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

Bruce A. Brown, Michael L. Czechanski
Wisconsin Geological and Natural History **Survey**
David M. Johnson ***Wisconsin Department of Natural Resources.***

Recognition of the Problem

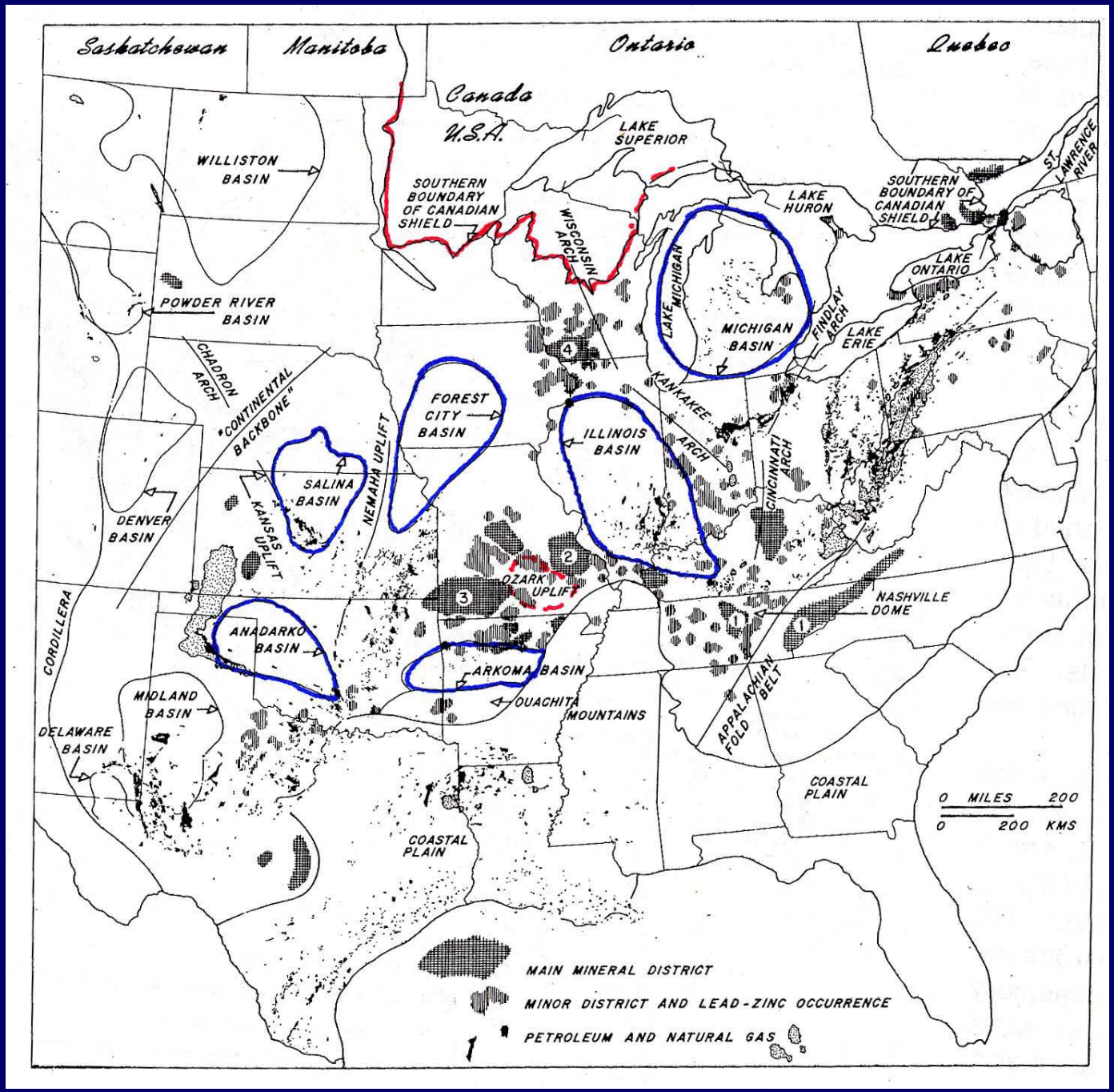
Elevated levels first discovered in late 1980's near a proposed landfill in Winnebago Co., thought to be spill but later shown to be natural.

