

**The Arsenic Special Well Casing Area in the  
Fox River Valley of East-Central Wisconsin :  
An Example of Data Integration and  
Interagency Cooperation From Initial  
Research to Rule Development**

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# Recognition of the Problem

Elevated levels first discovered in late 1980's near a proposed landfill in Winnebago Co., thought to be spill but later shown to be natural.

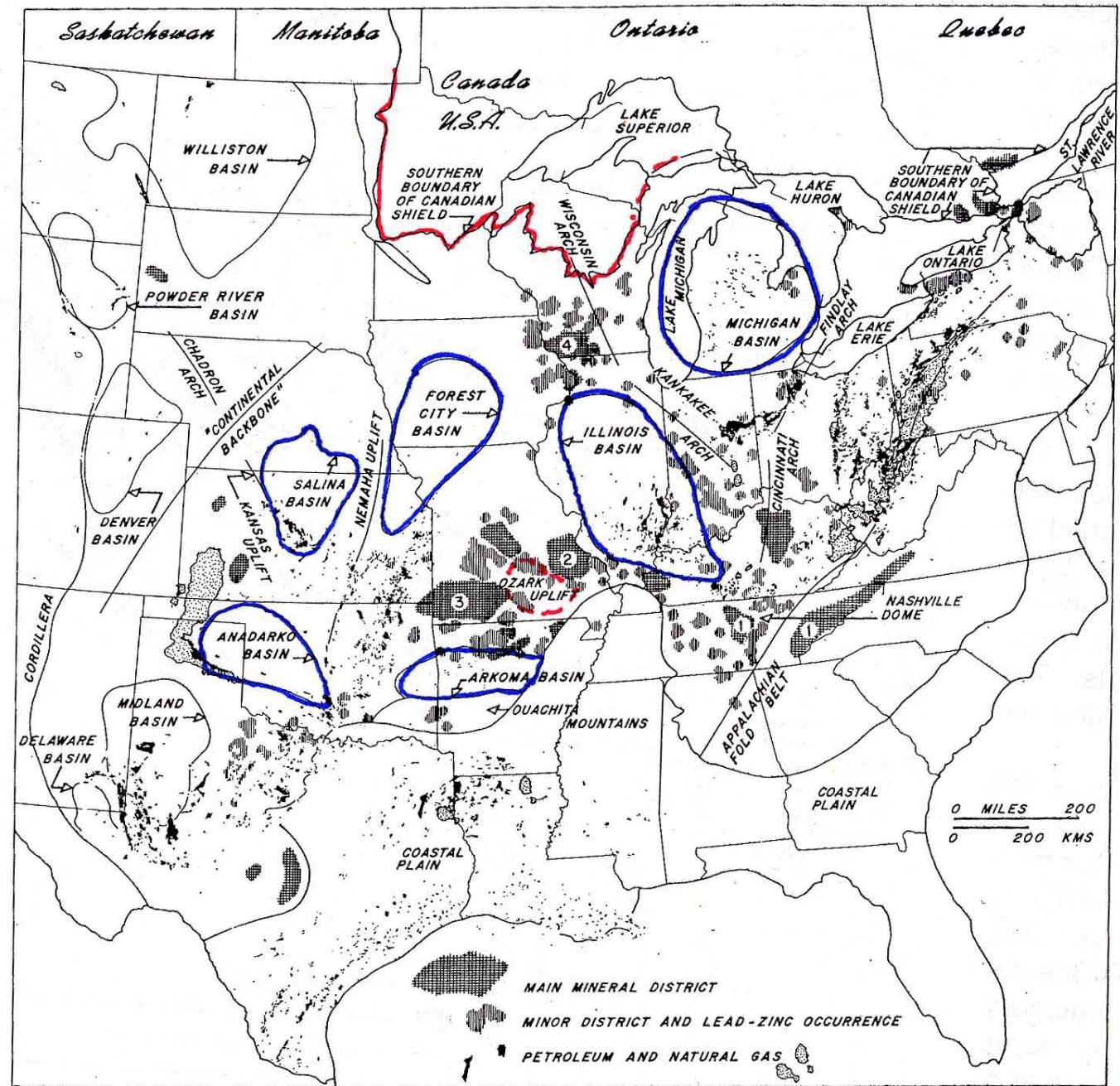
Private well near Seymour, Outagamie Co. developed problems and was found to have high metals.

pH = **2.05**, As = **4,300 ppb**, Cr = **84 ppb**, Cd = **220 ppb**, Ni = **11,000 ppb**, Al = **15,000 ppb**, Co = **5,500 ppb**, Pb = **400 ppb**



# MAJOR BASINS AND MVT DEPOSITS

*Mineral  
districts  
are  
located  
on the  
arches*

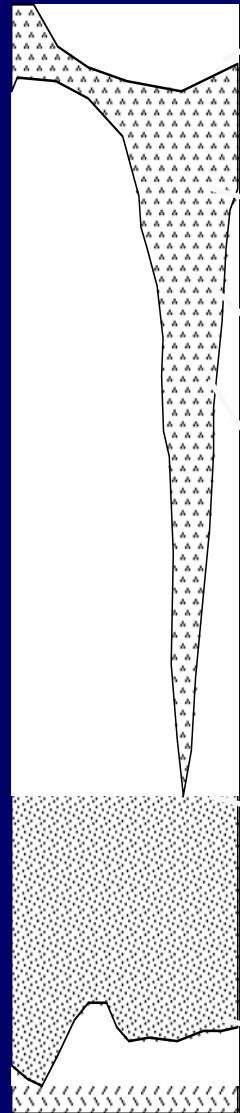


## THE IMMEDIATE PROBLEM

- Rural and suburban development is taking place rapidly, wells are failing and As is a public health issue that can't wait for further study.
- DNR has responded in the past by designating special well construction requirements in local areas where problems occur.
- DNR recognized regional nature of problem and partnered with WGNHS to quickly produce maps that will guide drillers to avoid As contaminated water in Winnebago and Outagamie Counties.
- The new rules must be easy to understand, easy to enforce, and scientifically sound.

