



MICHIGAN GEOLOGICAL SURVEY



Michigan Water!
What is needed and known after years
of nothing in Ottawa County, an
example for Michigan?

Groundwater Sustainability

Michigan Chapter
Soil and Water Conservation Society

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Michigan Statehood, **January 26, 1837**

Geological Survey, First Department **January 26, 1837**

Travel Promotions for Michigan

Water is Michigan – 1950's to present





What is Michigan Geology?

What is Michigan's most critical natural resource in the LP and UP for today and future generations?

Water!

Michigan glacial geology in the LP is:

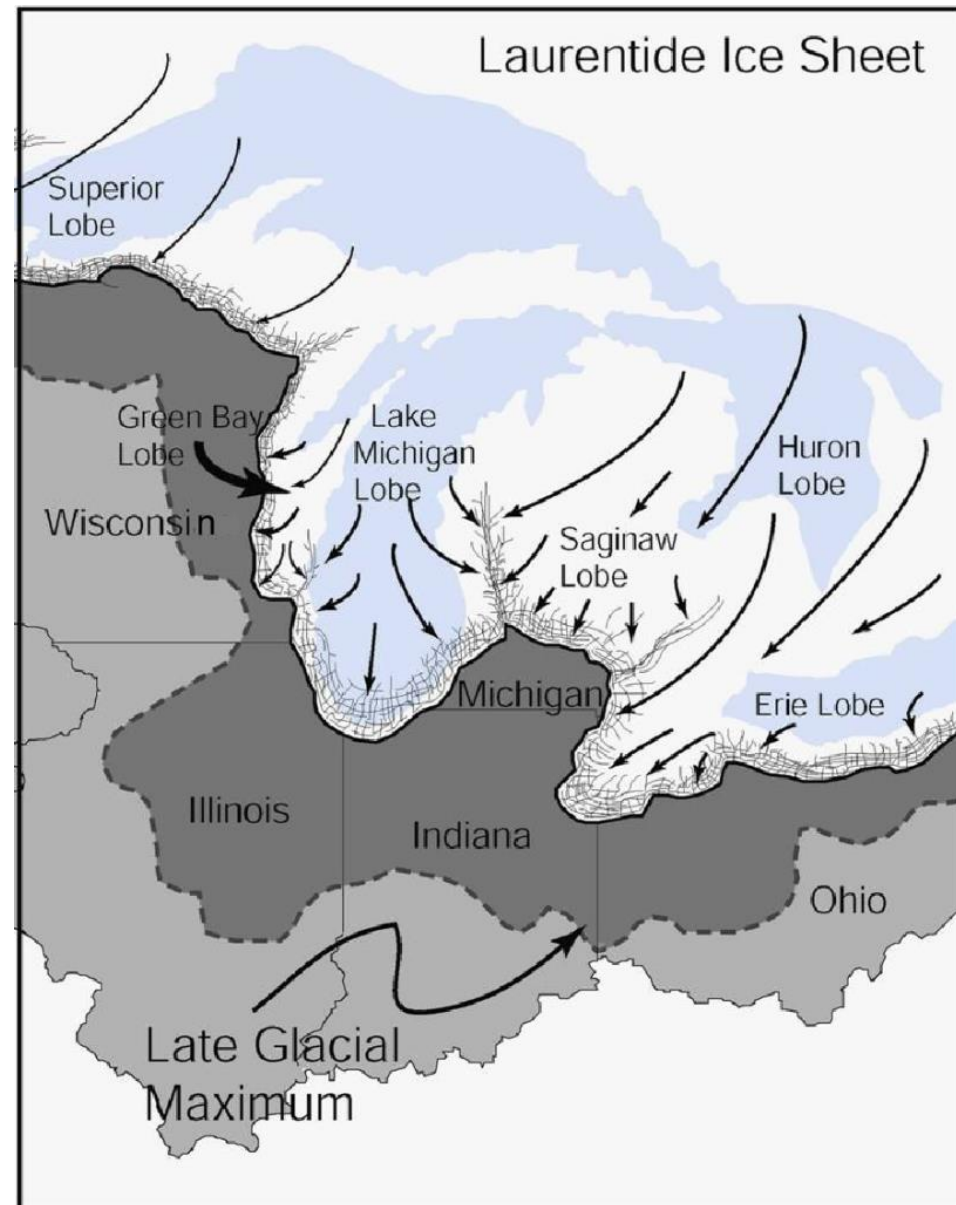
- Not uniform, vertically and laterally and what does it contain?
 - **Surface and subsurface geology contains these natural resources**
 - Groundwater
 - Surface water
 - Aggregates
 - Agricultural soils
 - Wetlands

What do we know about the geologic & water resource?

Almost NOTHING!

Michigan glacial geology is perhaps the most complicated discontinuous lithologic units that have been recorded.

- There are multiple stages of ice advances and retreats having crossed Michigan (200,000 to ~10,000 years ago).
- Glacial movement has resulted in the deposition of various glacial deposits and features and they include aggregates and water bearing sand zones, and
- Glacial moraines, which have the most important term, glacial till, is not in the only database, Wellogig terminology table. Till - no economic aquifers or aggregates documented.



Michigan Geological Survey (MGS)- October 2011



PA- 167 - MGS to Western Michigan University with the Legislative mandate for the Michigan Geological Survey:

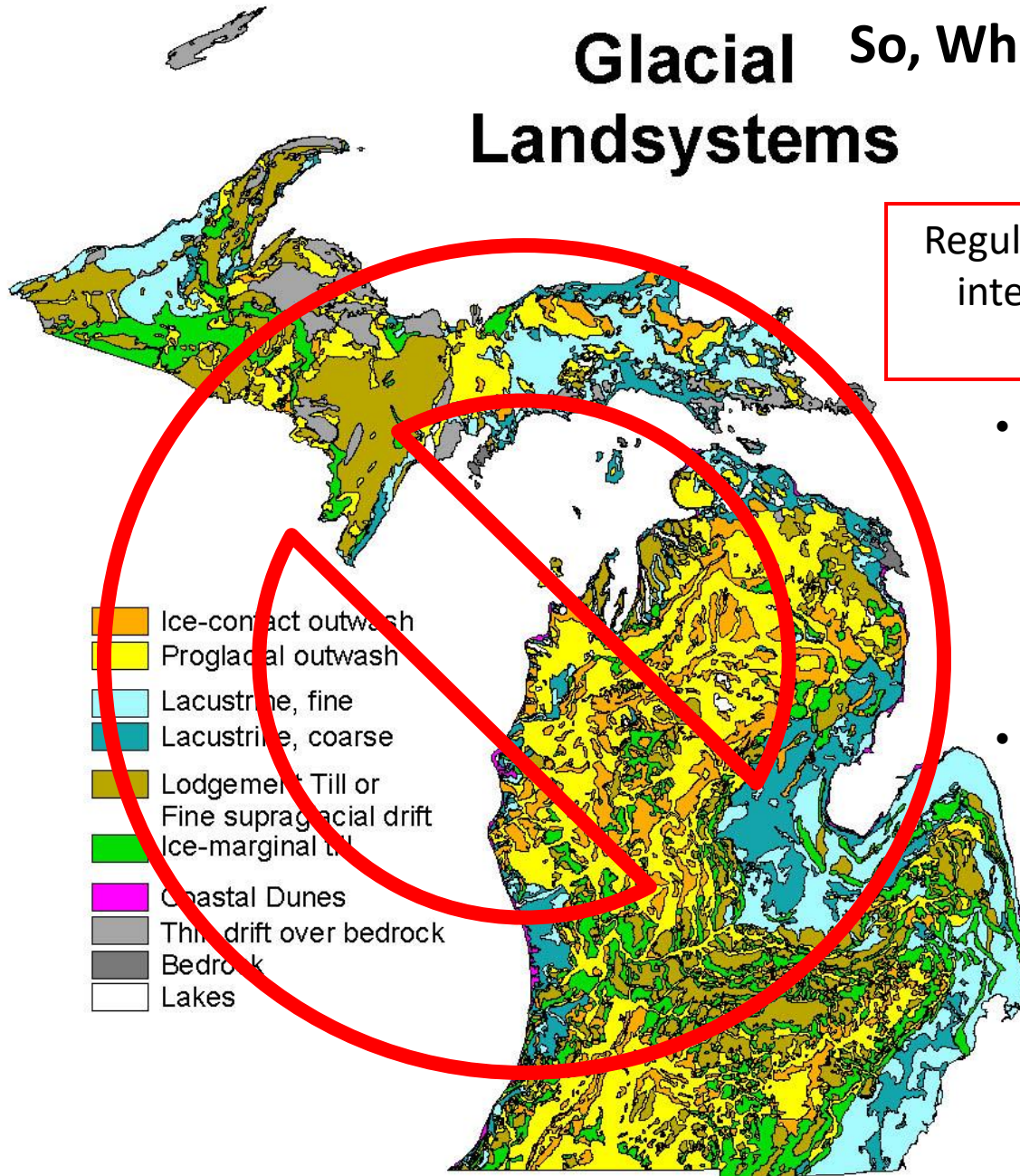
- Provide scientifically validated research and the data necessary for appropriate natural resource protection, discovery, assessment and management.
- Act as an independent, un-biased authority on geological matters underpinning Michigan's natural resource protection and management.
- Provide and preserve geologic records that can support the natural resource decision makers, public and private.
- **NOTE:** Michigan did not provide any funding to MGS in 2011!

MGS is mandated to compile geologic data and was the only Great Lakes state without an annually funded geological survey, UNTIL October 1, 2022!

Glacial Landsystems

So, Where do we begin?

Regulatory, Consulting and Mi WWAT interpretations and decisions are made using this map.



- This 1982 surficial geology map is based on 1915 (Leverett & Taylor) data, with minimal changes in 1955 (Helen Martin), 1982 (Farrand & Bell). This is **ONLY** a surficial geology map.
- No subsurface validation.

The role of the Survey is to provide unbiased updated surface and subsurface geology in priority areas.

Where is the Water?

Western US-South Dakota watershed drainage Map, a comparison

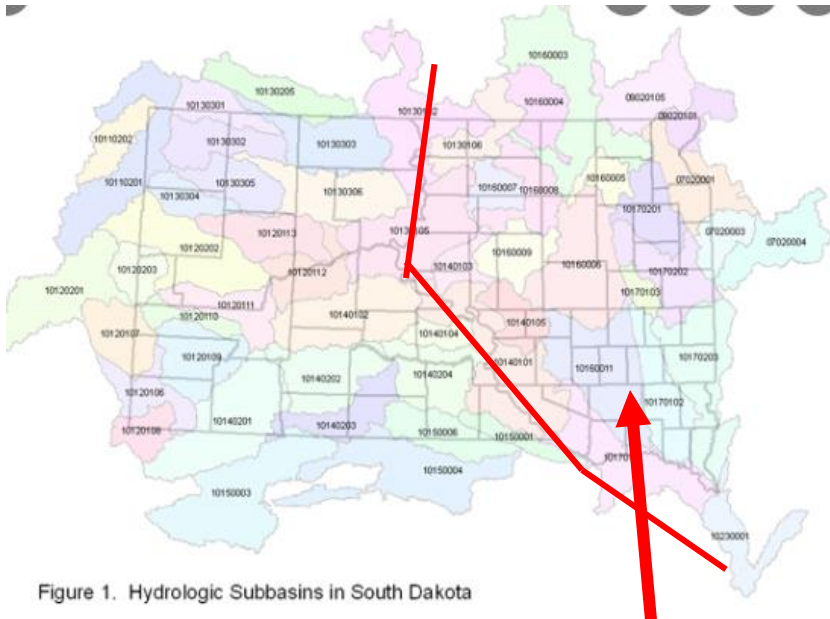
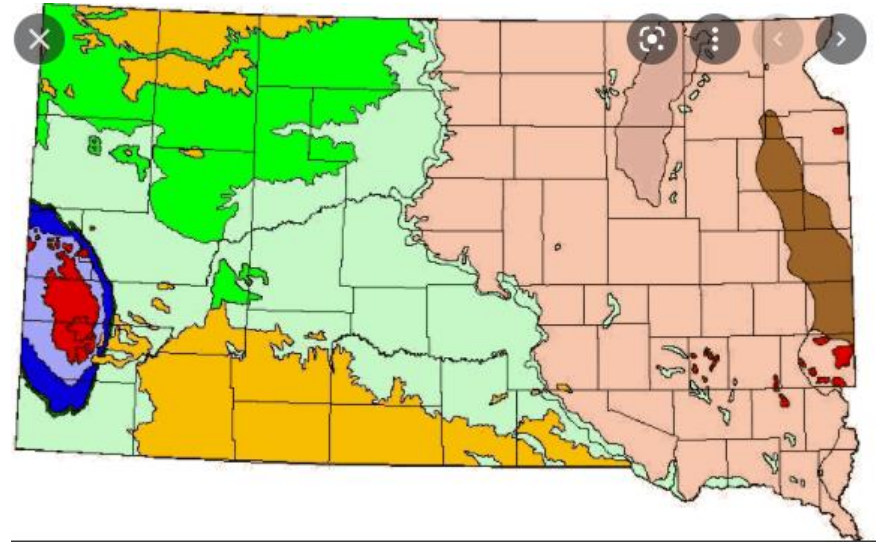


Figure 1. Hydrologic Subbasins in South Dakota

South Dakota the entire state.

~70+ watershed/basins that can contain water

~30 basins may only have 1 – 3 formation aquifers that need to be mapped- you can do large multi-basin modeling.



Entire State has eight to 20 geologic units/formations that can contain water in the entire state of South Dakota

Michigan has been told you can map water resources for the entire state with a single groundwater model.

