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Erickson Groundwater Investigation

March 21, 2024

HDR

Agenda

- What are Coal Combustion Residuals (CCR) / Regulations
- CCR Compliance Program Process
- Groundwater Program Development
- Status of Groundwater Monitoring at Erickson
- Private Well Sampling Results
- Numerous Approaches Reviewed to Determine Source of the Boron in the Private Wells
- Next Steps

Coal Combustion Residuals (CCR)

- Coal ash - created when coal is burned by power plants to produce electricity
- Types of Ash:
  - fly ash (dry) – landfills
  - bottom ash (slurry/wet) – impoundments
- Coal ash contains heavy metals
- EPA CCR Rule
- Michigan Part 115 Solid Waste Regulations

CCR at Erickson

- Fly ash – 80%
  - taken offsite and recycled
- Bottom Ash – 20%
  - Hydrobins – majority taken offsite to regulated landfill
  - Remainder <5% - 3 impoundments at Erickson
  - 1 Former Impoundment 1970-2014 not regulated
- Groundwater Compliance Monitoring
  - EPA CCR Rule
  - Michigan Part 115 Solid Waste Regulations

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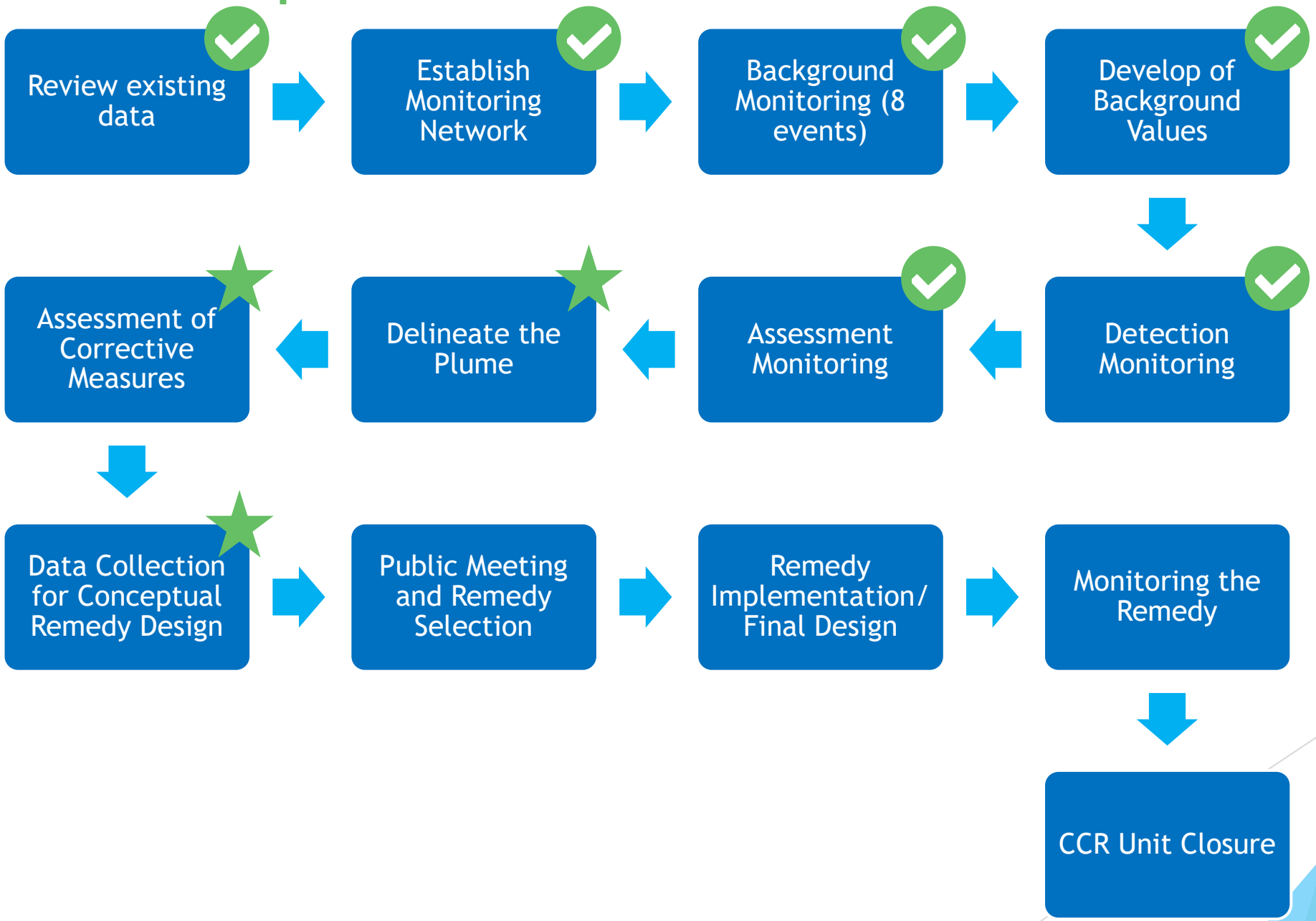
CCR Compliance Process



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Initial Groundwater Monitoring Network

- 5 monitoring wells
  - 2 upgradient
  - 3 downgradient
- Around the outside of the impoundments
- Groundwater flow direction – east under impoundments

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EATON COUNTY, MI

Sampling, Analysis, & Statistics

- Semiannual monitoring
- Establish site-specific background values from upgradient groundwater quality
- 6 parameters above Groundwater Protection Standards in glacial aquifer
  - Boron, Lithium, Molybdenum, Calcium, Sulfate, Total Dissolved Solids

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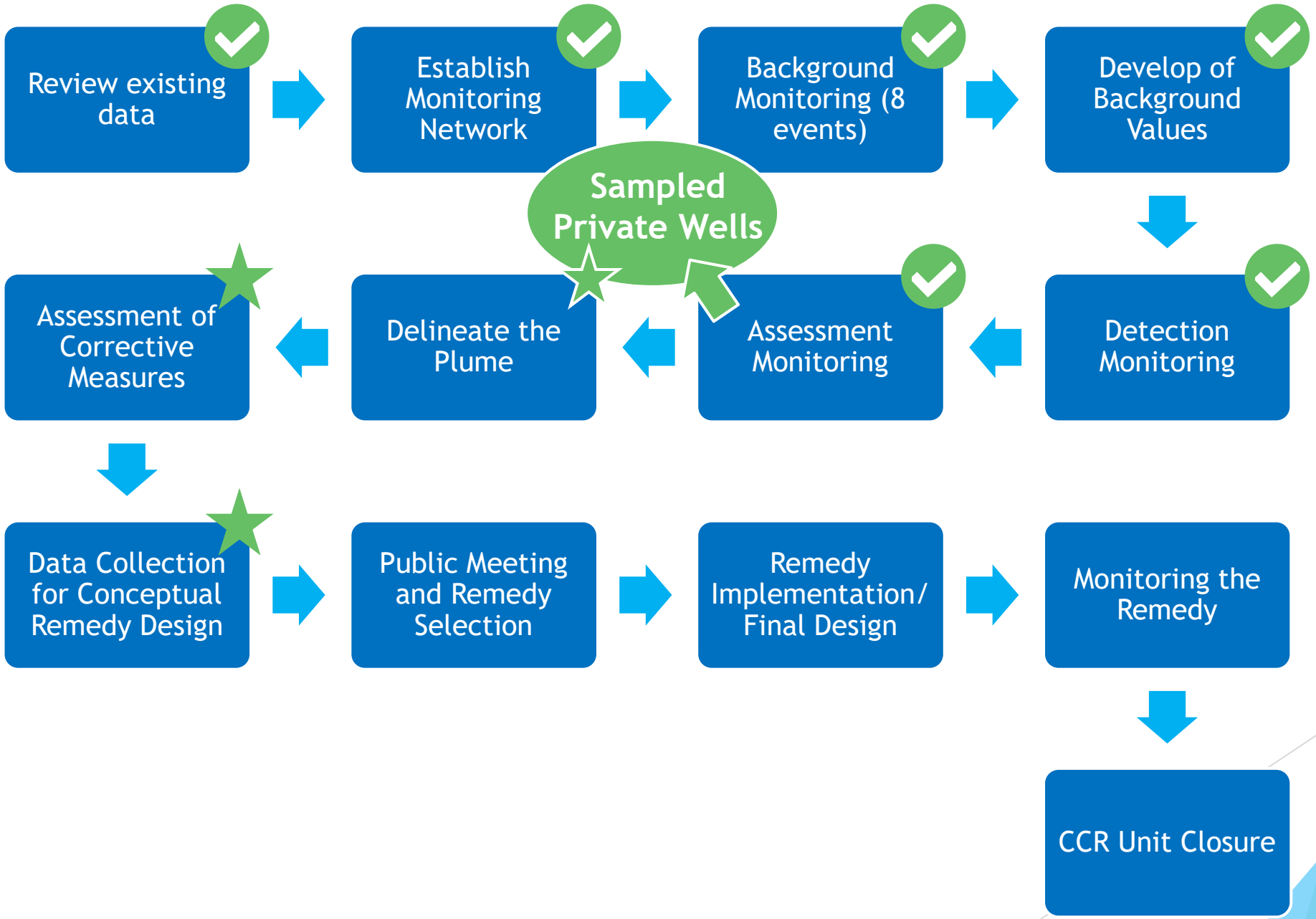
CCR Compliance Process



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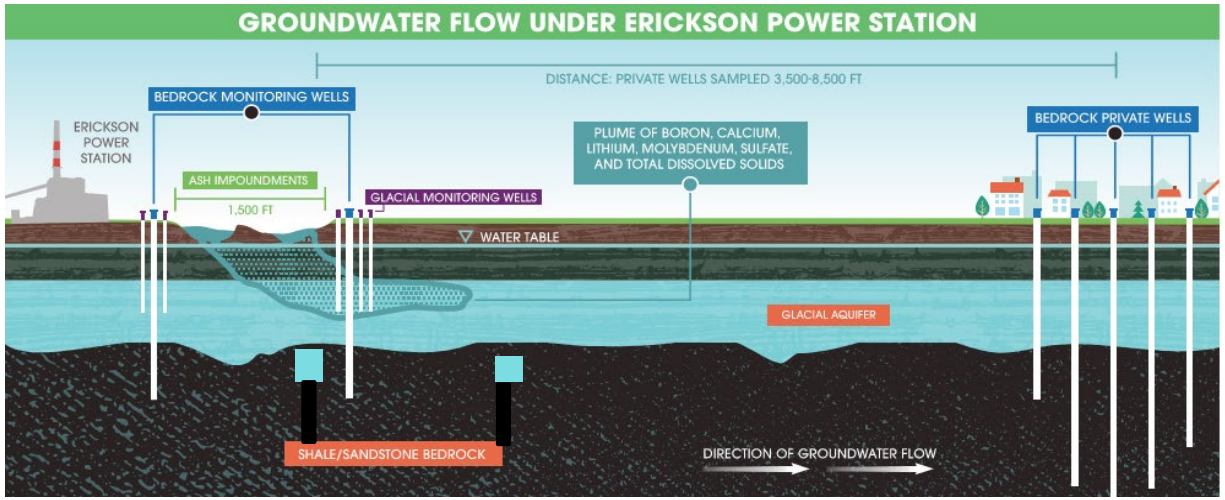
Private Well Sampling

- BWL initiated private well sampling
  - Focus Area - Downgradient of CCR Impoundments at Erickson
  - 59 homes & businesses
  - All private wells are in the deeper Saginaw Bedrock Aquifer (shale & sandstone)
  - Compliance monitoring had been in shallower glacial monitoring (clay, silt, sand)
- BWL initiated bedrock aquifer sampling
  - Install background and downgradient bedrock wells



