Groundwater Mapping in Lincoln and Sanders Counties; Study Area Introduction, Publications, and the Role that Long-Term Data Sets Play in Answering Local Concerns

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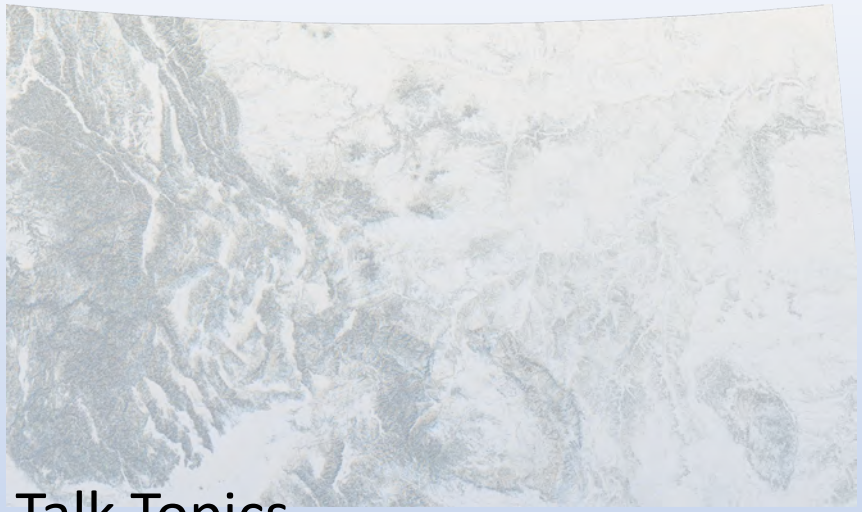
[1] Montana Bureau of Mines and Geology, Montana Ground Water Assessment Program

[2] University of Montana



Talk Topics

Introduce you to:

- *MBMG and the Groundwater Assessment Program*
- *The Lincoln and Sanders Counties Study Area and Our Work*
- *First Publications Out*

and finally

- *Discuss a local land-owner concern that Involves precipitation history and groundwater fluctuation*

Horseshoe Lake, Chain of Lakes, Lincoln County

Montana Bureau of Mines and Geology

A department of Montana Tech

- Established in 1919 to provide reliable and unbiased earth science information

- Non-regulatory, applied research
  - Geologic Mapping
  - Geohazards/Earthquake studies
  - Economic Geology
  - Environmental Assessment
  - Data Preservation
  - Groundwater

- **All data we collect is available to the public**

http://www.mbmg.mtech.edu/

MBMG Ground Water Assessment Program

"…systematically assess and monitor the state's ground water and to disseminate the information…"

85-2-902(2) MCA

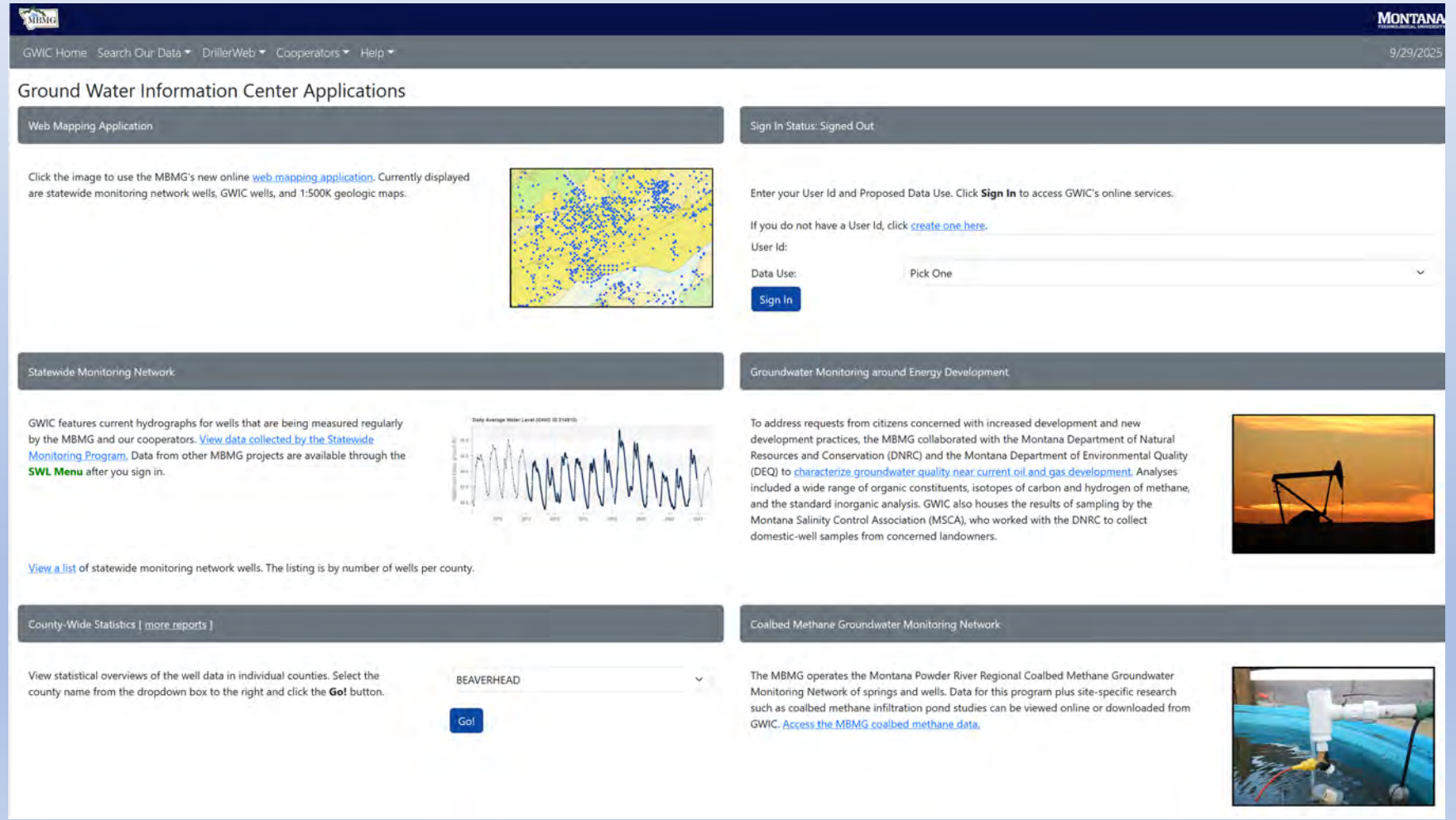
<u>Mandate accomplished in 3 parts</u>

- Groundwater Information Center
- Long-Term Groundwater Monitoring
- County-Scale Groundwater Mapping

Disseminating Information

Ground Water Information Center (GWIC)

- …houses all MBMG groundwater data



MBMG GIS Data Hub: Water Resources

GIS Data Hub

Home Geology Geohazards Water Resources Environmental Energy Resources Mineral Resources

Water Resources

This site presents maps and apps of water resources made by the GIS team at the MBMG. For more information about the MBMG's water programs, please go to the MBMG website

Ground Water Monitoring Map

The Ground Water Information Center (GWIC) database is the repository for the State's ground water information. It stores all the MBMG ground water data from past to current projects. The map below displays locations of the GWIC wells as well as statewide monitoring network wells (GWAMMON wells).

Groundwater Monitoring

Locations of GWIC wells and GWAAMON wells used by the MBMG to monitor ground water conditions. Data come from the Groundwater Information Center (GWIC) databas...

Surface-Water Monitoring Map

This map displays locations of water gaging stations monitored and maintained by the MBMG and other agencies.

Surface-Water Monitoring

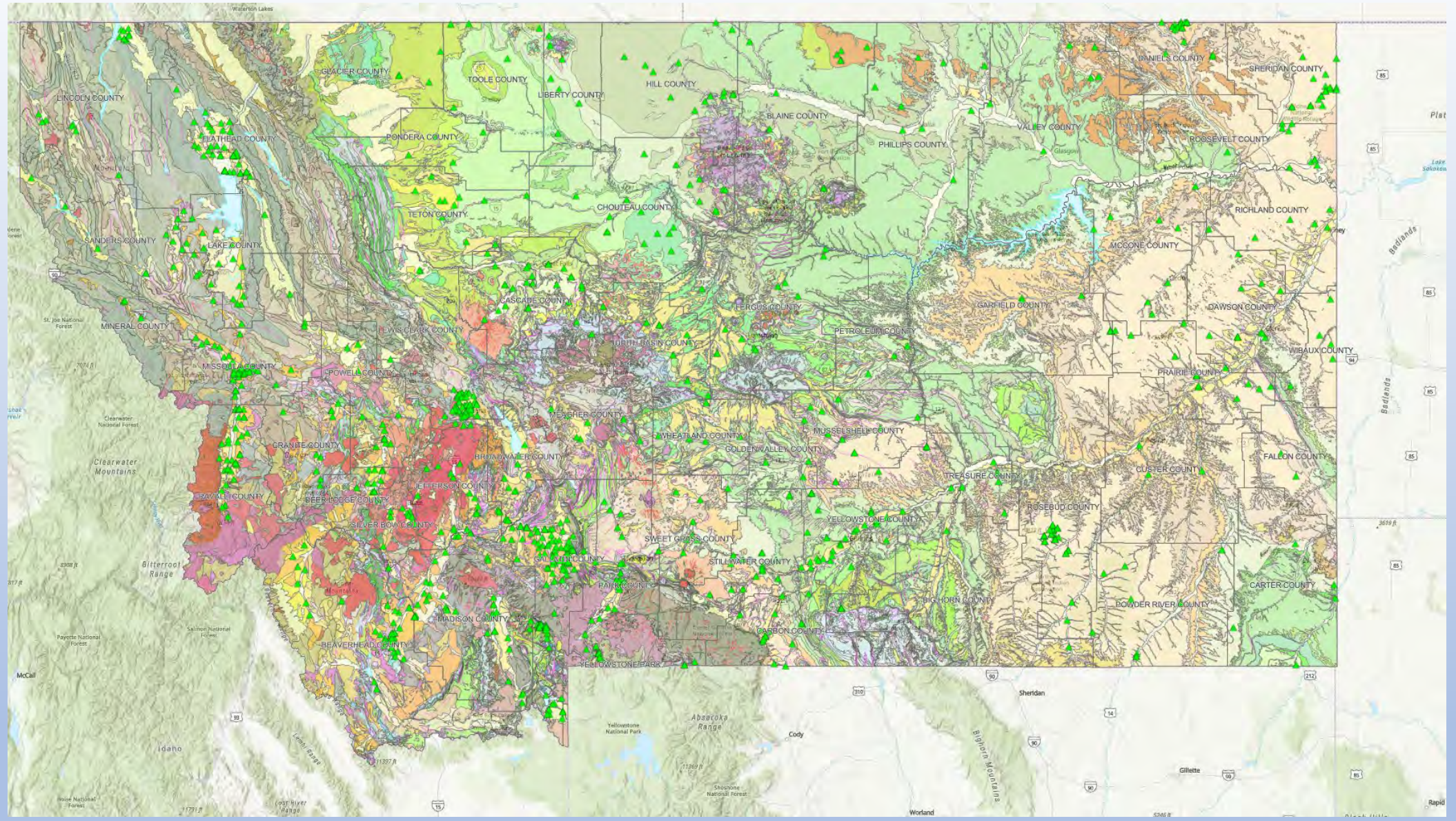
Locations of water gage stations managed by the MBMG and other agencies.

Principal Aquifers Map

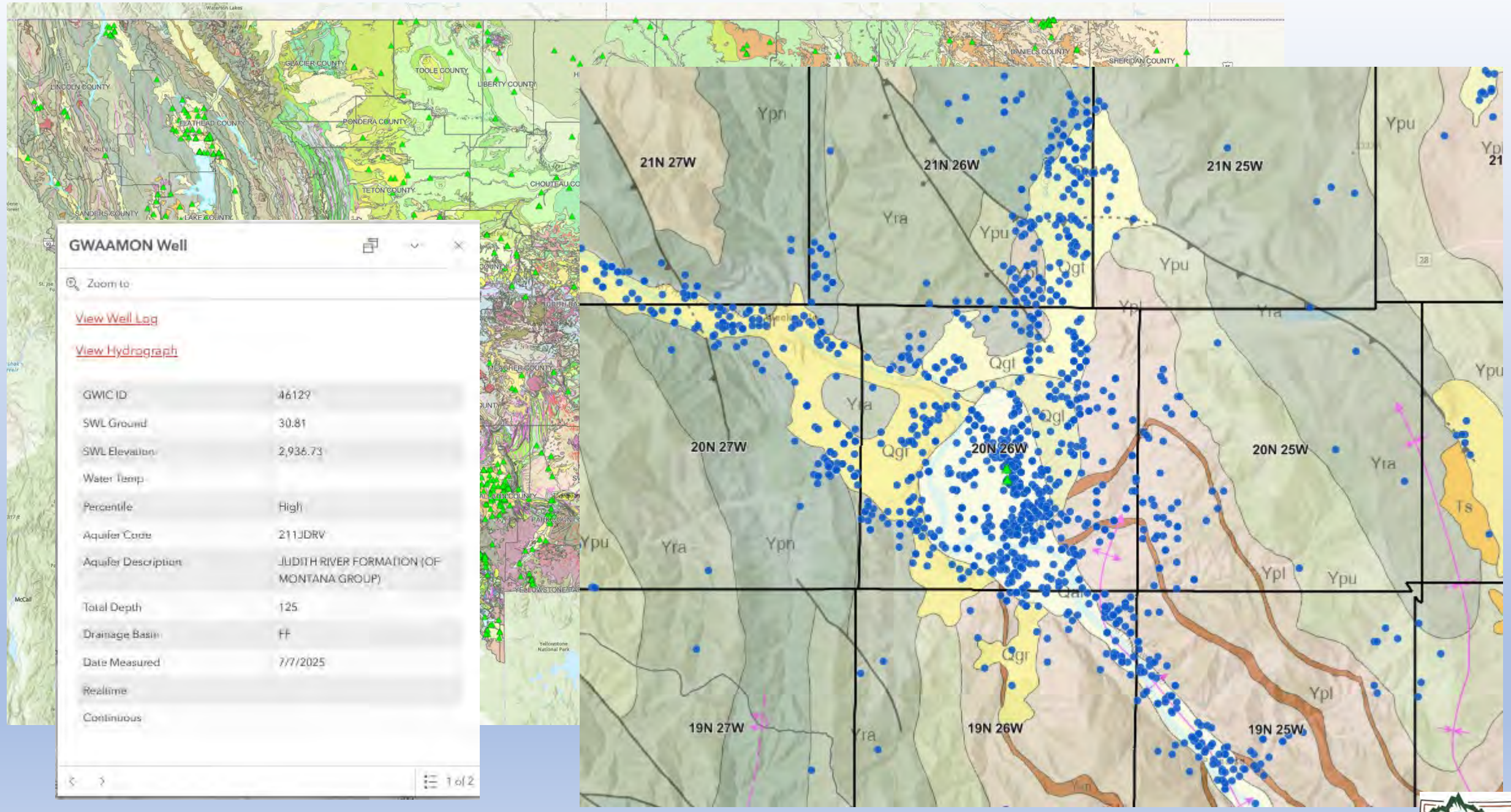
This is a map showing principal aquifers in Montana, which are geologic units or grouping of geologic units that have similar water-bearing characteristics.

