AGI
GREAT LAKES GEOLOGIC MAPPING COALITION WEBCAST

MICHIGAN MAPPING PRODUCTS FOR THE 21ST CENTURY

DECEMBER 6, 2017

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Supported by

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Michigan Geological Survey

http://wmich.edu/geologysurvey

Technical report
http://mgs.geology.wmich.edu/mgsmaps/coalition2017.zip

GREAT LAKES GEOLOGIC MAPPING COALITION

MAPPING GOALS & OBJECTIVES

- GEOLOGICAL
- ENVIRONMENTAL
- SOCIETAL
- ECONOMIC BENEFITS

- http://wmich.edu/geologysurvey

2015-16 CASS COUNTY MAPPING AREA

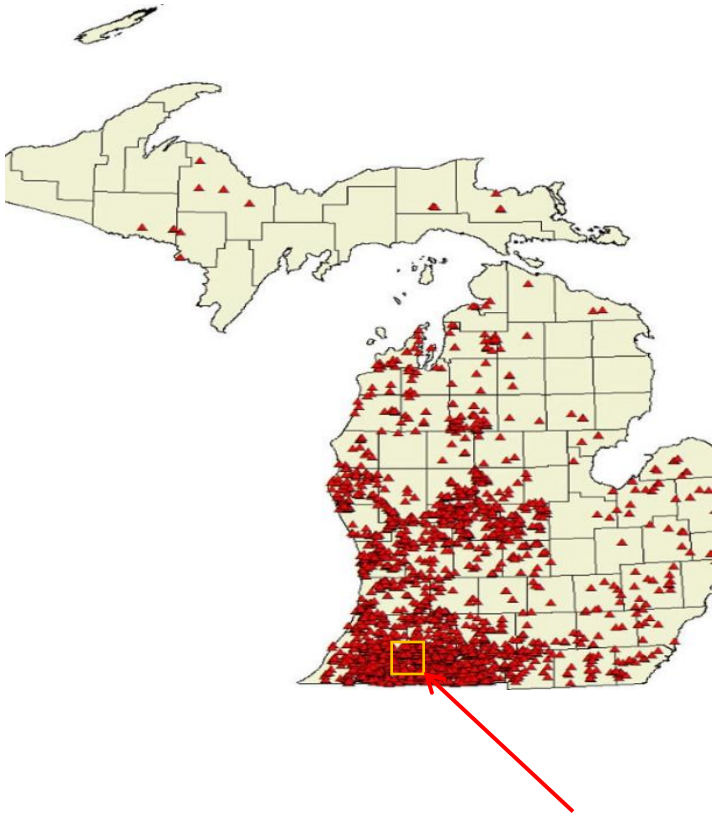
- Geological mapping/research dead zone (508 Sq mi.- 1,316 Km^2)
  - all surrounding counties have recently had the surficial geology mapped
  - Need to produce more 3D mapping products
- Agricultural demands
  - St Joseph, Cass, Berrien Counties
  - High capacity wells >70gpm, potential impact to cold water streams.
  - Support compliance with Great Lakes Water Compact (Streams and Groundwater)
- Scientific demands
  - Seeking incremental solutions to complex glacial history
- Aggregate Resources
  - Michigan Infrastructure

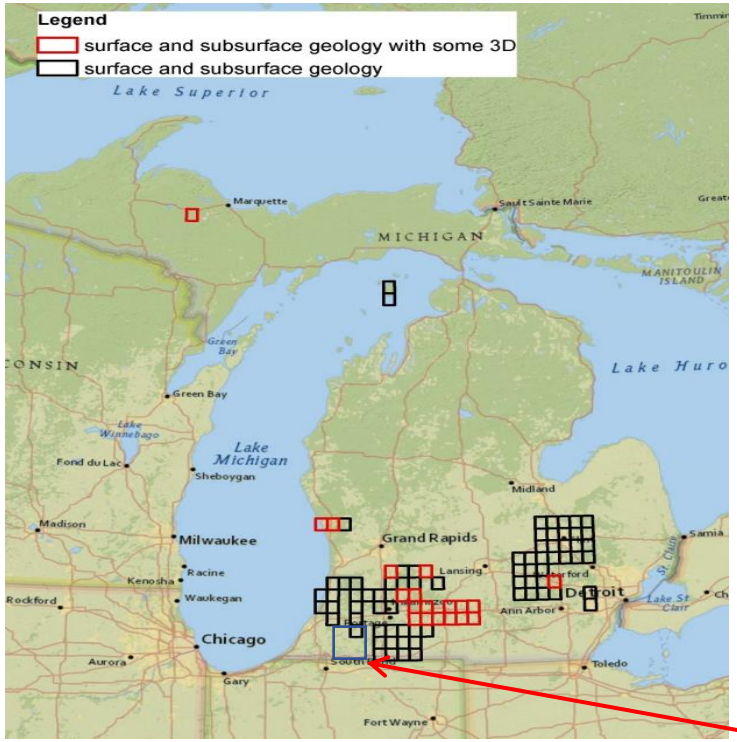
MI WWAT Applications vs detailed GEOLOGIC Map Products

Approximately 60% of the LP groundwater comes from glacial material

Mi WWAT Applications >70 GPM through 2014 for comparison

(Water Withdrawal Assessment Tool- a non-factual model)





This is the real summary of mapping of the detailed combined surface and subsurface by MGS, USGS or others for Lower Peninsula.

Less than 10 % Detailed MGS mapping.

*** Quads (~56 Sq Mi)**

- Black Surface only with validation of borings
- **Red - surface + some subsurface drilling / geology 3D**

- **Vandalia and Jones**

Mapping Methods used by all Surveys

Field Methods:

- Hand augered borings
- Road cuts, natural exposures, gravel pits, foundations
- Drilling/Coring & sampling other drilling
- Gamma-ray logging existing wells & new borings
- Grain-sized analysis
- **HVSR - Passive Seismic for bedrock depths**
- OSL sampling/age dating







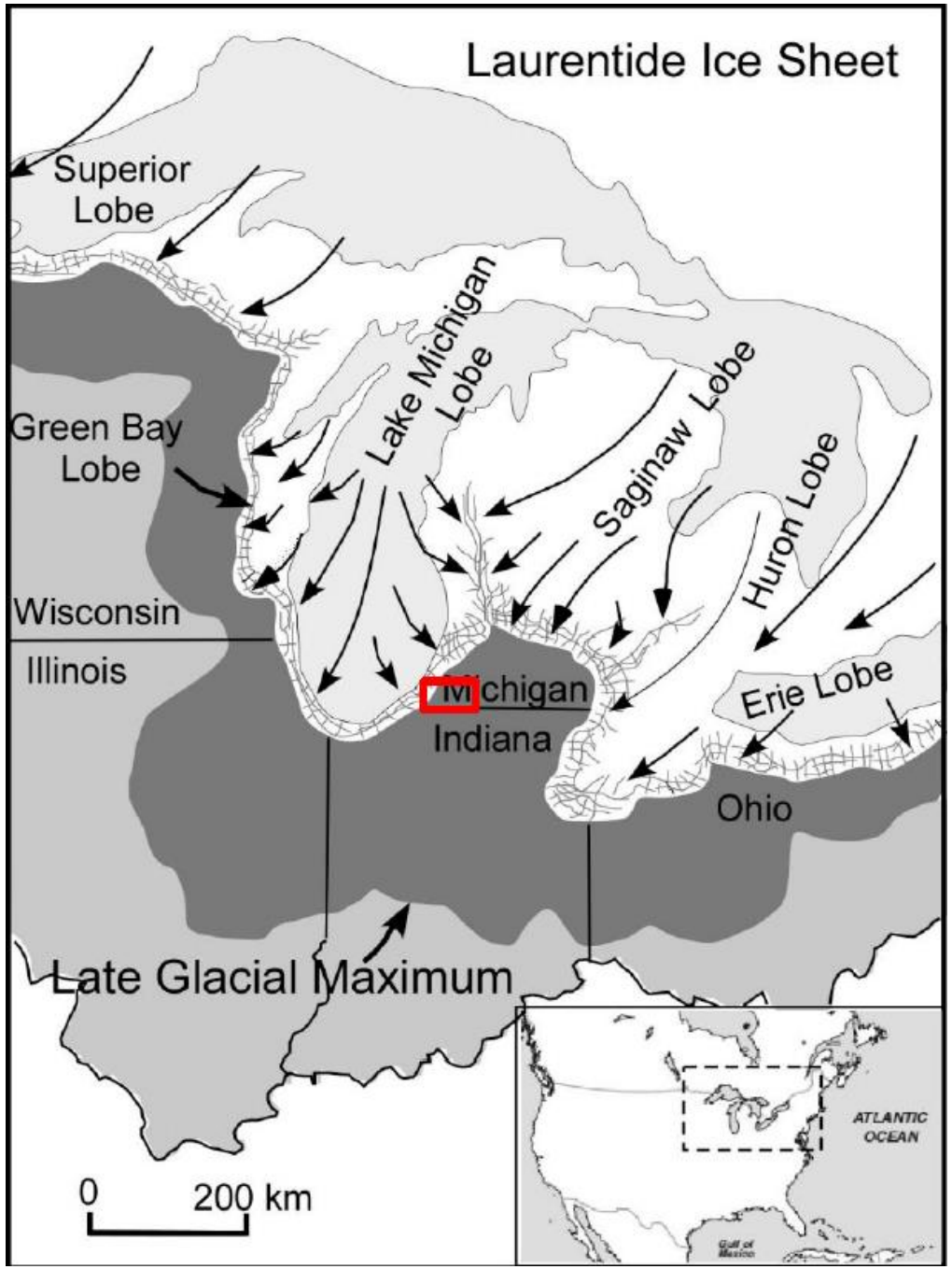


Desktop Survey:

- **LiDAR Elevation data**
- Soil Survey Data
- Aerial photos
- Review existing water well logs & Oil & Gas logs
- Cross-sections every mile and 3D visualization



