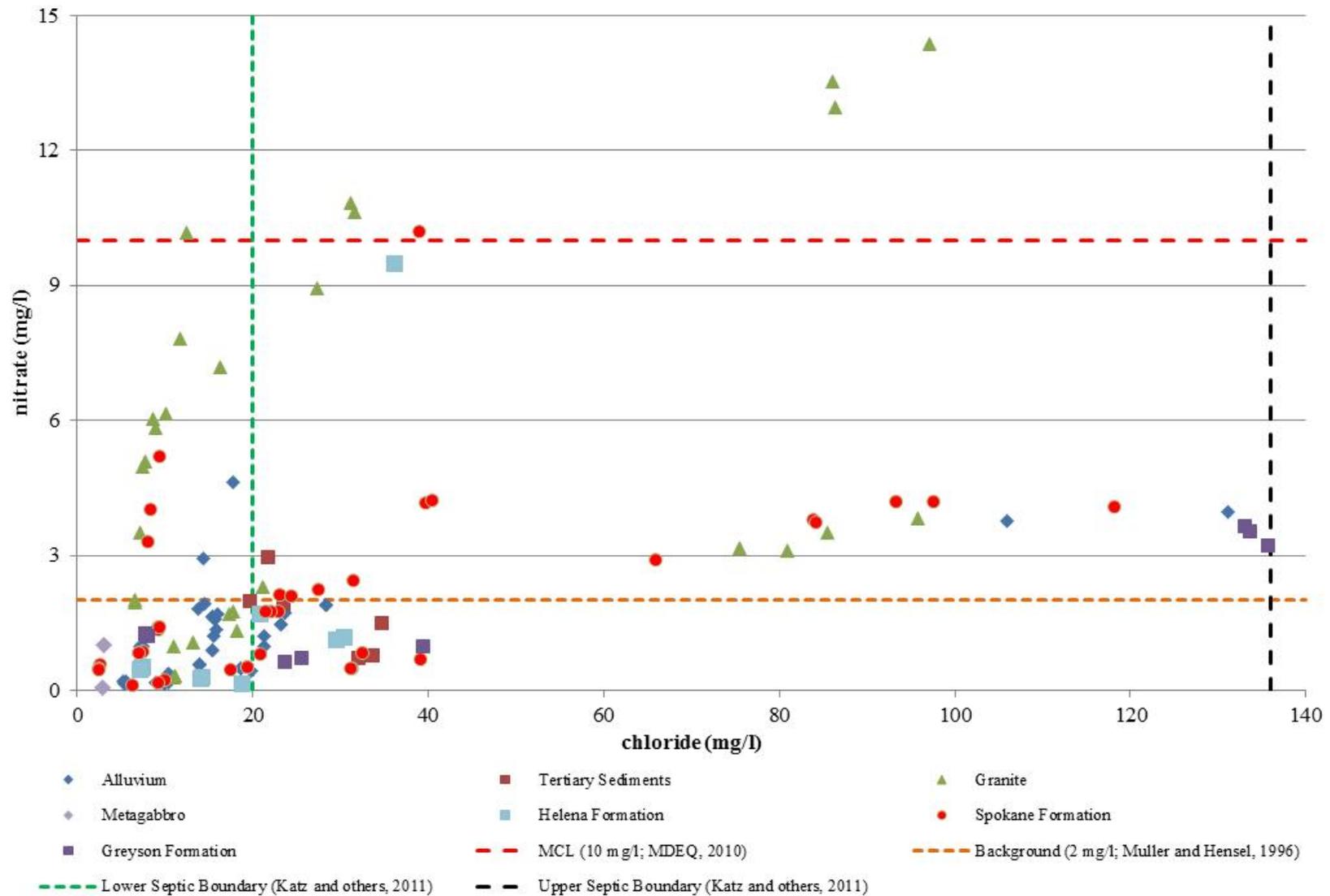


Source: National Atmospheric Deposition Program National Trends Network (after J.N. Galloway, G.E. Likens, and M.E. Hawley, 1984. *Science* 226:829).

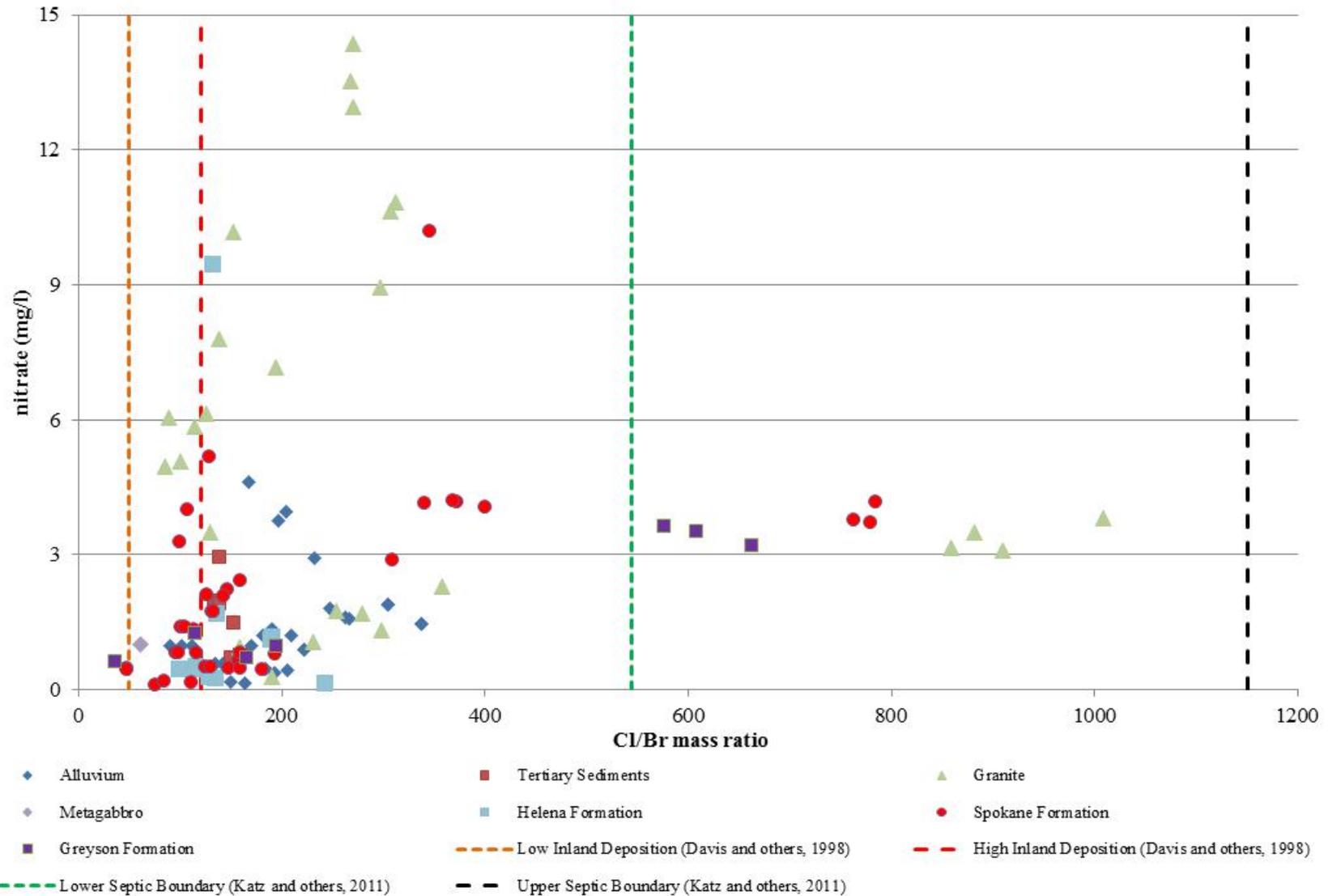
NITRATE CONCENTRATIONS IN PRECIPITATION MONTANA - 2012



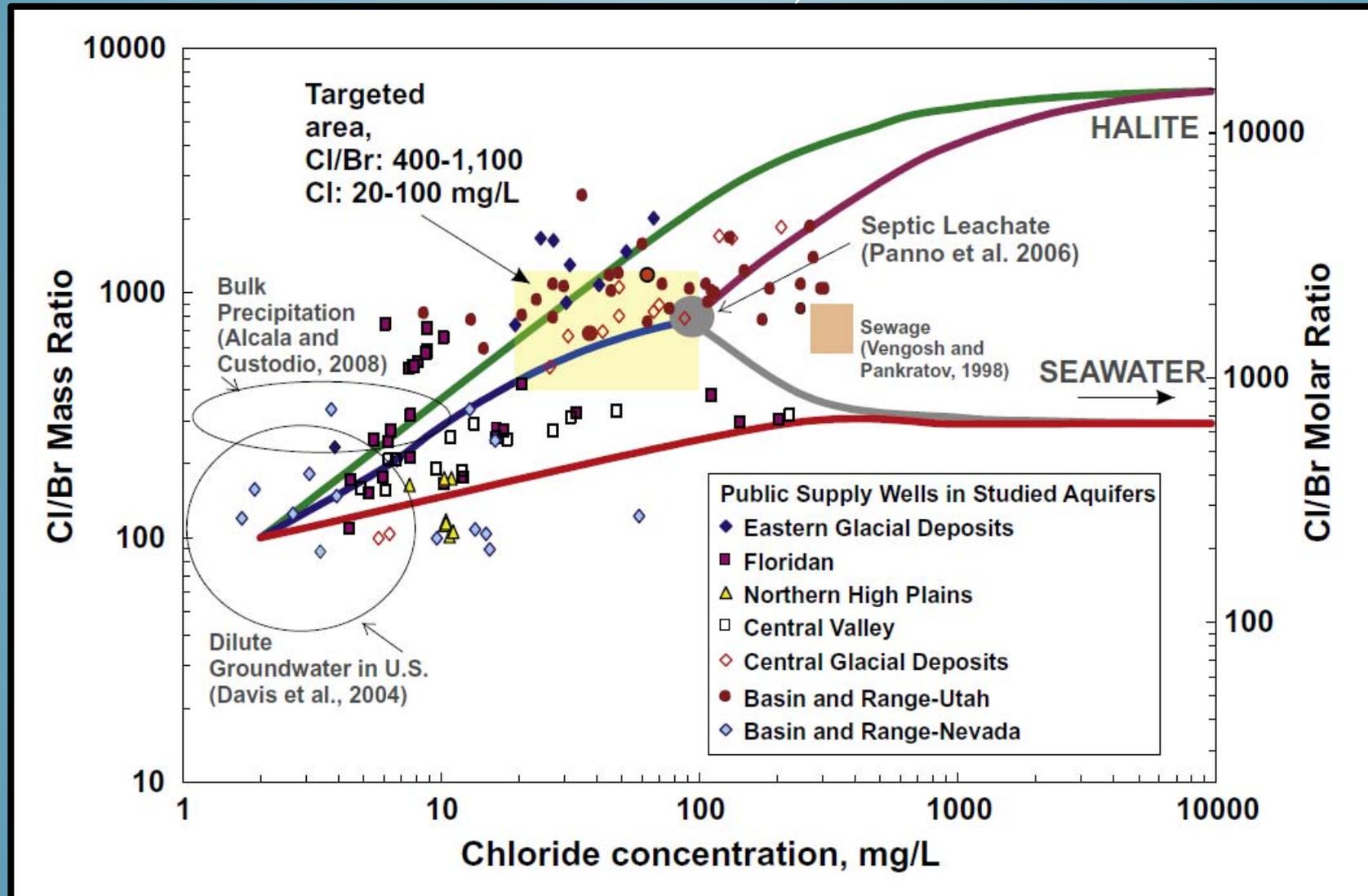
Nitrate vs. Chloride in the Scratchgravel and North Hills with differentiation by aquifer



Nitrate vs. Chloride / Bromide mass ratio in the Scratchgravel and North Hills with differentiation by aquifer

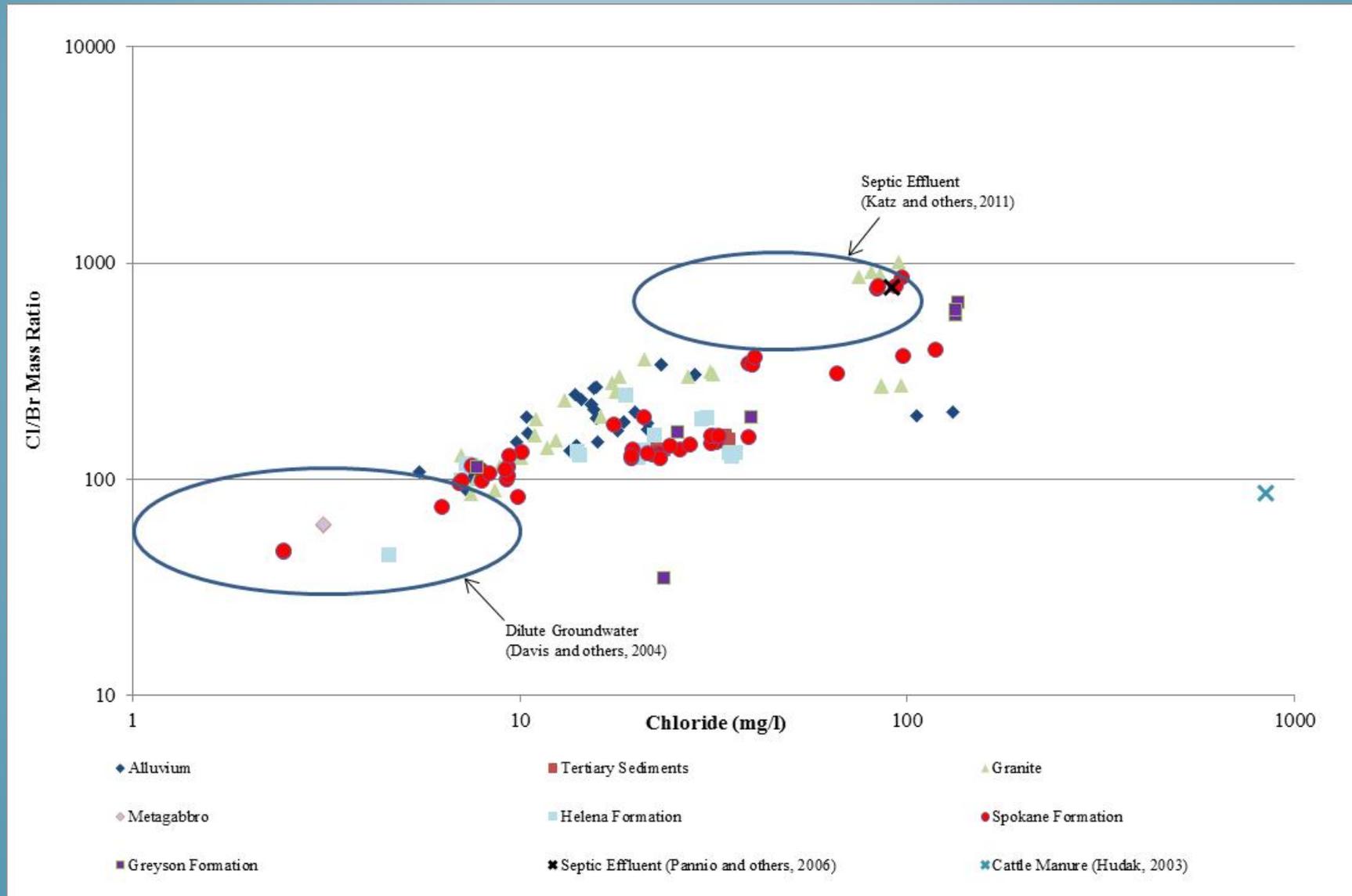


Chloride / Bromide mass ratio vs. Chloride
From Katz and others, 2011

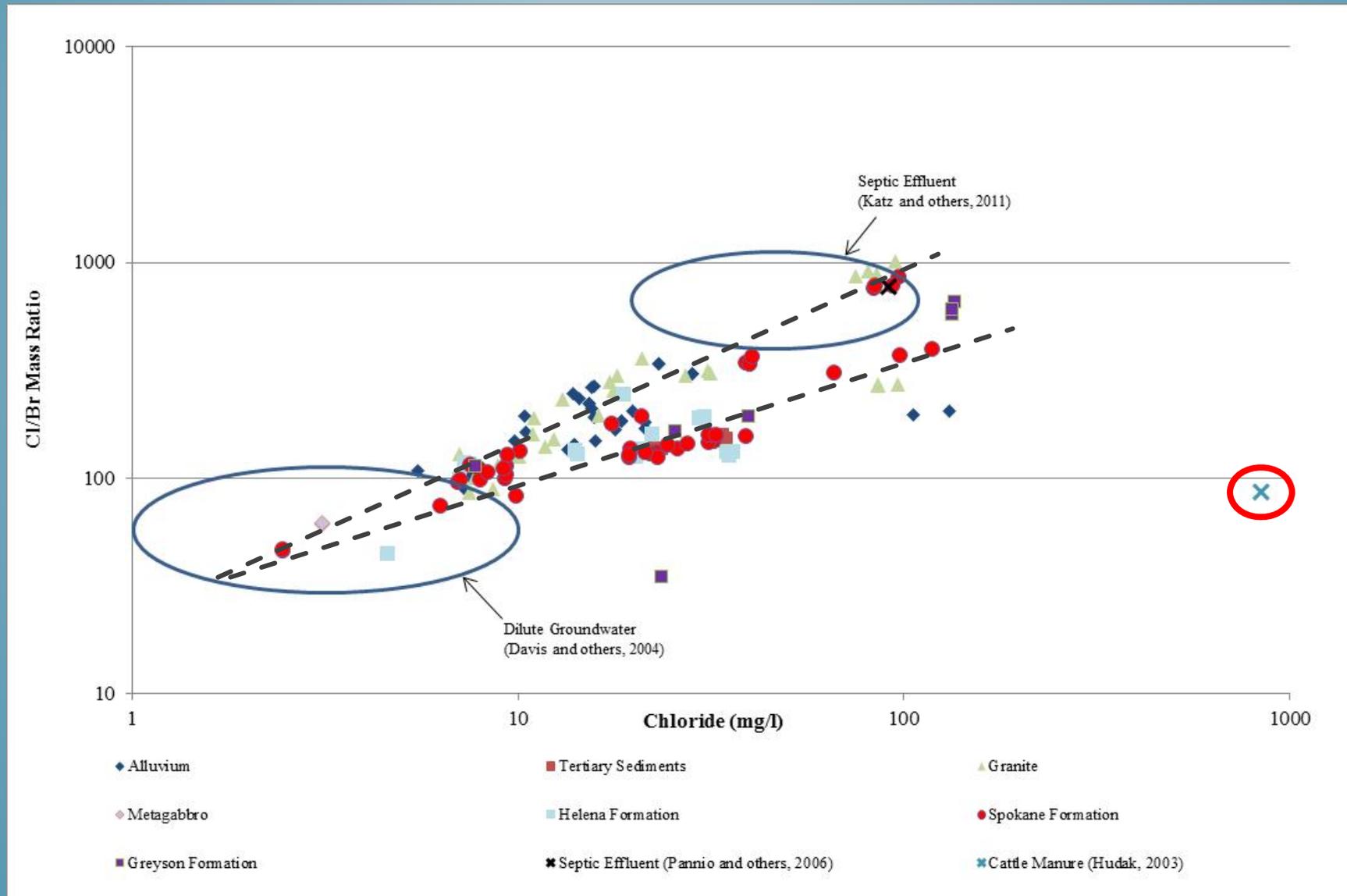


Katz, B.G., Eberts, S.M., and Kauffman, L.J., 2011, Using Cl/Br ratios and other indicators to assess the potential impacts on groundwater quality from septic systems: A review and examples from principal aquifers in the United States: *Journal of Hydrology*, v. 397, no. 3-4, p. 151-166.

Chloride / Bromide mass ratio vs. Chloride in the Scratchgravel and North Hills with differentiation by aquifer

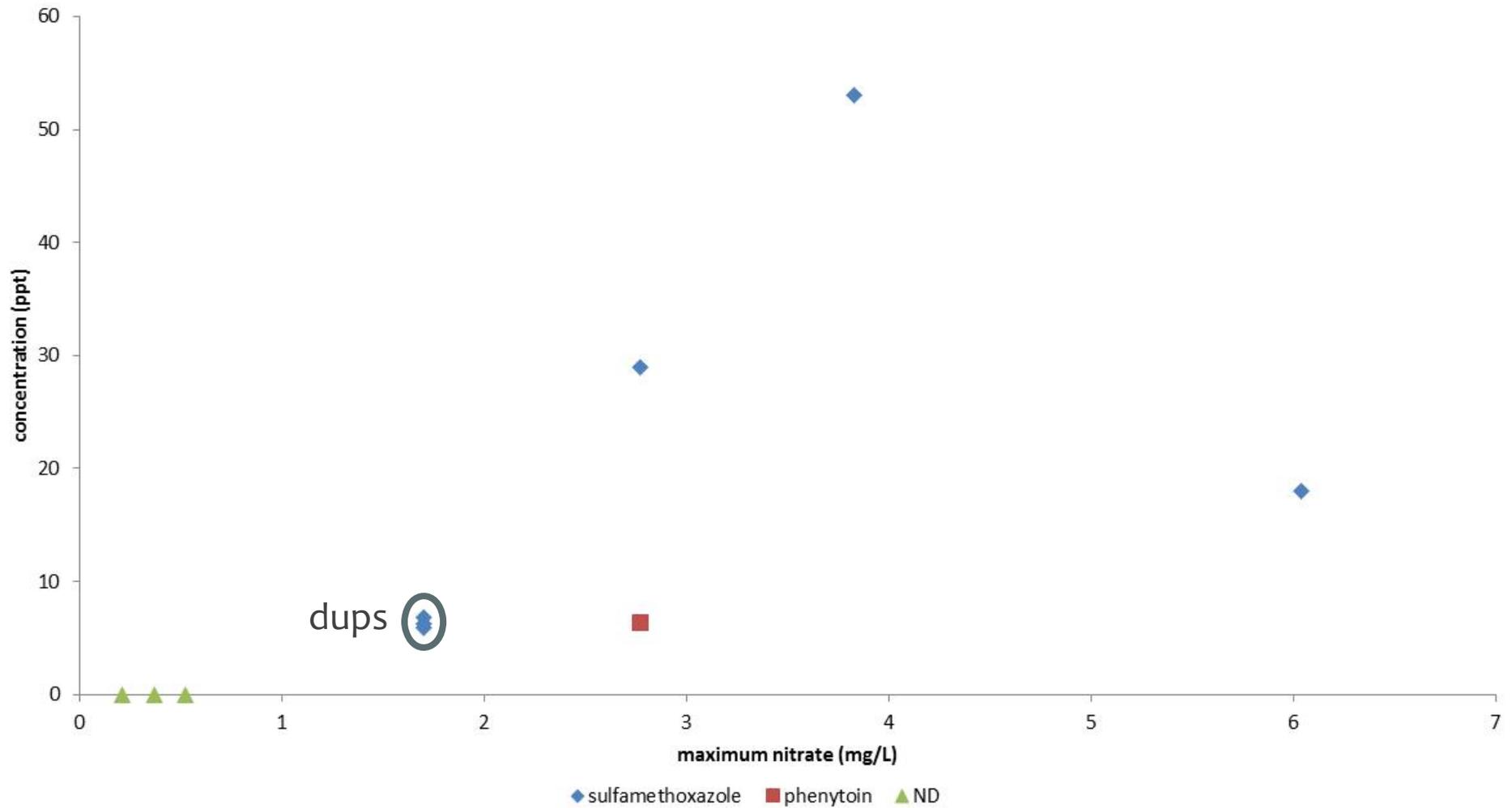


Chloride / Bromide mass ratio vs. Chloride in the Scratchgravel and North Hills with differentiation by aquifer



Note: Nitrate from soils would also not cause an increase in the Cl/Br mass ratio.

Pharmaceutical Compounds vs. Nitrate Scratchgravel and North Hills



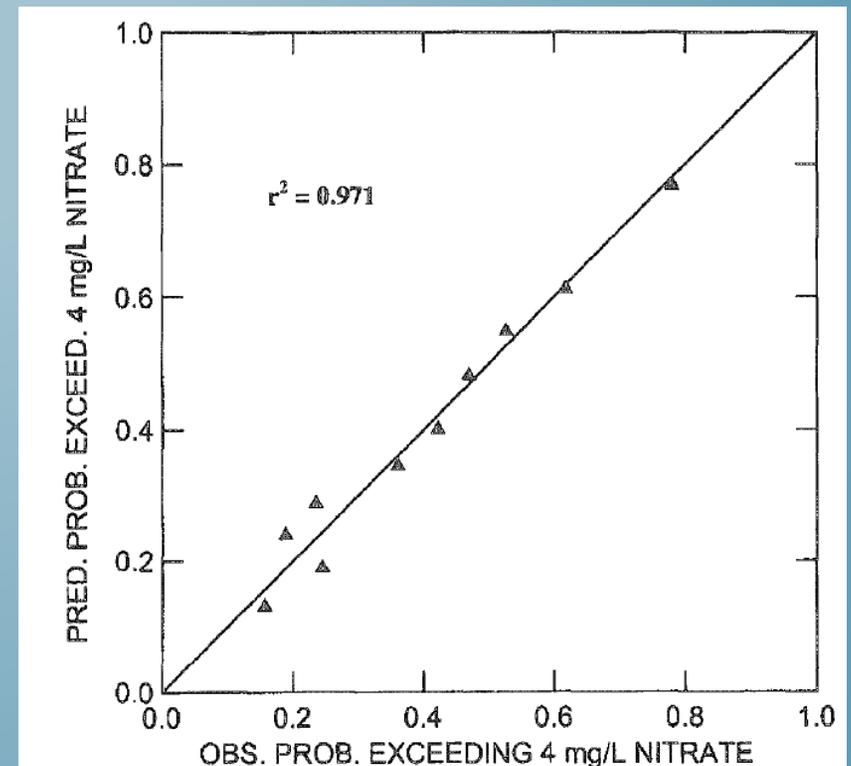
Concentrations of pharmaceutical compounds generally increase with increasing nitrate, consistent with the nitrate being from septic systems.

Nolan, B.T., 2001, Relating nitrogen sources and aquifer susceptibility to nitrate in shallow ground waters of the United States: Groundwater, v. 39, no. 2, p. 290-299.

Aquifer susceptibility factors:

- % well drained soil (vulnerability increases with more well drained)
- Depth to water table (vulnerability increases with depth)
 - Longer flow path, but not anoxic, thus little denitrification
 - If intervening low permeability layers vulnerability decreases
- Presence of fractured bedrock (vulnerability increases in fractured bedrock)

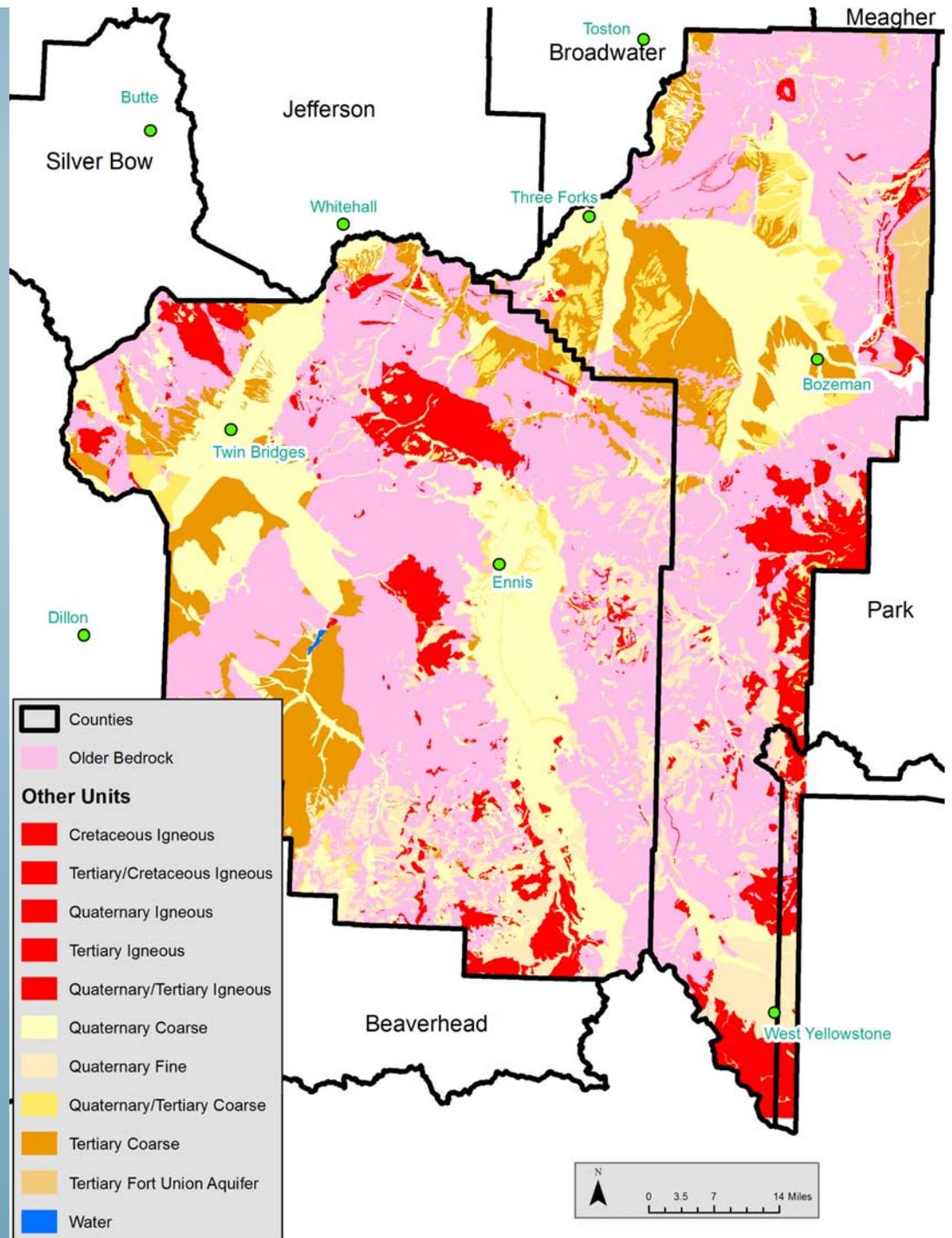
Upland areas with shallow fractured bedrock have all of these factors.



Based on the Hydrogeologic Units in Madison and Gallatin Counties (Crowley, 2013)

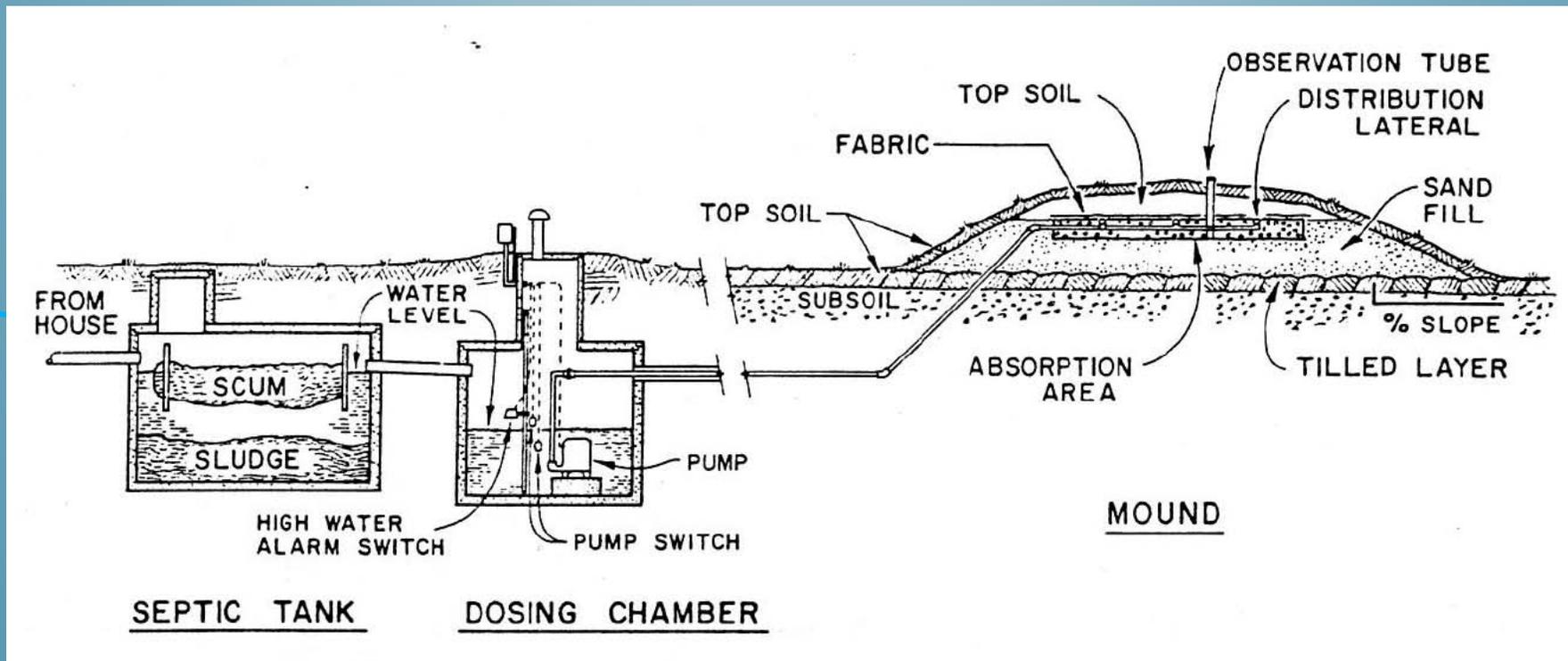
Bedrock at or near the surface is common in Western Montana.

- Much of it is USFS
- Some is private



Potential Alternatives – Mound Septic Systems (Converse and Tyler, 2000)

- Designed for areas with
 - Low or High Permeability soils
 - Shallow Soil over bedrock
 - High water table
- The mound is used to create acceptable soil conditions above the native surface
- Specifications in Circular DEQ-4

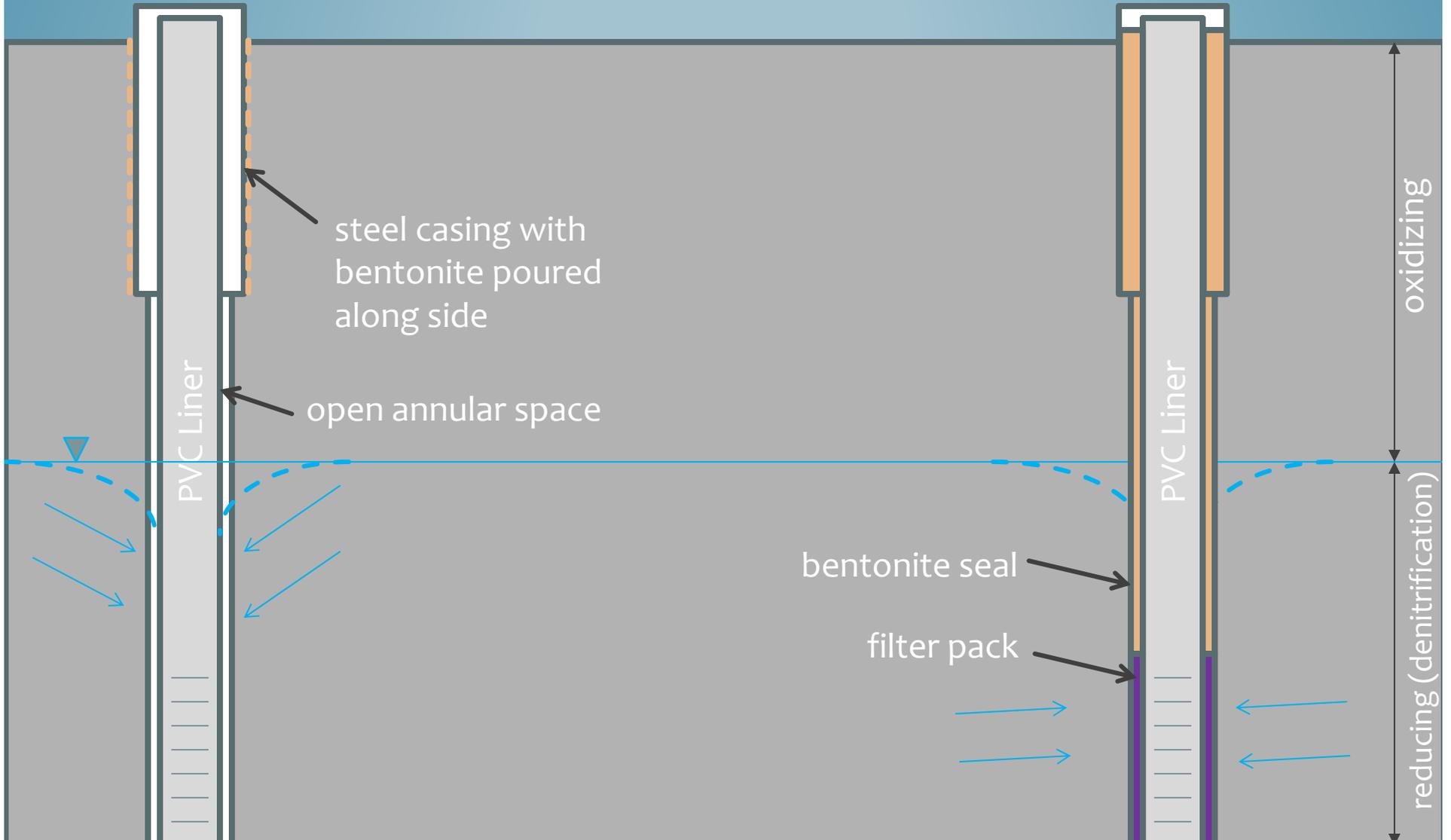


Also community sewage treatment systems.

Potential Alternatives – Well Construction

Typical Bedrock Well

Sealed Well



Conclusions

- 151 samples analyzed from the North Hills and the Scratchgravel Hills
 - 7 exceeded the nitrate MCL of 10 mg/L (4.6%)
 - ~30% above 2 mg/L
- The source of elevated nitrate levels appears to be septic effluent.
- Nitrate levels are more elevated in areas of fractured bedrock due to thin soils, shallow fractured bedrock, and a lack of denitrification.
- Much of Western Montana is underlain by shallow fractured bedrock.
 - In these areas conventional septic systems may not be effective.
- Modifications at the source or the receptor may be needed. Some potential alternatives include:
 - Individual mound septic systems
 - Community sewer systems
 - Modification of well completion methods

Questions?