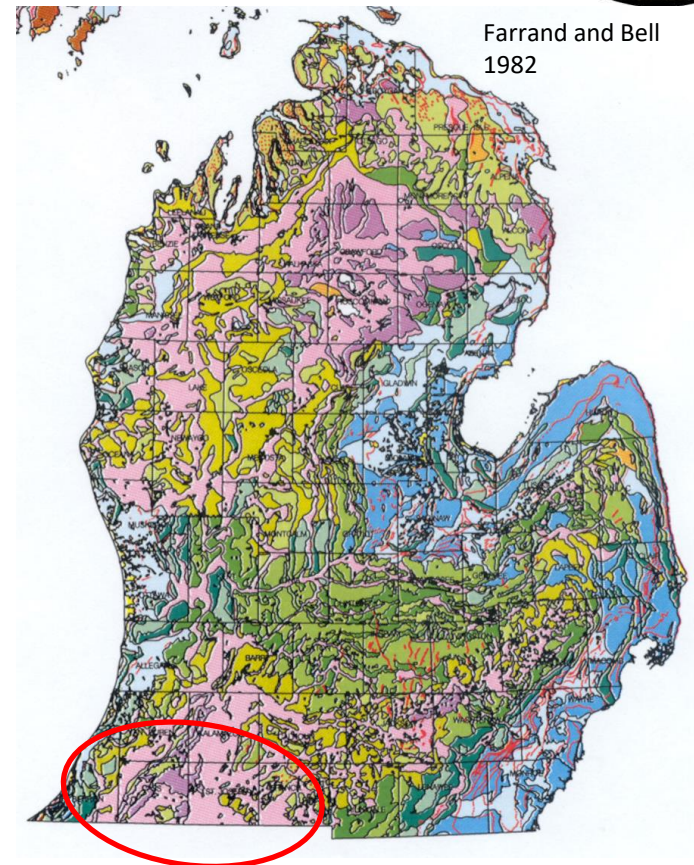
NOT!

Michigan Watersheds, geology NOT the same



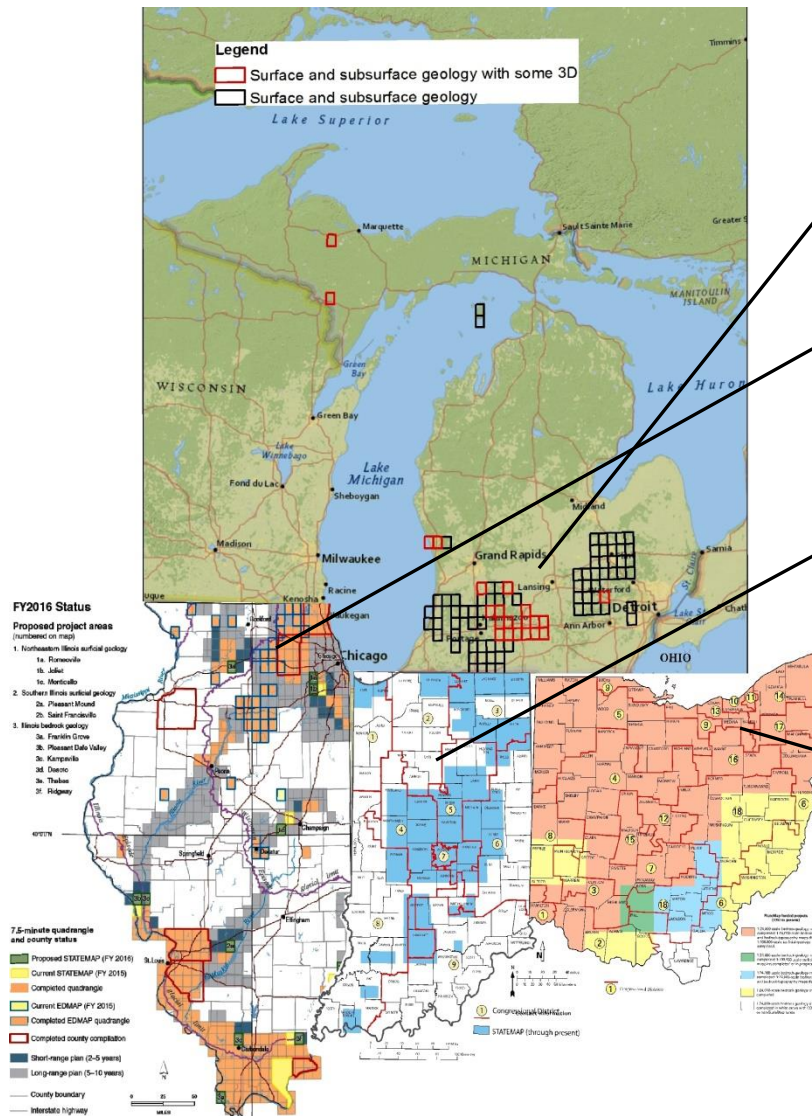
86 major water sheds in Michigan

Groundwater modeling in Michigan needs **validated geology for subsurface data** for each watershed – NOT statewide models.



Michigan glacial geology is NOT continuous.
Hundreds of glacial formations, not the same!
One Water shed can have 5->10 formations and multiple aquifers

Mapping-Michigan versus adjoining states!



Federal matching dollars in the last 29 years

- ✘ **Michigan**, no dedicated funds in 29 years, not until 2014, \$44,000 to support mapping in Cass County, < 10% mapped. (\$1.751 M = **\$72.9 K/yr**).
- ✘ **Illinois**, mapping in high impact and use areas, many priority areas for 3D mapping, ~ 30% mapped. (\$4.987M=**\$207.8 K/yr**).
- ✘ **Indiana**, mapping in high impact areas, some priority 3D mapping, ~ 40% mapped. (\$4.276 M=**\$178.2 K/yr**).
- ✘ **Ohio**, funding from energy and minerals, geo-hazards for mapping in addition to Fed funds ~ 80% mapped (\$3.069 M=**\$127.9 K/yr**).
- ✘ **Wisconsin**, mapping impact areas, \$3.762 M = **\$156.7k/ year**
- ✘ **Minnesota**, State funding (~\$2M/yr) map the entire state, \$2.834 M = **\$118.3k/year**.

All data from MGS mapping programs is OPEN FILES. National Cooperative Geologic Mapping Program



Kicking the geology can down the road!

1970's - Michigan legislature did not maintain survey funding

- 1970's- Legislature determined consultants and staff can provide the geologic data.
 - State could then compile the data, but no compilation dollars?
 - No urgency in doing subsurface or surface mapping.
- So where is the “geology can” now?
 - No funding for the state departments to compile the data.
 - “Use what we have”, “no time, no money” has been the mantra for geologic data.
 - Data costs money to compile and maintain so there were no staff costs attached to data compilation. Everyone must compile it themselves.
- What did Michigan do to stimulate a greater understanding of the natural resources for the economy for the last 30 years?
 - NOTHING!
- Only subsurface database in 2003, is Wellogig, it is not Validated
- Here are some examples of “kicking the geology can down the road”!!!

Michigan stakeholders were not told in 2000-03 they needed validated geologic data!



Michigan Lower Peninsula, ~ 60% of drinking water is from glacial sediments, what is important?

There is no scientific glacial or bedrock database that has validated and corrected data.

- **Many programs use Wellogic (water well) data, the only database, not geologic.**
 - Wellhead Protection,
 - Groundwater level,
 - Depth to bedrock,
 - WWAT, HC well program, etc.
- **Wellogic, 2003, was never location validated.**
 - Not until 2018-MGS.
- **Drillers were never trained to input standard terms.**
 - Not until 2015-MGS initiated training.

Wellogenic Summary, Drift vs Bedrock

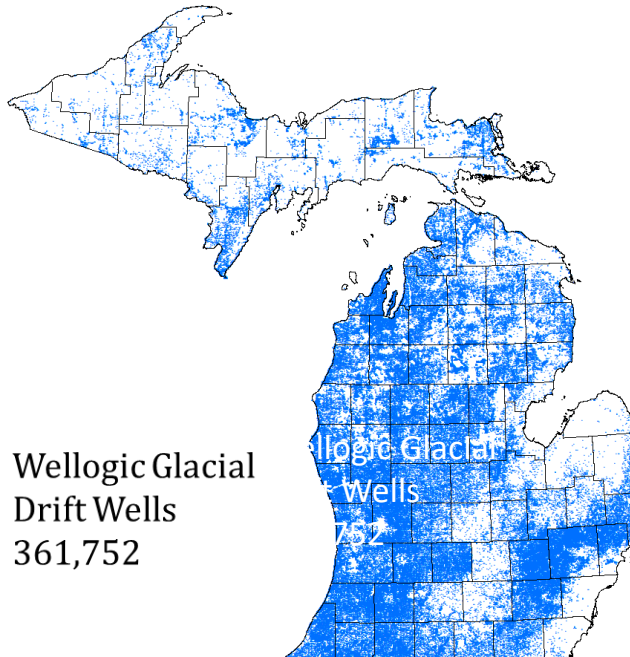


2019-MGS was contracted to validate and correct locations of all Wellogenic wells

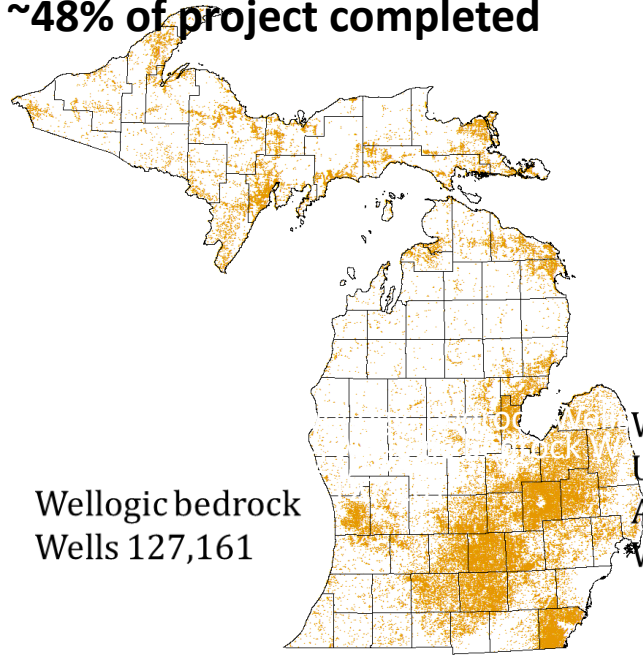
> 40% of Wellogenic wells not on the correct location.

MGS has completed: Validated Wellogenic Locations: 274,613
Input scanned historic wells: 220,940

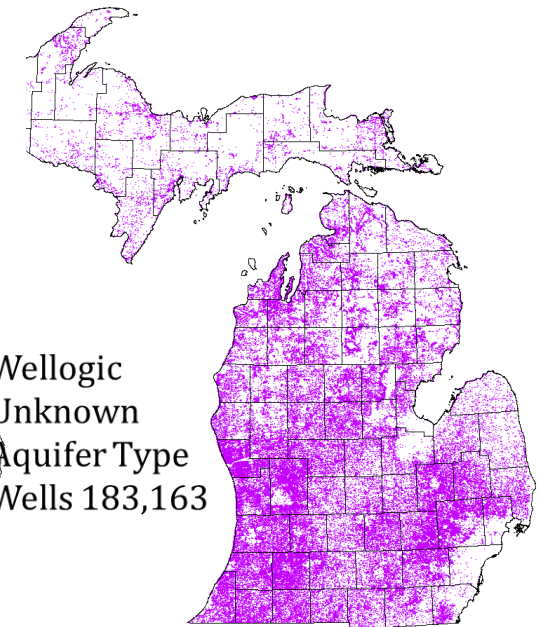
~48% of project completed



Wellogenic well data update,
January 2021



Note Aquifer Type field in Wellogenic
can often be unreliable



MGS inputting 700,000 scanned logs 1950's to 2003 to Wellogenic (~1.3M total # of wells)

MGS, 2015, training well drillers how to log consistently into Wellogenic.

Allegan and Ottawa county Wellogenic locations validated in 2020

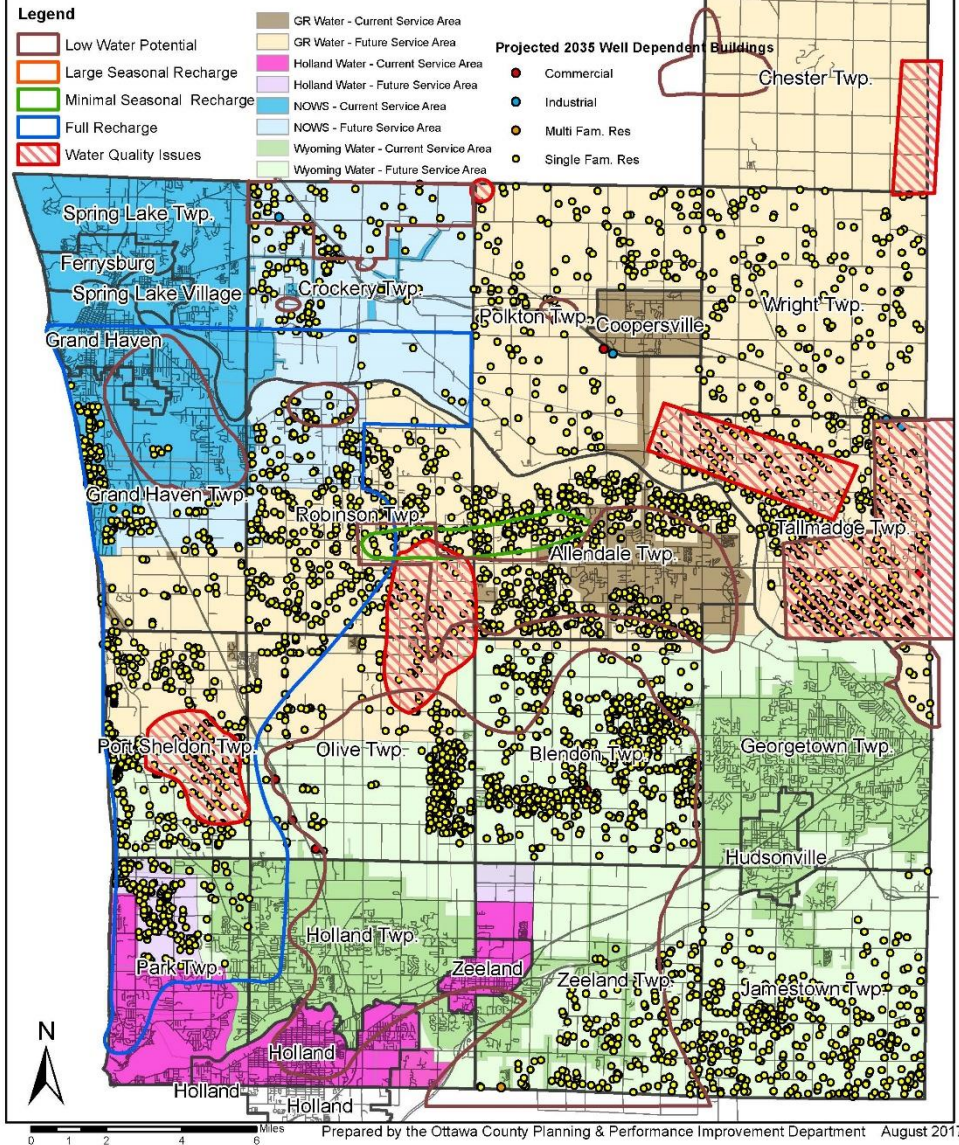


Where does Ottawa need geologic data?