OSL-CAS-16-02



Surficial geology of a complex interlobate area, Cass County, Michigan

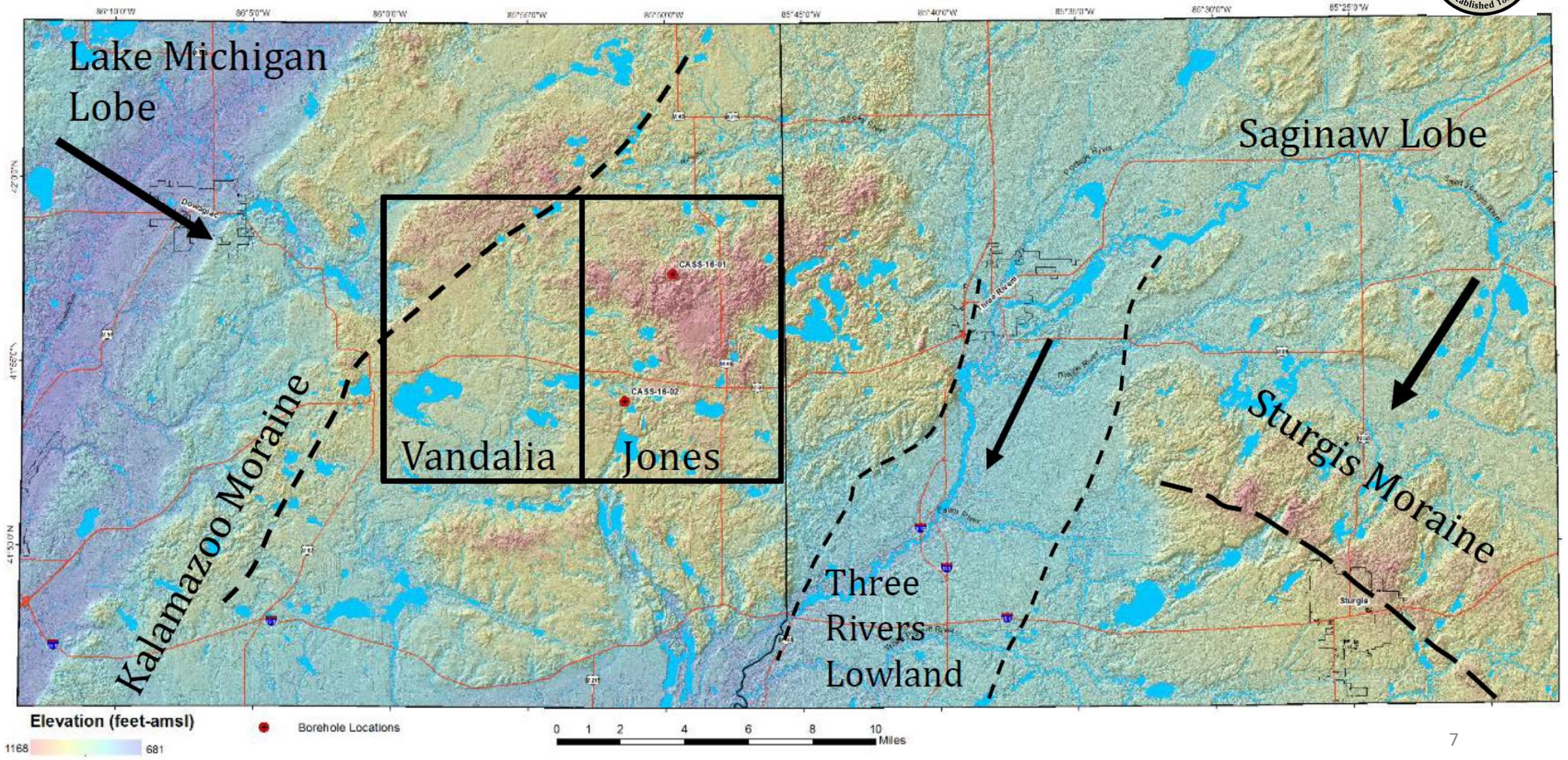
Ice Stream (lobe) behavior

- Asynchronous
- Many advances and retreats during deglaciation
- Overlapping boundaries

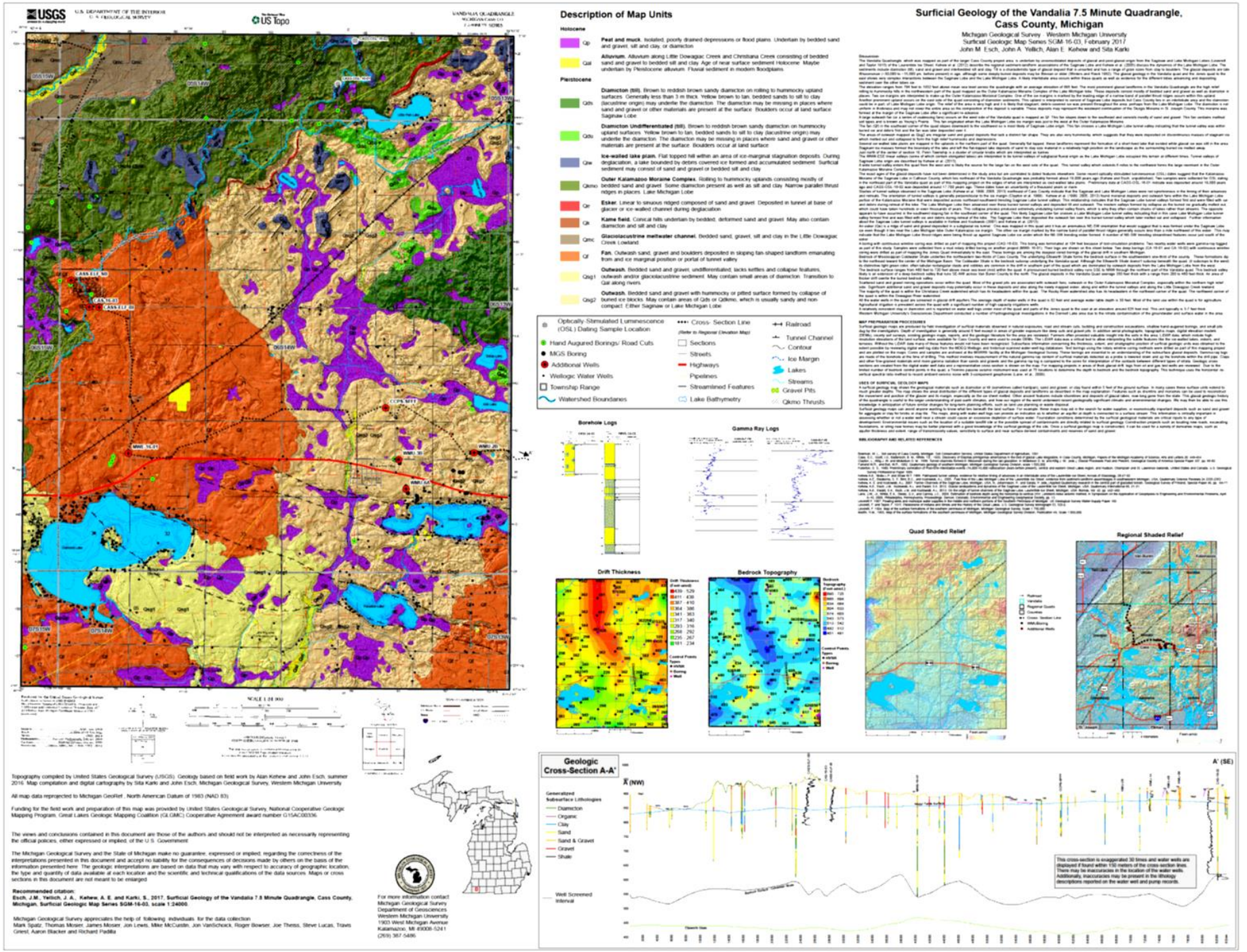
Cass County – new mapping project area!

- Geological mapping/research dead zone
  - all surrounding counties have had the surficial geology mapped recently
- Ground zero for high capacity water withdrawal from irrigation wells
- Large number of high capacity irrigation wells –but still have cold water fisheries (trout) in headwater of some streams
- Highest topography in SW Michigan.
- Complex interlobate area
- Thickest drift in SW Michigan.

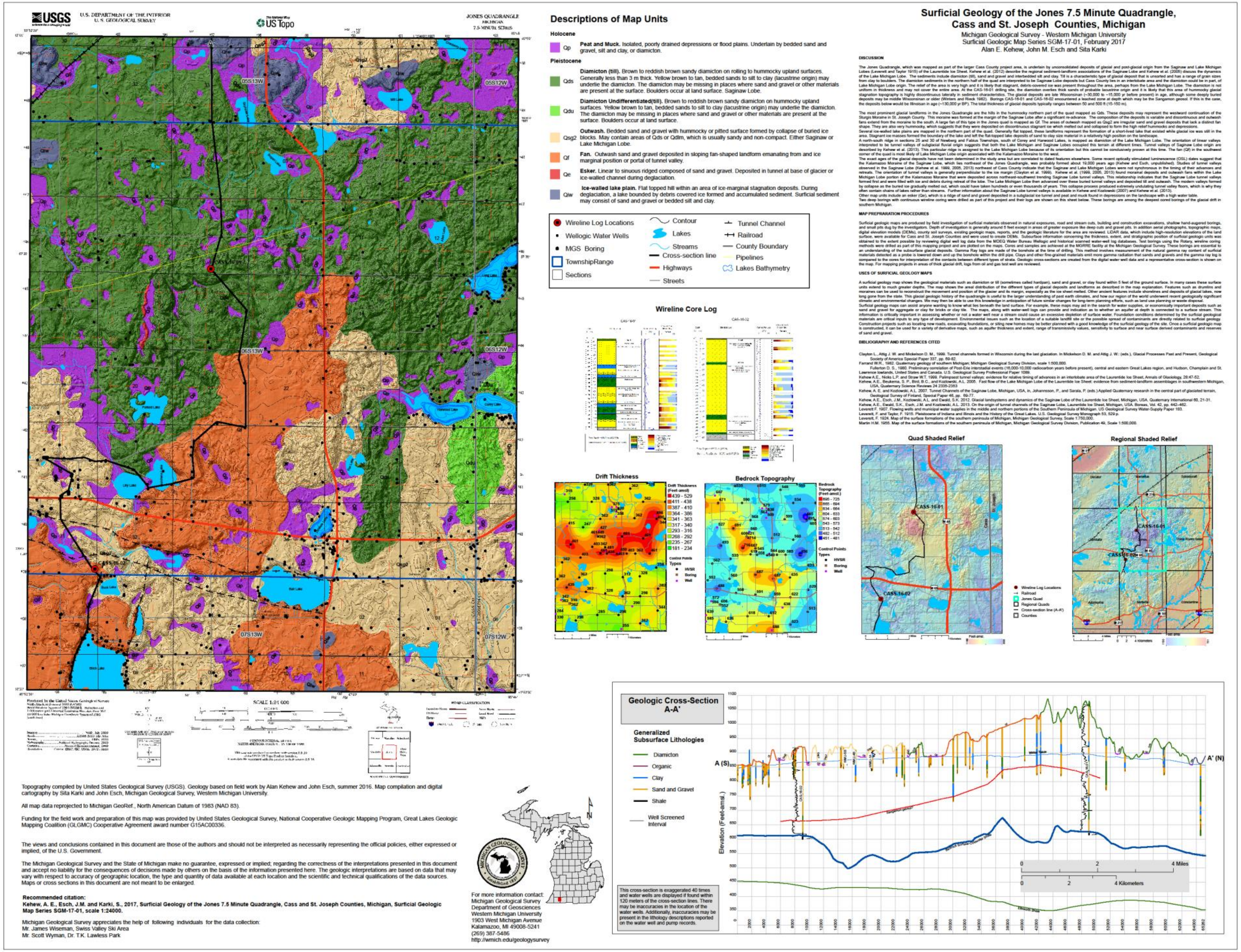
Digital Elevation Model (DEM) Location of mapping areas



Vandalia Map product



Jones map product



TECHNICAL REPORT

Surficial Geology of the Vandalia and Jones 7.5 Minute Quadrangles, Cass County, Michigan;

Award No. G 15AC00336

Michigan Geological Survey, Western Michigan University
PI: Alan E. Kehew, MGS. Co-PI: John A. Yellich
Contract Mapper: John M. Esch, MDEQ
Cartography/GIS: John Esch & Sita Karki