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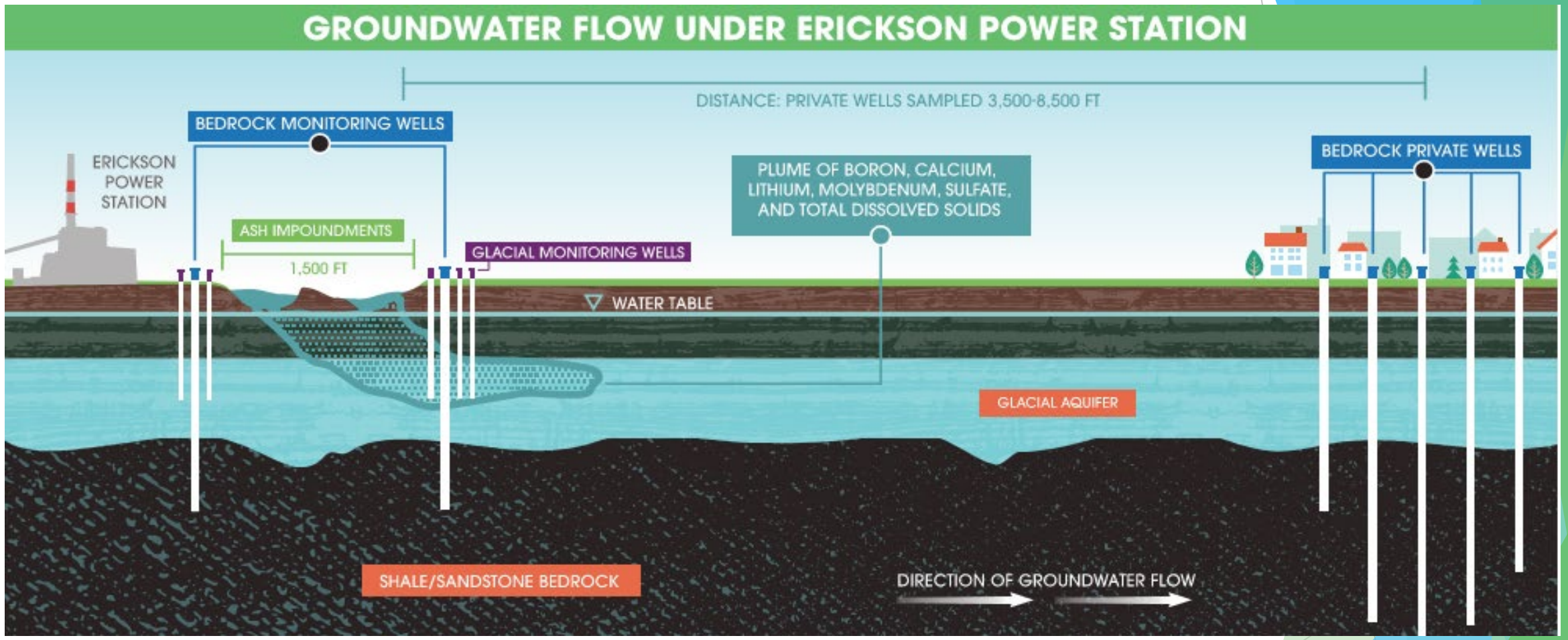

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Private Well Sampling

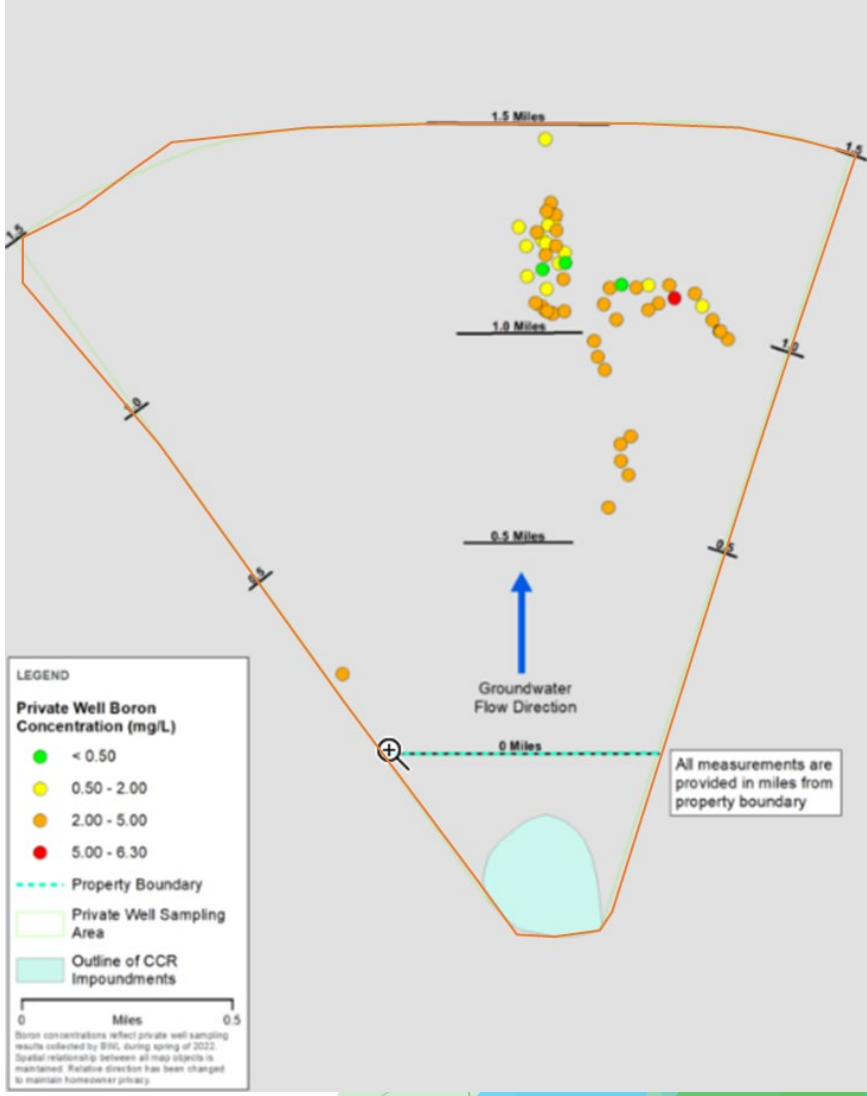
- Where/When
  - 59 homes and businesses within 1.5 mi
  - What we thought at the time was downgradient of the CCR impoundments
  - Majority between Feb – Apr 2022
  - Sampled several homes resampled to confirm results between Mar and May 2022
- Analytical List

Table 1. List of Parameters Analyzed
Bicarbonate
Carbonate
Chloride
Magnesium
Potassium
Sodium
Total Suspended Solids (TSS)
Boron, total and dissolved
Calcium
Lithium, total and dissolved
Molybdenum, total and dissolved
Sulfate
Total Dissolved Solids (TDS)
Fluoride

General Water Quality Parameters

Exceedances at Erickson

EGLE recommended - found with boron in Ingham County Groundwater



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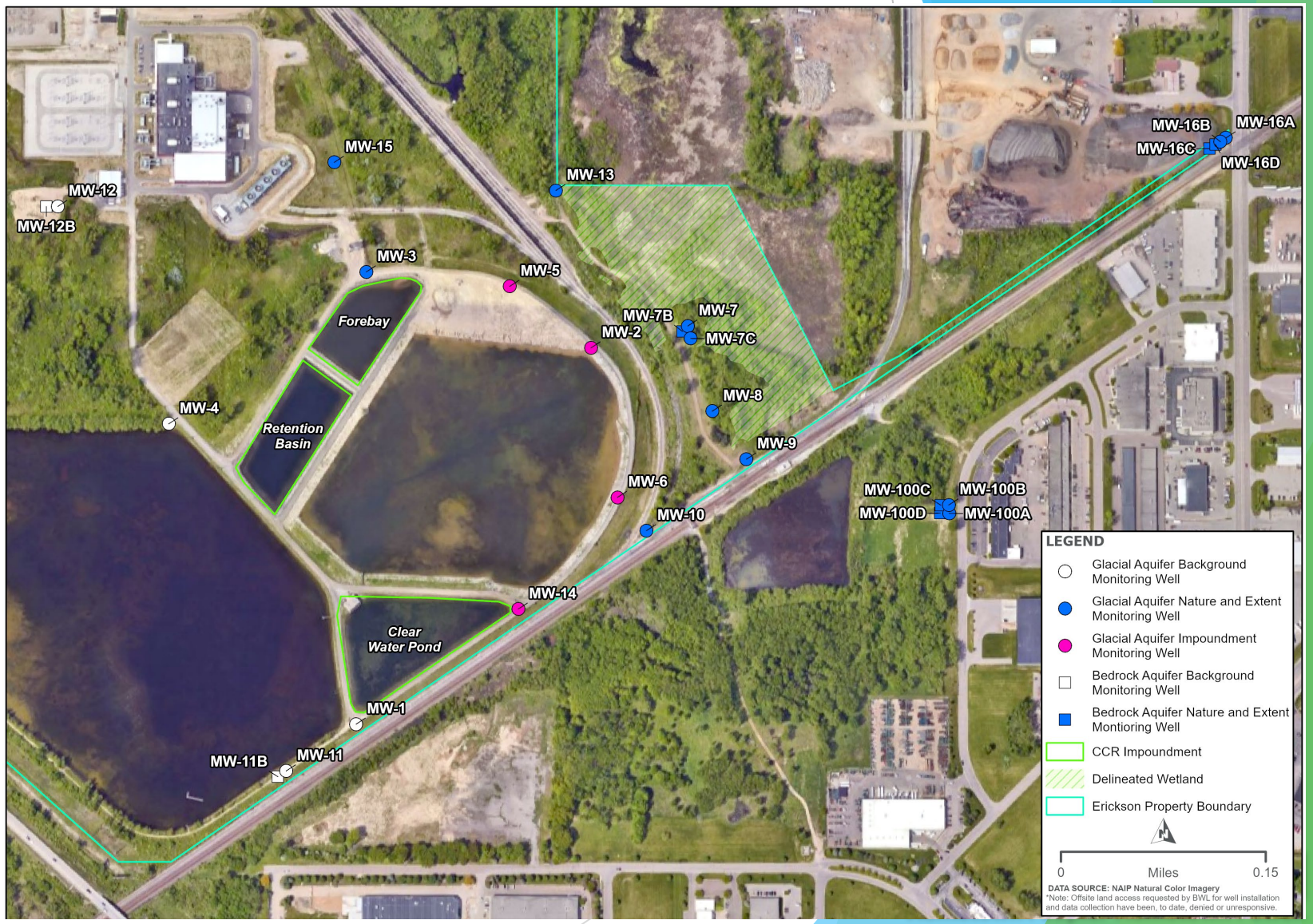
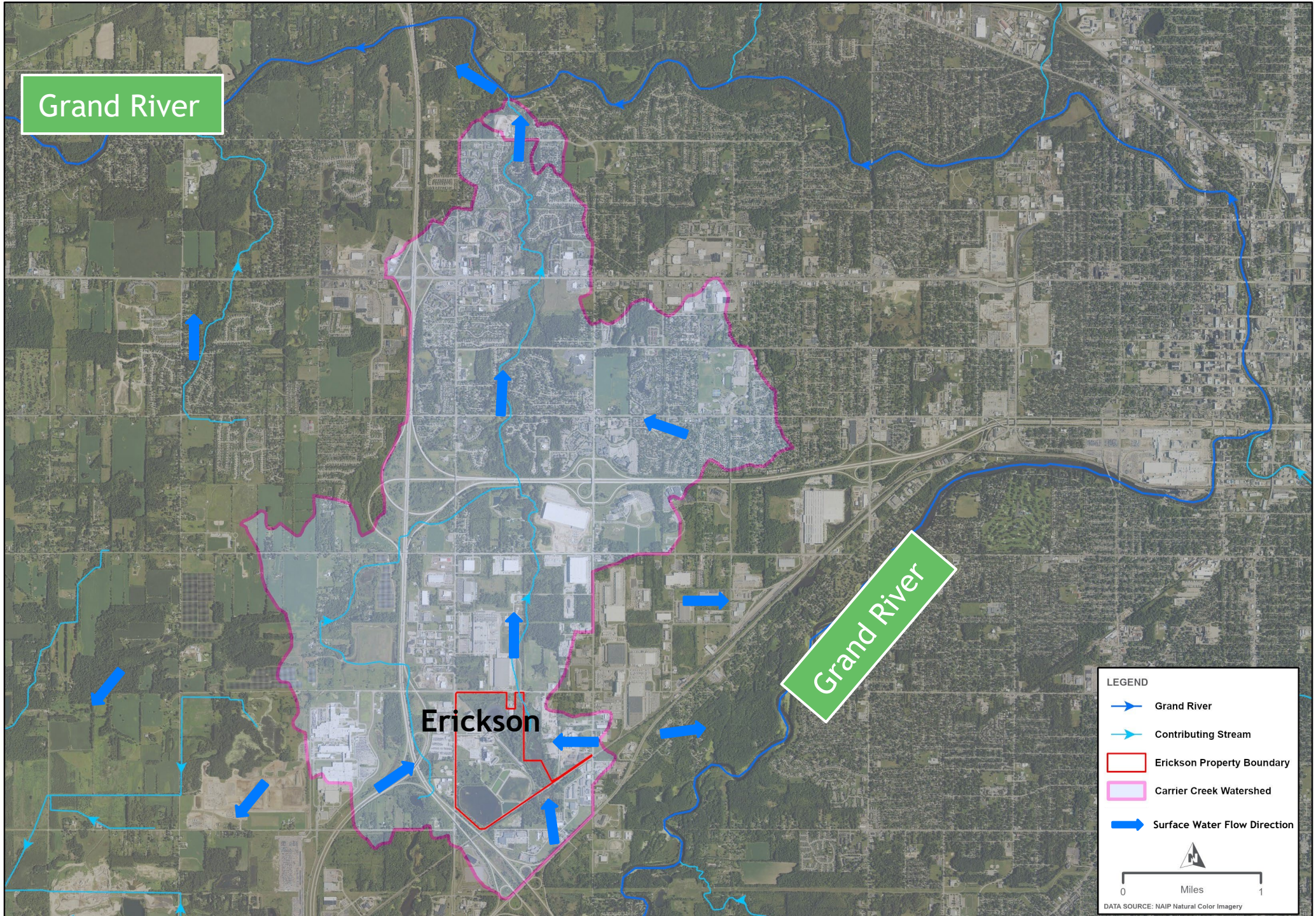
Current Groundwater Monitoring Network