- Fastest growing county in Michigan.
- 2016-17 Ottawa County identified water quantity and quality issues.
- MGS met with County commissioners, concerned officials and agricultural community and discussed data voids.
- Ottawa county did not have a factual summary of impacts, quantity and quality, all estimates.
- MGS, in 2017, met with 8 well drilling contractors and discussed understanding where there are water quantity and quality issues.
- Developed Glacial and Bedrock aquifer maps of known issues, never done before.

Reported Groundwater Data in Ottawa County

Glacial



2017- Glacial Map – Drillers data

- Ottawa County asked each township where they saw growth in next 20 years (Yellow dots).
- Eight drilling contractors prepared their maps of known water resources, development quantity and quality issues.
- This is the **ONLY** factual summary.



Reported Groundwater Data in Ottawa County

Bedrock

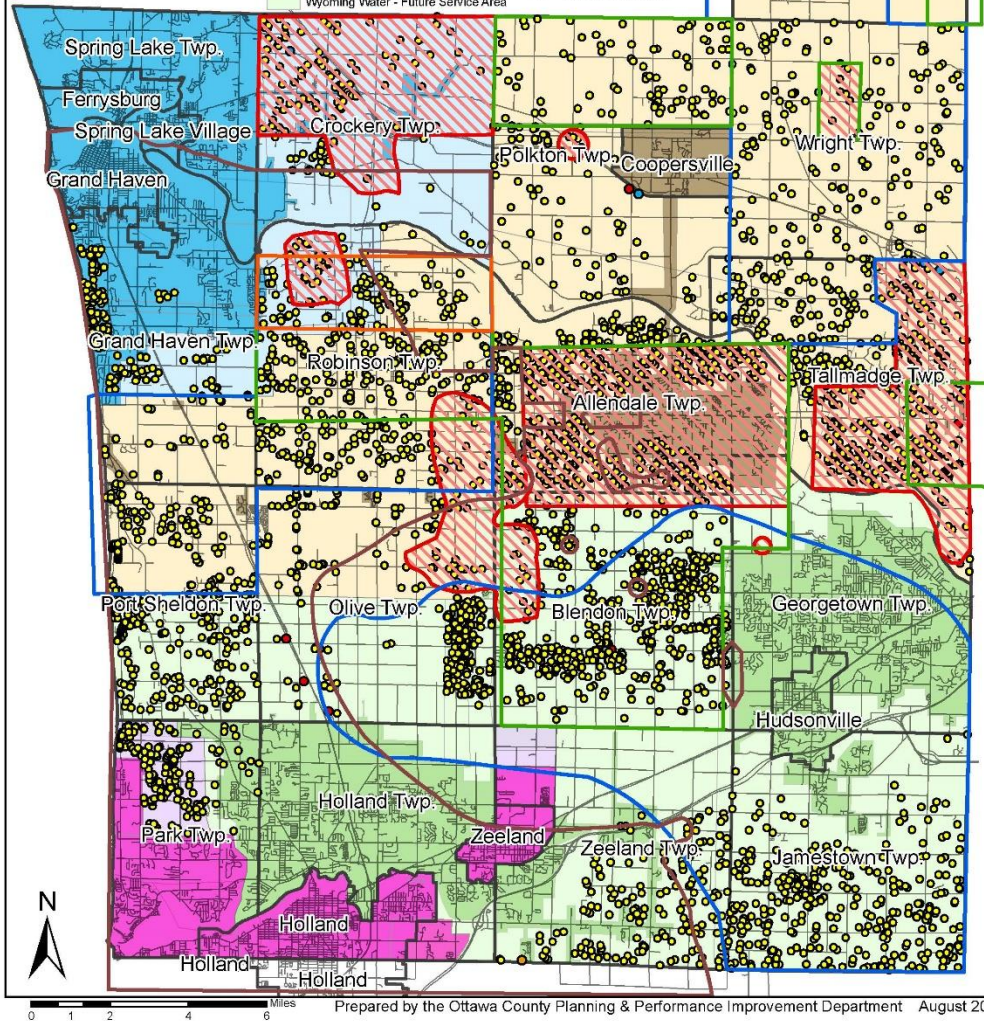
Legend

- Low Water Potential
- Large Seasonal Recharge
- Minimal Seasonal Recharge
- Full Recharge
- Water Quality Issues

- GR Water - Current Service Area
- GR Water - Future Service Area
- Holland Water - Current Service Area
- Holland Water - Future Service Area
- NOWS - Current Service Area
- NOWS - Future Service Area
- Wyoming Water - Current Service Area
- Wyoming Water - Future Service Area

Projected 2035 Well Dependent Buildings

- Commercial
- Industrial
- Multi Fam. Res
- Single Fam. Res

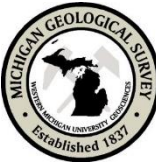


Prepared by the Ottawa County Planning & Performance Improvement Department August 2017

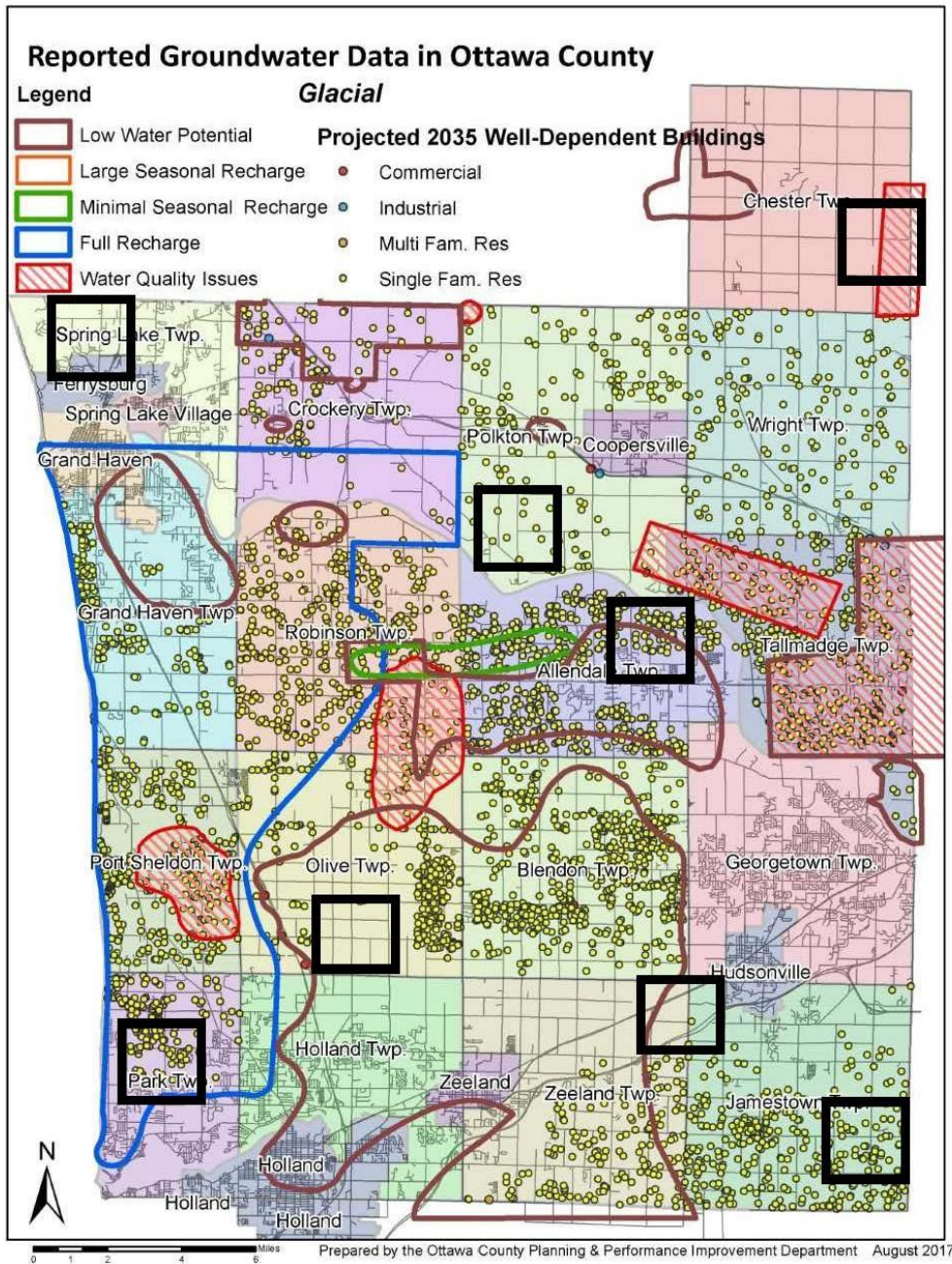
2017-Marshall Fm., bedrock Map – Drillers data

- Ottawa County asked each township where they saw growth in next 20 years (Yellow dots).
- Eight drilling contractors prepared their maps of known water resources, development quantity and quality issues.
- This is the **ONLY** factual summary.

MGS mapping Ottawa and Allegan County



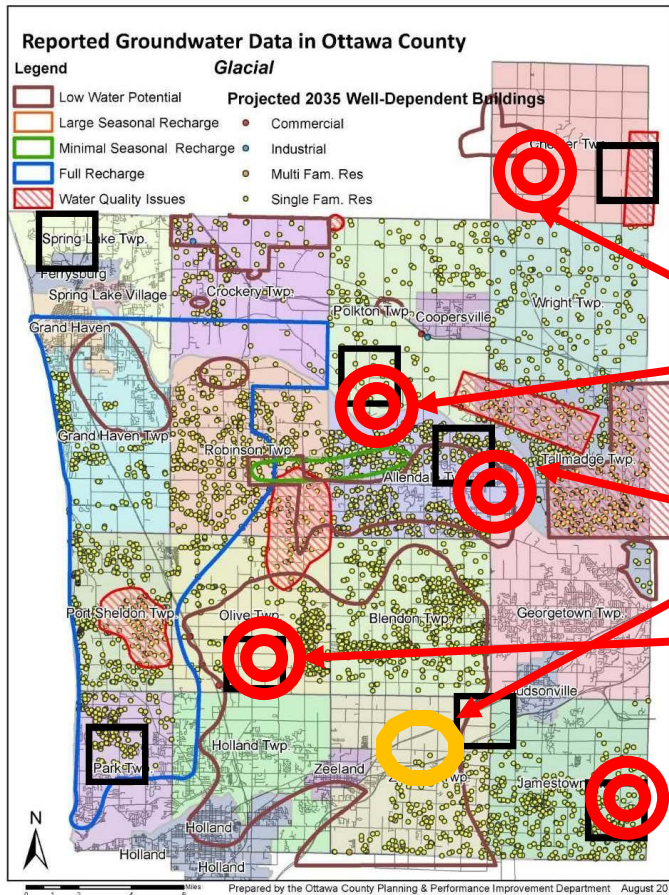
- MGS has been collaborating with Ottawa County “Planning” since 2016.
- MGS proposed and received a USGS NCGMP funding grant in 2020 to support mapping Ottawa and Allegan Counties
- Ottawa and Allegan are listed as priority counties by EGLE-WRD and MPART.
- MGS has teamed with Ottawa County since 2016, and MGS presented where MGS would want to drill and confirmed with Ottawa, where they could use a monitor well, a technical collaboration for both entities.
- MGS mapping and coring details indicate many areas have high clay/till material supporting minimal Glacial aquifer and minimal Marshall SS, bedrock aquifer recharge.



MGS has four glacial geomorphologists working on the Ottawa County map.

- **Dr. Patrick Colgan, GVSU, and the other geologists identified areas where drill hole data was needed.**
- **Discussed with Ottawa Co and identified locations that Ottawa could have a monitor well.**
- **Six drill sites cleared with Ottawa County staff.**

MGS Drilling Targets collaboration with Ottawa County – Core & Monitor well location map



Final drilling - Six Ottawa locations

- Core Hole & Monitor well
- Core Hole only
- **OTT 22-06** 120' TD Drift
- **OTT 22-05** 125' TD Drift, no Marshall
- **OTT 21-1 M** 120' TD Marshall
- **OTT 21-2** 185' TD Coldwater Sh
- **OTT 21-3 M** 135' TD Marshall
- **OTT 21-4 M** 100' and 185' TD Drift and Marshall

Glacial drift and Marshall Fm. monitor well technical collaboration.

MGS with Ottawa County, since 2017.
Now working with Allegan Co.