Principal Aquifers of Montana

Principal aquifers in Montana, representing geologic units or groupings of geologic units that have similar water-bearing characteristics.



https://gis-data-hub-mbmg.hub.arcgis.com/apps/d226763591a0433285c0057031d22d60/explore


GWAAMON Well
Zoom to
View Well Log
View Hydrograph
GWIC ID 46129
SWL Ground 30.81
SWL Elevation 2,936.73
Water Temp
Percentile High
Aquifer Code 211JDRV
Aquifer Description JUDITH RIVER FORMATION (OF MONTANA GROUP)
Total Depth 125
Drainage Basin FF
Date Measured 7/7/2025
Realtime
Continuous
1 of 2
21N 27W
21N 26W
21N 25W
20N 27W
20N 26W
20N 25W
19N 27W
19N 26W
19N 25W
Ypr
Ypu
Yra
Qgt
Qgr
Qgl
Ypl
Ts
LINCOLN COUNTY
FLATHEAD COUNTY
GLACIER COUNTY
TOOLE COUNTY
LIBERTY COUNTY
PONDERA COUNTY
TETON COUNTY
SANDERS COUNTY
LAKE COUNTY
DANIELS COUNTY
SHERIDAN COUNTY
MEAGHER COUNTY
Yellowstone National Park

Ground Water Characterization

- …maps and assesses aquifers within specific areas

Map aquifers at a county scale

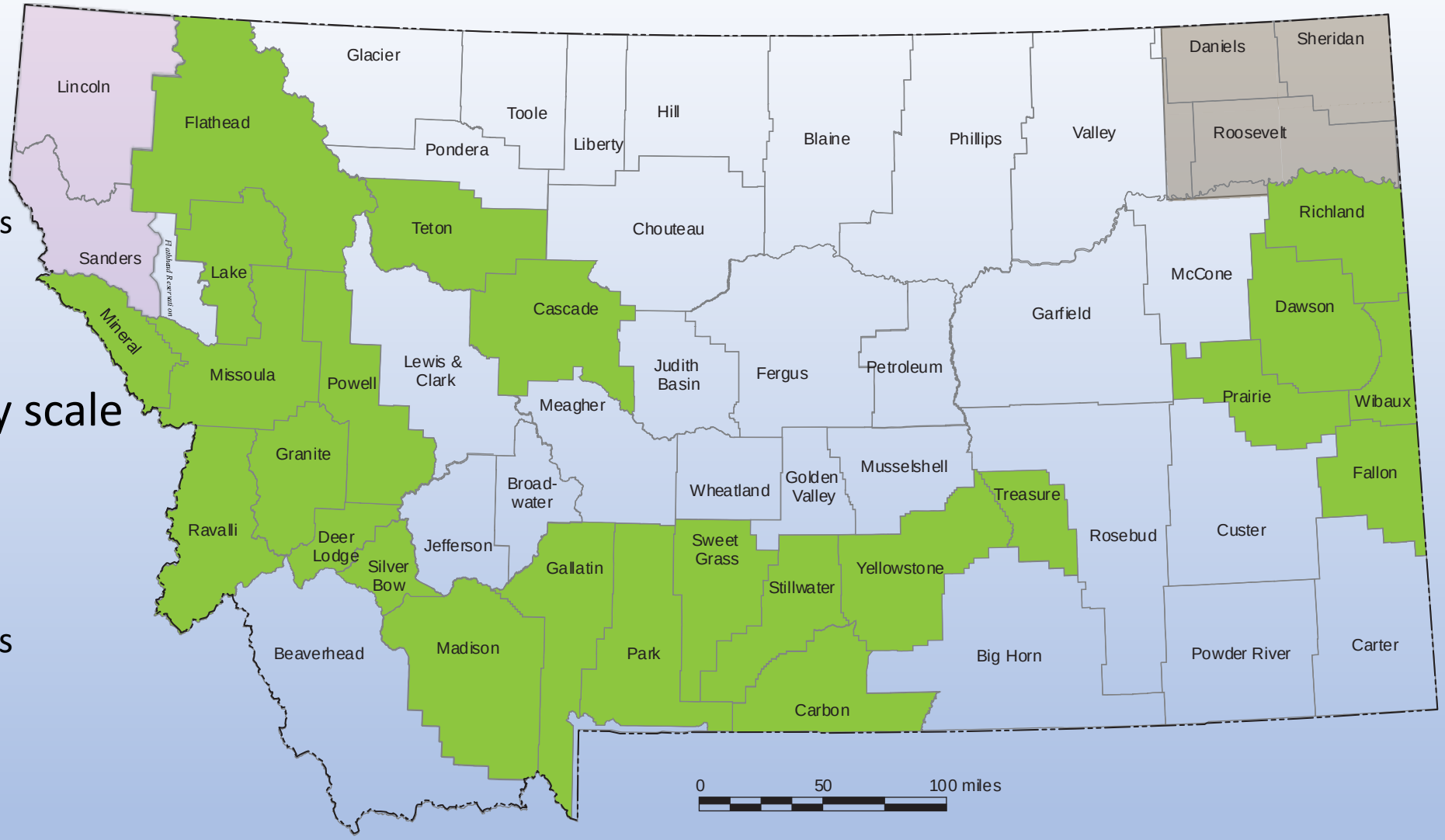
Using:

Previous Work

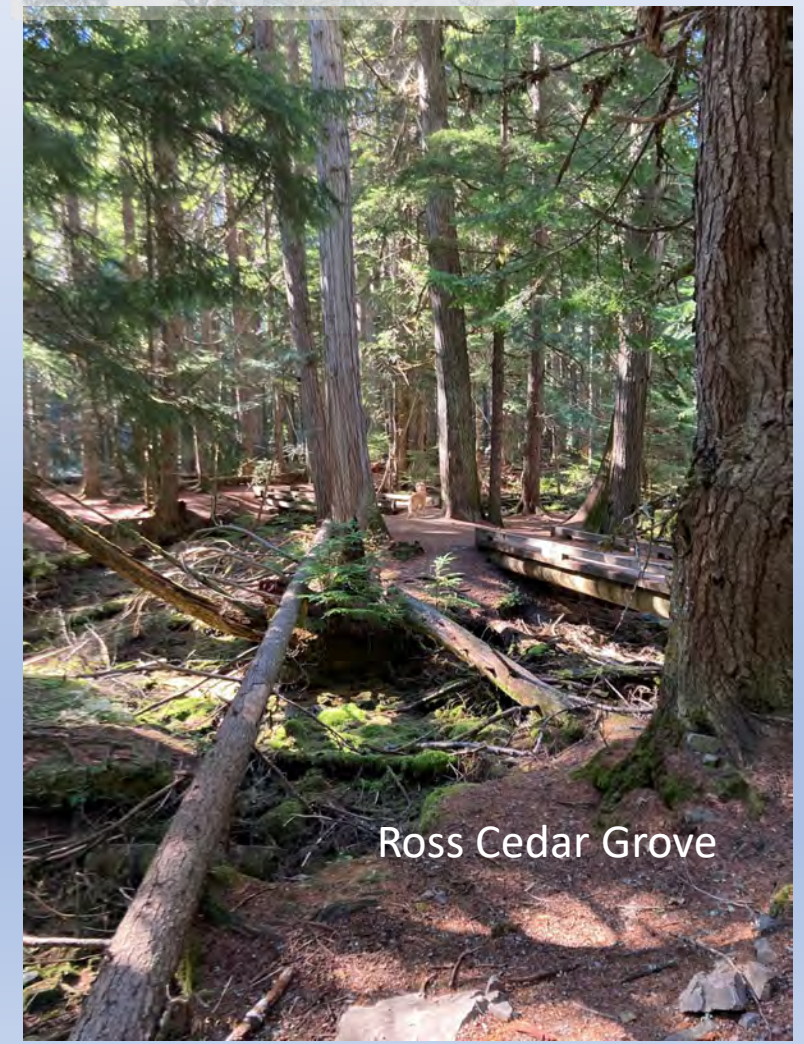
Geologic Mapping

Well Log Data

Field Visits to Wells and Springs

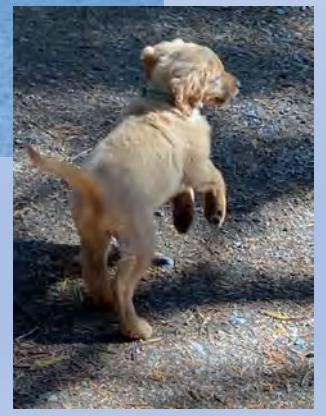


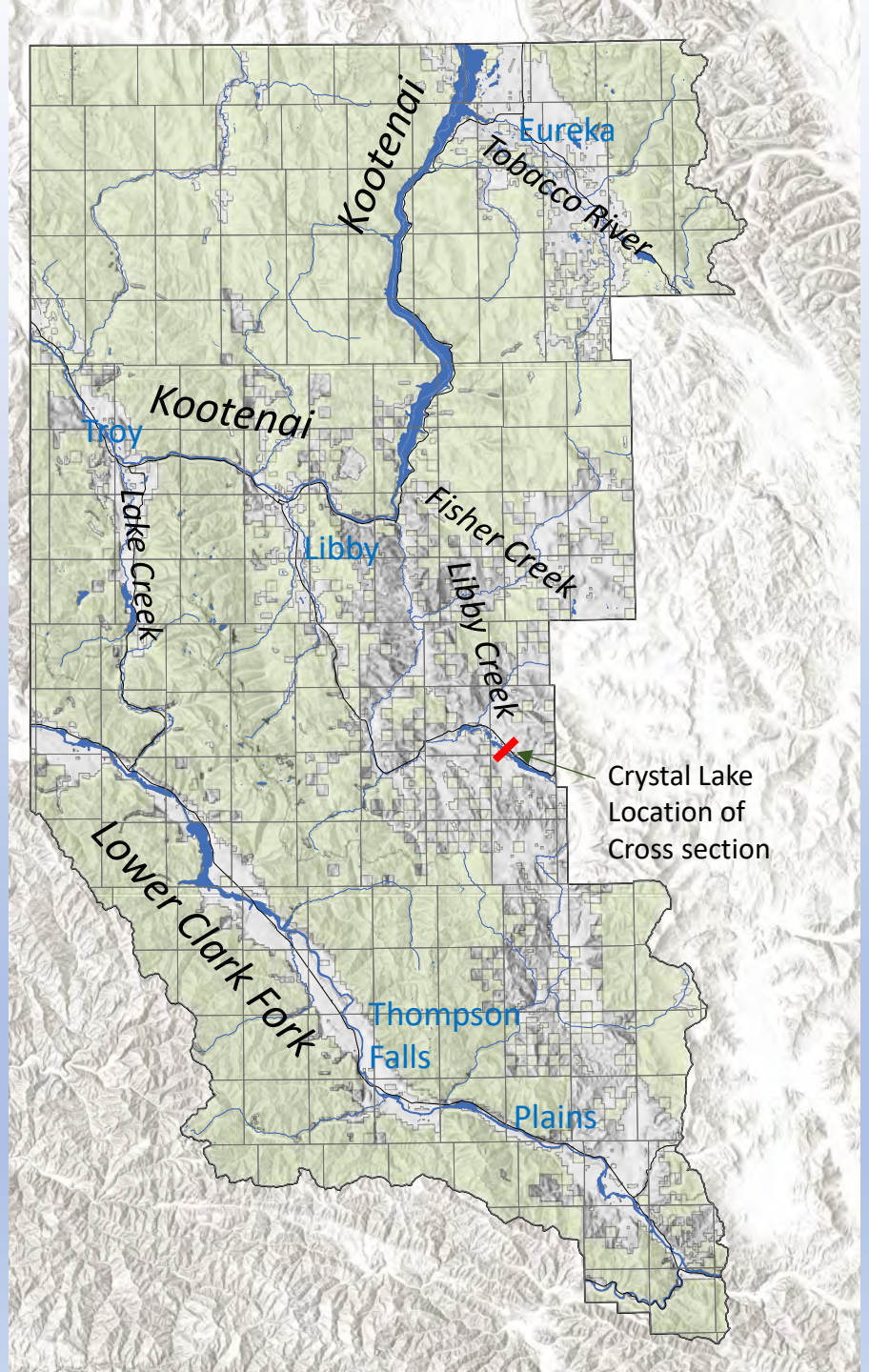
Lincoln and Sanders Counties: A Brief Introduction