# Stratigraphic Column Eastern Wisconsin

225 m



Pleistocene and Recent - *glacial and lacustrine*

Sinnipee Group - carbonate

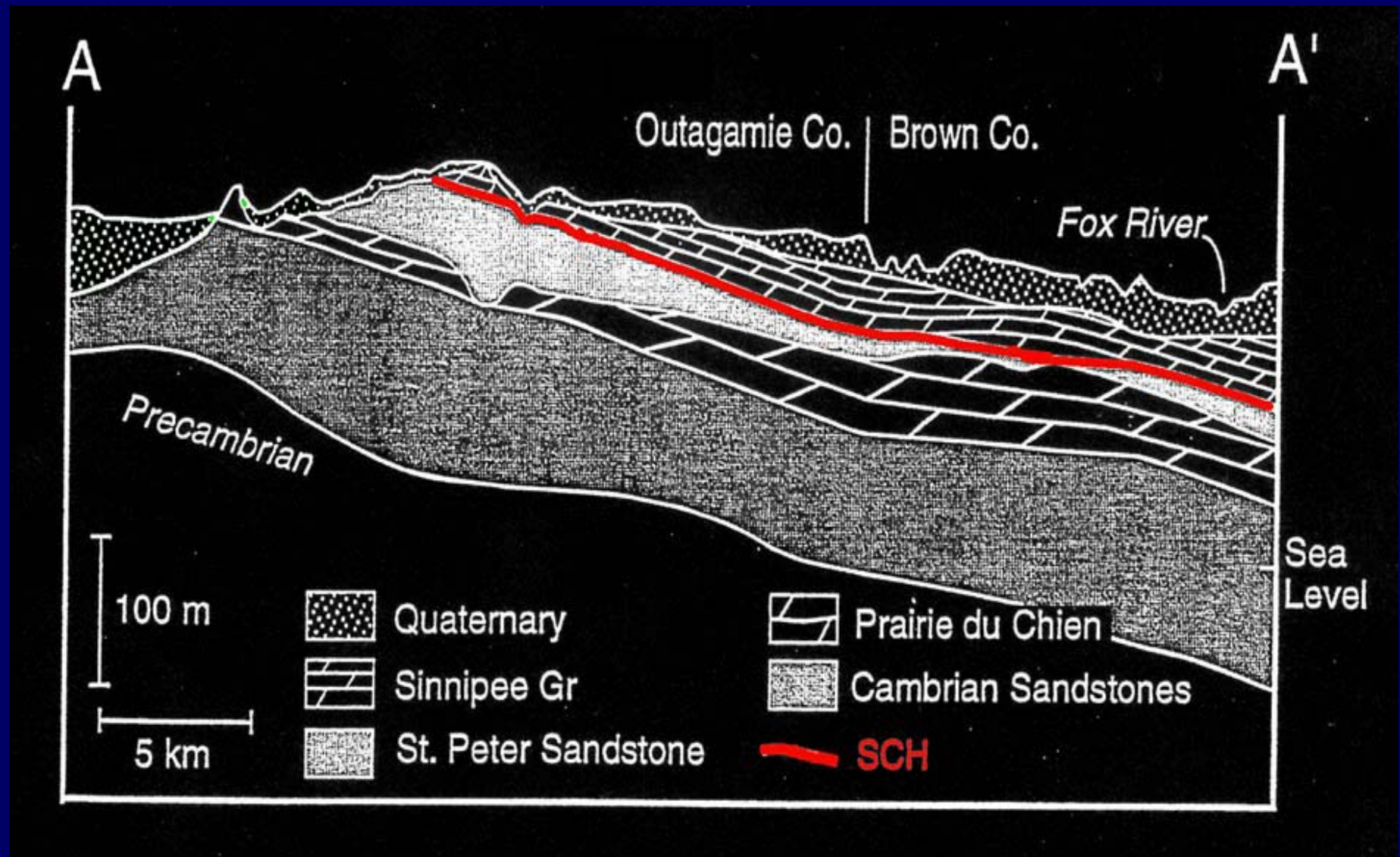
Ancell Group - *sandstone*

Prairie du Chien Group - *carbonate*

Cambrian - *sandstone*

Precambrian - *granite*

# Northeast Wisconsin Stratigraphy: Old Model



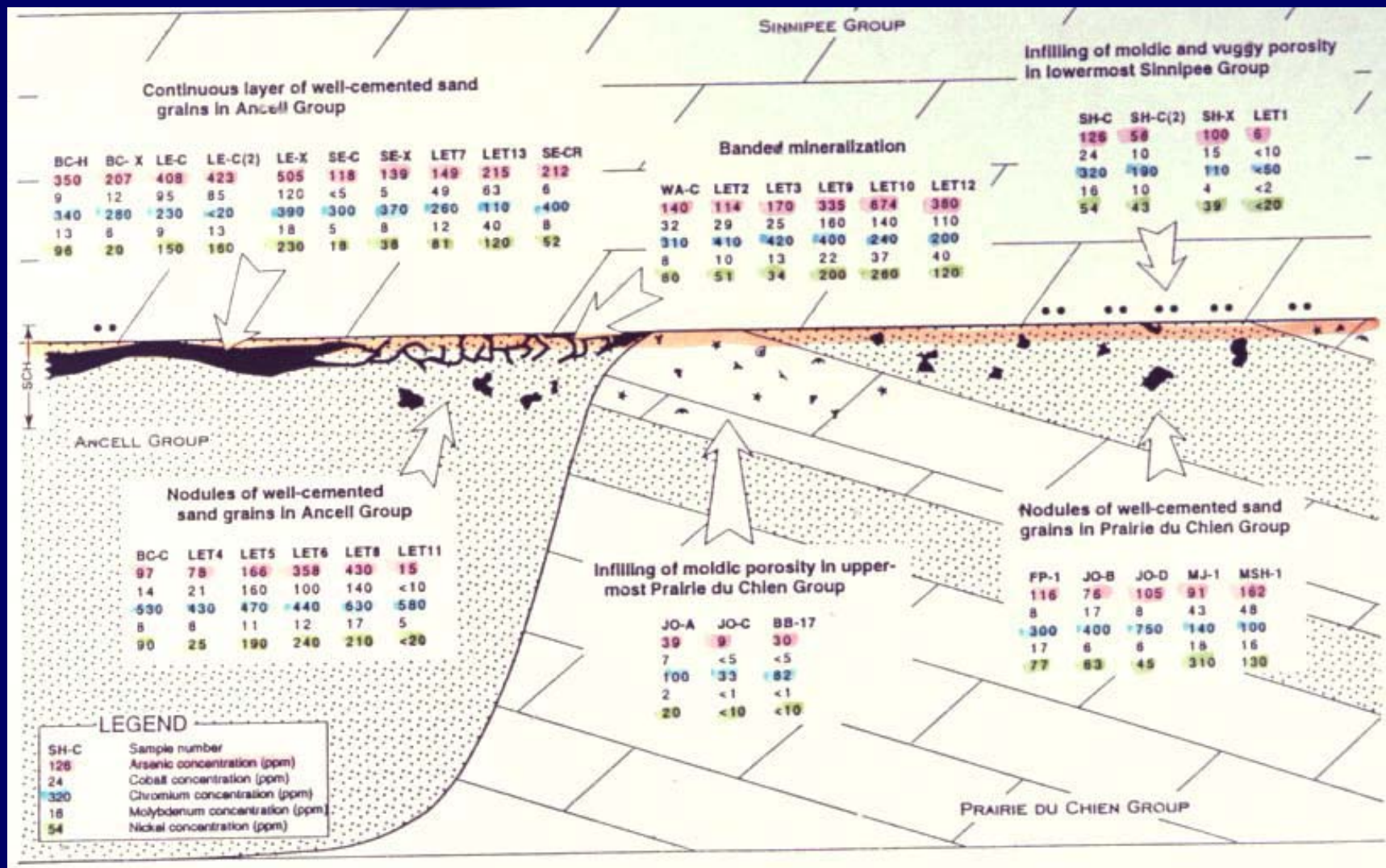
# Minerals typical of Mississippi Valley-type Mineralization

- **Major Minerals**
  - Pyrite ( $\text{FeS}_2$ )
  - Marcasite ( $\text{FeS}_2$ )
  - Galena ( $\text{PbS}$ )
  - Sphalerite ( $(\text{Zn}, \text{Fe})\text{S}$ )
- **Minor Minerals**
  - Chalcopyrite ( $\text{CuFeS}_2$ )
  - Millerite ( $\text{NiS}$ )
  - Barite ( $\text{BaSO}_4$ )
  - Celestite ( $\text{SrSO}_4$ )
  - Fluorite ( $\text{CaF}_2$ )

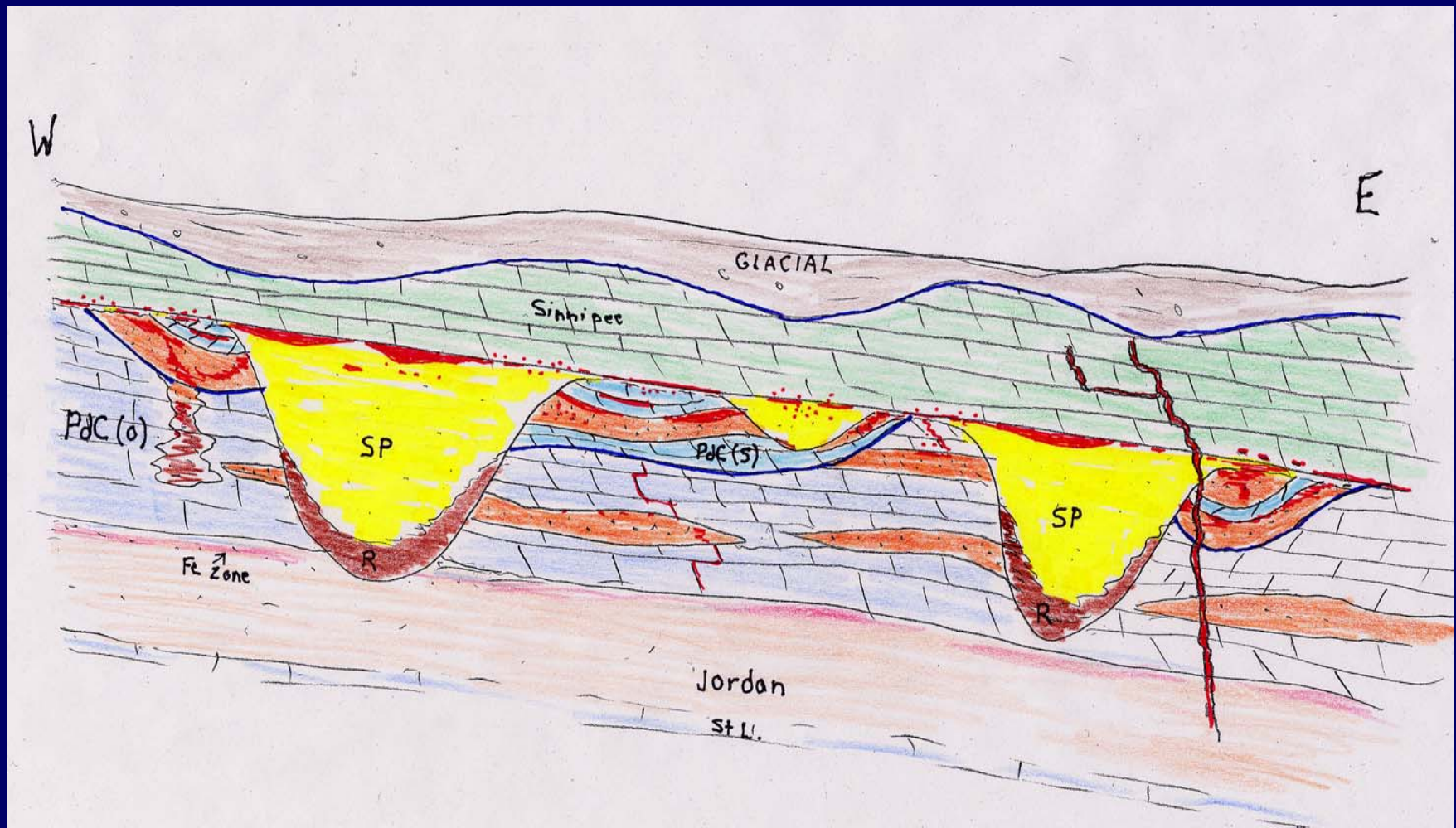


# METAL VALUES IN SULFIDES

(Max PPM, As=674, Cr=750, Ni= 310)



