Finding Large Capacity Groundwater Supplies for Irrigation

December 14, 2012

Presented by: Michael L. Chapman, Jr., PG

MICHIANA IRRIGATION ASSOCIATION

PEERLESS MIDWEST INC.

Irrigation Well Site Evaluation

Background Investigation

- Identify Hydrogeologic Conditions
  - Bedrock Aquifer(s) Groundwater Production Potential
  - Unconsolidated Aquifer(s) Groundwater Production Potential
  - Review Well Logs and other published documentation
- Withdrawal Assessment (Michigan)

Field Investigation

- Fracture Trace Analysis
- Surficial Geophysics
- Test Drilling
  - Lithology Sampling & Well Design
  - Borehole Geophysics
- Aquifer Performance Testing

Background Investigation

Goal: Identify published sources of information from the USGS, MDEQ, EPA and graduate studies that are relevant to the site of interest.

- Type of aquifer(s) available for groundwater resource development;
- Hydraulic parameter values;
- Thickness and continuity of aquifer(s);
- Location of potential sources of contamination;
- Potentiometric surface and flow directions.

Background Investigation

Purpose: To construct a conceptual model of the aquifer system and identify potential sources of sustainable groundwater production.

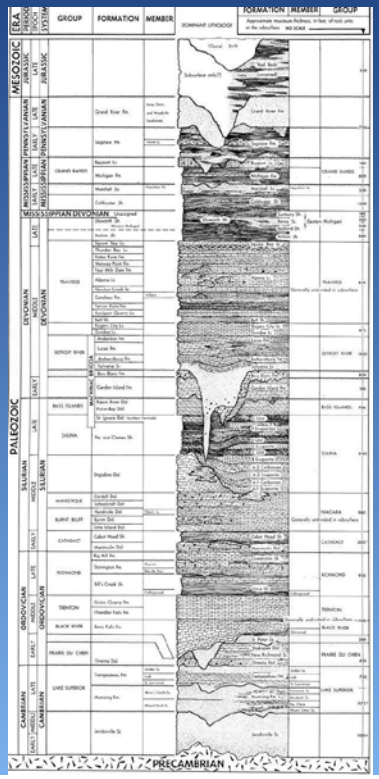
- Bedrock vs Unconsolidated (Sand and Gravel);
- Confined vs Unconfined Aquifer;
- Potential for Adverse Impact to Surface Water;
- Identify appropriate method for Field Investigation.