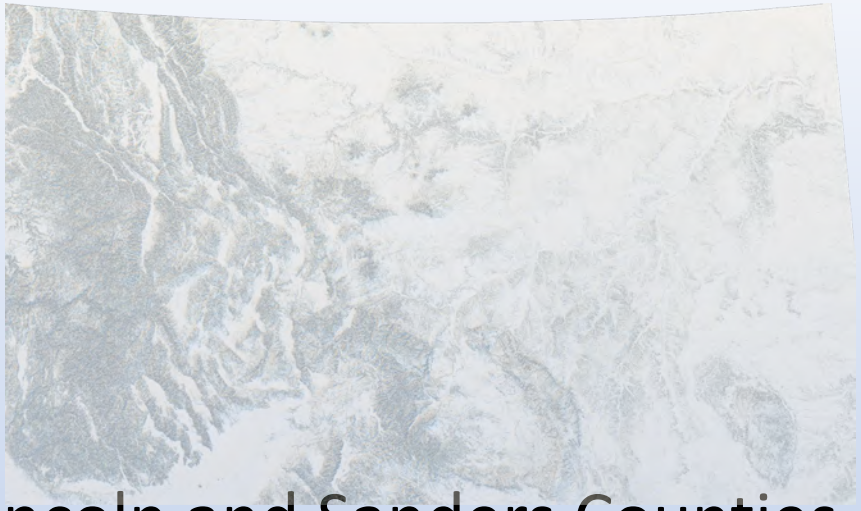

Ross Cedar Grove


Lower Clark Fork River at Trout Creek

Mountain Topograpy
Dense Forests
Large River Systems


Gnomes running around the forest





Lincoln and Sanders Counties

<u>Main River Valleys</u>

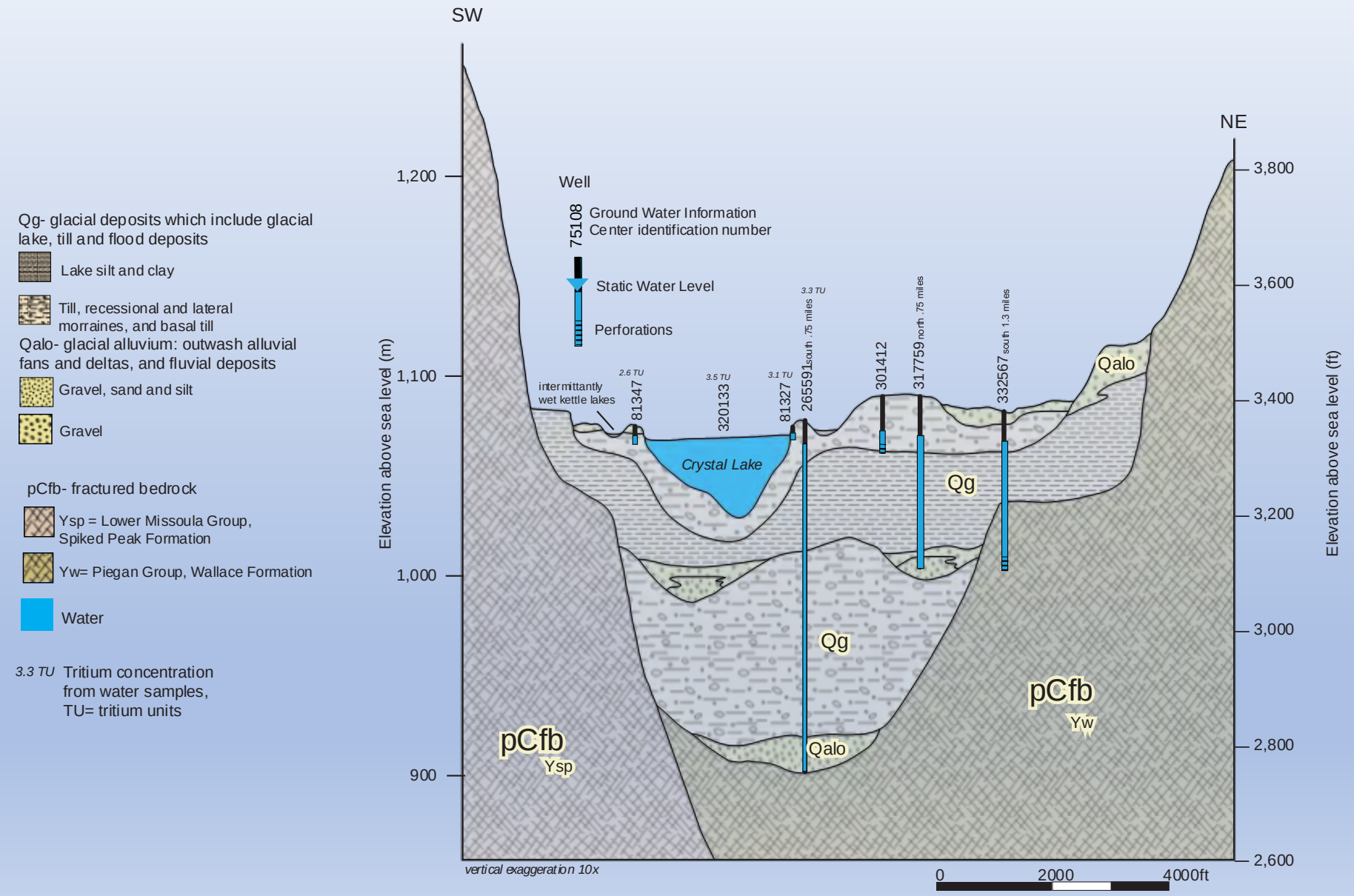
Lower Clark Fork River

Kootenai River

- Lake Creek
- Libby Creek
- Fisher Creek
- Tobacco River

Fault-Bounded Valley Structures

Schematic Cross Section Illustrating Basic Hydrogeologic Units



Qg- glacial deposits which include glacial lake, till and flood deposits

- Lake silt and clay
- Till, recessional and lateral morraines, and basal till

Qalo- glacial alluvium: outwash alluvial fans and deltas, and fluvial deposits

- Gravel, sand and silt
- Gravel

pCfb- fractured bedrock

- Ysp = Lower Missoula Group, Spiked Peak Formation
- Yw= Piegan Group, Wallace Formation

Water

3.3 TU Tritium concentration from water samples, TU= tritium units

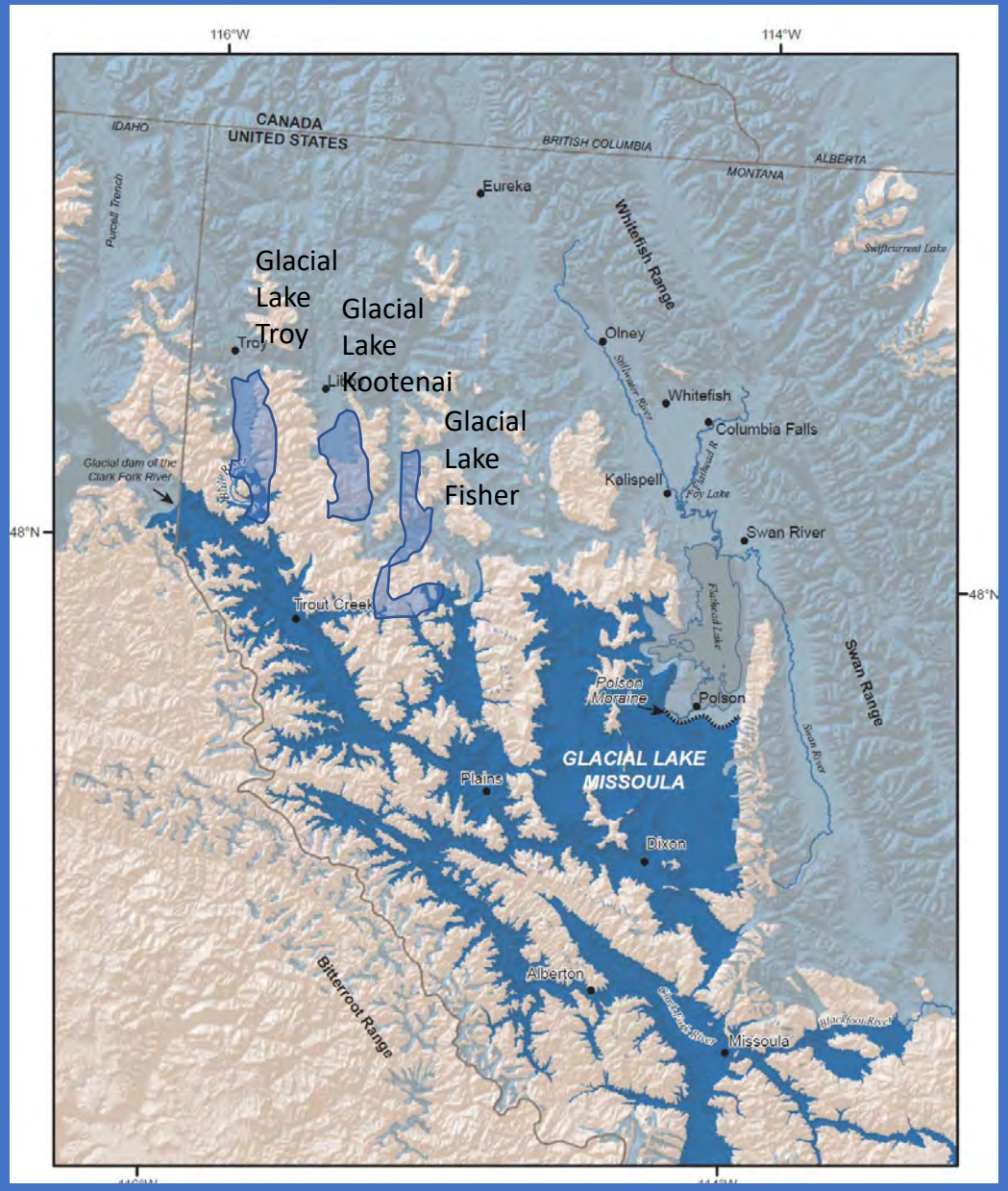
Frame and Fill!

Fractured Bedrock of the Belt Supergroup Frames Valleys

Thick Sequence of Glacial Deposits Fill Valleys

- Till
- Outwash
- Glacial Lake Deposits
- Glacial Lake Flood Deposits

Glacial lake Missoula was not alone

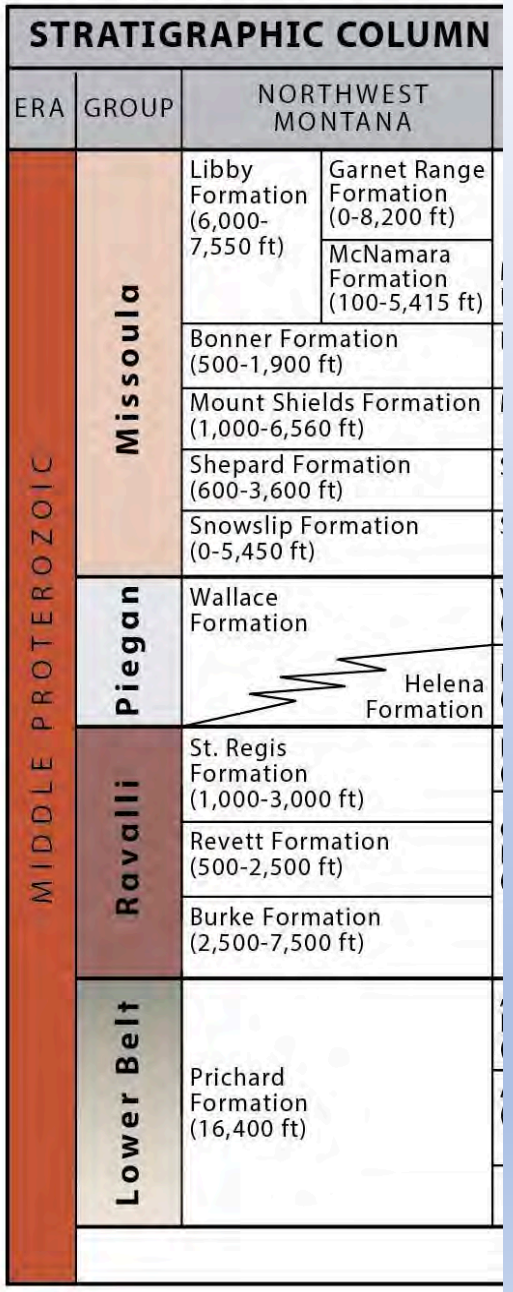


modified from Smith and others (2020)

Libby-
Bluff of over 300 feet
Glacial Lake Kootenai deposits

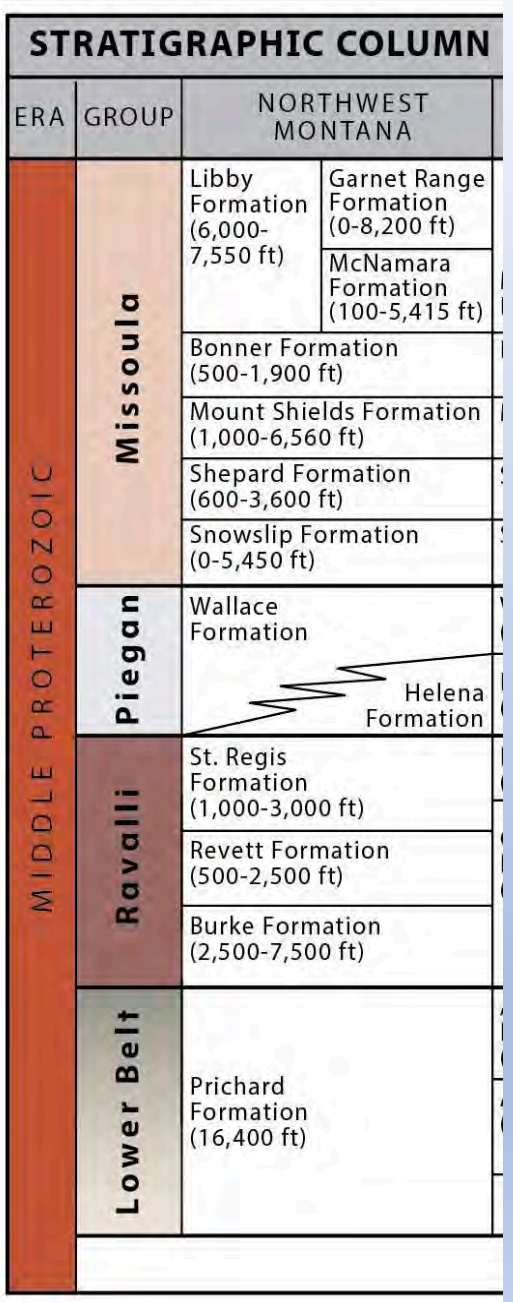
Lake Creek;
exposure of Glacial Lake Troy deposits