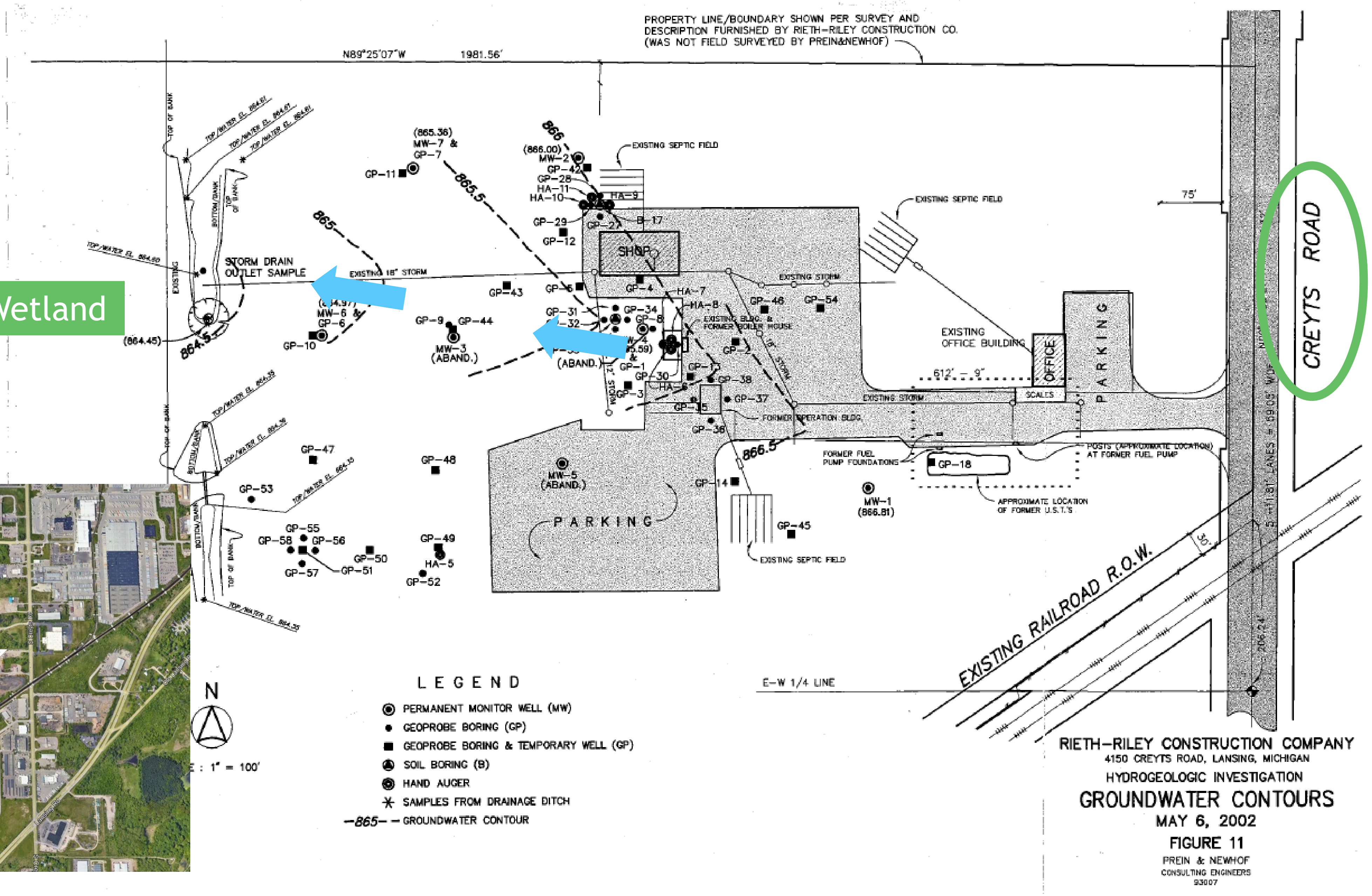
- 27 monitoring wells
  - Glacial
    - Four (4) upgradient
    - 16 downgradient
  - Bedrock
    - Two (2) upgradient
    - Five (5) downgradient
- Seven (7) installed 2022
- 10 installed in 2023



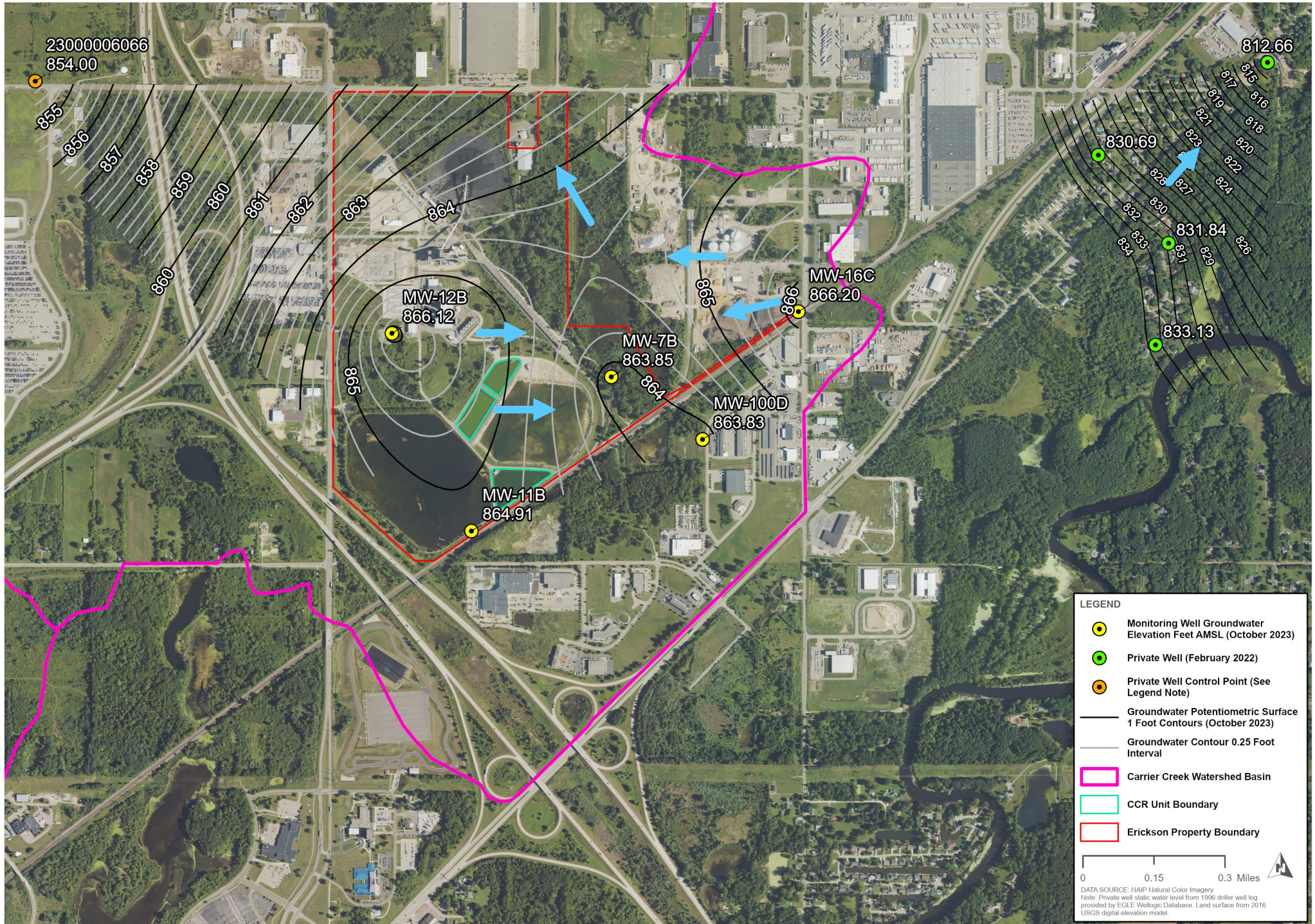
- Glacial aquifer groundwater flow direction

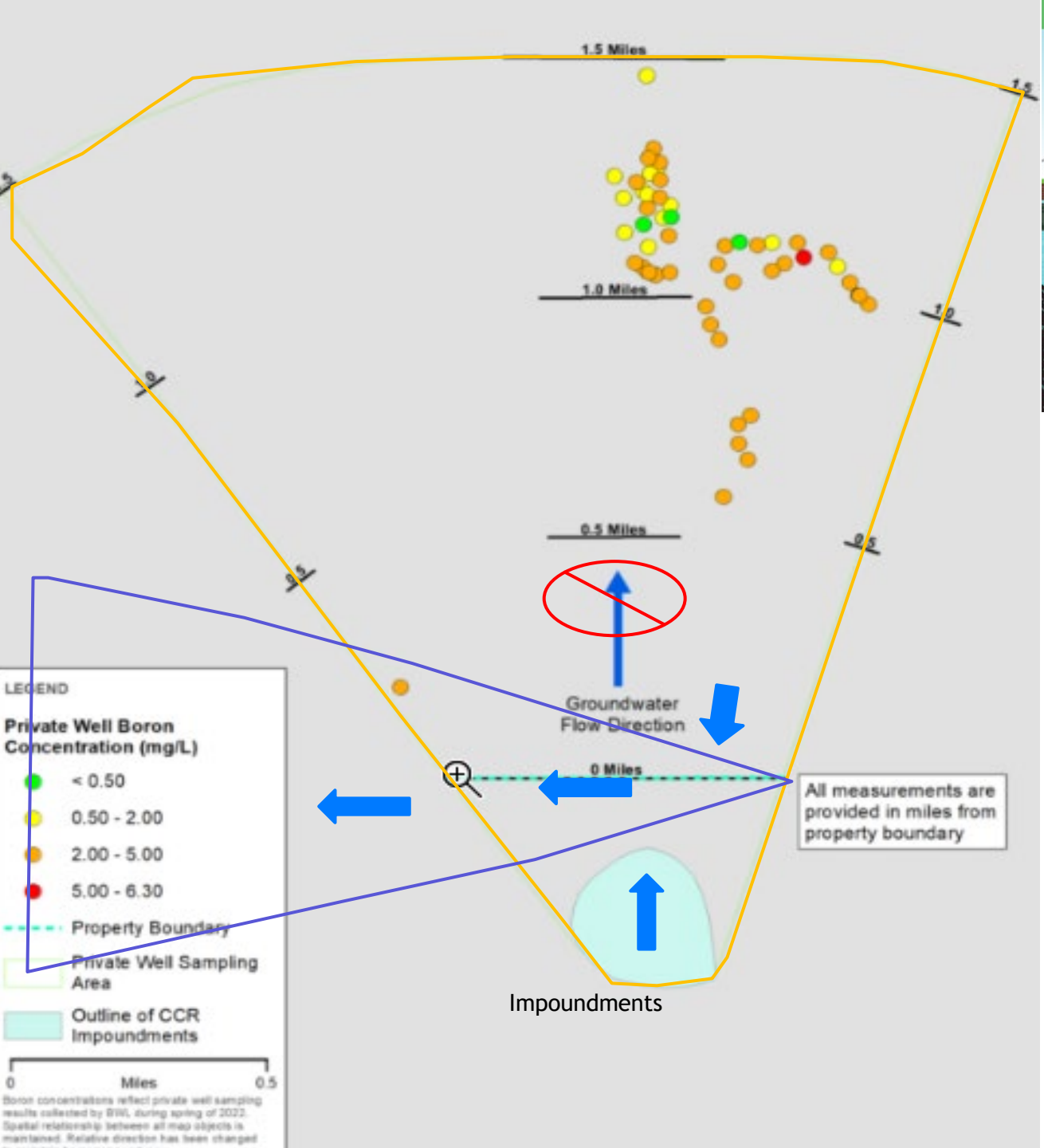

Grand River
Grand River
Erickson
LEGEND
Grand River
Contributing Stream
Erickson Property Boundary
Carrier Creek Watershed
Surface Water Flow Direction
N
0
Miles
1
DATA SOURCE: NAIP Natural Color Imagery