# REALISTIC MODEL OF STRATIGRAPHY FROM CURRENT FIELD STUDIES



# Arsenic in Drill Cuttings

| Formation               | As Conc.<br>mg/kg |
|-------------------------|-------------------|
| 0                       |                   |
| Drift                   |                   |
| 12                      |                   |
|                         |                   |
|                         |                   |
|                         |                   |
|                         | 2.2               |
|                         |                   |
| Galena -<br>Platteville |                   |
|                         | 4.4               |
|                         |                   |
|                         | 15                |
|                         | 13                |
| 75                      |                   |
|                         |                   |
| St. Peter               |                   |
|                         | 14                |
|                         |                   |
| 95                      | 3.4               |

|     |                        |     |  |
|-----|------------------------|-----|--|
|     |                        | 3.7 |  |
|     |                        | 27  |  |
|     |                        |     |  |
| 125 |                        | 3.0 |  |
|     |                        |     |  |
|     |                        | 2.2 |  |
|     |                        | 3.7 |  |
|     |                        | 2.5 |  |
|     | Prairie<br>du<br>Chein | 2.5 |  |
|     |                        | 5.9 |  |
|     |                        |     |  |
|     |                        | 2.6 |  |
|     |                        | 3.8 |  |
|     |                        | 8.3 |  |
|     |                        |     |  |
|     |                        | 39  |  |
|     |                        | 23  |  |
|     |                        | 93  |  |
| 200 |                        |     |  |
|     |                        | 67  |  |
|     |                        |     |  |

|     |             |     |  |
|-----|-------------|-----|--|
| 215 |             | 43  |  |
|     |             | 26  |  |
|     |             | 36  |  |
|     |             | 12  |  |
|     |             |     |  |
|     | Trempealeau | 11  |  |
|     |             | 15  |  |
|     |             | 7.1 |  |
|     |             |     |  |
|     |             | 9.8 |  |
| 260 |             | 2.6 |  |
|     |             |     |  |
|     |             | 3.6 |  |
|     |             |     |  |
|     |             | 36  |  |
|     |             | 84  |  |
|     | Tunnel City | 5.0 |  |
|     |             | 2.7 |  |
|     |             |     |  |
|     |             |     |  |
|     |             |     |  |

Maple Leaf Dairy Well, Vinland Township, Winnebago County

# Classic Sulfide Cement Zone

*Commonly present  
at the top of Ancell  
Group (St. Peter),  
but can be present  
in sandstone of  
Prairie du Chien  
Group*



**Base of  
Platteville- top  
of St. Peter  
with shaly  
zone  
(Glenwood  
equivalent)  
and little  
visible  
mineralization**



# **CALCITE VEIN IN QUARRY**

***VEIN  
CONTAINS  
MARCASITE  
AND PYRITE IN  
MATRIX OF  
WHITE  
CALCITE,  
TYPICAL MVT  
MINERALS***



# Iron stain from sulfide weathering





**Black mud and  
cuttings typical of  
sulfide cement  
zones**

# GIS-BASED MAPPING APPROACH

- Assemble available subsurface (WCR, Geol. Log, other drill records) data for region.
- Clean up address data on logs and match to county address data.
- Construct spatial database containing usable well information. (6000+ wells used for this study.)
- Interpret geology and formation contacts.
- Produce contour maps of bounding surfaces of mineralized geologic formations.

# Well Construction Report

|                                                                                                    |  |                                                       |                            |                                             |  |                                               |                                                |                                                  |  |
|----------------------------------------------------------------------------------------------------|--|-------------------------------------------------------|----------------------------|---------------------------------------------|--|-----------------------------------------------|------------------------------------------------|--------------------------------------------------|--|
| City<br><b>SEYMOUR</b>                                                                             |  | State<br><b>WI</b>                                    | Zip Code<br><b>54185</b>   | County of Well Location<br><b>OUTAGAMIE</b> |  | Co. Well Permit No.<br><b>August 24, 1988</b> | Well Completion Date<br><b>August 24, 1988</b> | of <b>OSBORN</b>                                 |  |
| City<br><b>45</b>                                                                                  |  | State<br><b>WI</b>                                    | Zip Code<br><b>54106</b>   | City<br><b>4</b>                            |  | State<br><b>WI</b>                            | Zip Code<br><b>54106</b>                       | City<br><b>4</b>                                 |  |
| Well Contractor (Business Name)<br><b>SCHMIDT'S WATER SERVICE</b>                                  |  | License #<br><b>6</b>                                 | 1. Date<br><b>09/19/88</b> | 2. Date<br><b>10/10/89</b>                  |  | 3. Date<br><b>10/10/89</b>                    |                                                | 4. Date<br><b>10/10/89</b>                       |  |
| Address<br><b>RT 3 BOX 27</b>                                                                      |  | City<br><b>BLACK CREEK</b>                            |                            | State<br><b>WI</b>                          |  | Zip Code<br><b>54106</b>                      |                                                | City<br><b>4</b>                                 |  |
| M= Munic. C= CDM N= NonCom P= Priv Z= Other<br>K= NonPot. A= Anoda L= Loop H= Drillhole            |  | 10/10/89                                              |                            | 10/10/89                                    |  | 10/10/89                                      |                                                | 10/10/89                                         |  |
| 4. Well name: <b>1</b> # of homes and/or (Ex: barn, restaurant, church, school, industry, etc.)    |  | High Capacity: <b>W</b>                               |                            | Well? <b>N</b>                              |  | Property? <b>N</b>                            |                                                | 1. Drilled 2 = Driven Point 3 = Jetted 4 = Other |  |
| 5. Well located on highest point of property, consistent with the general layout and surroundings? |  | Well located in floodplain? <b>N</b>                  |                            | Distance in feet from well to nearest:      |  | 1. Landfill                                   |                                                | 10. Building Overhang                            |  |
| 7. Septic or Holding Tank (circle one)                                                             |  | 8. Sewage Absorption Unit                             |                            | 9. Nonconforming Pit                        |  | 10. Buried Home Heating Oil Tank              |                                                | 11. Buried Petroleum Tank                        |  |
| 8. Shallow/Swimming Pool                                                                           |  | 14. Clearwater Sump                                   |                            | 15. Collector or Street Sewer               |  | 16. Clearwater Sump                           |                                                | 17. Wastewater Sump                              |  |
| 18. Paved Animal Barn Pen                                                                          |  | 19. Animal Yard or Shelter                            |                            | 20. Silo - Type                             |  | 21. Barn Gutter                               |                                                | 22. Manure Pipe 1=Gravity 2=Pressure             |  |
| 23. Other Manure Storage                                                                           |  | Other NR 112 Waste Source                             |                            | 24.                                         |  | 25.                                           |                                                | 26.                                              |  |
| 6. Drillhole Dimensions                                                                            |  | Method of constructing upper enlarged drillhole only: |                            | 7. Casing Liner Screen                      |  | Material Weight Specification                 |                                                | From To                                          |  |
| Dia. (in.)                                                                                         |  | From To                                               |                            | Dia. (in.)                                  |  | From To                                       |                                                | Dia. (in.)                                       |  |
| 9.0                                                                                                |  | surface                                               |                            | 83                                          |  | surface                                       |                                                | 83                                               |  |
| 6.0                                                                                                |  | 83                                                    |                            | 100                                         |  | surface                                       |                                                | 83                                               |  |
| 1. Rotary - Mud Circulation                                                                        |  | 2. Rotary - Air                                       |                            | 3. Rotary - Foam                            |  | 4. Reverse Rotary                             |                                                | 5. Cable-tool Bit                                |  |
| 6. Temp. Outer Casing                                                                              |  | 7. Other                                              |                            | 8. Temp. Outer Casing                       |  | 9. Temp. Outer Casing                         |                                                | 10. Temp. Outer Casing                           |  |
| 11. Pump Test                                                                                      |  | 12. Well Is:                                          |                            | 13. Pump Test                               |  | 14. Well Is:                                  |                                                | 15. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 16. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 17. Static Water Level                      |  | ft. B ground surface                          |                                                | 18. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 19. Pump Test                                                                                      |  | 20. Well Is:                                          |                            | 21. Pump Test                               |  | 22. Well Is:                                  |                                                | 23. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 24. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 25. Static Water Level                      |  | ft. B ground surface                          |                                                | 26. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 27. Pump Test                                                                                      |  | 28. Well Is:                                          |                            | 29. Pump Test                               |  | 30. Well Is:                                  |                                                | 31. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 32. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 33. Static Water Level                      |  | ft. B ground surface                          |                                                | 34. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 35. Pump Test                                                                                      |  | 36. Well Is:                                          |                            | 37. Pump Test                               |  | 38. Well Is:                                  |                                                | 39. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 40. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 41. Static Water Level                      |  | ft. B ground surface                          |                                                | 42. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 43. Pump Test                                                                                      |  | 44. Well Is:                                          |                            | 45. Pump Test                               |  | 46. Well Is:                                  |                                                | 47. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 48. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 49. Static Water Level                      |  | ft. B ground surface                          |                                                | 50. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 51. Pump Test                                                                                      |  | 52. Well Is:                                          |                            | 53. Pump Test                               |  | 54. Well Is:                                  |                                                | 55. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 56. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 57. Static Water Level                      |  | ft. B ground surface                          |                                                | 58. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 59. Pump Test                                                                                      |  | 60. Well Is:                                          |                            | 61. Pump Test                               |  | 62. Well Is:                                  |                                                | 63. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 64. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 65. Static Water Level                      |  | ft. B ground surface                          |                                                | 66. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 67. Pump Test                                                                                      |  | 68. Well Is:                                          |                            | 69. Pump Test                               |  | 70. Well Is:                                  |                                                | 71. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 72. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 73. Static Water Level                      |  | ft. B ground surface                          |                                                | 74. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 75. Pump Test                                                                                      |  | 76. Well Is:                                          |                            | 77. Pump Test                               |  | 78. Well Is:                                  |                                                | 79. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 80. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 81. Static Water Level                      |  | ft. B ground surface                          |                                                | 82. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 83. Pump Test                                                                                      |  | 84. Well Is:                                          |                            | 85. Pump Test                               |  | 86. Well Is:                                  |                                                | 87. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 88. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 89. Static Water Level                      |  | ft. B ground surface                          |                                                | 90. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 91. Pump Test                                                                                      |  | 92. Well Is:                                          |                            | 93. Pump Test                               |  | 94. Well Is:                                  |                                                | 95. Pump Test                                    |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 96. Static Water Level                                                                             |  | ft. B ground surface                                  |                            | 97. Static Water Level                      |  | ft. B ground surface                          |                                                | 98. Static Water Level                           |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 99. Pump Test                                                                                      |  | 100. Well Is:                                         |                            | 101. Pump Test                              |  | 102. Well Is:                                 |                                                | 103. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 104. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 105. Static Water Level                     |  | ft. B ground surface                          |                                                | 106. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 107. Pump Test                                                                                     |  | 108. Well Is:                                         |                            | 109. Pump Test                              |  | 110. Well Is:                                 |                                                | 111. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 112. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 113. Static Water Level                     |  | ft. B ground surface                          |                                                | 114. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 115. Pump Test                                                                                     |  | 116. Well Is:                                         |                            | 117. Pump Test                              |  | 118. Well Is:                                 |                                                | 119. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 120. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 121. Static Water Level                     |  | ft. B ground surface                          |                                                | 122. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 123. Pump Test                                                                                     |  | 124. Well Is:                                         |                            | 125. Pump Test                              |  | 126. Well Is:                                 |                                                | 127. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 128. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 129. Static Water Level                     |  | ft. B ground surface                          |                                                | 130. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 131. Pump Test                                                                                     |  | 132. Well Is:                                         |                            | 133. Pump Test                              |  | 134. Well Is:                                 |                                                | 135. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 136. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 137. Static Water Level                     |  | ft. B ground surface                          |                                                | 138. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 139. Pump Test                                                                                     |  | 140. Well Is:                                         |                            | 141. Pump Test                              |  | 142. Well Is:                                 |                                                | 143. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 144. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 145. Static Water Level                     |  | ft. B ground surface                          |                                                | 146. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 147. Pump Test                                                                                     |  | 148. Well Is:                                         |                            | 149. Pump Test                              |  | 150. Well Is:                                 |                                                | 151. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 152. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 153. Static Water Level                     |  | ft. B ground surface                          |                                                | 154. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 155. Pump Test                                                                                     |  | 156. Well Is:                                         |                            | 157. Pump Test                              |  | 158. Well Is:                                 |                                                | 159. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 160. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 161. Static Water Level                     |  | ft. B ground surface                          |                                                | 162. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 163. Pump Test                                                                                     |  | 164. Well Is:                                         |                            | 165. Pump Test                              |  | 166. Well Is:                                 |                                                | 167. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 168. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 169. Static Water Level                     |  | ft. B ground surface                          |                                                | 170. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 171. Pump Test                                                                                     |  | 172. Well Is:                                         |                            | 173. Pump Test                              |  | 174. Well Is:                                 |                                                | 175. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 176. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 177. Static Water Level                     |  | ft. B ground surface                          |                                                | 178. Static Water Level                          |  |
| 52.0                                                                                               |  | ft. B ground surface                                  |                            | 52.0                                        |  | ft. B ground surface                          |                                                | 52.0                                             |  |
| A= Above B= Below                                                                                  |  | A= Above B= Below                                     |                            | A= Above B= Below                           |  | A= Above B= Below                             |                                                | A= Above B= Below                                |  |
| 179. Pump Test                                                                                     |  | 180. Well Is:                                         |                            | 181. Pump Test                              |  | 182. Well Is:                                 |                                                | 183. Pump Test                                   |  |
| Pumping Rate 3.0                                                                                   |  | ft. below ground surface                              |                            | Pumping Rate 3.0                            |  | ft. below ground surface                      |                                                | Pumping Rate 3.0                                 |  |
| Pumping at 15.0 GPM                                                                                |  | 8.00 hrs                                              |                            | Pumping at 15.0 GPM                         |  | 8.00 hrs                                      |                                                | Pumping at 15.0 GPM                              |  |
| 184. Static Water Level                                                                            |  | ft. B ground surface                                  |                            | 185. Static Water Level                     |  | ft. B ground surface                          |                                                |                                                  |  |