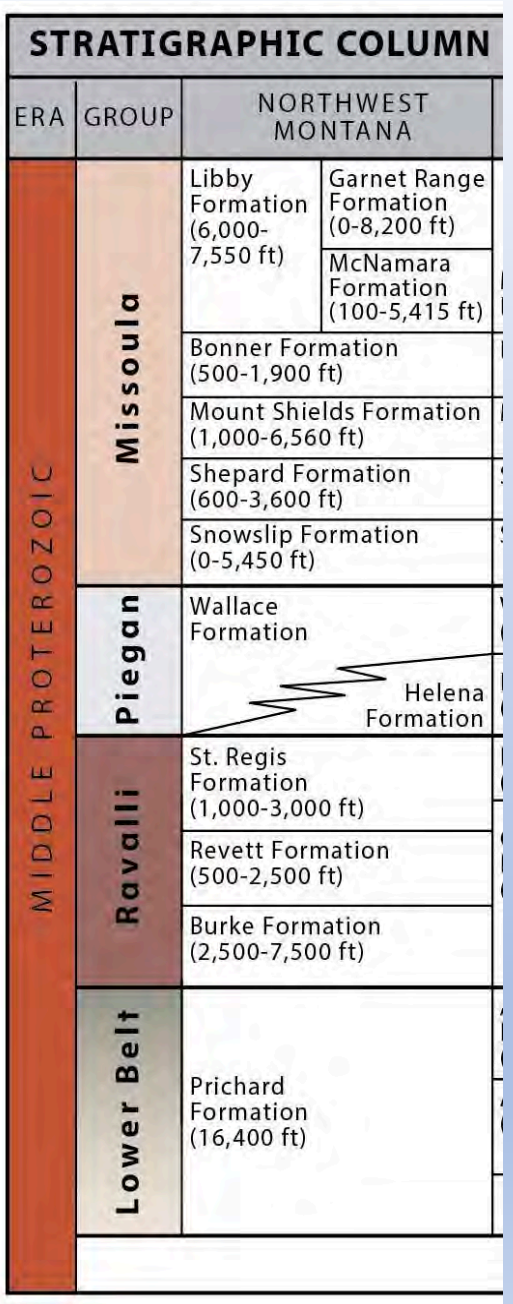
Stuart Parker, MBMG geologist



Outcrop of Prichard

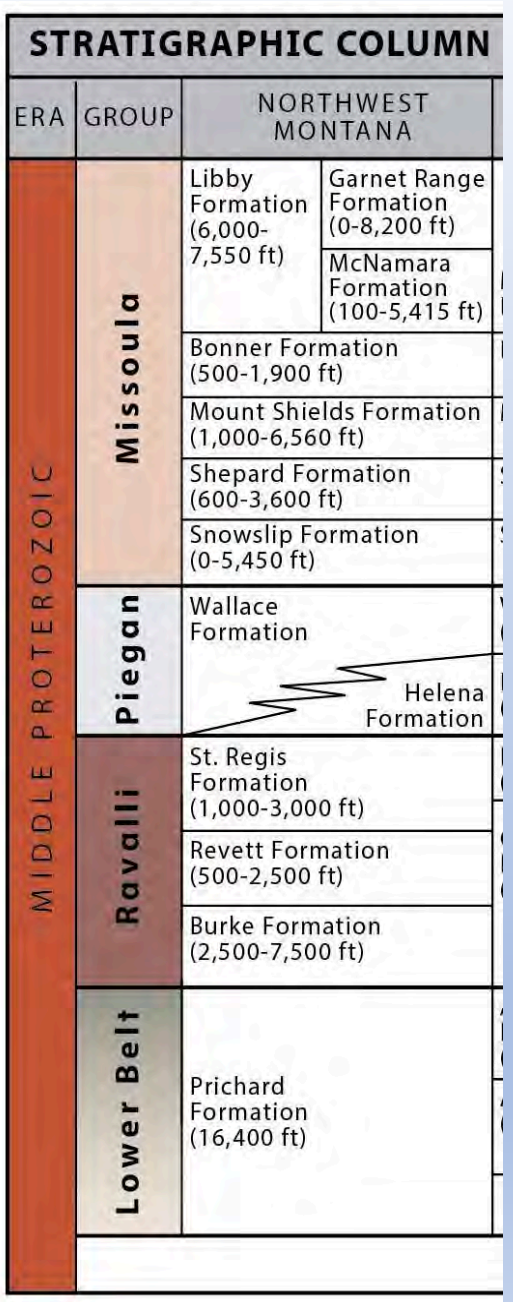
Ravalli Group

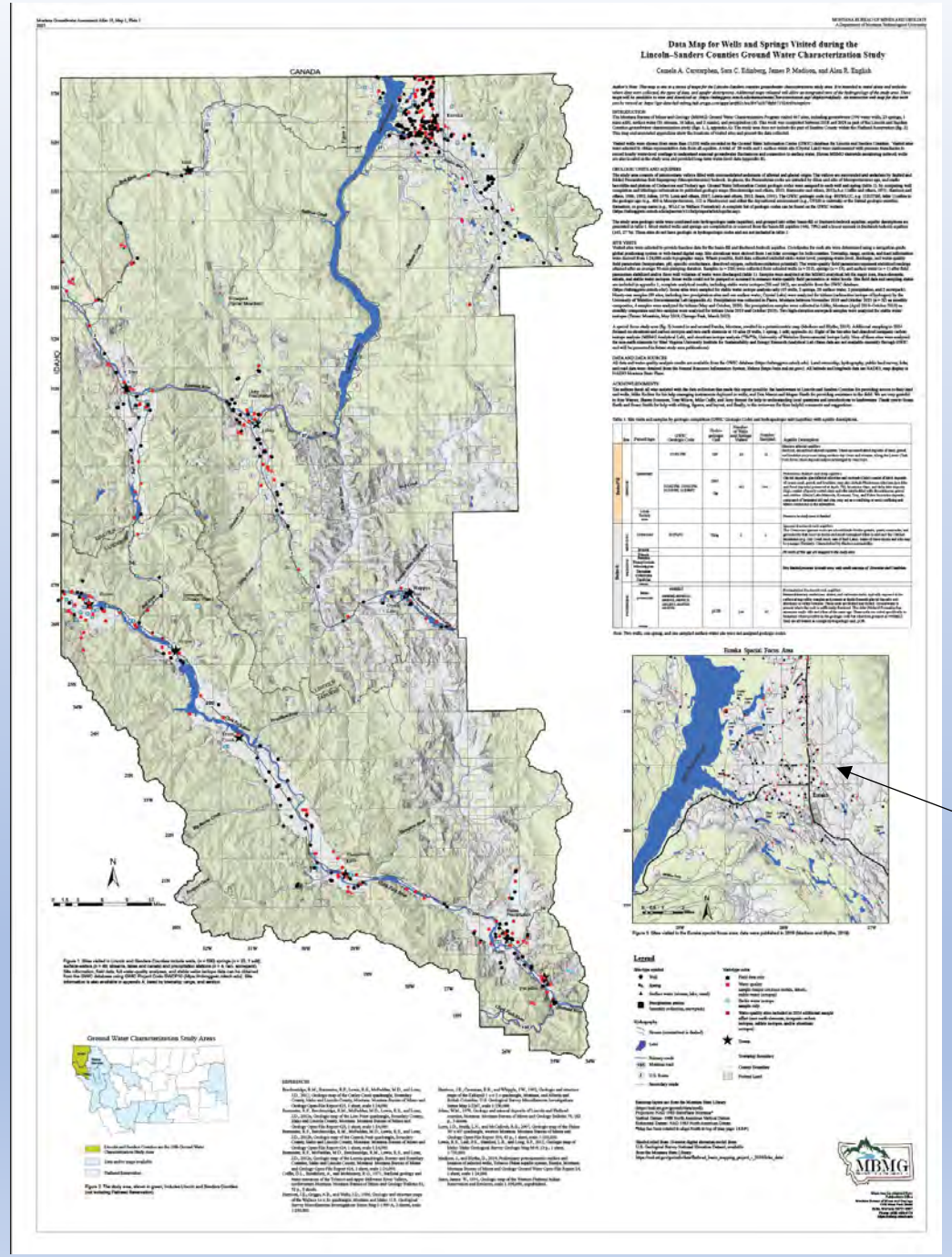




Wallace Formation (Piegan Group)

Kootenai Falls: outcrops of the Missoula Group (Mount Shields Formation)



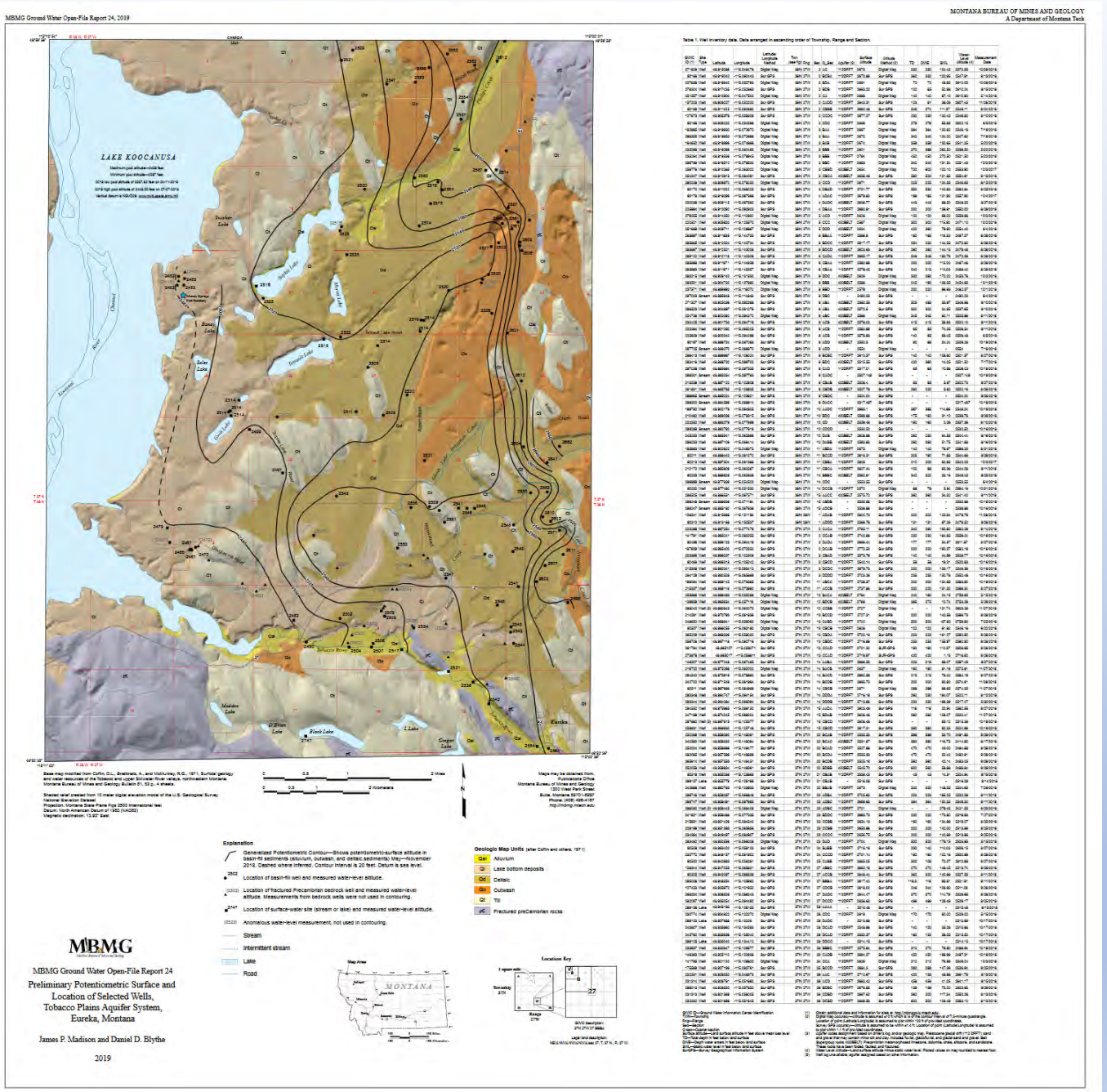


Early Products from Our Work

Data Map
- Where did we visit?
- What data did we collect?

Available in paper-form or download from MBMG website
And as a web map publication at our
MBMG HUB SITE-
- showcased during poster session tonight