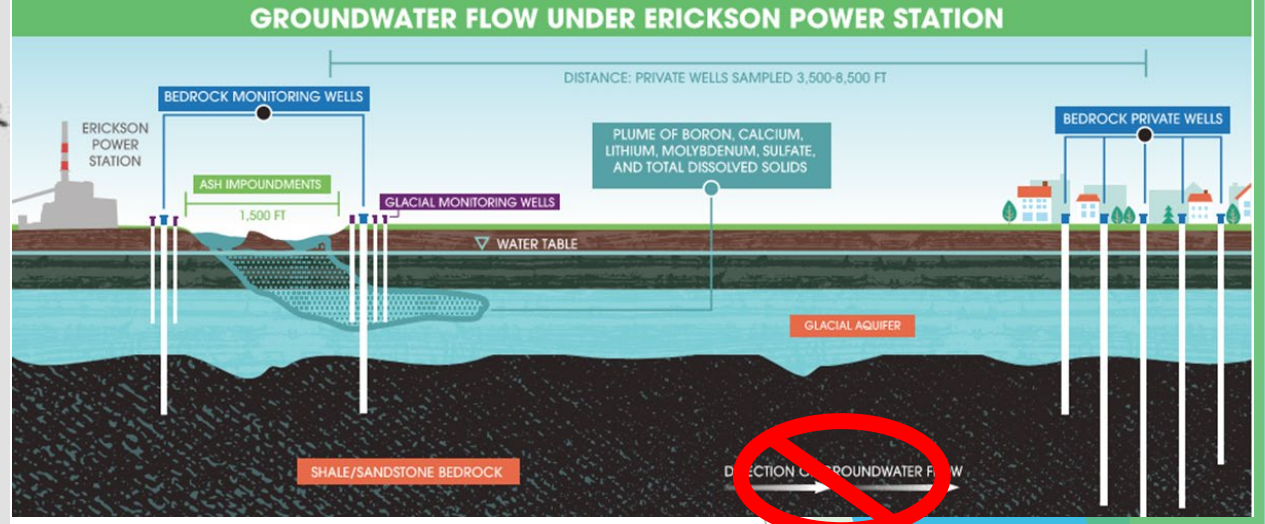
Wetland


PROPERTY LINE/BOUNDARY SHOWN PER SURVEY AND DESCRIPTION FURNISHED BY RIETH-RILEY CONSTRUCTION CO. (WAS NOT FIELD SURVEYED BY PREIN&NEWHOF)
N89°25'07"W
1981.56'
EXISTING SEPTIC FIELD
EXISTING SEPTIC FIELD
EXISTING SEPTIC FIELD
STORM DRAIN OUTLET SAMPLE
EXISTING 18" STORM
EXISTING STORM
SHOP
EXISTING BLDG. & FORMER BOILER HOUSE
EXISTING OFFICE BUILDING
OFFICE
PARKING
PARKING
SCALES
FORMER OPERATION BLDG.
FORMER FUEL PUMP FOUNDATIONS
POSTS (APPROXIMATE LOCATION) AT FORMER FUEL PUMP
APPROXIMATE LOCATION OF FORMER U.S.T.'S
CREYTS ROAD
EXISTING RAILROAD R.O.W.
E-W 1/4 LINE
75'
612' - 9"
865
865.5
866
866.5
864.5
MW-1 (866.81)
MW-5 (ABAND.)
MW-3 (ABAND.)
N
SCALE: 1" = 100'
LEGEND
PERMANENT MONITOR WELL (MW)
GEOPROBE BORING (GP)
GEOPROBE BORING & TEMPORARY WELL (GP)
SOIL BORING (B)
HAND AUGER
SAMPLES FROM DRAINAGE DITCH
-865- - GROUNDWATER CONTOUR
RIETH-RILEY CONSTRUCTION COMPANY
4150 CREYTS ROAD, LANSING, MICHIGAN
HYDROGEOLOGIC INVESTIGATION
GROUNDWATER CONTOURS
MAY 6, 2002
FIGURE 11
PREIN & NEWHOF
CONSULTING ENGINEERS
93007

- Bedrock aquifer groundwater flow direction







- New 2023 wells provide more data that shows the groundwater flow direction flows east to the wetland and then north
- Groundwater from the impoundments does not flow to the private wells that were sampled

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Draft
Glacial Aquifer Boron Plume

Bedrock monitoring wells - no exceedances above bedrock background levels

CONCENTRATIONS OF BORON IN GLACIAL AQUIFER WELLS

ERICKSON POWER STATION

Private Well Sampling Results

- Levels of Boron & Lithium
  - Boron 0.15 – 4.49 mg/L + 1 value at 6.3 mg/L
    - Unregulated in drinking water
    - MDHHS recommended using the EPA Health Advisory Level - 2.0 mg/L for children - we used to define “elevated”
  - Lithium non-detect - 0.096 mg/L
    - Unregulated in drinking water
    - MDHHS recommended using the EPA Regional Screening Level – 0.040 mg/L - we used to define “elevated”
- Molybdenum concentrations were non-detect
- Majority 200-460 feet deep
- Saginaw bedrock aquifer (shale and sandstone), below the glacial aquifer (composed of clays, silts, and sands)
- Wide variety of results - No pattern horizontally or vertically

Reviewed Sampling Results using Numerous Approaches

- Comparison to Background Bedrock Groundwater Quality
- Pattern of Concentrations relative to Depth and Distance
- Plume Geometry
- Transport Solution for Continuous Release to Groundwater
- Flow and Transport Model
- Water quality / Types of waters
- Literature by Others– Ingham County and Delta Township Groundwater Quality Studies
- Lithology correlation with boron
- Boron isotope data
- Groundwater flow direction

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Additional Groundwater Studies

- Rowe, Garry, 1999. Journal of Environmental Health (Ingham County)
  - "statistical analysis confirmed the **correlation between high levels of boron in groundwater and a higher percentage of shale bedrock** in sampled wells"
- Rowe et al. (2021) Ingham County Groundwater Quality Study
  - Found groundwater with elevated concentrations of boron
  - Characterized the **boron** levels as **"naturally occurring"**
    - Associated the higher boron with the shale bedrock
- Rowe (2022) Delta Township Groundwater Quality Study
  - Found groundwater with elevated concentrations of boron
  - Water quality at private wells similar characteristics as observed in the Ingham County study
  - Characterized the **boron** levels as **"naturally occurring"**
    - Associated the higher boron with the shale bedrock

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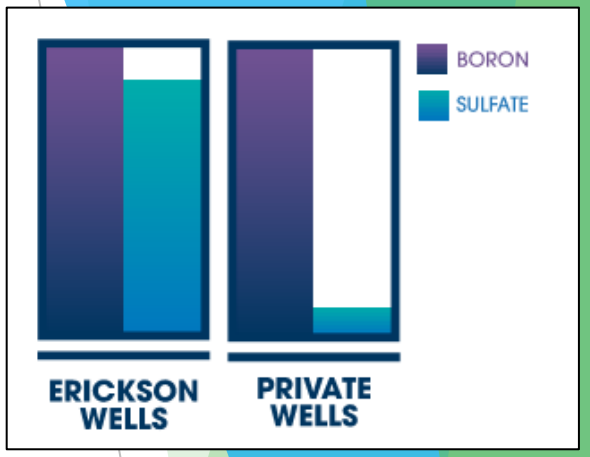
Garry Rowe, RS, MS, Retired Division of Environmental Health, Ingram County Health Department, currently on the Ingram County Board.

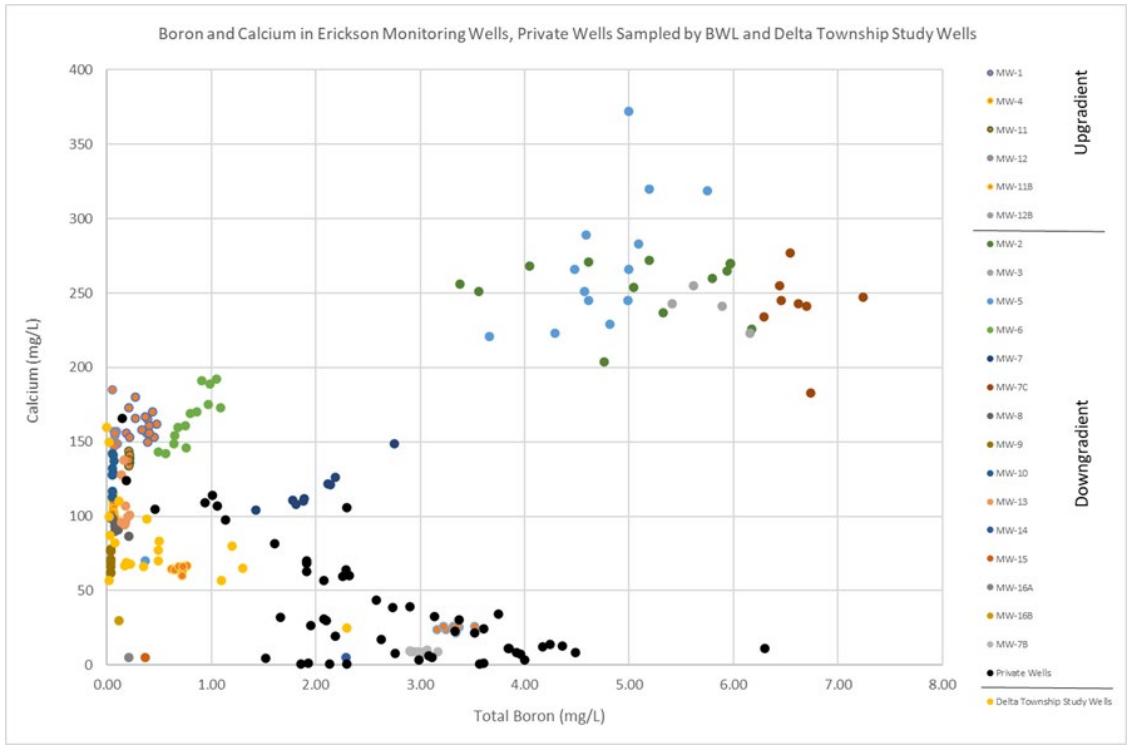
Additional Groundwater Studies

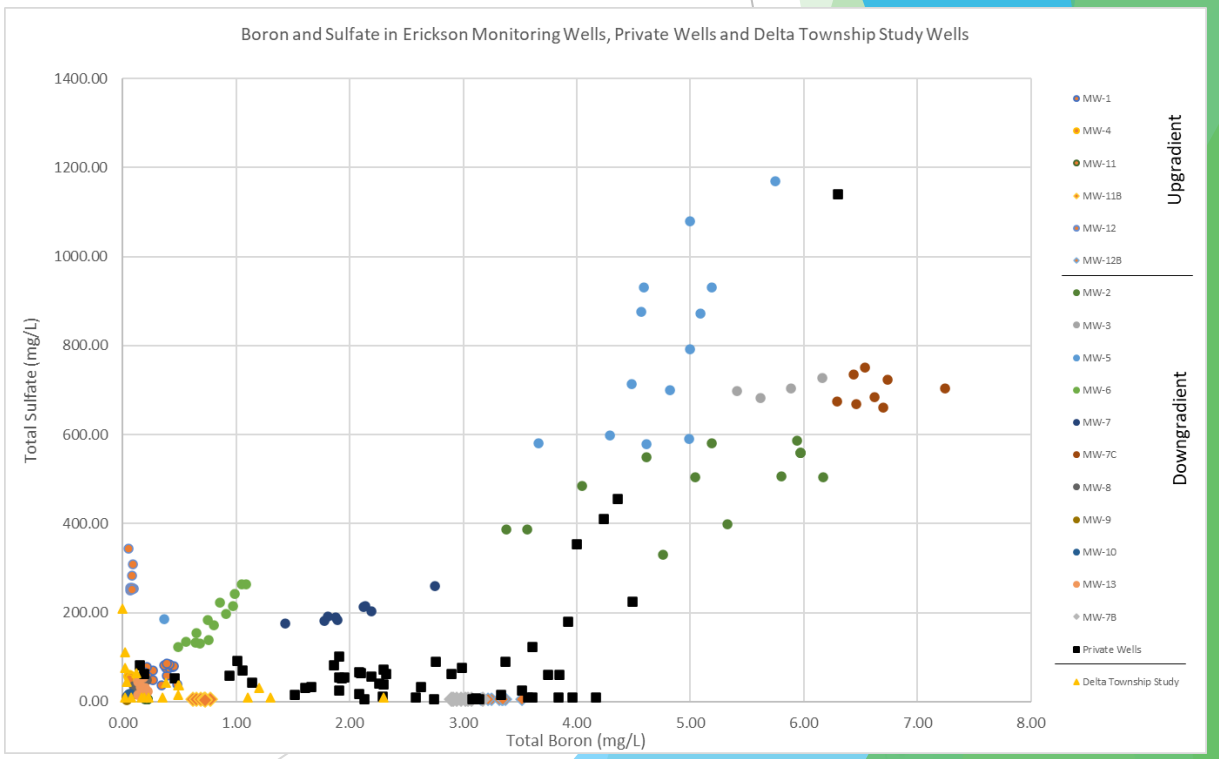
- Slayton, D.S., 1982, Field evidence for shale membrane filtration of groundwater, south-central Michigan: East Lansing, Michigan State University, M.S. Thesis, 80 p.
- Ravenscroft and McArthur, 2004. Mechanism of regional enrichment of groundwater by boron: the examples of Bangladesh and Michigan, *Applied Geochemistry*, Volume 19, Issue 9, September 2004, Pages 1413-1430
  - "**Boron has desorbed from mineral surfaces** as freshwater flushing displaces saline waters from the aquifers."
- USGS, 2007. Evaluation of Ground-Water and Boron Sources by Use of Boron Stable-Isotope Ratios, Tritium, and Selected Water Chemistry Constituents near Beverly Shores, Northwestern Indiana
  - Characterized the **boron** levels as **"naturally occurring"**
    - Associated the higher boron with the shale bedrock