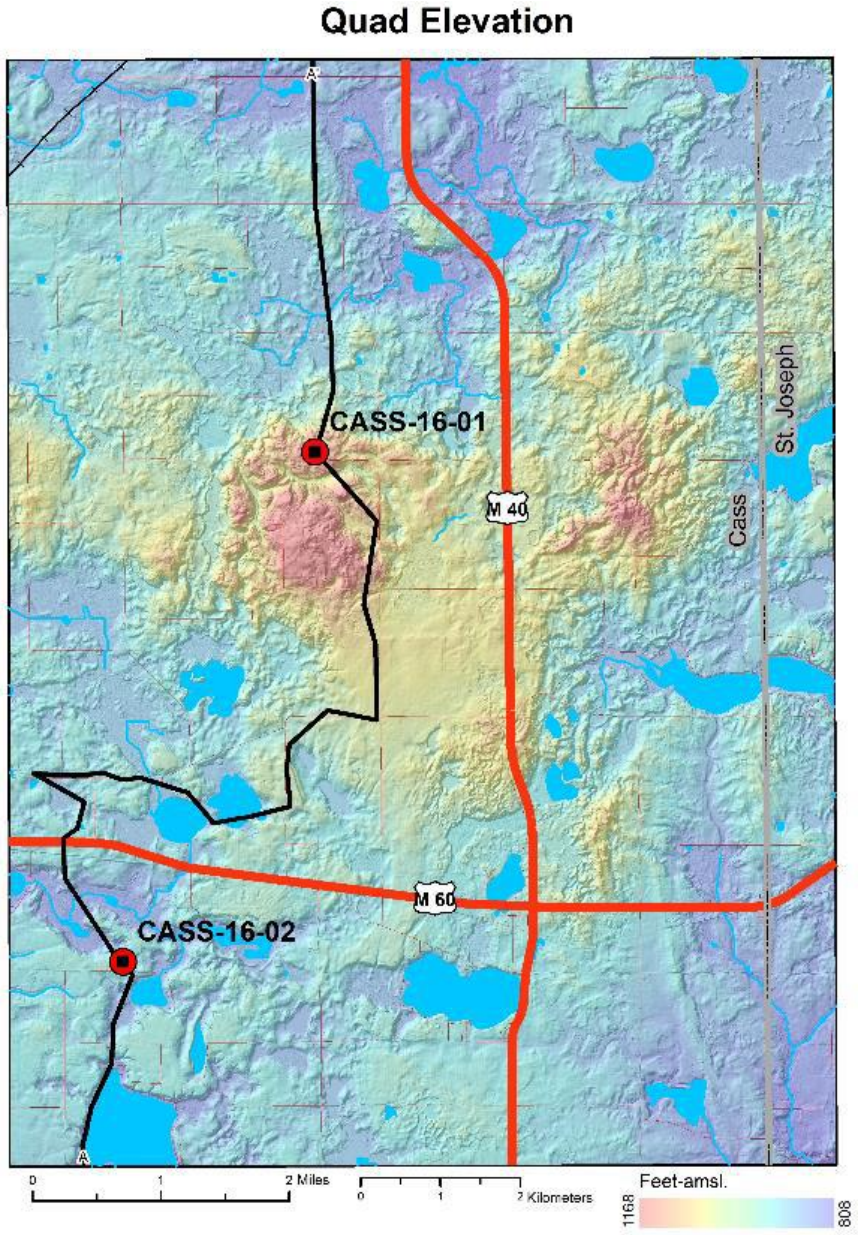
http://mgs.geology.wmich.edu/mgsmaps/coalition2017.zip

February 2017

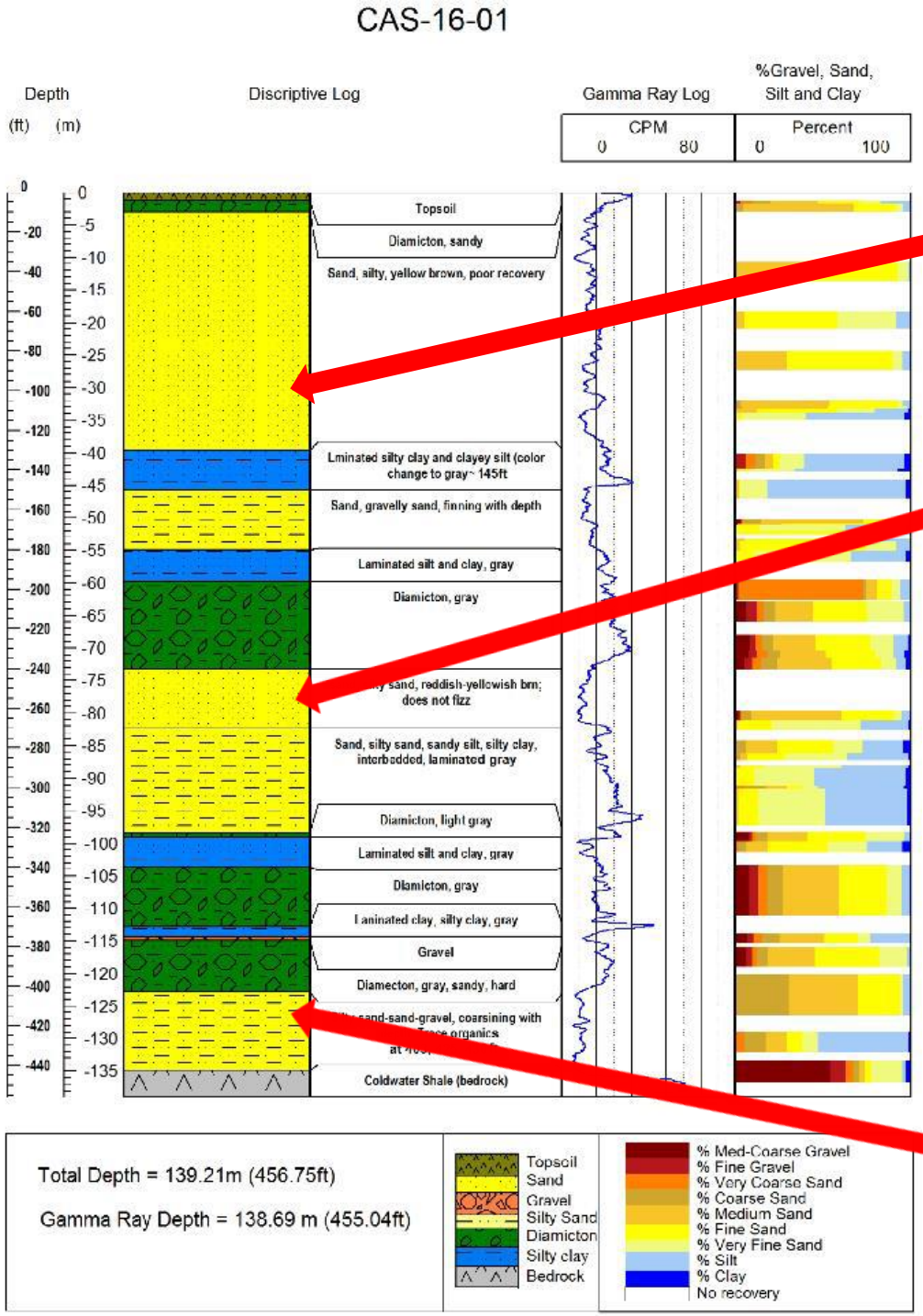
Scientific milestones in this first detailed Cass County assessment

- Jones Quad is westward extension of the northeast - Sturgis Moraine.
- **Deeper glacial/drift aquifers >200 feet than published data.**
  - **Lower 1/2 -2/3 of the drift package has potential aquifers that have not been tapped.**
- Likely Sangamon Geosol encountered in the two deep borings (Illinoian age).
- **Highly irregular bedrock surface, valleys and ridges.**
- OSL sampling of the Lake Michigan Lobe - Outer Kalamazoo ice margin in consistent with age dates of the Saginaw Lobe Outer Kalamazoo ice margin – this has implications for source of the Kankakee Torrent.
- **First evidence of Saginaw Lobe fans burying Lake Michigan Lobe tunnel valleys.**
- **First evidence of Saginaw Lobe tunnel valleys crossing Lake Michigan Lobe tunnel valleys. These two glacial systems were active at the same time.**
- Ice-walled lake plains common on uplands – 1st time seen in area.
- Potentially regional till unit across large areas of NW Cass county.

Hydrostratigraphy: 2 deep coreholes drilled by Illinois State Geological Survey (ISGS) wireline coring rig, an inter Survey collaboration.



CAS-16-01



Lacustrine sand and silt sequence underlain by diamicton

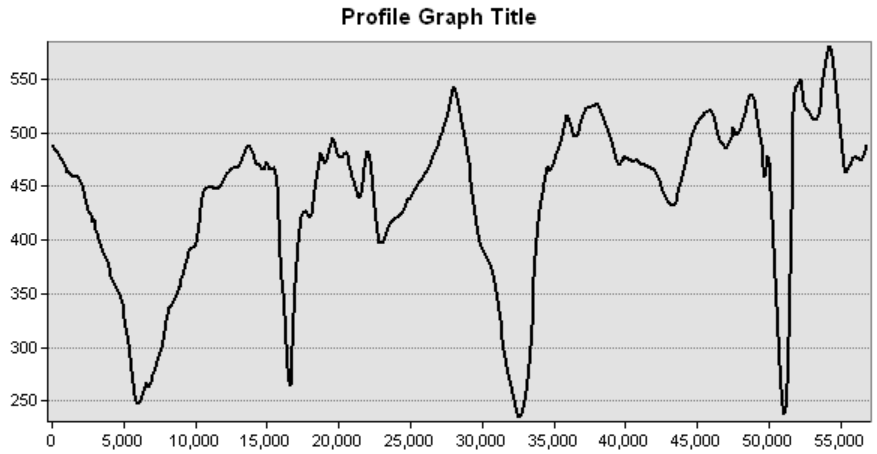
Highly weathered, leached zone: possible Sangamon Geosol

