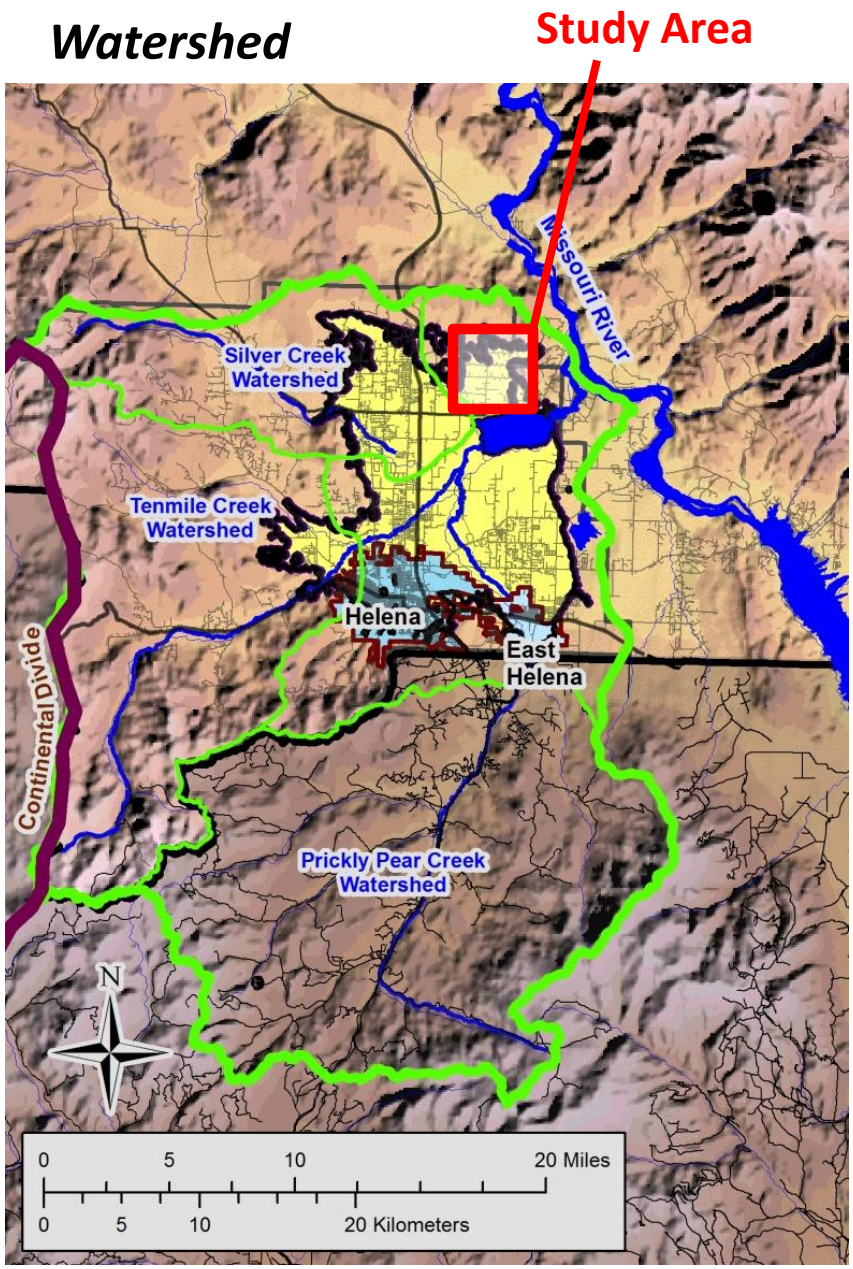
Lake Helena Watershed



East North Hills Groundwater Hydrology

James Swierc, PG
Hydrogeologist
Lewis & Clark Water Quality Protection District

October 1, 2019

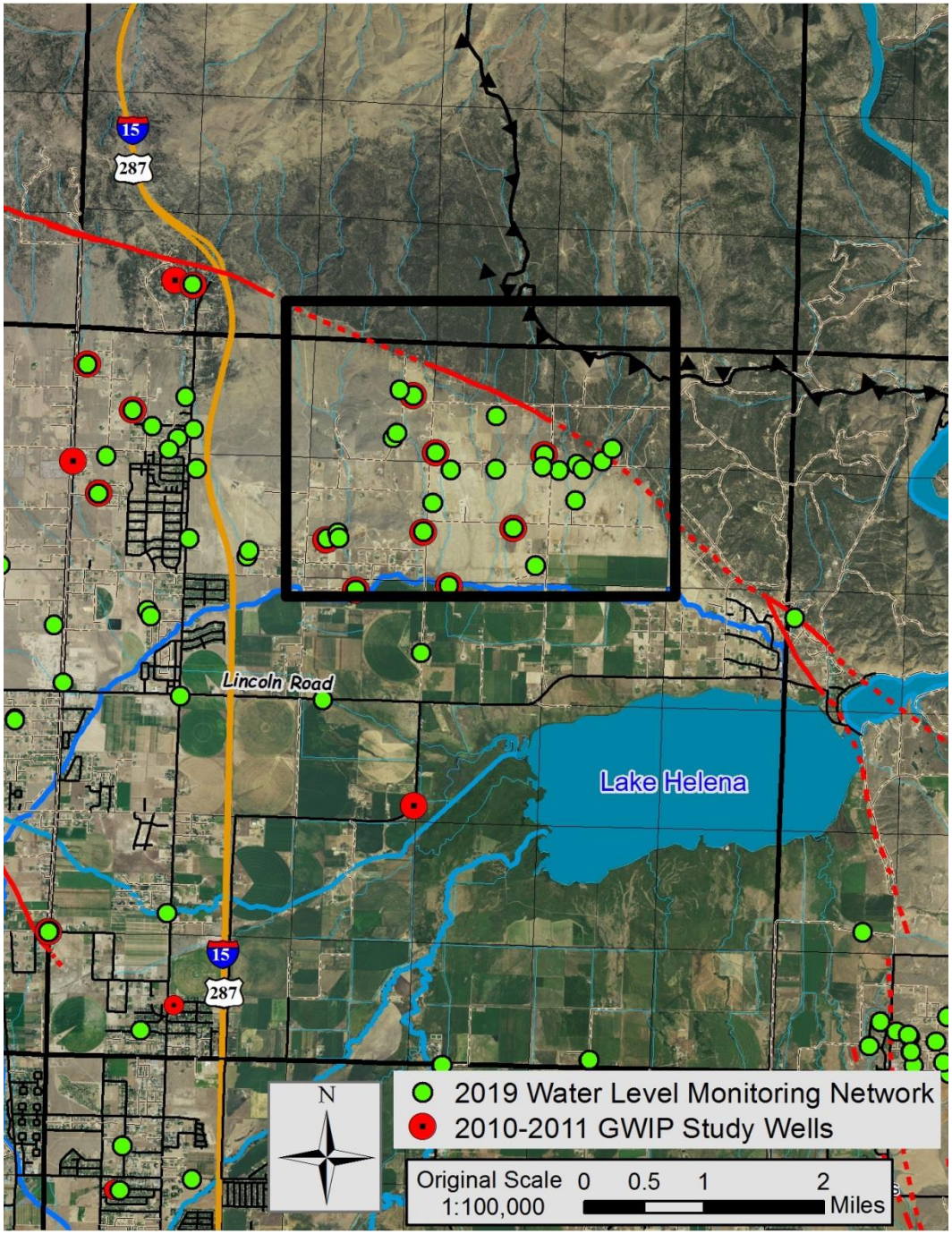
Introduction/Why We're Here

- Local Citizens Group Showed Concerns over Groundwater Depletion from Residential Growth
  - Hydrograph(s) shows declining water levels
  - Requested LCWQPD petition DNRC for a Controlled Ground Water Area
- Previous Studies – MBMG 2006; MBMG 2012
  - Temporary Controlled Ground Water Areas (CGWA)
    - "North Hills" Areas
    - focus – west side of area (where the growth/population is)

Note – copies of reports are available at MBMG website

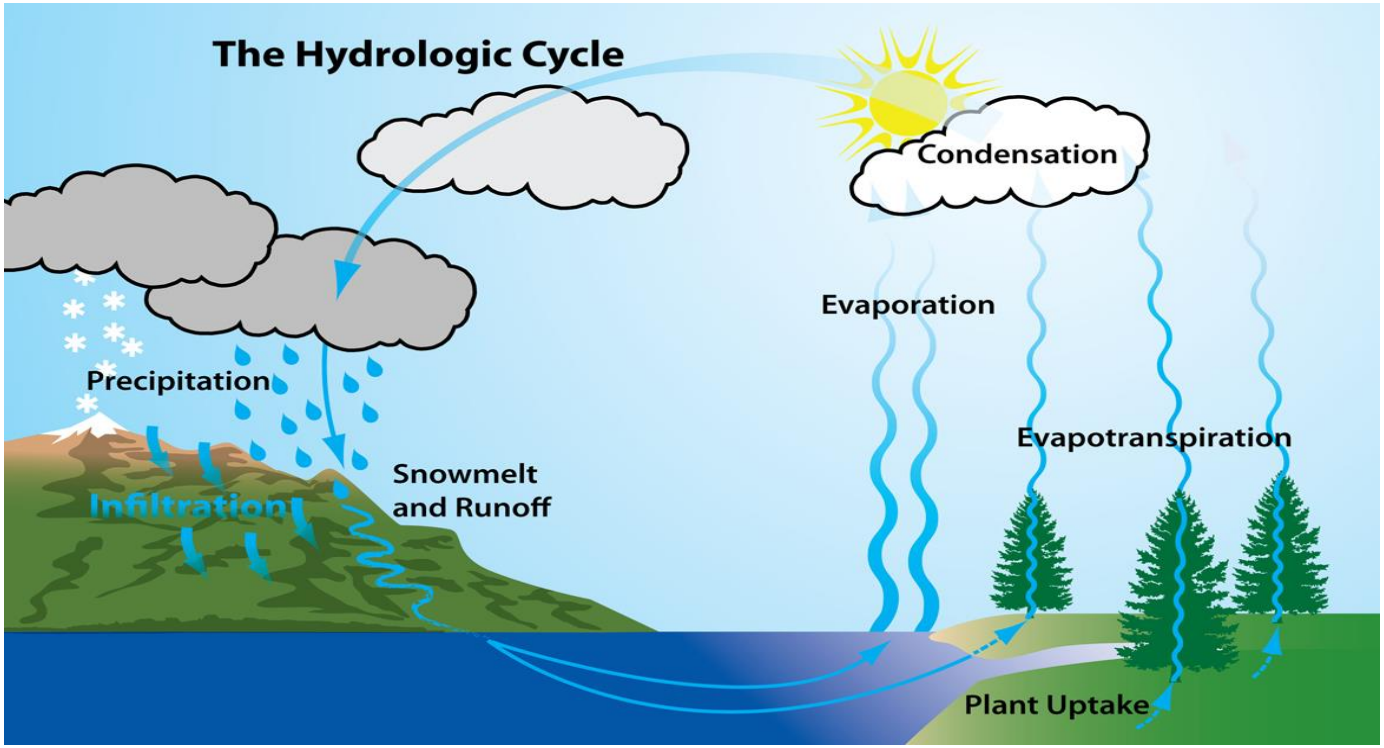
LCWQPD Study

- Focus – East Side of North Hills
  - North of HVID Canal
- Supplement Data from previous studies
  - Water Levels
  - Water Quality
  - Water Isotopes
  - Geology of Aquifer
  - Groundwater Temperature
- Evaluate feasibility of CGWA Proposal
  - Boundaries?



Basic Hydrology and Hydrologic Cycle

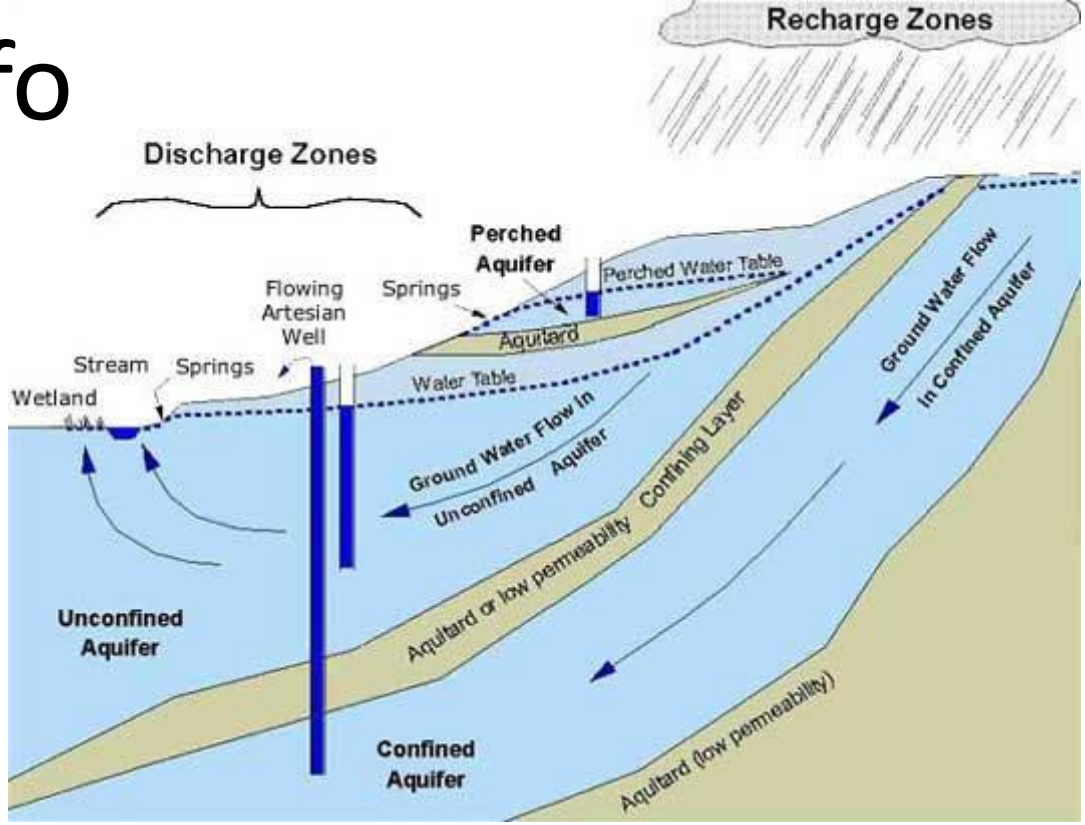
- Hydrologic Cycle – all water is connected
  - Evaporation, condensation in clouds
  - Precipitation and Infiltration/Runoff
- With respect to Groundwater and Study
  - Only a finite amount of groundwater available



Background Info

- **Groundwater Depletion** – long term decline in water levels **from pumping**.
  - Not related to changing precipitation patterns

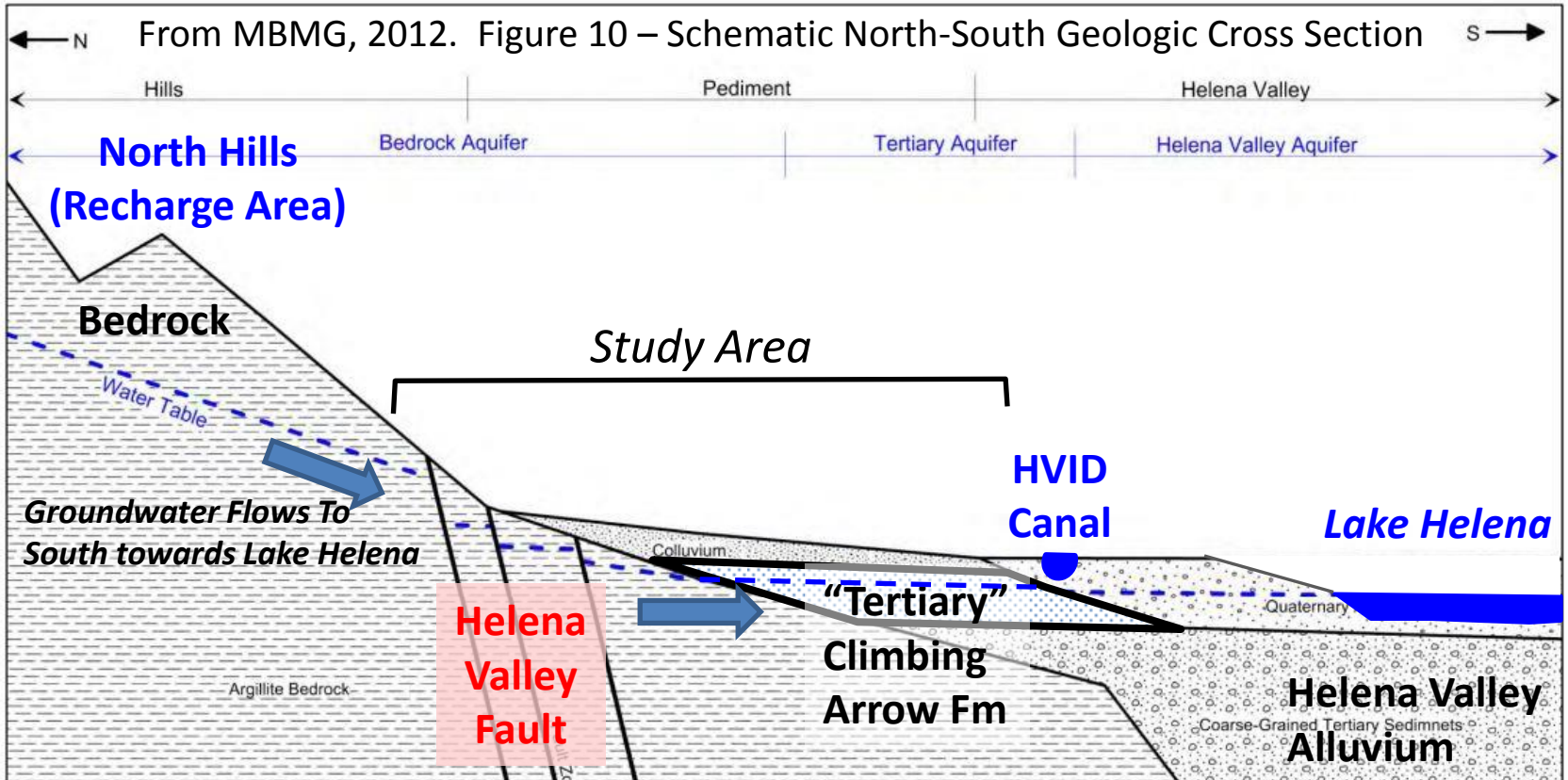
- **Aquifer** – geologic underground layer which transmits water
  - "usable" quantities, high permeability, yields
  - ***Unconfined*** – water table surface
  - ***Confined*** – "artesian" pressure, surface rises above top of aquifer



- Water Balance
  - Water in (recharge) = water out (discharge)
  - Equals water available for use
- North Hills Area
  - Recharge from ***precipitation*** in higher elevations
  - **Infiltration is main/only groundwater recharge**
  - HVID Canal in downgradient area

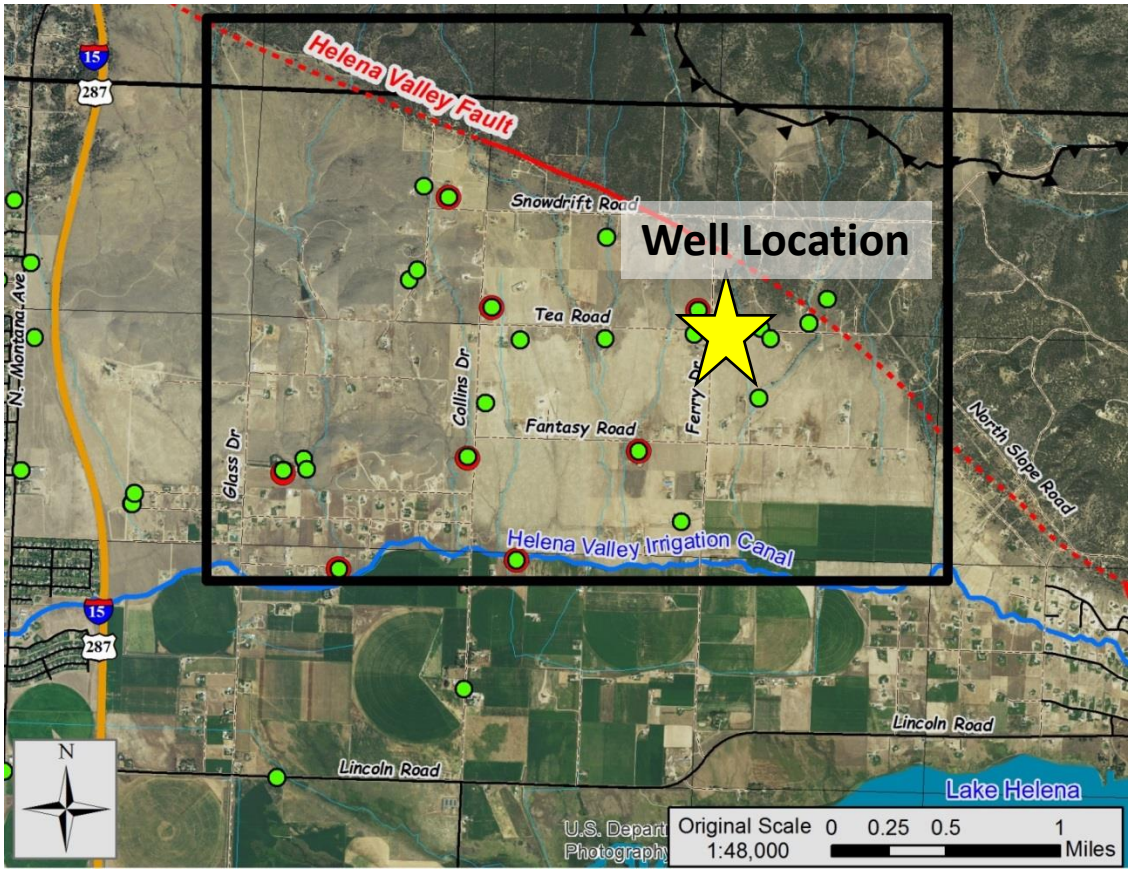
Concepts to East North Hills Area

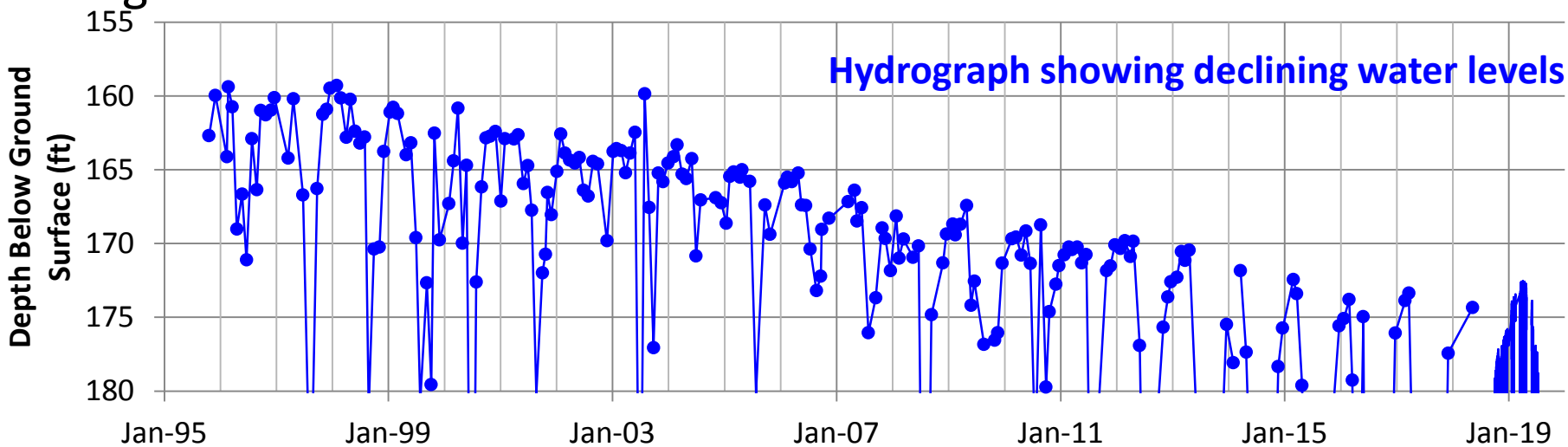
- Recharge from precipitation.
- Groundwater flows south towards Lake Helena
- HVID Canal – adds water to downgradient area only
- MBMG Model (2012) – rain amount sufficient for water needs
  - Things are a little different than modeled conditions



Water Levels

- ***Hydrograph***
  - Graph showing changes in water levels over time
- Types (still same graph)
  - Depth to groundwater surface
  - Elevation of groundwater surface

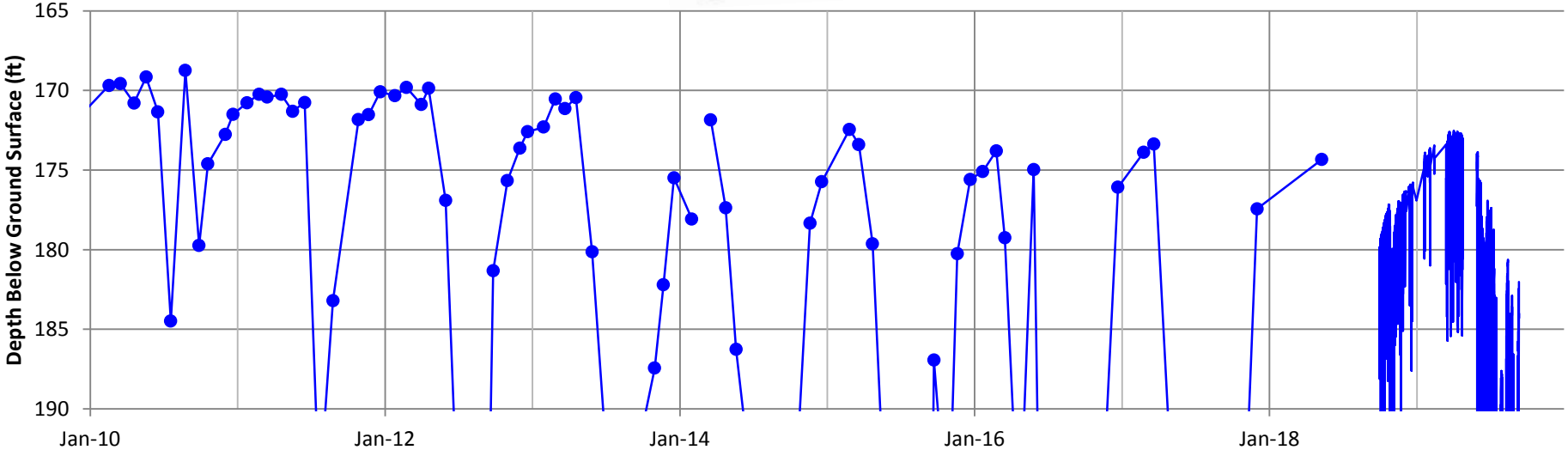




Note on Water Level Measurements

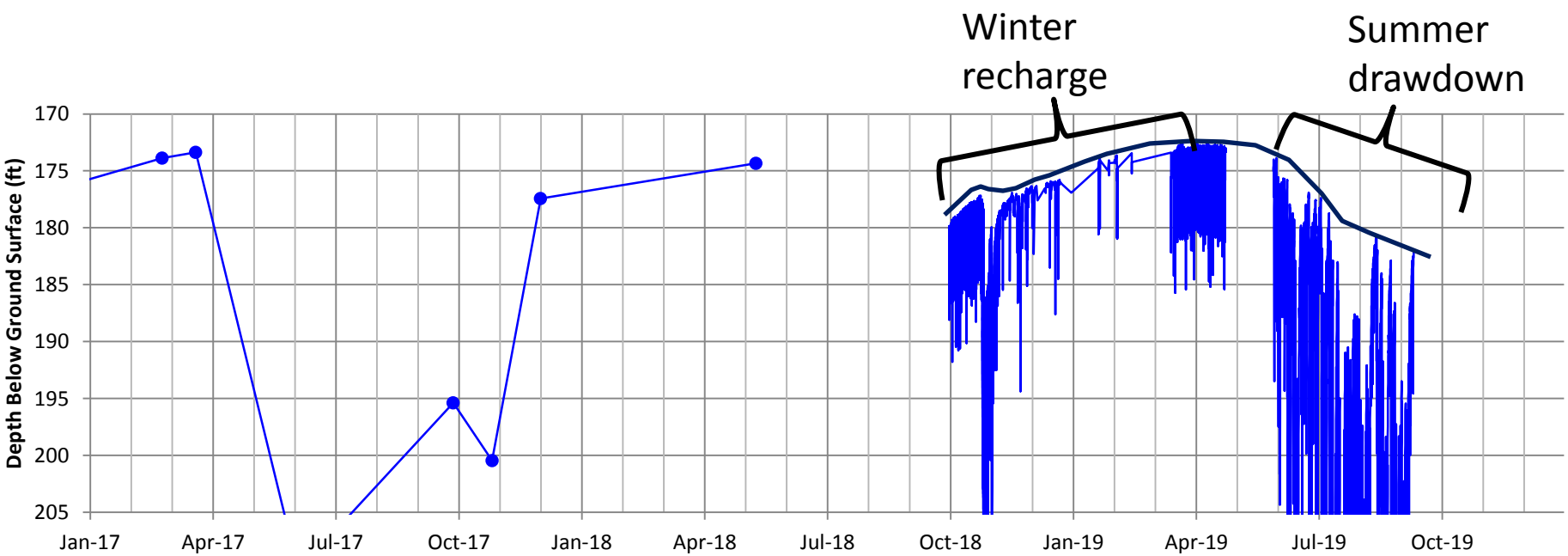
- Term – ***Static Water Level*** – depth to water
  - No drawdown from pumping
  - Reported on well logs (MBMG-GWIC)
- Term – ***Drawdown***
  - How much water levels falls from static during pumping

- Regular measurements by hand
  - Potential for non-static results
  - LCWQPD Program – monthly measurements
- Dataloggers – frequent measurements
  - Sensors (pressure transducers)
  - Sonic sensors at wellhead



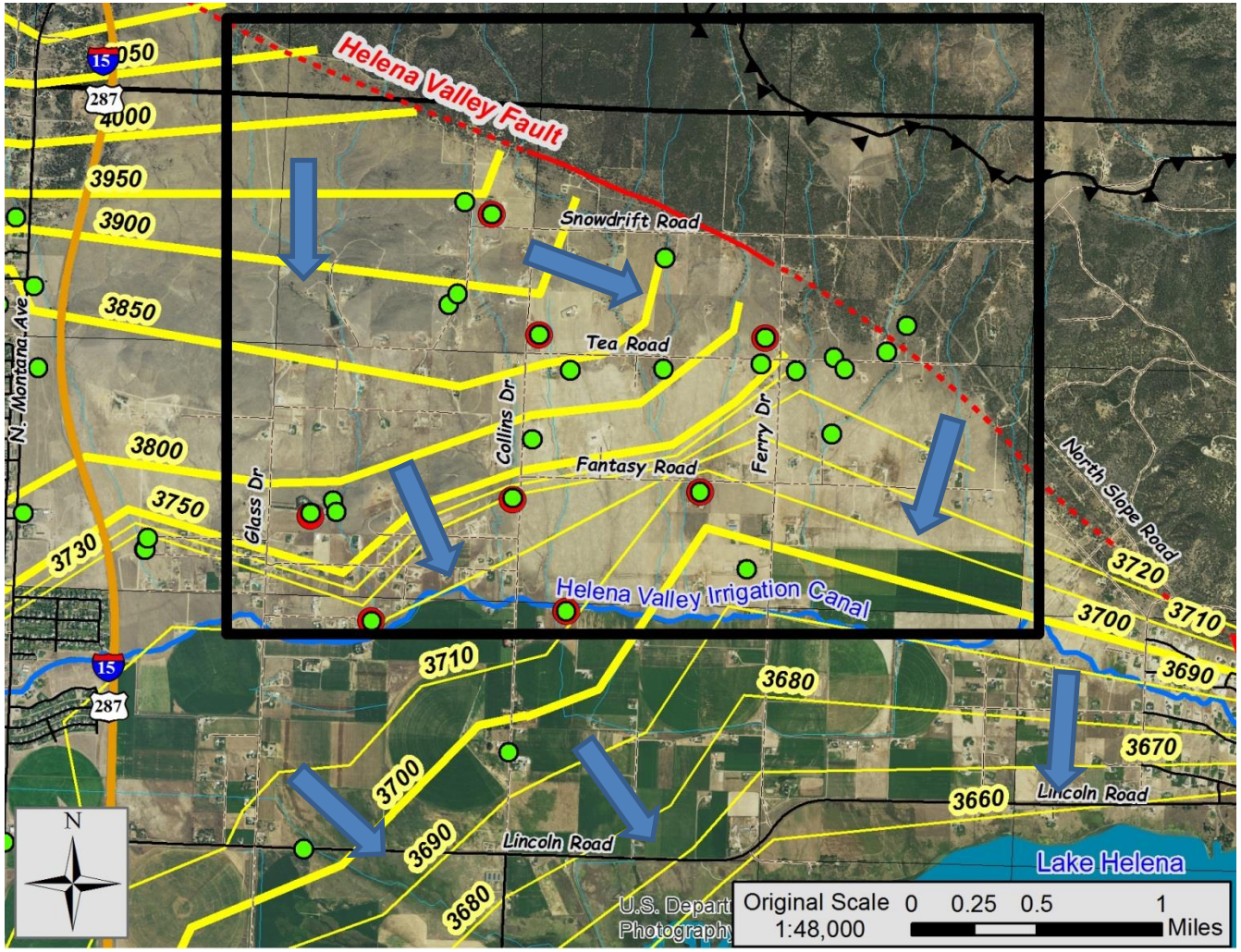
Note on Water Level Measurements

- Information from Datalogger and regular measurements
  - Drawdown from normal pumping
  - Low Yield Aquifers – recovery takes time
    - Extended period of time for return to static levels
  - Connect line at “peaks” to get “static” hydrograph
- East North Hills Study Area
  - “Aquifer” is clay-rich with sand seams providing water
    - Climbing Arrow Formation
  - Limited yield and permeability



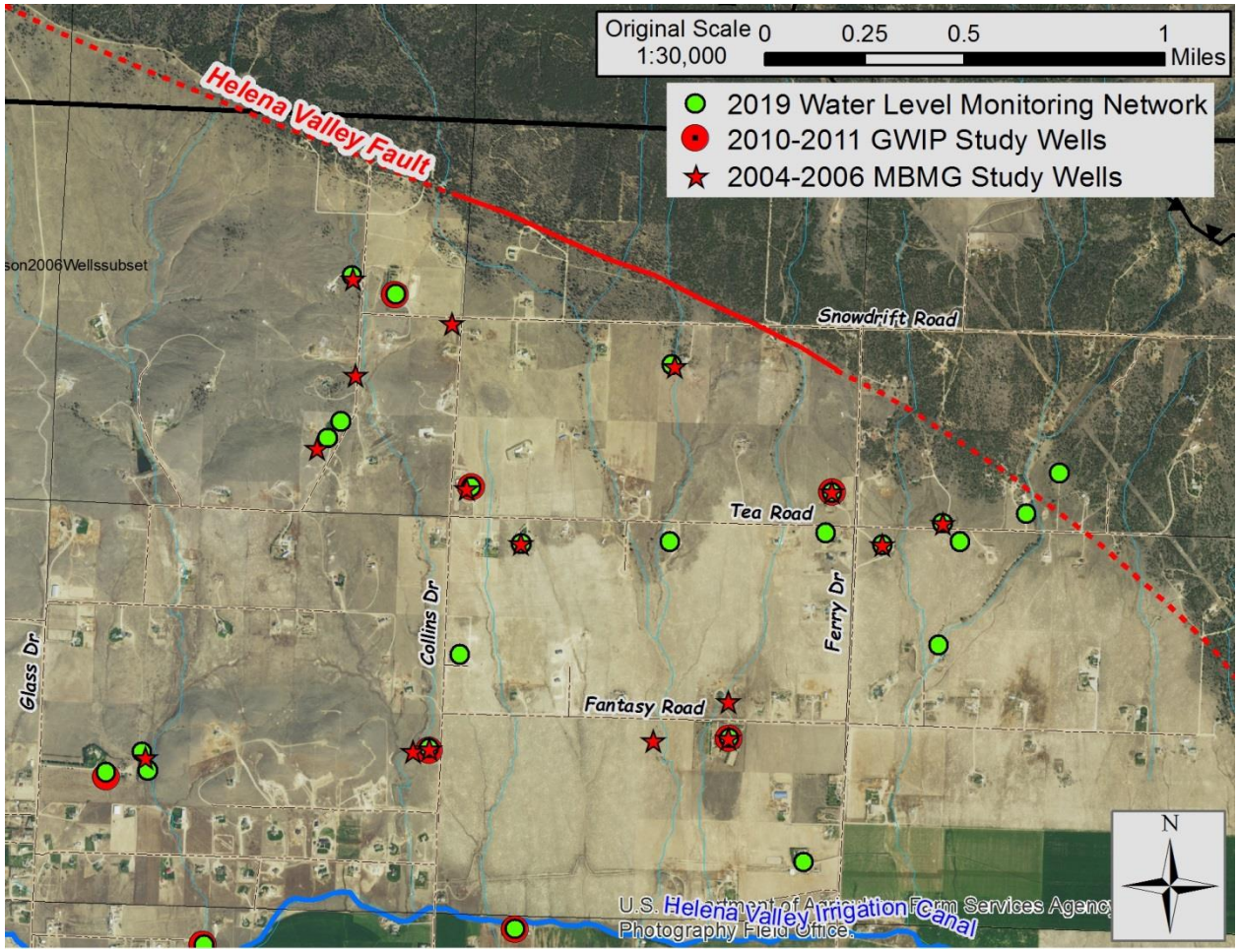
Water Levels and Groundwater Flow

- Elevation of water surface
  - Vs. depth to ground water below surface
- Contours made like topography
  - Interpolate between wells with data
  - But surface may be different then land surface
- Water flows perpendicular (90°) to contours



Groundwater Flow Direction

2019 Water Level Program

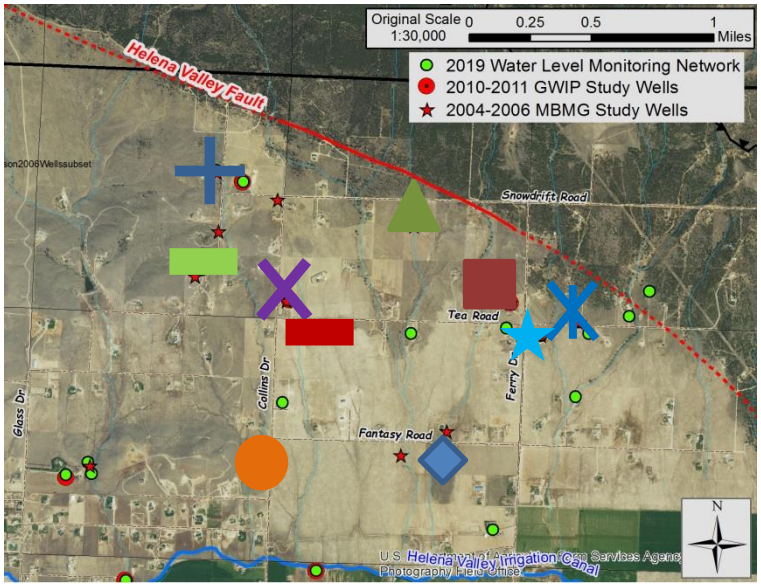


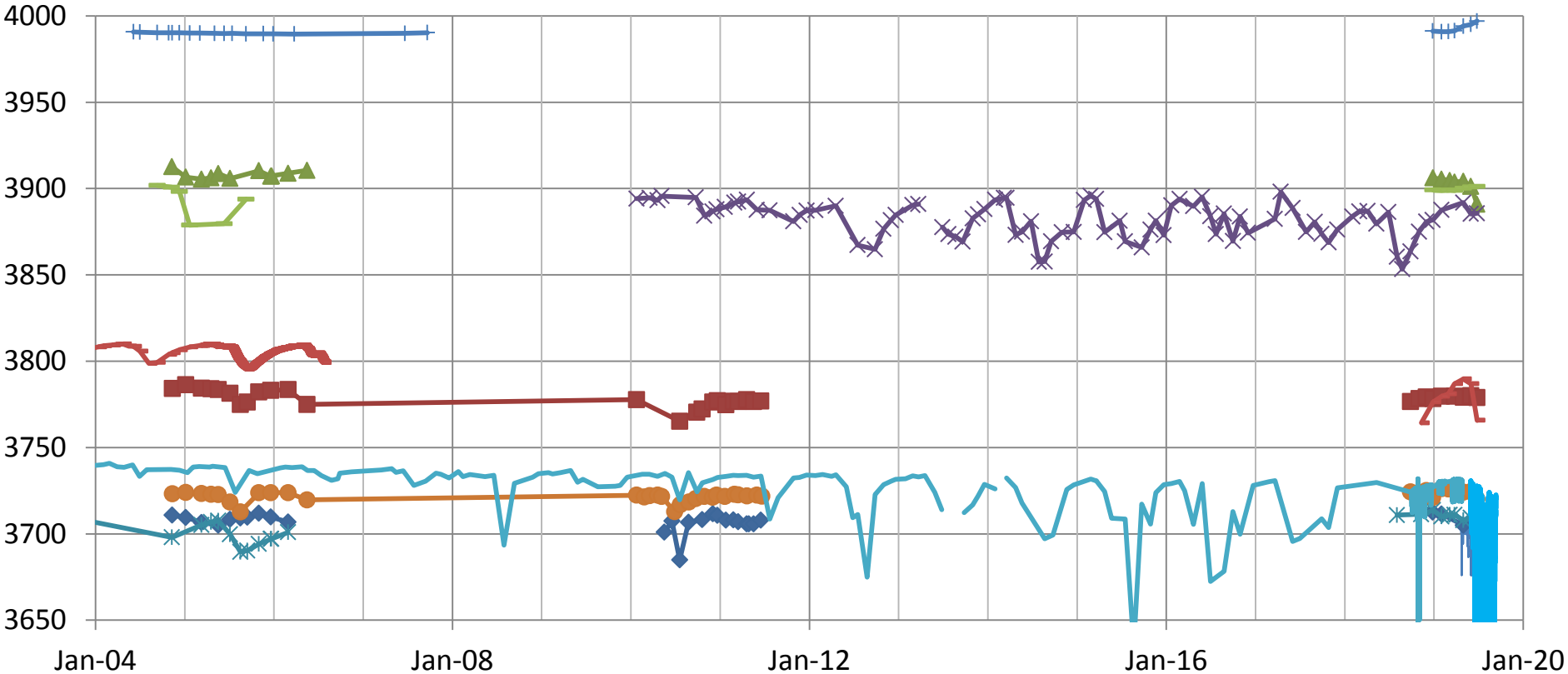
Remember link to precipitation – "wet" years more recharge
"dry" or "drought" years less

- Identify wells with data from previous projects
  - Collect monthly data to see how water levels have changed over time
  - Monthly to account for seasonal trends
- Dataloggers
  - Transducers placed into two bedrock wells
  - Well-n-tel sonic water level datalogger provide data from one location.

Water Levels and Hydrographs

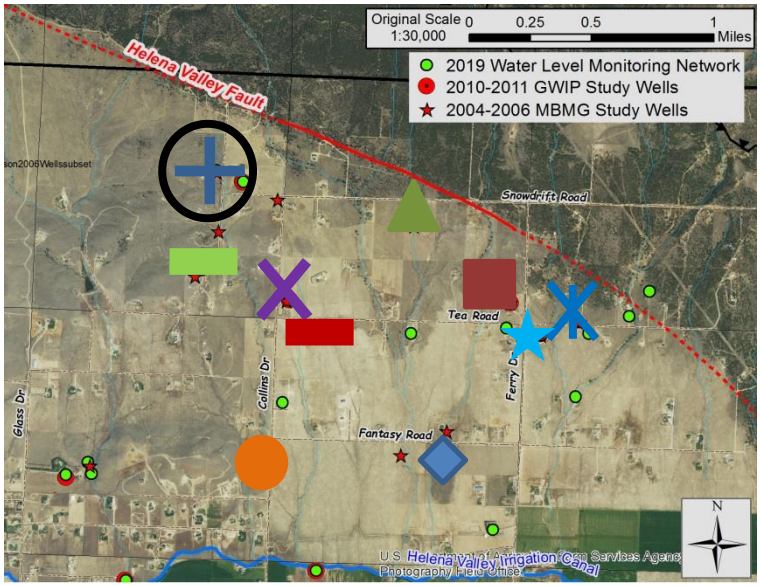
- 10 location on map with data from 2004-2005
- Elevations from high to low





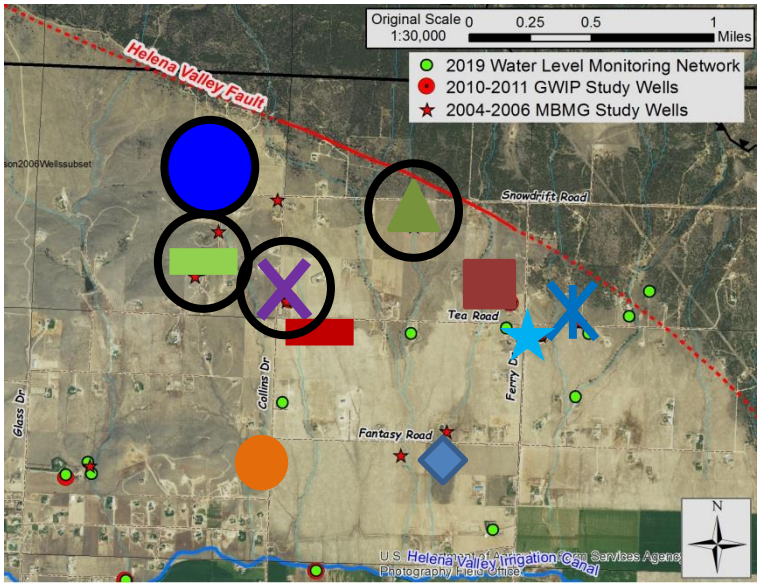
Water Levels and Hydrographs

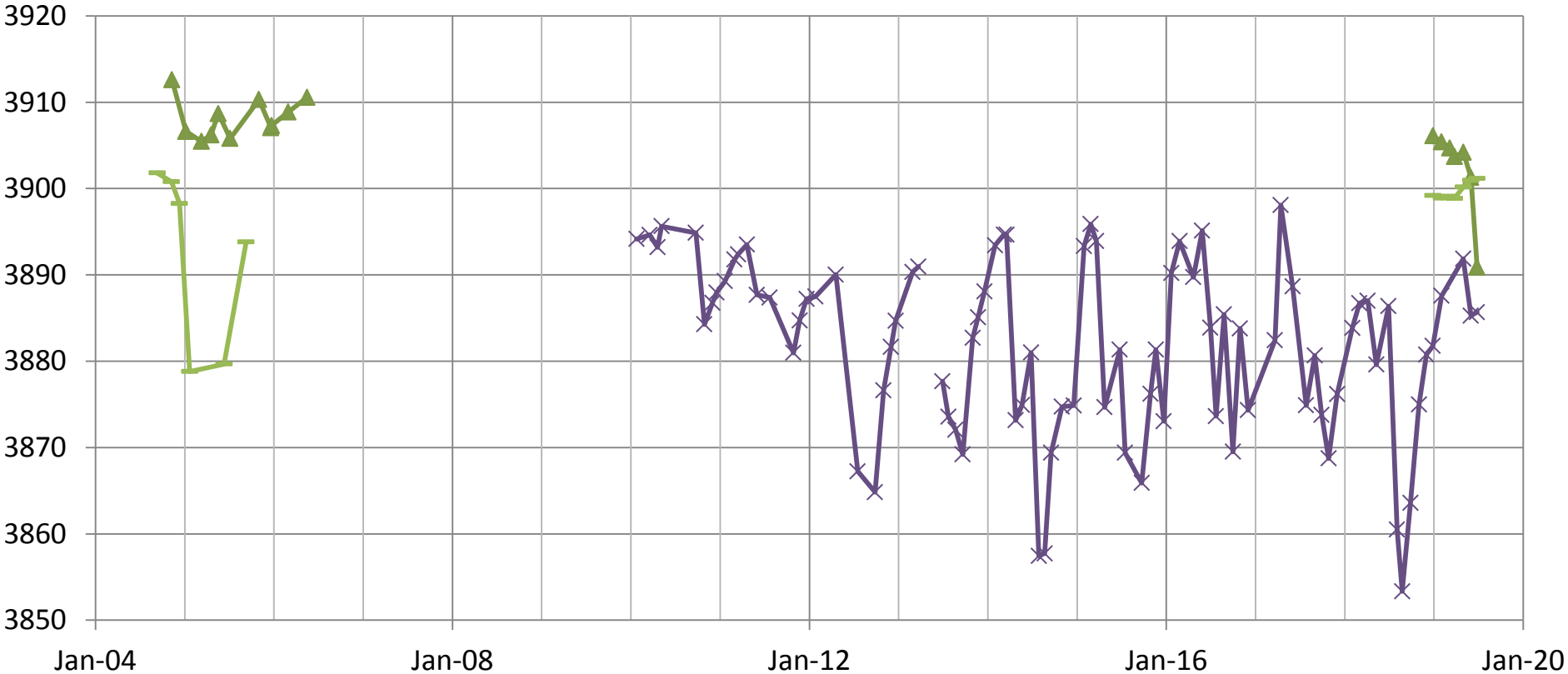
- Upgradient Well
  - TD 48’,
  - No change – rising WL



Water Levels and Hydrographs

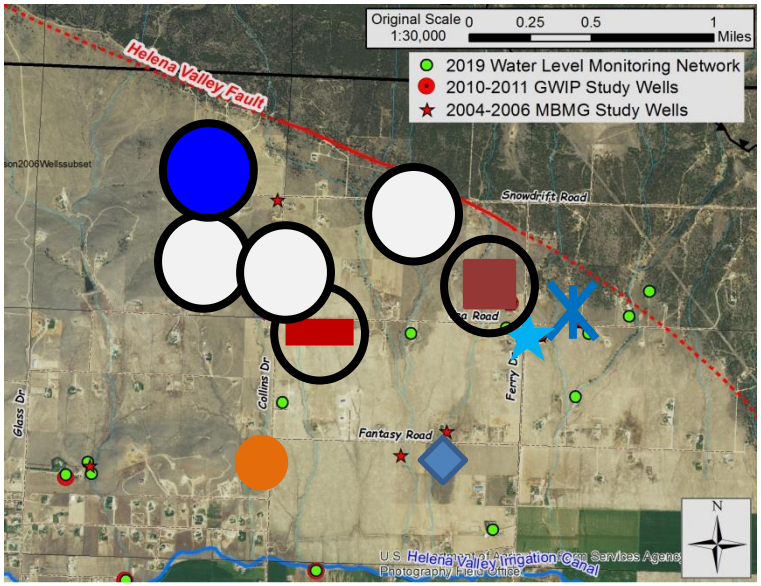
- 3 Wells
  - ▲ – TD 178’, same
  - ✕ – TD 192’, same
  - ▬ – TD 324’, same

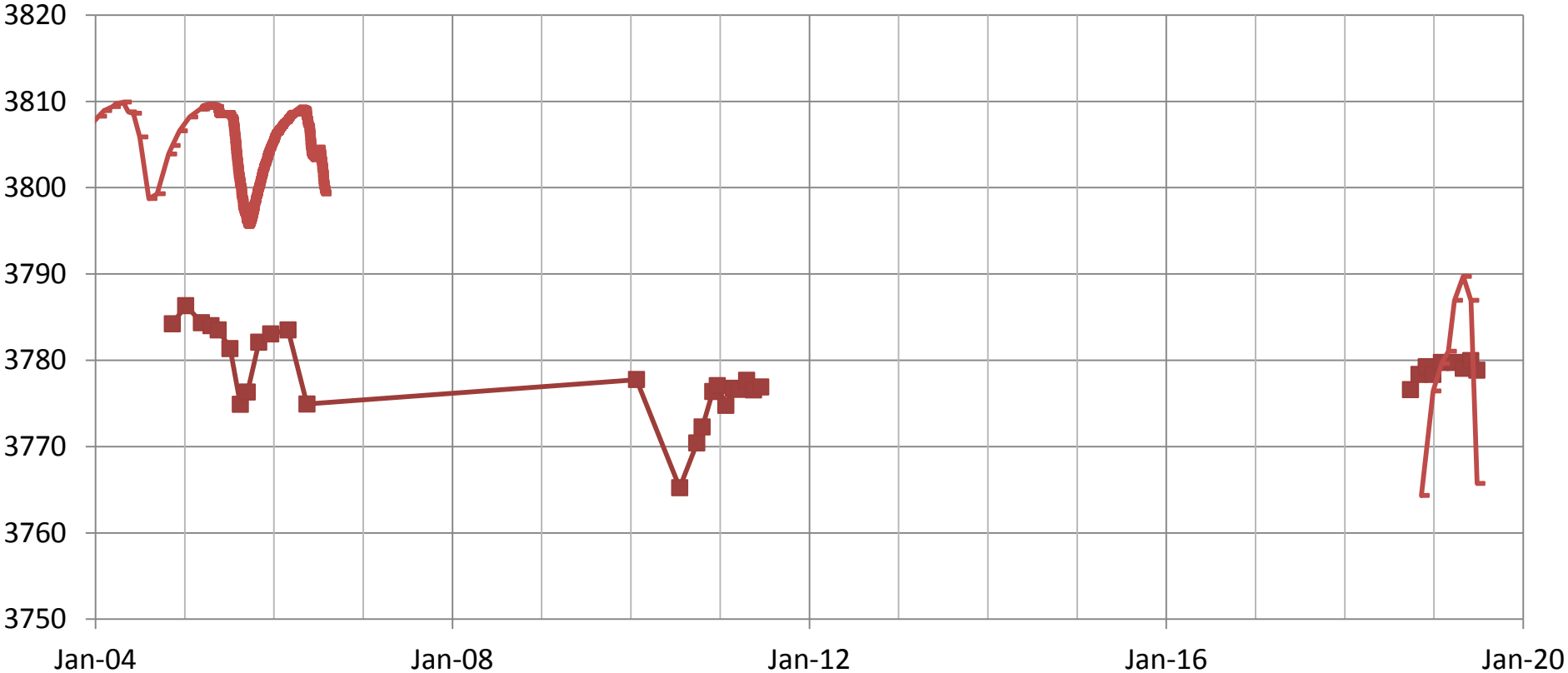




Water Levels and Hydrographs

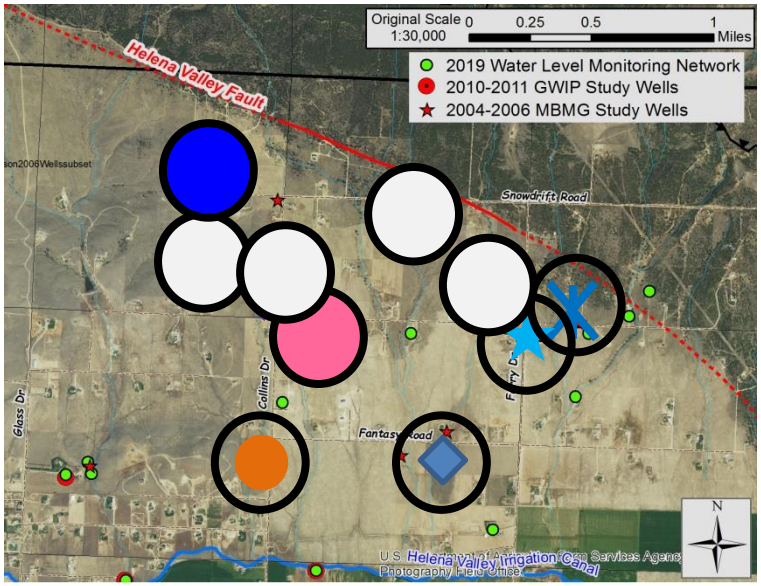
- 2 wells
  - TD 420’, drawdown 20’
  - TD 390’, same

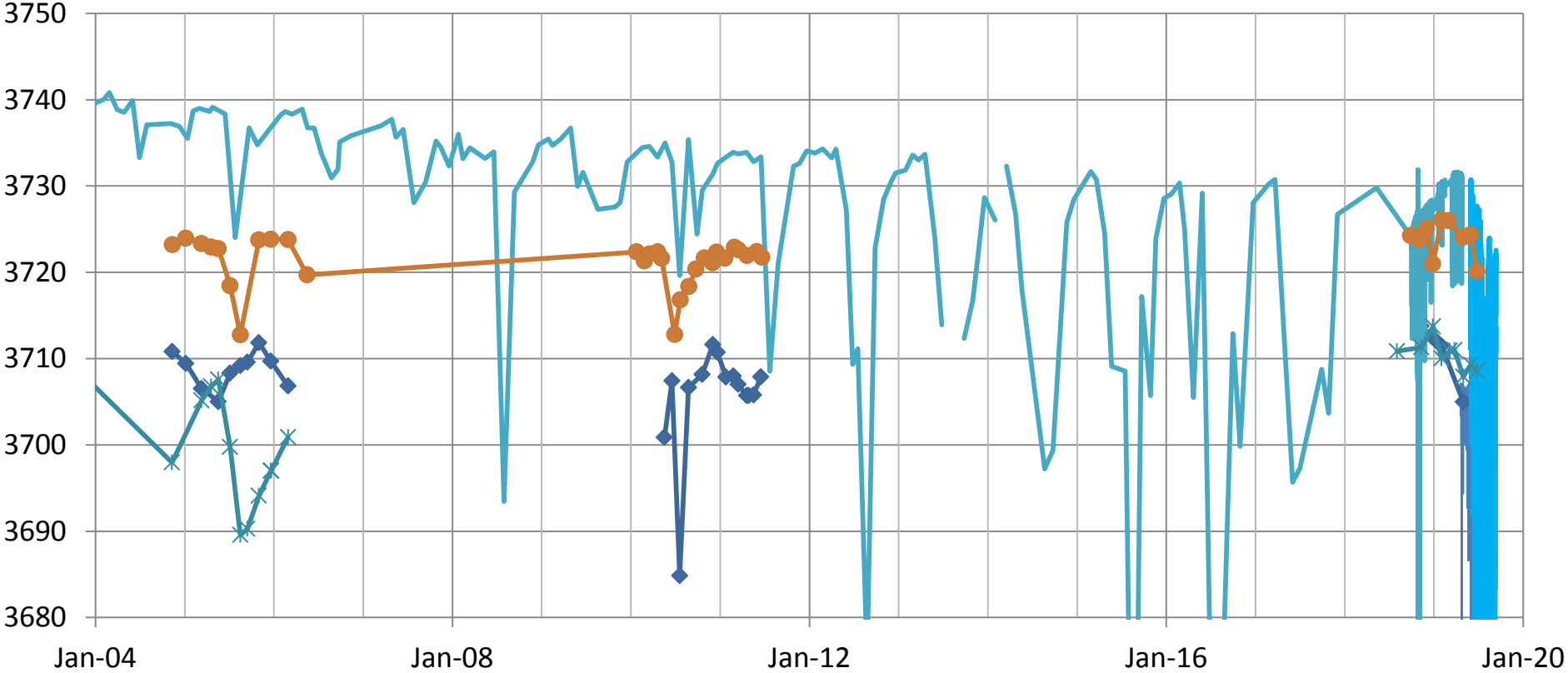




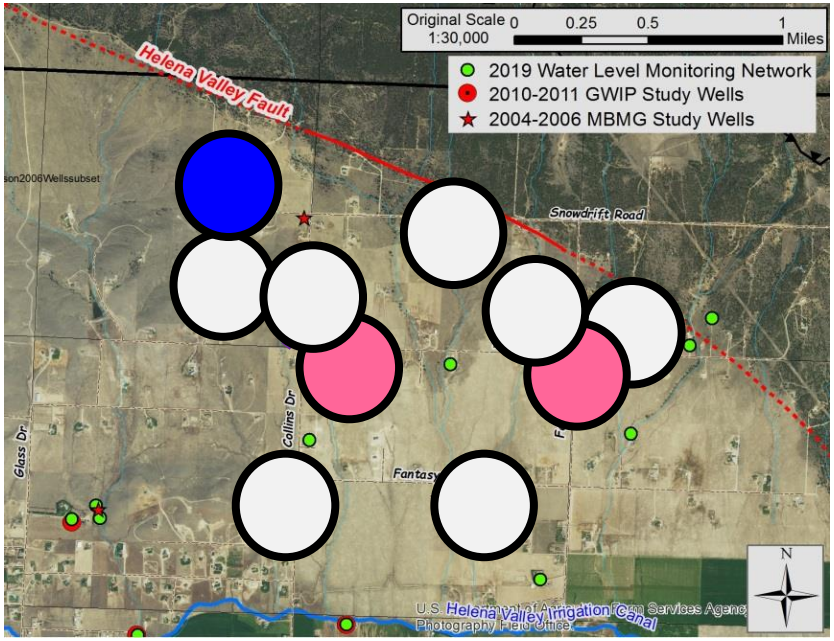
Water Levels and Hydrographs

- Downgradient 4 wells
  - TD 259’, same
  - TD 420’, same
  - TD 350’, 10’ drawdown
  - TD 254’, same





Hydrograph Information



Slight increase in Water Level

"Stable" Water Levels

Slight decrease in Water Level

- Do we see changes in water levels since 2004?
  - Generally No
  - Slight drawdown in 2 wells
    - 10' over 15 years

What drawdown do we see?

- Change in "Storage"

Concept - ***Groundwater Storage***

Clay rich aquifer

- Holds water in small pores – not available for pumping
- Slowly released over time

Difference between recharge and discharge

- Some aquifers have excess "storage" built up over time
- Pumping (discharge) exceeds natural recharge

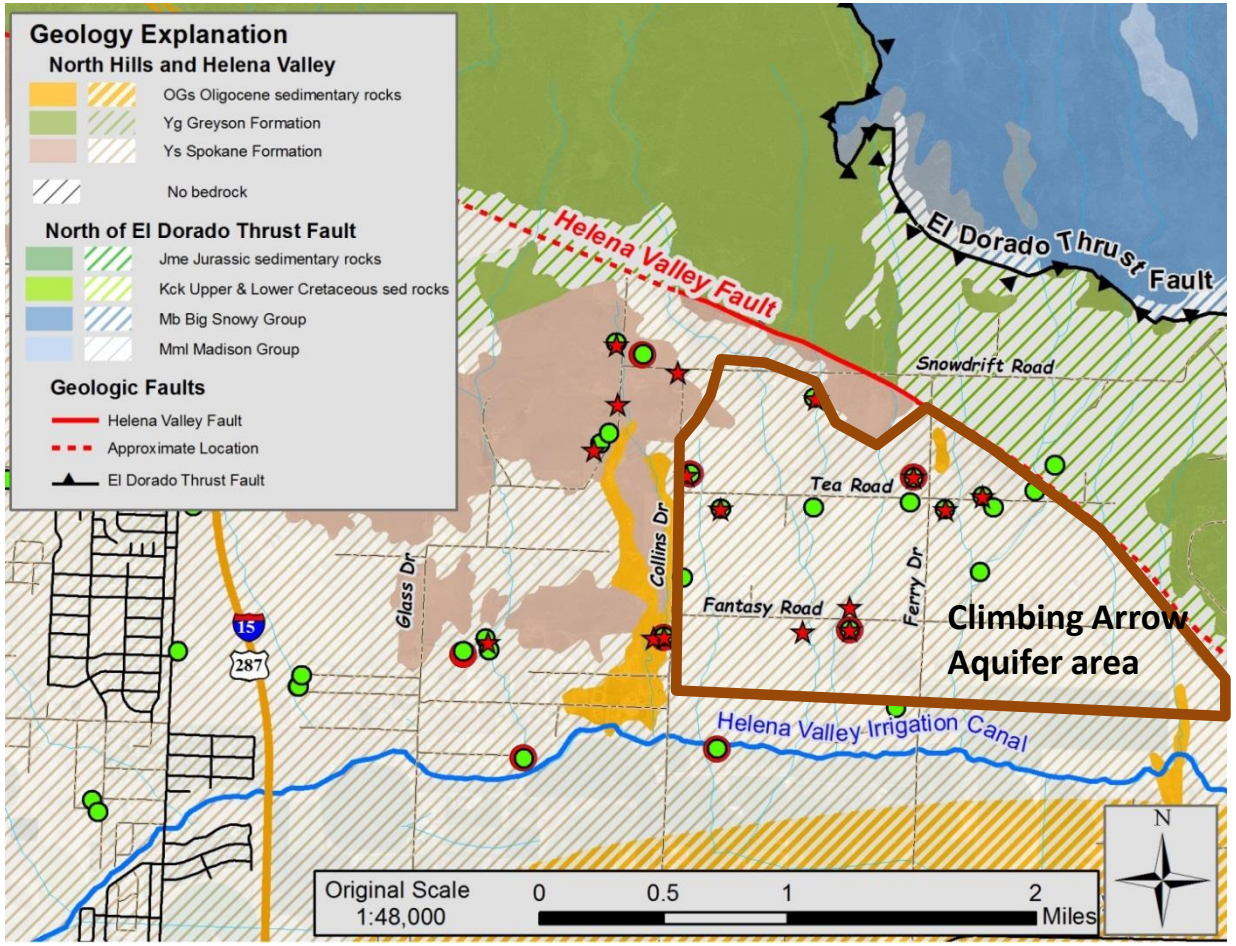
- Aquifer may have "extra" water from prehistoric times
  - Recharge exceeds discharge

Aquifers in Study Areas

- Geology (rock type) determines aquifer properties
  - Clay-rich aquifer system – most of East North Hills
  - Climbing Arrow Formation (MBMG, 2017)
    - Sand/gravels seams in mostly clay/silt aquifer
    - Low yields
    - Confined conditions
  - "Bedrock" wells – variable yields but generally good.
    - At surface in west side of study area
      - Water Table, unconfined aquifer
    - Beneath clay-rich system in central part of area
      - Confined conditions
  - Sand & Gravel wells – south side of study area
    - "Shallow" wells, water table (unconfined) system

Aquifer Delineation and Geology

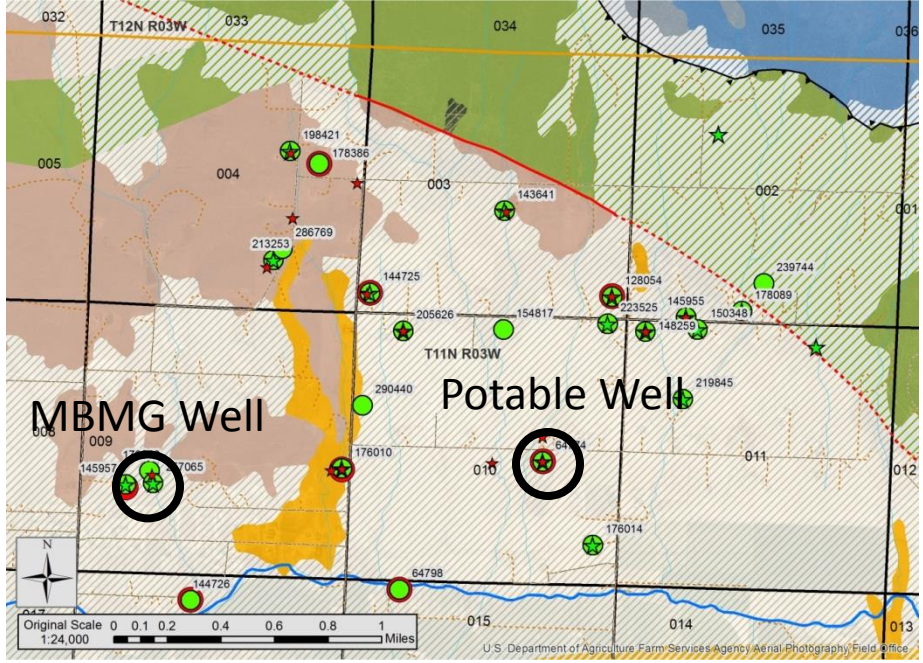
- Geology determines aquifer properties
  - **Yield**
- Ogs – Tertiary
  - Climbing Arrow Fm
    - Clay rich
    - Sand seams
    - Low yields
  - BEDROCK present beneath Climbing Arrow Fm
- Bedrock
  - Fracture flow
  - Variable Yields

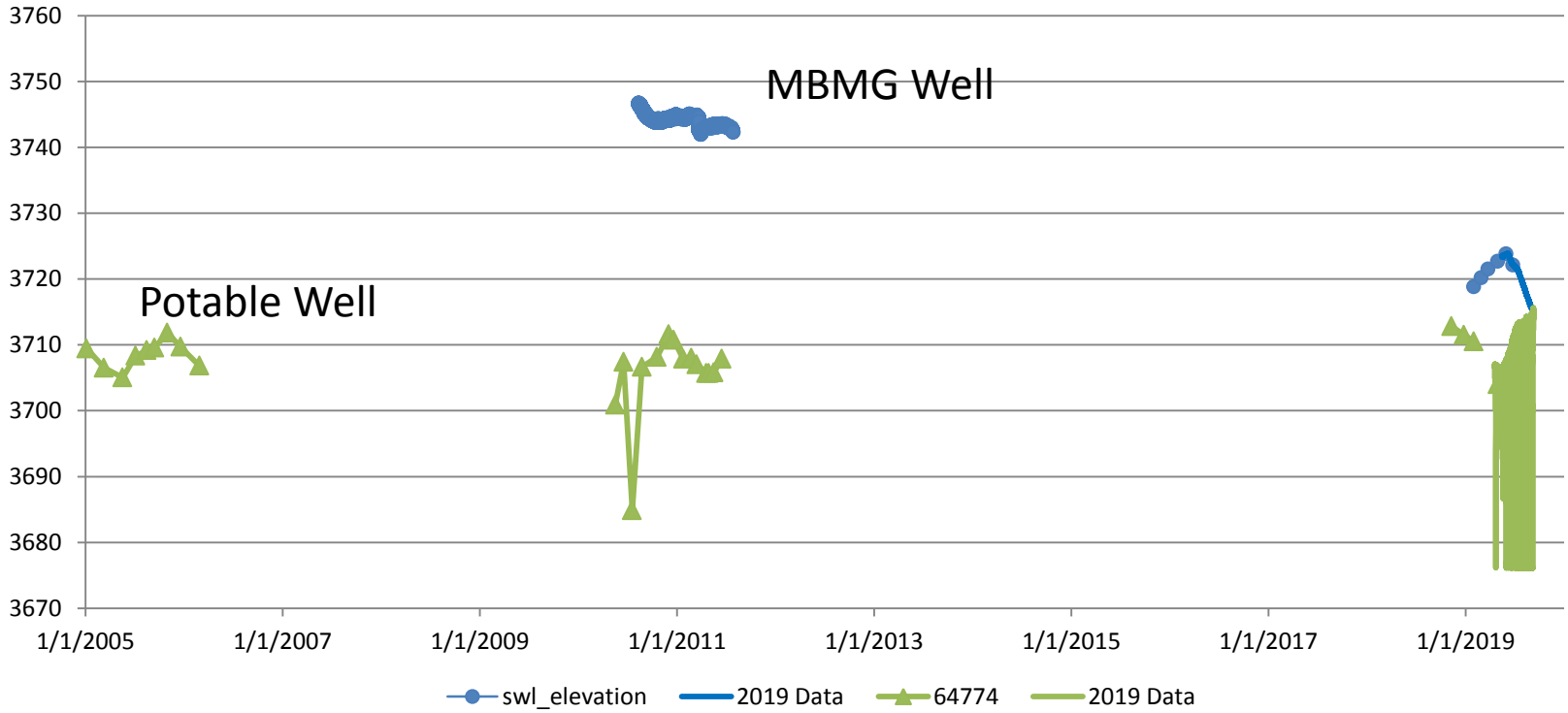


(will come back to Geology later in presentation)

Bedrock Wells

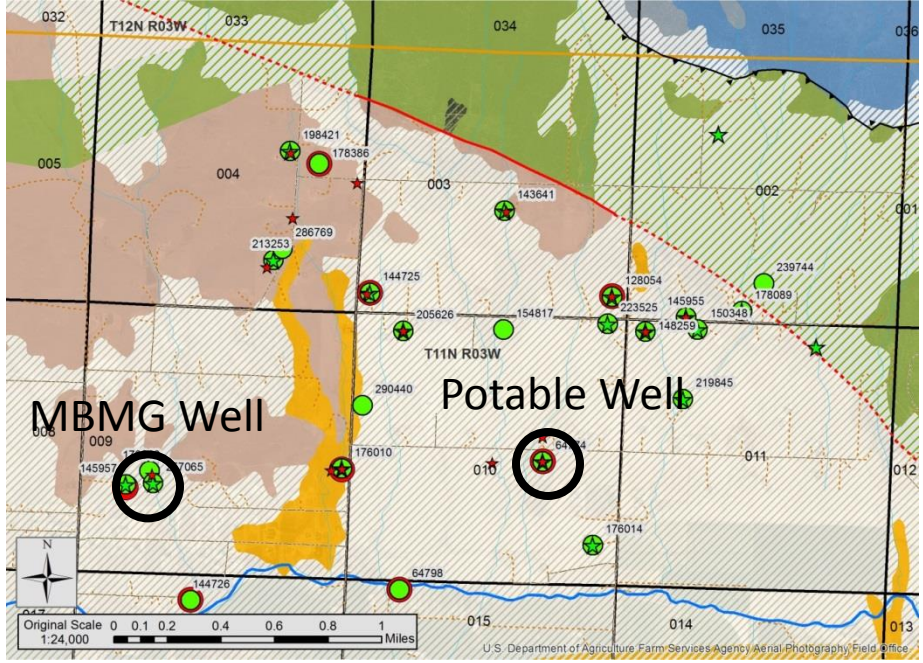
- MBMG Pumping Well
  - Bedrock at surface, TD 360’
  - WL falls, STORAGE
- Potable well into bedrock
  - TD 420’, Clay/shale to 380’
  - Argillite (bedrock) at 380’-420’

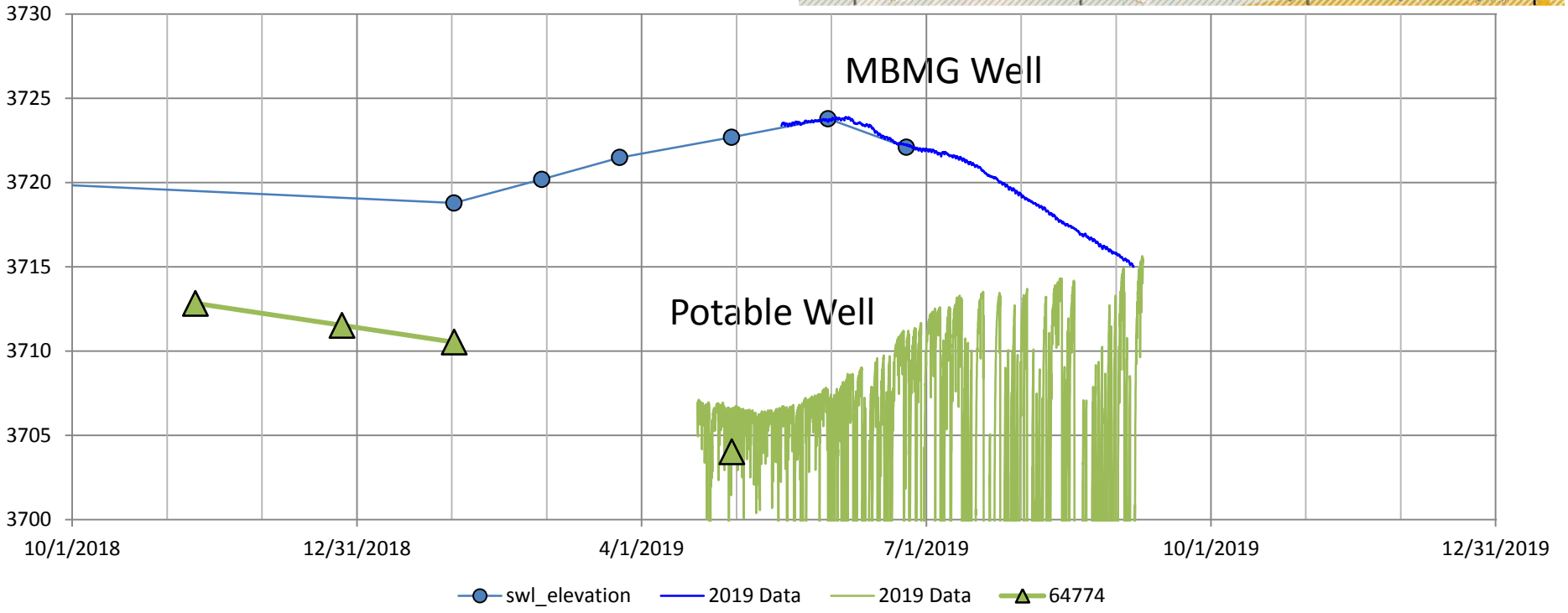




Bedrock Wells - 2019

- Two different recharge sources
  - West well – surface bedrock/recharge
  - East well – 300’ of clay over bedrock
- ***Different Aquifers***





Summary of Hydrograph Conclusions

- Water Levels are generally stable
  - Limited drawdown in 2 wells attributed to storage

- Bedrock aquifer
  - Different when exposed at surface
    - “Water Table”, Unconfined
  - Beneath clay-rich sequence
    - Confined

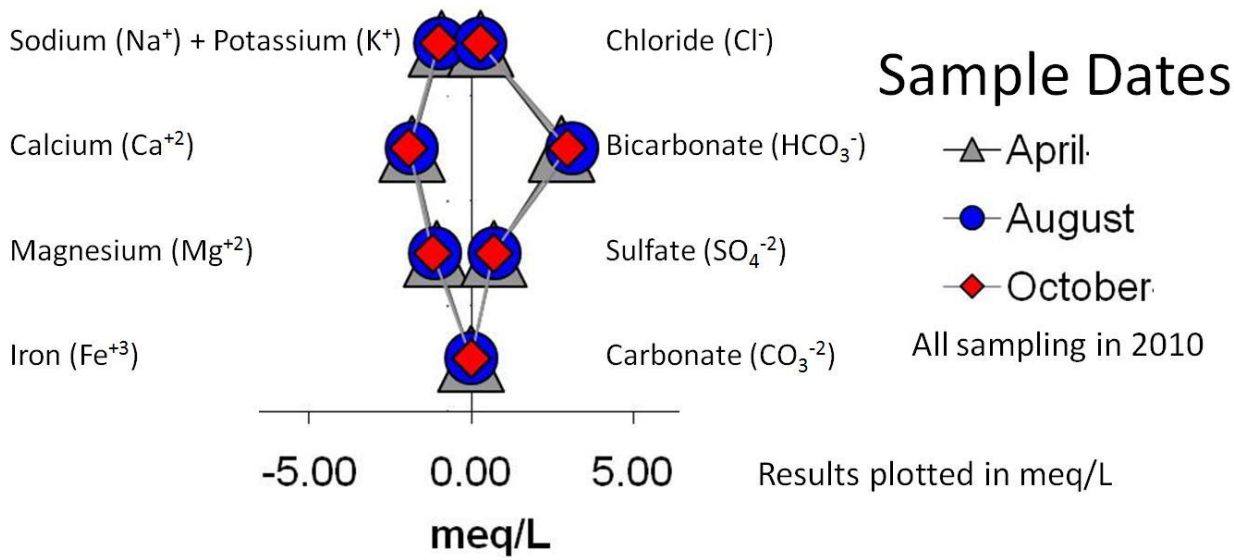
Water Quality (Major Ions)

- Major ions to characterize water "type"
  - Example, "hard" water, "soft" water, etc
  - Process/Method applied to >500 sites in area

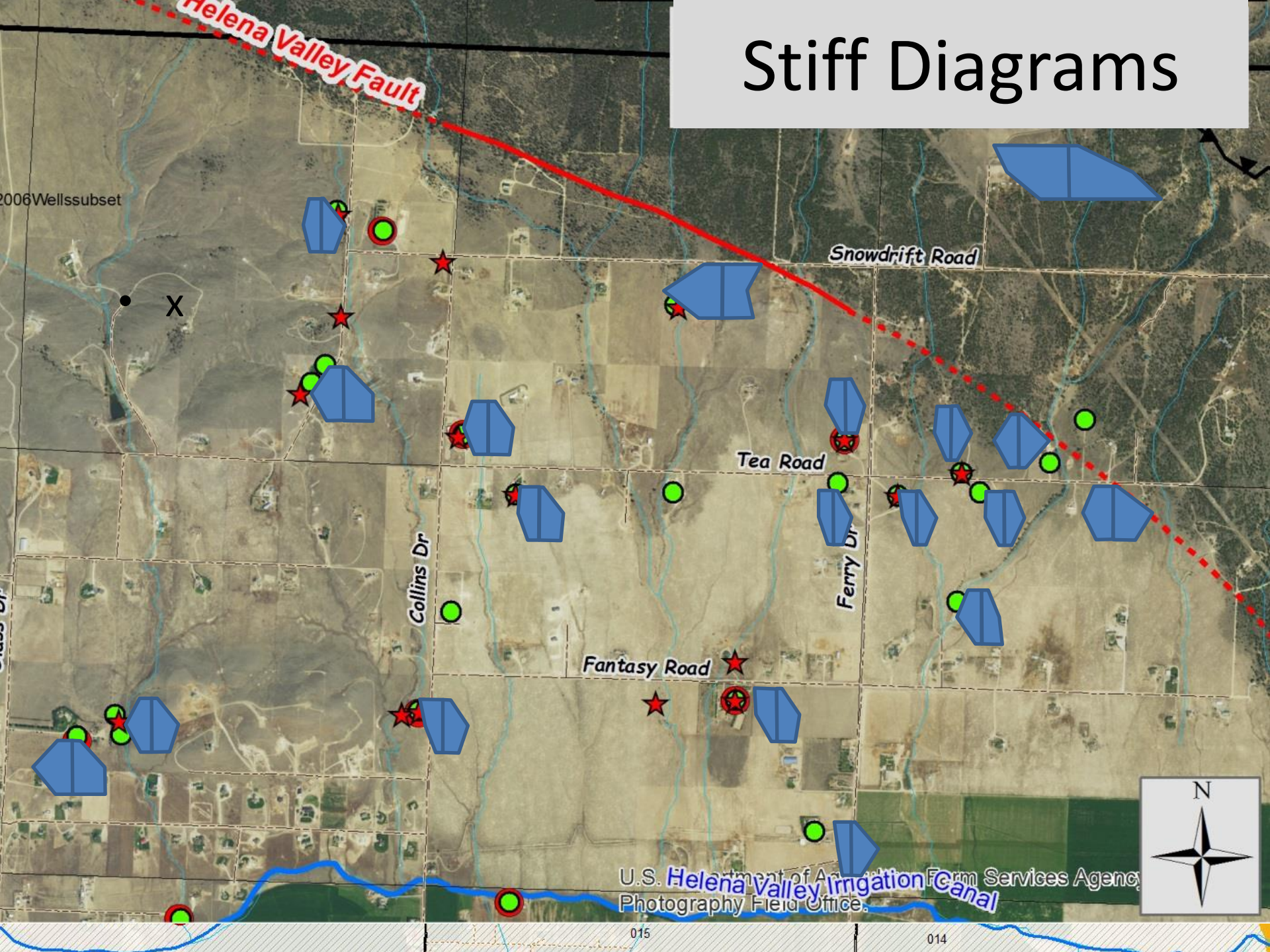
- Major ions comprise 99% of dissolved solids
  - Reflect geology/minerals of aquifer
  - Water quality type can change with time in subsurface
  - With geology, can link to trace elements (e.g. arsenic, uranium)

Stiff Diagram

Size of polygon reflect Total Dissolved Solids (TDS)



Stiff Diagrams

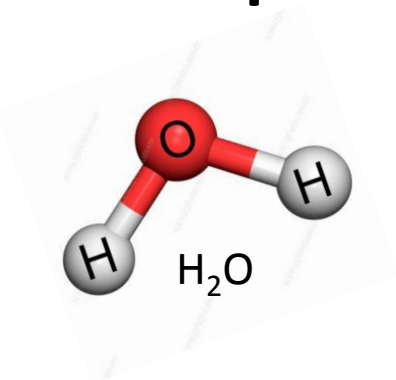


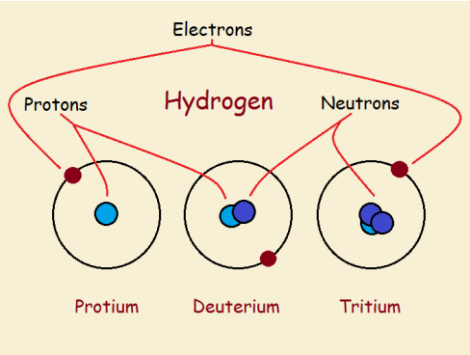
Chemistry Conclusions

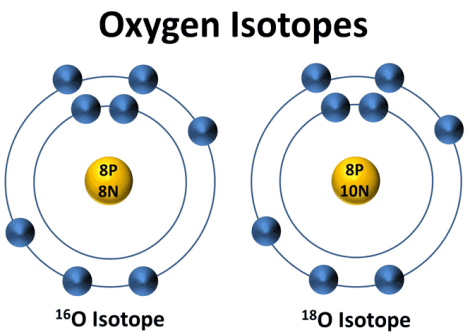
- See Differences across study area
  - Some areas with same chemistry
- Bedrock wells – different aquifers
  - Different chemistry

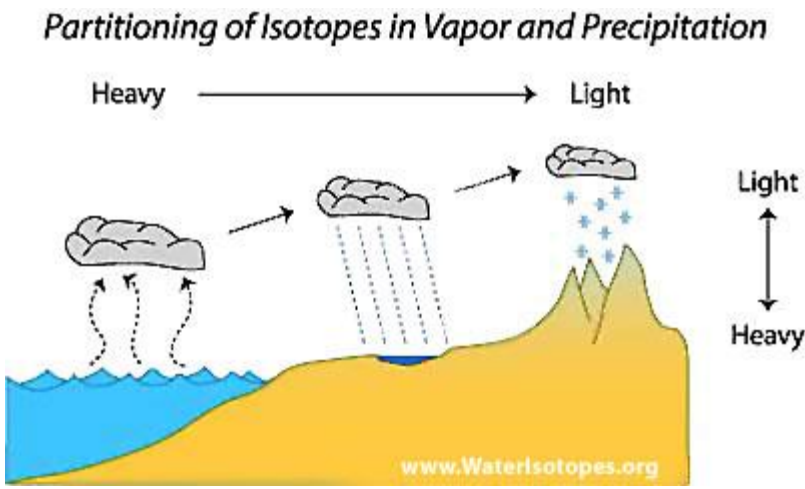
- North of Helena Valley Fault – High TDS
  - Different Aquifer Properties