Water Quality Comparisons between Private Wells and the Monitoring Wells at Erickson

- Boron and sulfate correlate in groundwater impacted by CCR
  - Not the case for private wells
- Boron and calcium correlate in groundwater impacted by CCR
  - Not the case for private wells



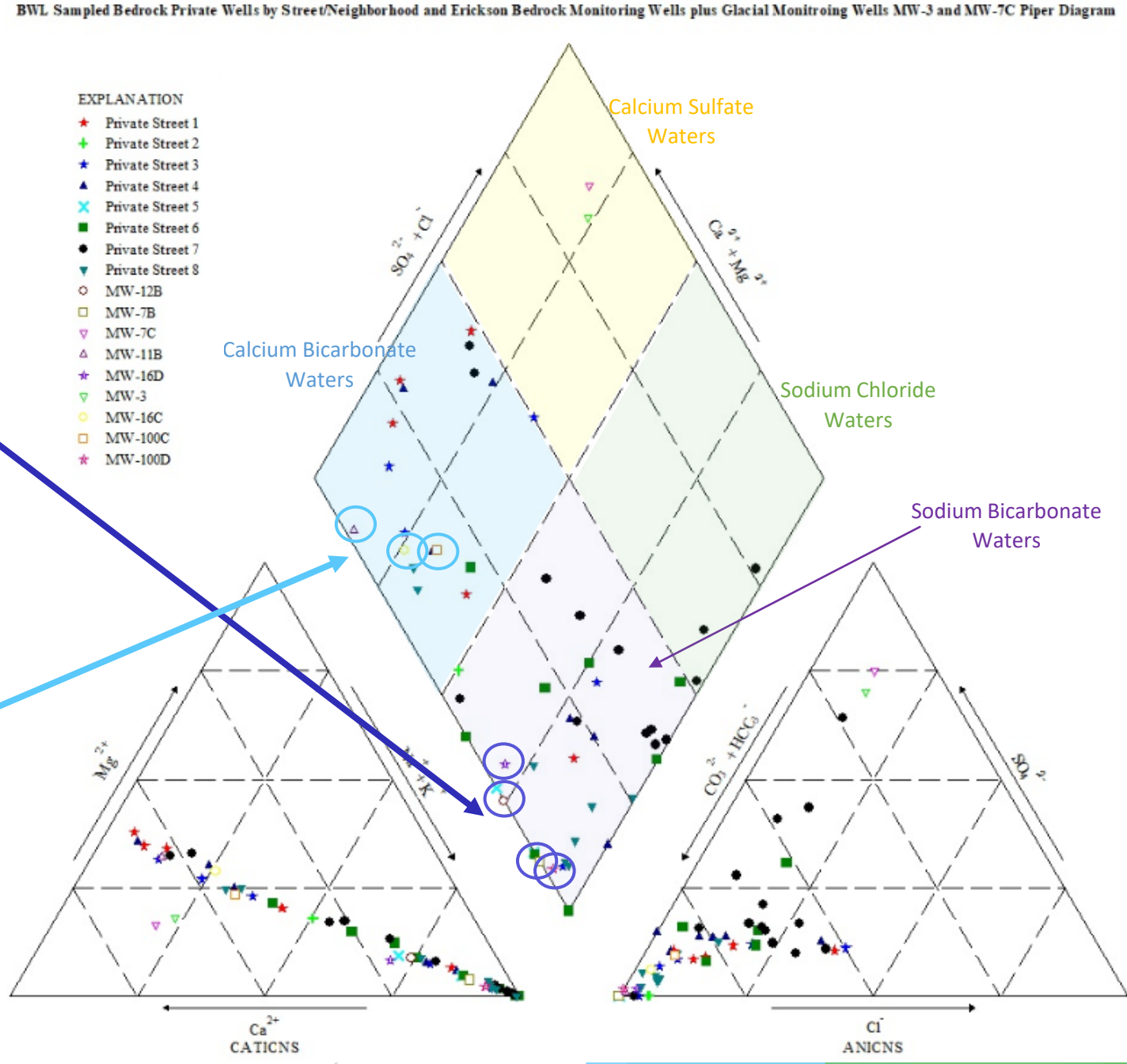




Differing Types of Water

- Higher sodium levels
- Very low water hardness
- Higher pH
- Higher concentrations of boron (3.0 mg/L and up)
- Highest percent of shale in the well screened interval (80-100% of the well screen is in shale)

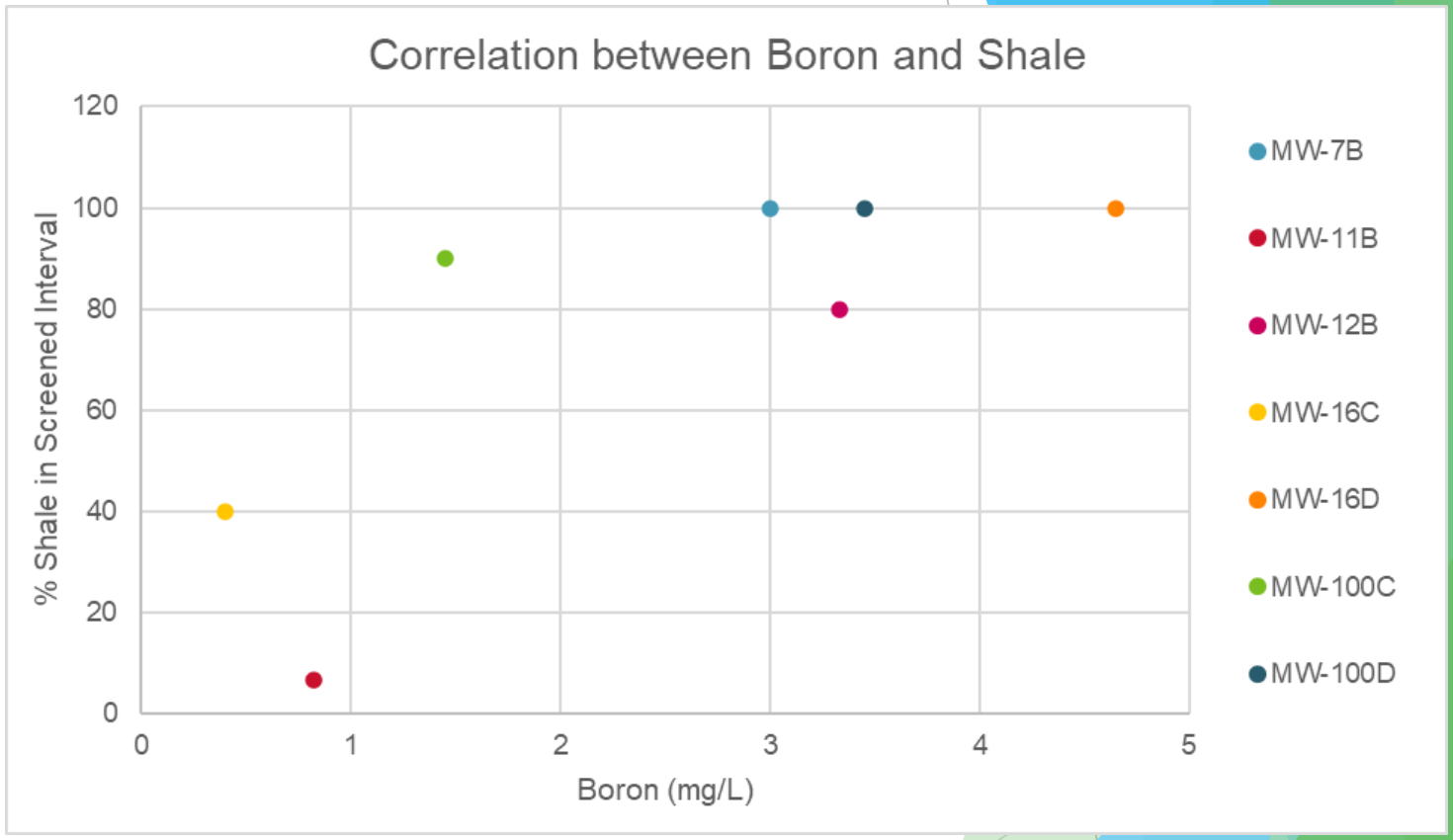
- Lower sodium levels
- Higher water hardness
- Lower pH
- Lower concentrations of boron (<1.45 mg/L)
- Lower percent of shale in the well screened interval (7-40% of the well screen is in shale)



Boron Concentrations in Bedrock Aquifer Correlate to Shale

↑ Shale = ↑ Boron

- This correlation implies we would expect wells completed in significant thicknesses of shale in the Saginaw Formation to have groundwater with higher boron



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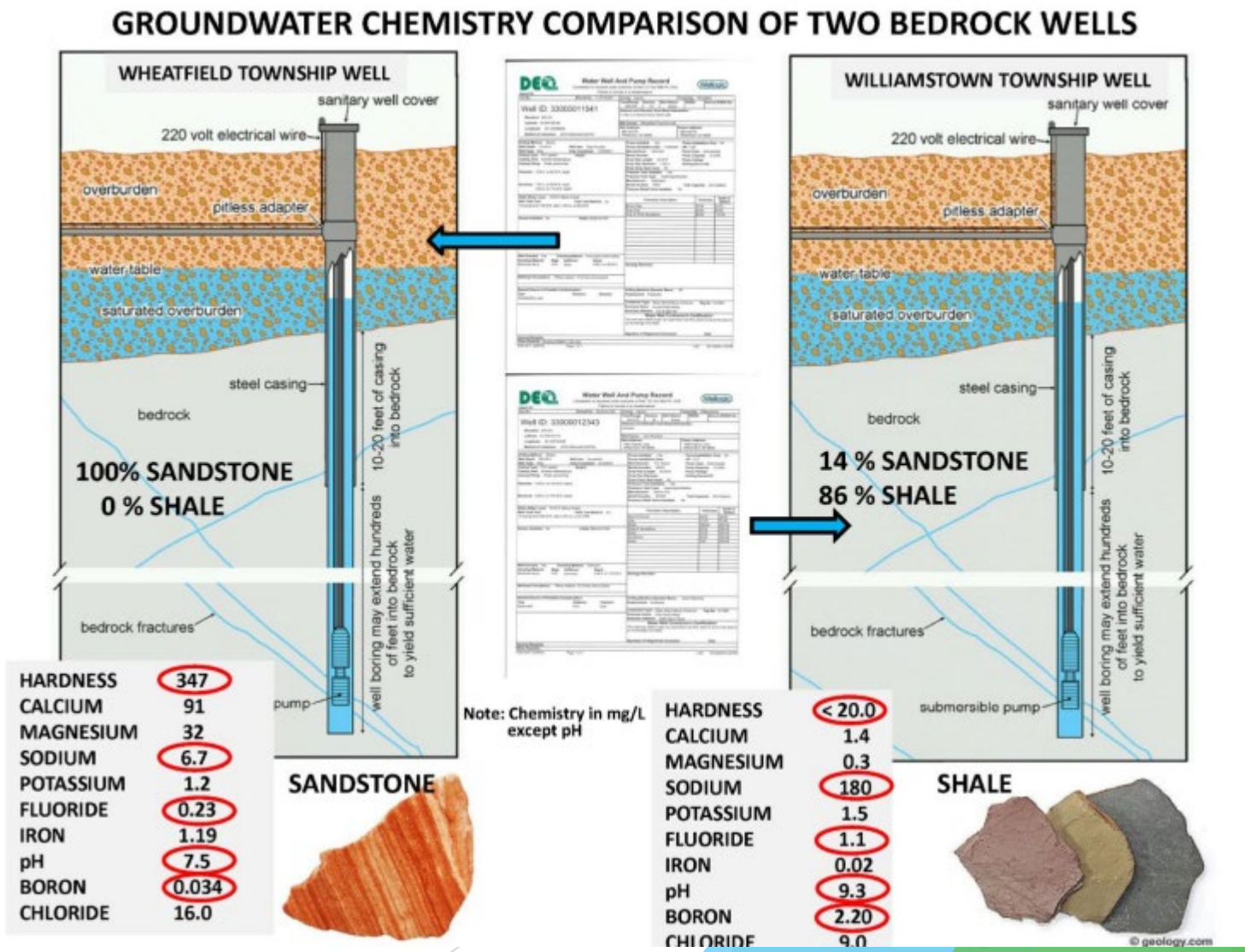
Differing Types of Water Due to Rock Type