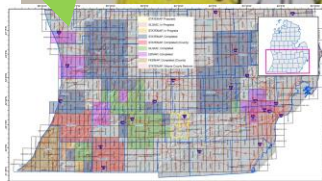
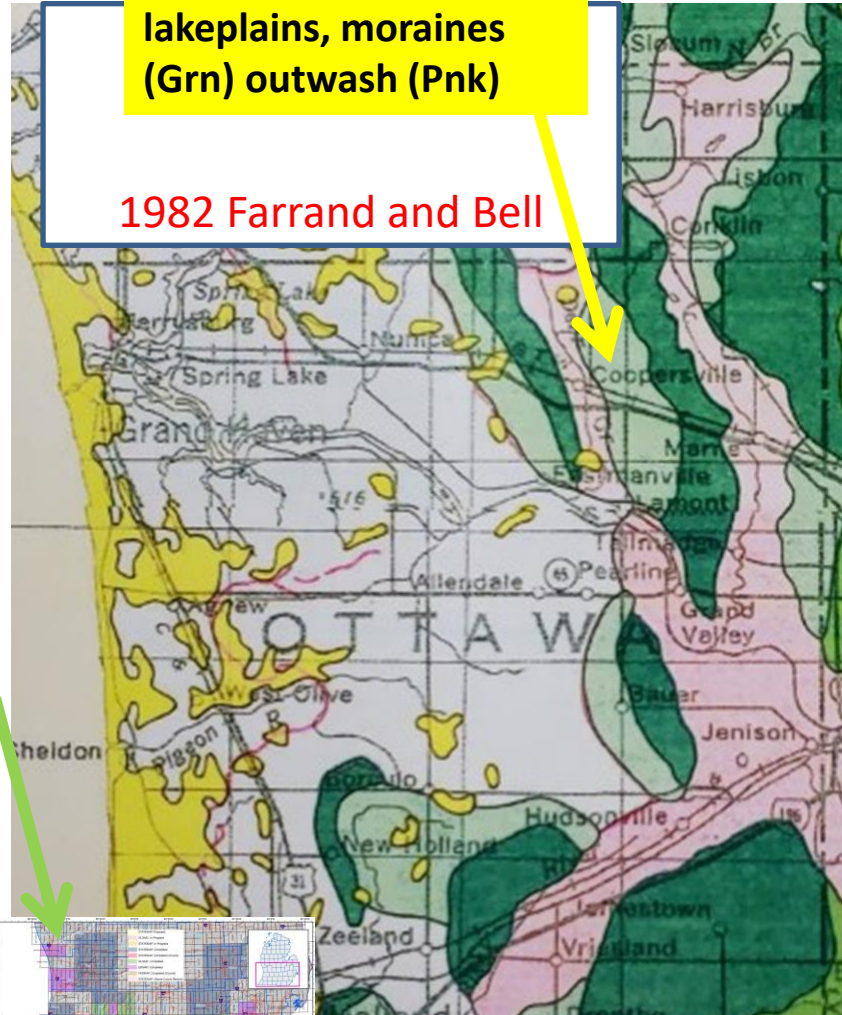
Map comparison 1982 versus 2022



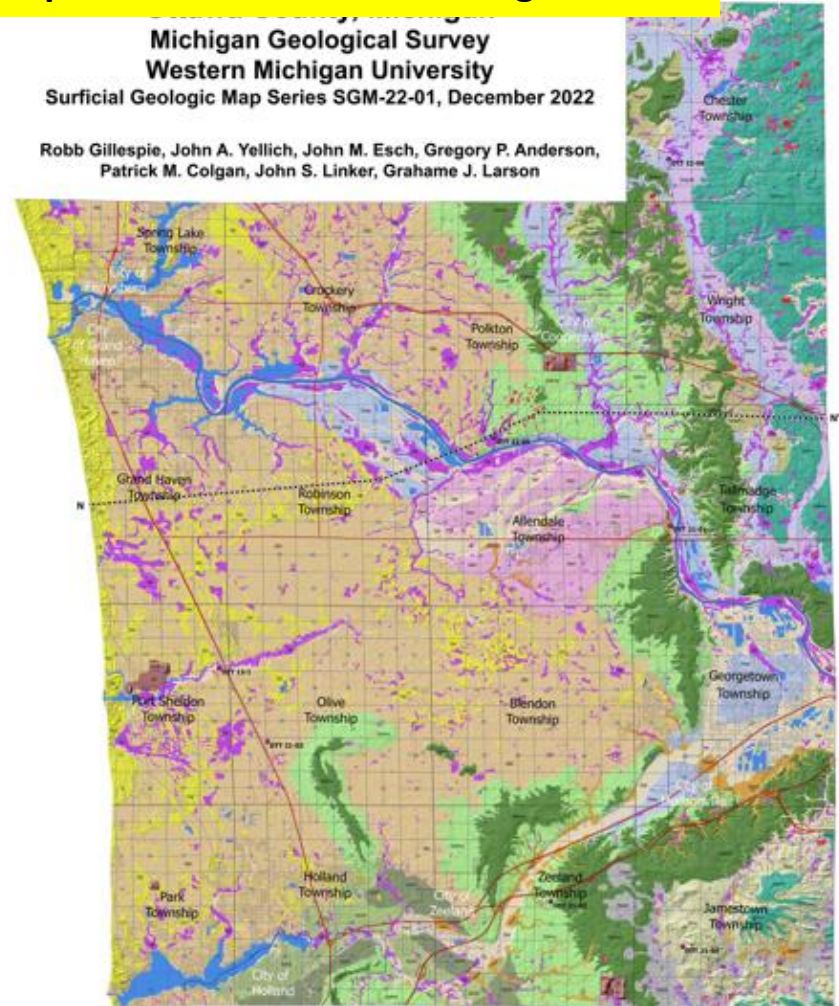
Ottawa County

1982 interprets this as
lakeplains, moraines
(Grn) outwash (Pnk)

1982 Farrand and Bell



2022 Diamicton/till at the surface, three
deltas, outwash in channels, Ice Walled
lake plains, soils favorable for agriculture.



Cross section index for Ottawa County Map 2022




What MGS does
with the data.
Cross sections and
groundwater flow
maps, shown next

Cross Section Index

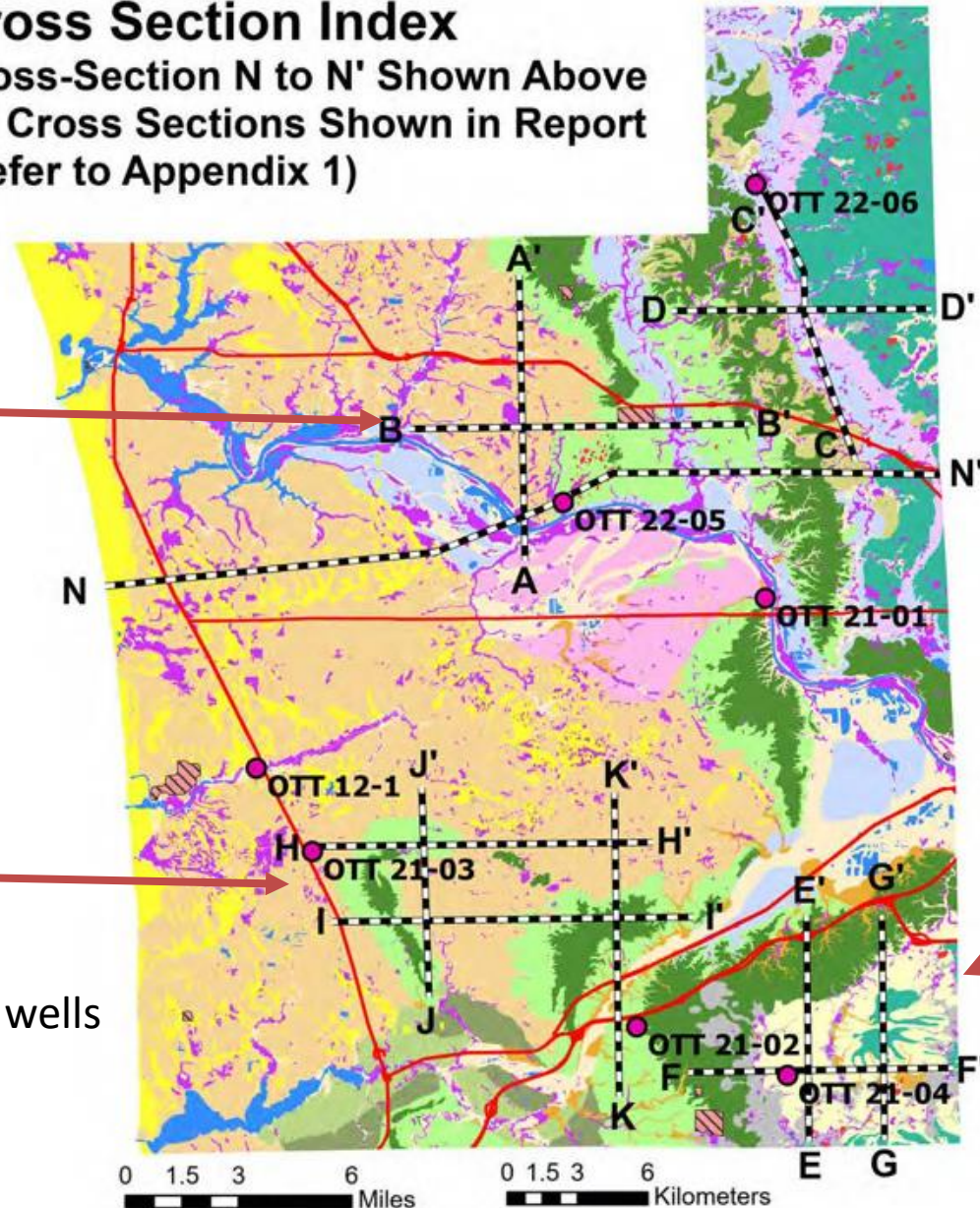
Cross-Section N to N' Shown Above
All Cross Sections Shown in Report
(Refer to Appendix 1)