Early special focus area in Eureka area



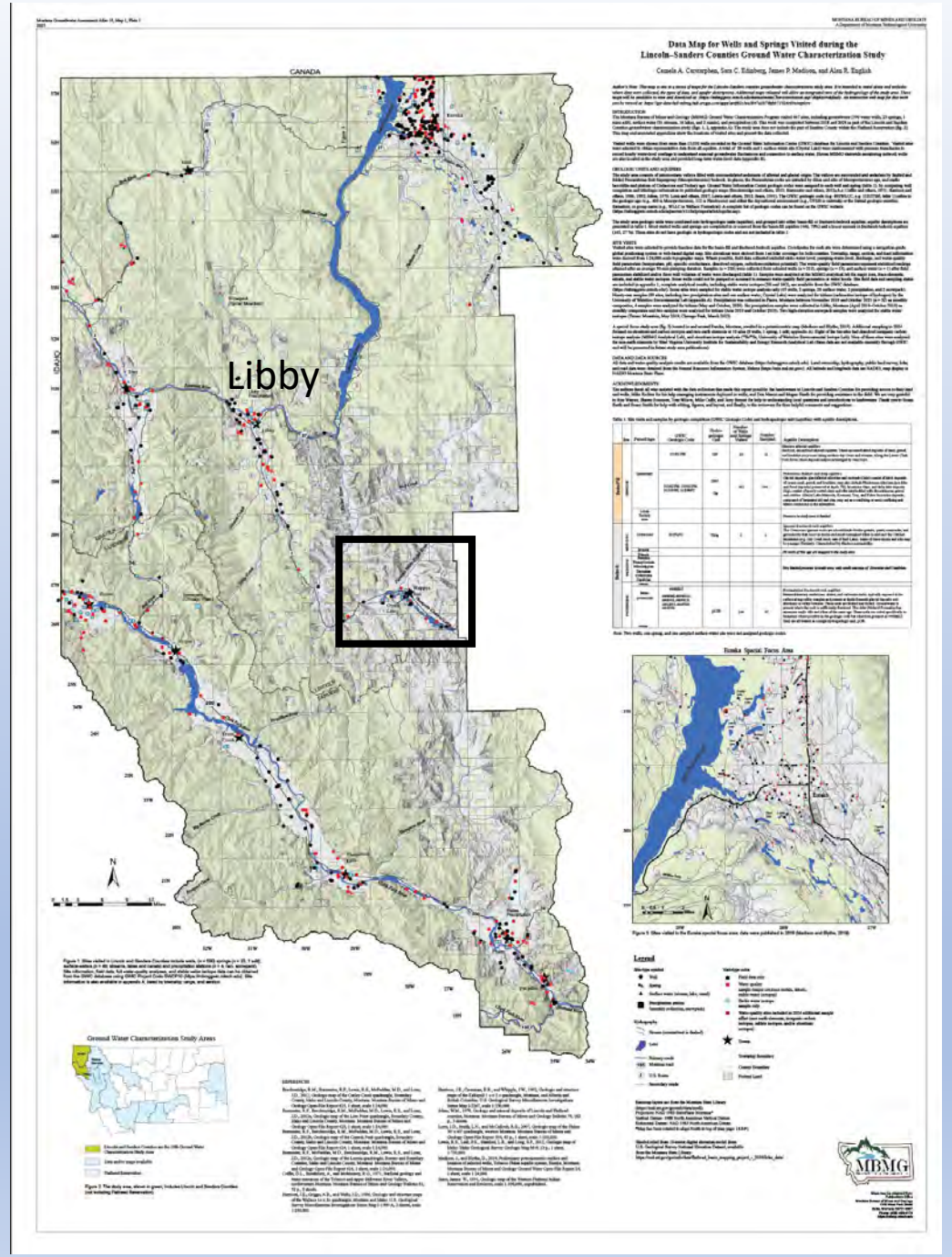
James Madison

Groundwater Flow Map of Eureka Area

Publications to Follow

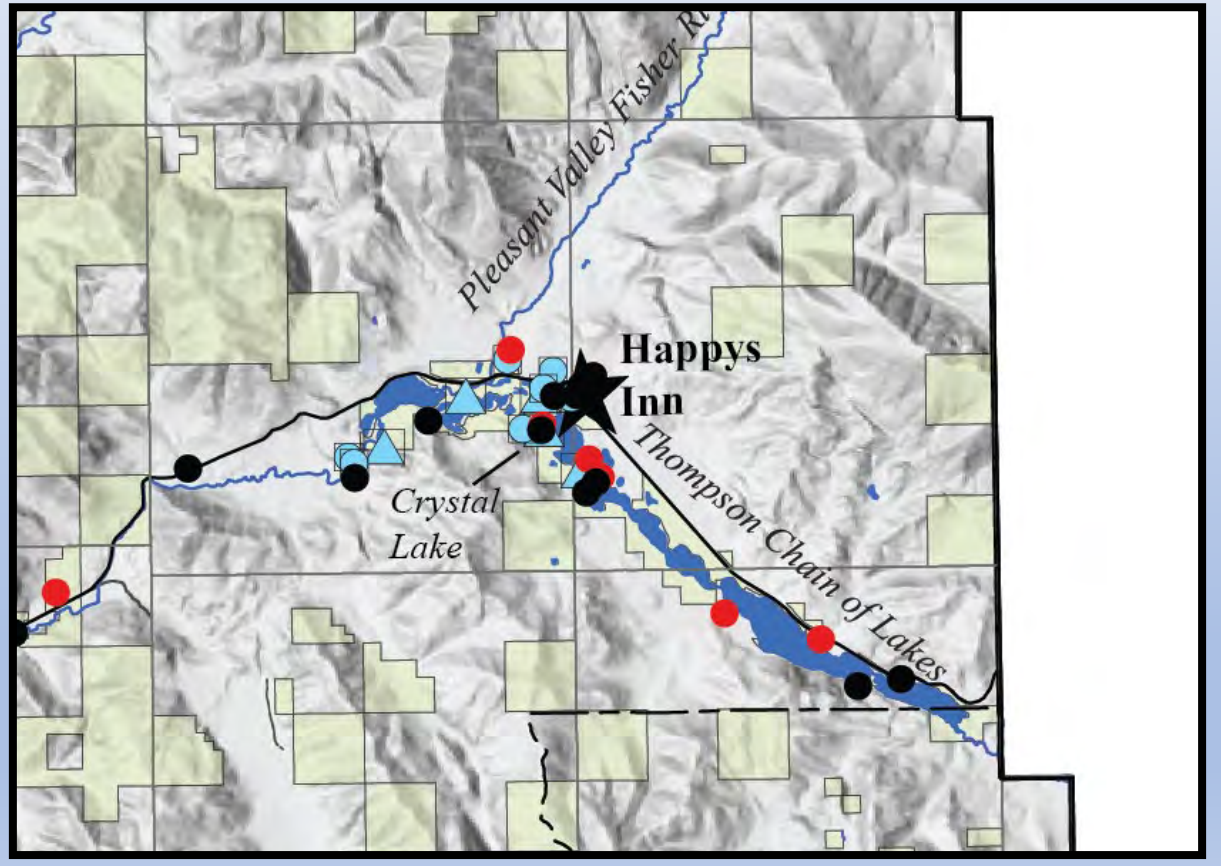
- Hydrogeologic Framework
- Groundwater Flow
- Groundwater Quality

https://mbmg.mtech.edu/pdf-publications/GWOF2



Crystal Lake, Chain of Lakes, Happy's Inn

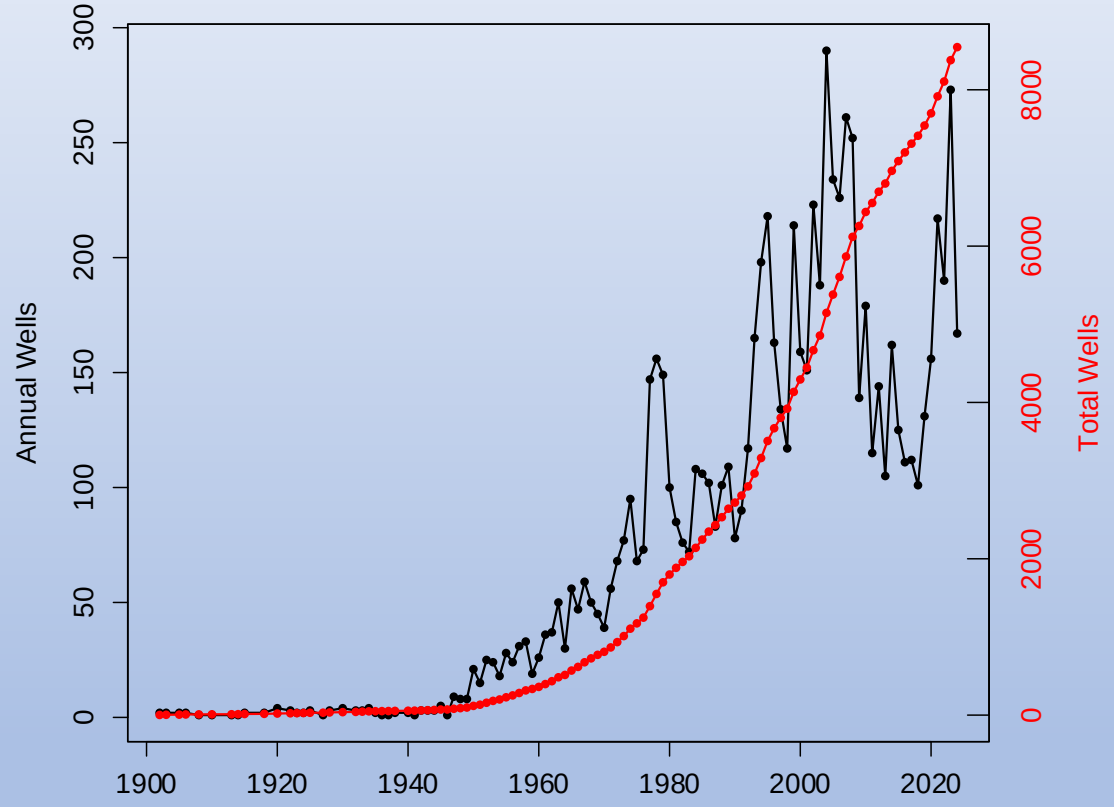
Special Focus Effort in 2022



MBMG

Lincoln County is not Immune to the Challenges Facing Most of Montana

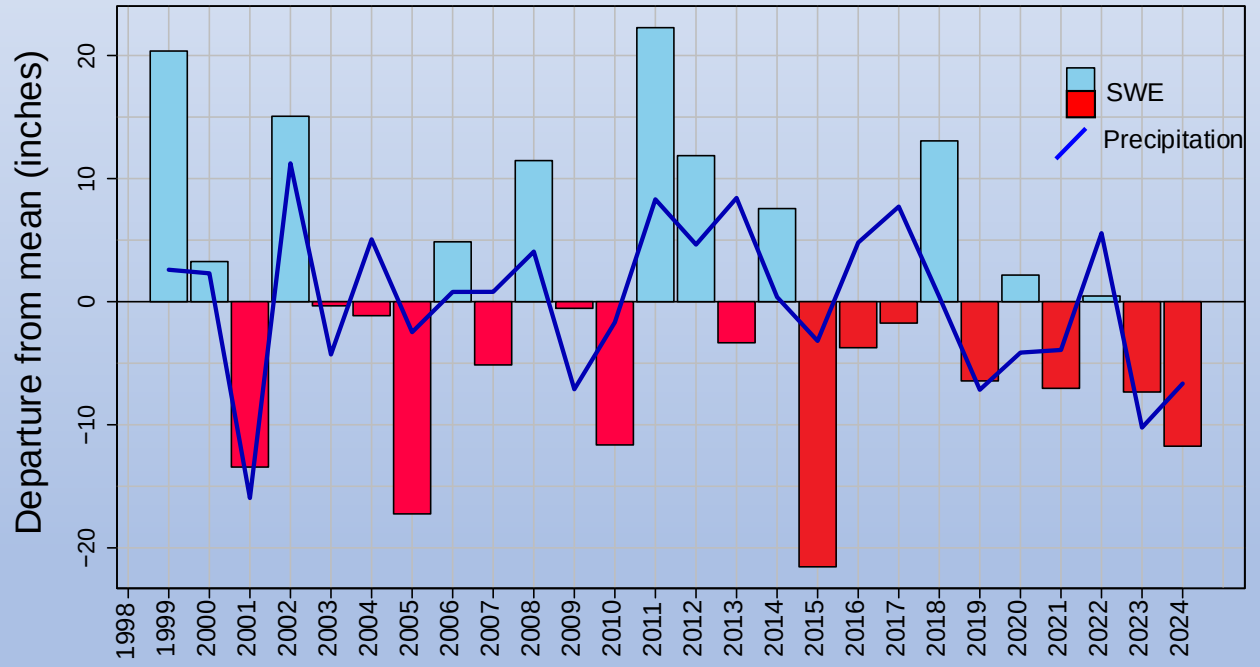
Development



Lincoln County Groundwater wells drilled by year and cumulatively

Drought Conditions

Poorman Creek SNOTEL (#932) Annual Peak SWE and Mean Precipitation Departures (Period of Record: 26 yrs)

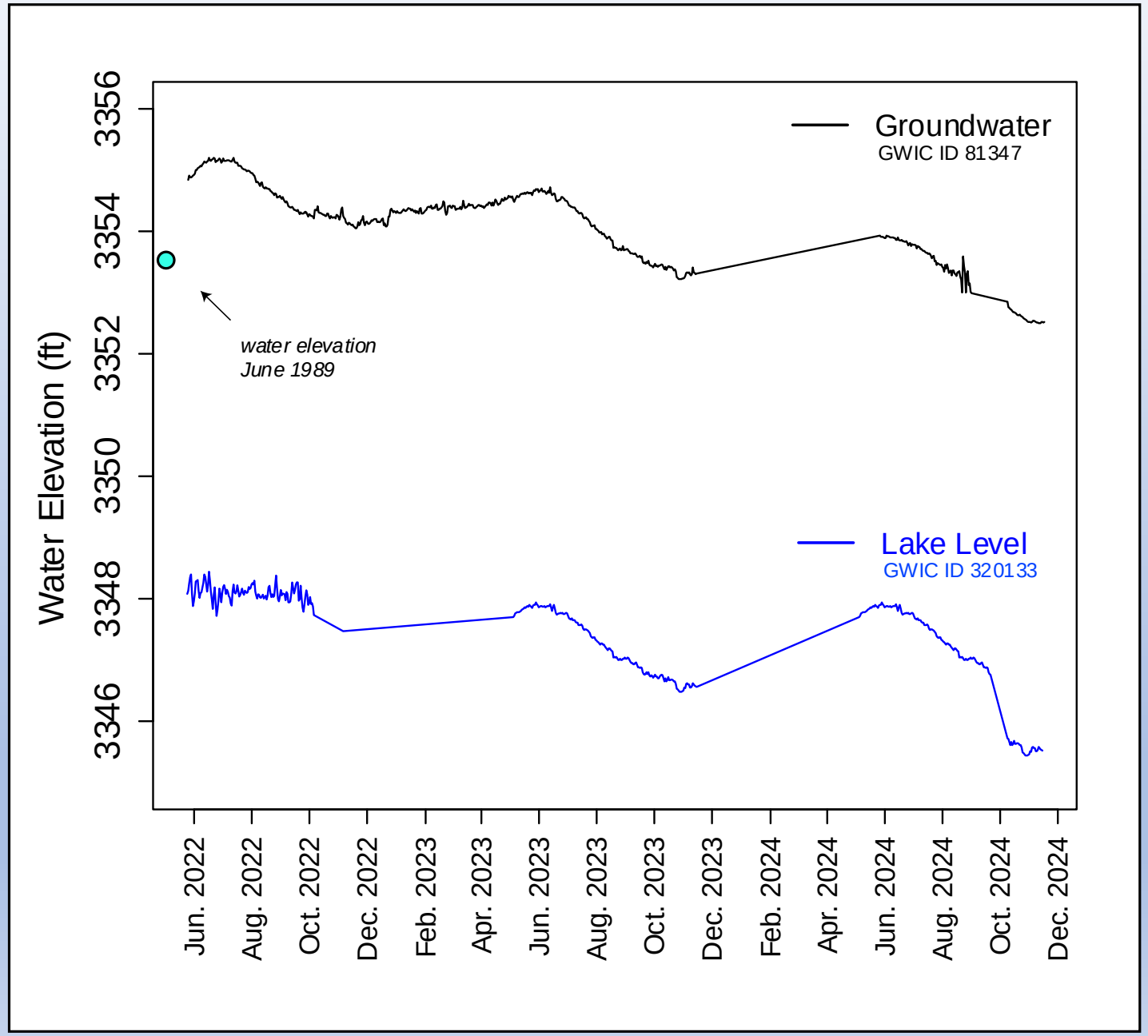


Crystal Lake: installation of a lake staff gage transducer and a groundwater well transducer