AMS date on plant fragments: >47,200 yrs

HVSR predicted 460 feet, TD 456

Regional Bedrock Topography SW MICHIGAN

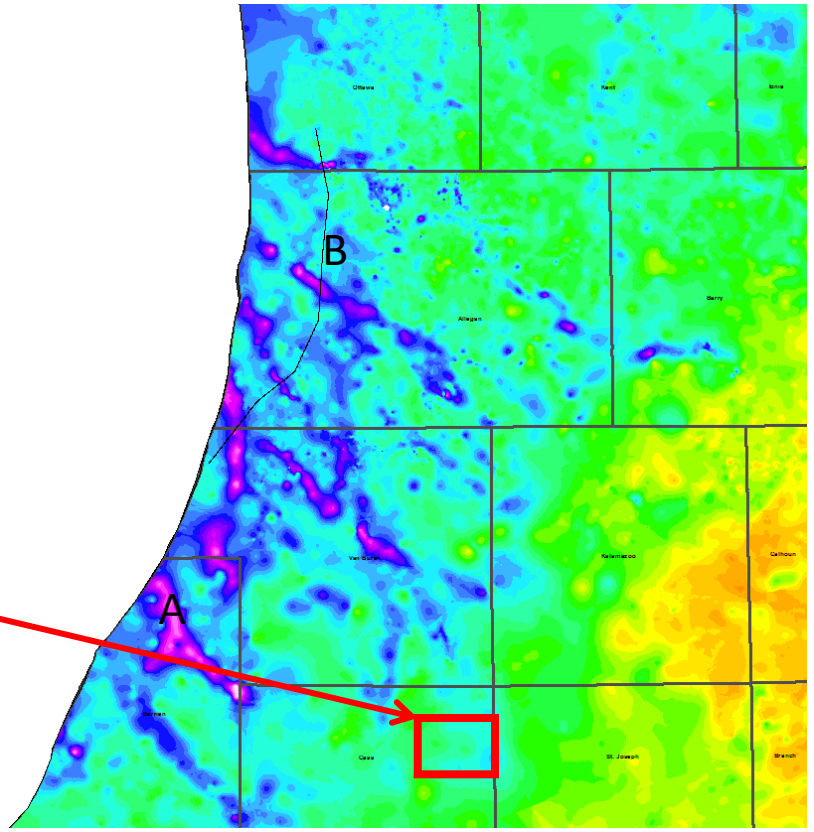
A B



Some of these bedrock valleys in SW Michigan are 300 feet deep

X=feet; y=feet

No historic evidence of Bedrock valleys in mapping area

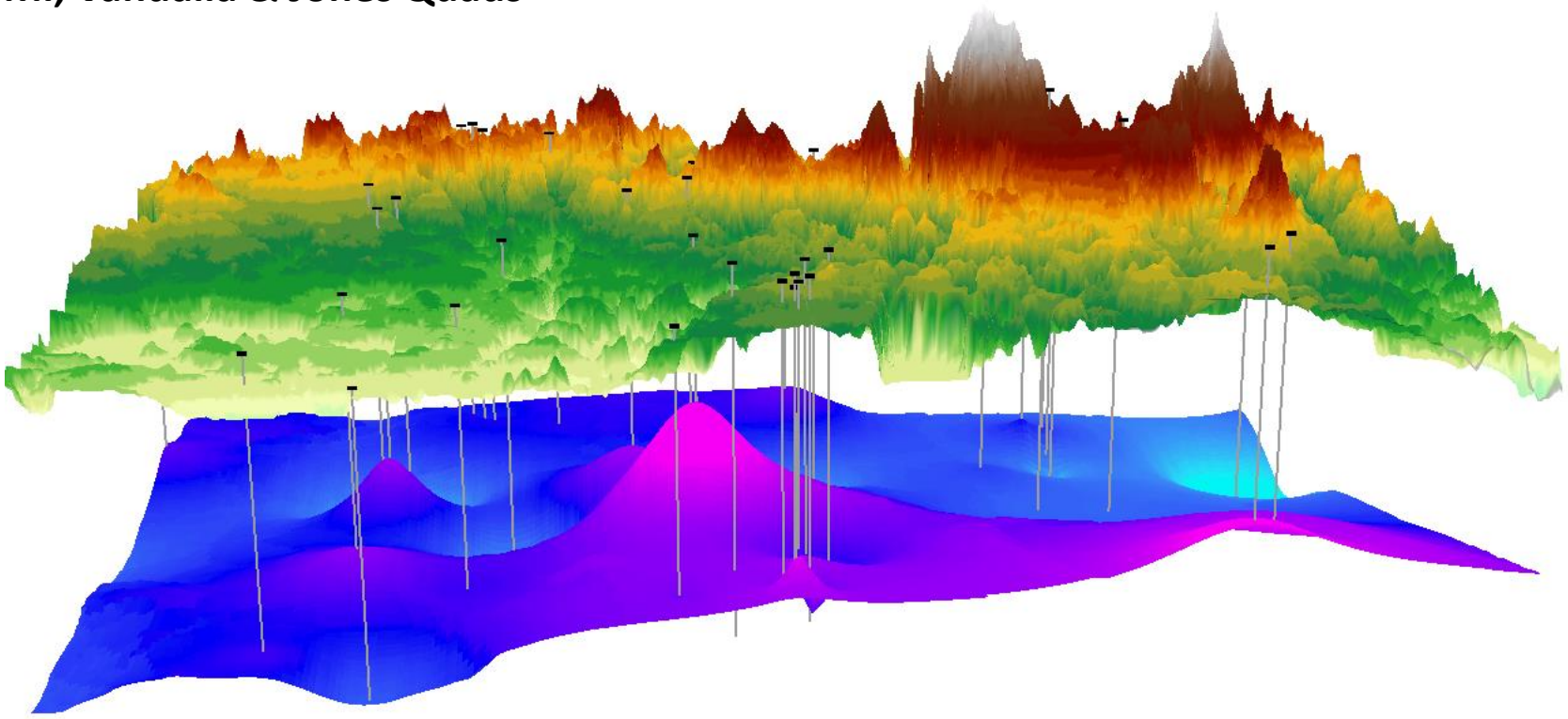


Horizontal Vertical Spectral Ratio (HVSR)
Cass County Michigan/quads – Proven example of HVSR

- Unknown unconsolidated drift thickness in contact with bedrock topography.
- Hints of deep bedrock valleys from surrounding counties.
- Starting a new mapping project, high volume aquifer withdrawals.
- Very little control little with 42 bedrock data points over 2 quads (~100 sq mi).
- Complex interlobate/glacial area in east-central part of county-not much is known.
- **Drift thickness is estimated at 300-450 feet.**
  - **With minimal water wells, must use other control to tag bedrock.**
  - **Expensive and time consuming to tag bedrock with drilling.**
  - **Expensive and time consuming to run geophysical surveys.**
- How do you target drilling to intercept greatest stratigraphic section?
- **Highest Return on Investment (ROI).**

Only 42 Bedrock Control Points Over 2 Quads

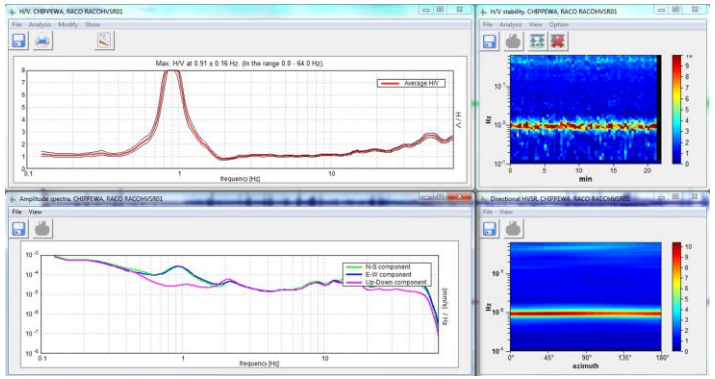
DEM - Cass County Mi, Vandalia & Jones Quads

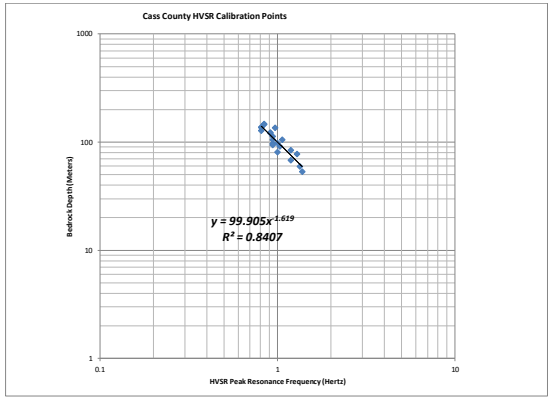


Generalized bedrock projection using ~42 data points.