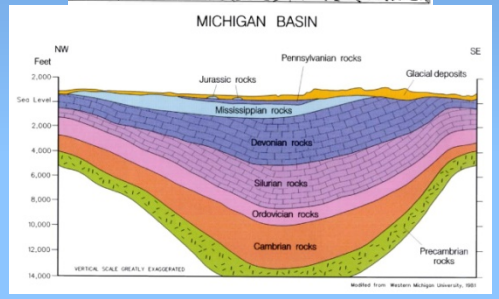
Background Investigation

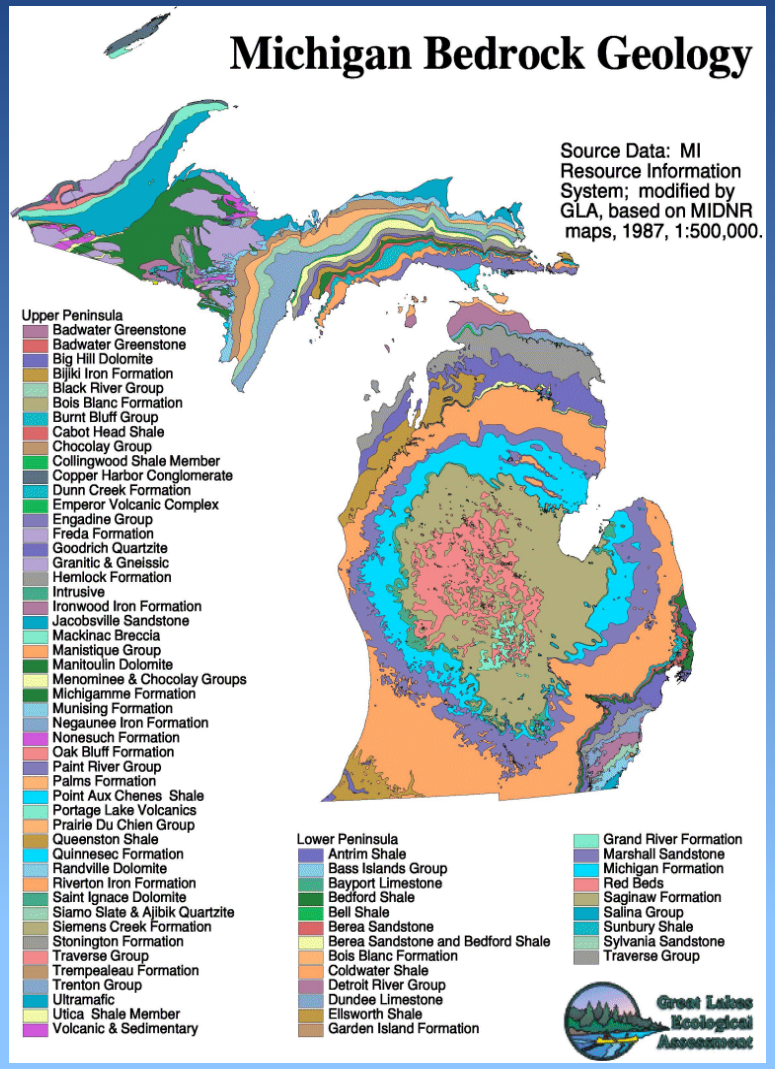
Bedrock Geology

Background Investigation

Bedrock Geology

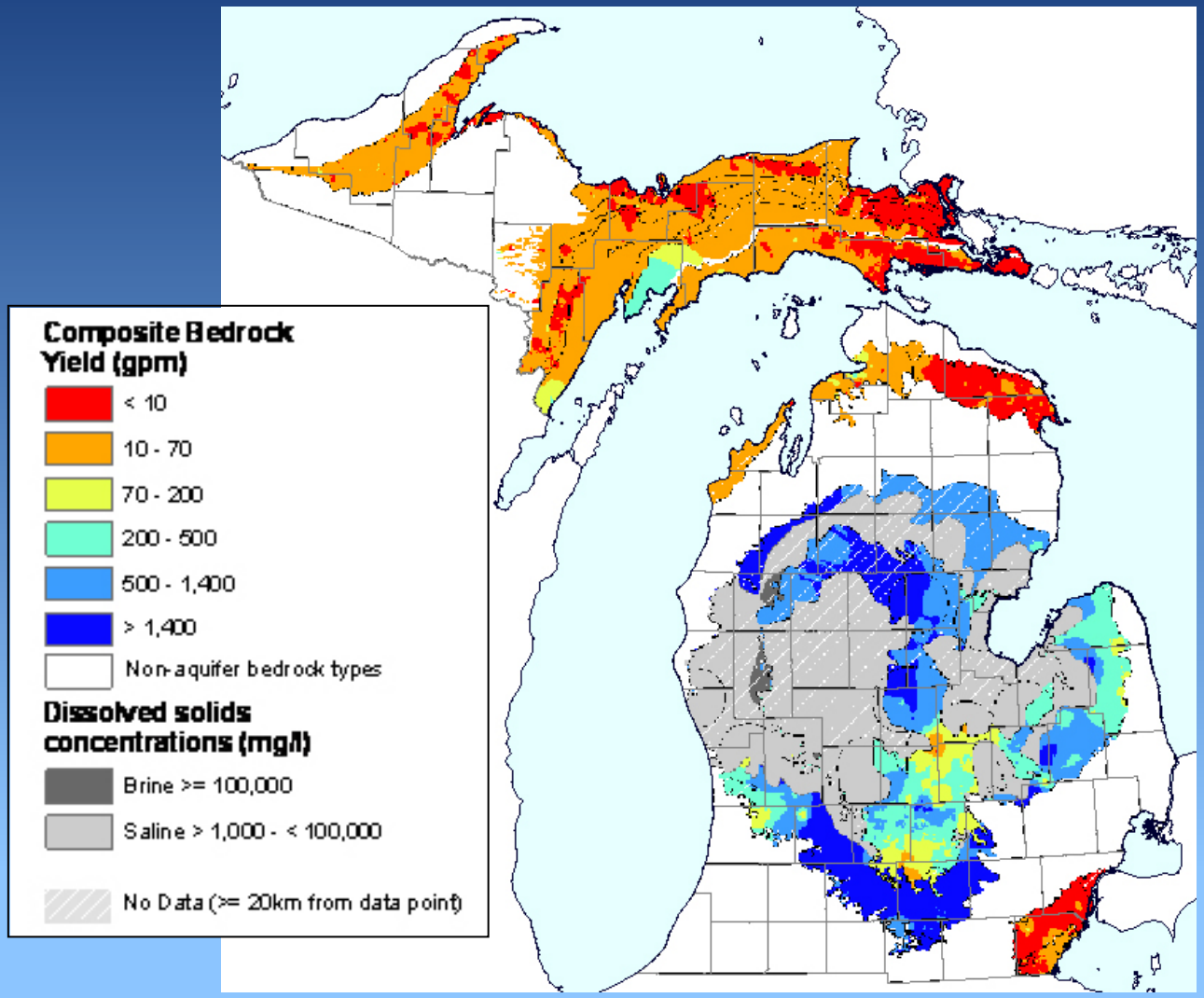






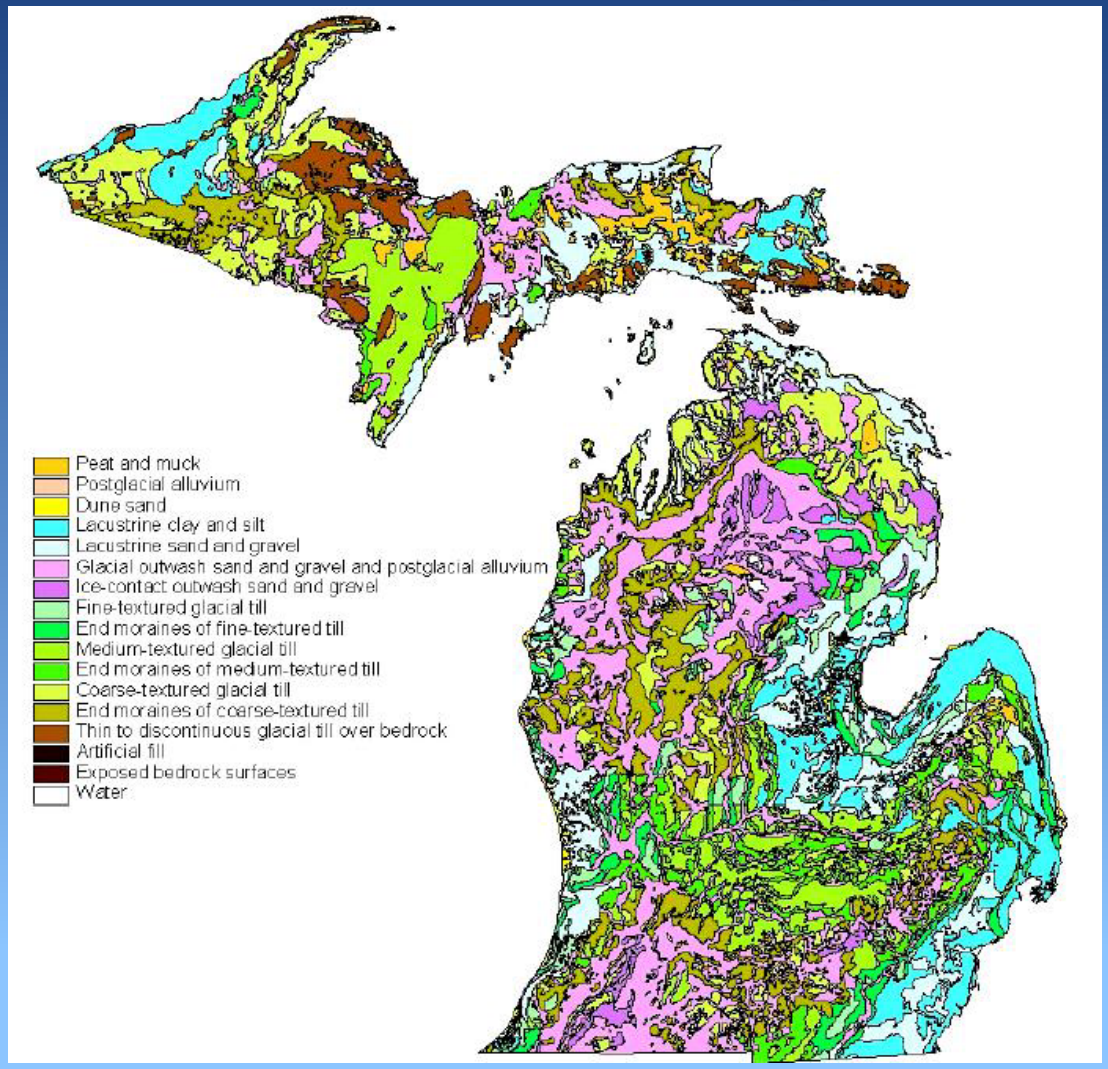
Background Investigation

Bedrock Groundwater Availability



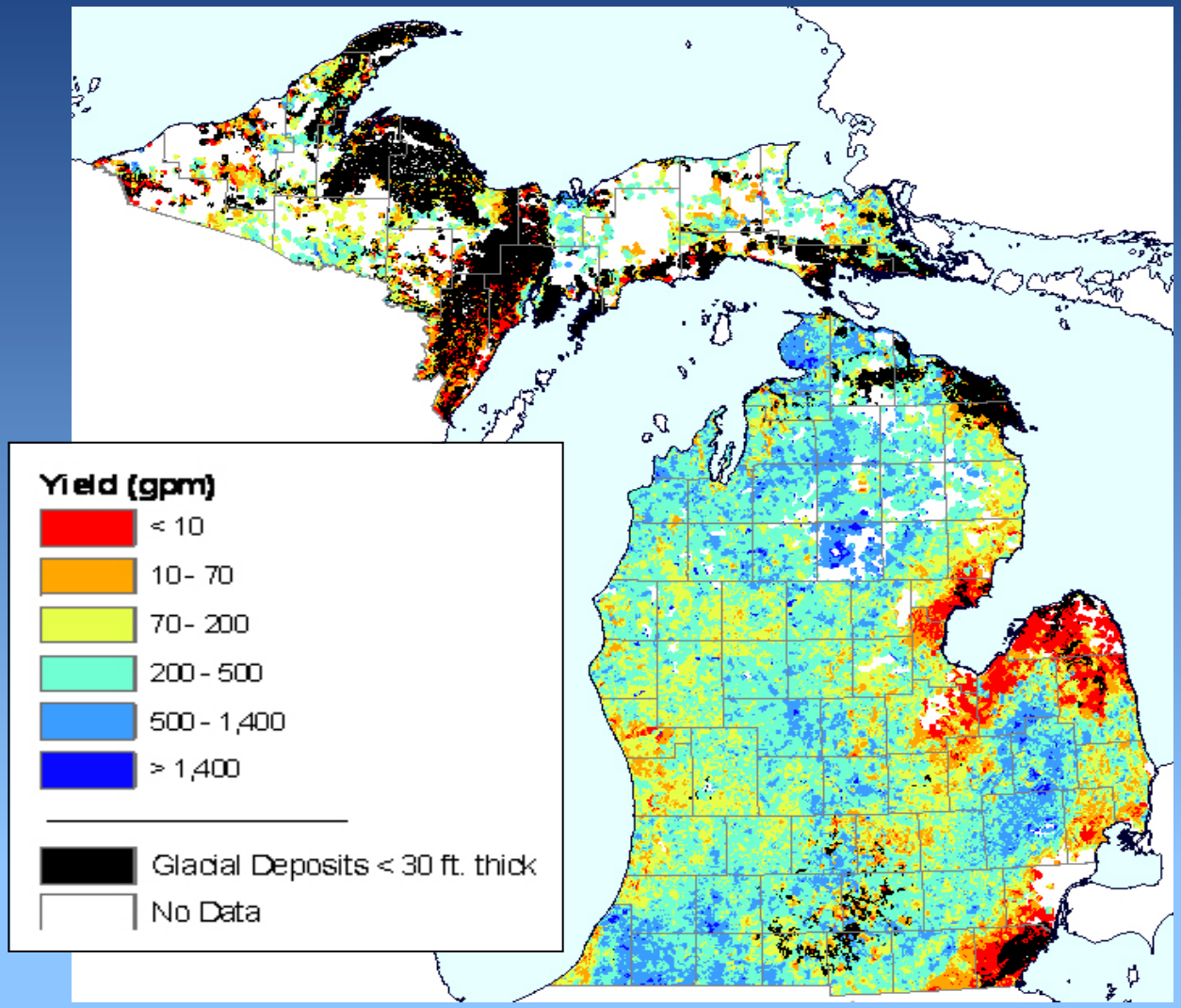
Background Investigation

Surficial Geology



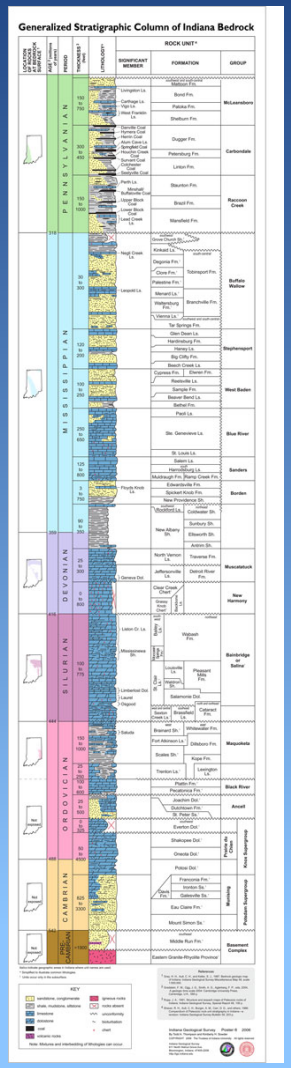
Background Investigation

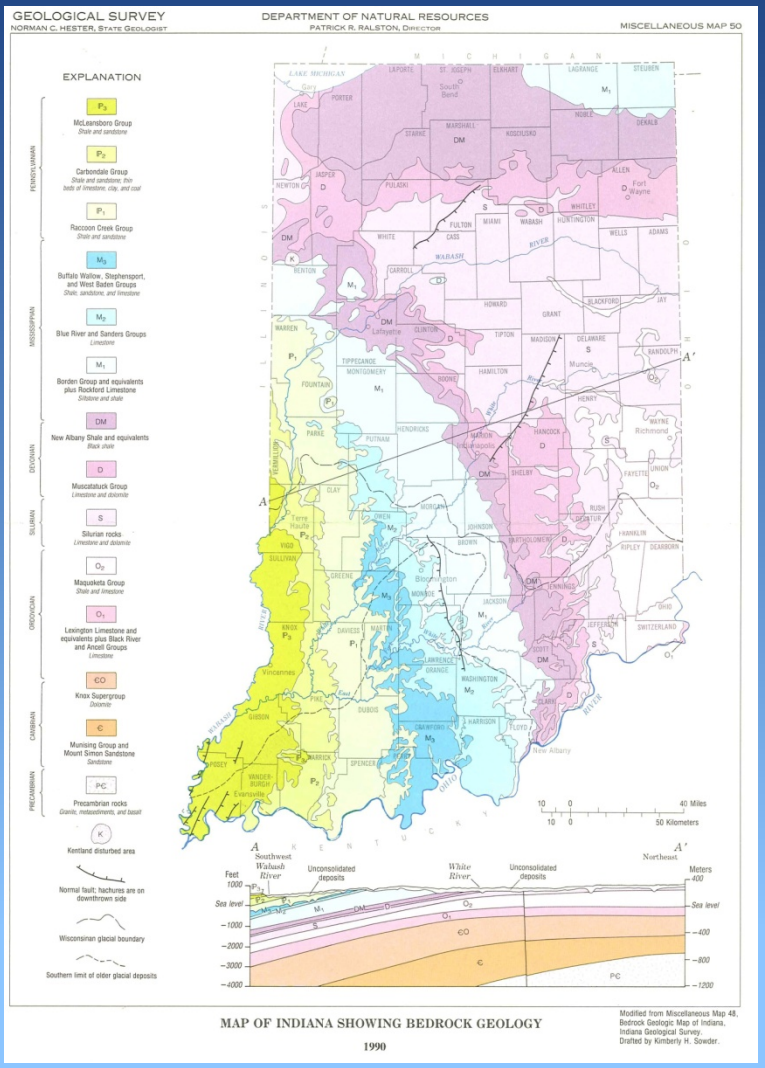
Unconsolidated Groundwater Availability

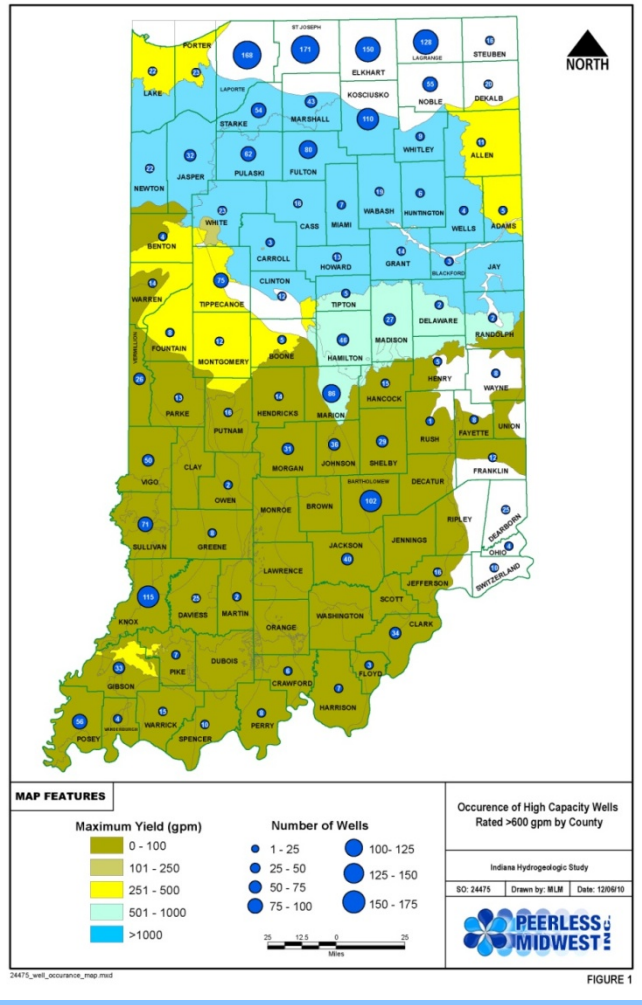