May 2022 – November 2024

Gage at southwest end of lake

Well in trees at NW corner



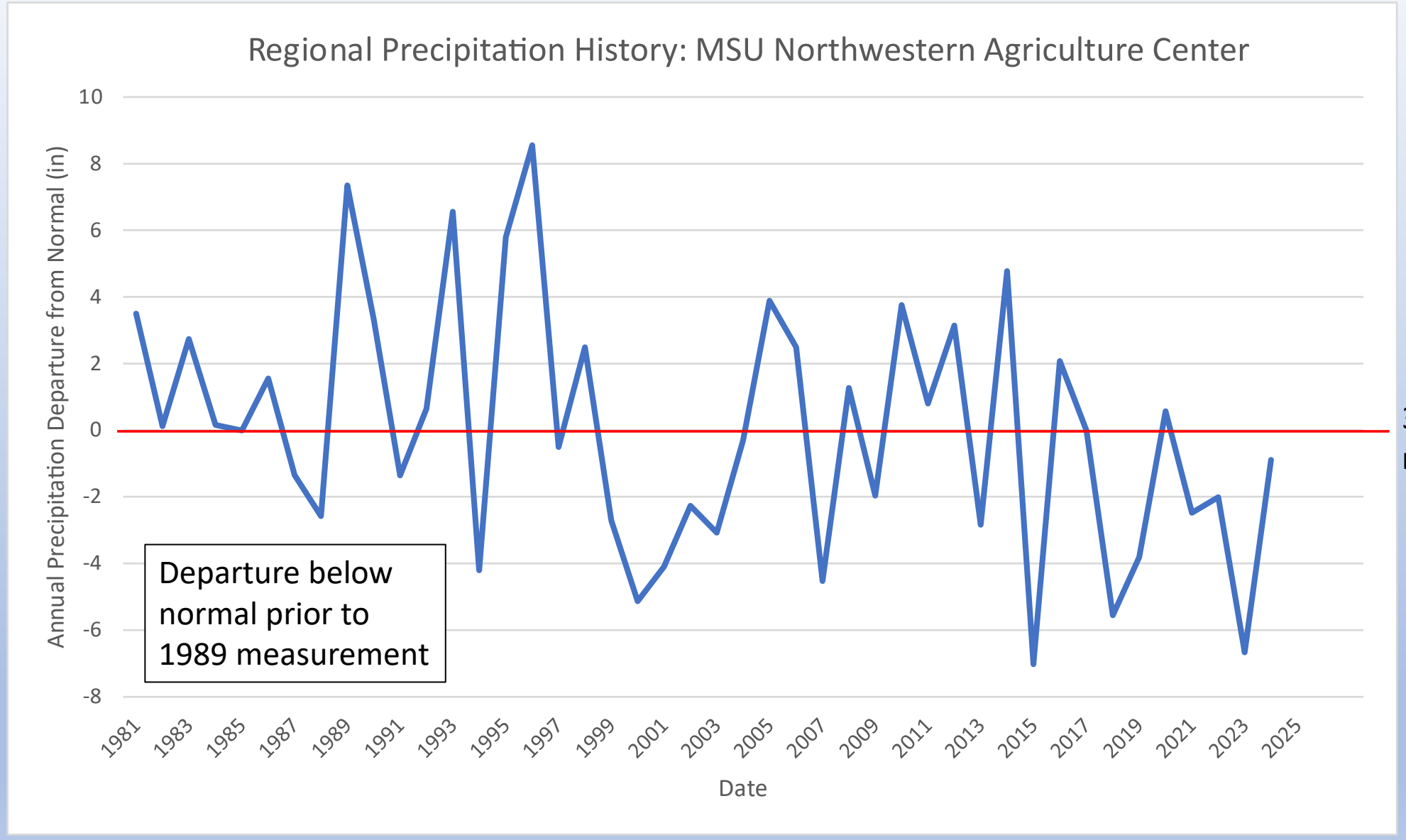
Observations:

- Both groundwater and the Lake fluctuate seasonally by a foot

- Over the two year data period, Water levels dropped in both (2 foot decline)

Historic water level record for well Indicates:

- That there has not been a decline over the thirty-year period, and
- that levels might fluctuate intermittently over several years


Regional Precipitation History: MSU Northwestern Agriculture Center
Annual Precipitation Departure from Normal (in)
10
8
6
4
2
0
-2
-4
-6
-8
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2025
Date
Departure below normal prior to 1989 measurement
34-year mean

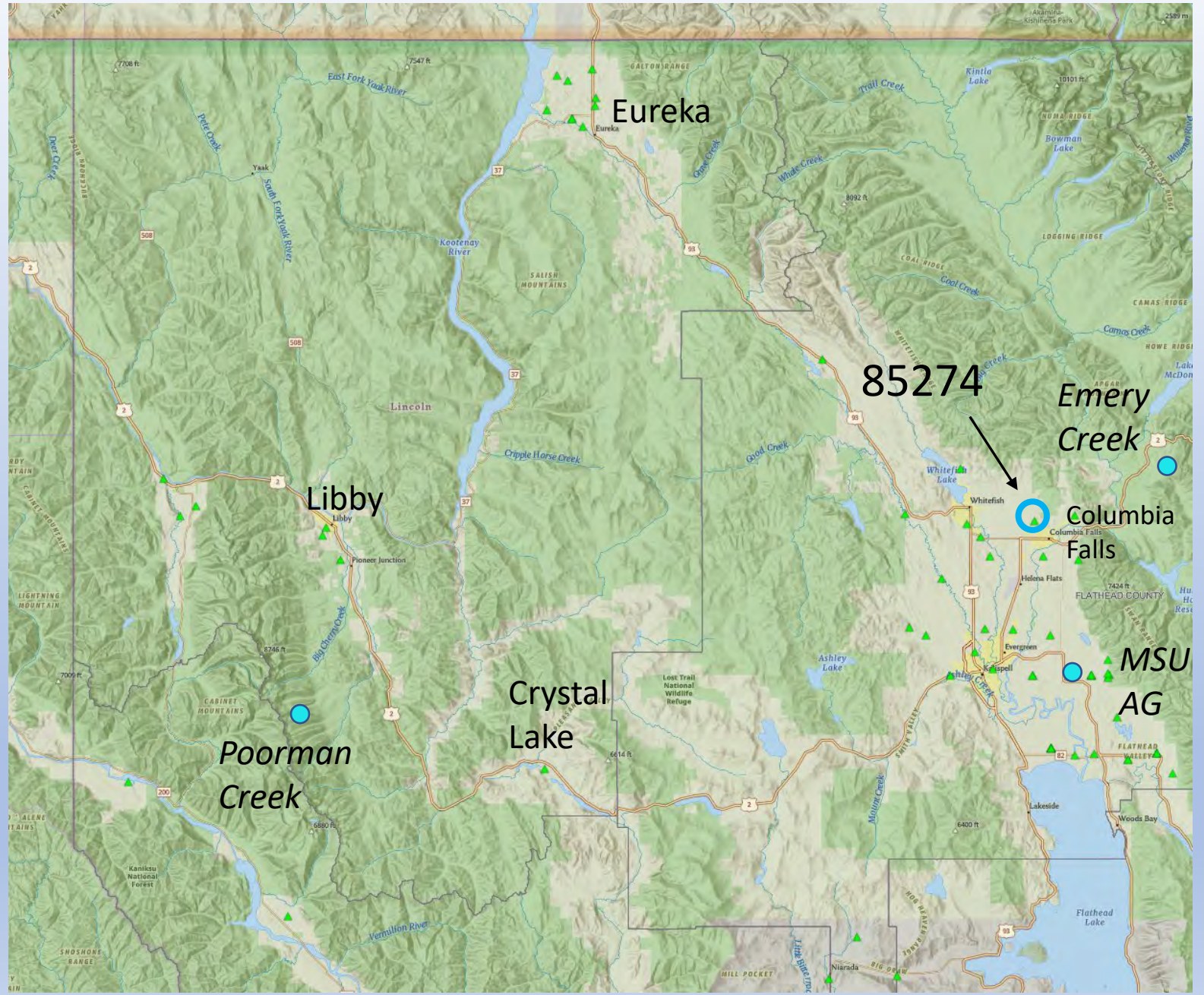
Northwest Region

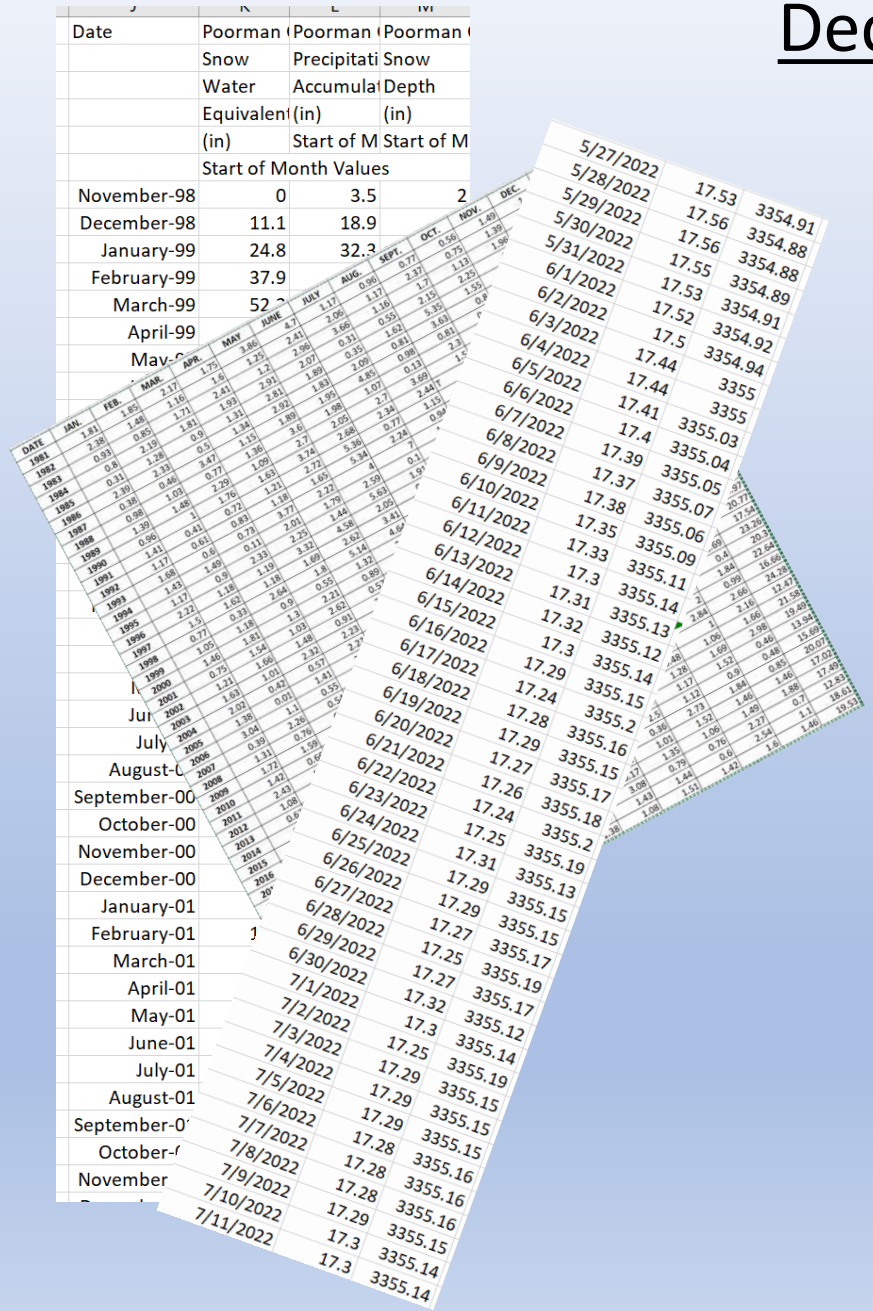
Looking for Long-Term Data Sets

<u>We found!</u>
MBMG has as a regional groundwater data of instrumented (hourly) data with a 30-year record
GWIC 85274

Available long-term precipitation included

- Poorman Creek SNOTEL site
- <u>Emery Creek SNOTEL site</u>
- MSU Northwestern Ag Center





Decisions on Data Handling

- Data grouped as annual values and by water year not calendar year
- Data normalized using gamma distribution protocol(anomalies)

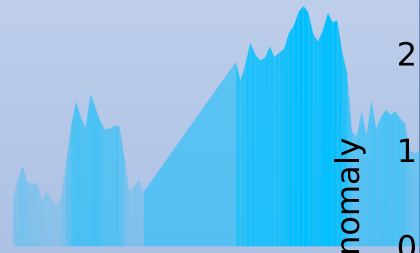
Data Analysis

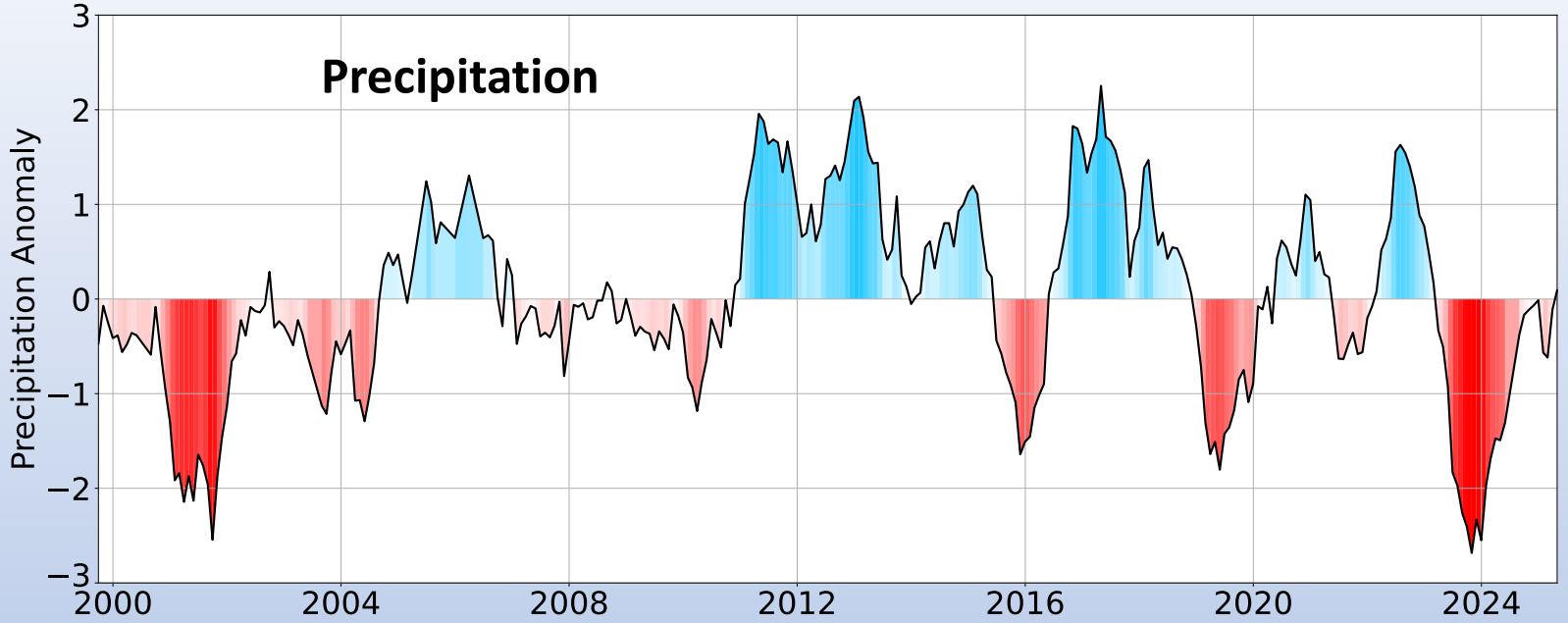
- Produced anomaly graphs for groundwater and precipitation over period of record
- Used Pearson Correlation protocol to compare groundwater values to precipitation over multiple time scales (0 – 120 months)