2 - Polkton

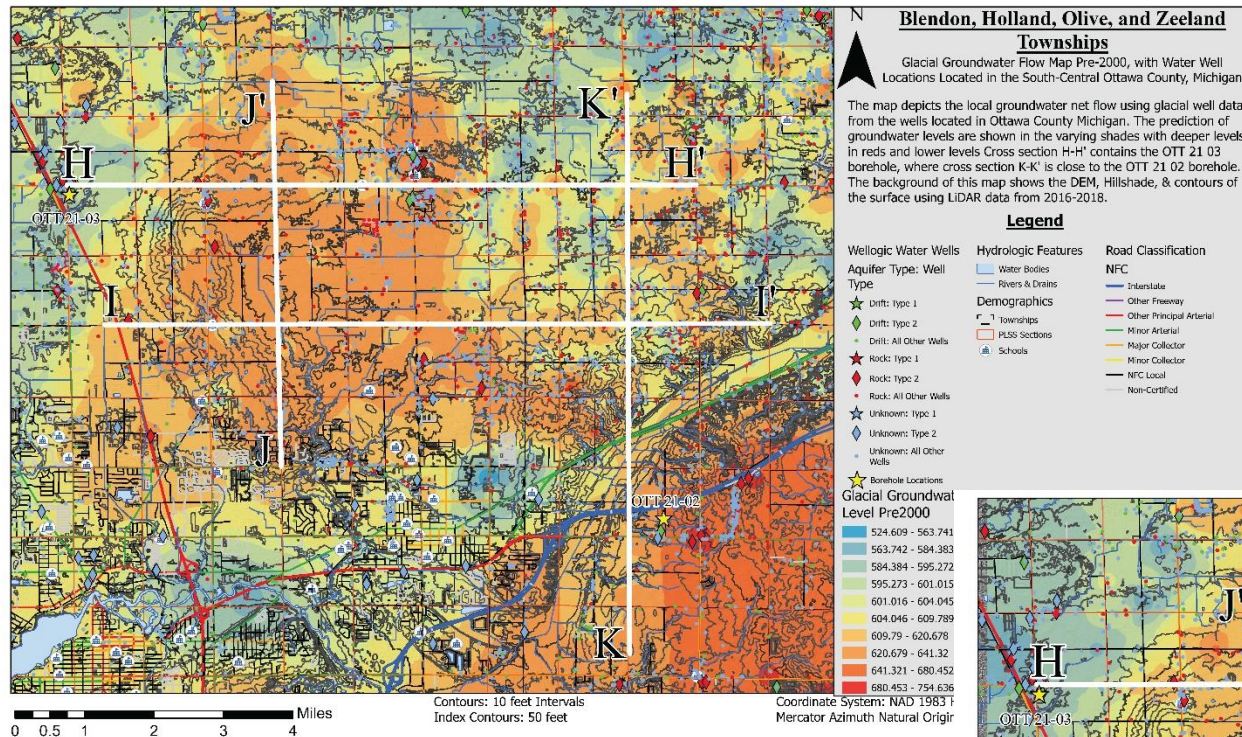
1- Zeeland

 MGS Core/Monitor wells
i.e. OTT-21-02

3 - Jamestown

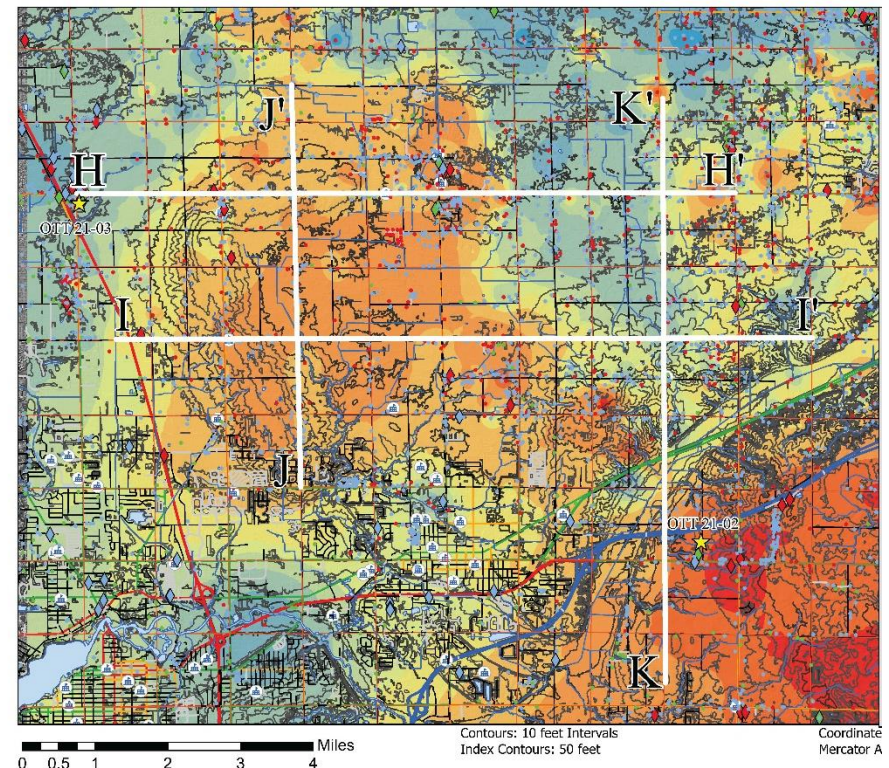


Comparison, Zeeland Drift Groundwater Pre 2000



Glacial/drift aquifer

Post 2000



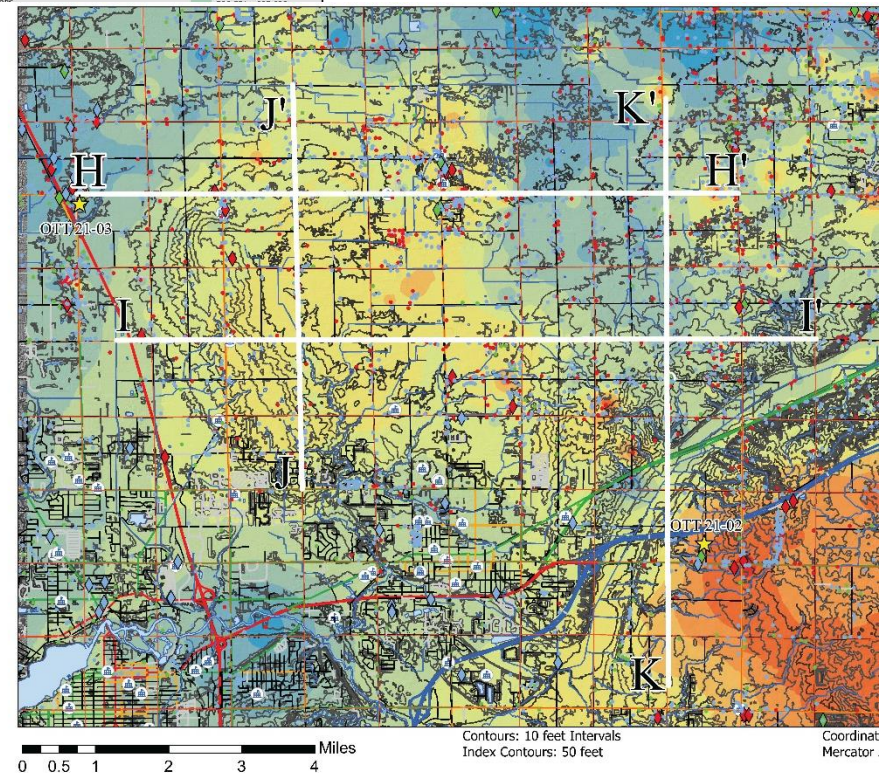
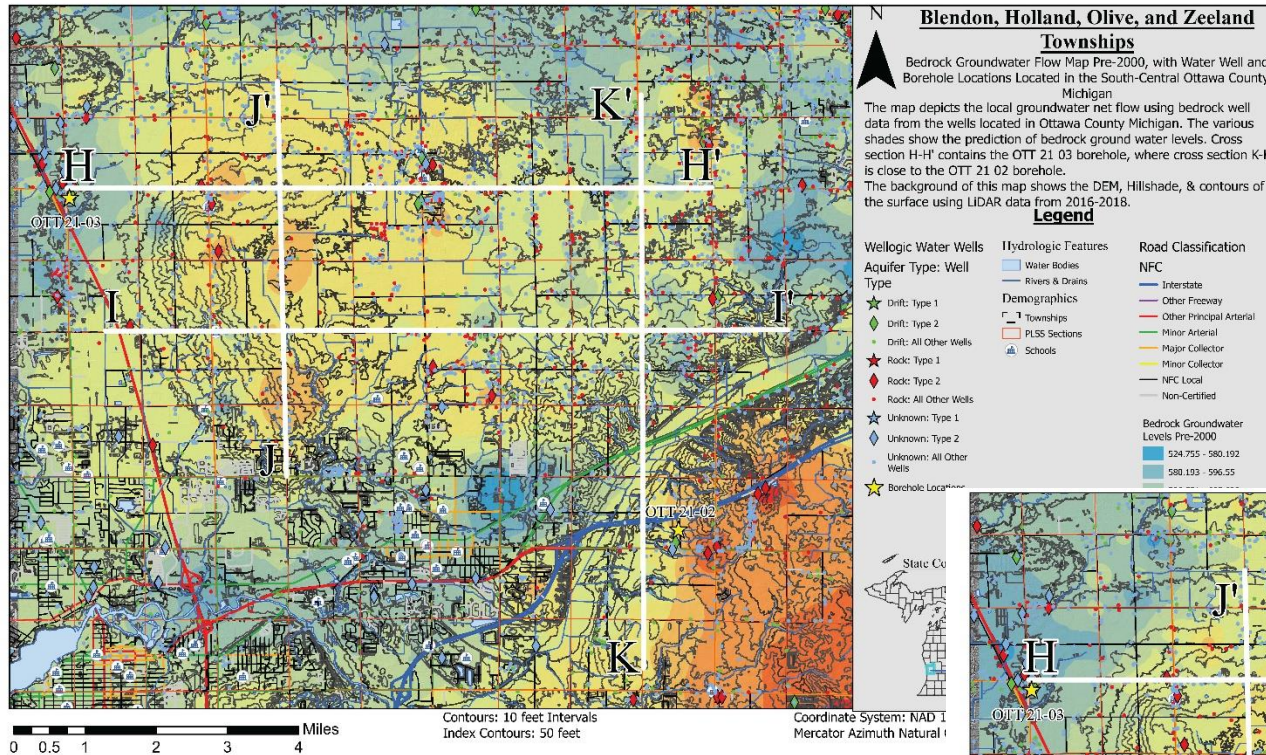
NOTE: Distribution of water wells
Blue colors represent water level reduction/change in certain areas.
Red indicates increase in water levels in certain areas.

Comparison, Zeeland Bedrock Groundwater Pre 2000



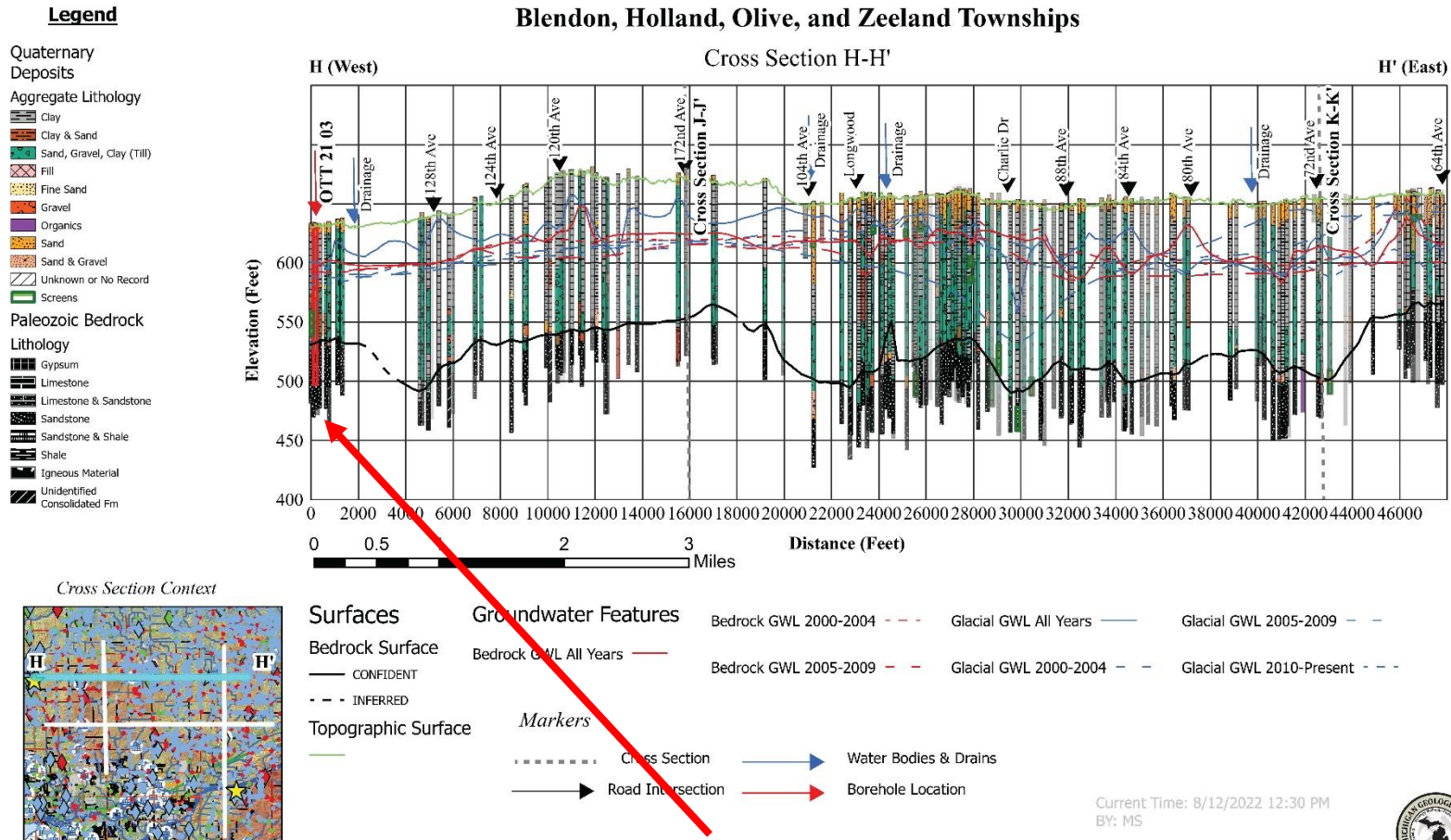
**Bedrock - Marshall
aquifer, Pre 2000**

**No Bedrock wells
drilled after 2010
Post 2000**



NOTE: Distribution of water wells
Blue colors represent water level reduction/change in certain areas.
Red indicates increase in water levels in certain areas.

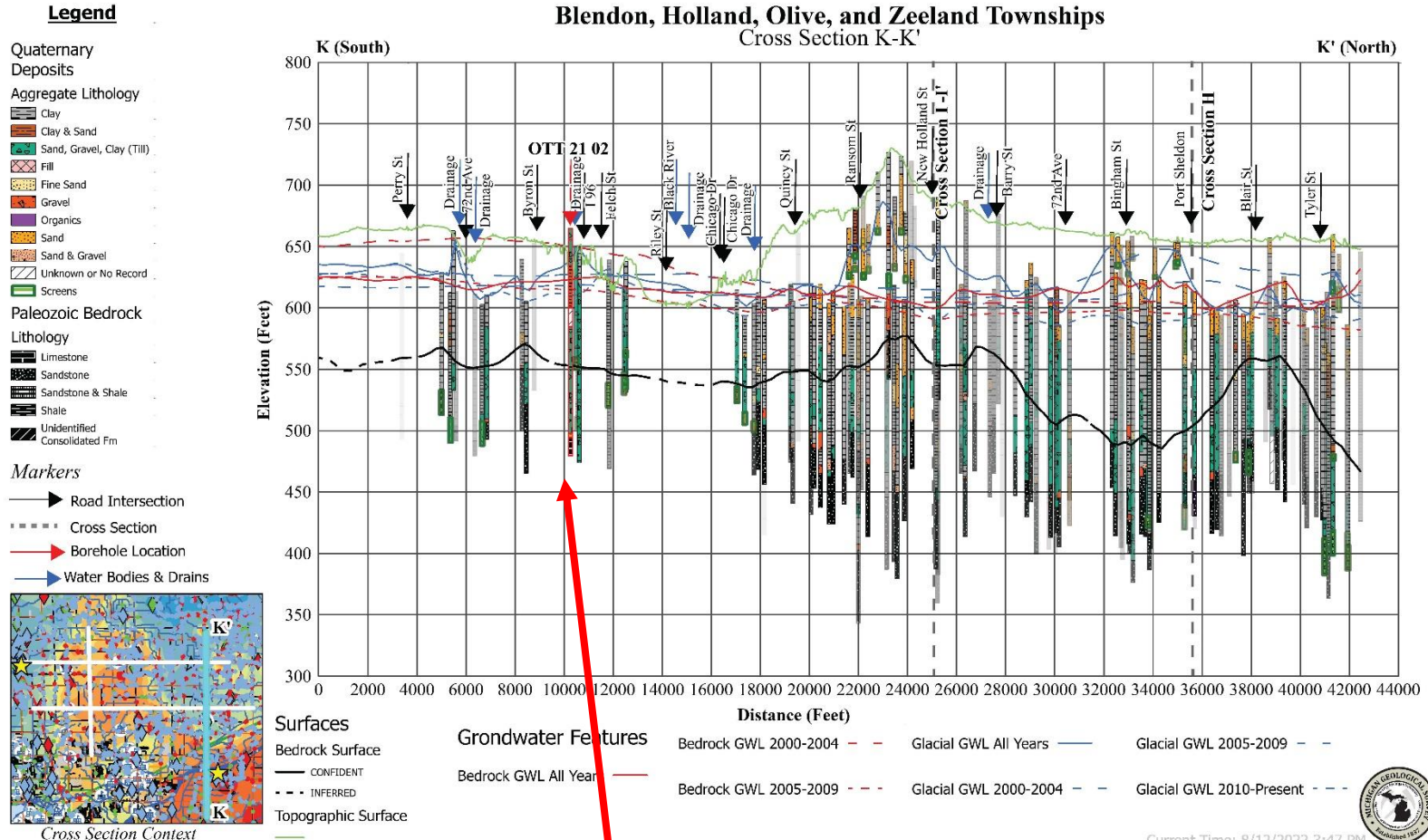
Cross Sections H-H', Zeeland, Groundwater Pre 2000 Post 2000



Detailed plots of Bedrock and Drift Wellogic water levels with time. Changes in WL, includes MGS/Ottawa Core/monitor wells, minimal to NO recharge.