- Rowe et al. (2021) Ingham County groundwater study
- Saginaw bedrock groundwater (shale and sandstone) just like Delta Township
- Correlation between the rock type and the groundwater chemistry
- Hard water / soft water
- Shale like a water softener

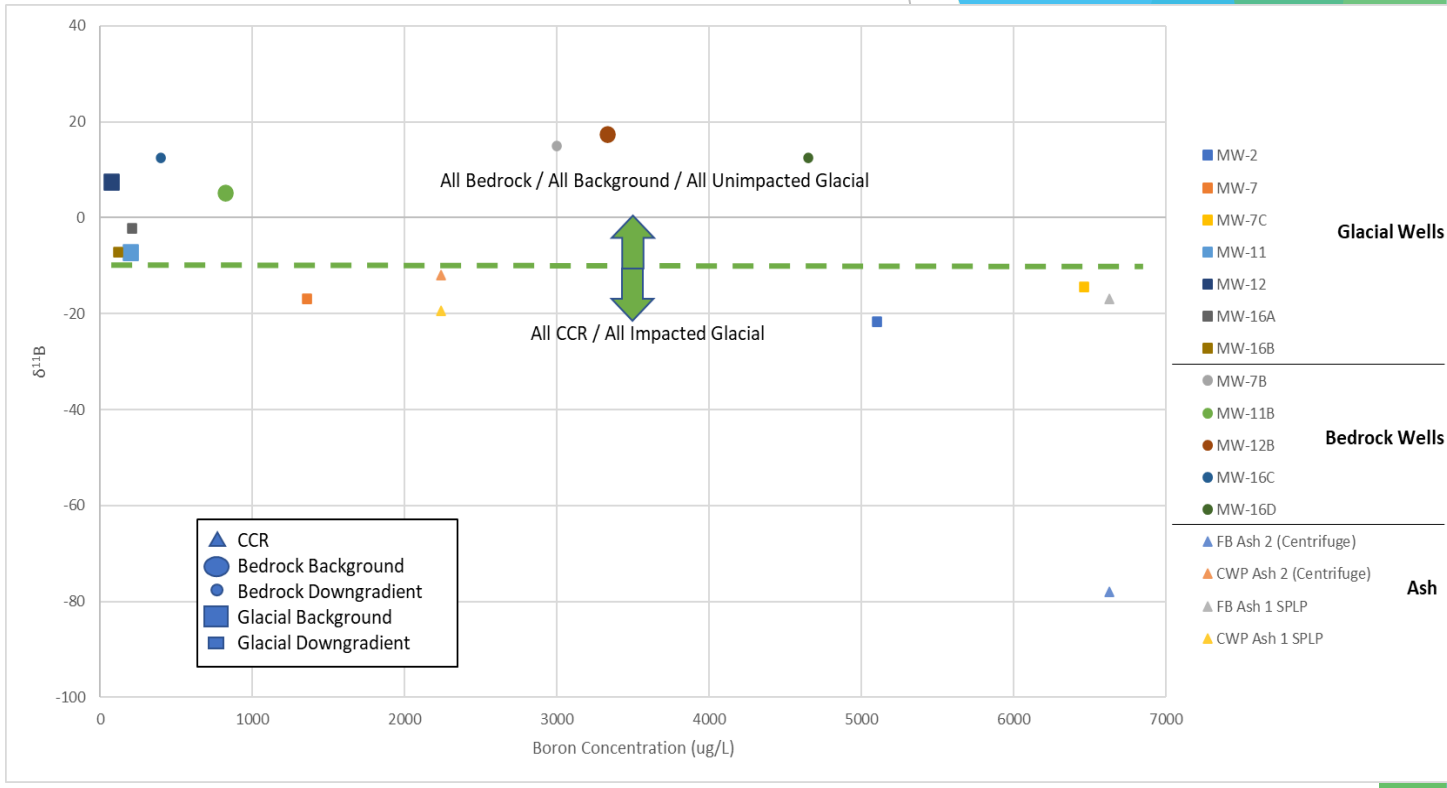


Rowe et al. (2021)

Boron Isotopes of Ash, Impacted and Unimpacted Groundwater

Higher $\delta^{11}B$	Lower $\delta^{11}B$
• Background wells • Unimpacted glacial wells • **Bedrock wells**	• CCR Ash • Impacted Wells

- Bedrock wells isotopic boron makeup more similar to the *background* water and *unimpacted* groundwater



$$\delta^{11}B=\{[(^{11}B/^{10}B)_{sample}-(^{11}B/^{10}B)_{standard}]/(^{11}B/^{10}B)_{standard}\}*1000$$

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Private Well Summary

- All data review approaches suggested the same interpretation
  - boron concentrations in private wells appear to be naturally occurring and from the shale
- Plausible given similarities with the Ingham County groundwater study
  - Same shale and no CCR source
- BWL presented to the regulatory agencies intent not to sample private wells further at this time, met with verbal approval

Impoundment Physical Closure

Before

Impoundment Physical Closure

During

Impoundment Physical Closure

After

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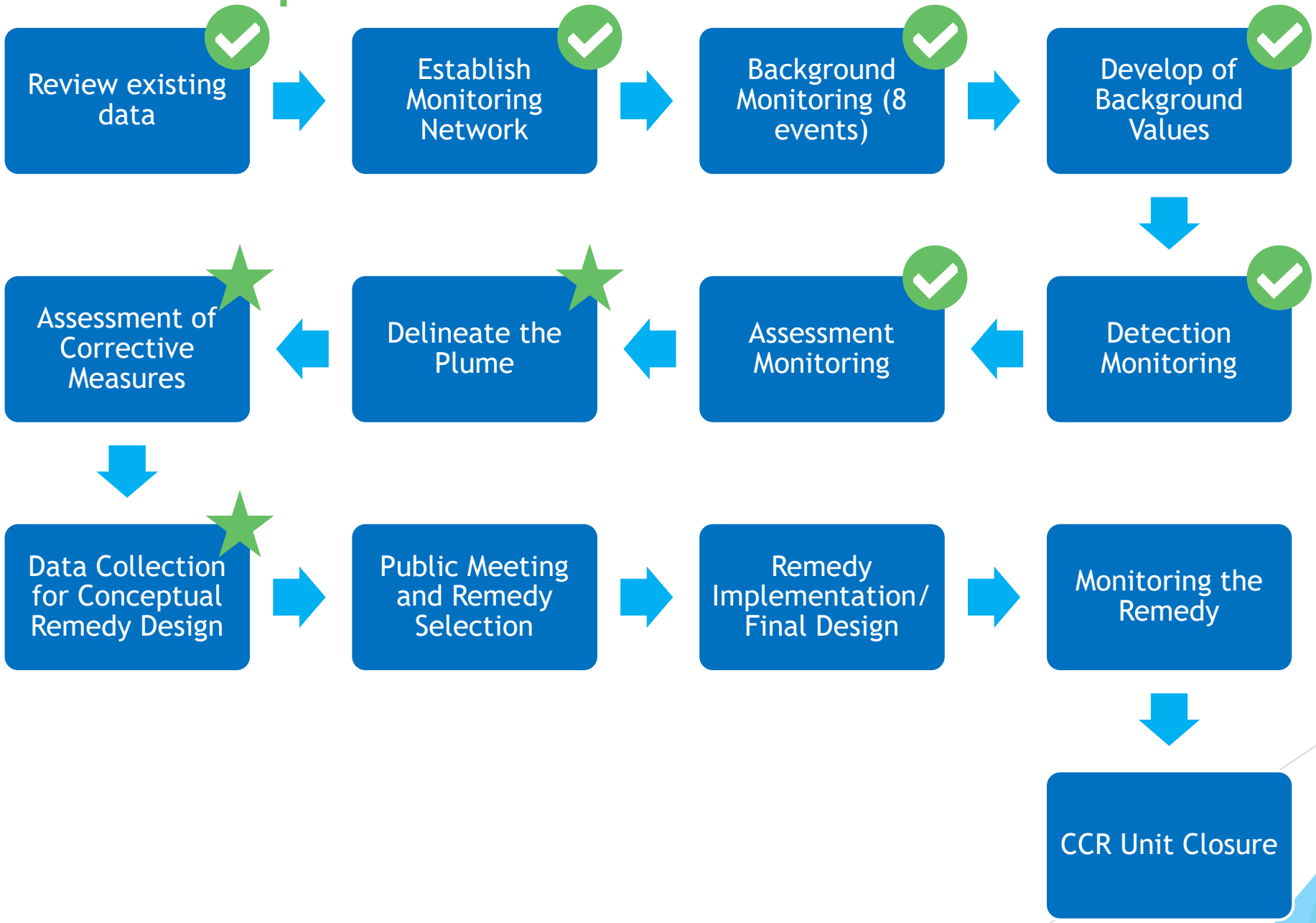
CCR Compliance Process