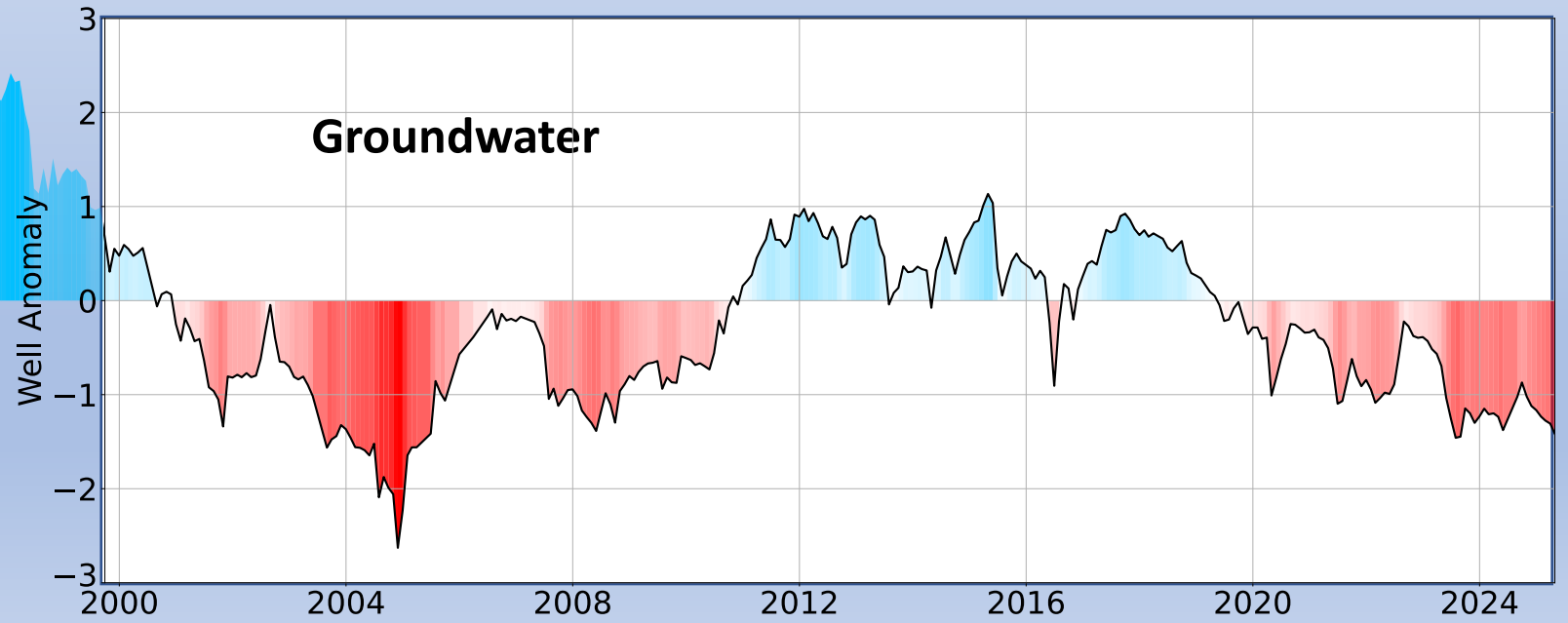
- looking for any strong correlation (coefficients close to 1)
….what time frame of precipitation history best predict groundwater response

Normalized Precipitation and Groundwater Data: Departure from Normal Over Entire Period of Record

The anomaly graphs highlight, visually, the powerful driver that precipitation history has been for groundwater deficit and surplus

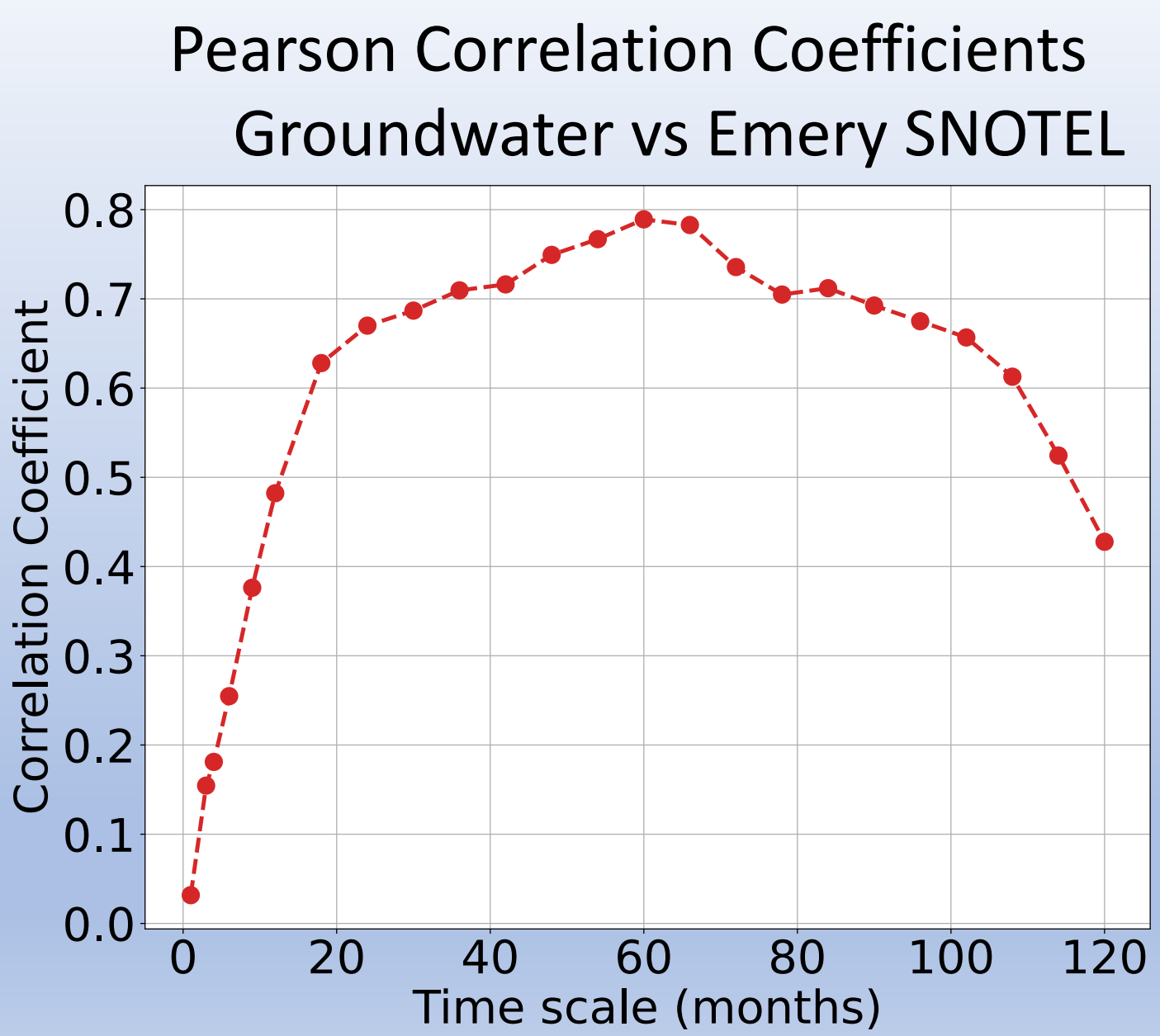






Groundwater anomaly values are correlated to varying precipitation time scales

A strong correlation with 5-year period



Brad Helding, Crystal Lake

Lake and Groundwater levels fluctuate seasonally on the order of a foot, and have seen a 1.5+ ft decline between years

However, inventory evidence suggests that groundwater levels seem to be steady over a 30+ year period

The extended Northwest regional drought is likely the driver for the decline

Crystal Lake Staff Gage

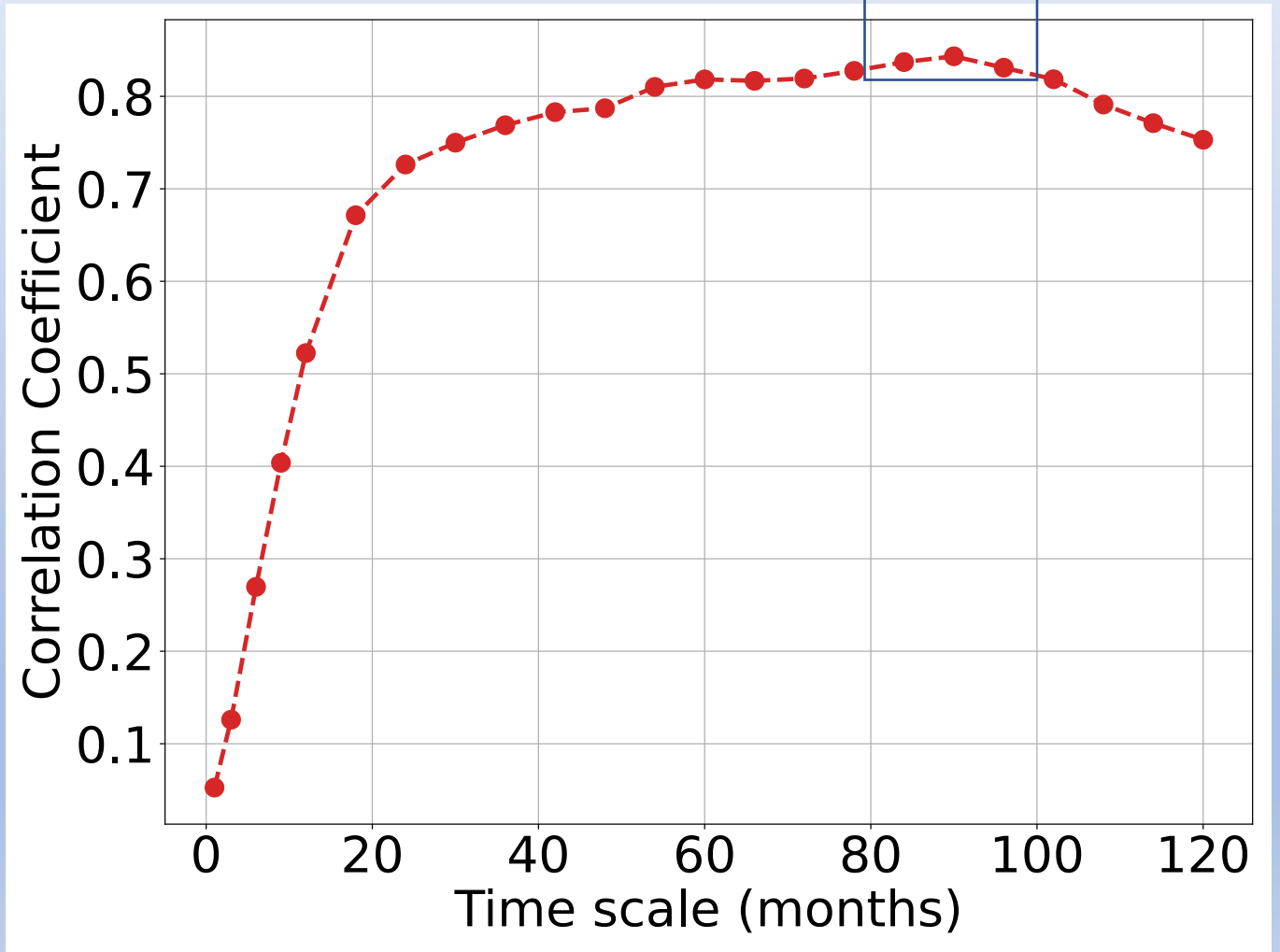
Thank You

Acknowledgements
-All the gracious landowners of Lincoln and Sanders County
-The help and conversations with local groundwater folks
Senator Mike Cuffe
County Planner Jesse Haag
County Commissioner Jerry Bennet
Surveyor Ron Warren
County Planner/DEQ Shawn Sorenson

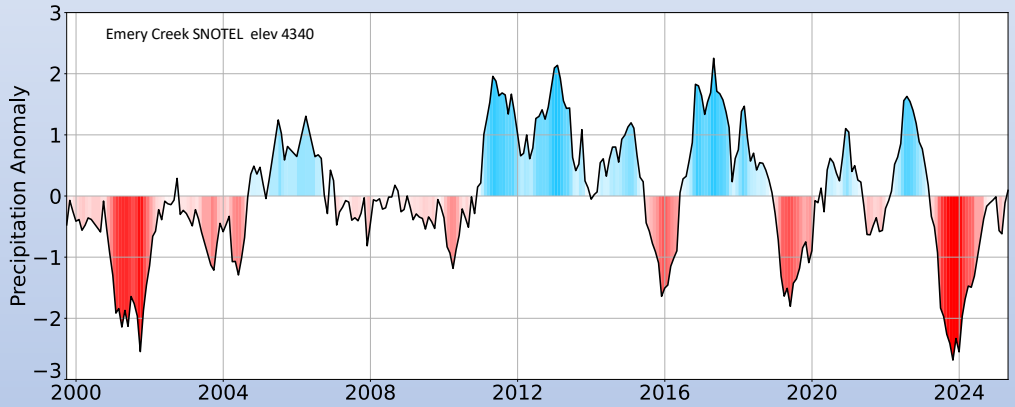
Pearson Correlation Coefficients
Groundwater vs MSU AG