HVSR - Passive Seismic Method

for bedrock depth estimation

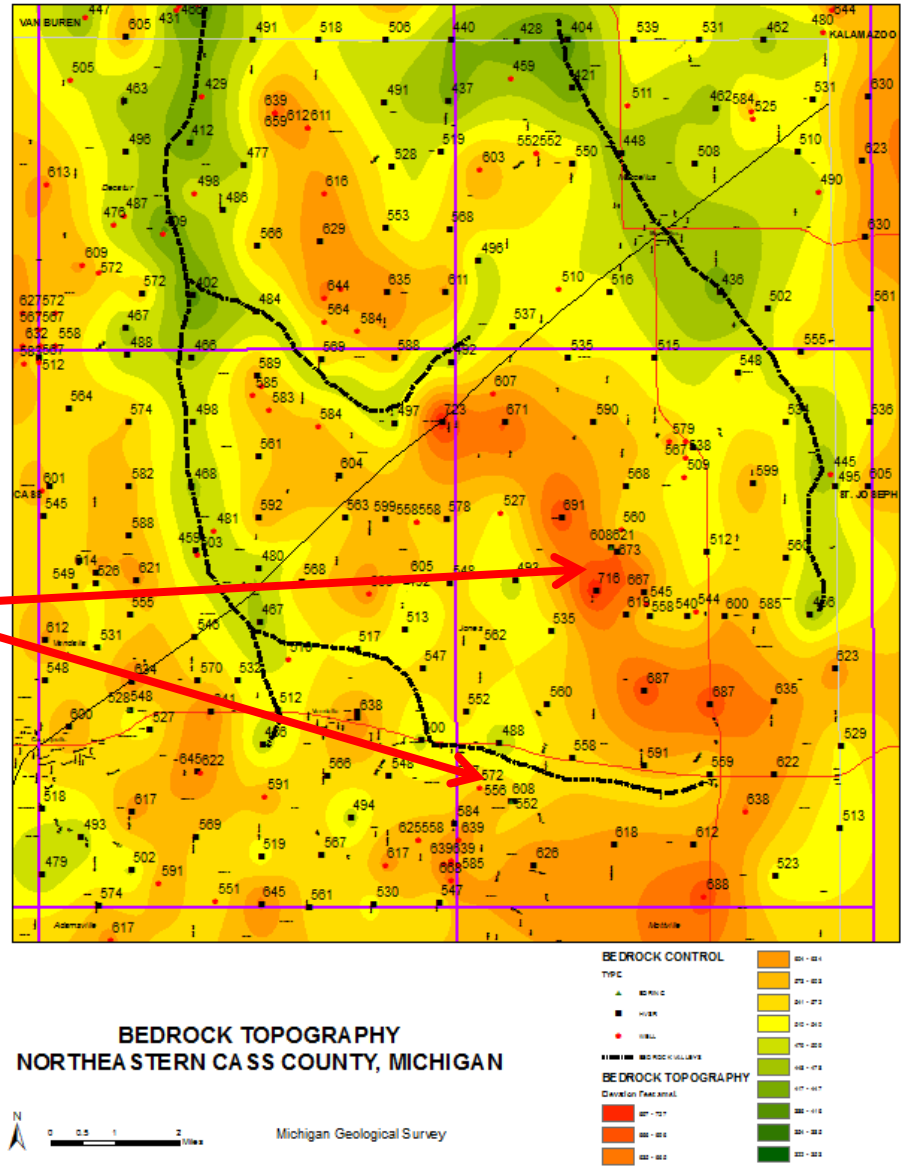


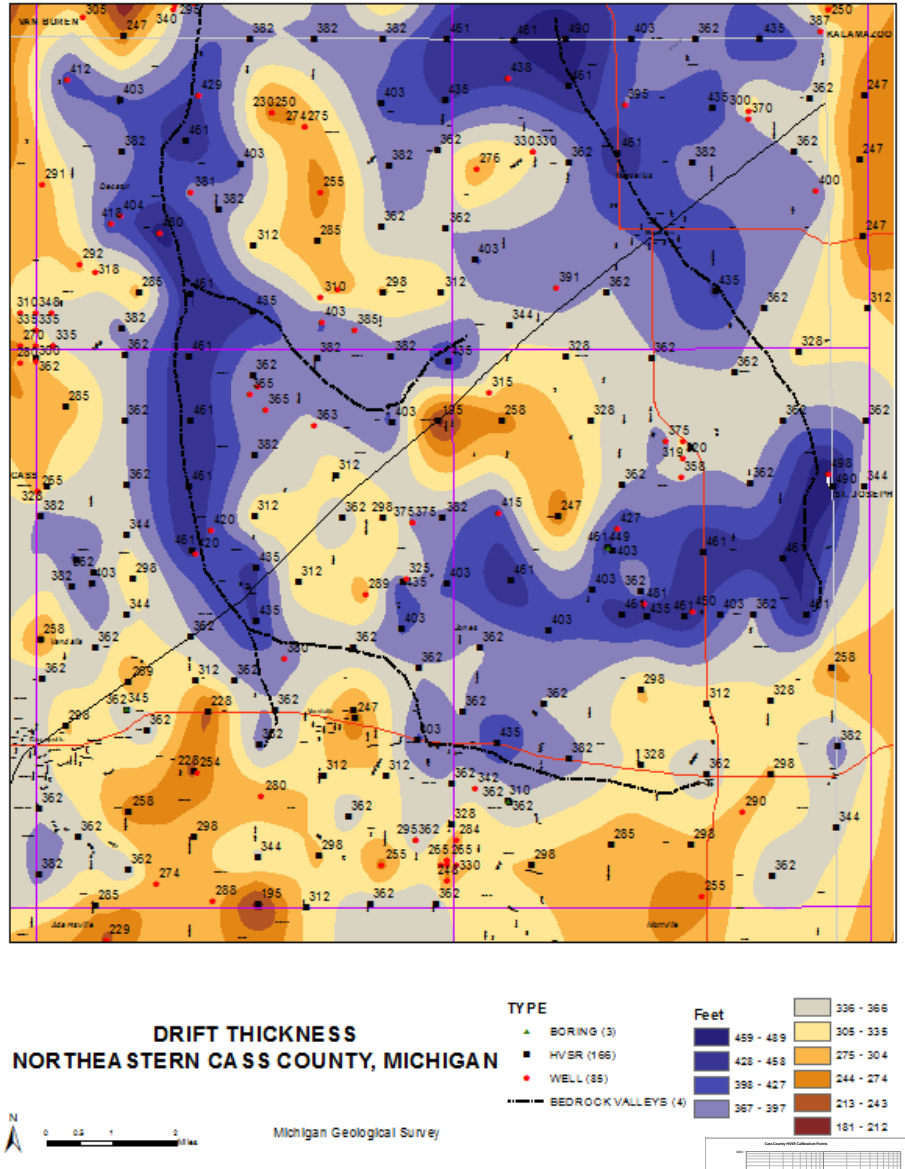


- Small
- Simple
- AA batteries
- Inexpensive
- 3 Component
  Geophone NS, WE, V

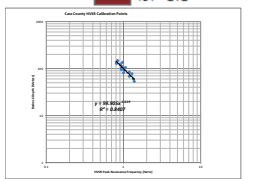
186 HVSR exploration readings (Vandalia, Jones, ½ Decatur, ½ Marcellus)

MGS Drill hole confirmation of thickness

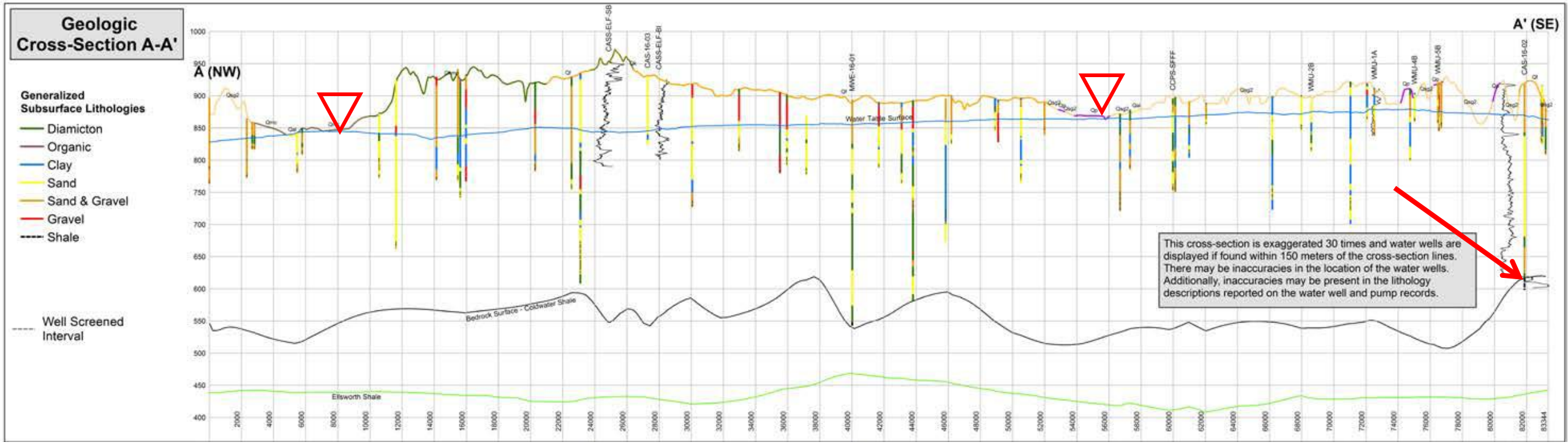




21 Calibration readings



Vandalia Cross Section
Interpretation with HVSR data to top of bedrock, Coldwater Shale



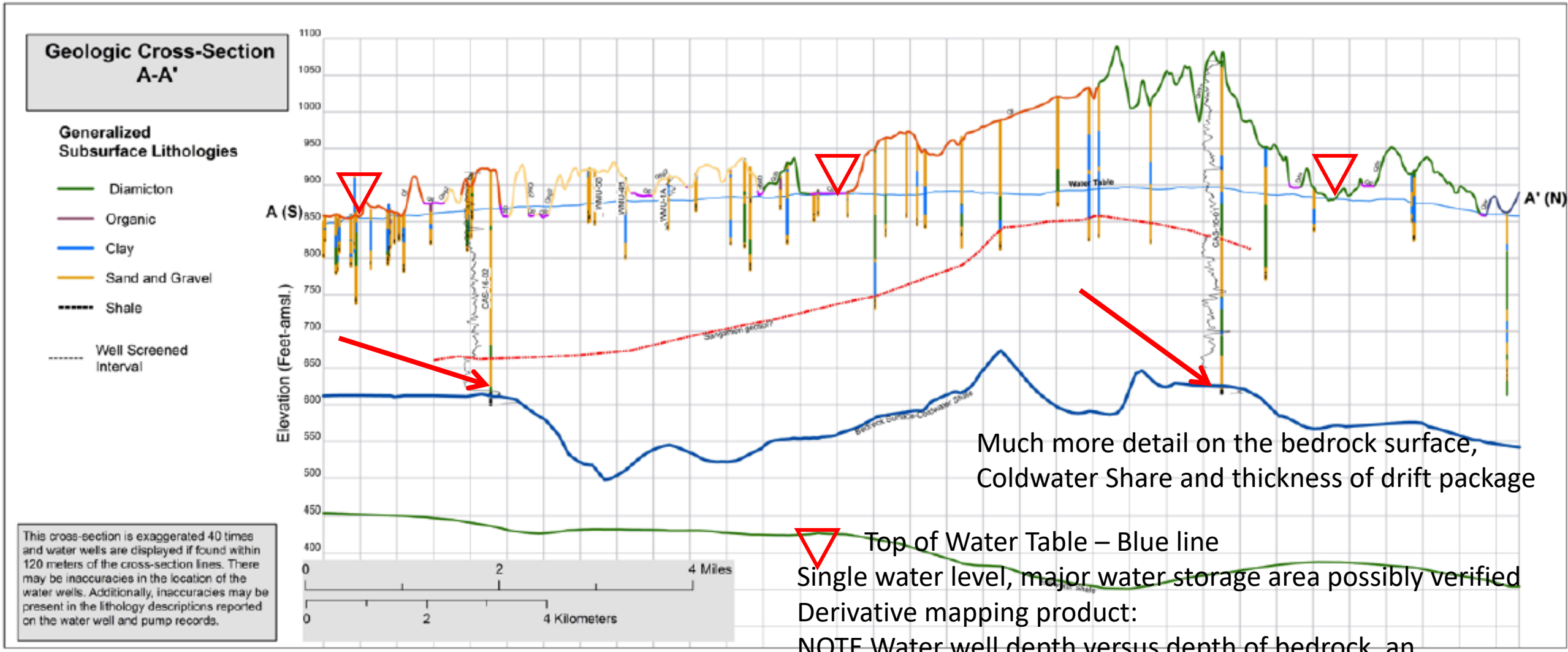
▽ Top of Water Table – Blue line

Single water level, major water storage area possibly verified

Derivative mapping product:

NOTE Water well depth versus depth of bedrock, an additional 100 to 250 feet.

Jones Cross Section



Much more detail on the bedrock surface,
Coldwater Share and thickness of drift package

▽ Top of Water Table – Blue line

Single water level, major water storage area possibly verified

Derivative mapping product:

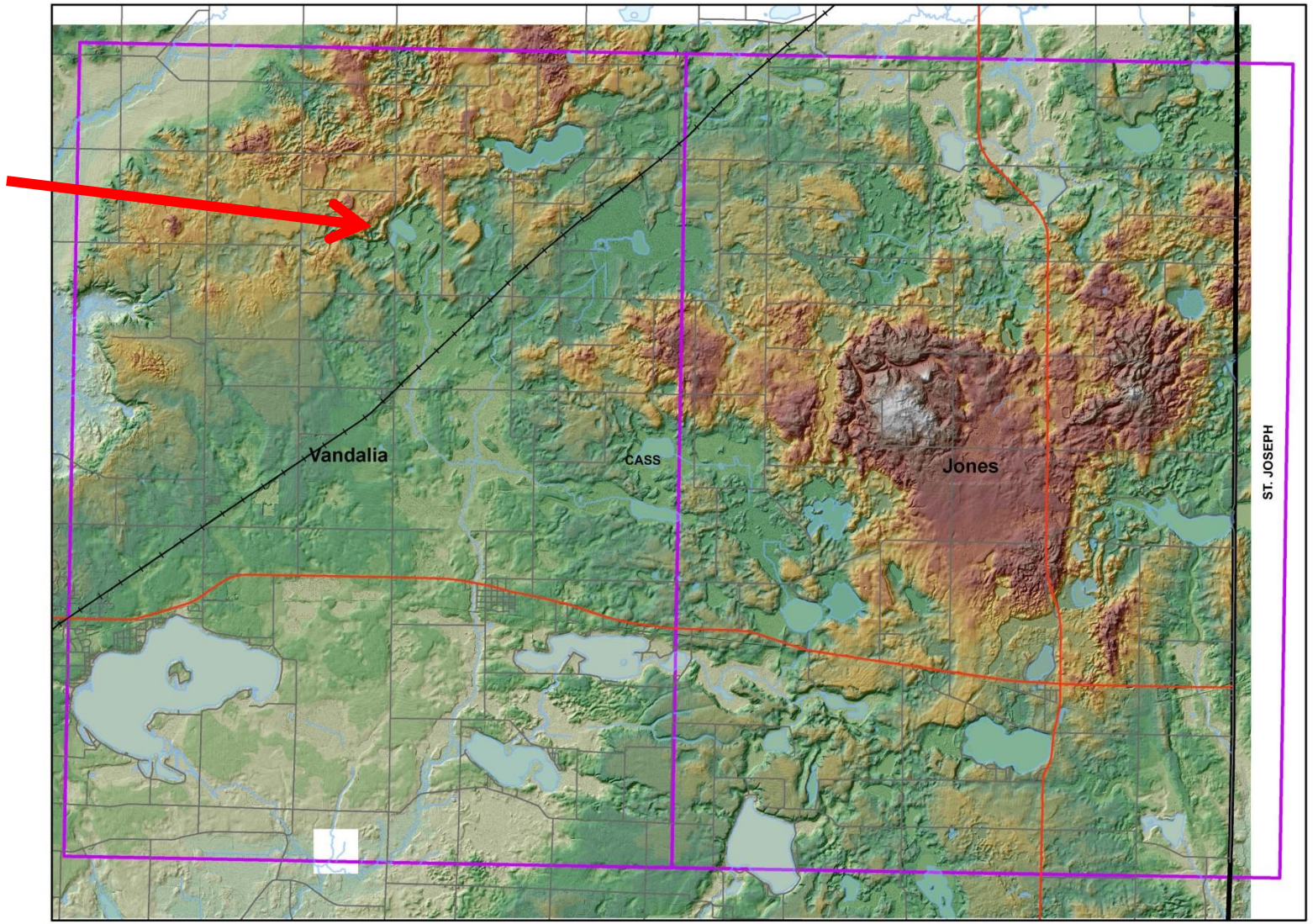
NOTE Water well depth versus depth of bedrock, an additional 100 to 250 feet.