NOTE: No Bedrock wells post 2010, glacial till/clay, but note, orange-sand and gravel at surface

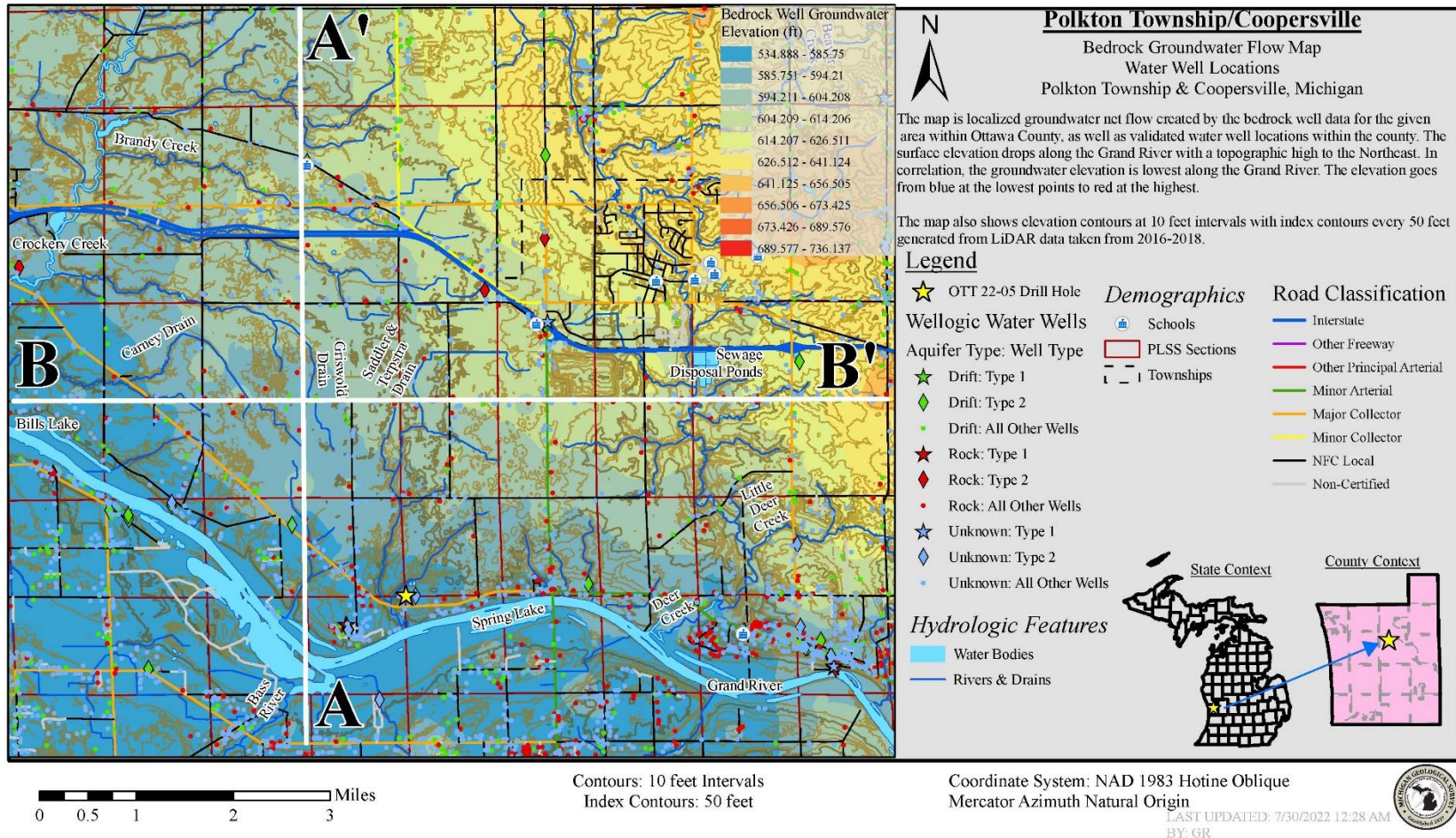
Cross Sections K-K', Zeeland, Groundwater Pre 2000 Post 2000



Detailed plots of Bedrock and Drift Wellogic water levels with time. Changes in WL, includes MGS/Ottawa Core/monitor wells, minimal to NO Recharge.

NOTE: No bedrock wells post 2010, glacial till/clay, but note, orange-sand and gravel at surface

Polkton Map - Bedrock Groundwater Pre 2003



Polkton-No Bedrock wells drilled after 2003, so only pre 2003 bedrock groundwater plotted



Figure 1 consists of four maps (A, A', B, B') showing the location of the study area in the northern part of the Great Plains. Map A shows the Grand River, Spring Lake, Deer Creek, and Little Deer Creek. Map A' shows the same area with a different color scheme. Map B shows Brandy Creek, Crockery Creek, and Carney Drain. Map B' shows the same area with a different color scheme. A legend on the right indicates Glacial Well Groundwater Elevation (ft) 2010-Present, with color-coded ranges from 537.290 to 736.137. A scale bar at the bottom indicates 0 to 3 miles.

Glacial Well Groundwater Elevation (ft) 2010-Present

- 537.290 - 585.75
- 585.751 - 594.21
- 594.211 - 604.208
- 604.209 - 614.206
- 614.207 - 626.511
- 626.512 - 641.124
- 641.125 - 656.505
- 656.506 - 673.425
- 673.426 - 689.576
- 689.577 - 736.137

Contours: 10 feet Intervals
Index Contours: 50 feet

Cross Section A-A', Geology & Groundwater Pre 2010 Post 2010

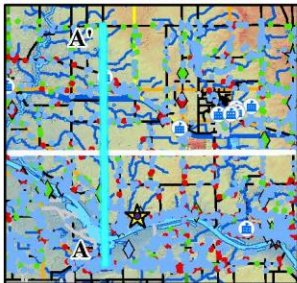


Legend

- | | |
|----------------------------|------------------------------|
| Quaternary Deposits | Paleozoic Bedrock |
| Aggregate Lithology | Lithology |
| Clay | Limestone |
| Clay & Sand | Sandstone |
| Sand, Gravel, Clay (Till) | Sandstone & Shale |
| Fill | Shale |
| Fine Sand | Unidentified Consolidated Fm |
| Gravel | |
| Organics | |
| Sand | |
| Sand & Gravel | |
| Unknown or No Record | |
| Screens | |
| Surfaces | |
| Topographic Surface | Bedrock Surface |
| | CONFIDENT |
| | INFERRED |

- Markers**
- OTT 22-05 Drill Hole Projection
 - Road Intersection
 - Water Bodies & Drains
 - Cross Section

Cross Section Context

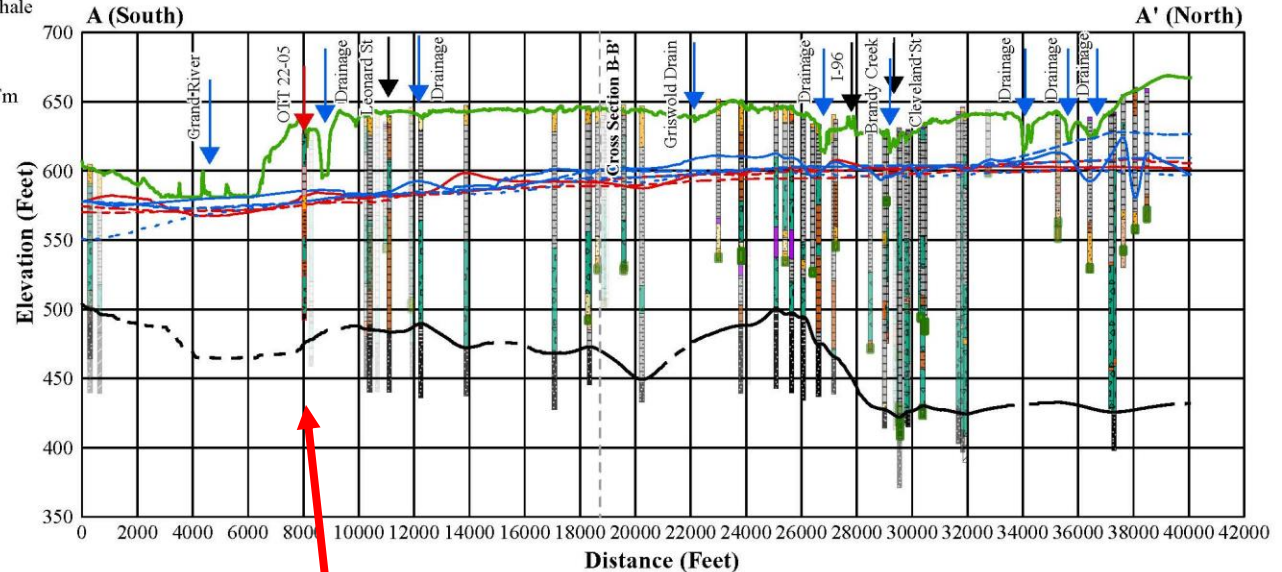


Groundwater Features

- | | | | |
|-----------------------|--------------------------|-----------------------|-----------------------|
| Glacial GWL All Years | Glacial GWL 2005-2009 | Bedrock GWL All Years | Bedrock GWL 2005-2009 |
| Glacial GWL 2000-2004 | Glacial GWL 2010-Present | Bedrock GWL 2000-2004 | |

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BY: GR

Polkton Township/Coopersville Cross Section A-A'



MGS OTT 22-05, Bedrock, Marshall Fm, no aquifer, silica cemented sand.
NOTE: Drift wells, glacial till/clay. Note- orange-sand and gravel at surface, With minimal sand to recharge lower drift aquifers, slow recharge.

Cross Section B-B', Geology & Groundwater Pre 2010 Post 2010



Legend

Quaternary Deposits

Aggregate Lithology

- Clay
- Clay & Sand
- Sand, Gravel, Clay (Till)
- Fill
- Fine Sand
- Gravel
- Organics
- Sand
- Sand & Gravel
- Unknown or No Record
- Screens

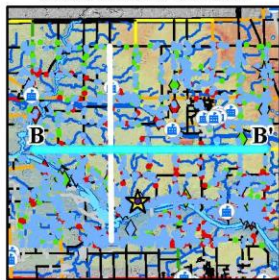
Surfaces

- Topographic Surface
- Bedrock Surface
- CONFIDENT
- INFERRED

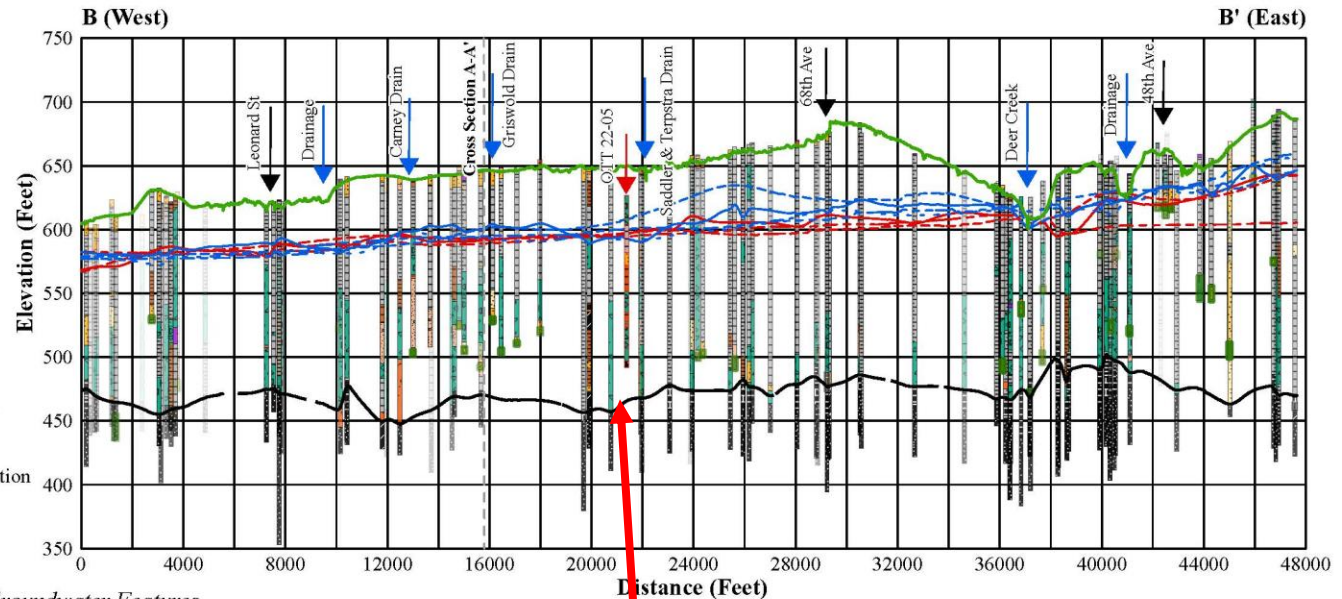
Markers

- OTT 22-05 Drill Hole Projection
- Road Intersection
- Water Bodies & Drains
- Cross Section

Cross Section Context



Polkton Township/Coopersville Cross Section B-B'



Groundwater Features

- | | | | |
|-----------------------|--------------------------|-----------------------|------------------------------|
| Glacial GWL All Years | Glacial GWL 2005-2009 | Bedrock GWL All Years | Bedrock GWL 2005-2009 |
| Glacial GWL 2000-2004 | Glacial GWL 2010-Present | Bedrock GWL 2000-2004 | |
| Paleozoic Bedrock | | | |
| Lithology | | | |
| Gypsum | Limestone & Shale | Shale | Unidentified Consolidated Fm |
| Limestone | Sandstone | | |

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MGS - OTT 22-05, Bedrock, Marshall Fm, no aquifer, silica cemented sand.
NOTE: Drift wells, glacial till/clay, but note, orange-sand and gravel at surface,
With minimal sand to recharge lower drift aquifers, slow recharge.

So where does Michigan need to go?



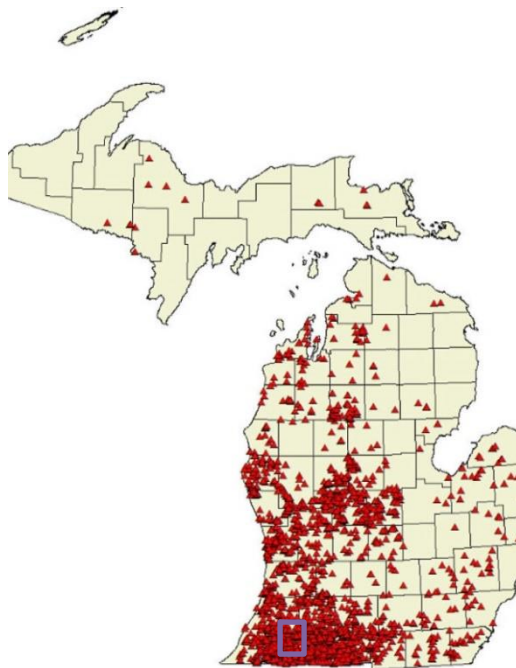
Multiple objectives to achieve validated, unbiased geologic data.