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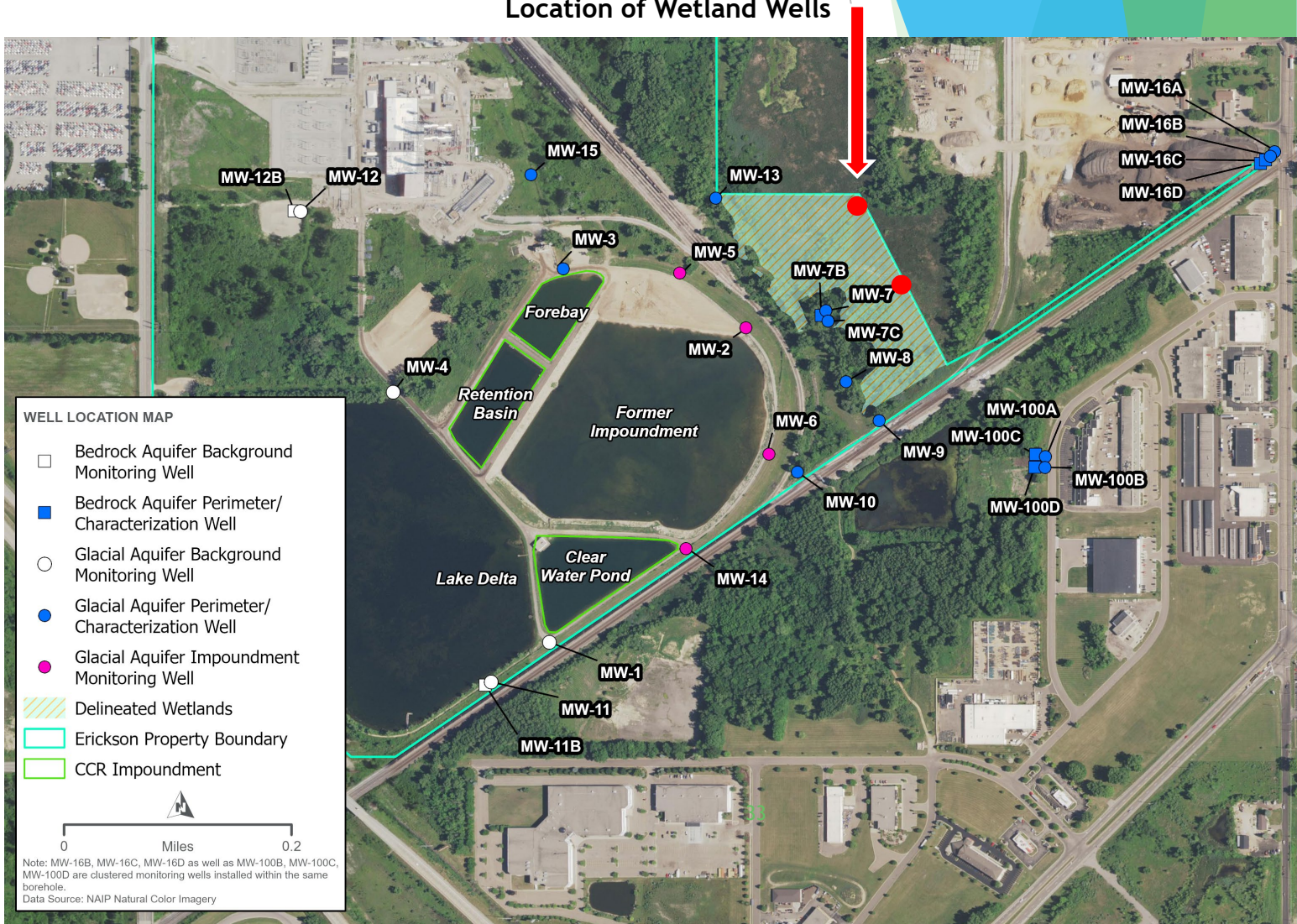
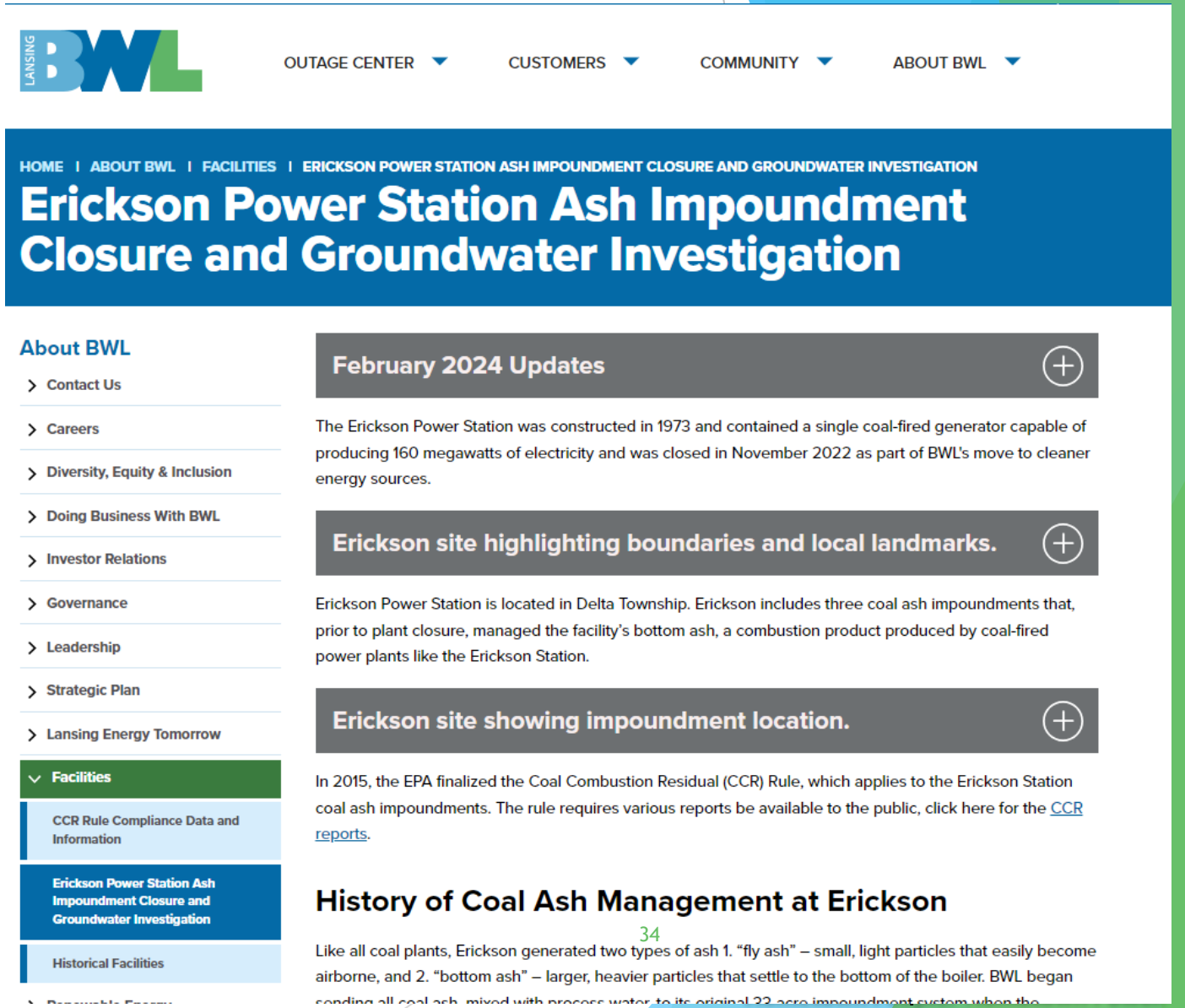
Next Steps

- Continued groundwater assessment monitoring and reporting
- Installation of wetland wells to delineate plume on east side
- Pump test to evaluate pumping capacity for remediation alternatives
- Additional data gathering for remediation



For Information Regarding Ongoing Investigation Visit our Website

www.lbwl.com/closure



Reference Slides

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Sampling, Analysis, & Statistics

- GPS = MCL drinking water std or site-specific background, whichever is higher
- GPS – becomes site specific cleanup standard

- Semiannual monitoring
- Establish site-specific background values from upgradient groundwater quality
- 6 constituents above **Groundwater Protection Standards (GPS)** in glacial aquifer
  - Boron, Lithium, Molybdenum, Calcium, Sulfate, Total Dissolved Solids

Requires Groundwater Remediation, "plume", "contamination"

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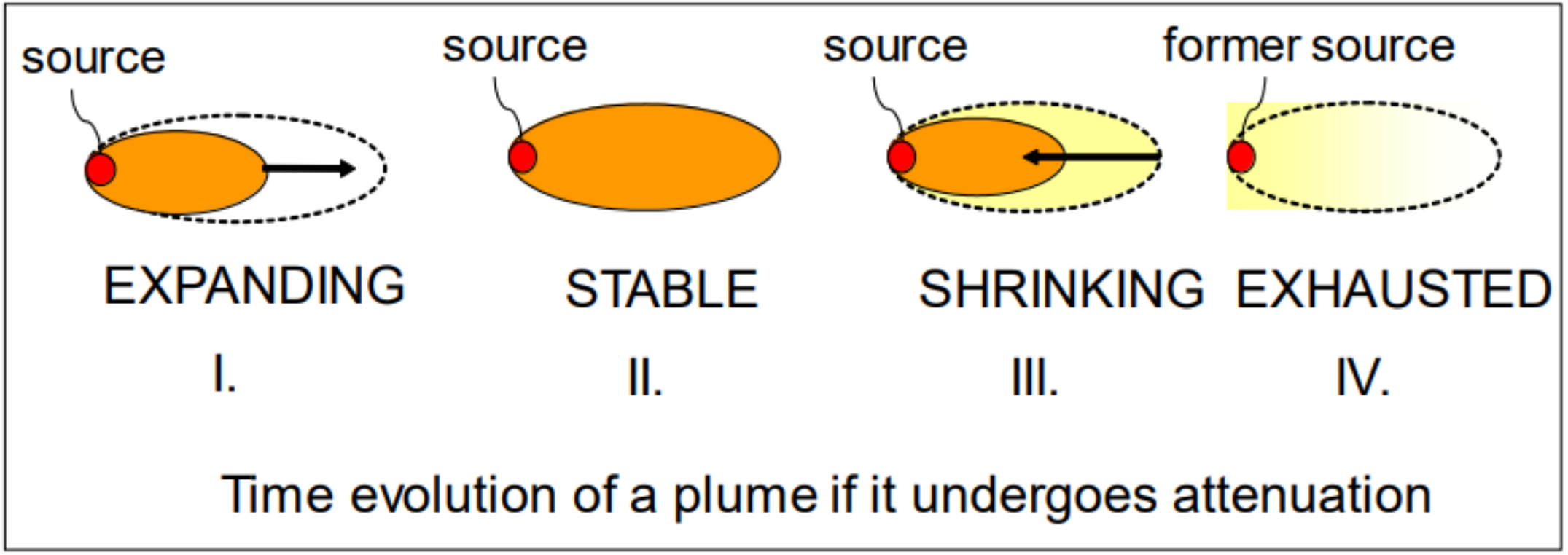
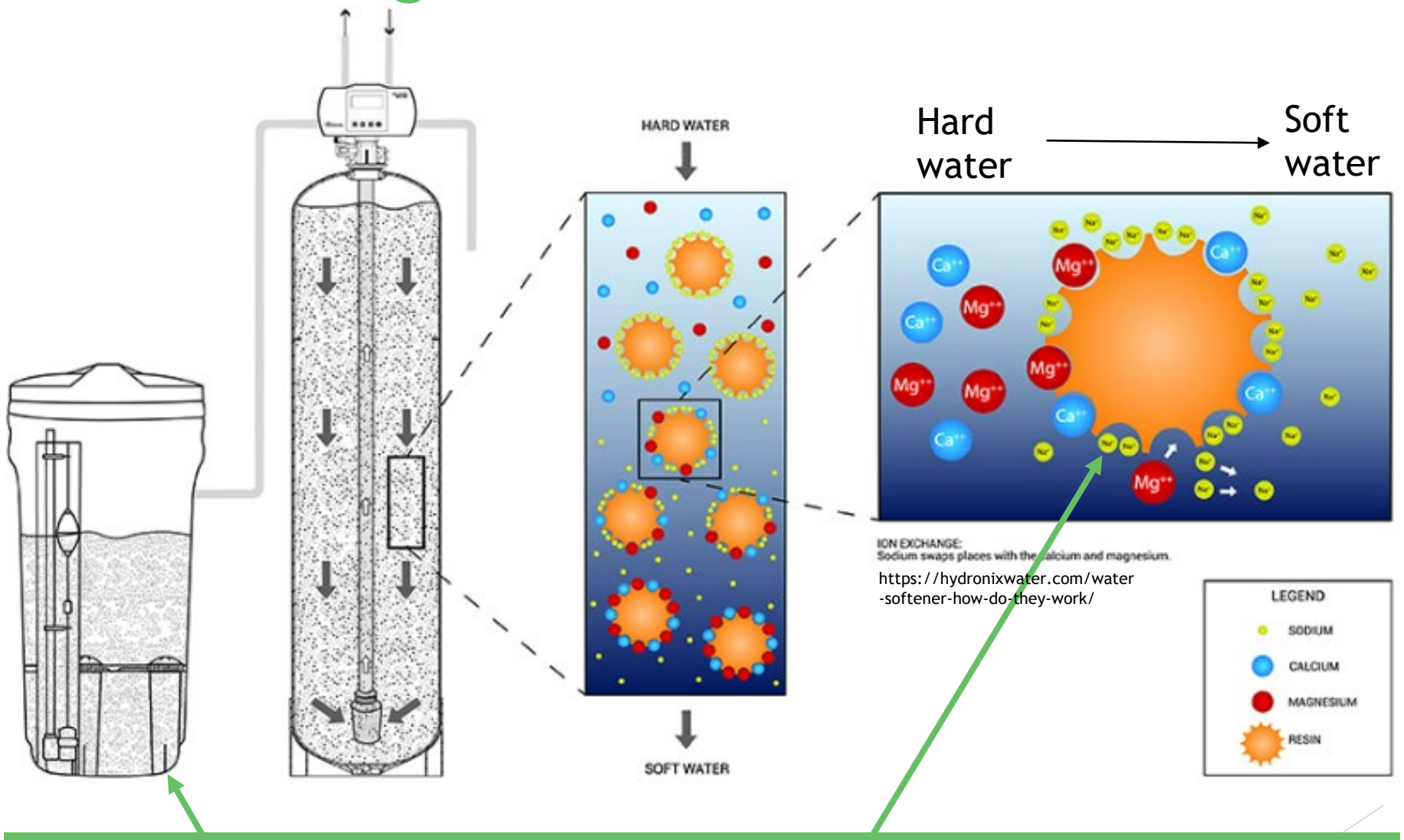
Plume Dynamics



Savannah River National Laboratory, U.S. DOE Project
https://www.energy.gov/em/articles/sustainable-remediation-approaches-using-common-sense-approach-enhanced-attenuation

Shale is Acting like a Water Softener



- Salt provides the sodium = NaCl
- Ion exchange = sodium swaps places with the calcium and magnesium