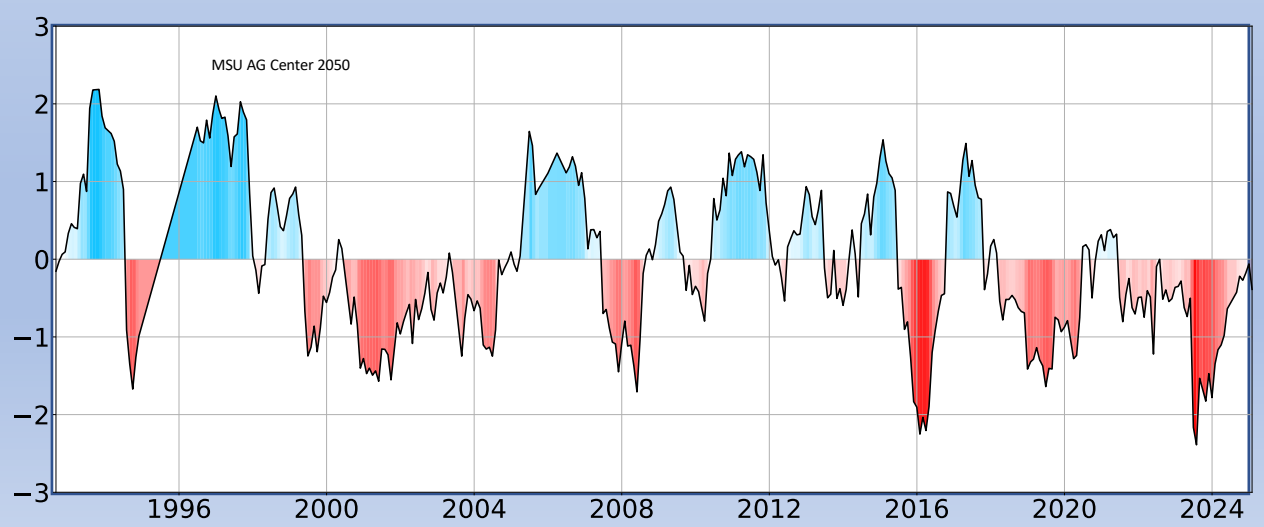
Groundwater anomaly values are compared to varying precipitation time scales

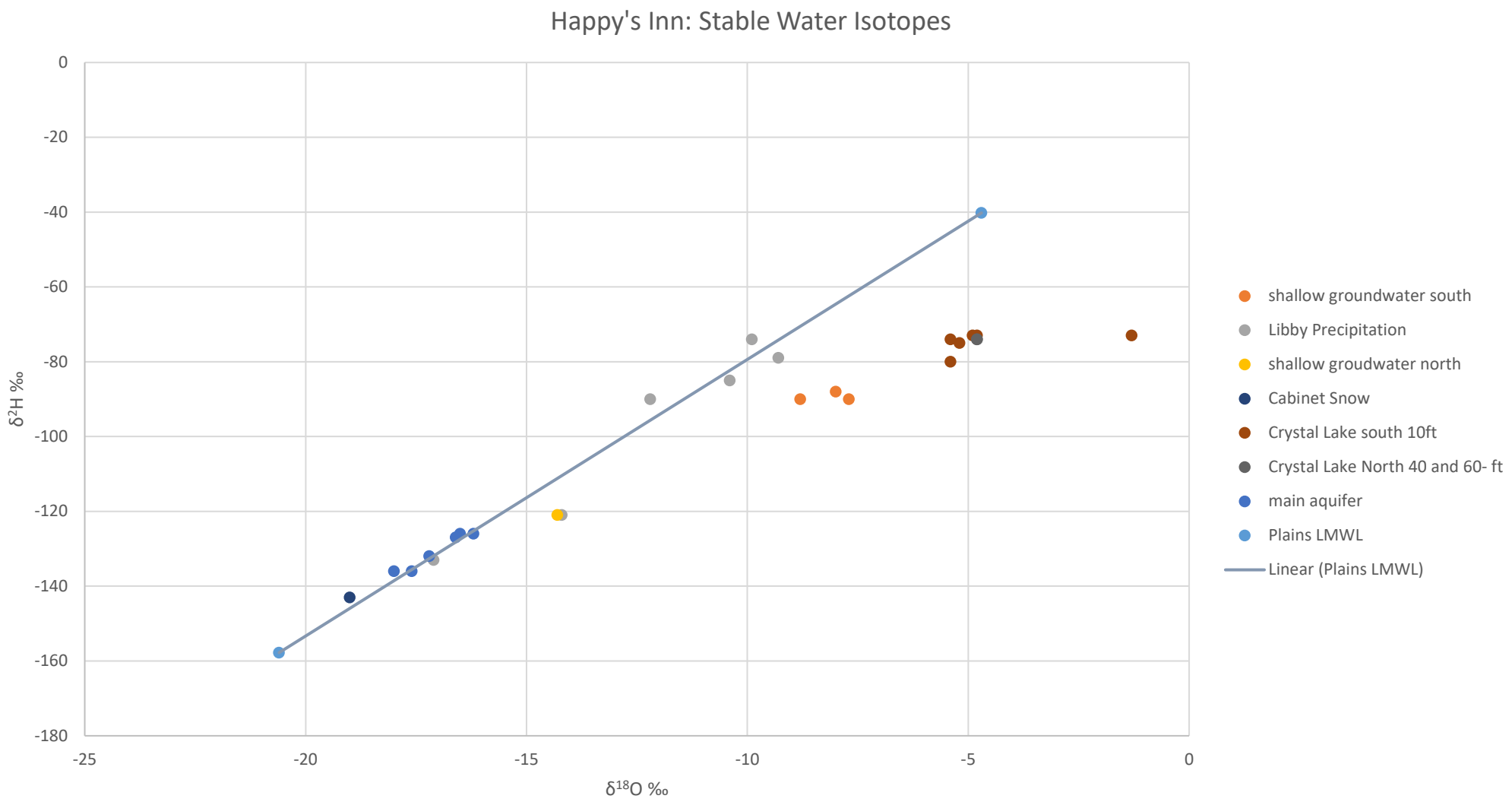
A strong correlation with 7-8 year time period

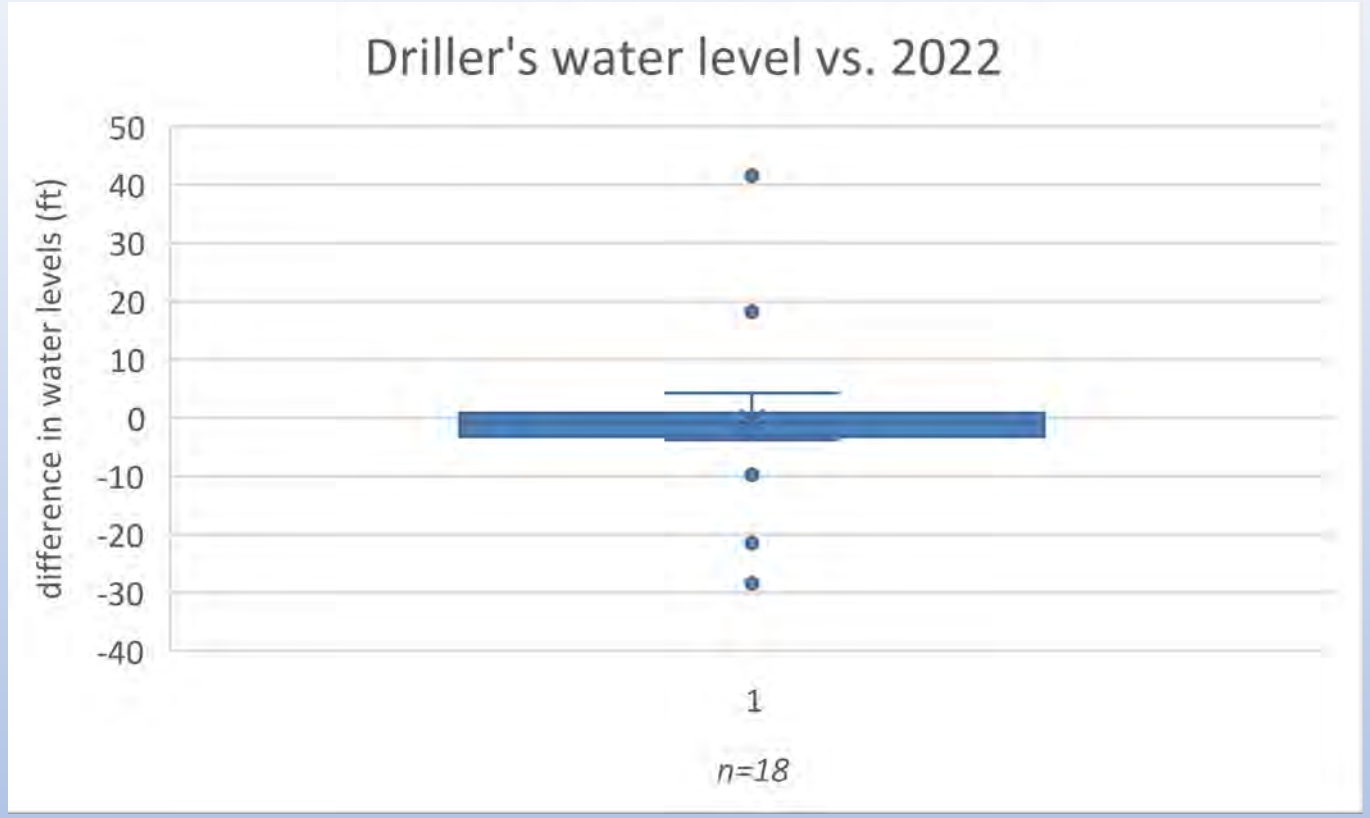


Three Regional Precipitation Data Sets

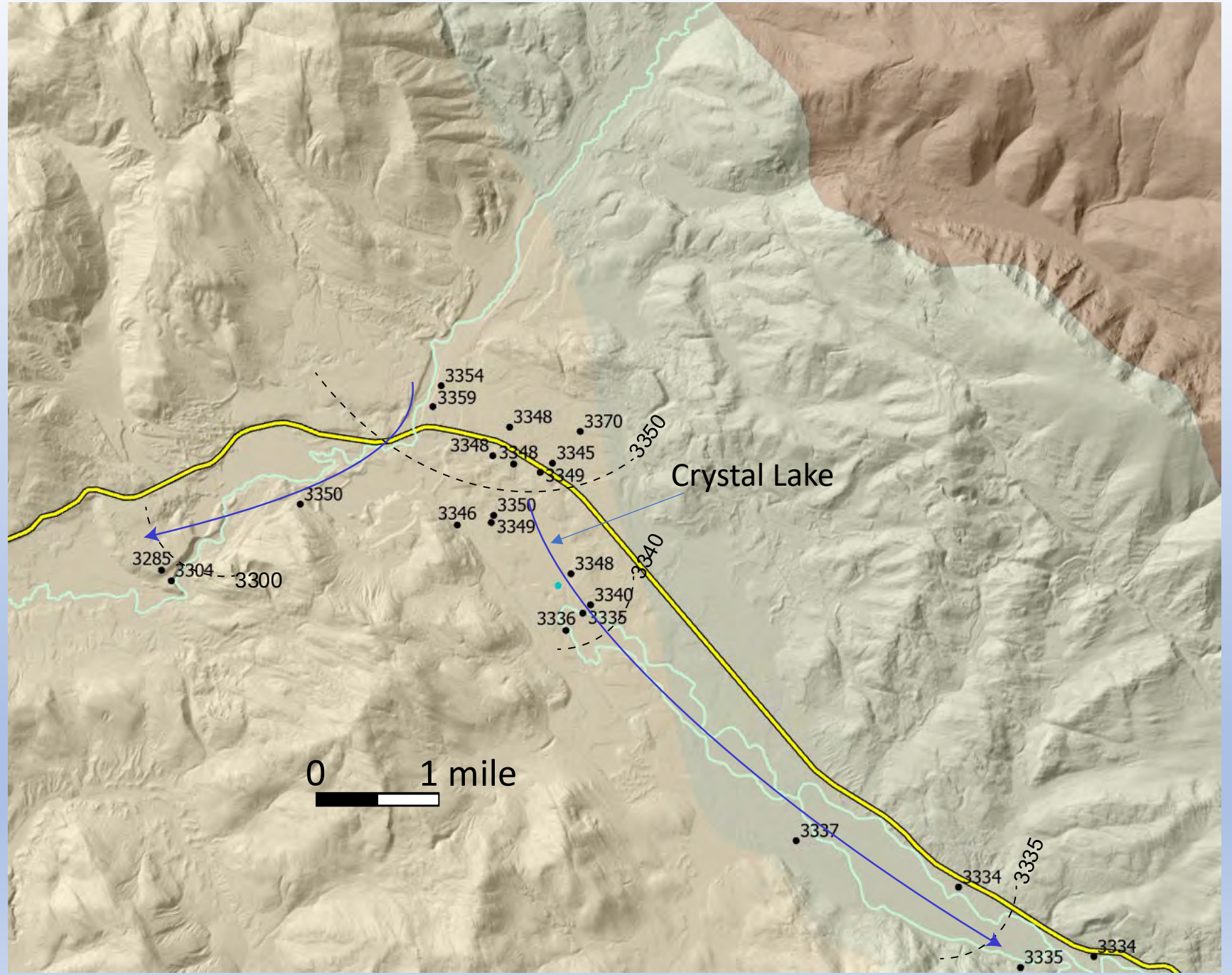





Happy's Inn: Stable Water Isotopes
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
δ²H ‰
-25
-20
-15
-10
-5
0
δ¹⁸O ‰
shallow groundwater south
Libby Precipitation
shallow groudwater north
Cabinet Snow
Crystal Lake south 10ft
Crystal Lake North 40 and 60- ft
main aquifer
Plains LMWL
Linear (Plains LMWL)



mean = -.81ft
median =-.55 ft


Crystal Lake
3354
3359
3348
3370
3348
3348
3345
3349
3350
3350
3346
3350
3349
3285
3304
3300
3348
3340
3340
3336
3335
3337
3334
3335
3335
3334
0
1 mile