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

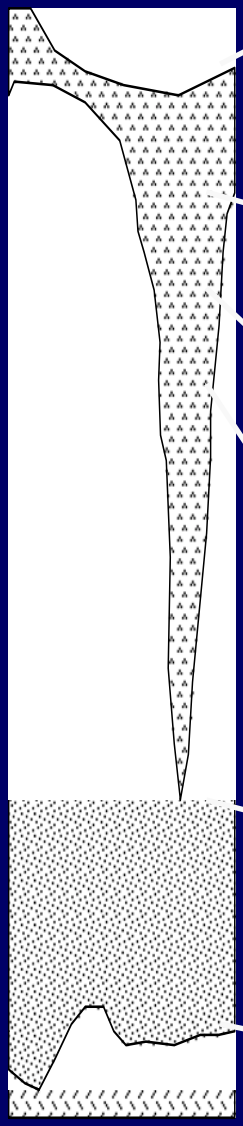


THE IMMEDIATE PROBLEM

- 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*

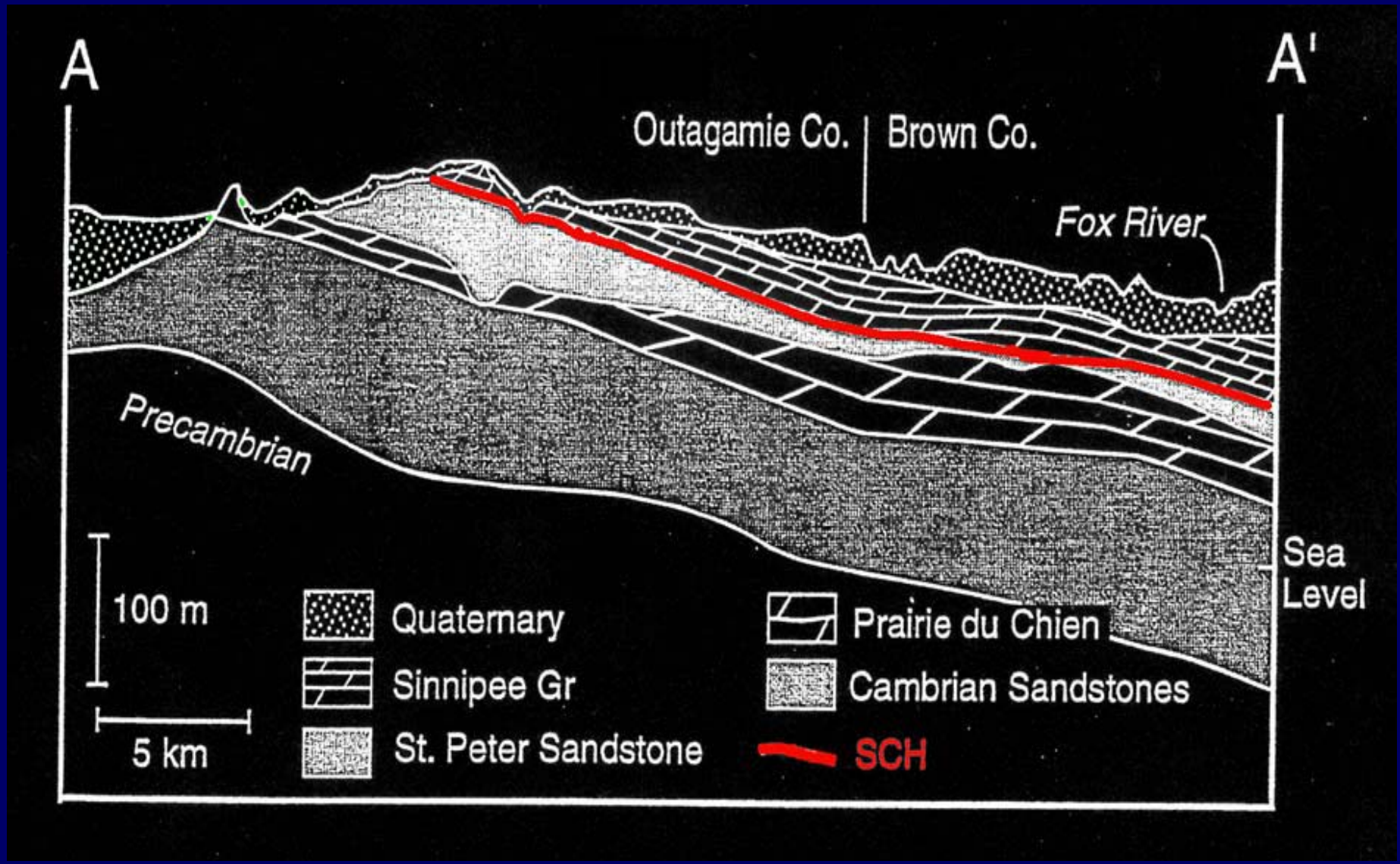
Prairie du Chien Group - *carbonate*

Cambrian - *sandstone*

Precambrian - *granite*

WEX GNHS

Northeast Wisconsin Stratigraphy: Old Model

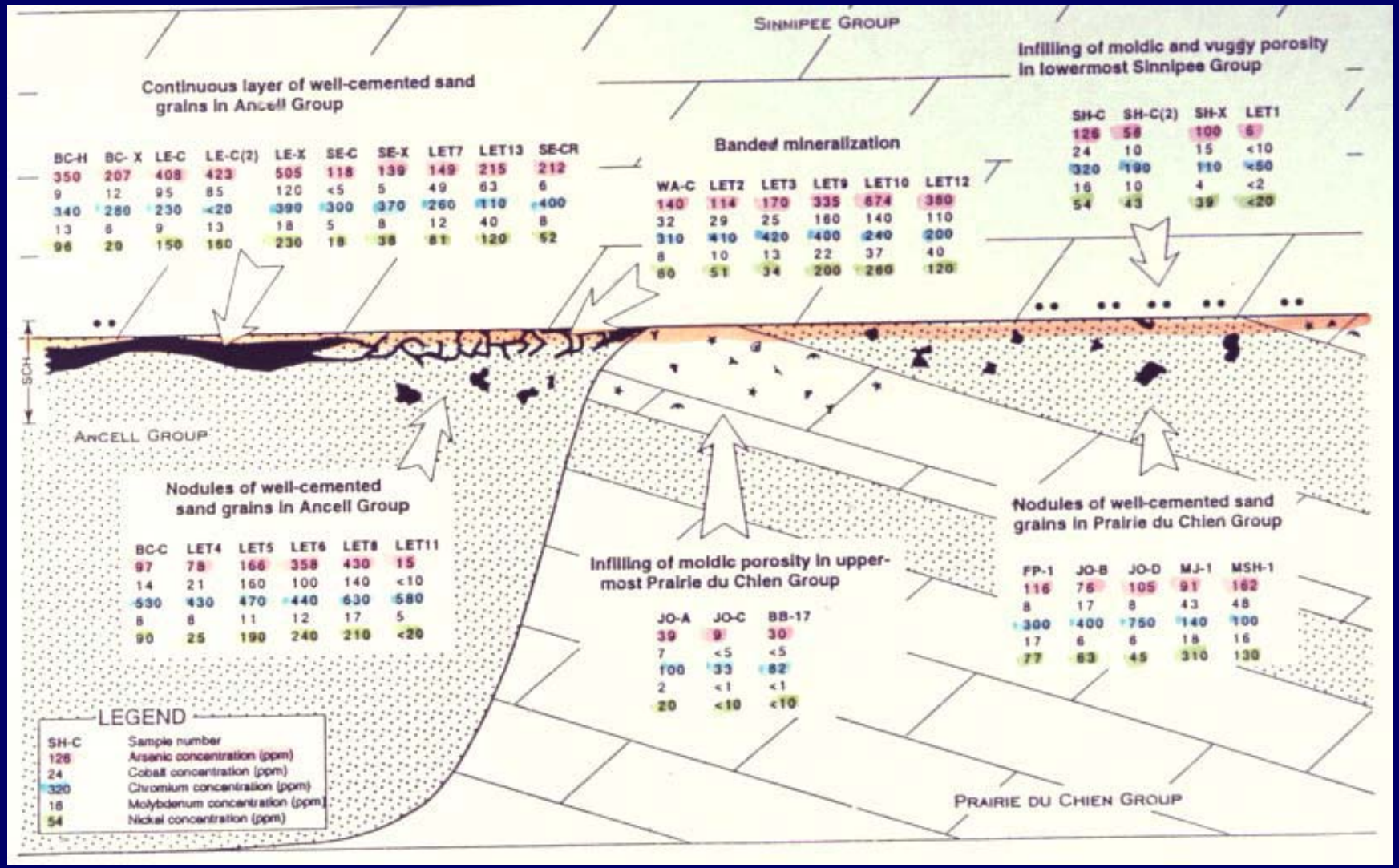


Minerals typical of Mississippi Valley-type Mineralization

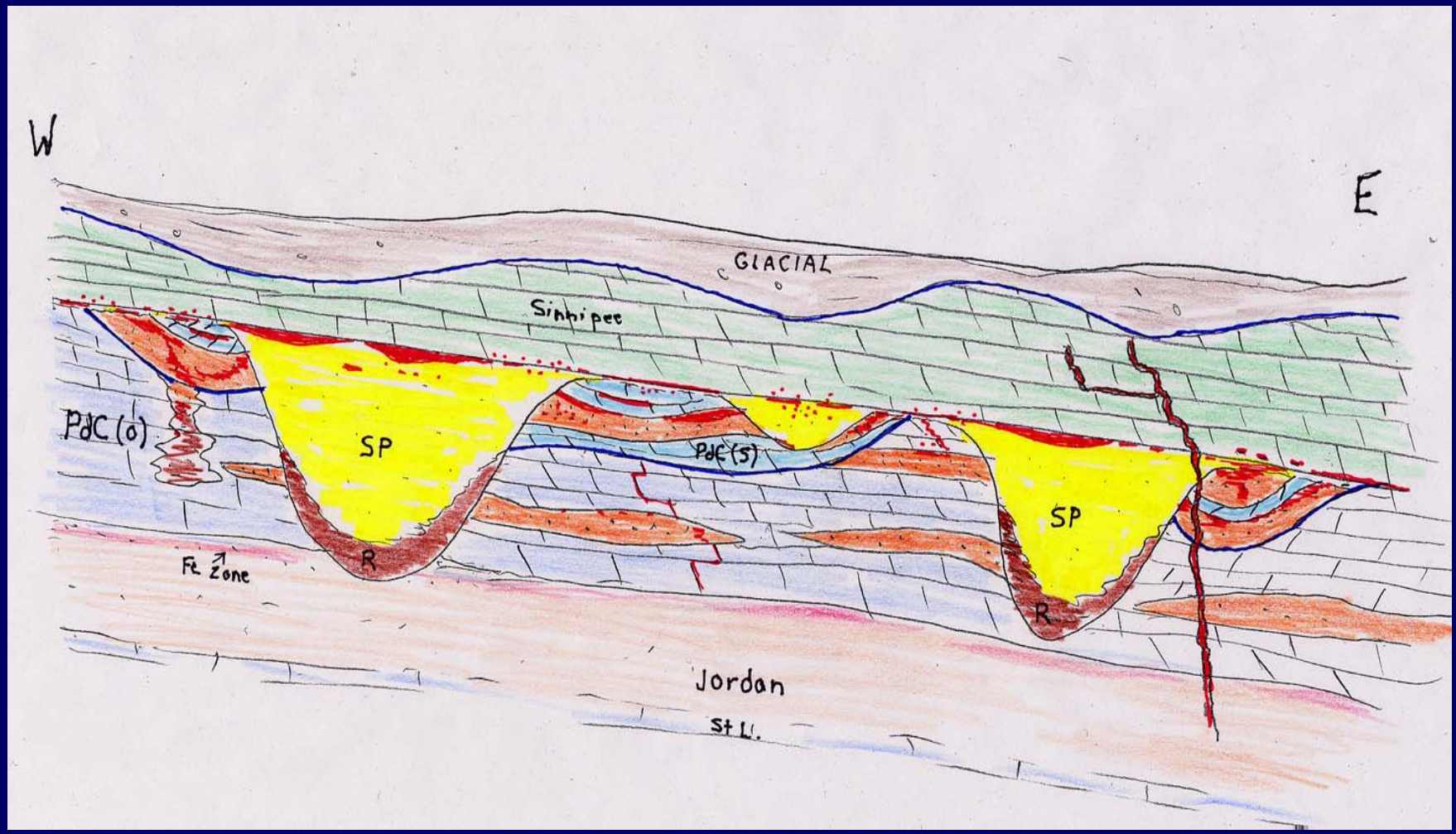
- **Major Minerals**
  - Pyrite (FeS_2)
  - Marcasite (FeS_2)
  - Galena (PbS)
  - Sphalerite ((Zn, Fe)S)
- **Minor Minerals**
  - Chalcopyrite ($CuFeS_2$)
  - Millerite (NiS)
  - Barite ($BaSO_4$)
  - Celestite ($SrSO_4$)
  - Fluorite (CaF_2)