MI WWAT Applications vs detailed GEOLOGIC Map Products

Approximately 60% of the LP groundwater comes from glacial material

Mi WWAT Applications >70 GPM through 2021 for comparison

Beginning in ~2003 (Water Withdrawal Assessment Tool- well drillers logs, non-factual model)



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

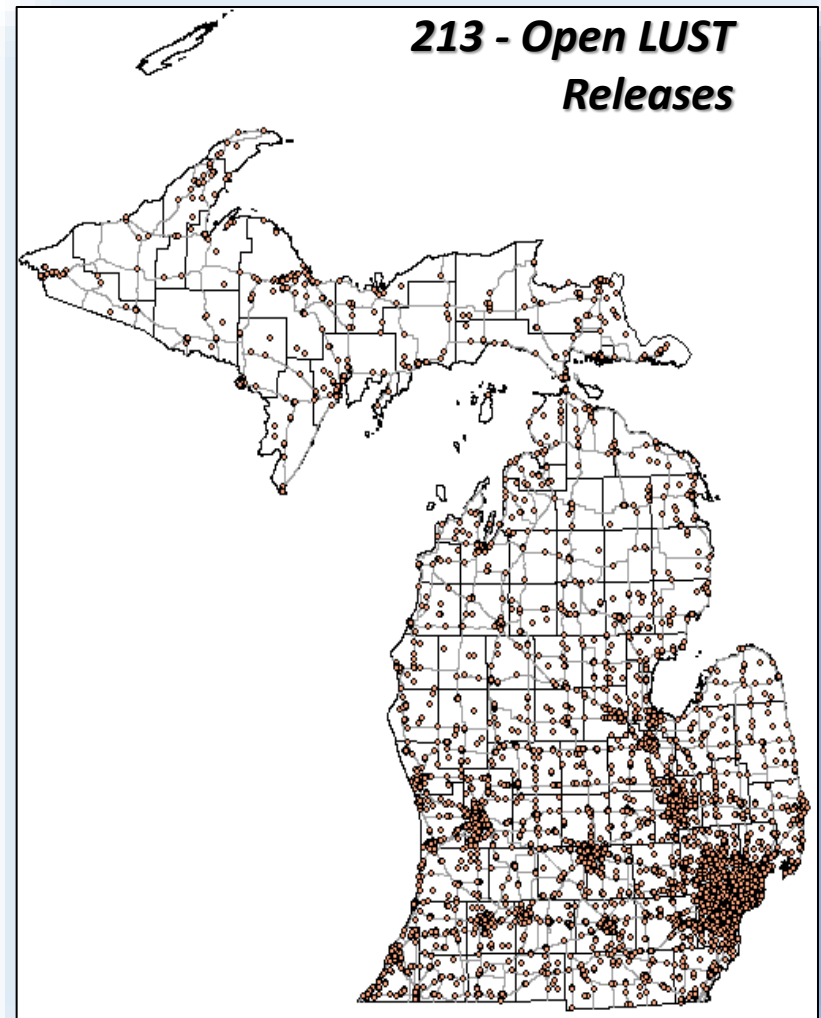
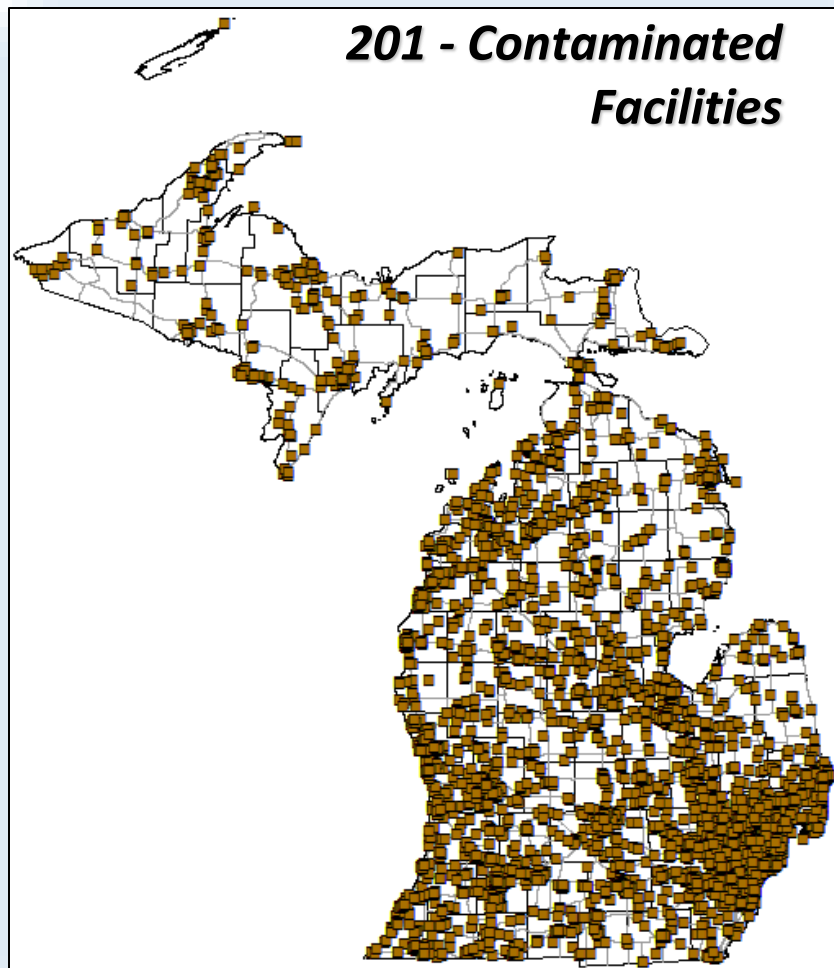
Less than 10 % Detailed MGS mapping.

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

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

***Lets review the history of Data!
EGLE -Estimated 30,000 sites***

***Hazardous Substances
Released to the Environment***

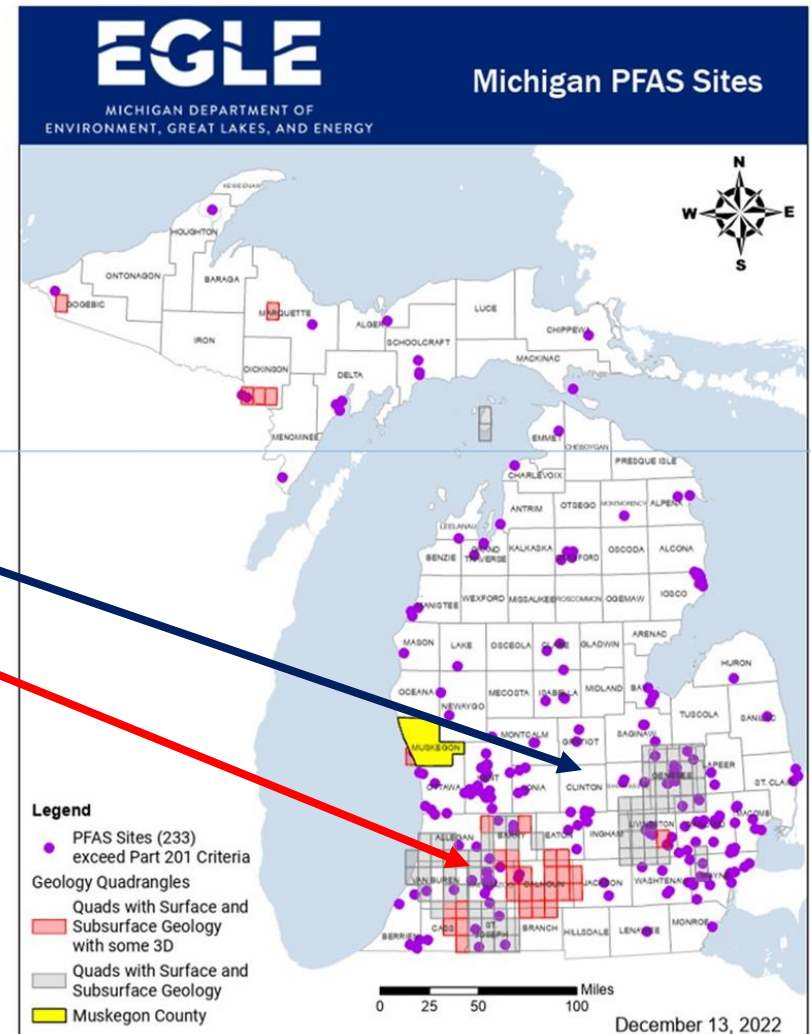


***1980's Pre – CERCLA
to present-geologic data
No geologic data compilation-
Until now!***

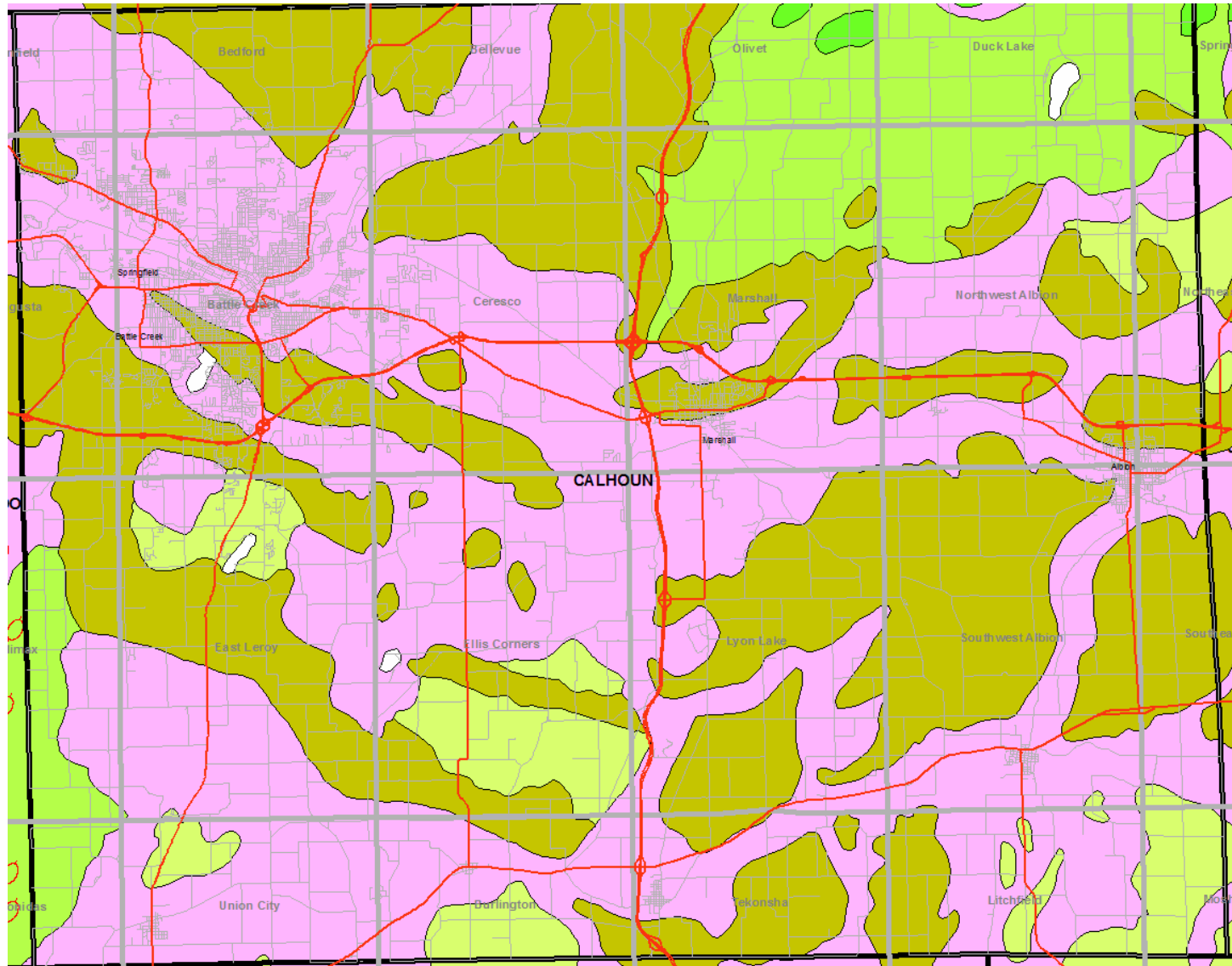
What is the new Michigan contaminant crisis?

Michigan – the Water Wonderland!

- Perfluorinated Alkyl Substances (PFAS) – Soils and water multiple locations and there may be more.
- Geologic mapping-completed counties Berrien, Cass, St. Joseph, Barry, Calhoun, Kent, Kalamazoo, Genesee, Van Buren.
- Where Michigan has open file subsurface geologic data (Red/Blk).
- What's wrong with this picture?
- Stop using just water well data.
- Mapping and drilling data is needed to define the full aquifer section for each watershed.
- Let's compare recent results.