**Address point  
data provided  
by Winnebago  
and Outagamie  
Counties**

**These points  
were matched  
with addresses  
in WDNR well  
database**

***Initial match in  
Winnebago Co.  
2000+ points***



# ARSENIC SAMPLING FOX VALLEY

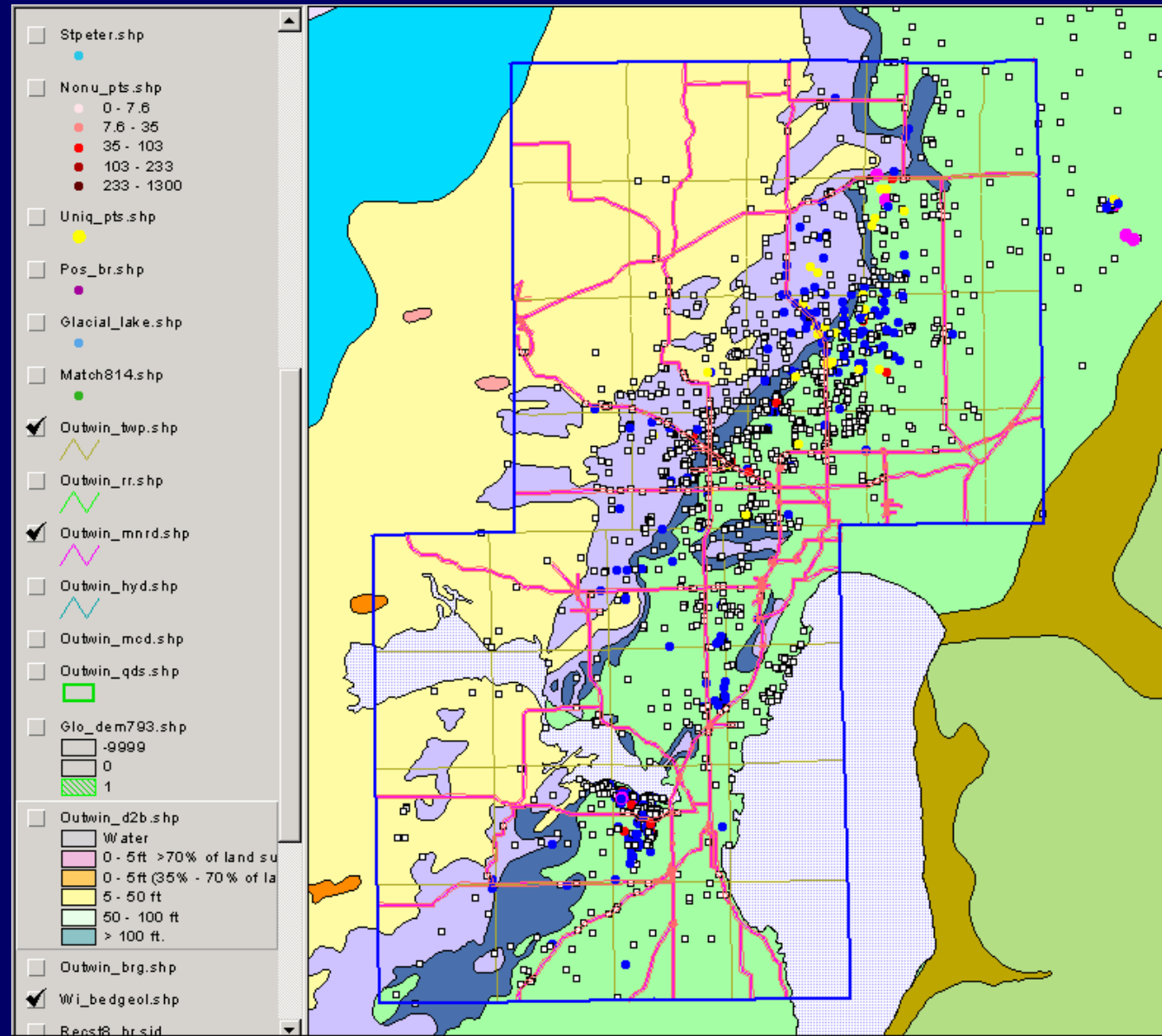
A COUNTY TO  
REGIONAL  
SCALE  
PROBLEM