LiDAR has high utility in mapping today

LiDAR expedites the assessment of surficial features. Do I go look?

Or does this confirm extensions to known features when topo and photos have minimal indication.

Focus field efforts! **Higher Return on Investment (ROI)**

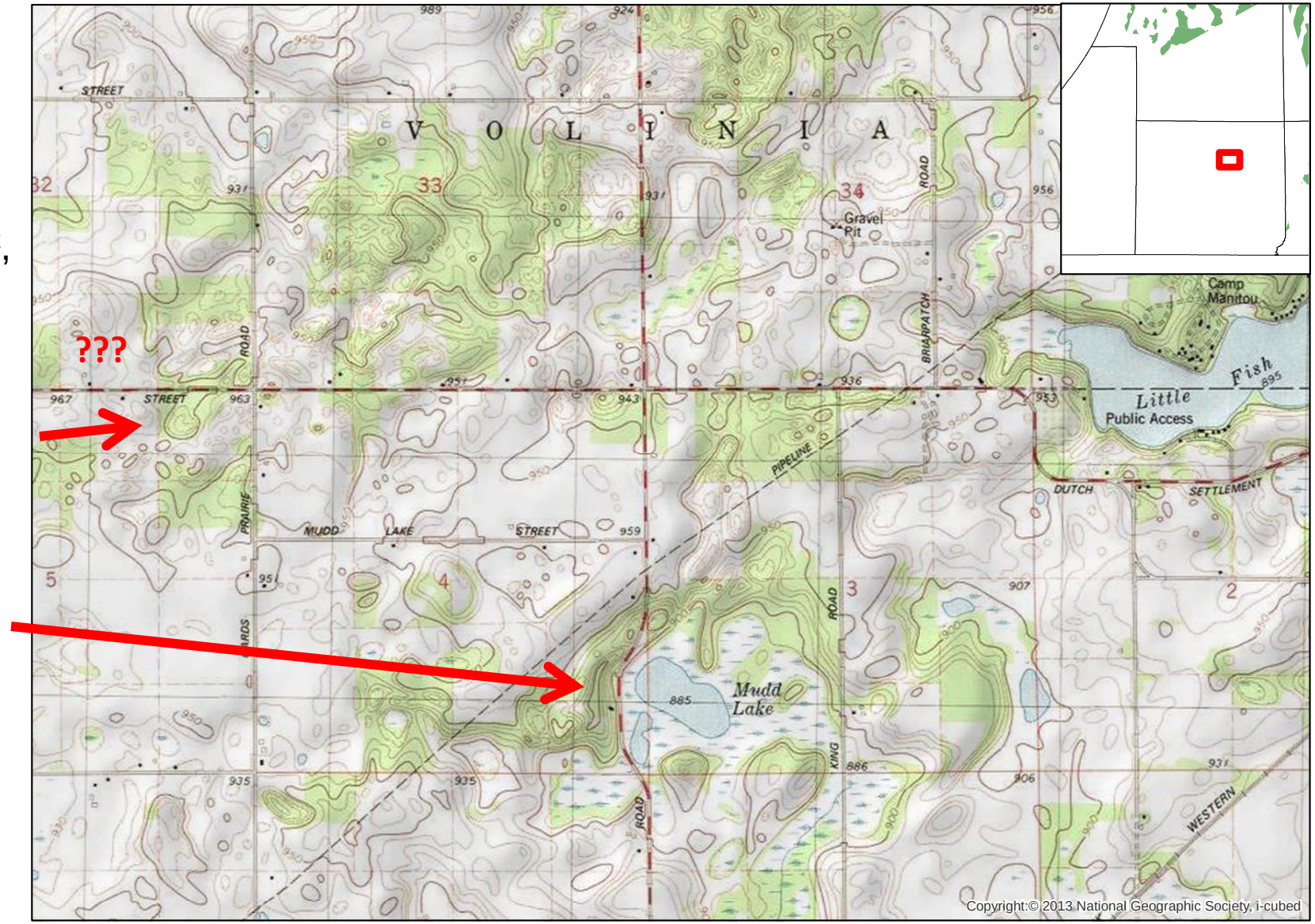


VANDALIA & JONES QUADS CASS COUNTY - LIDAR

Complex scenarios:
New Mapping Area, Cass County-Literature & Common Knowledge.
Lake Michigan Lobe Outer Kalamazoo Moraine in this part of the Vandalia quad

Elsewhere in SW Michigan, the Saginaw Lobe arrived 1st, stagnated and then was overridden by the Lake Michigan Lobe from the west.

Arrow to Esker.



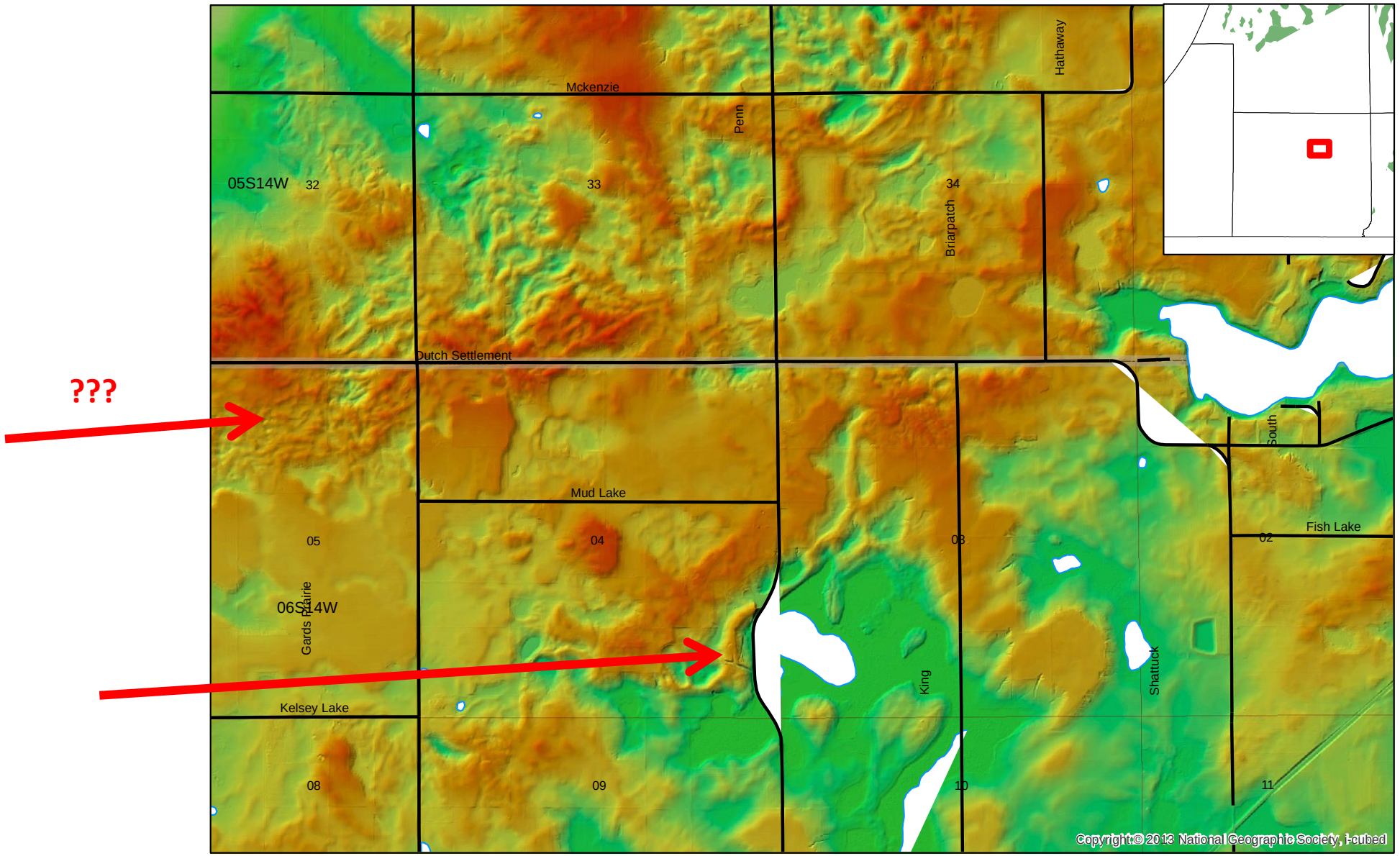
Cass County
4 miles northwest of Vandalia

0 900 1,800 3,600 Feet

Vandalia 7.5 Minute Topo Quad

This is a USGS 7.5 minute ~ 10' accuracy

LiDAR Shows: Saginaw Lobe Oriented Esker Up On Top of Lake Michigan Lobe Moraine!
At least locally this is a very different picture than most of SW Michigan, a reversal?