METAL VALUES IN SULFIDES

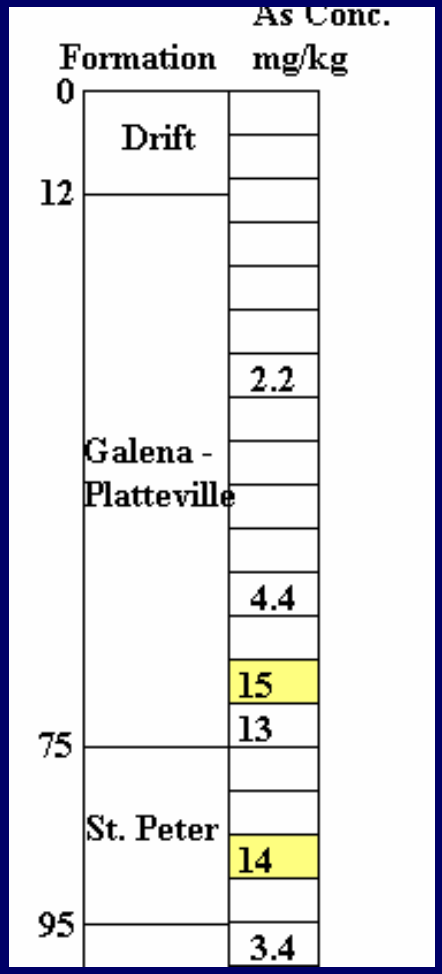
(Max PPM, As=674, Cr=750, Ni= 310

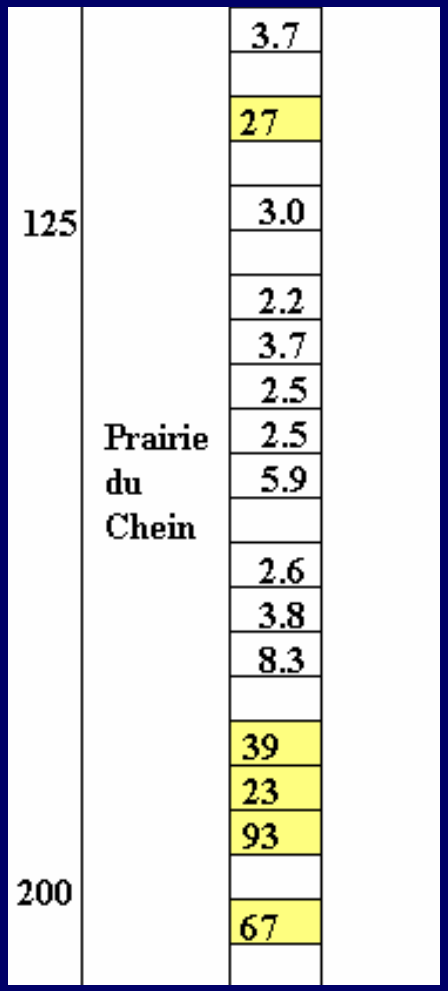


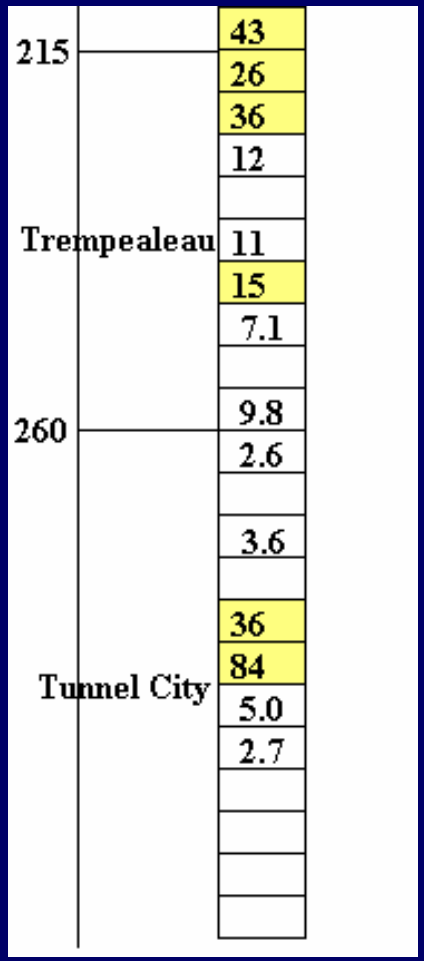
REALISTIC MODEL OF STRATIGRAPHY FROM CURRENT FIELD STUDIES



Arsenic in Drill Cuttings







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: SEYMOUR | State: WI | Zip Code: 54165

County of Well Location: OUTAGAMIE | Co. Well Permit No. | Well Completion Date: August 24, 1988

of OSBORN

Grid or Street Address or Road Name and Number: FRENCH ROAD

Subdivision Name | Lot# | Block#

Cnty 45 | Well Constructor (Business Name): SCHMIDTS WATER SERVICE | License # 6 | 2. Dates 09/19/88 Rcvd

Dst 4 | Address: RT 3 BOX 27

City: BLACK CREEK | State: WI | Zip Code: 54106

Gov't Lot# ______ or SW 1/4 of NW 1/4 of Section 5, T 23 N; R. 18 E (E/W)

P | M=Munic. O=OTM N=NonCom P=Priv Z=Other X=Non-Pot A=Anode L-Loop H=Drillhole

Grade 10/10/89 Last FM

3. Well Type 2 | 1 = New 2 = Replacement 3 = Reconstruction of previous unique well # ______ constructed in 19__

Reason for new, replaced or reconstructed well? OLD WELL CONTAMINATED

1 | 1 = Drilled 2 = Driven Point 3 = Jetted 4 = Other

4. Well serves 1 # of homes and or (Ex: barn, restaurant, church, school, industry, etc.)

High Capacity: Well? N Property? N

5. Well located on highest point of property, consistent with the general layout and surroundings? Y

Well located in floodplain? N

Distance in Feet From Well To Nearest:

1. Landfill
10 2. Building Overhang
77 3. Septic or Holding Tank (circle one)
87 4. Sewage Absorption Unit
5. Nonconforming Pit
6. Buried Home Heating Oil Tank
7. Buried Petroleum Tank
8. Shoreline/Swimming Pool
9. Downspout/Yard Hydrant
10. Privy
11. Foundation Drain to Clearwater
12. Foundation Drain to Sewer
13. Building Drain — 1 = Cast Iron or Plastic 2 = Other
14 14. Building Sewer 1 1=Gravity 2=Pressure — 1 1 = Cast Iron or Plastic 2 = Other
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 — 1 = Cast Iron or Plastic 2 = Other
23. Other Manure Storage — Other NR 112 Waste Source
24.

6. Drillhole Dimensions

Dia. (in.)	From (ft.)	To (ft.)
9.0	surface	83
6.0	83	100

Method of constructing upper enlarged drillhole only.

1. Rotary - Mud Circulation
X 2. Rotary - Air
3. Rotary - Foam
4. Reverse Rotary
5. Cable-tool Bit ______ in. dia.
6. Temp. Outer Casing ______ in. dia. Removed?
7. Other

7. Casing, Liner, Screen

Dia. (in.)	Material, Weight, Specification, Manufacturer & Method of Assembly	From (ft.)	To (ft.)
6.0	NEW BLACK STEEL, P.E., TAIWAN PIPE ASTM	surface	83

Dia. (in.) | Screen type, material & slot size | From | To

8. Grout or Other Sealing Material

9. Geology

DNR USE ONLY	Type, Caving/Noncaving, Color, Hardness, Etc.	From (ft.)	To (ft.)
C	CLAY	Surface	4
L	LIMESTONE	4	42
KN	BLACK SANDSTONE	42	61
GN	GREY SANDSTONE	61	82
IN	WHITE SANDSTONE	82	100

10. Static Water Level: 52.0 ft. B ground surface (A=Above B=Below)

11. Pump Test: Pumping Level 73.0 ft. below ground surface; Pumping at 15.0 GPM 8.00 hrs

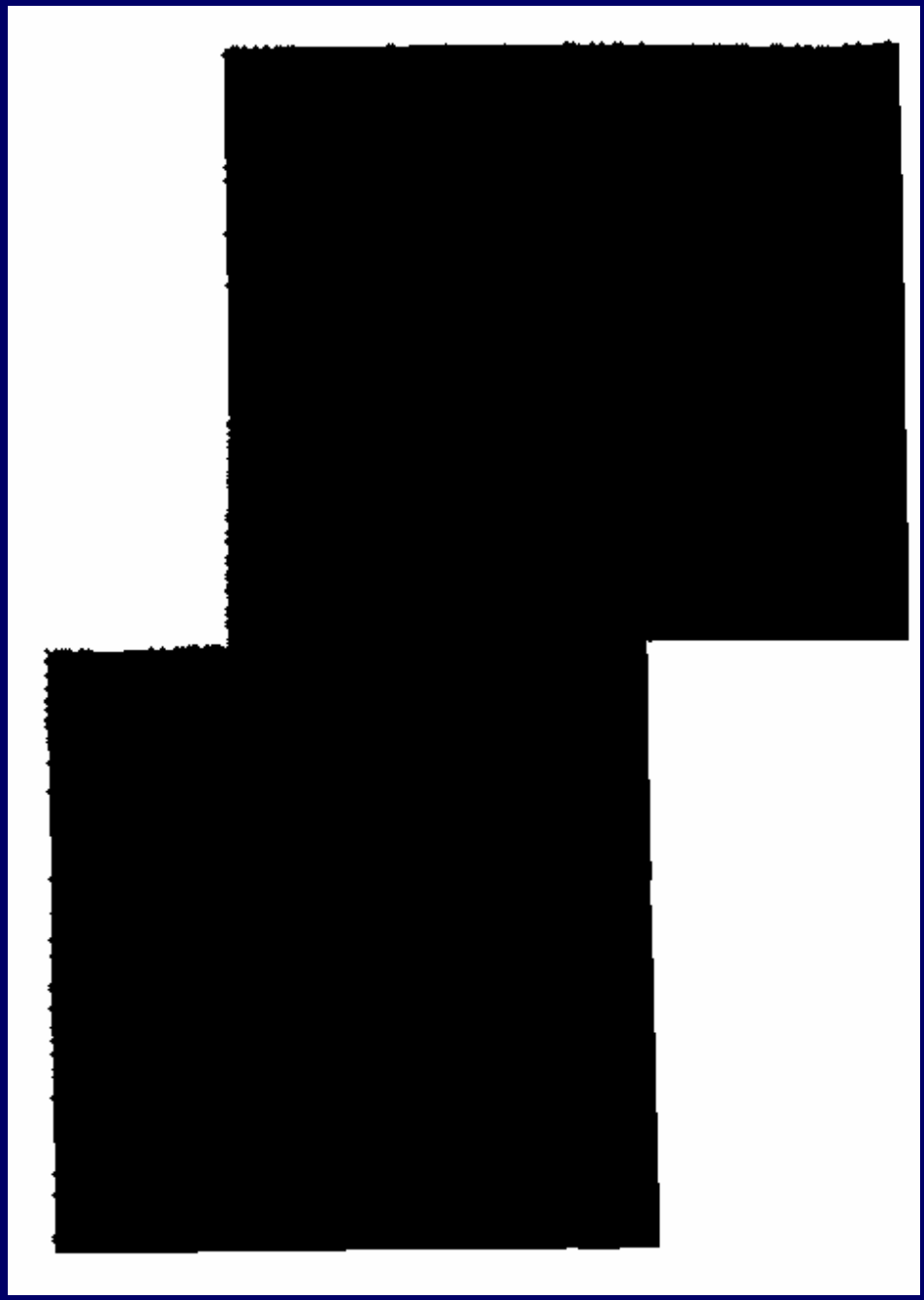
12. Well Is: 12 in. A Grade (A=Above B=Below)