*Red dots*

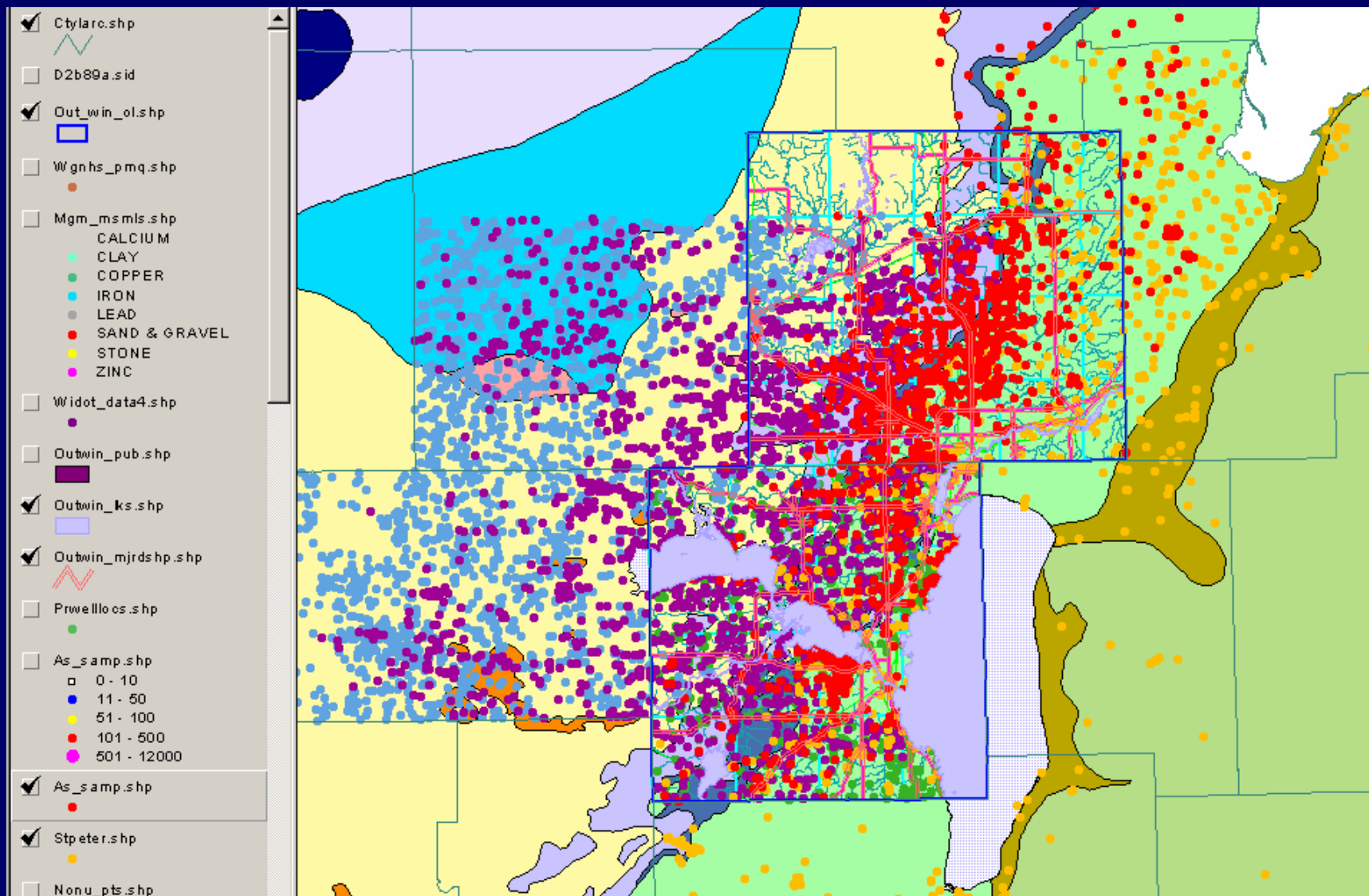
*100 to 500*

*Purple*

*500 to 12000*

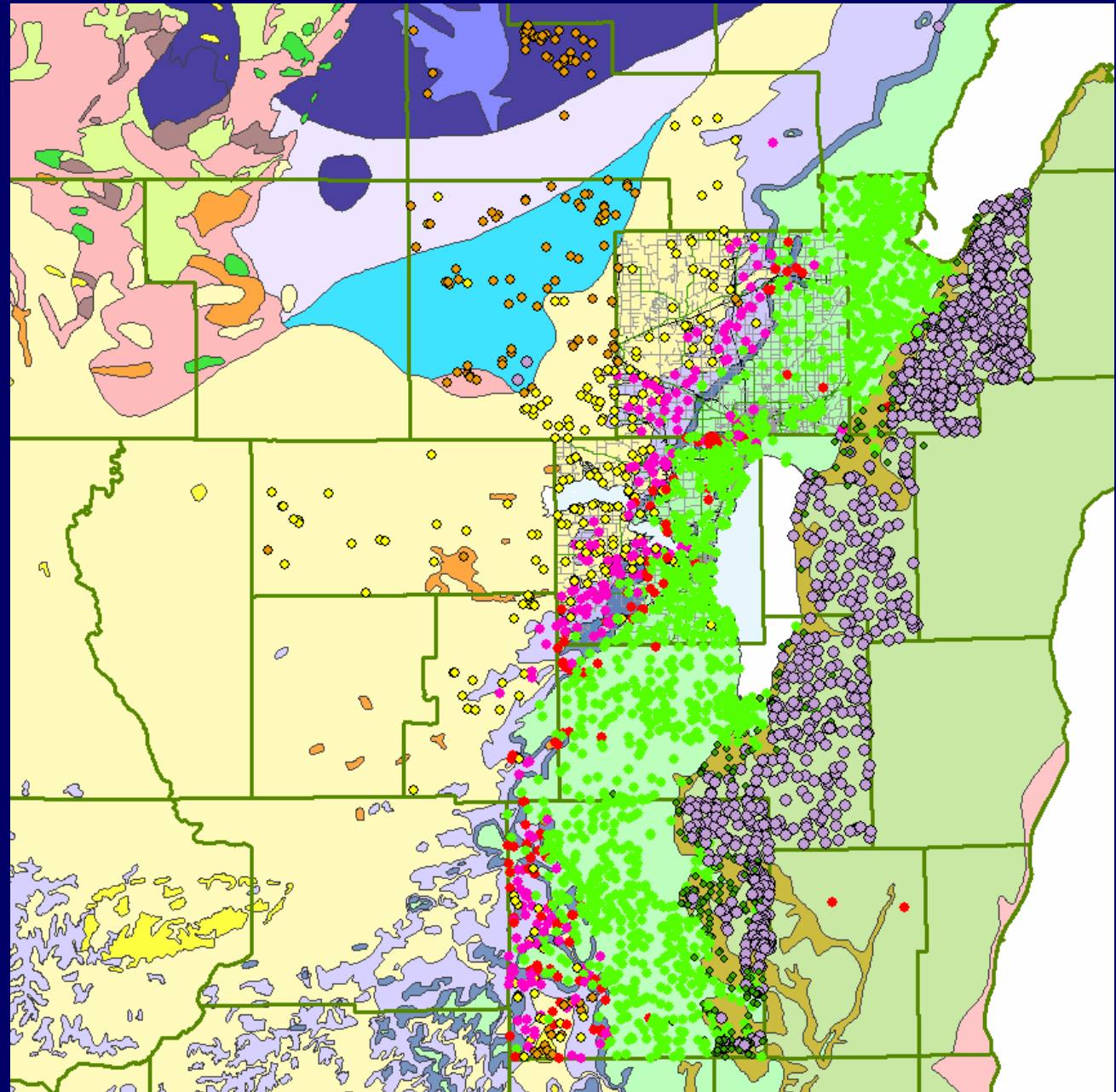


# Data points from WGNHS mapping projects and WDNR arsenic sampling



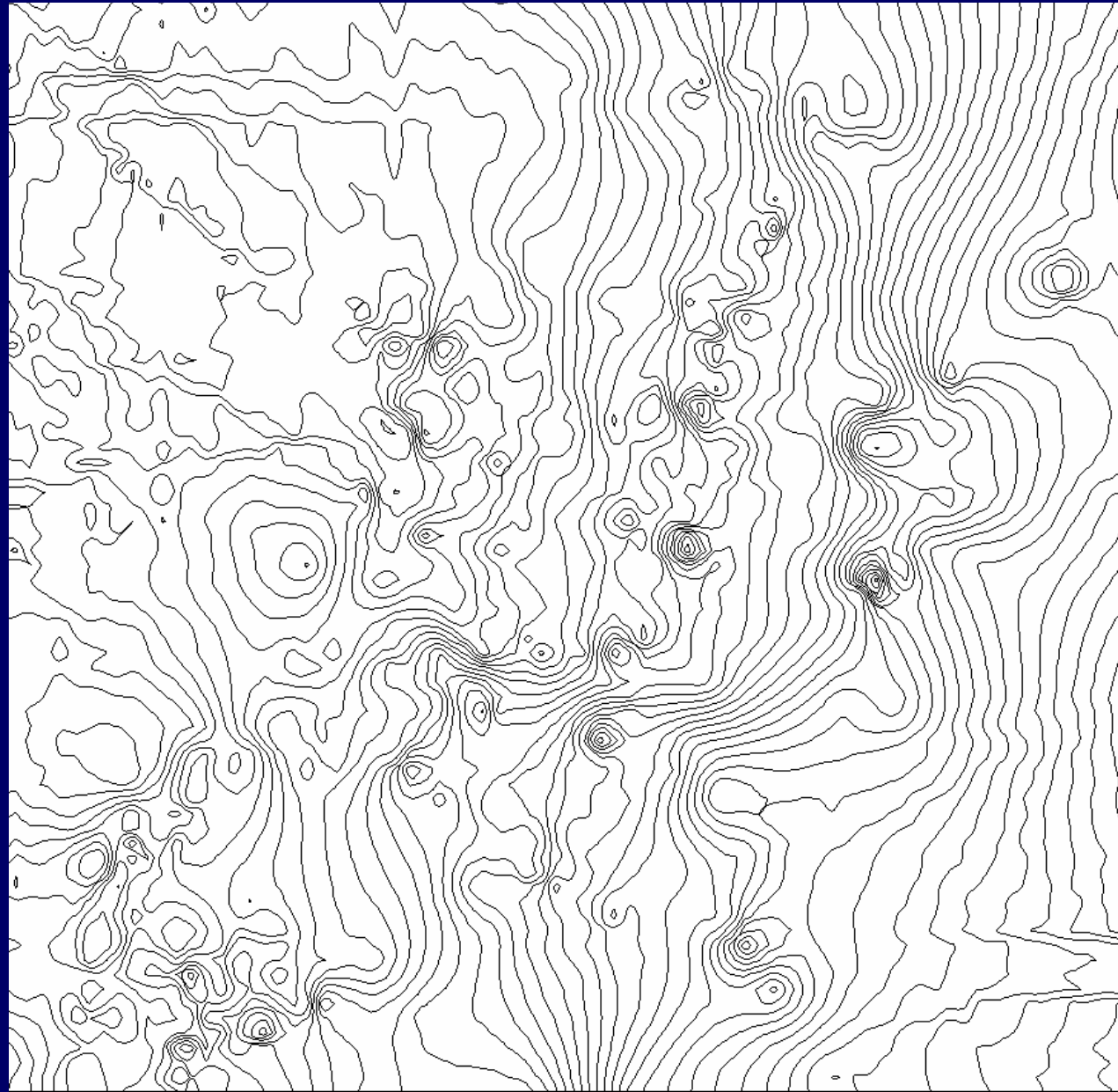
# WELL DATA FROM WISCLITH AND OTHER SOURCES

*Data  
compiled  
over large  
area to define  
trends of  
formation  
contacts on  
regional  
scale*

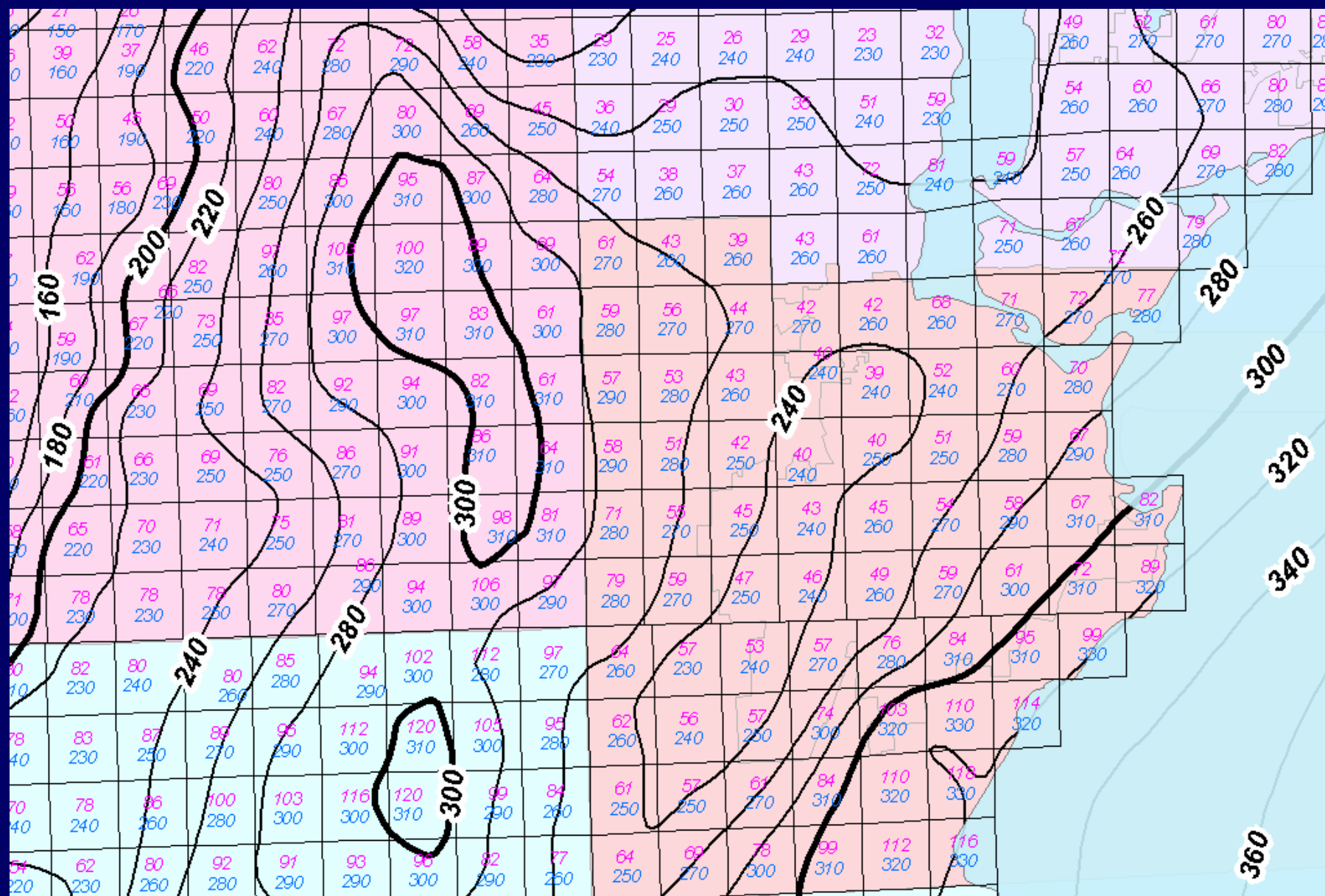


**Early version  
of top surface  
of St. Peter  
Sandstone  
elevation  
contouring**

**Numerous  
“bullseyes”  
are from  
mislocated or  
misinterpreted  
well reports**



## Top of the Cambrian contours- ¼ Sec. depth in blue



# FINAL DNR MAP SHOWING MINIMUM AND MAXIMUM CASING DEPTH FOR EACH ¼ SECTION

**RED  
NUMBERS  
ARE FOR  
SINNIPEE  
WELLS,  
BLACK FOR  
CAMBRIAN**

## Minimum Well Casing & Cement Grout Depth\* For Bedrock Wells Within the Arsenic "Special Well Casing Pipe Depth Area"

Towns of Nekimi & Black Wolf, Winnebago County

T17N, R16E

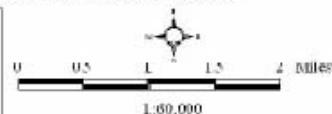
(Maximum Total Depth for Shallow Well Option - Option A)



\*Within each quarter section the minimum depth of the upper-enlarged drillhole, casing pipe and cement grout is indicated by the number provided. Although unlikely, the minimum casing/grout depths provided above may not get you down to the Cambrian Sandstone. However, in any case, the casing and grout shall extend at least to the top of the Cambrian Sandstone.

(Note: The first 10-15 feet of the Cambrian Sandstone is usually reddish in color and can produce water with a high iron content. You may want to also case and grout through this top layer.)

Within the gray shaded area the red numbers indicate the maximum total depth for wells constructed under Option A that must terminate within the shallow Calena-Platteville Dolomite unit.



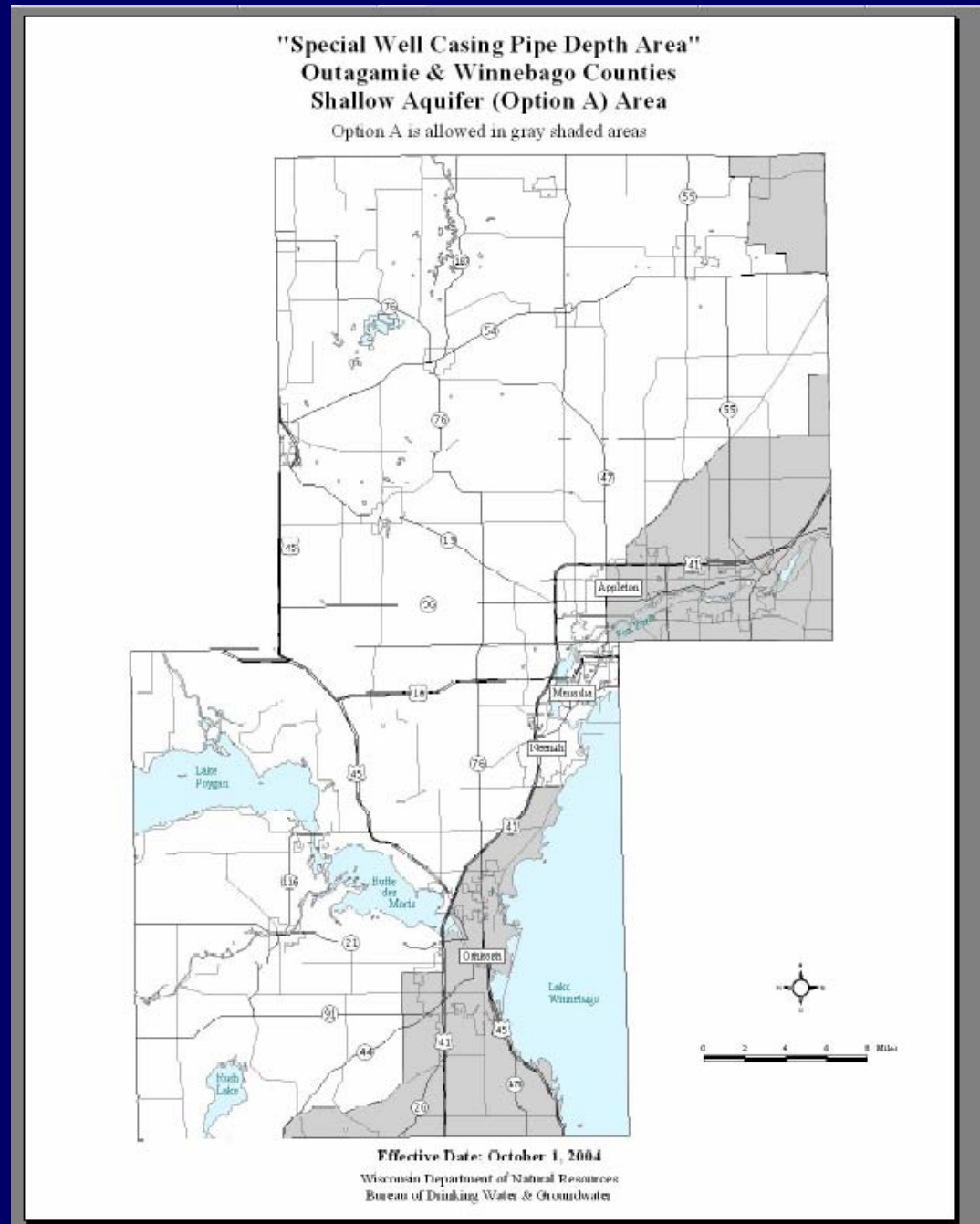
Wisconsin Department of Natural Resources  
Bureau of Drinking Water & Circumvention



Effective Date: October 1, 2004

**FINAL MAP  
SHOWING  
AREA WHERE  
SHALLOW  
WELLS  
COMPLETED  
IN SINNIPEE  
GROUP ARE  
ALLOWED**

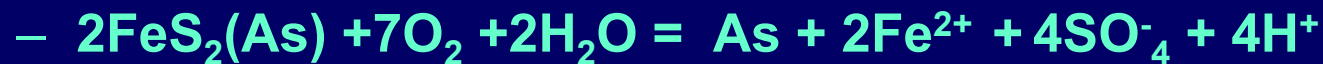
*Area shown  
shaded in  
gray*



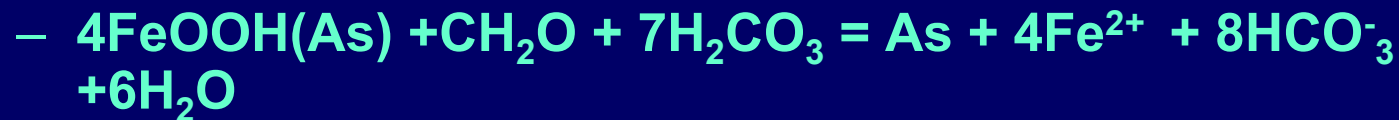
# Arsenic Release

- Oxidation

- Oxygen, Nitrate, Hypochlorite & Other



- Reduction

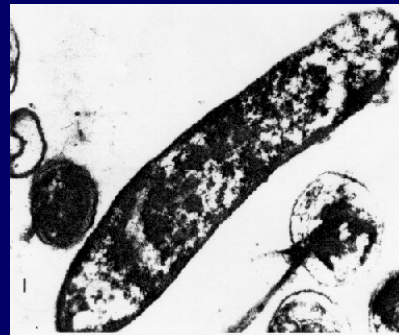


- Replacement

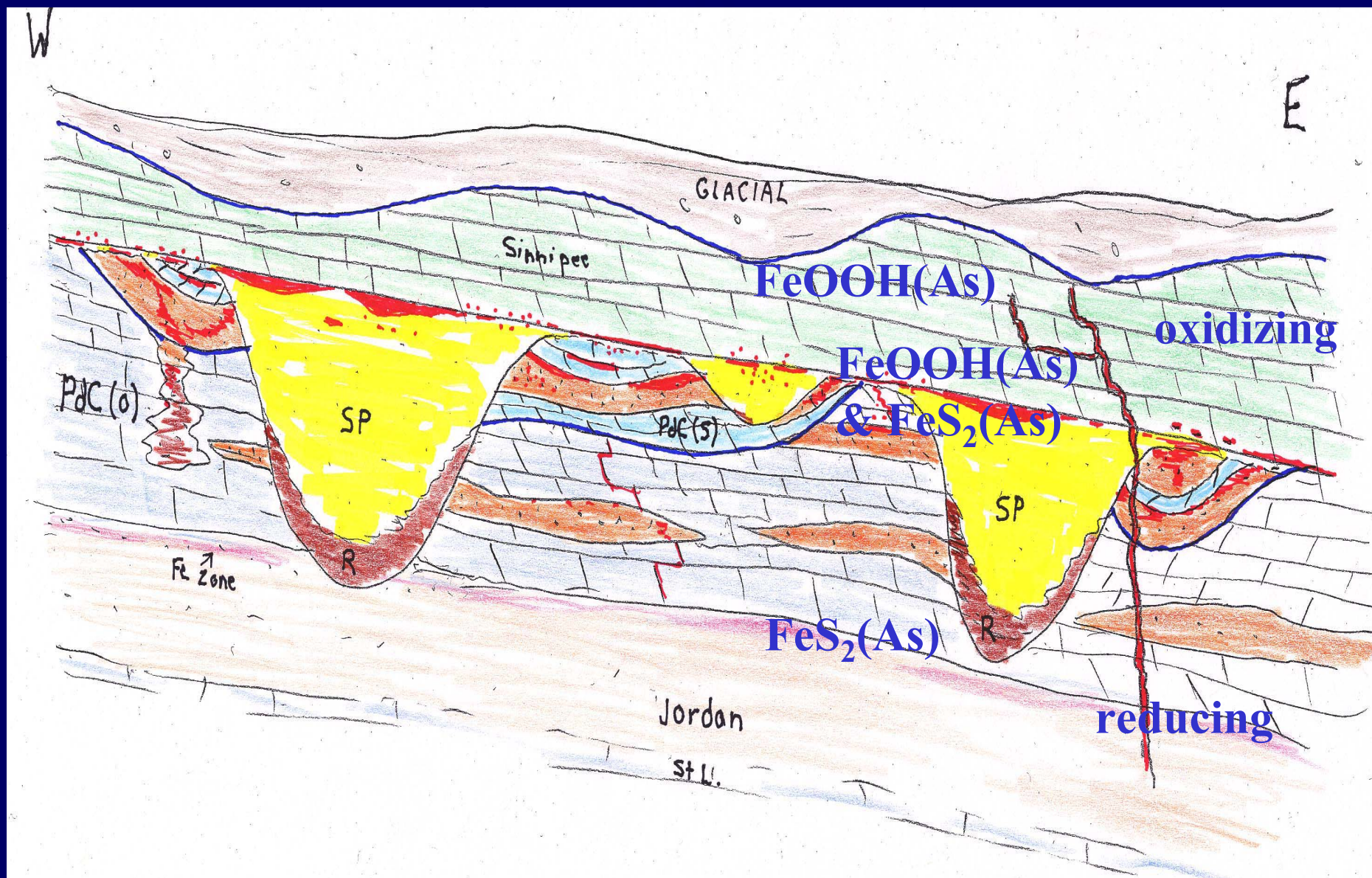
- Changes in pH, Phosphate & Silica

- Microbial

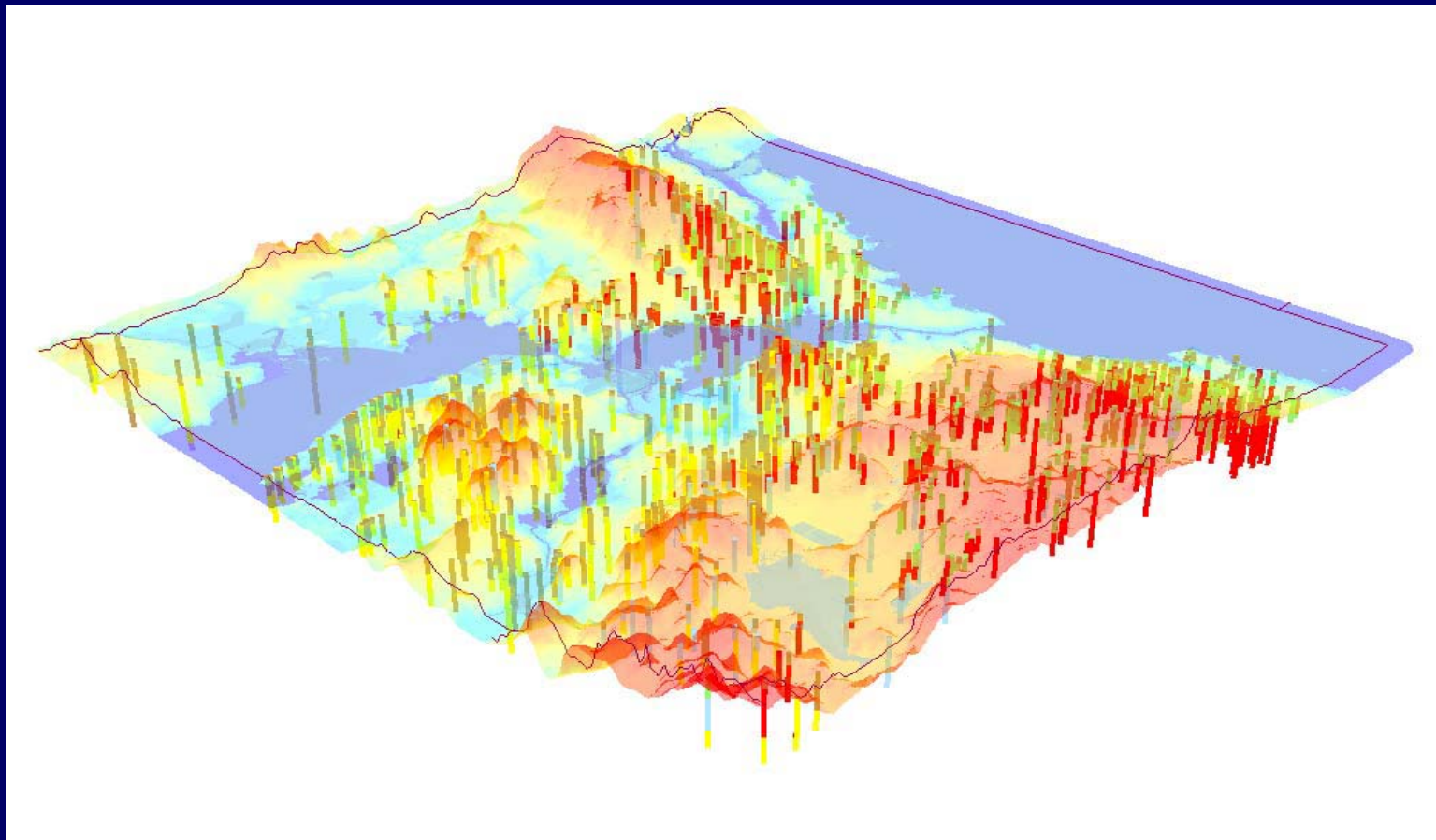
Thiobacillus  
ferrooxidans



# ARSENIC OCCURRENCE AND RELEASE



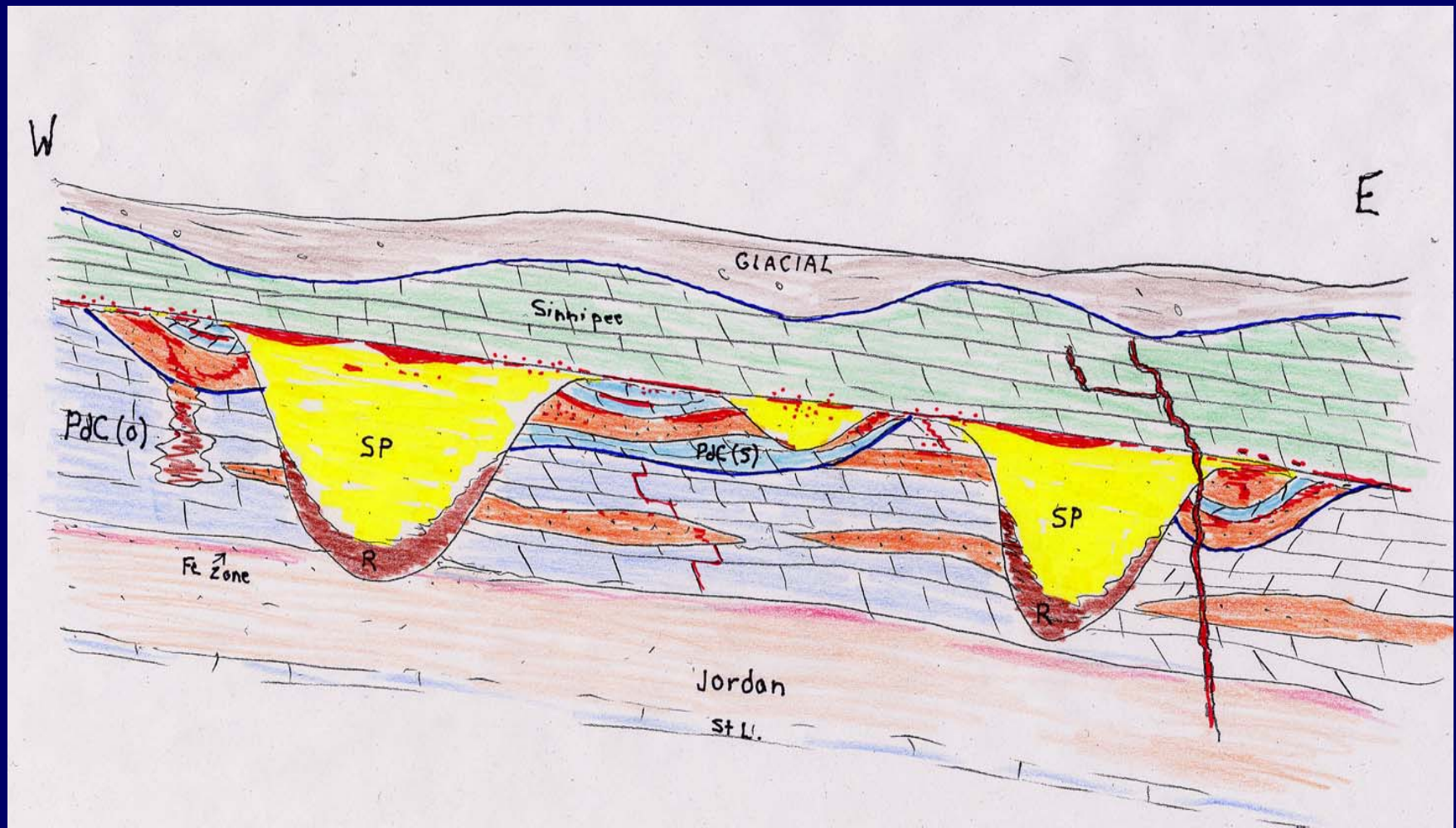
## 3-DIMENSIONAL WELL VISUALIZATION, WINNEBAGO COUNTY



# CONCLUSIONS

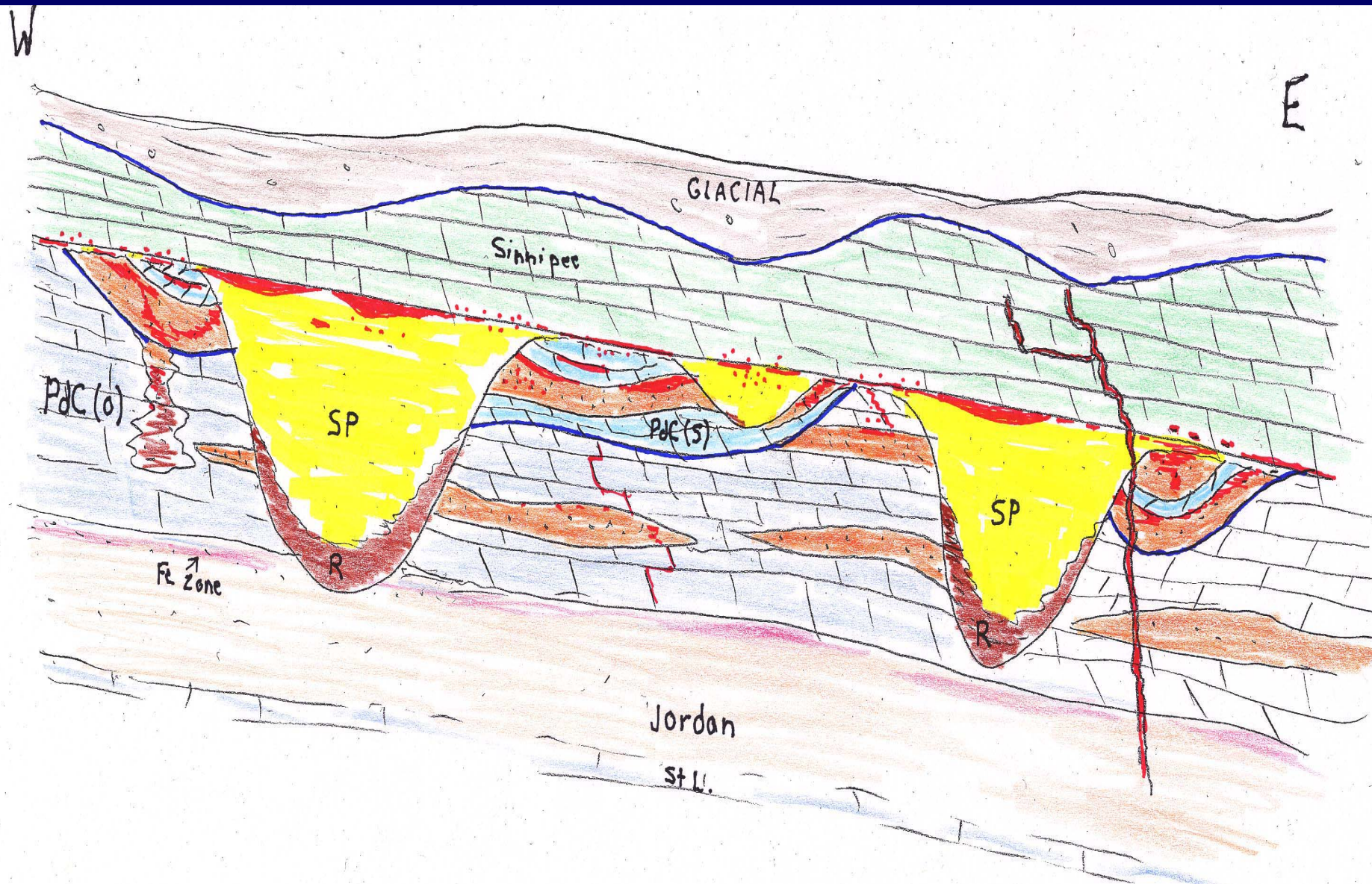
- GIS MAPPING TECHNOLOGY MADE POSSIBLE THE COMPILATION AND ANALYSIS NEEDED TO PRODUCE THESE MAPS IN A SHORT TIME.
- ALTHOUGH WE ARE A LONG WAY FROM SOLVING THE PROBLEM, THE NEW CASING REQUIREMENTS SHOULD HELP MANY HOMEOWNERS OBTAIN A SAFE DRINKING WATER SUPPLY, AND DRILLERS SATISFIED CLIENTS.
- THIS PROJECT WOULD NOT HAVE BEEN POSSIBLE WITHOUT EXTENSIVE COOPERATION AND SHARING OF RESOURCES AND DATA AT THE STATE, COUNTY, AND LOCAL LEVEL AND WITHOUT THE COOPERATION OF THE WATER WELL INDUSTRY.

# REALISTIC MODEL OF STRATIGRAPHY FROM CURRENT FIELD STUDIES



## Nodular Sulfide Cement – St. Peter Fm.





# THE FOX VALLEY ARSENIC PROBLEM- WHAT IS IT?

- Elevated values of arsenic in private and public water supplies have been detected since the early 1990s.
- The arsenic and other heavy metals are naturally occurring, and are contained in sulfide minerals.
- A regional decline in water table caused by heavy usage has exposed the sulfides to weathering, releasing arsenic and other toxic metals into groundwater.
- The EPA has lowered the health standard from 50 to 10 ppb As. Only public supplies are regulated.
- Health problems are beginning to appear.