Compare Calhoun County 1982 Map



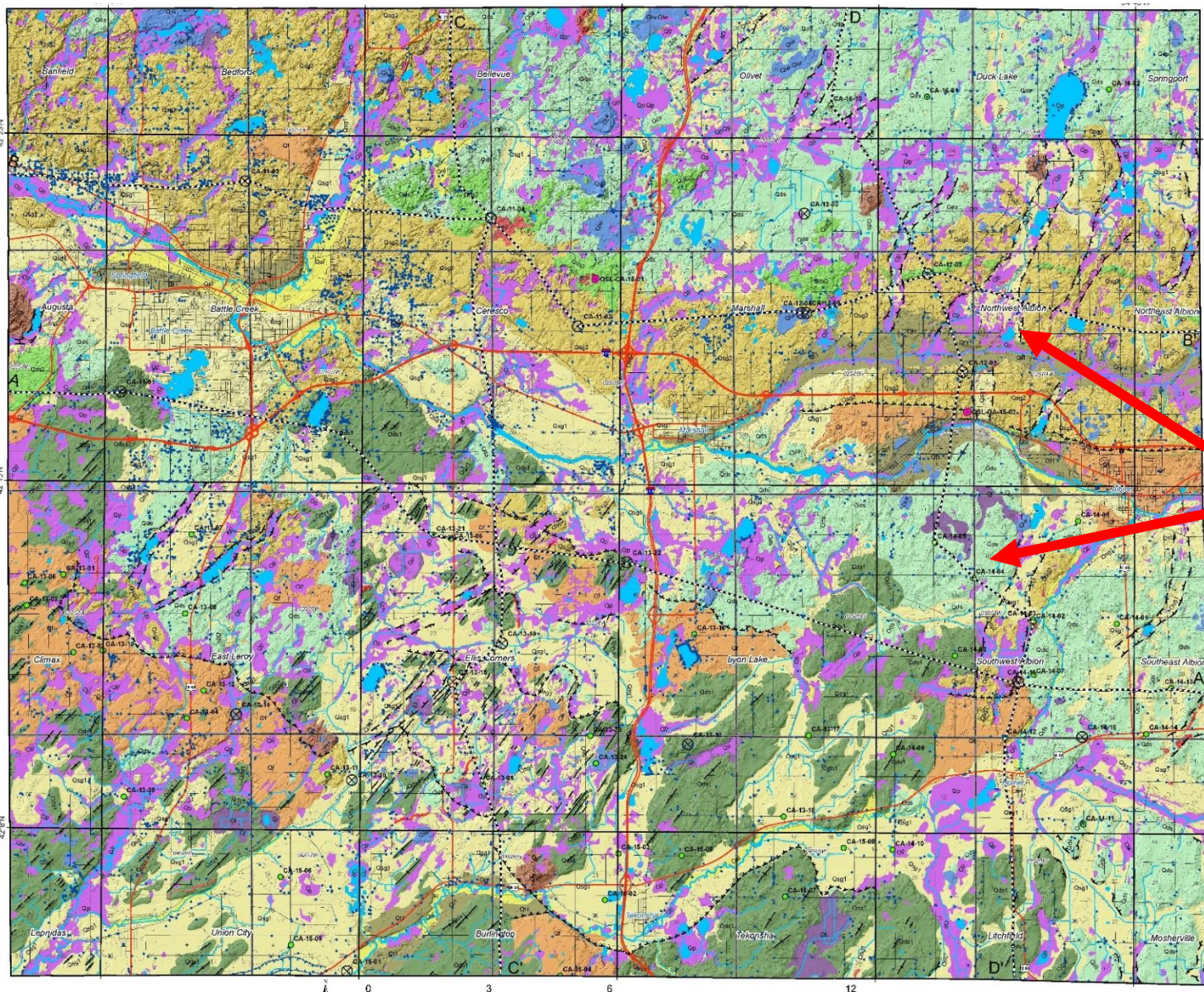
Calhoun County 2017 Map



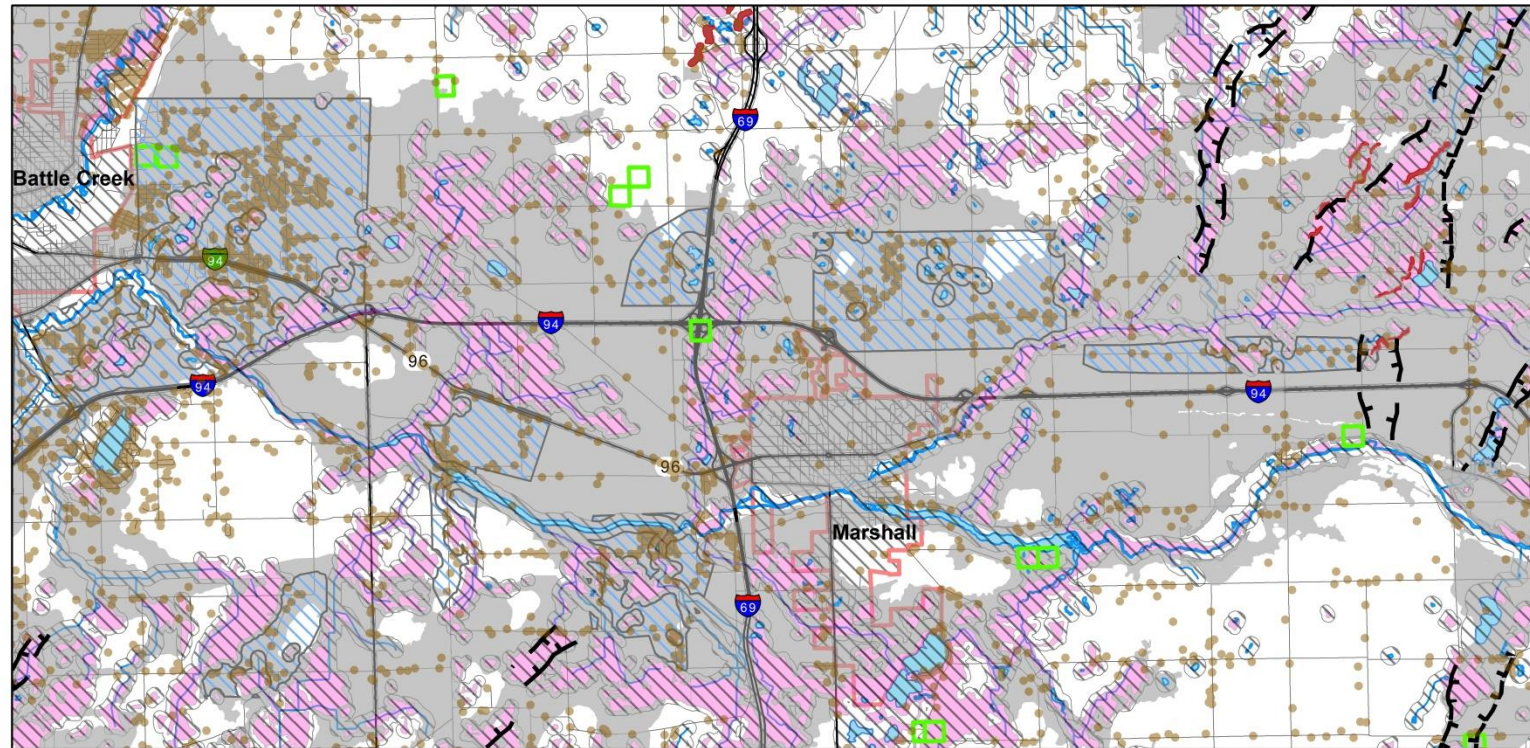
All can see the level of detail in new mapping.

This is where we have aggregates?

- Aggregates also mean water.
- Let's review a recent aggregate assessment for this area.



Selected Area of Calhoun County Potential Aggregate Resources

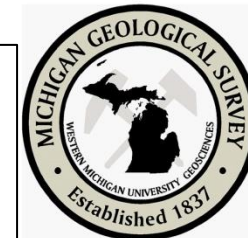


0 0.75 1.5 3 4.5 6 Miles

Legend

- | | |
|-------------------------------|-------------------------------------|
| Potential Aggregate Resources | Lakes |
| Tunnel Valley | Existing Sand and Gravel Operations |
| Eskers | State Roads |
| City Limits | Local Roads |
| Setback Buffer | Streams |
| Development Buffer | Water Wells |
| Wetlands | |

Aggregate Resources in all glacial types
Reduction of resources by setback, etc.
Resources = 147 Sq mi minus 81 Sq mi
restricted = 66 (~45%) Sq mi available.
Including residences in Un-graded
resources.



Date: 2/6/2019

Allendale (01) & Olive Township (03) locations Ottawa County



August 2021

Zeeland Township (02)



August 2021

TD 185', 80 feet of Gypsum (White rock), **no glacial (Till) or bedrock aquifer**, Coldwater Shale.



Training students, Sara Hayes and Sophia White to log core.



Fire station, top of gravel pit, future home development below



Jamestown Fire Station (04)

August 2021



- Two students learning how to log core, Sara Hayes and Yanni Philopoulos.
- Presenting core samples to Ottawa County Water administrator, Mathew Chappuies
- Two completed monitor wells at Jamestown Fire Station



MGS - geologic projects, Past and Future

**Supported by MI Water Division, Natural Resources,
Agriculture, MPART, others,**

**Cass, Ottawa, Allegan, Muskegon Counties- WRD,
MPART, others**

Need maps using new and proven technologies and methods

- **MGS confirmed counties having growth and water quantity demands**
- **Localized geologically derived water quality issues**
- **3D maps and reports are needed and developed with validated information, in real time.**
- **Data in formats (e.g. ArcGIS) accessed by phones, tablets, laptops, actively showing multi layers of data..... in seconds, in the field.**
- **Secondary MGS mapping products of surface and subsurface data include: Water tables, water bearing zones, surface drainage, aggregates, wetlands, NRCS-Soils, recharge areas, deeper subsurface research and data, etc.**
- **Interactive electronic standard databases to capture existing and new data.**



MGS - geologic projects, Past and Future

MGS products, Continued:

Need maps using new and proven technologies and methods

- Critical Mineral geologic units through out Michigan.
- Federal Projects - Carbon Sequestration, Abandoned Mine lands, other.
- 21st Users: Citizen scientists, city and county planners & developers, geologists, earth scientists, engineers, consultants, industry representatives, regulators.
- Where should you get your data, Wikipedia or the Geologic Survey?

MGS - geologic projects, today, Eastmanville



Coring, monitor well installation, purging well



Drift/till-
130'
Marshall

So what is the answer to scientific data?



Annual Funding for the Geological Survey, now secured.

A big thank you to all the support from the local and regional Senate and House legislators, local Directors and Managers, county administrators and residents who wrote or noted the benefits of needing geologic data!



- **Priority driven areas!**
- **Use unbiased geological scientist, not data manipulators**
 - Scientists and public using data in open file format
- **What do we need to understand for today and future generations?**
 - **Geologic hydrostratigraphy,**
 - **3D geology of the entire stratigraphic section,**
 - **Soil profiles to correspond with subsurface geology,**
 - **Water storage and recharge are defined,**
 - **Usage of resources, then**

Geologic mapping can support identification and protection of those resources which are associated with:

- **Water storage/availability, aggregates, soils, wetlands, PFAS, other,**
- **WUAC Recommended Geologic mapping, 2014 & 2020**

So what is the answer to scientific data?



 MICHIGAN GEOLOGICAL SURVEY SUMMARY OF COUNTY MAPPING PRIORITIES PRESENTING THE % OF VALIDATED GEOLOGIC MAPPING PRODUCTS 					
	Proposed Priority Counties (Mapping data needed)	EGLE County maps WRD Water Use Priority list	Estimate % Completed Maps	EGLE County Maps MPART PFAS Areas	Estimate % Completed Maps
1	Kalamazoo	Branch	20%	Kalamazoo	95%
2	Ottawa	Cass	100%	Muskegon	<10
3	Allegan	St. Joseph	100%	Oakland	<10
4	Montcalm	Calhoun	100%	Kent	80%
5	Muskegon	Van Buren	50%	Montcalm	<10
6	Kent	Ottawa	100%	Ottawa	<10
7	Oakland	Berrien	100%	Allegan	<10
8	Jackson	Allegan	25%	Calhoun	100%
9	Branch	Montcalm	<10	Ionia	<10
10	Washtenaw	Hillsdale	<10	Monroe	<10
11	St. Joseph	Jackson	40%	Livingston	60%
12	Hillsdale	Gratiot	<10	Lenawee	<10
13	Jackson	Isabella	<10	Marquette	50%
14	Livingston			Washtenaw	<10
15	Monroe			Barry	100%
16	Ionia			Berrien	100%
17	Lenawee			Charlevoix	<10
18	Marquette			Delta	<20
19	Charlevoix			Jackson	40%
20	Delta			Newaygo	<10
21	Gratiot				
22	Isabella				
		Top Priority			
		Second Priority			
		Done			

NOTE: This is a specific list of priority counties requiring validated geologic mapping. These two lists were provided in 2018 and 2019 by the EGLE departments of MPART and WRD, respectively. MGS has included a statement of map % completion for each County. This list will be modified as needed after discussions and agreement with EGLE and DNR Departments. The United Tribes of Michigan has endorsed mapping of water resources where needed in the State.

- Prioritization by EGLE-WRD, EGLE – MPART and supported by United Tribes of Michigan, others (Priorities provided by 10-11-19).
- What counties are most important? 20-25 counties now identified
- Four Counties mapping 3D completed.

Michigan Geological Survey



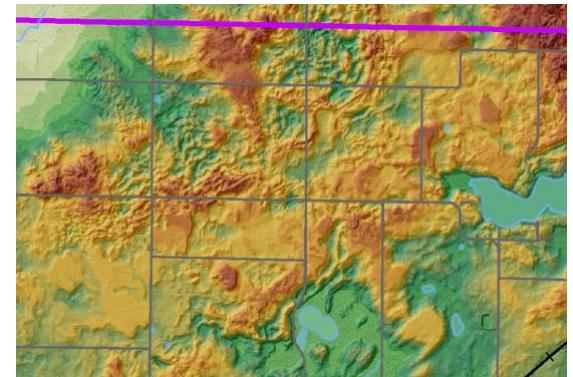
Summary as of May 1, 2015

MICHIGAN GEOLOGICAL SURVEY (MGS) - STATE DATA SUMMARY
WITH DATA LOCATION NOTED

County	Number of RRD site entries in Environmental Mapnet	RRD Files	Oil and Gas (OOGM) permitted boreholes	Wellologic water wells	Number of O.G. Wireline log files - MGRMC	Shallow bedrock cored wells at MGRMC - WMU	Drill cuttings sets MGRMC
Alcona	108		334	3,300	755	0	73
Alger	56		0	2,386	4	0	1
Allegan	1,642		3,473	11,927	654	0	892
Alpena	321		1,469	2,877	1,367	2	116
Aurum	268		2,750	4,356	2,291	0	181
Arenac	352		1,076	2,498	457	0	731



**Thank you
Questions?**



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