Background Investigation

Bedrock Geology & Groundwater Availability

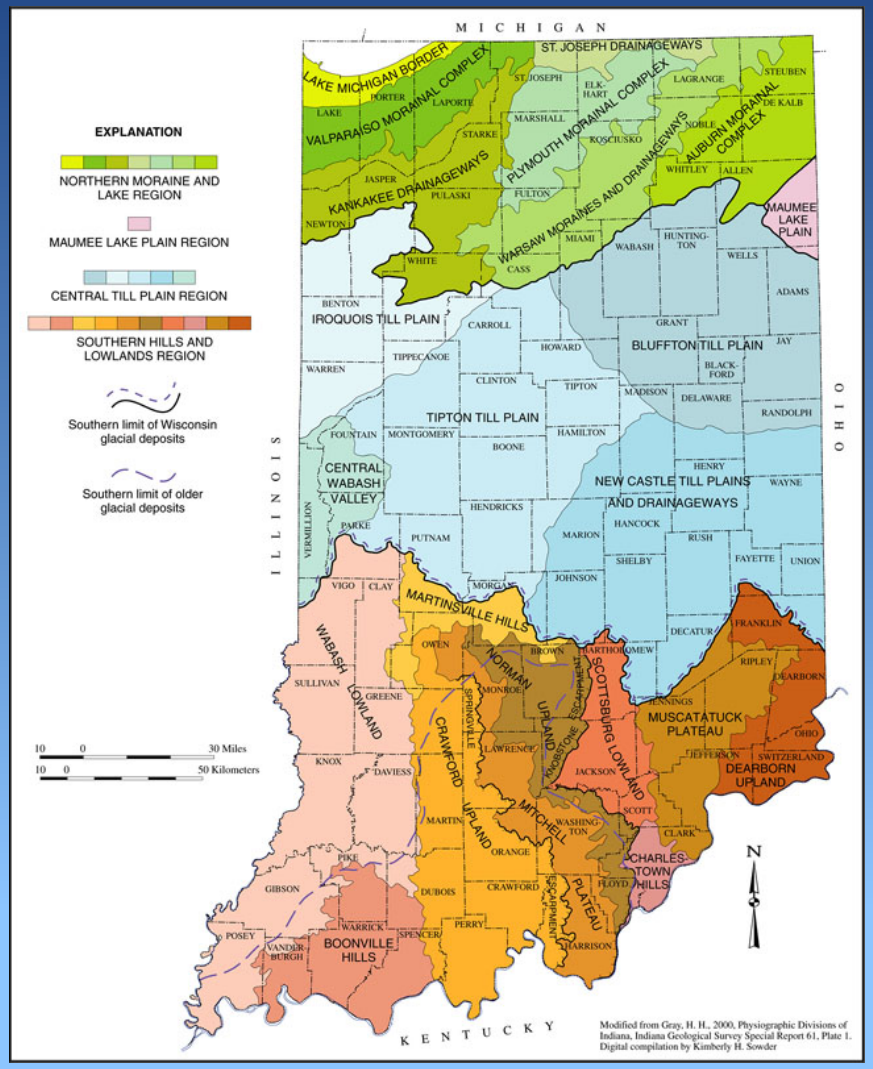


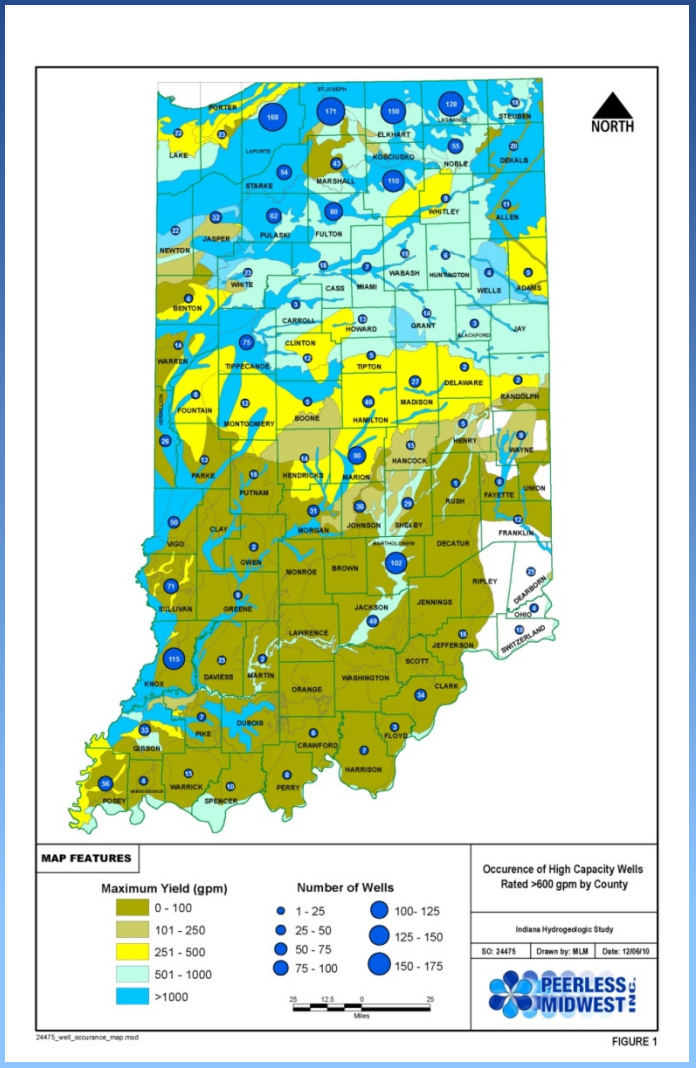




Background Investigation

Surficial Geology & Groundwater Availability





Geologic Cross-Sections

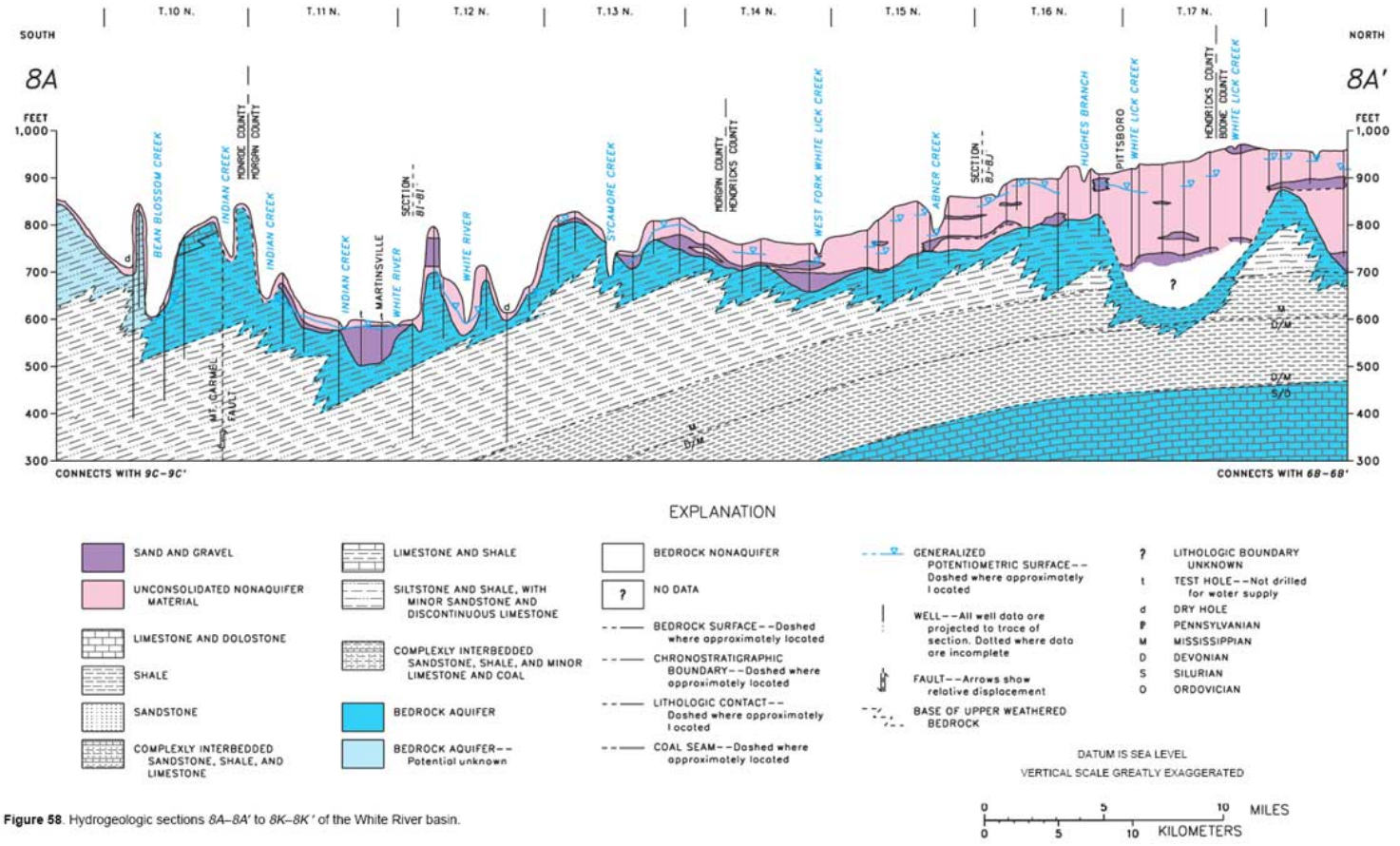


Figure 58. Hydrogeologic sections *8A–8A'* to *8K–8K'* of the White River basin.

Aquifer System Characteristics

Hydraulic Conductivity (K)

- One-dimensional
- Measures the rate that water moves past a point in time
- Typical units of feet per day (ft/day)
- K = T/b (where T = transmissivity & b = aquifer thickness