Developed? Y
Disinfected? Y
Capped? Y
Depth (feet)

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

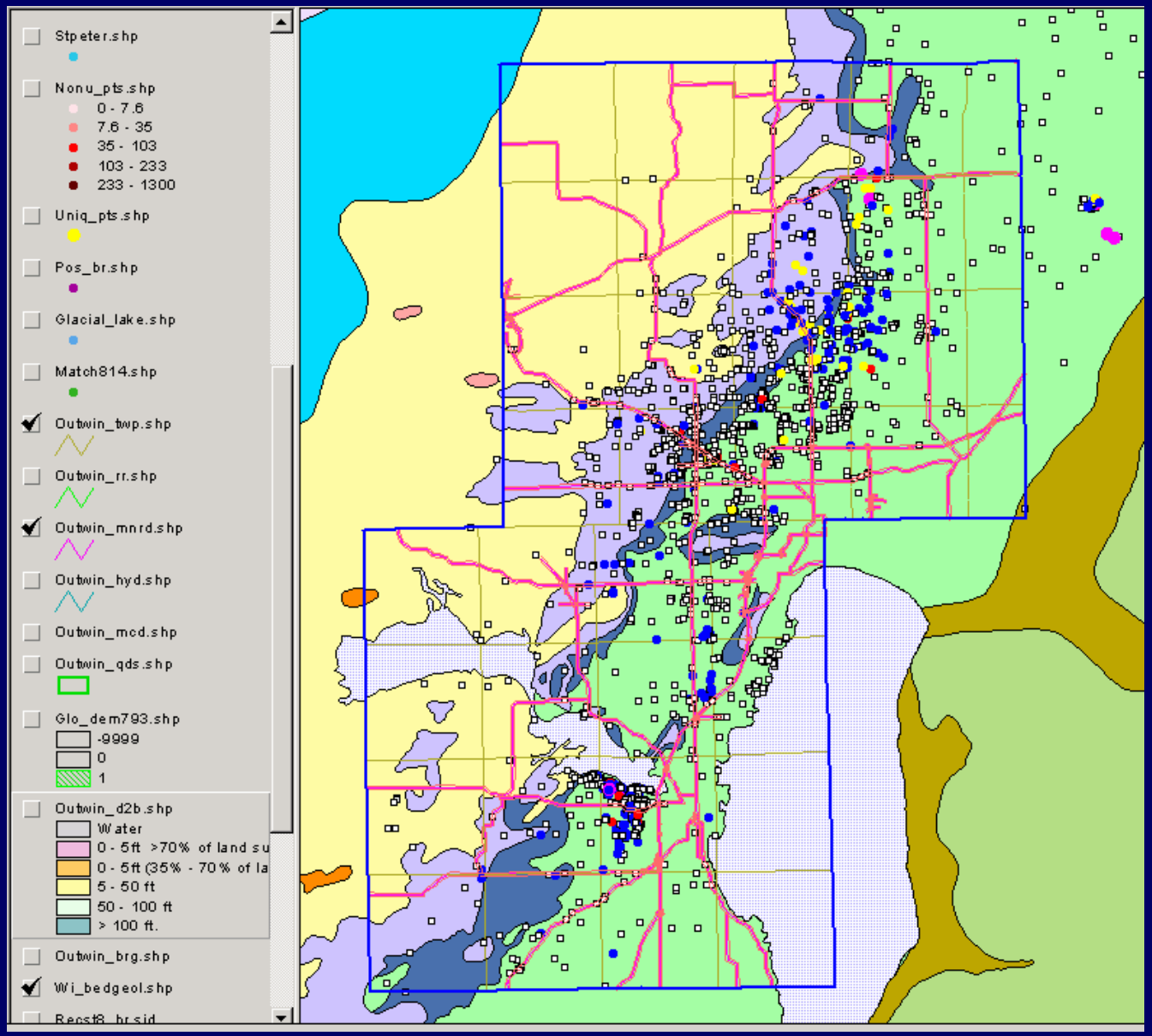
A COUNTY TO REGIONAL SCALE PROBLEM

Red dots

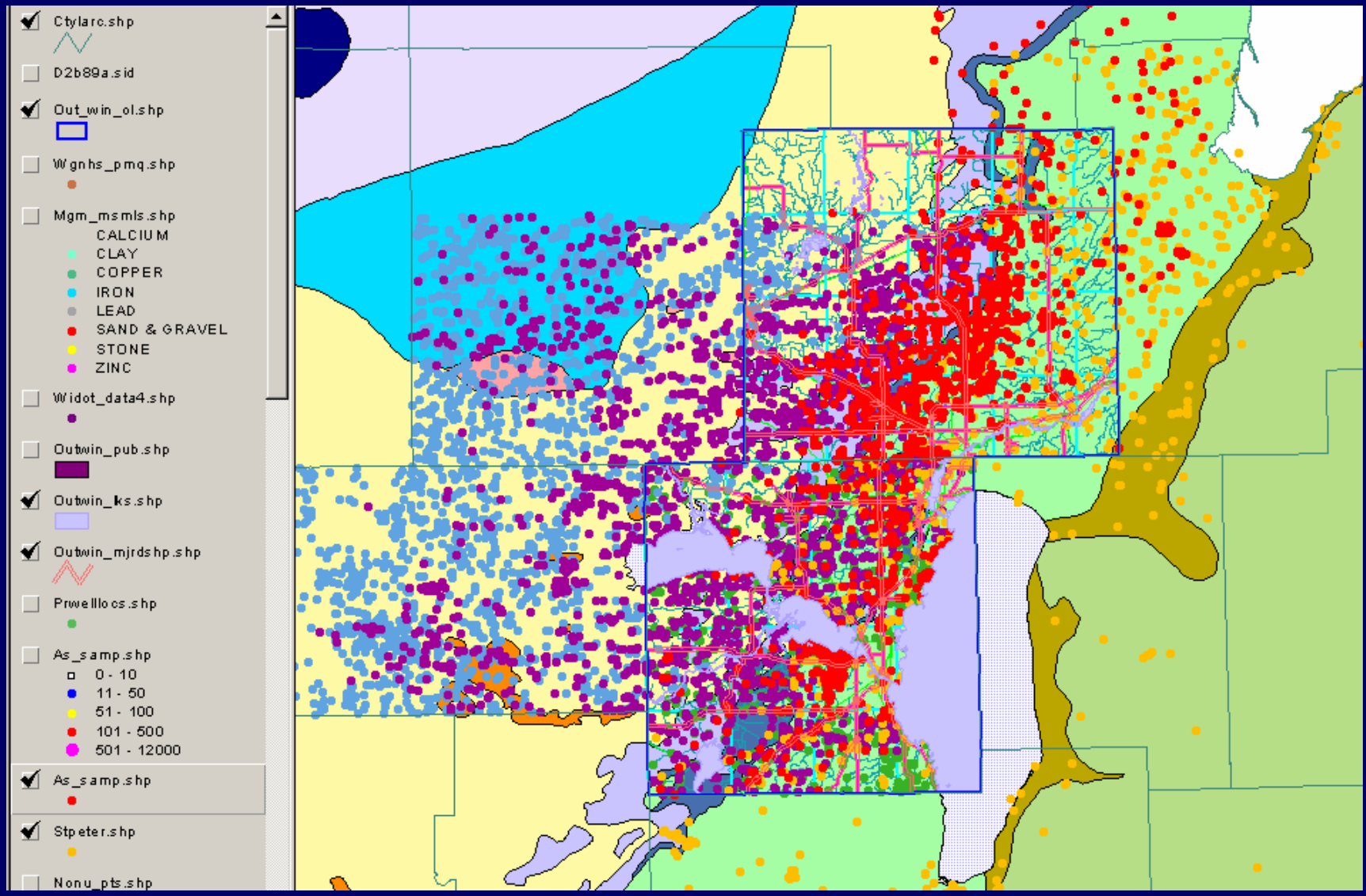
100to 500

Purple

500 to 12000

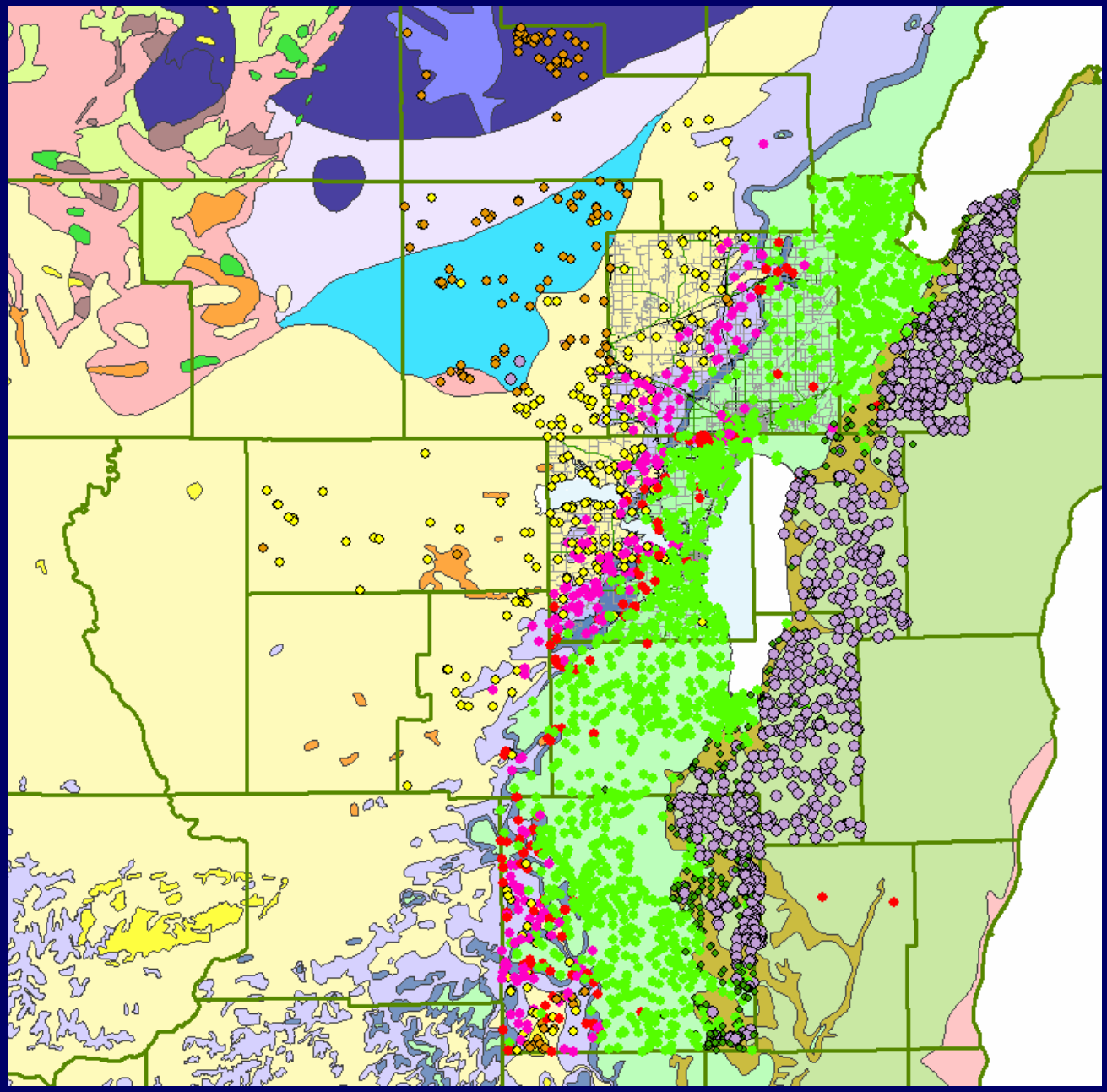


Data points from WGNHS mapping projects and WDNR arsenic sampling



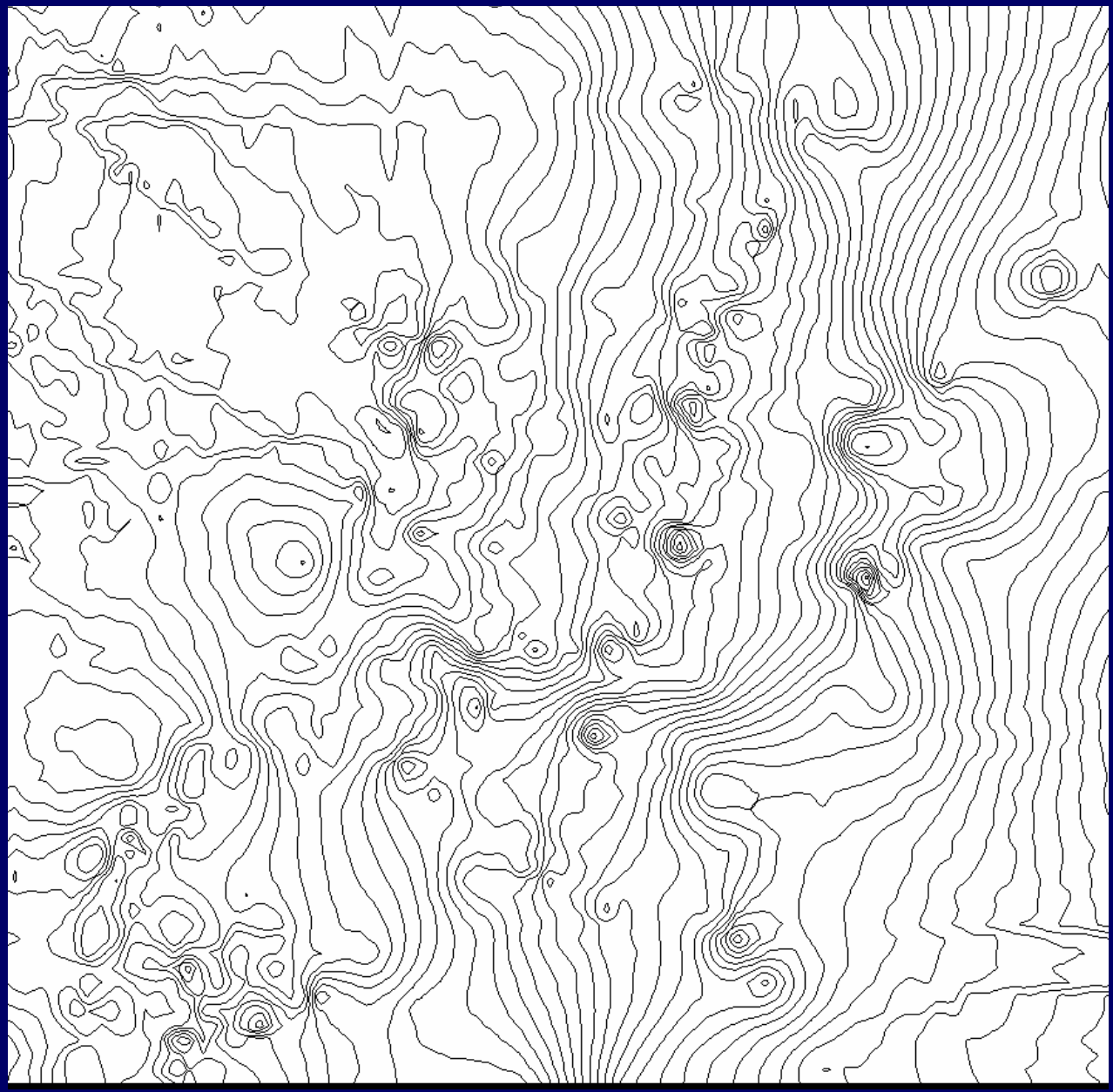
WELL DATA FROM WISCLITH AND OTHER SOURCES

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

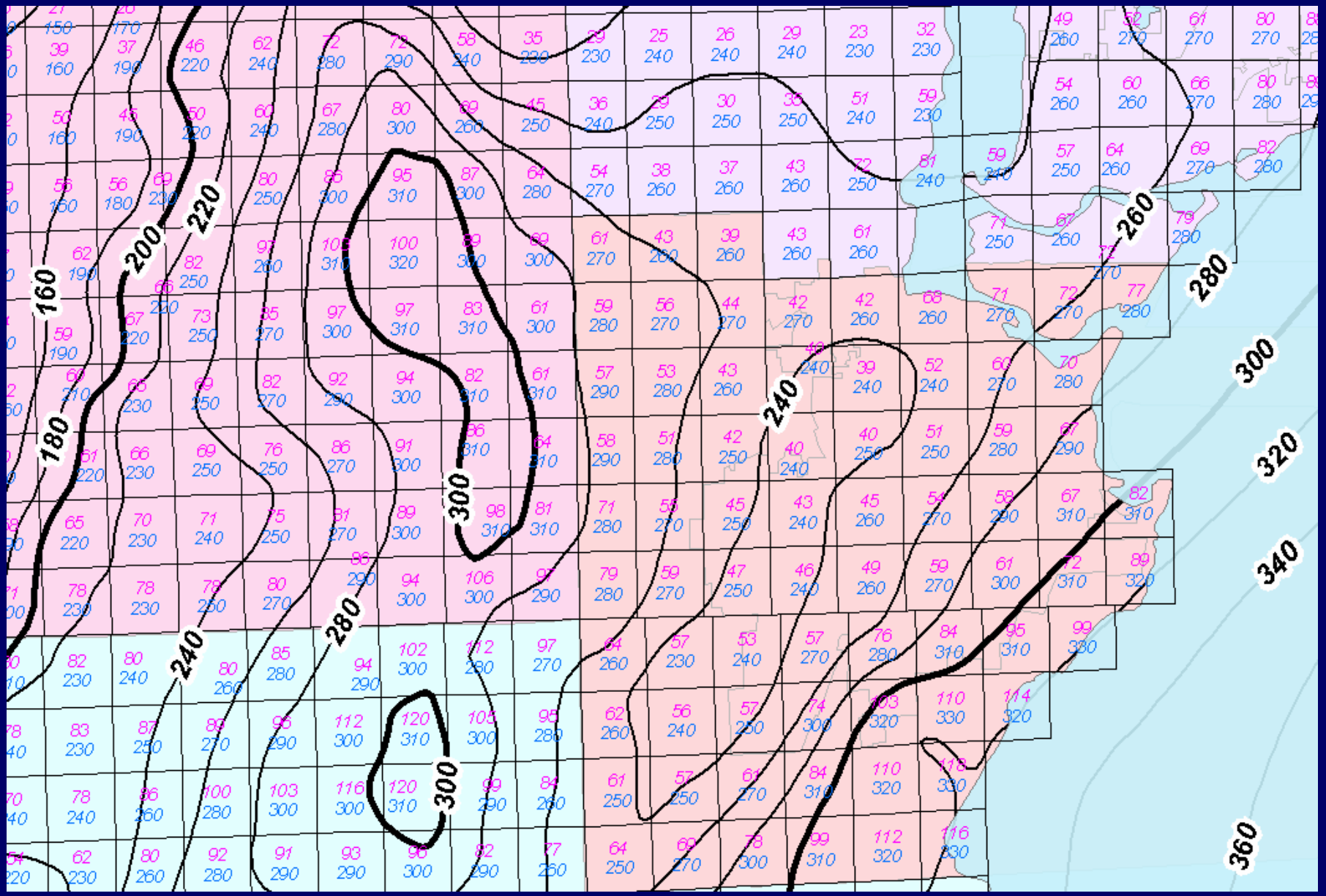


Early version of top surface of St. Peter Sandstone elevation contouring

Numerous "bullseyes" are from mislocated or misinterpreted well reports

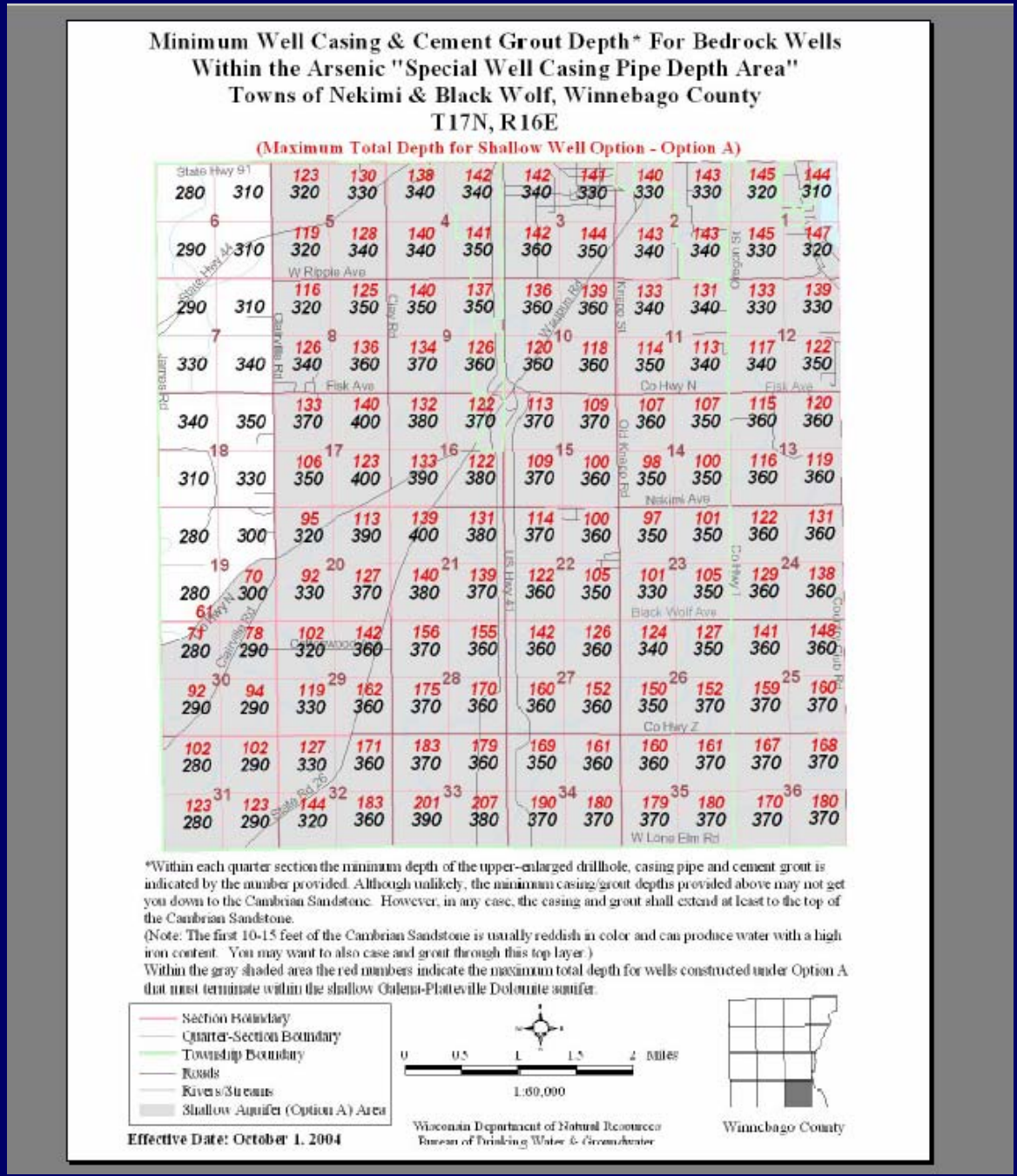


Top of the Cambrian contours- ¼ Sec. depth in blue



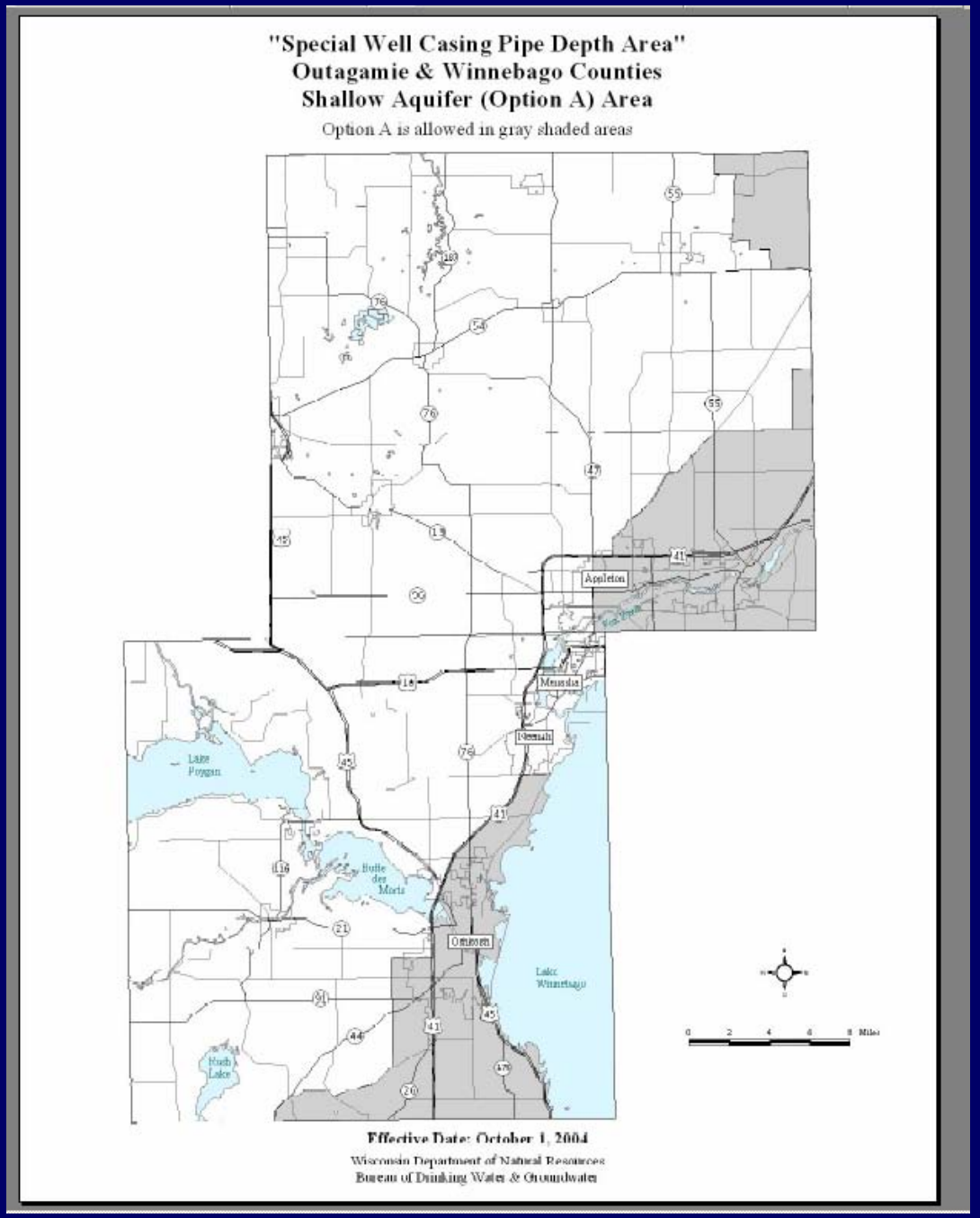
FINAL DNR MAP SHOWING MINIMUM AND MAXIMUM CASING DEPTH FOR EACH ¼ SECTION

RED NUMBERS ARE FOR SINNIPEE WELLS, BLACK FOR CAMBRIAN



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

Area shown shaded in gray

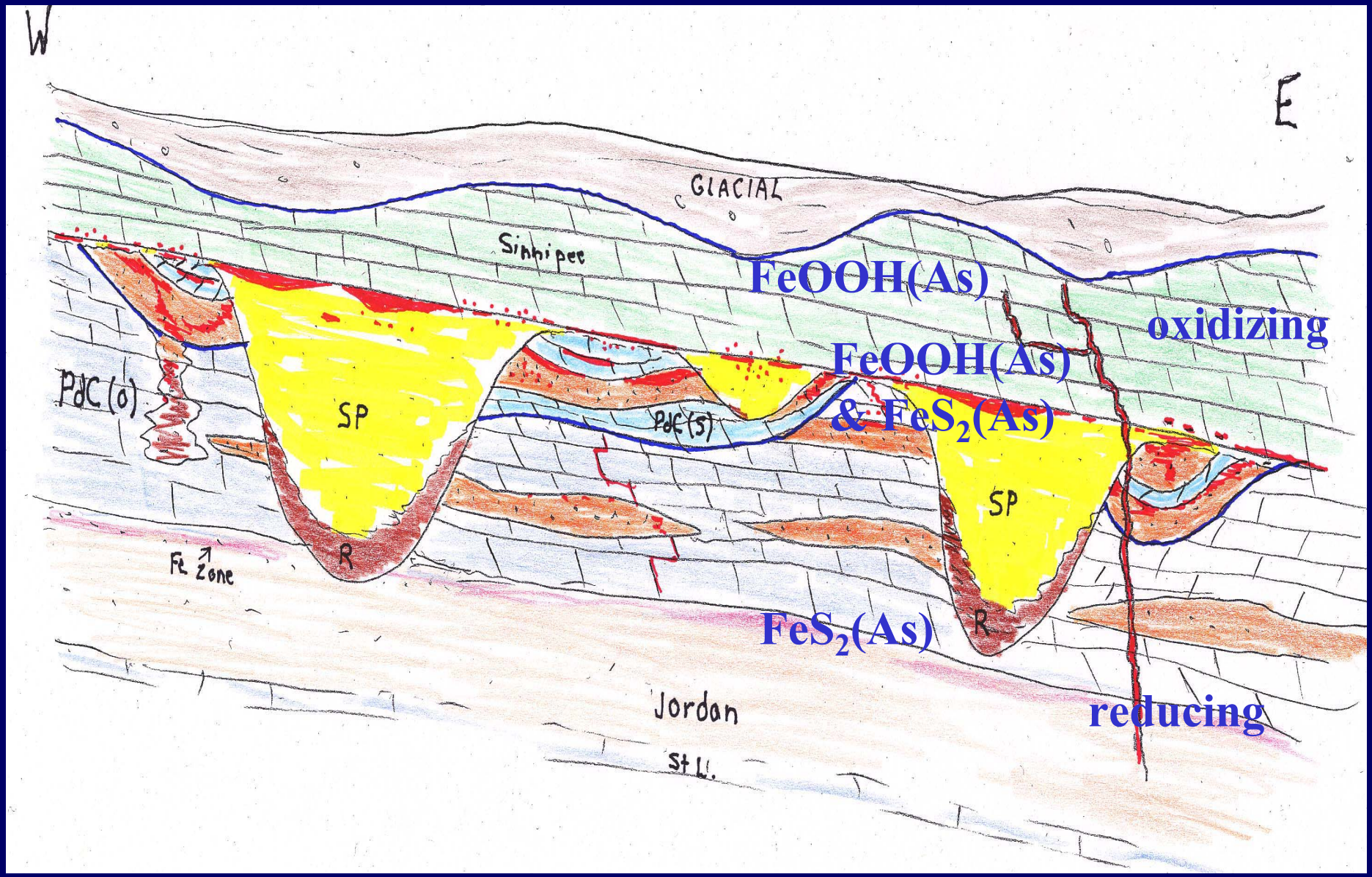


Arsenic Release

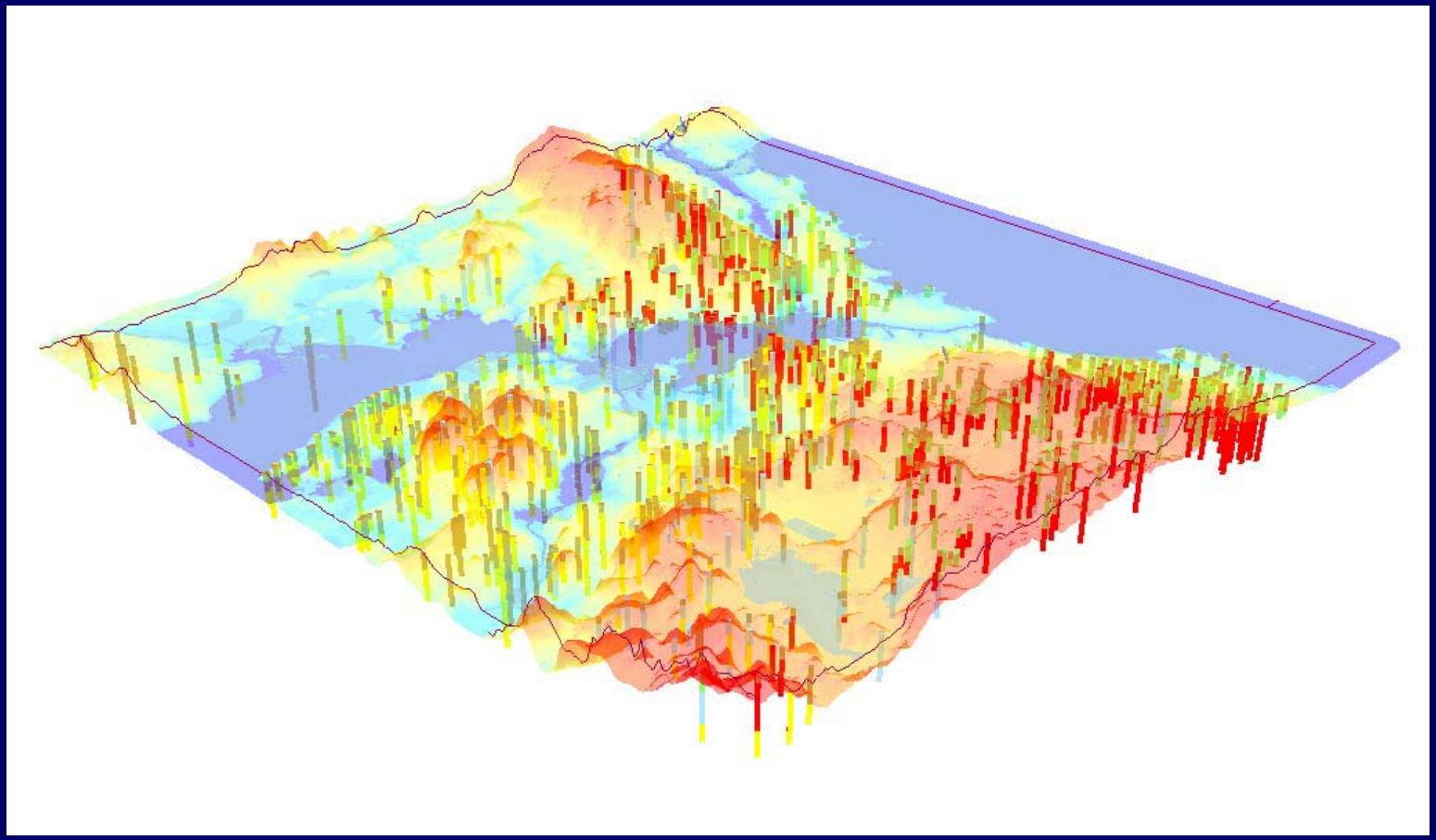
- Oxidation
  - Oxygen, Nitrate, Hypochlorite & Other
  - $2FeS_2(As) + 7O_2 + 2H_2O = As + 2Fe^{2+} + 4SO^{-}_4 + 4H^{+}$
- Reduction
  - $4FeOOH(As) + CH_2O + 7H_2CO_3 = As + 4Fe^{2+} + 8HCO^{-}_3 + 6H_2O$
- Replacement
  - Changes in pH, Phosphate & Silica
- Microbial

  Thiobacillus ferrooxidans

ARSENIC OCCURRENCE AND RELEASE



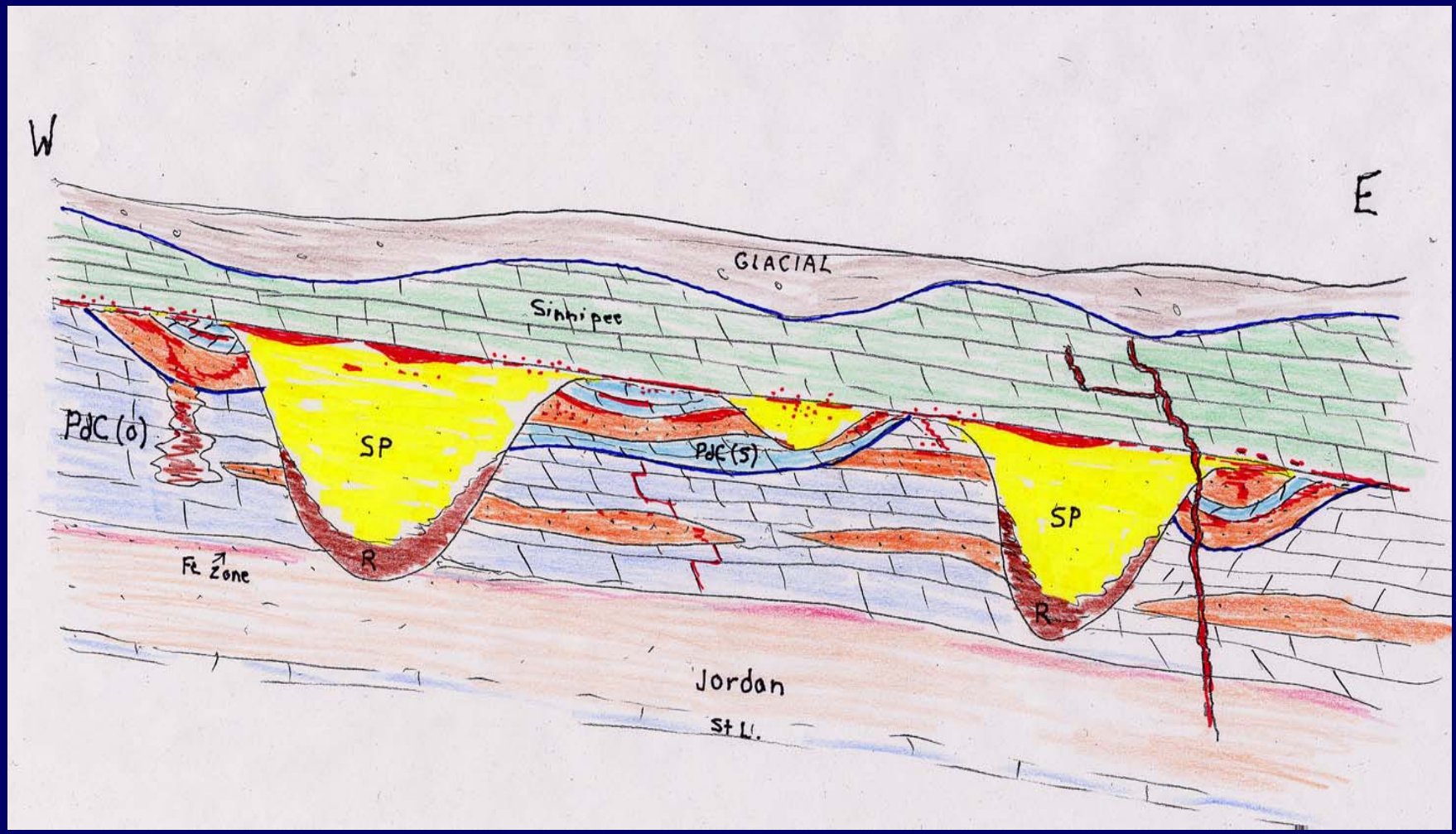
3-DIMENSIONAL WELL VISUALIZATION, WINNEBAGO COUNTY



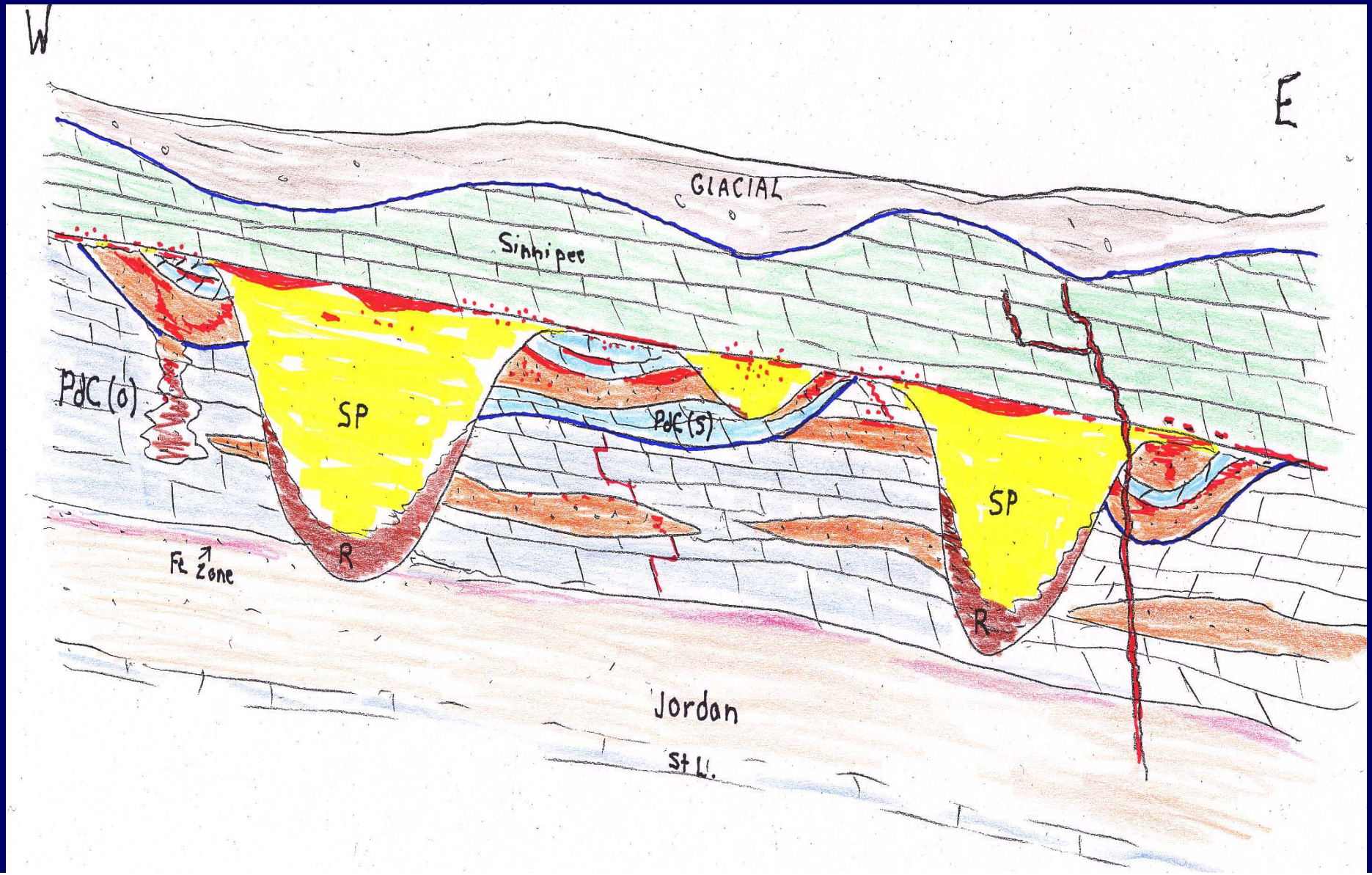
CONCLUSIONS

- 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.


W
E
GLACIAL
Sinnipee
PdC (o)
SP
PdC (s)
SP
R
R
Ft. Zone
Jordan
St L.

THE FOX VALLEY ASENIC 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.