Cass County
4 miles northwest of Vandalia

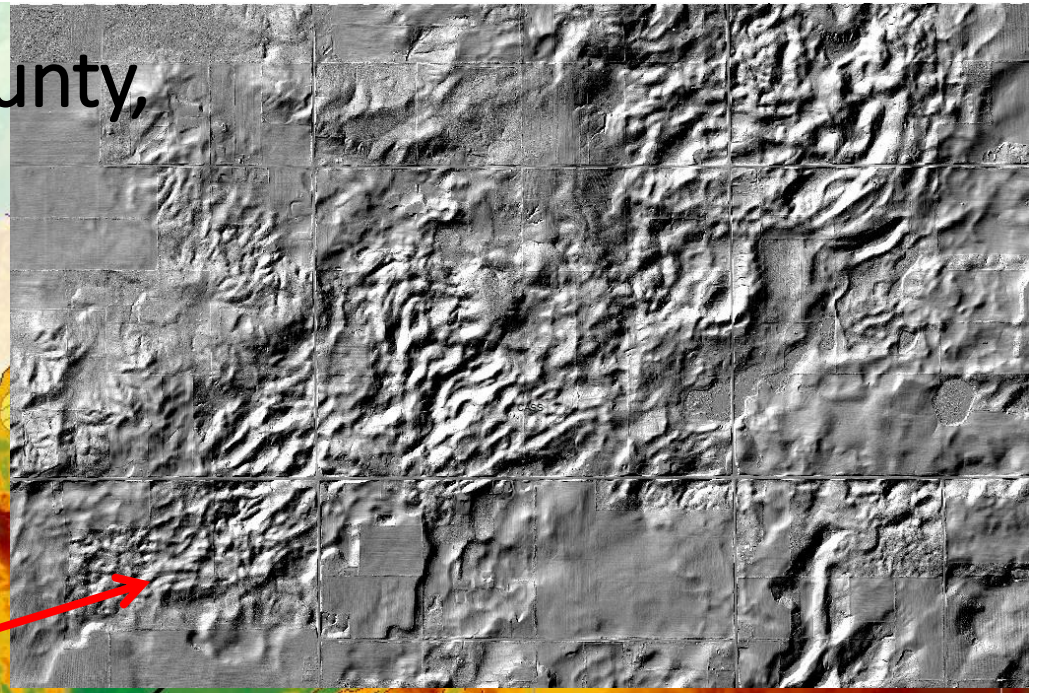
0 900 1,800 3,600 Feet

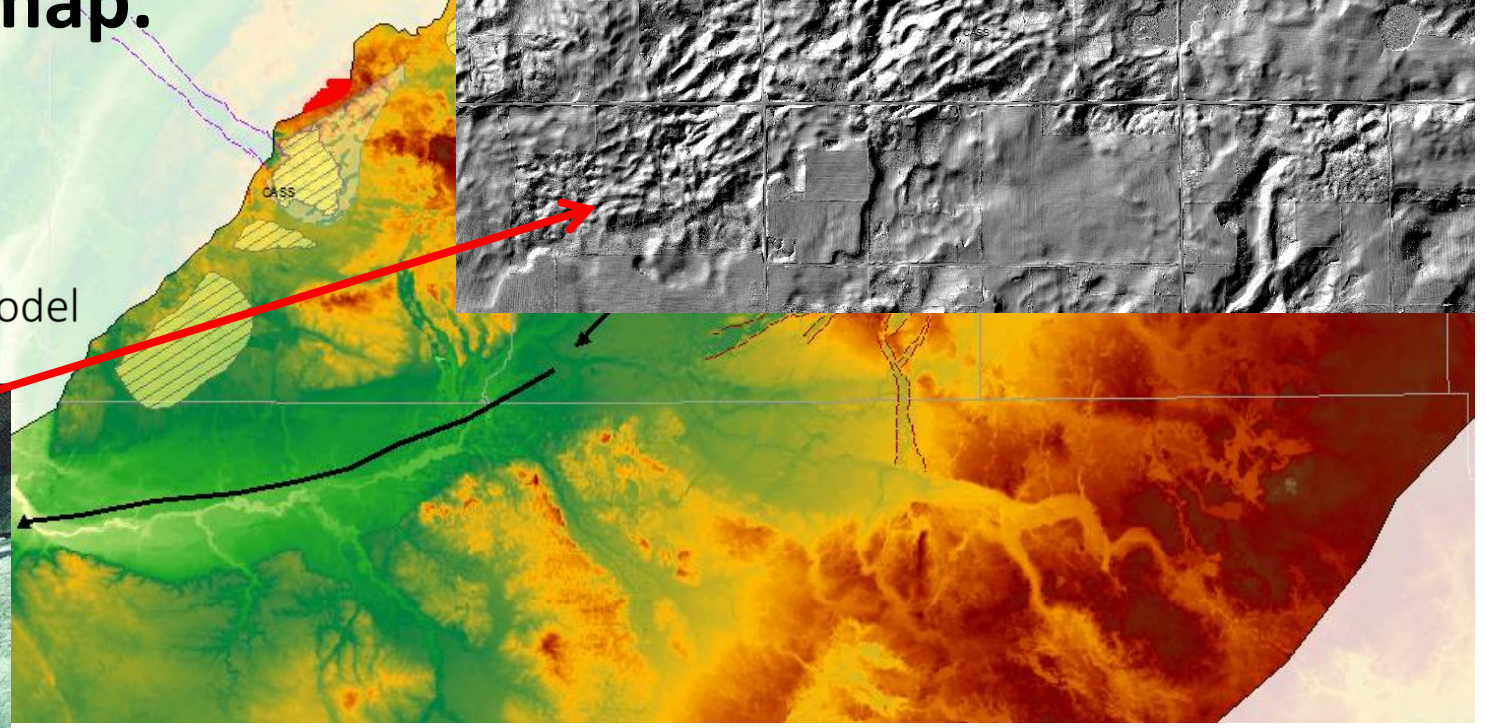
Vandalia 7.5 Minute Topo Quad

Thrusting - Lake Michigan Lobe Re-advance – Kalamazoo Outer “2B” Ice Margin

(a) Active example versus Cass County, Nothing indicated on the topo.

These features are not seen on the topographic map.



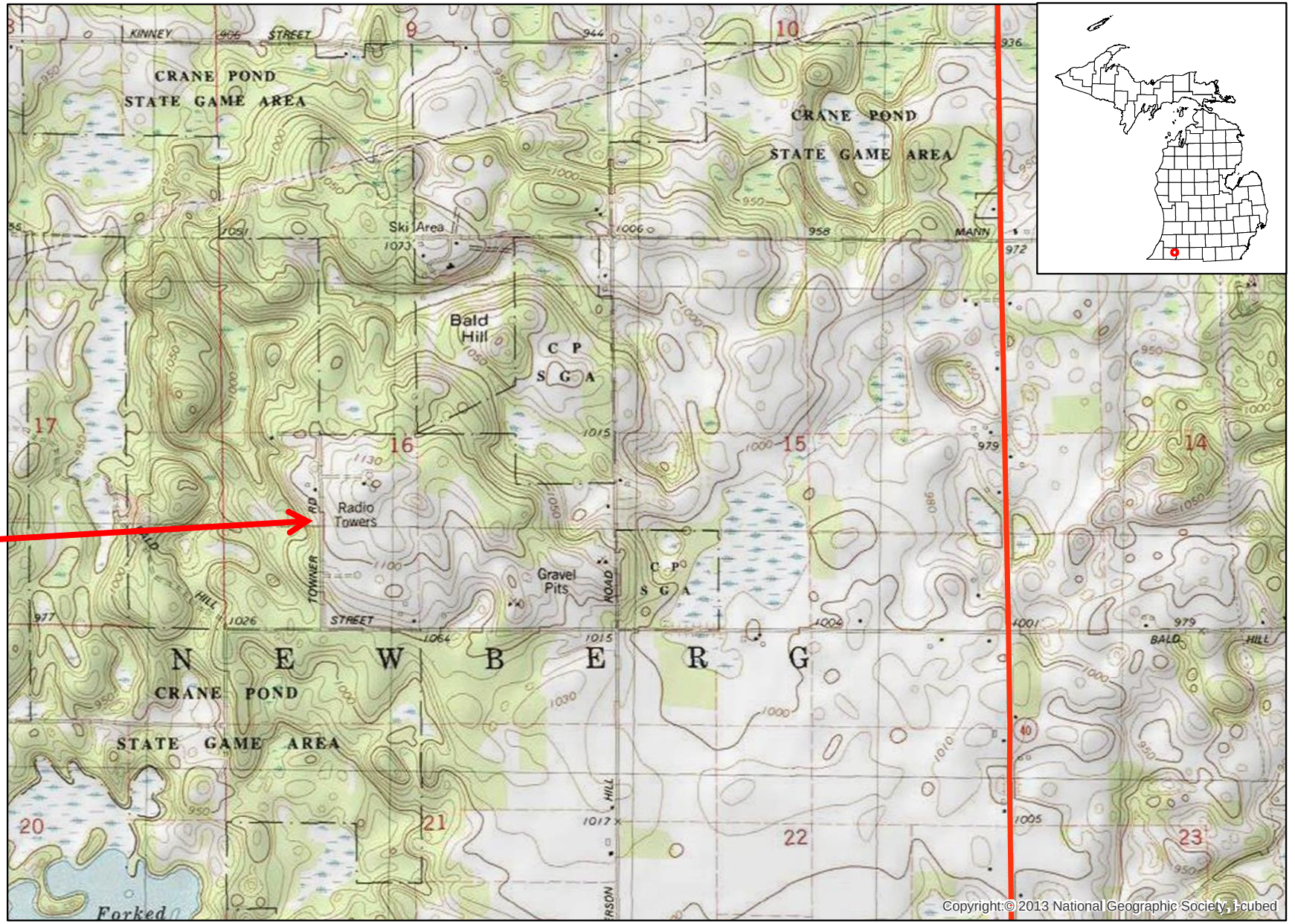


Proglacial thrust-gravity spreading model

From Benn & Evans, 2010

Highest Point in SW Lower Peninsula

1150 feet amsl. at radio towers

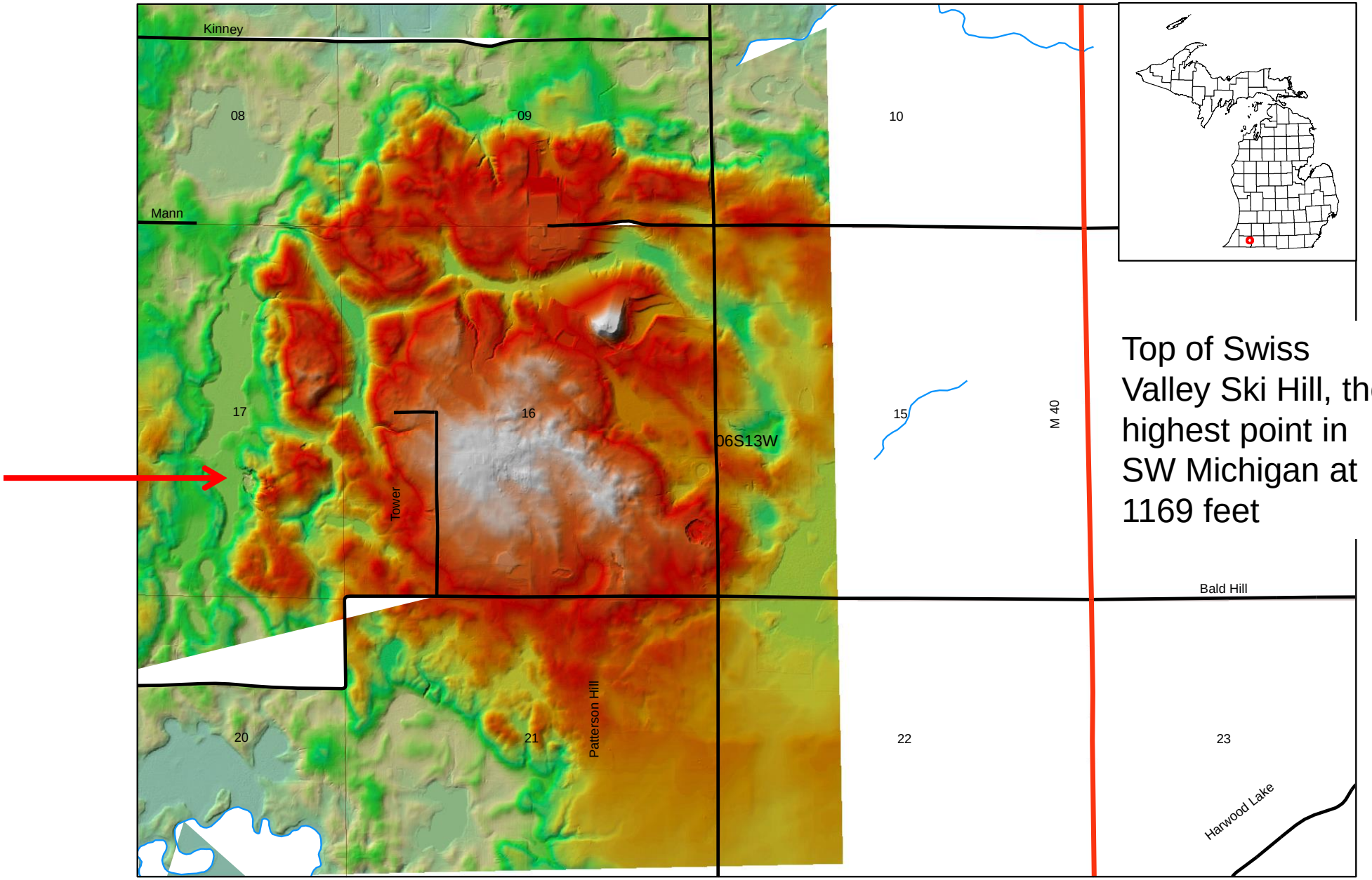


Cass County, Crane Pond State Game Area.
T06S13W

0 1,000 2,000 4,000 Feet

Jones 7.5 Minute Topo Quad

LiDAR - Highest Point in SW Lower Peninsula Cass Co.



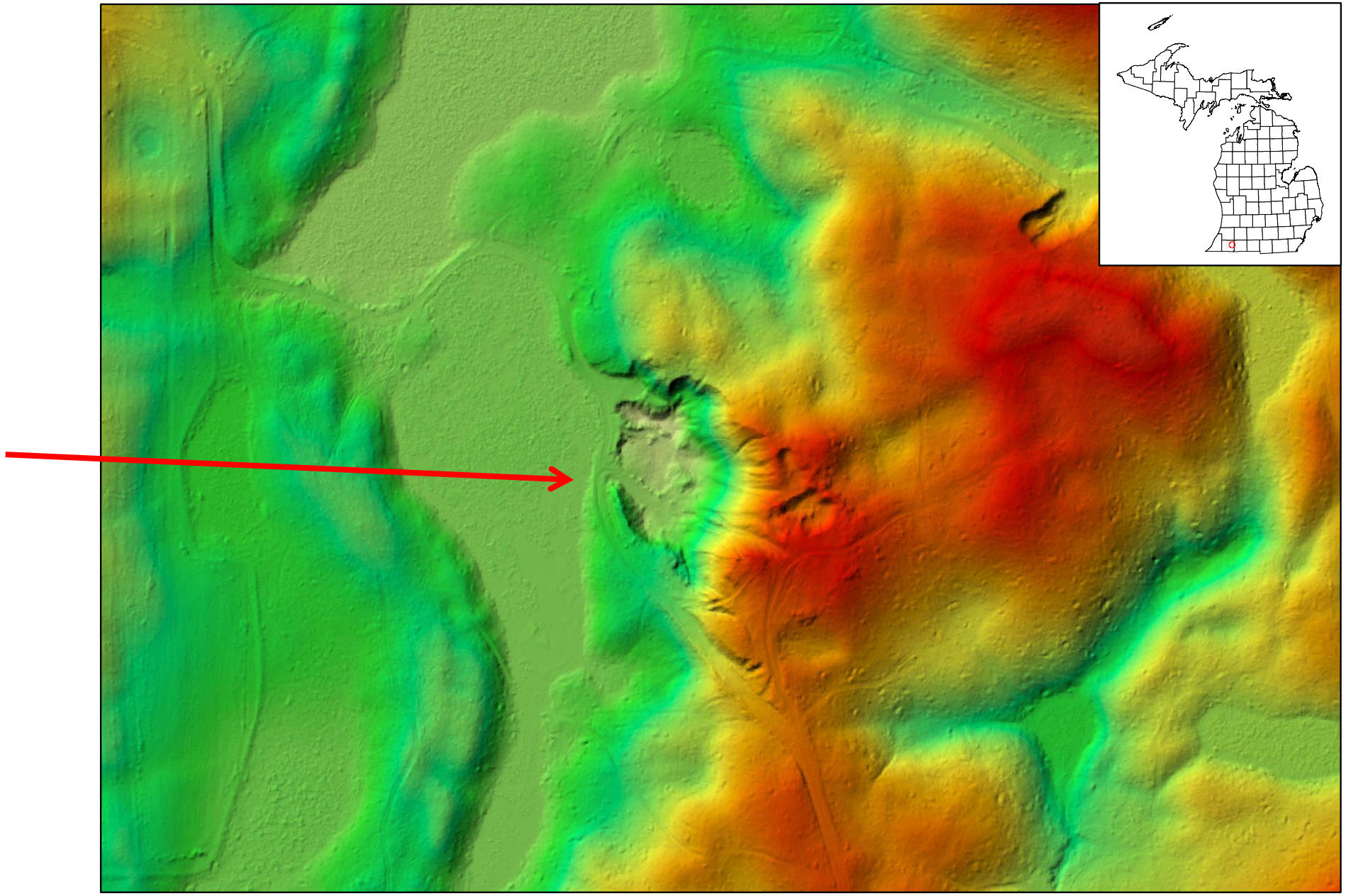
Top of Swiss Valley Ski Hill, the highest point in SW Michigan at 1169 feet

Cass County, Crane Pond State Game Area.
T06S13W

0 1,000 2,000 4,000 Feet

Jones 7.5 Minute Topo Quad

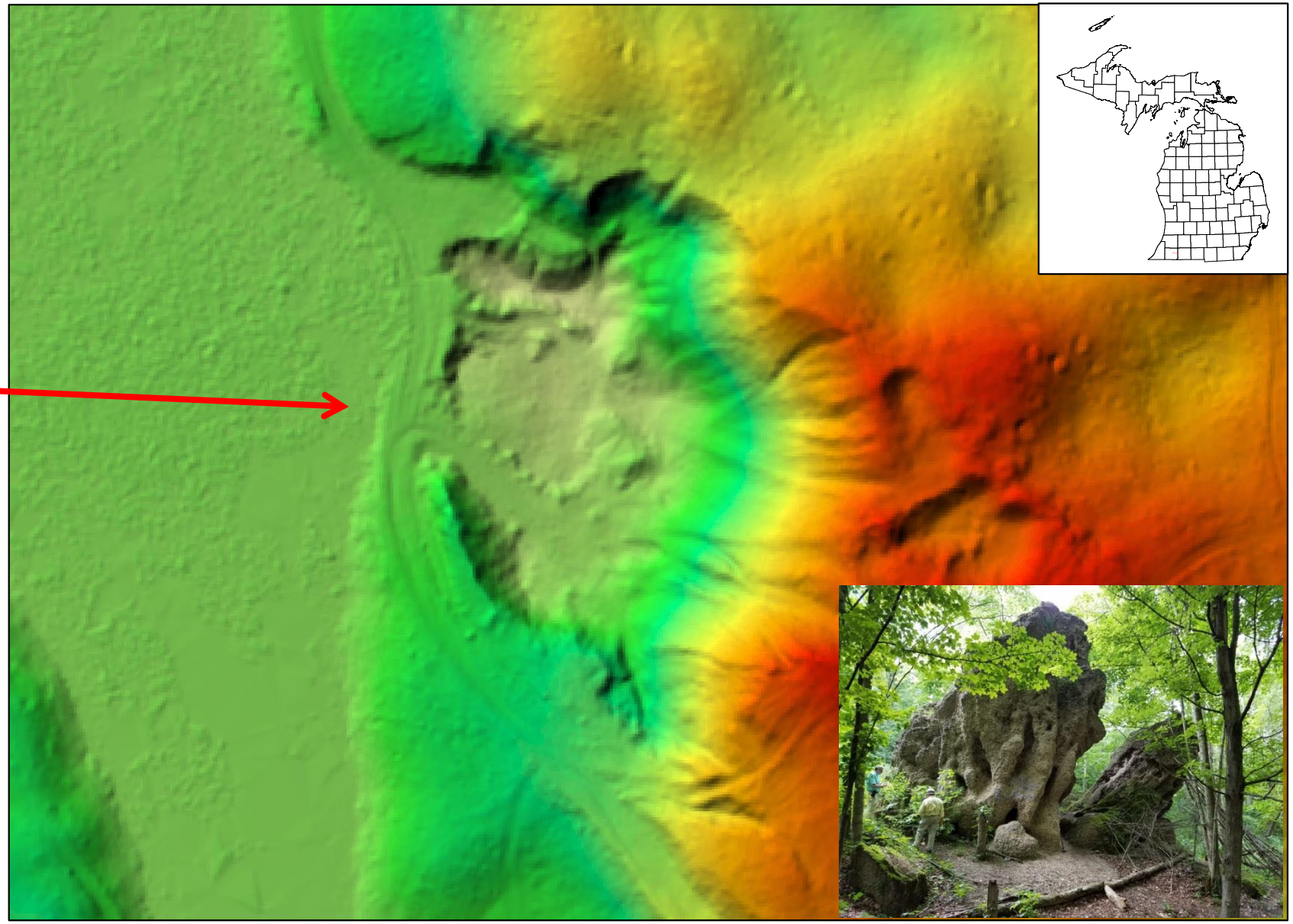
Zoom into the gravel pit



Cass County, Crane Pond State Game Area.
T06S13W

Jones 7.5 Minute Topo Quad

Zoom in a little further



Cass County, Crane Pond State Game Area.
T06S13W

0 55 110 220 Feet

Jones 7.5 Minute Topo Quad

Summary of Michigan GLGMC – NCGMP mapping products Cass County Michigan/quads

Michigan mapping data is based on: Leverett and Taylor 1915, Helen Martin 1955 and Ferrand and Bell **1982-GEOLOGICAL DEAD ZONE**

- Standard methods for data compilation, desktop, field check.
- **Develop data in ArcGIS and present interpretations and final 3D products –GLGMC Collaborative.**

1. Glacial history developed and locally defined.
2. **Hydrostratigraphic assessment in little known complex geologic setting.**
    1. **Stratigraphy and water levels indicate this is a single hydrogeologic zone.**
3. HVSR data compilation, 186 field readings, 21 calibration points.
    a. Drift thickness greater than expected,
    b. Target drill holes in areas having greatest glacial thickness for stratigraphic interpretation.
4. **LiDAR identifies features, field check to confirm not shown on topographic base maps.**
    a. **Complex interlobate area in east-central part of county-not much is known until LiDAR.**
5. **Drift thickness is 100-250 feet greater than published reports and water well data.**
    a. **Depths at 300-450 feet, as noted by HVSR Tromino bedrock contours.**
6. New presentation of glacial lobes and features, Michigan, Saginaw and Sturgis (Michigan, Illinois, Indiana).
    a. Possible Illinoian paleosol, Sangamon Geosol >100,000 yrs defined in drilling/coring data.
7. Identifies and confirms aggregate resource areas.
8. **Geologic mapping documents, water & aggregates resources and detailed stratigraphy, combined highest Returns On Investment (ROI).** http://wmich.edu/geologysurvey

All 3 Lobes to LGM South of Michigan

Multiple picture animation of current interpreted glacial history for Cass County, SW Michigan.

Late Glacial Maximum (LGM), Wisconsin age