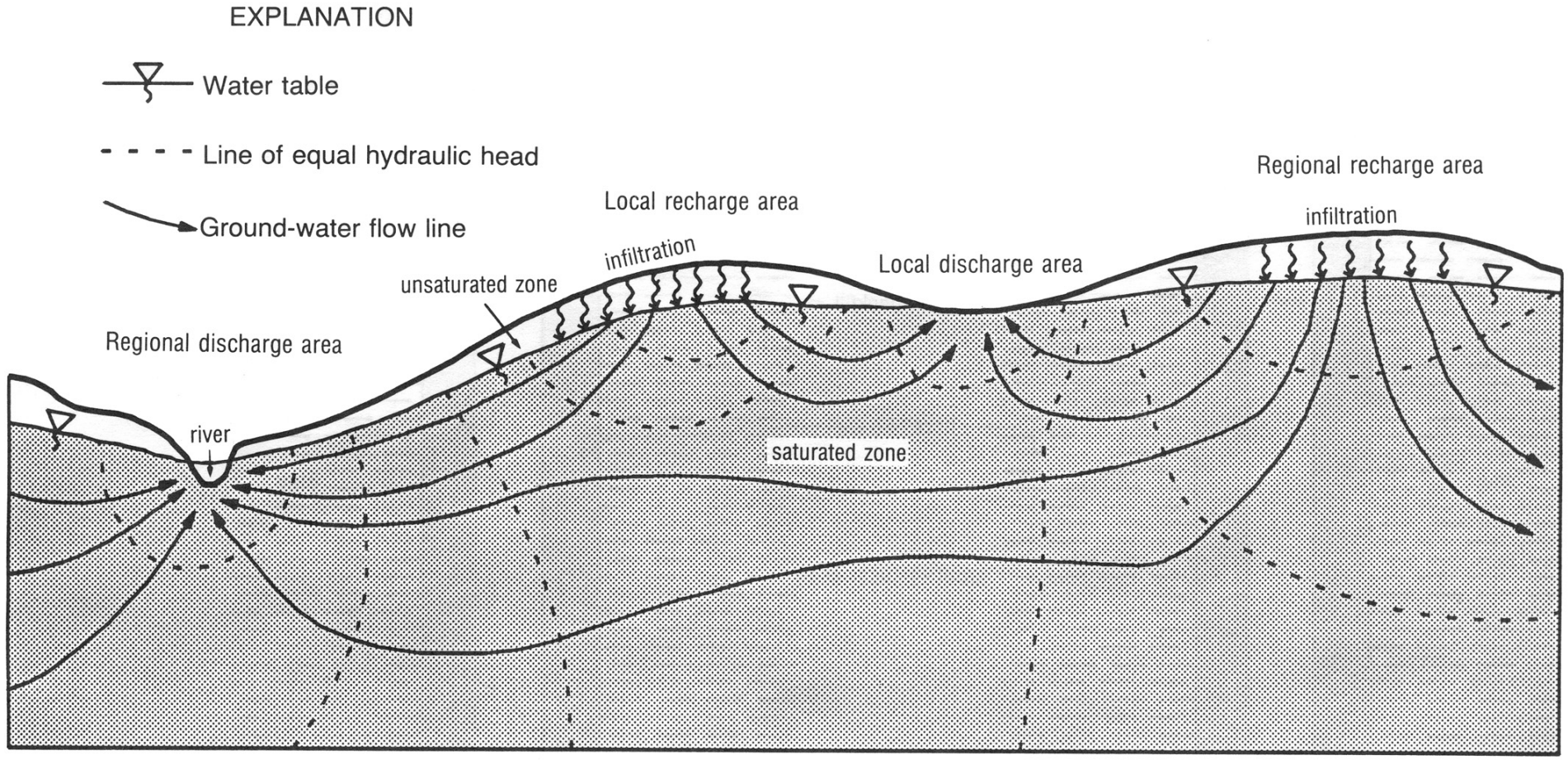
Transmissivity (T)

- Two-dimensional
- Refers to how fast water is moving past a cross-sectional area of the aquifer
- Typical units of square feet per day
- T = K/b (K = hydraulic conductivity & b = aquifer thickness)

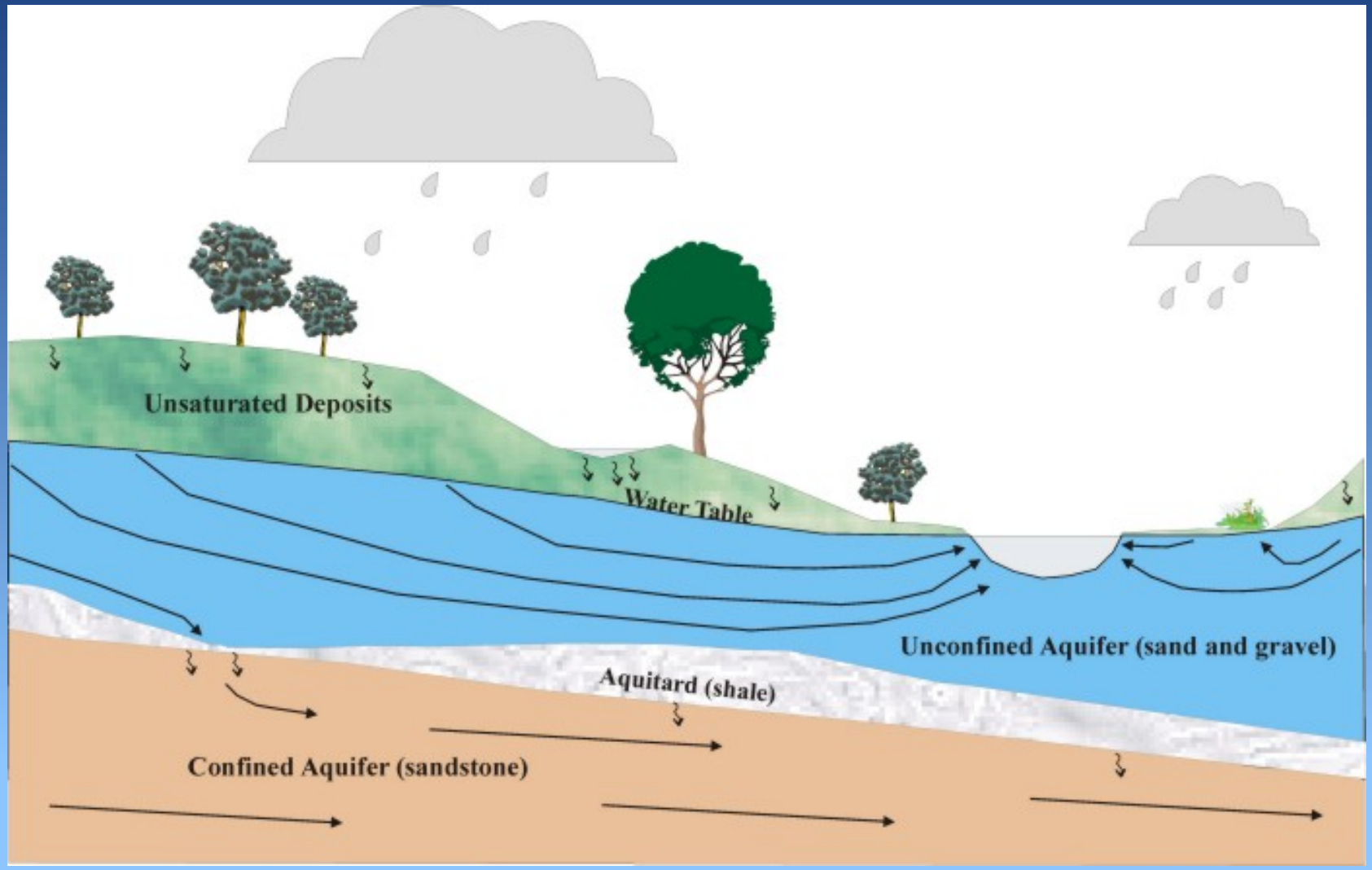
Storativity (S/S_y)

- How much water is in pore spaces (or fractures) of aquifer that can be removed
- Dimensionless
- Confined aquifer = storativity
- Unconfined aquifer = storage coefficient or specific yield
- Need K & T to calculate storativity