Water Isotopes







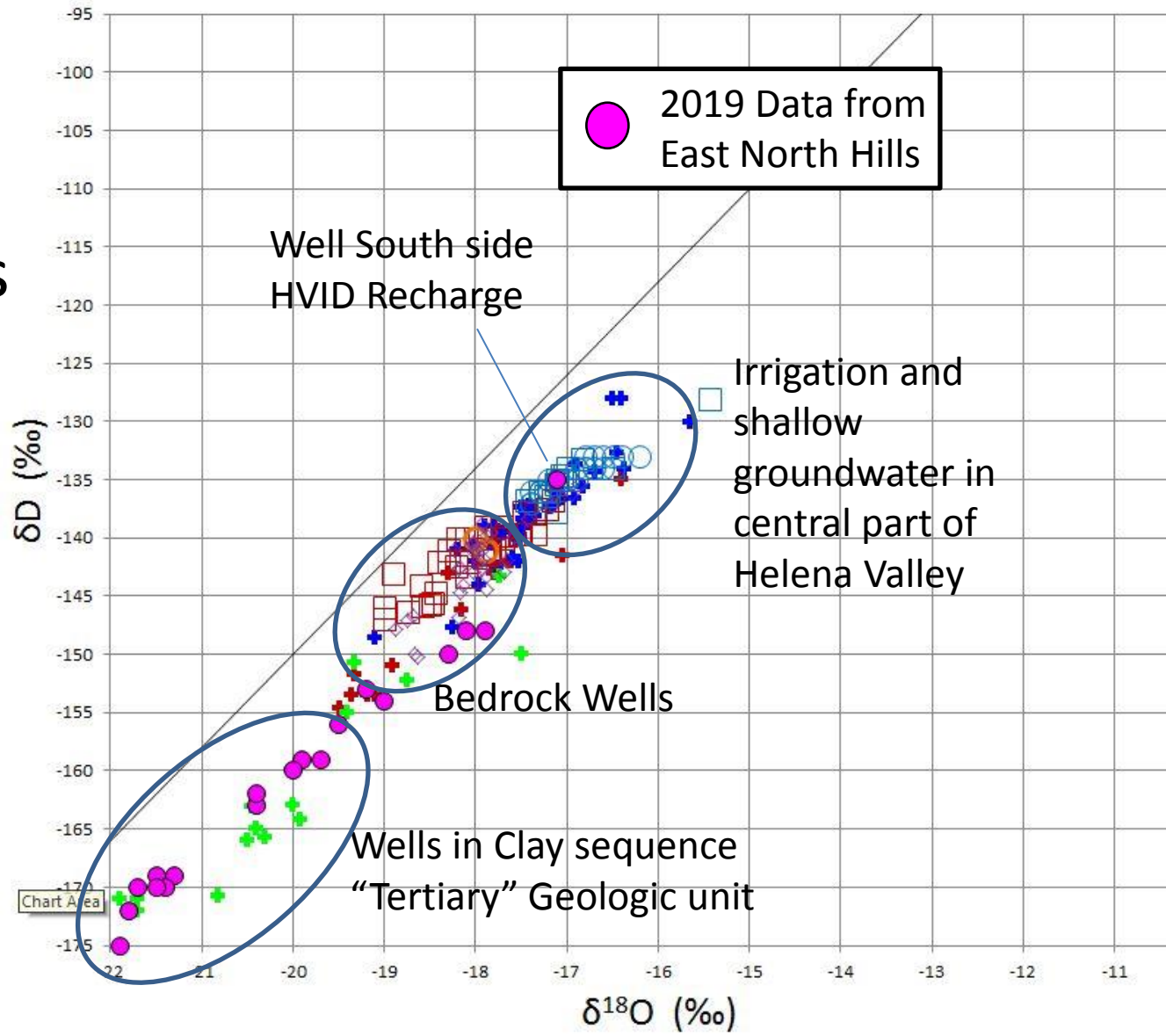


- Oxygen and Hydrogen in water molecules
- "Conservative" ***tracer*** since it doesn't change with water quality
  - But can have "mixed" values, from mixed recharge sources
- Allows ***tracing*** from recharge (precipitation, stream or irrigation waters)

  to discharge (well or spring)

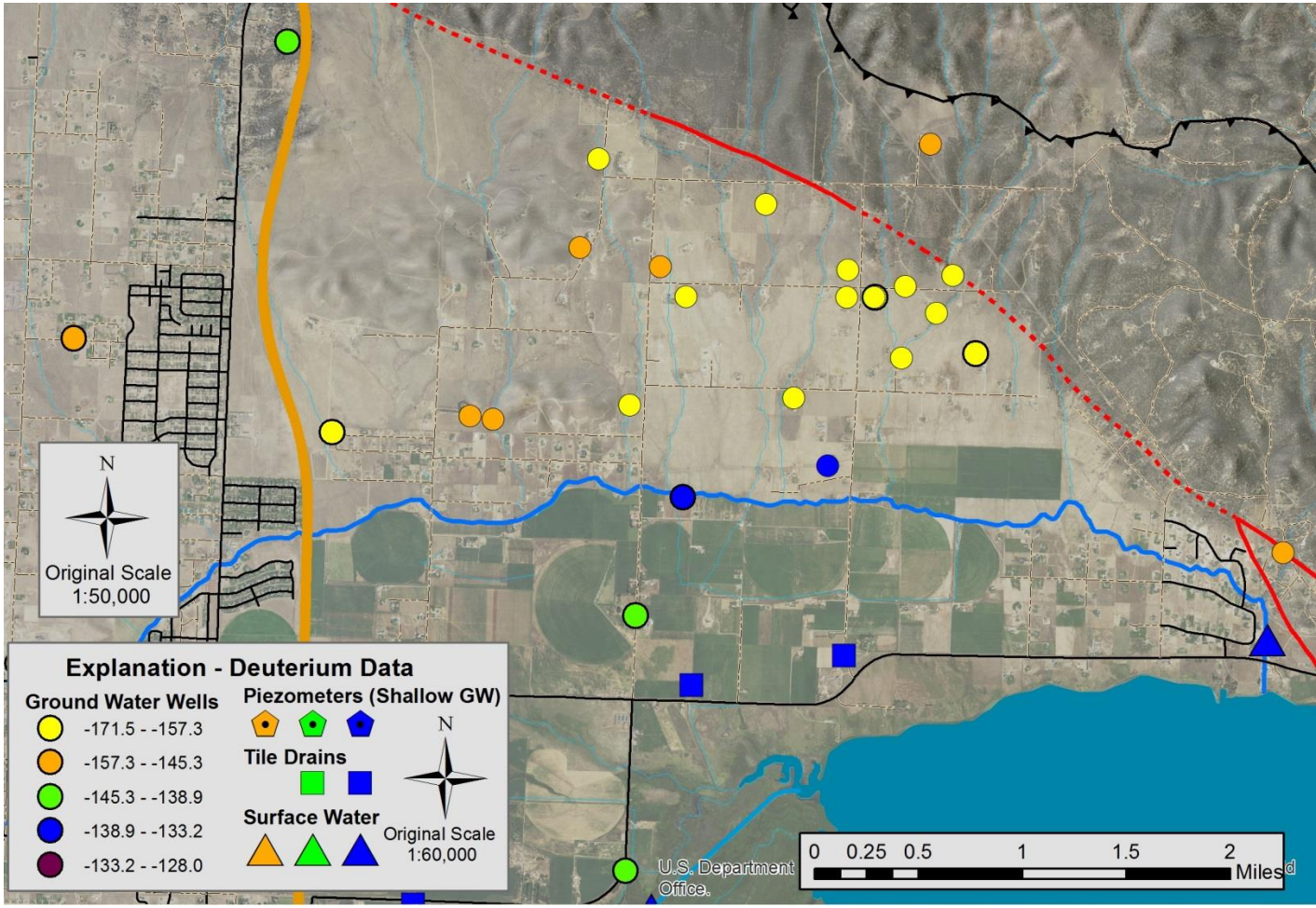
Graph of Groundwater Isotope Data

- Irrigation Waters
- Stream Waters
- Groundwater
  - Bedrock
  - HVA
  - "Tertiary" areas

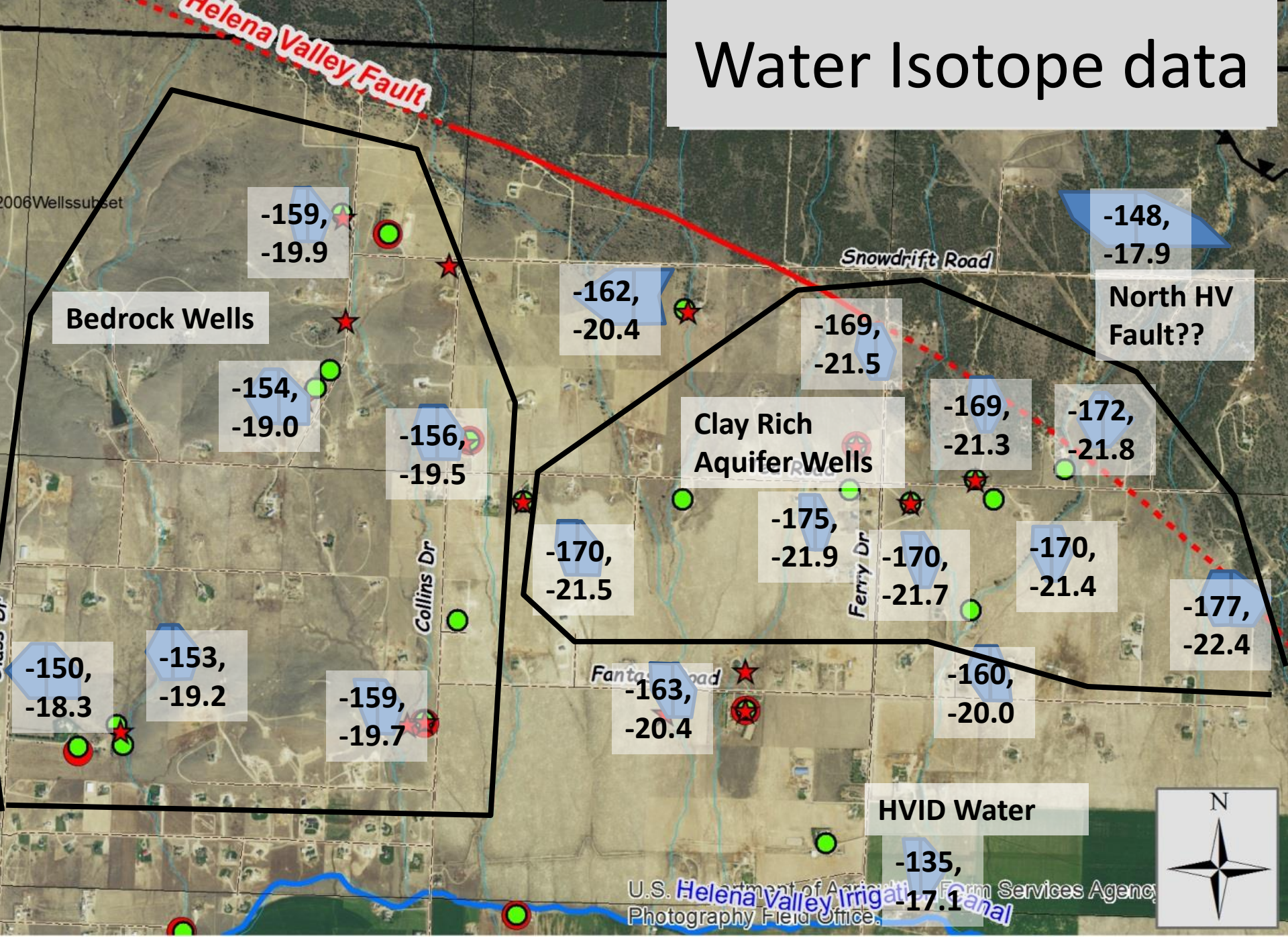


Water Isotopes

- Takeaway
- Different Recharge Sources
  - Different from valley
- See HVID Recharge



Water Isotope data



Water Isotope Conclusions

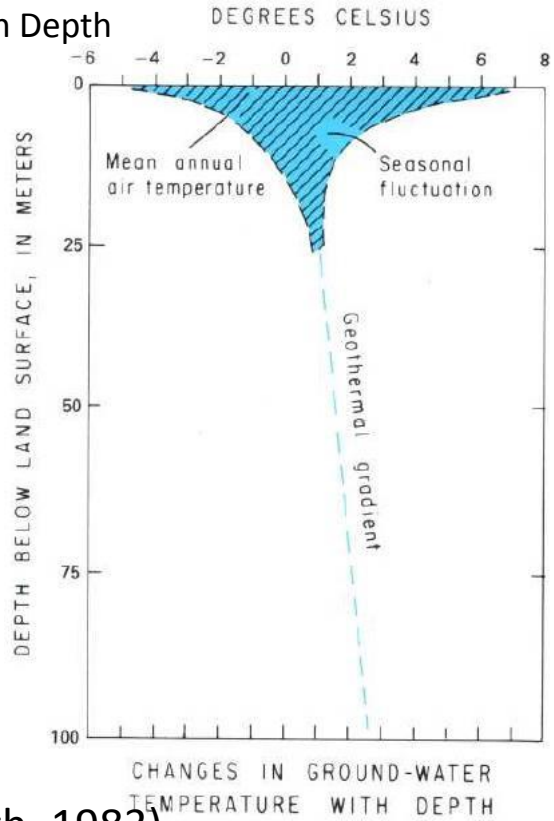
- