Hydrogeologic Sensitivity in Ohio – Identifying Criteria for Pathogen Barriers

Chris Kenah, Michael Slattery, Linda Slattery, and Michael Eggert

OhioEPA

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Outline of Talk

- Describe Ohio sensitive aquifers based on nitrate concentration in public water systems;
- Summarize role of hydrogeologic barriers in proposed GW rule;
- Share initial results of approaches to identify/define hydrogeologic barriers in Ohio:

  - Summarize microbiological sampling results in non-vulnerable wells with pathogen sources – documents existence of barriers;

  - Present analysis of existing PWS bacteria monitoring data to determine if data identifies the presence of hydrogeologic barriers.

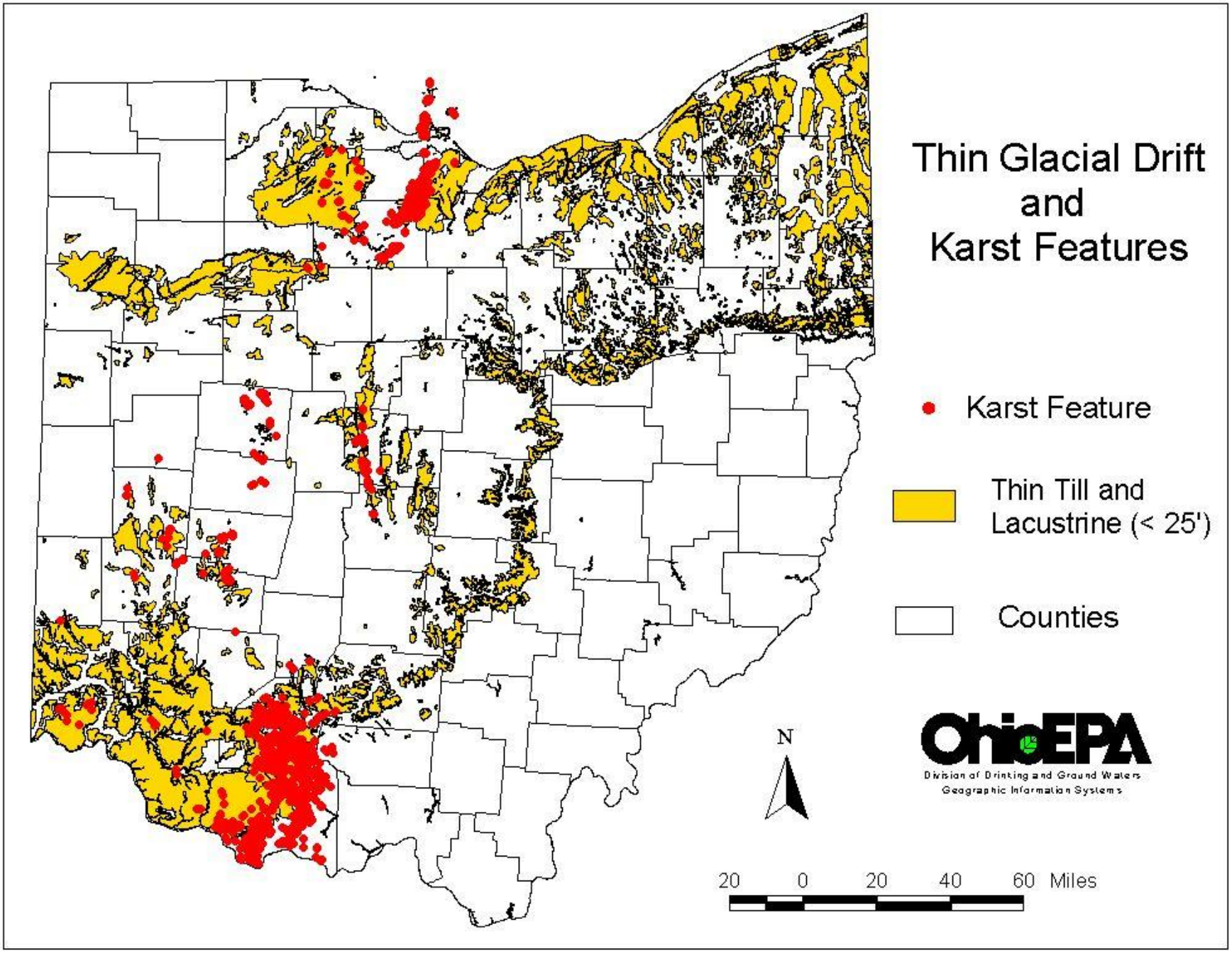
Sensitive Aquifers in Ohio

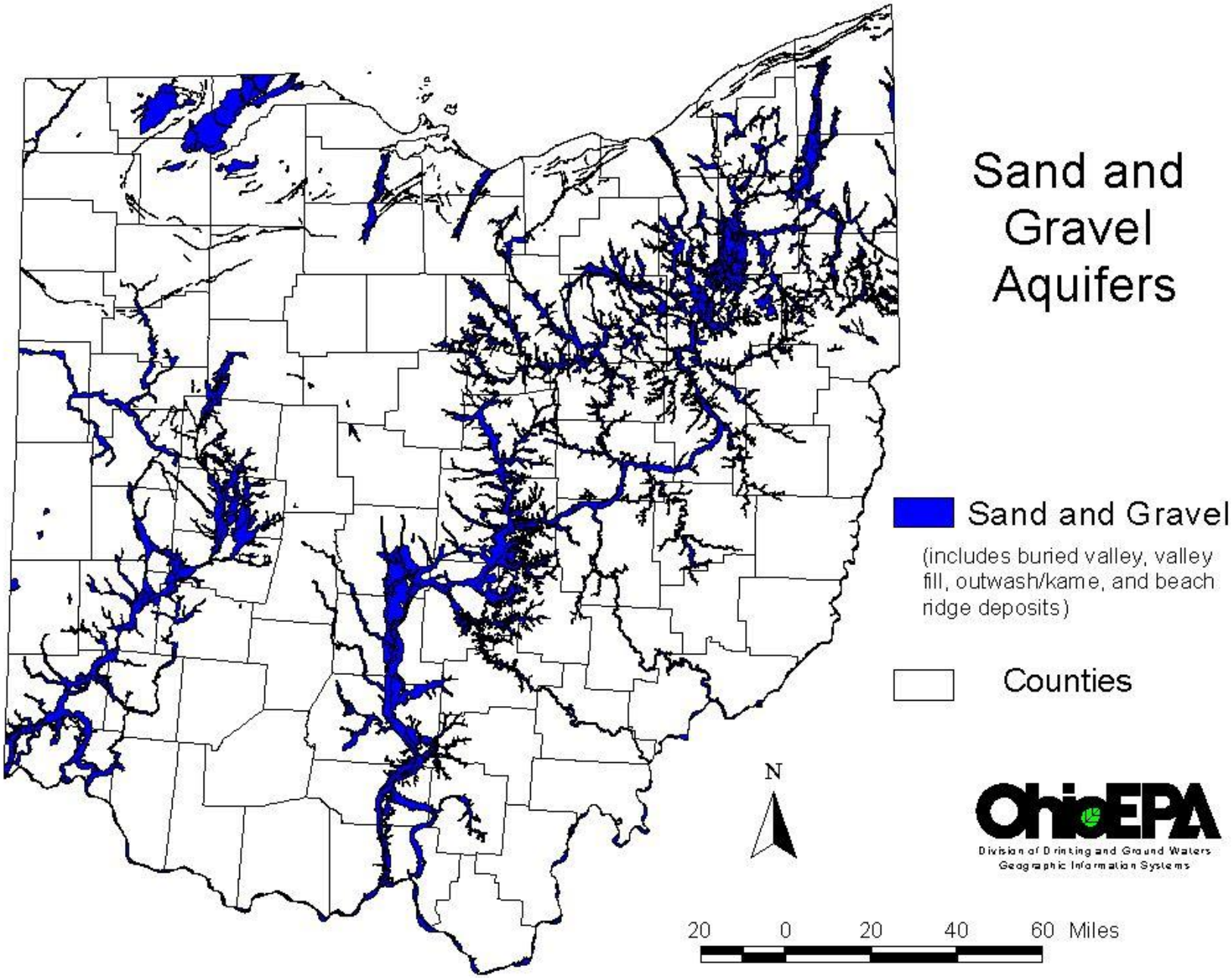
- Thin drift over bedrock aquifers

  Nitrate impacted bedrock wells are more common in areas of thin glacial cover. Karst and Fractured Bedrock are sensitive hydrogeologic settings in the GW Rule.

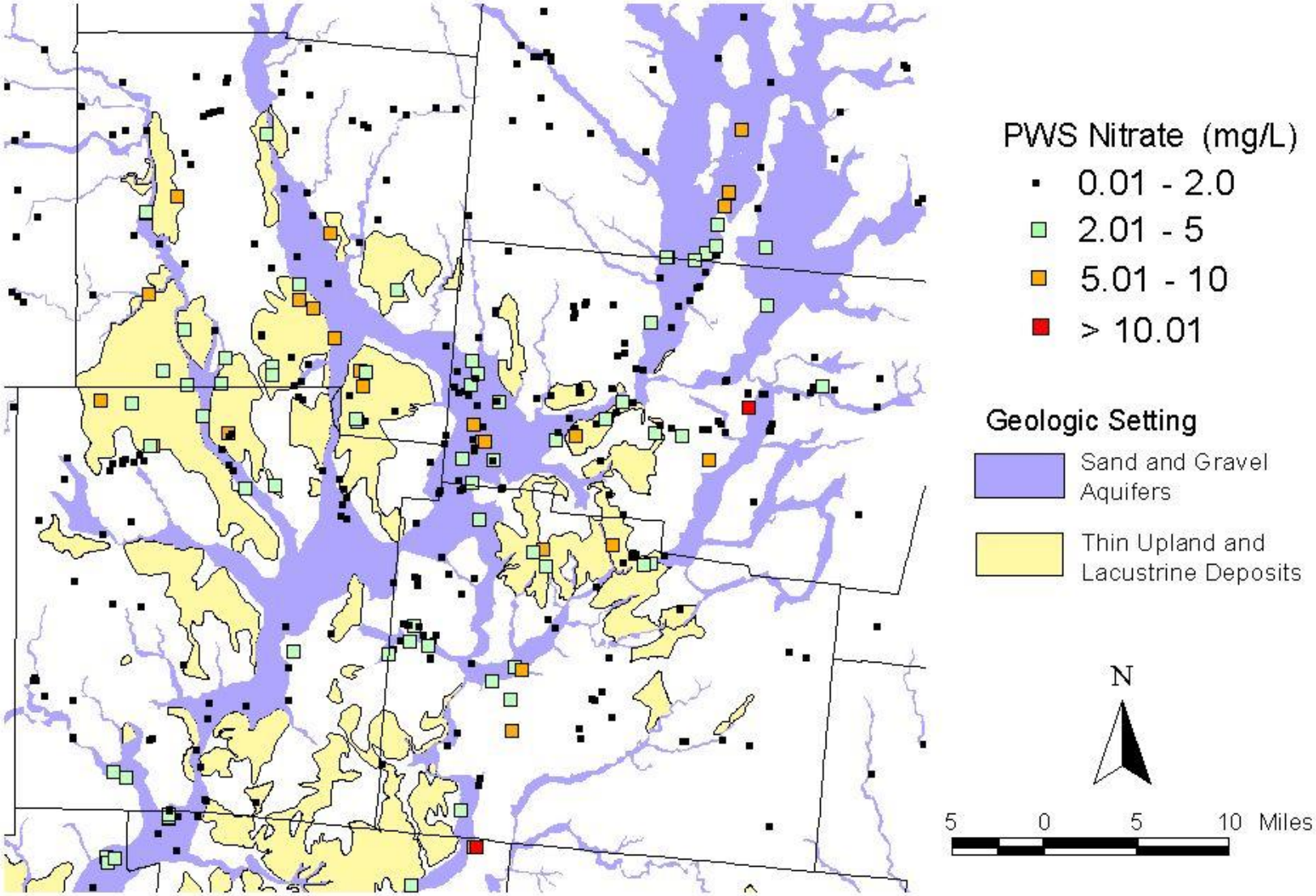
- Buried Valleys

  Distribution of nitrate impacted PWS confirms sensitivity of the sand and gravel aquifers, but sensitivity to nitrate may not mean sensitivity to pathogens; Considered sensitive hydrogeologic setting for GW Rule?????


Thin Glacial Drift
and
Karst Features
Karst Feature
Thin Till and
Lacustrine (< 25')
Counties
N
OhioEPA
Division of Drinking and Ground Waters
Geographic Information Systems
20 0 20 40 60 Miles


Sand and Gravel Aquifers
Sand and Gravel
(includes buried valley, valley fill, outwash/kame, and beach ridge deposits)
Counties
N
OhioEPA
Division of Drinking and Ground Waters
Geographic Information Systems
20 0 20 40 60 Miles

SW Ohio - PWS Nitrate Concentration Associated with Sensitive Glacial Settings



GW Rule - Sensitive PWSs

- U.S. EPA identifies wells obtaining water from **karst**, **fractured bedrock**, or **gravel** aquifers as sensitive to fecal contamination unless a hydrogeologic barrier is present;
- Hydrogeologic Assessments will identify PWSs sensitive to pathogens.

Hydrogeologic Barrier

- Sensitivity of PWS hinges on presence or absence of a Hydrogeologic Barrier.
- Analysis of nitrate impact suggests:
  - More than25 feet of till limits rapid infiltration and constitutes a hydrogeologic barrier.
  - Nitrate is frequently present to depths of 75 –100 feet in S&G aquifers, however the natural filtration in sand and gravel can remove pathogens.
    - Is 25 feet of sand and gravel sufficient to protect production well from pathogen impact?

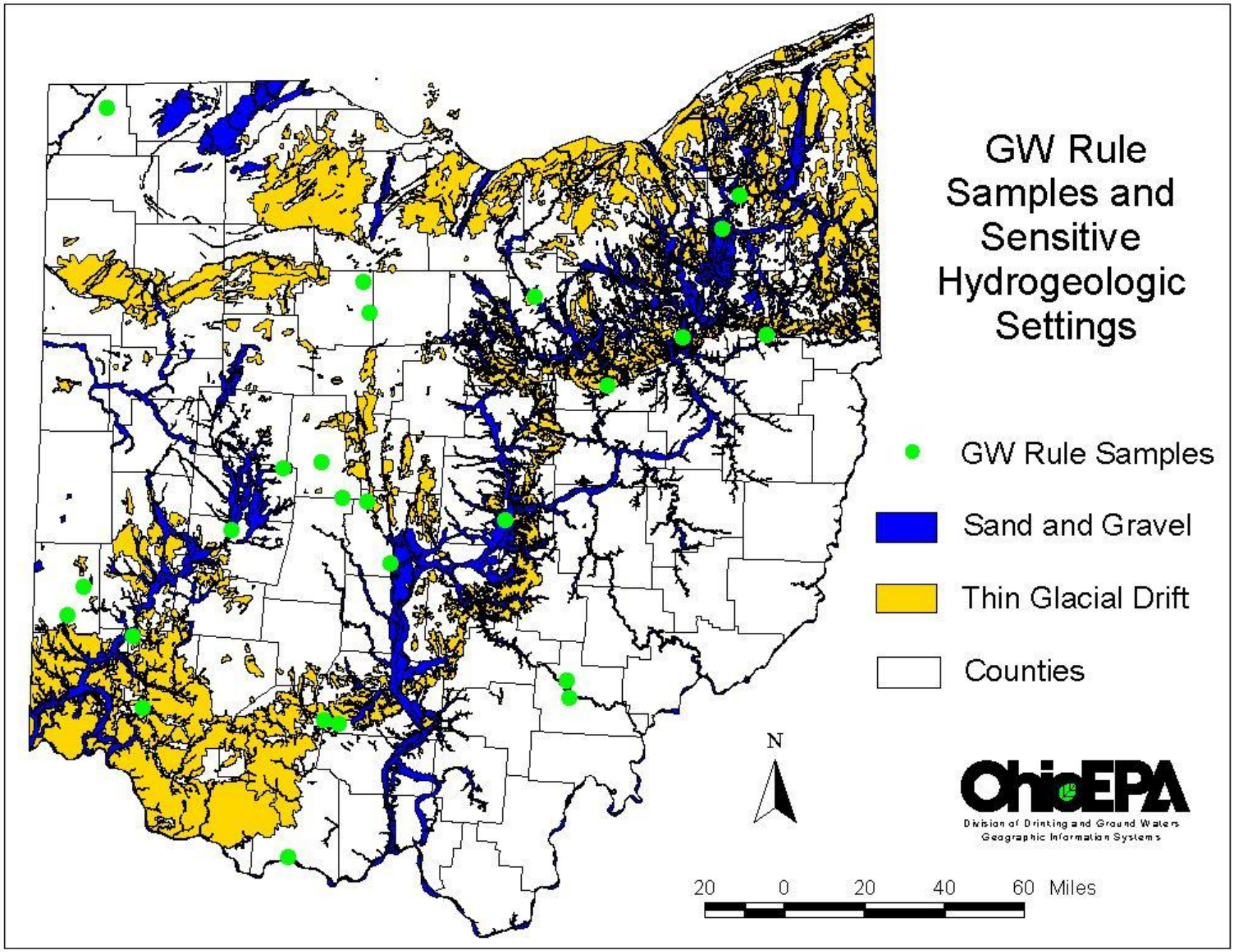
Microbiological Sampling Grant Partners – MDH and U.S. EPA

- Design: To confirm the efficiency of hydro-geologic barriers in areas of sensitive aquifers;
- Philosophy: To demonstrate that we can identify non-vulnerable wells, i.e. wells in which hydro-geologic barriers are present in areas of sensitive aquifers;
- Goal: To support states argument that GW Rule focus should be vulnerable PWSs.

Experiment designed to produce null set results.

Selected Wells - Barriers

- Sand and Gravel Hydrogeologic Barrier
  - 18 wells, 1 confined, 1 Ranney well;
  - Casing length: 27 - 182 feet;
- Glacial Drift Hydrogeologic Barrier
  - 7 wells, 2 tritium non-detect;
  - Casing length: 39 - 100 feet;


GW Rule Samples and Sensitive Hydrogeologic Settings
GW Rule Samples
Sand and Gravel
Thin Glacial Drift
Counties
N
OhioEPA
Division of Drinking and Ground Waters
Geographic Information Systems
20 0 20 40 60 Miles

Microbiological Sampling

- Six quarters of sampling completed for 25 wells, 149 samples collected, results for 148 samples;
- Only six samples with detections:
  - One total coliform positive with fecal contamination (Enterococci);
  - Five total coliform positive with no positive fecal indicators; (2 of the 5 attributed to sample contamination).

Microbiological Sampling

Results emphasize the importance of the local setting in S&G aquifers.

- Adams County Water Co.
  - Well is 70 feet from Ohio River floodplain on 20-25 foot terrace with 39 feet of casing in 66 foot well. Sample collected at flood stage with water up to base of terrace.
- Columbus South Wellfield
  - Well is a ranney well with 5 laterals at depth of 74 feet. Sample was collected when surrounding field was flooded and frozen.
- Highland County Water Co.
  - Well is 63 feet deep with 40 feet of casing and is 125 feet from stream. Bedrock is exposed in stream bank. Sample collected during high flow.
- Millersburg Wellfield
  - Well 93 feet deep with 73 feet of casing and is located on mound in flood plain behind dike. Sample collected when field was flooded.

Bacteria Compliance Data

- Demonstrate association between sensitive aquifers and detections of bacteria?
- Document associations between well depth/casing length and Total Coliform detections?

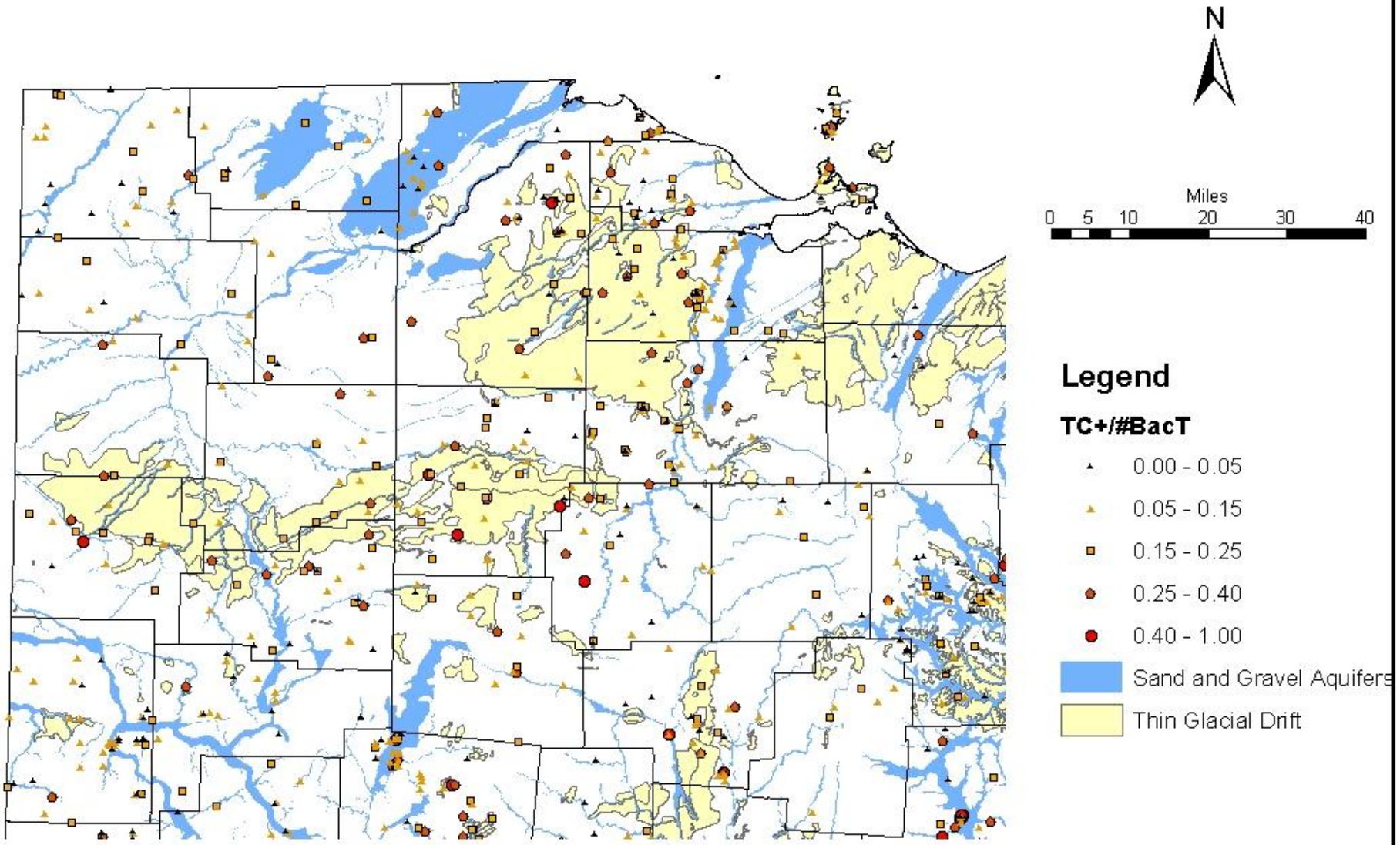
Compliance Data Limitations

- Sampling protocol requires repeat sample if detections occur – results in lots of samples from PWS with TC detections;
- Compliance bacteria data are from distribution samples - not raw water data;
- Poor well construction and /or slimes in well/ pipes may contribute to detections.

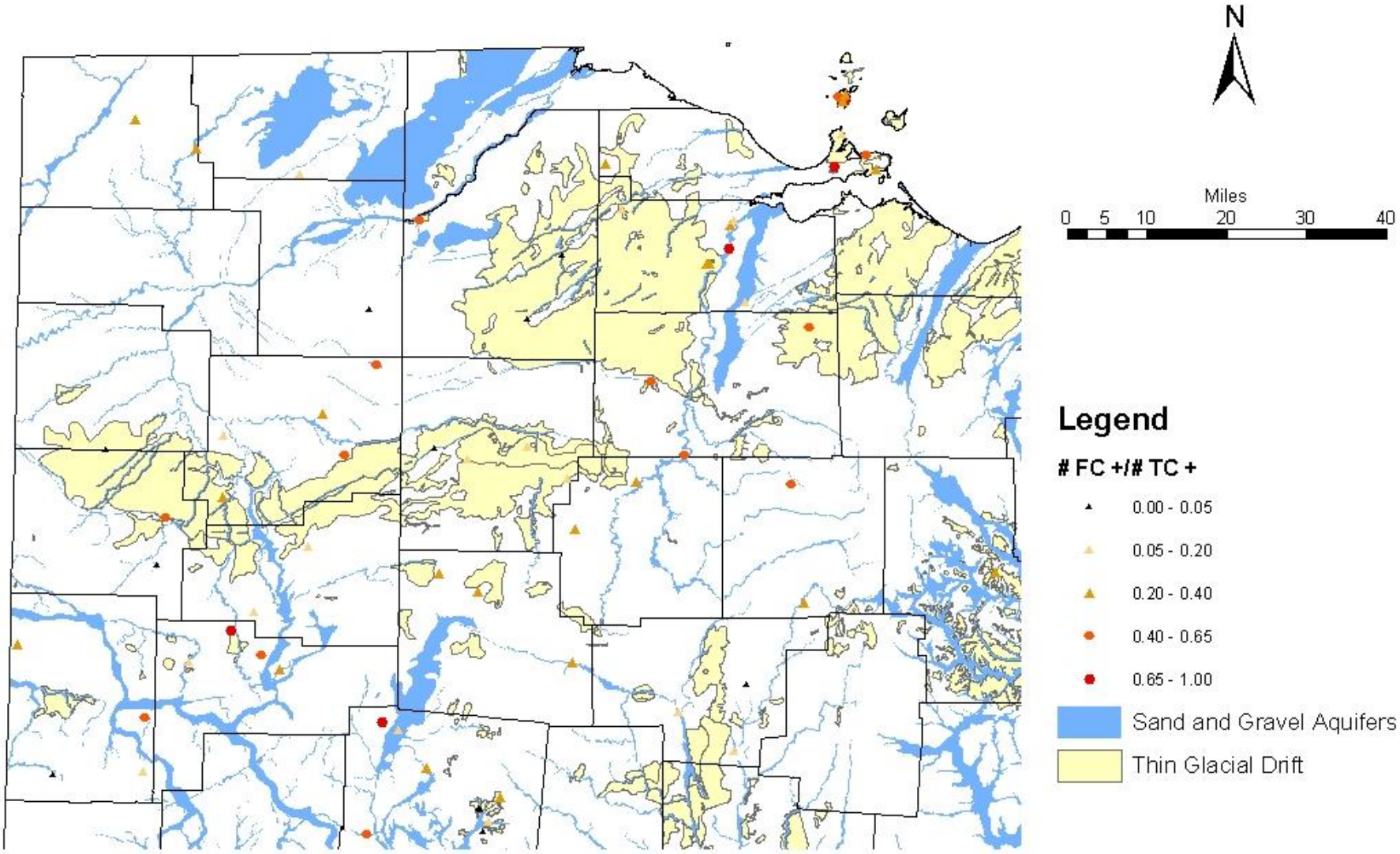
Analysis – Sensitive Aquifers

- Bacteria data from TNC PWSs with no treatment used as data most representative of raw water samples;
- Associated PWS bacteria data from PWSs with no treatment with location and geology;
- Plotted bacteria ratio of detections over sensitive aquifer distribution;

Total Coliform Positive Ratios Associated With Sensitive Aquifers

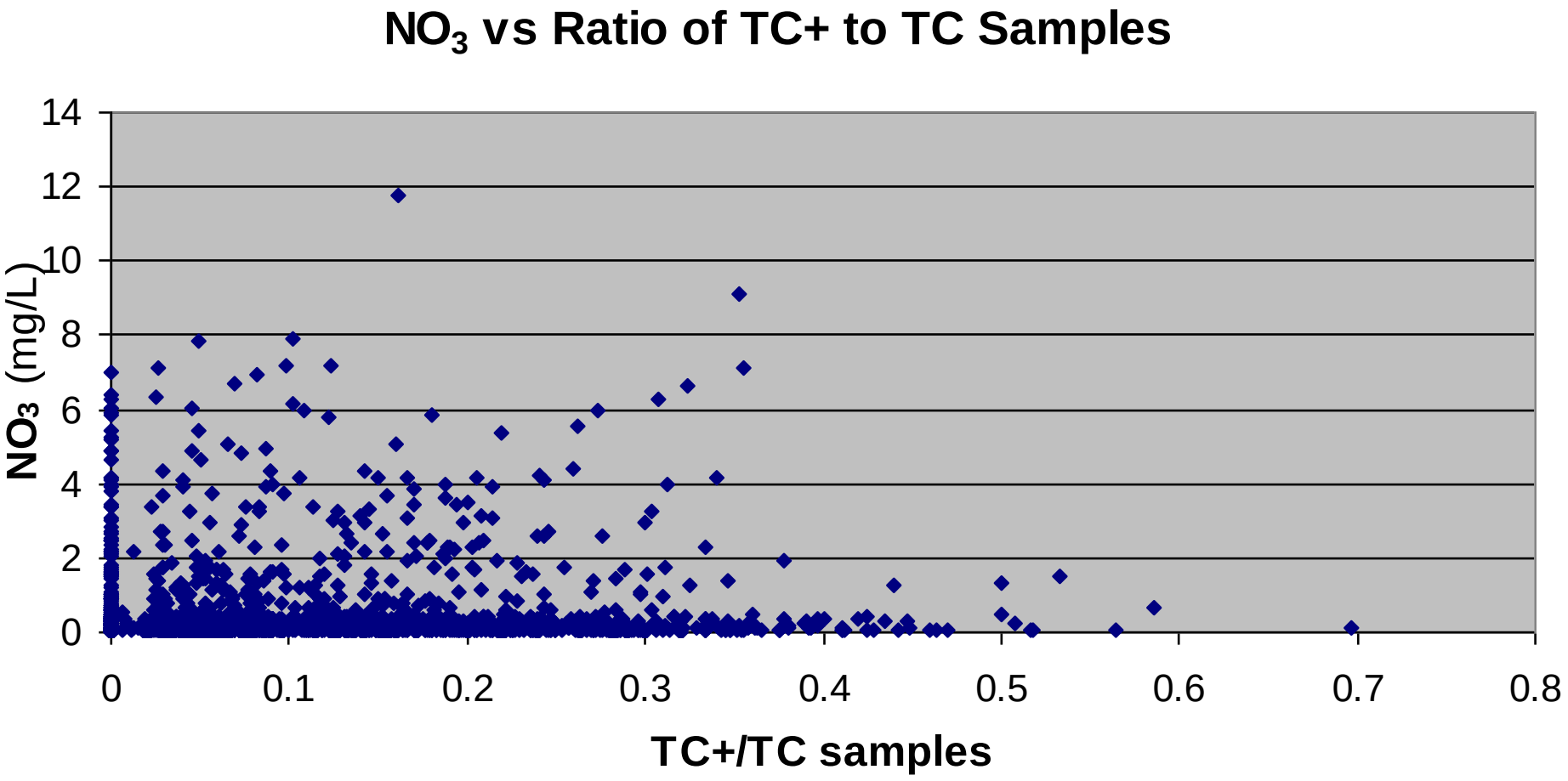


Fecal Coliform Positive Ratios Associated With Sensitive Aquifers



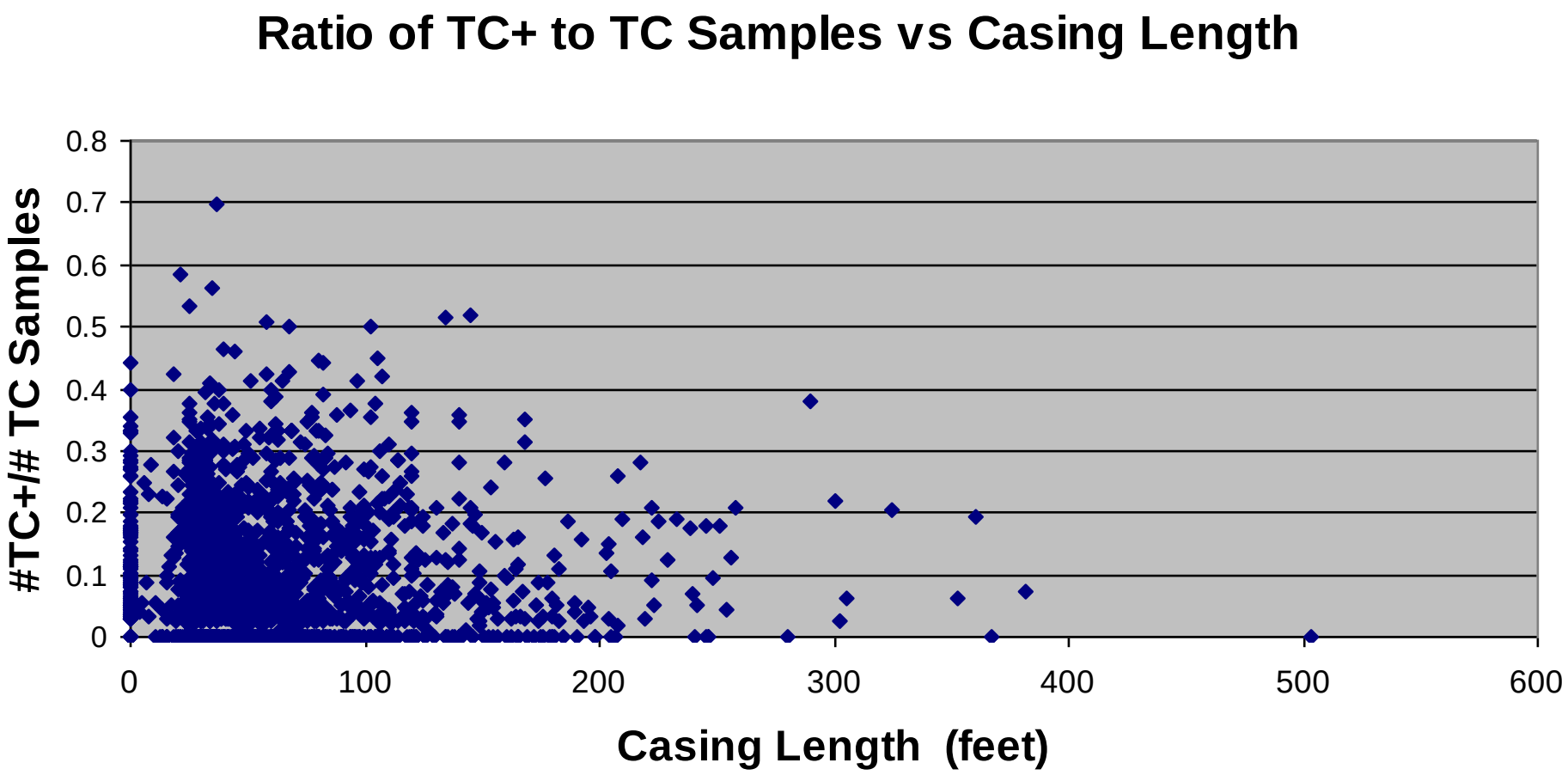
Nitrate – Bacteria Correlation

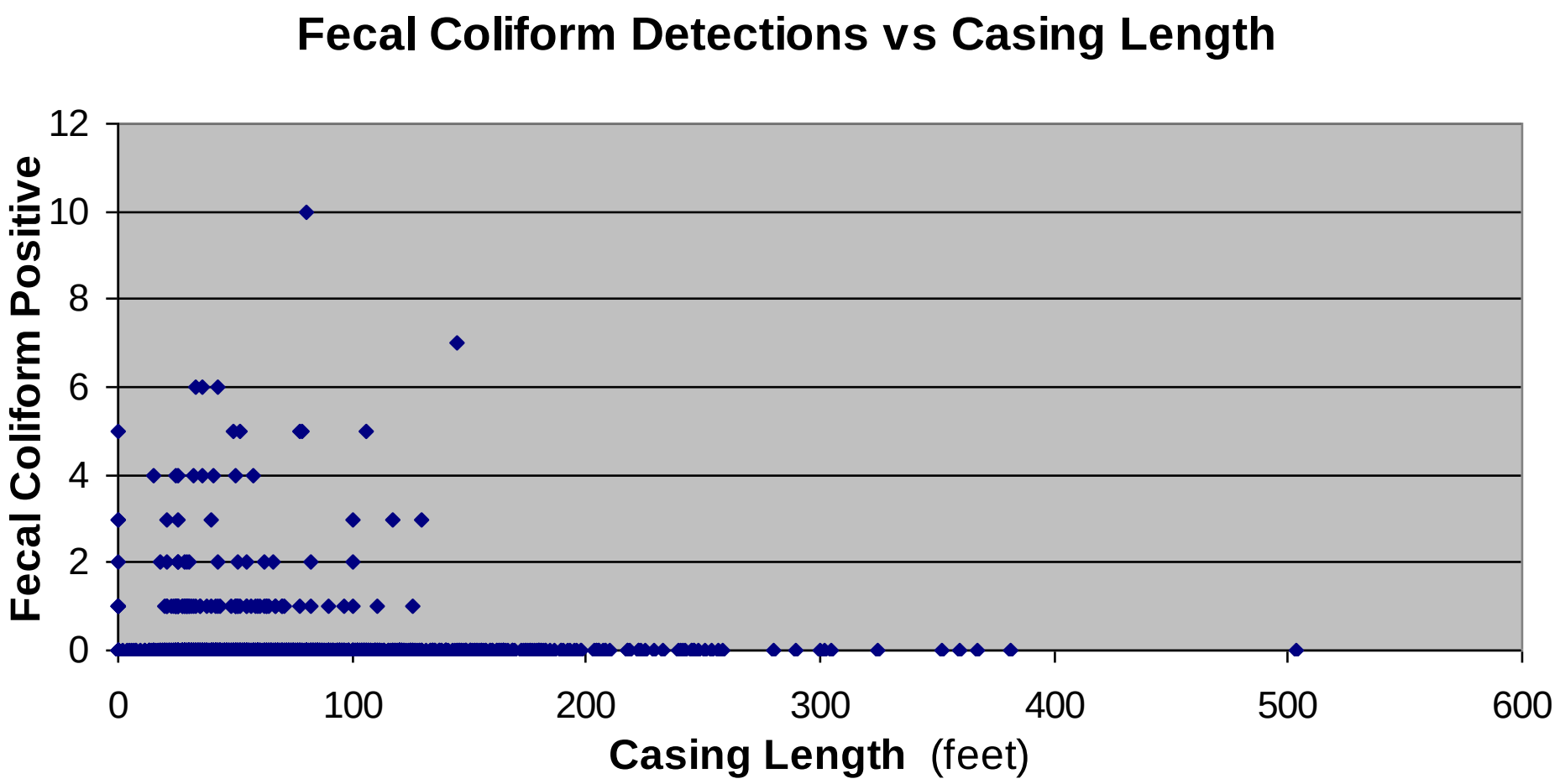
- Poor visual correlation between TC+ ratio and nitrate sensitive aquifers;
- Poor visual correlation between FC+ ratio and sensitive aquifers?
- Statistics (bacteria detections in % of PWSs in glacial lithology categories) confirms lack of correlation of TC+ & FC+ with glacial geology.
- Poor correlation between nitrate concentration and bacteria detections.


NO3 vs Ratio of TC+ to TC Samples
14
12
10
8
6
4
2
0
NO3 (mg/L)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
TC+/TC samples

Analysis - Depth Relationships

- Data associated with average well/ casing depth for PWS
- Total coliform detections associated with well depth/casing length;
- Fecal coliform detections associated with well depth/casing length (small PWS set – 158 PWS).


Ratio of TC+ to TC Samples vs Casing Length
#TC+/# TC Samples
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
100
200
300
400
500
600
Casing Length (feet)


Fecal Coliform Detections vs Casing Length
Fecal Coliform Positive
12
10
8
6
4
2
0
0
100
200
300
400
500
600
Casing Length (feet)

Analysis - Depth Relationships

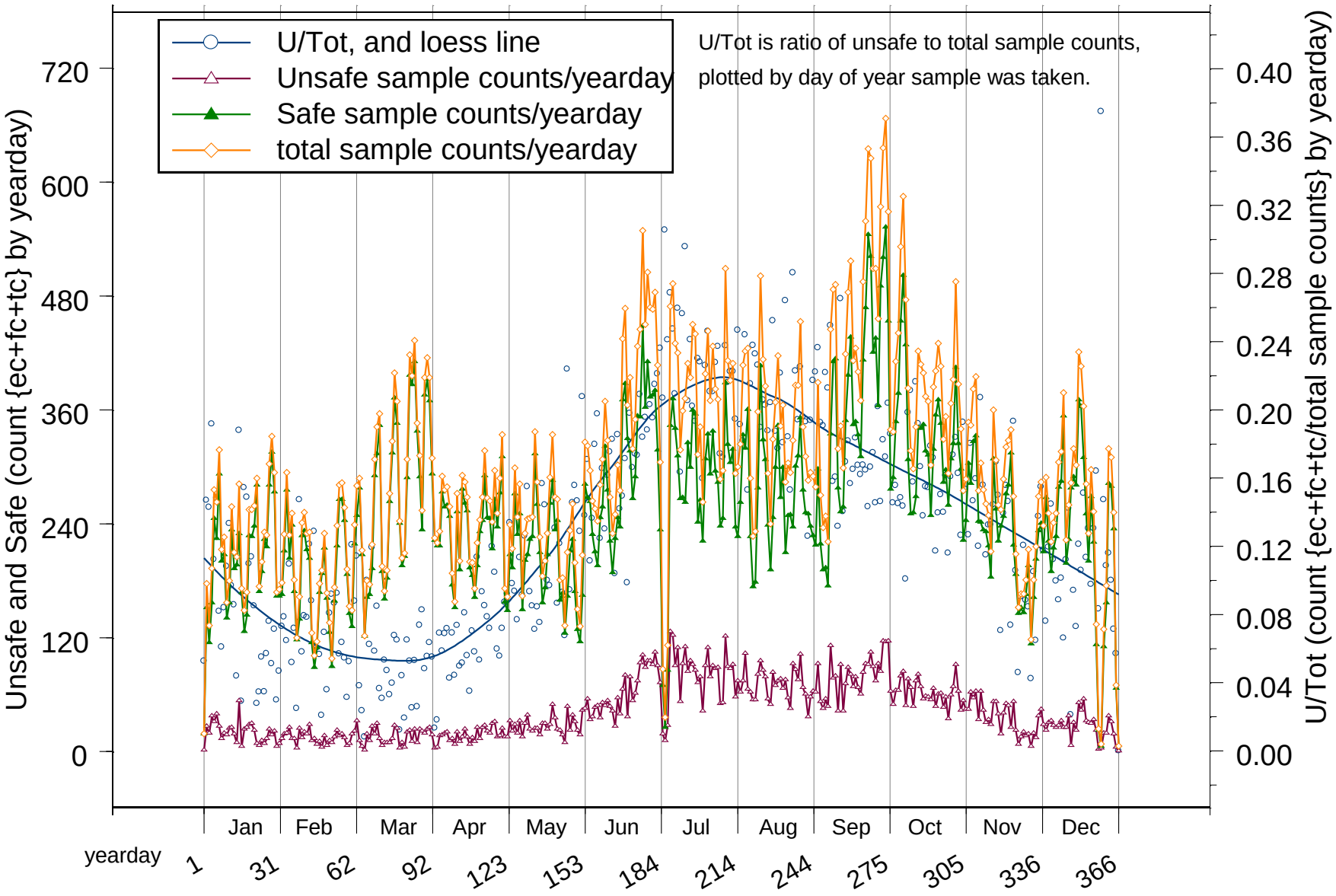
- Total coliform detections less frequent at depth;
  - but occur at significant depths.
- No fecal coliform detection below 150 feet;
  - Significant? (small PWS set – 158 PWS);

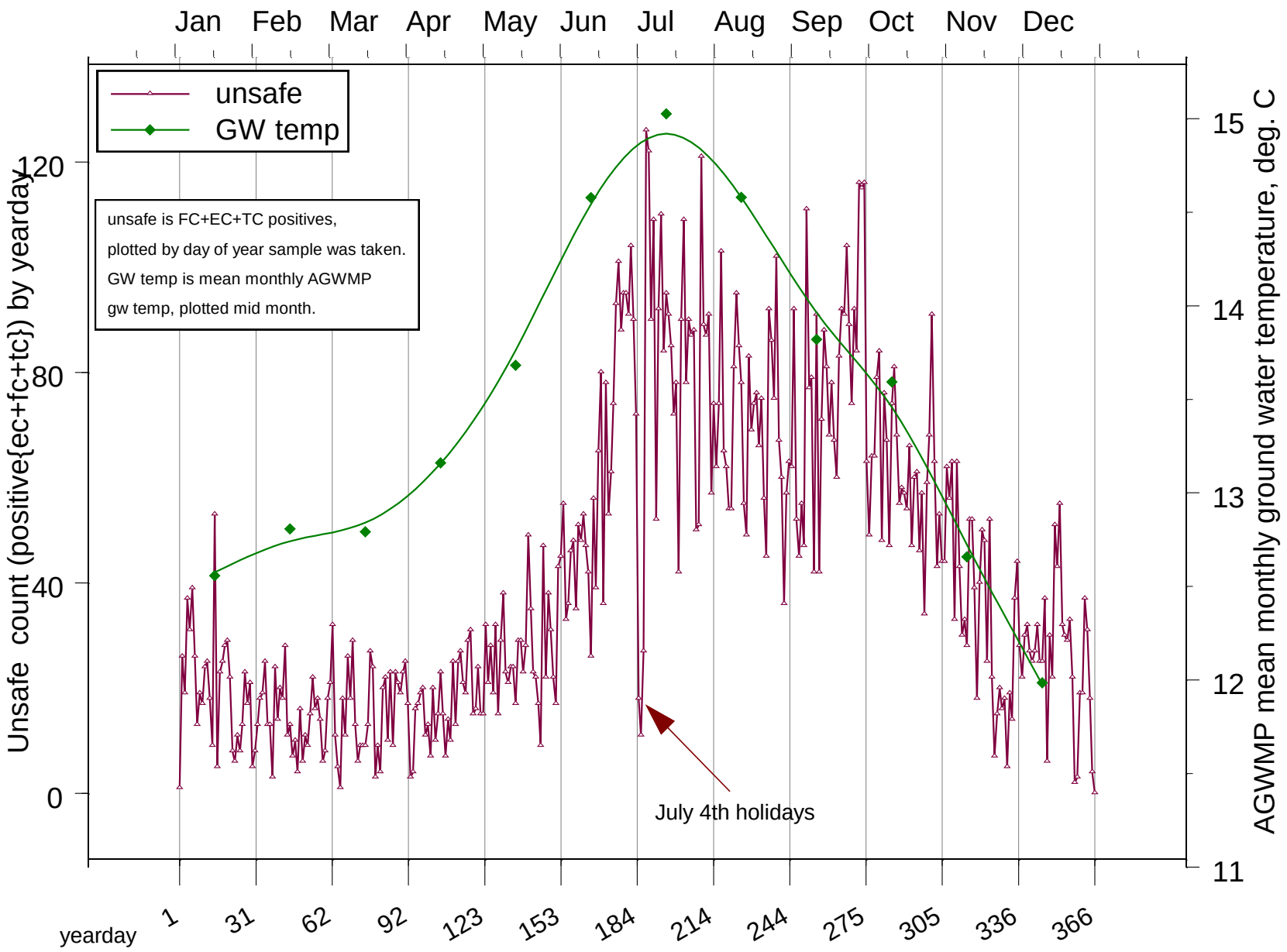
Conclusions

- Selected GW Rule sampling identifies flooding/ saturated settings as likely to increase TC+ detections;
- Poor correlations exist between sensitive aquifers (nitrate) and TC+ compliance results;
- TC+ and FC+ results decrease with depth, but detection depths are much greater than proposed 25 foot thickness as GW Rule barriers;

Implications/Inferences

- The lack of lithologic/geologic control suggests that the location (distance to well) of the pathogen sources may be the critical parameter;
- If pathogen source promotes saturation of vadose zone, like septic system or flooding – this increases likelihood of rapid transport of pathogens to the water table;
  - Significant distinction between point and non-point source.
- Emphasizes the site specific nature of determining the presence of barriers for GW Rule.


U/Tot, and loess line
Unsafe sample counts/yearday
Safe sample counts/yearday
total sample counts/yearday
U/Tot is ratio of unsafe to total sample counts,
plotted by day of year sample was taken.
Unsafe and Safe (count {ec+fc+tc} by yearday)
U/Tot (count {ec+fc+tc/total sample counts} by yearday)
0
120
240
360
480
600
720
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
0.36
0.40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
yearday
1
31
62
92
123
153
184
214
244
275
305
336
366


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
unsafe
GW temp
unsafe is FC+EC+TC positives,
plotted by day of year sample was taken.
GW temp is mean monthly AGWMP
gw temp, plotted mid month.
Unsafe count (positive{ec+fc+tc}) by yearday
120
80
40
0
AGWMP mean monthly ground water temperature, deg. C
15
14
13
12
11
July 4th holidays
yearday
1
31
62
92
123
153
184
214
244
275
305
336
366