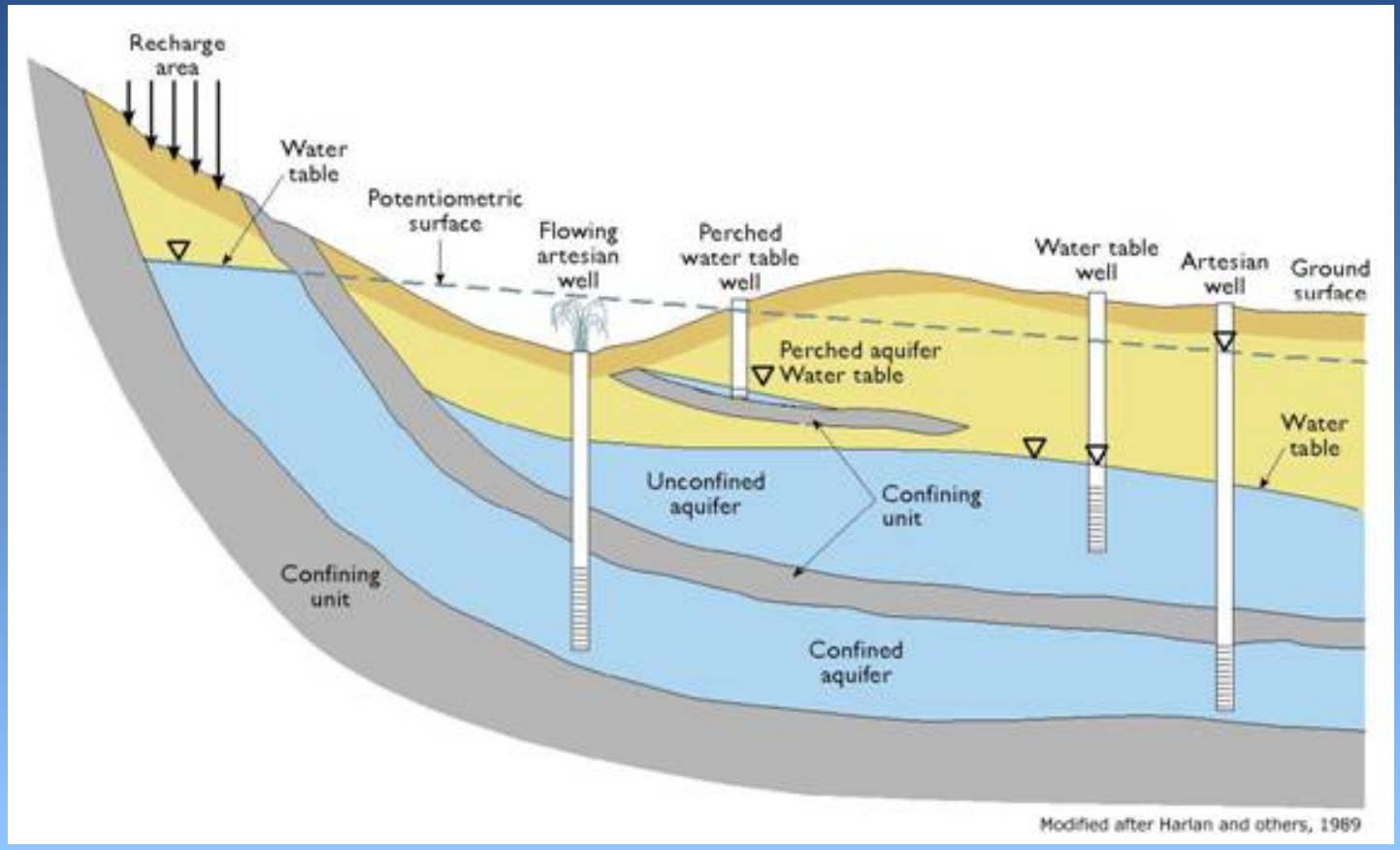
Aquifer System Characteristics



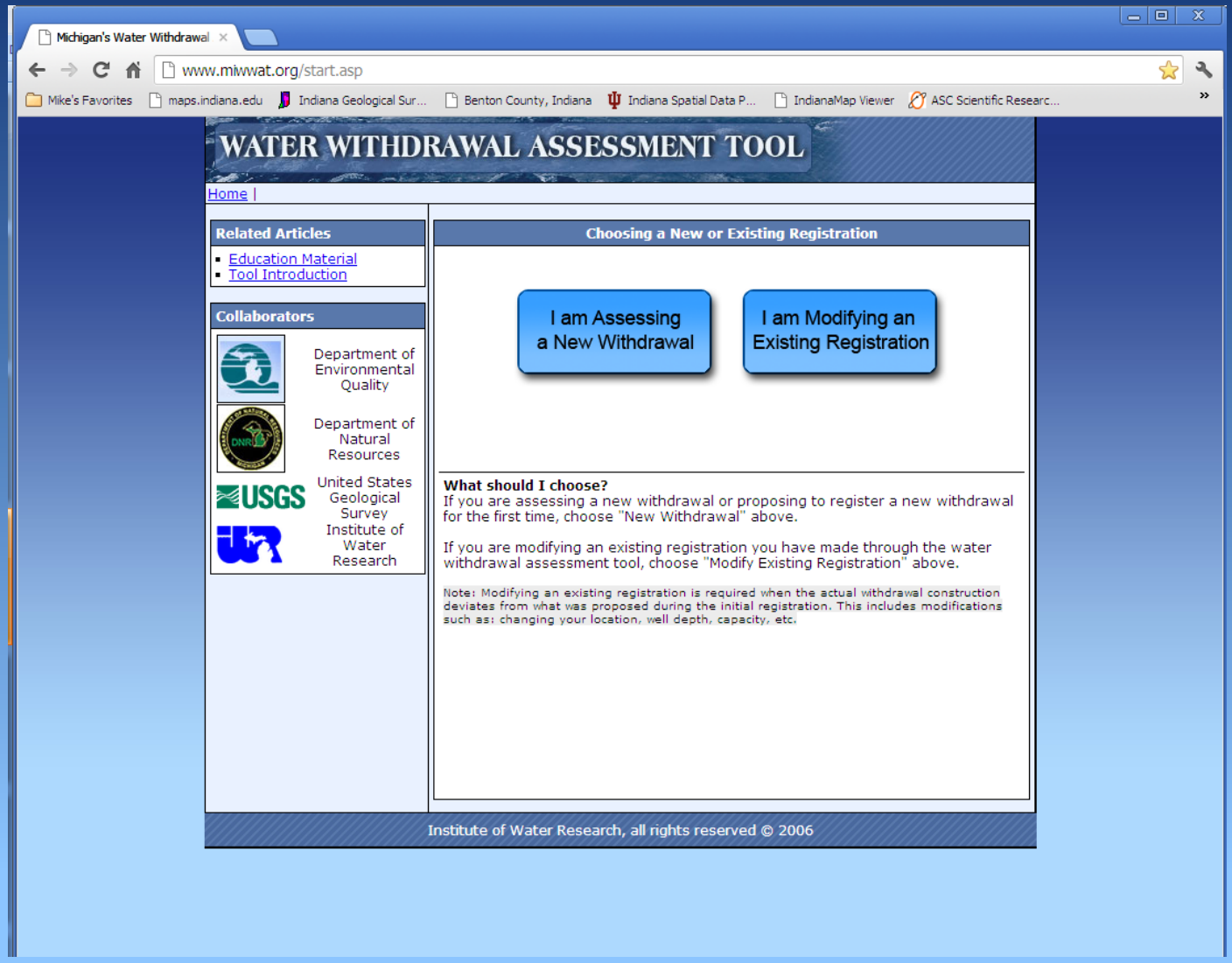
Aquifer System Characteristics



Aquifer System Characteristics



Aquifer System Characteristics



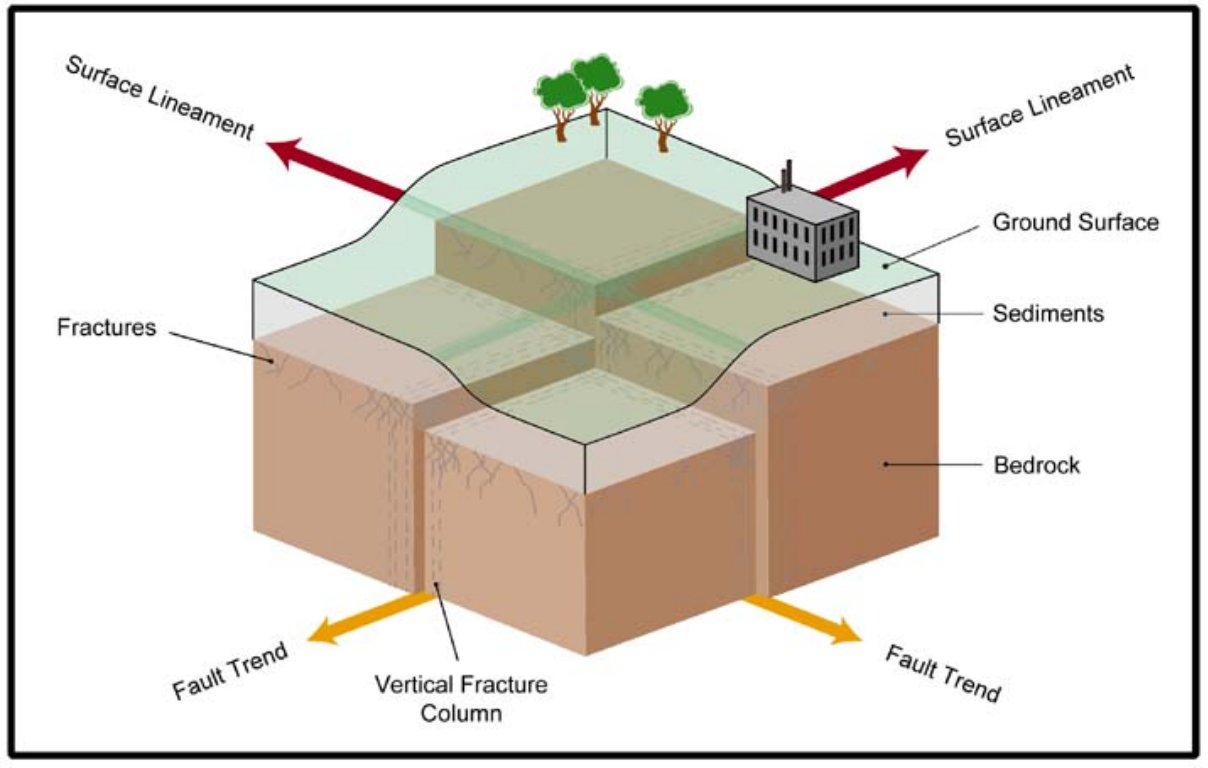
Field Investigation

Goal: Develop a Sustainable Irrigation Water Supply.

- **Fracture Trace Analysis**
- **Surficial Geophysics**
- **Test Drilling**
- **Lithology Sampling**
- **Borehole Geophysics**
- **Well Construction**
- **Aquifer Performance Testing**

Fracture Trace Analysis

Lineaments are linear features that are identifiable on stereographic pairs of aerial photographs. They are identified based upon subtle changes in topography and shading at the ground surface. Fractures and faults in bedrock or basement rocks are often propagated up through unconsolidated sediments to the surface as failure planes. These features are often expressed as lineaments that have subtle surface expressions. Lineaments usually result from the minor reactivation of fractures and faults that occurs because of occasional seismic activity.



Fracture Trace Analysis

Lineaments are identified using stereographic pairs of aerial photographs.

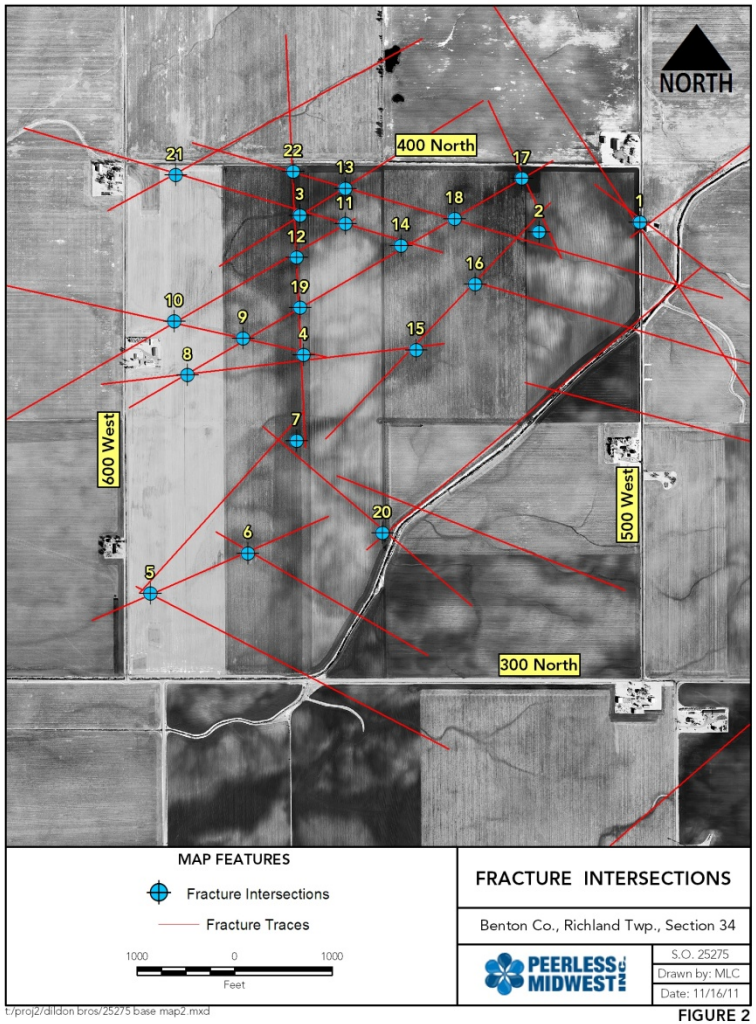


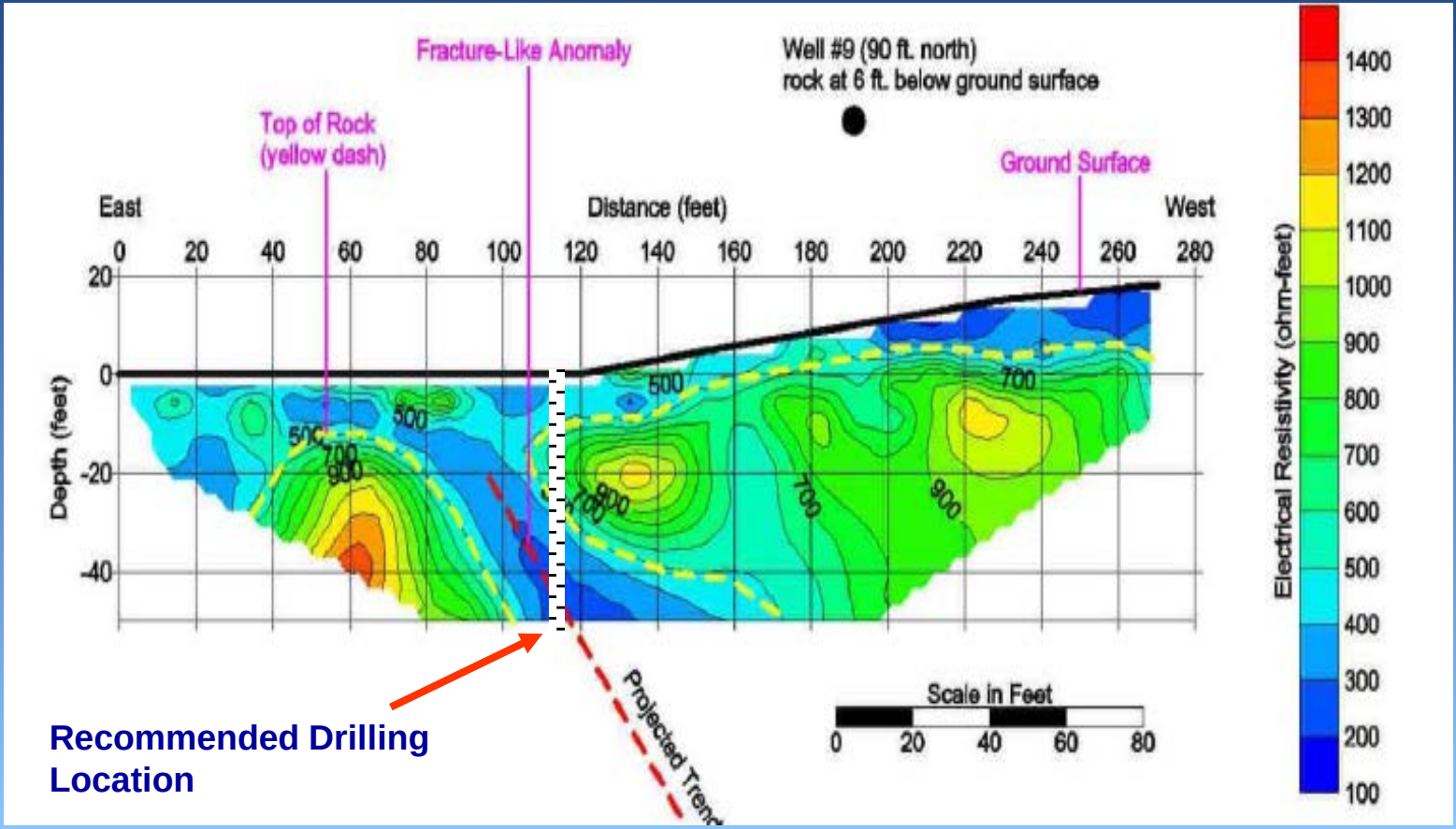
FIGURE 2

Electrical Resistivity Surveying

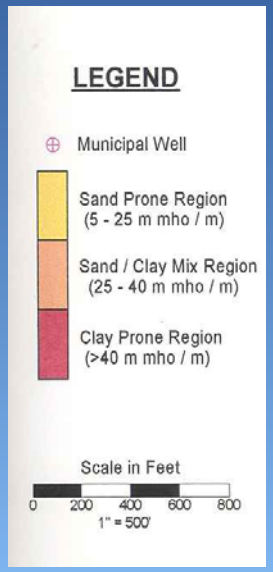
ER Detects:

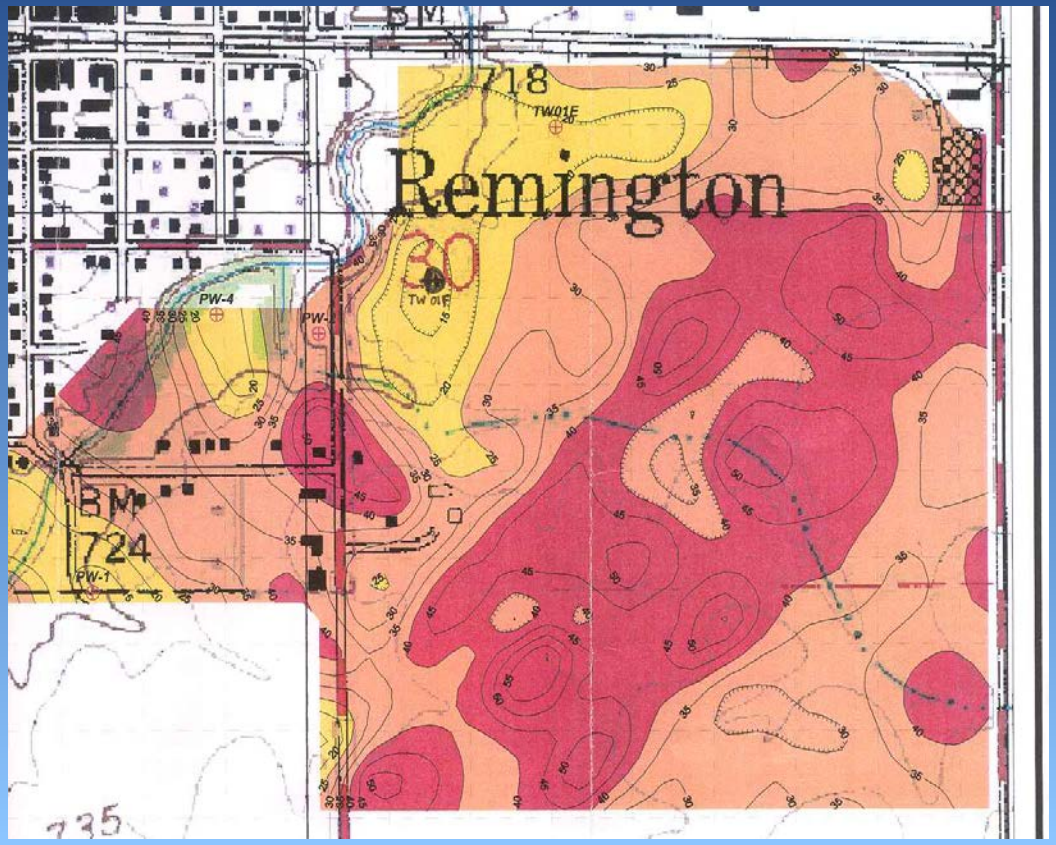
- **Stratigraphic horizons and continuity;**
- **Boundary Conditions**
- **Bedrock weathering and faulting**
- **Clay and water content**

Electrical Resistivity Surveying

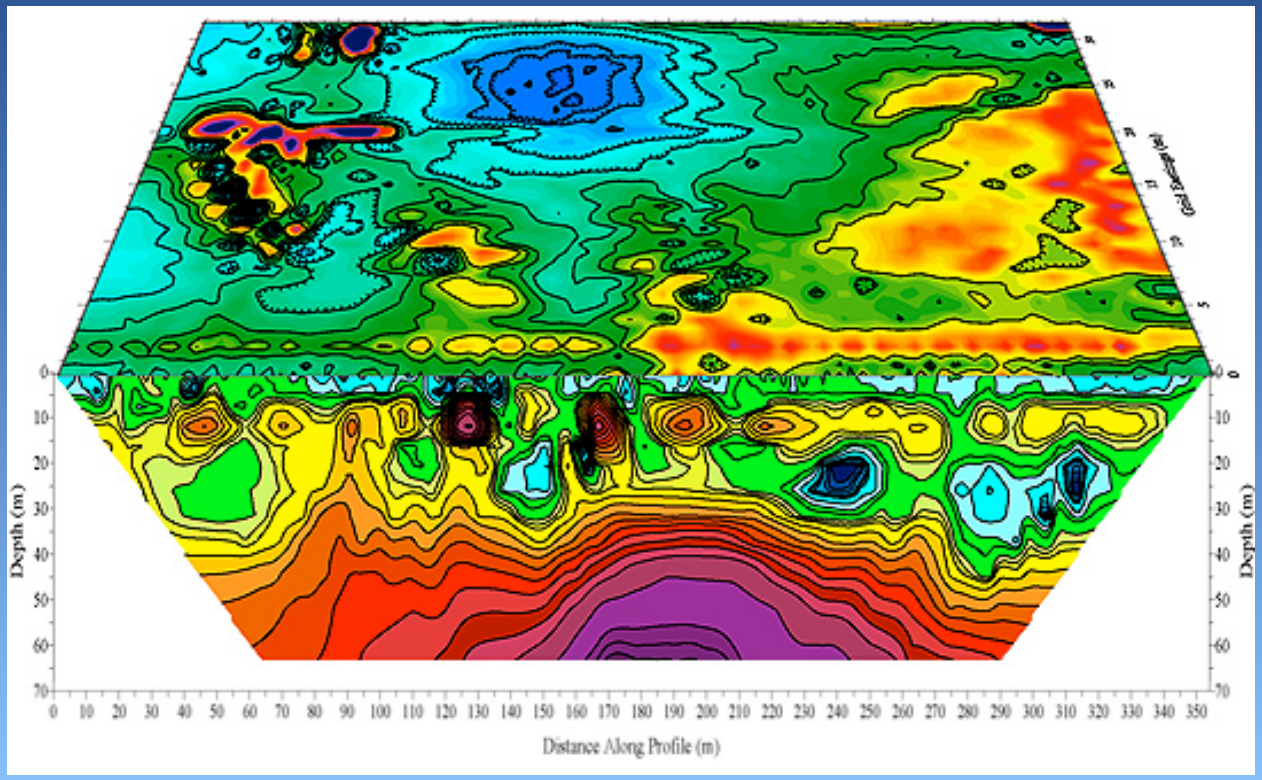


Electrical Resistivity Surveying





Electrical Resistivity Surveying



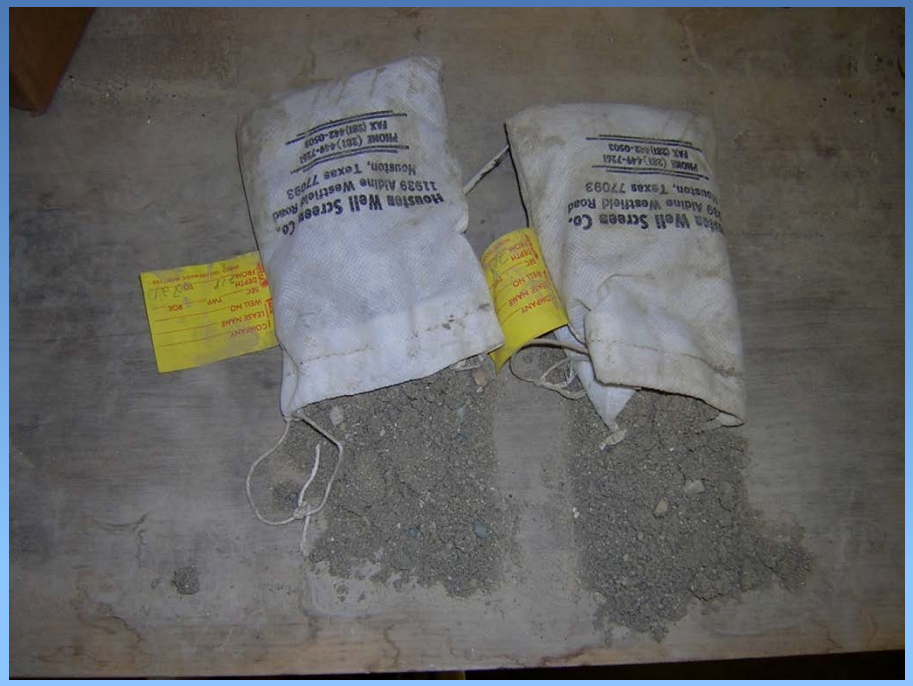
Test Drilling

Mud Rotary Drilling

- Bentonite clay used as drilling fluid
- Lithology samples collected at 5 ft intervals
- Borehole advanced to base of available aquifer(s)

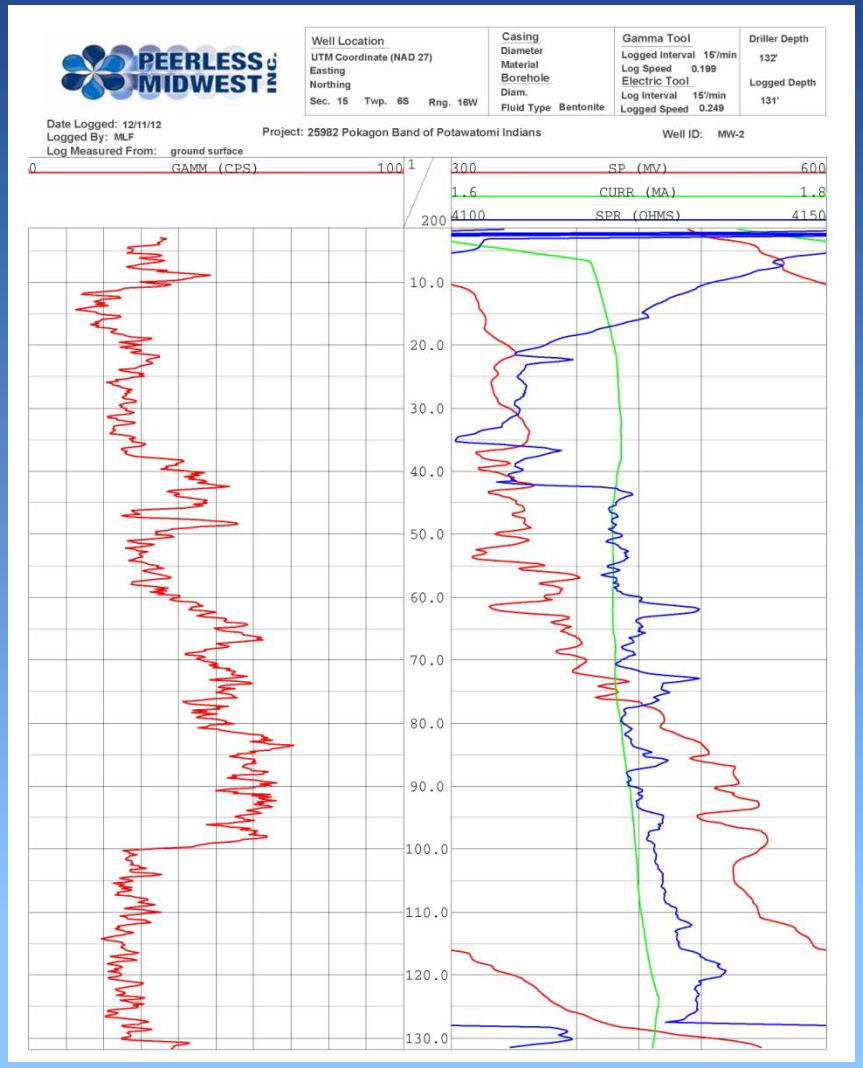
Lithology Sampling

- **Lithology samples collected at 5 ft intervals within aquifer formations**
- **Samples are bagged and labeled for review and sieve analysis**

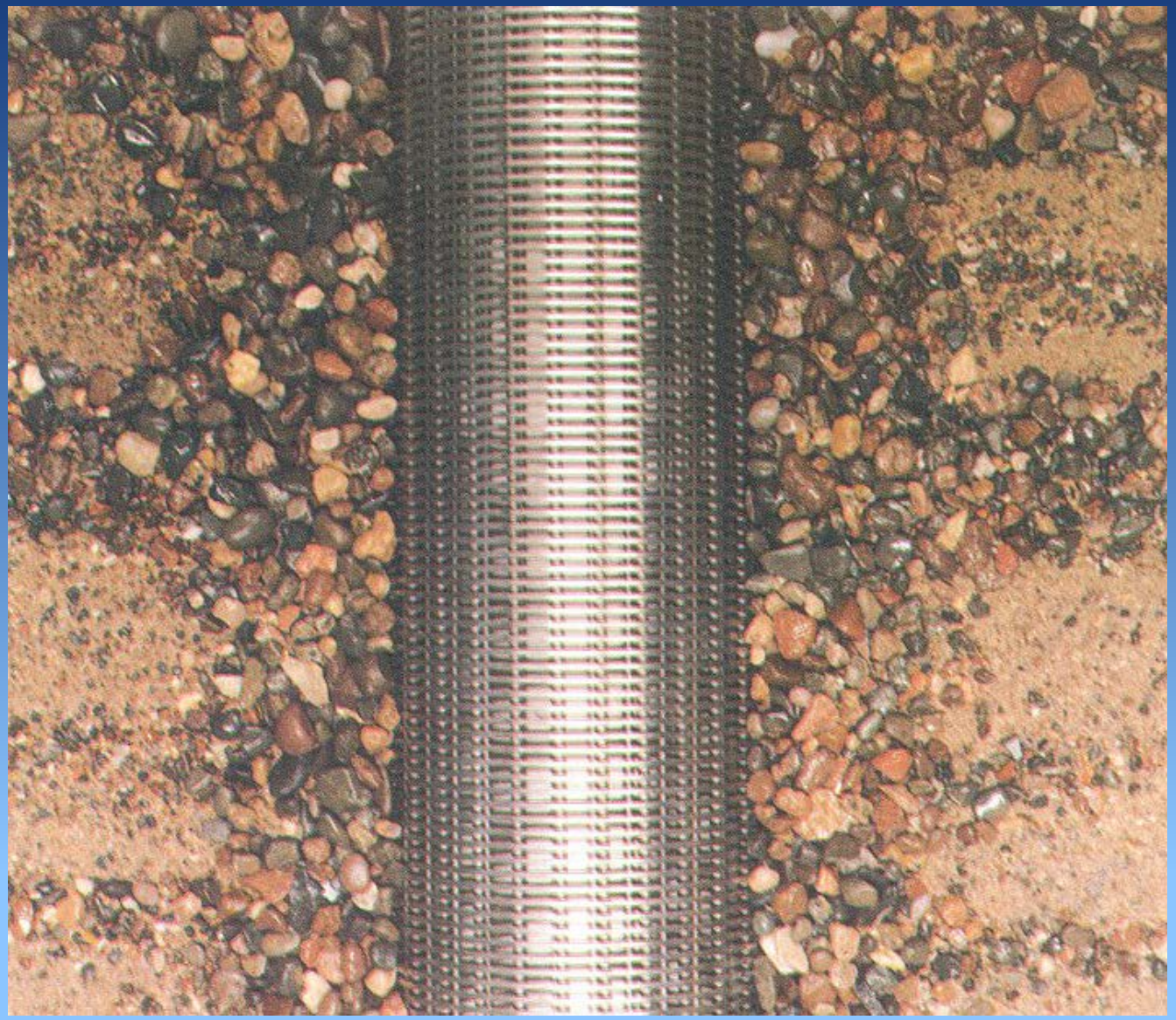


Borehole Geophysics

- **Natural gamma ray & single point resistivity logging conducted to verify aquifer intervals.**

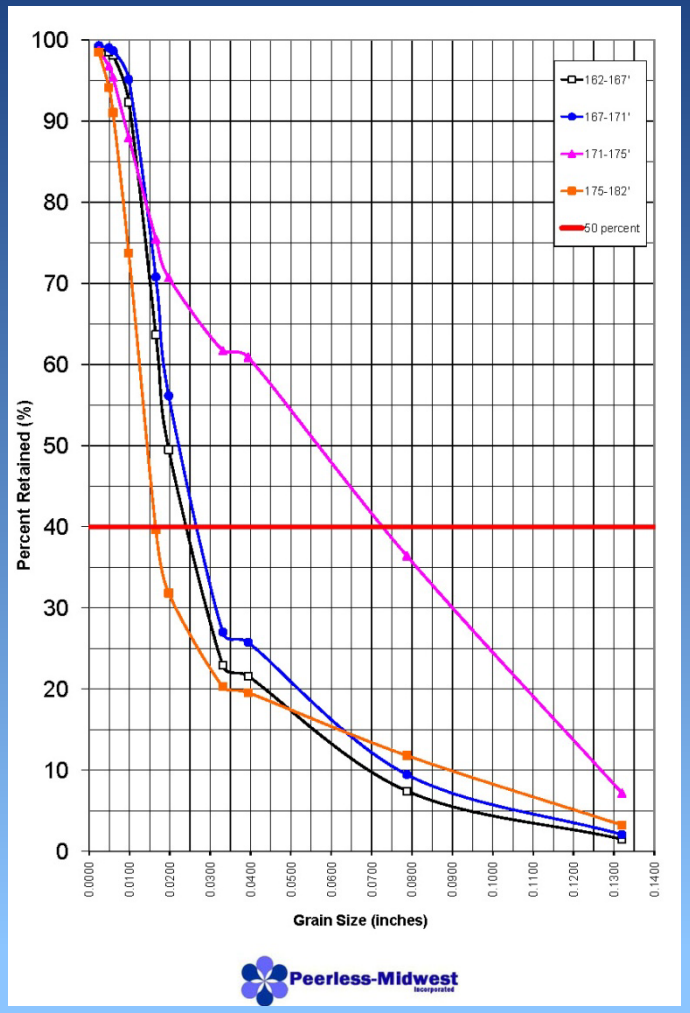


Sieve Analysis & Screen Selection



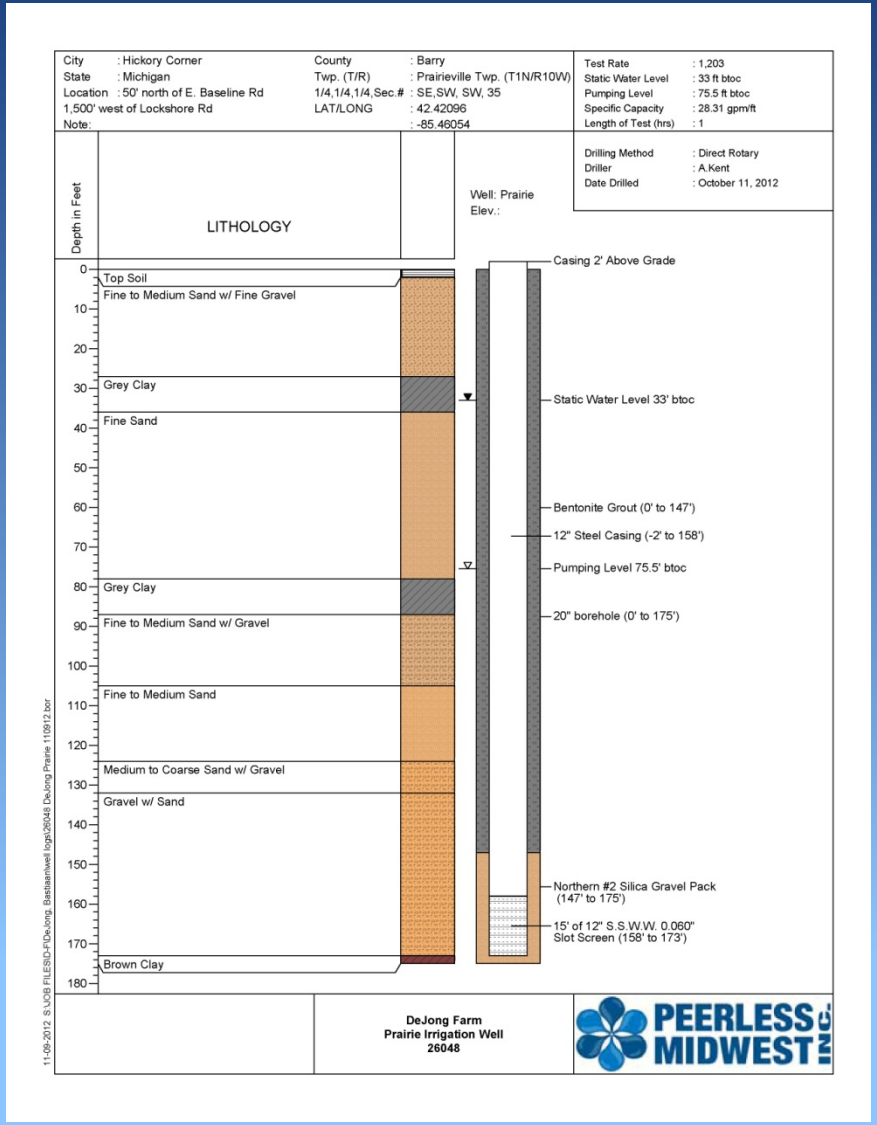
Sieve Analysis & Screen Selection

Sample ID		W-20				
Interval (ft)		145-155	155-165	165-175	175-185	185-190
U.S. Screen	Inches Opening	ACC % Retained	ACC % Retained	ACC % Retained	ACC % Retained	ACC % Retained
6	0.132	0.1%	0.2%	0.0%	0.0%	0.0%
9	0.0784	0.4%	1.4%	0.0%	0.4%	0.1%
16	0.0394	1.2%	8.6%	0.8%	1.7%	0.8%
20	0.0331	1.4%	10.1%	1.6%	2.8%	1.2%
35	0.0197	14.7%	43.7%	37.5%	30.9%	17.1%
40	0.0165	48.4%	61.7%	44.7%	41.8%	39.4%
60	0.0098	87.4%	90.7%	85.8%	88.5%	89.5%
100	0.0059	94.7%	97.2%	97.1%	97.6%	97.0%
120	0.0049	96.3%	97.7%	97.8%	98.6%	98.0%
230	0.0024	98.5%	99.2%	99.3%	99.7%	99.5%
pan	<0.0024	100.0%	100.0%	100.0%	100.0%	100.0%

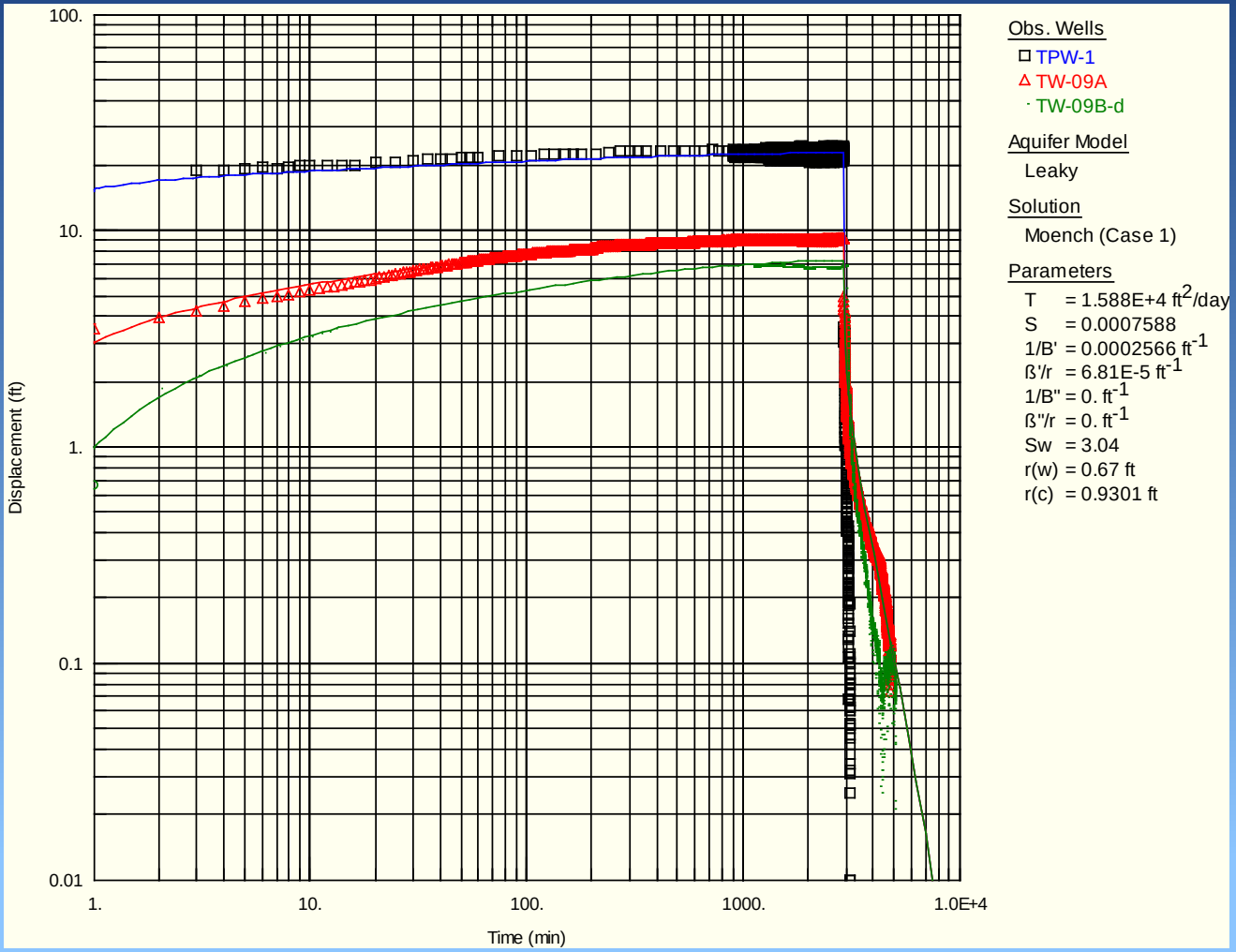


Test/Production Well Construction

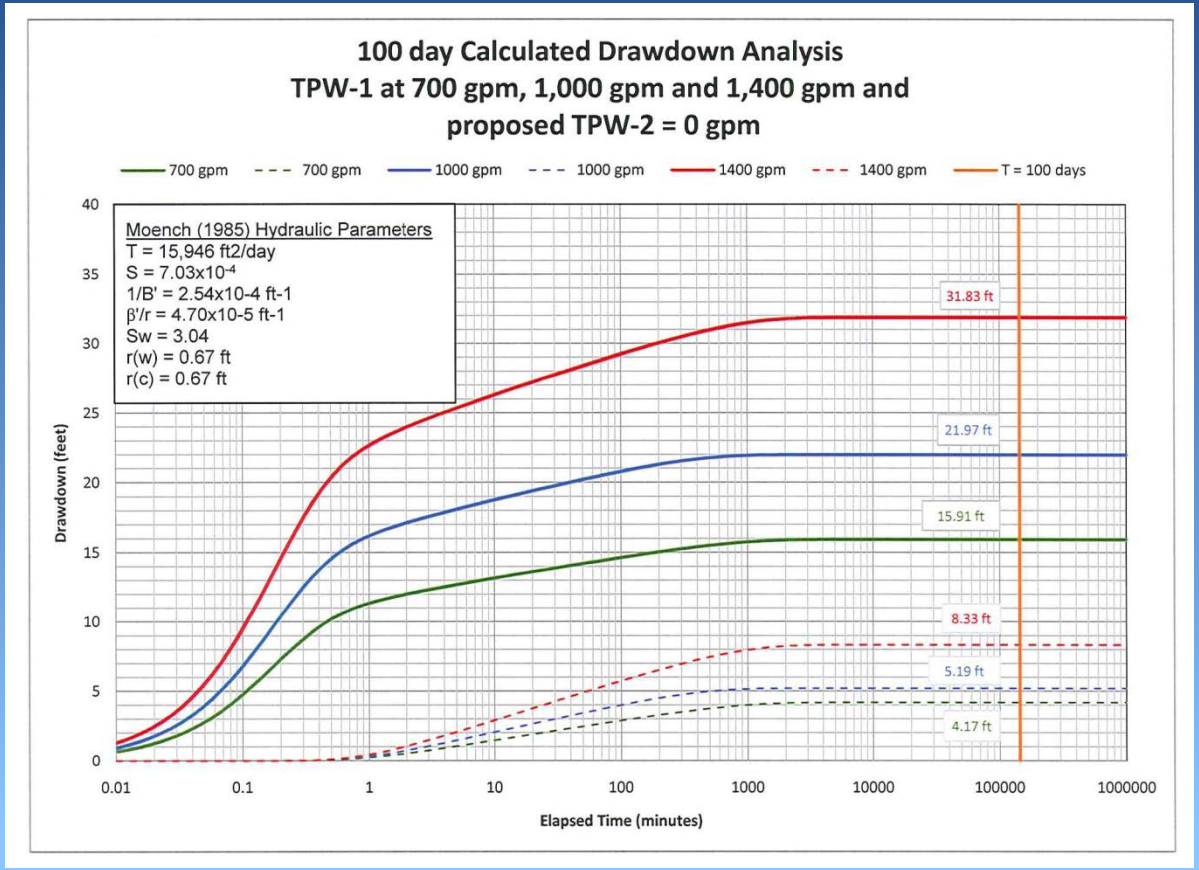
- **Large diameter borehole drilled**
- **Well screen and casing installed.**
- **Annular space back filled with gravel pack and grout**
- **Well is then developed and tested**



Aquifer Performance Test

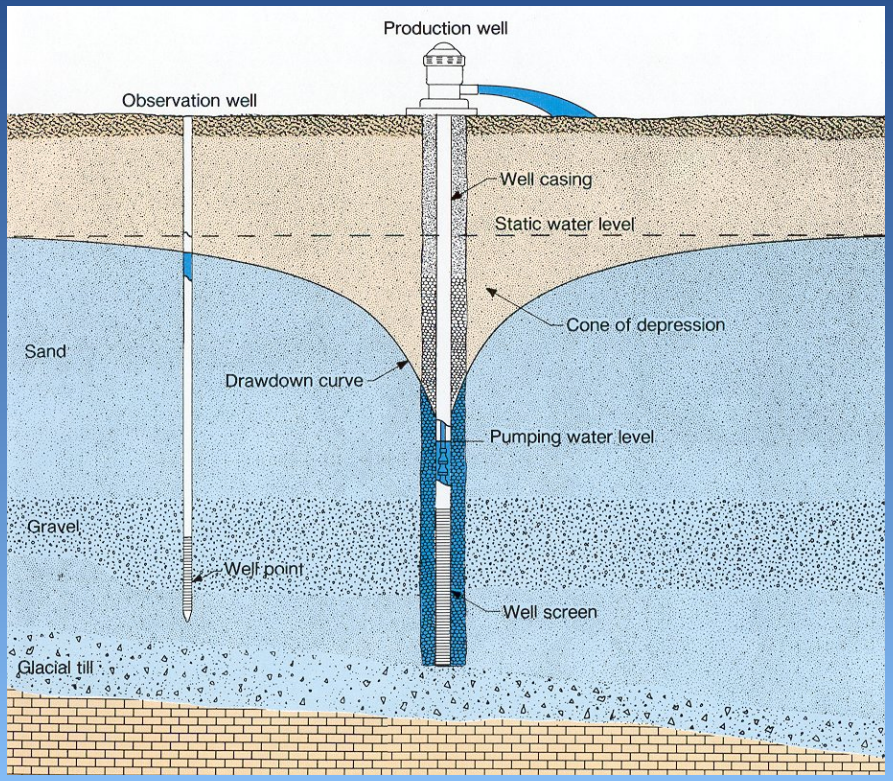


100 Day Safe Yield Calculation



Aquifer System Characteristics

- **Aquifer hydraulic parameters used to calculate sustainable yield;**
- **Pumps designed based upon total dynamic head, well diameter, available drawdown.**



Sustainable Irrigation

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