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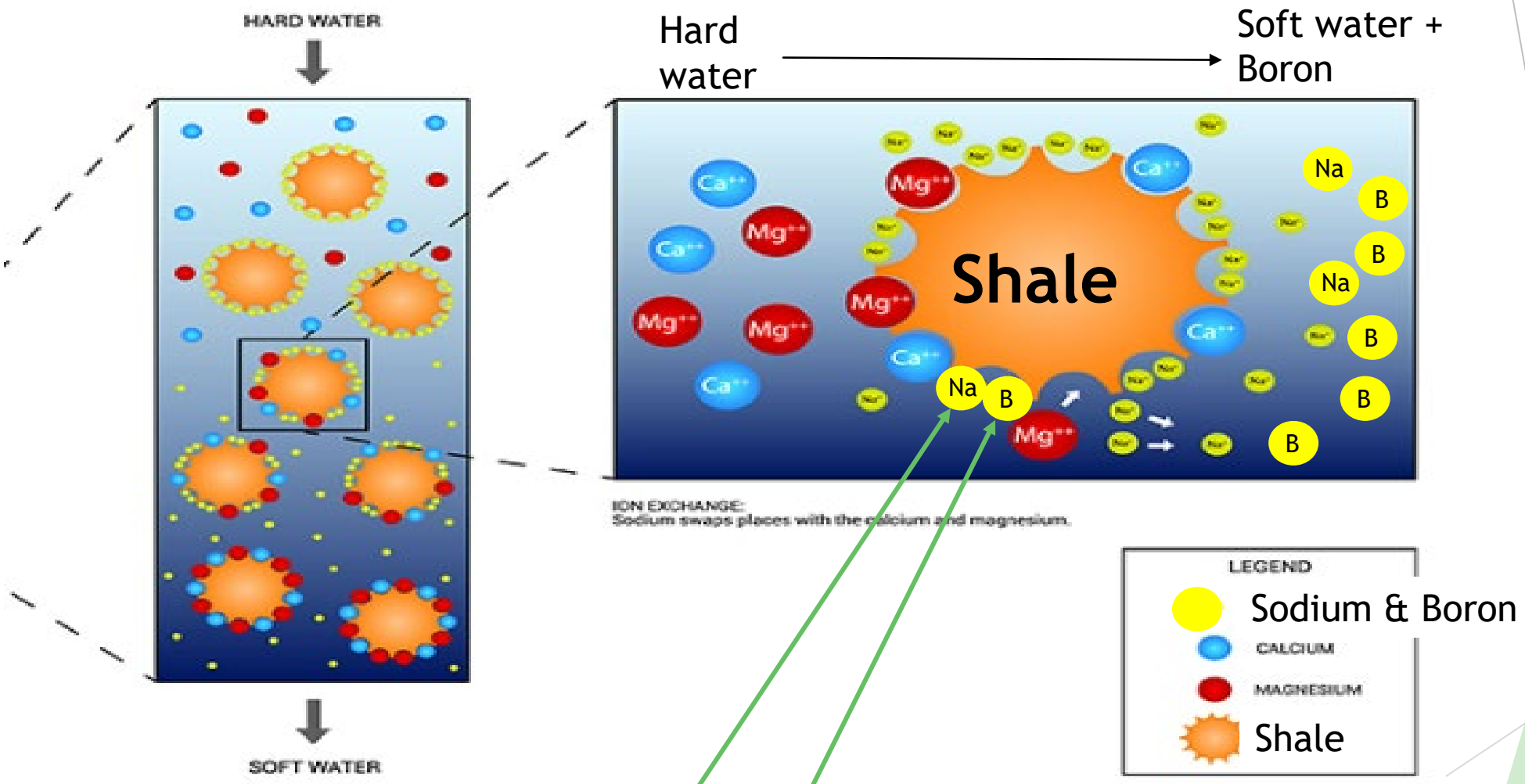
Shale is Acting like a Water Softener



- Shale (sea water chemistry) = salt + boron
- Ion exchange = sodium & boron swaps places with the calcium and magnesium

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Draft Glacial Aquifer Lithium Plume

CONCENTRATIONS OF LITHIUM IN GLACIAL AQUIFER WELLS

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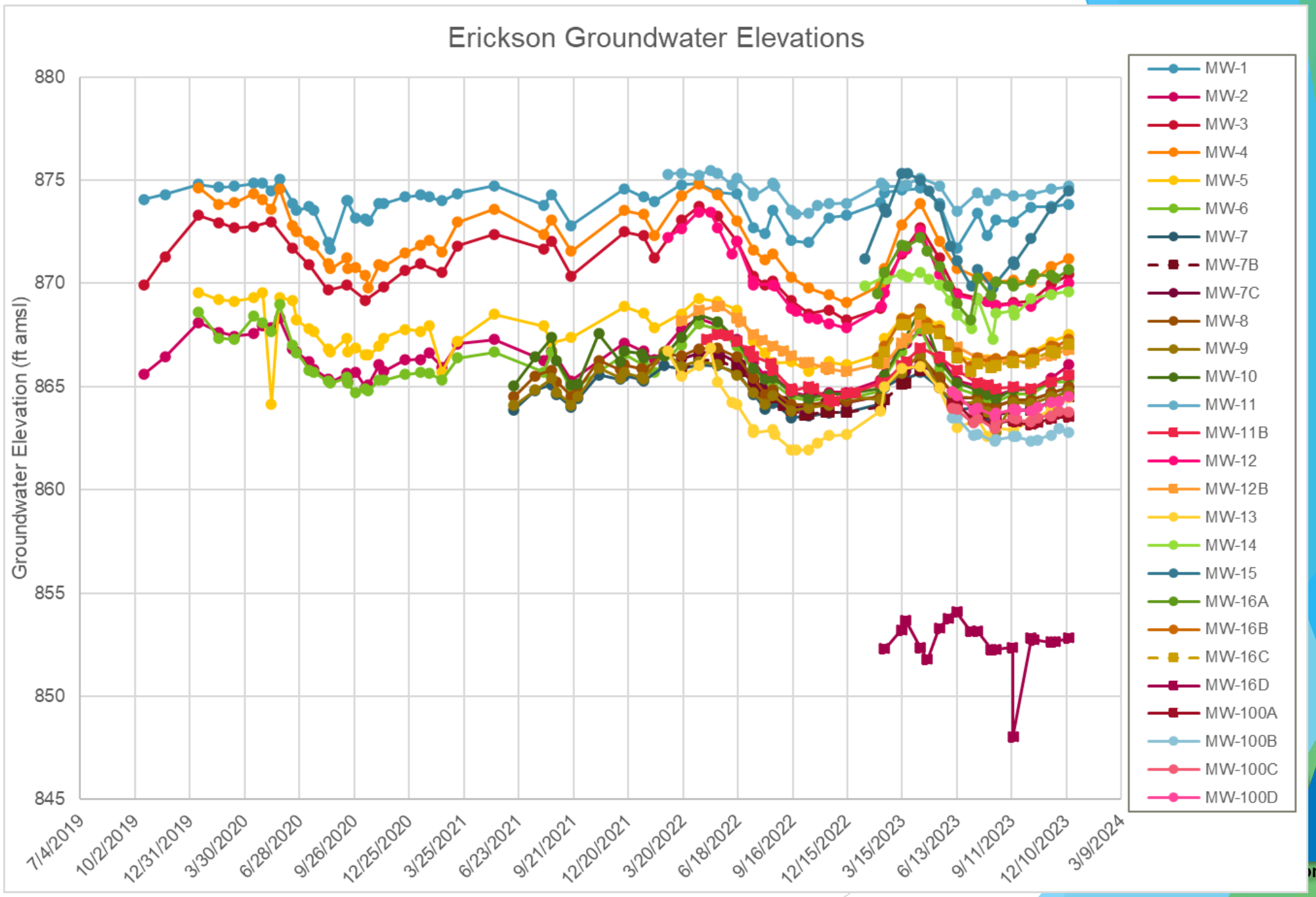
Erickson Groundwater Elevations
Groundwater Elevation (ft amsl)
880
875
870
865
860
855
850
845
7/4/2019
10/2/2019
12/31/2019
3/30/2020
6/28/2020
9/26/2020
12/25/2020
3/25/2021
6/23/2021
9/21/2021
12/20/2021
3/20/2022
6/18/2022
9/16/2022
12/15/2022
3/15/2023
6/13/2023
9/11/2023
12/10/2023
3/9/2024
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-7B
MW-7C
MW-8
MW-9
MW-10
MW-11
MW-11B
MW-12
MW-12B
MW-13
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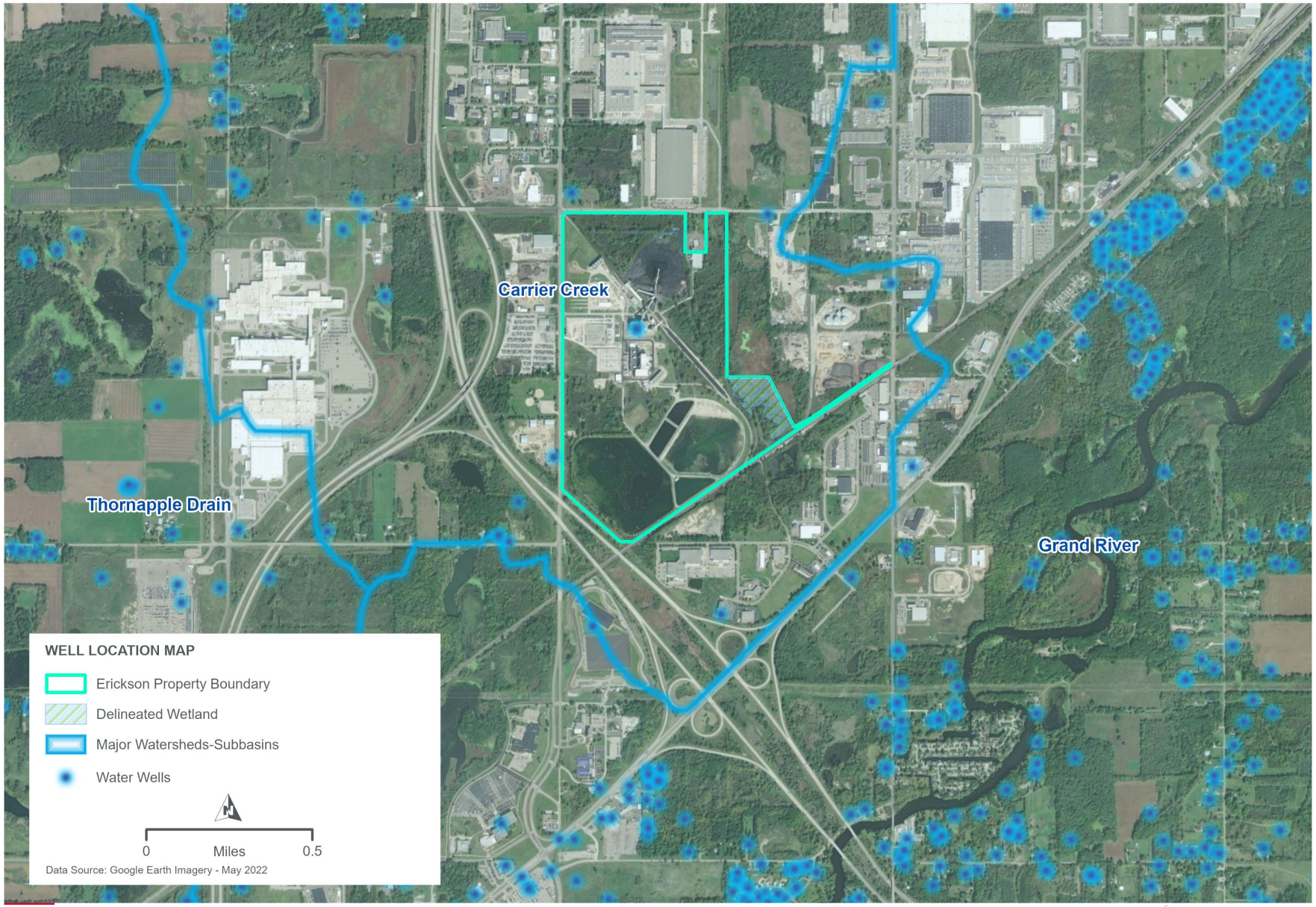
MW-16D
MW-100A
MW-100B
MW-100C
MW-100D



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Plume Geometry

- If the data represented a plume of boron, the plume geometry would not match what is typically seen in contaminant transport, because the plume would be wider and deeper than typical
- 6.3 mg/L boron is near a residence with a concentration of 0.19 mg/L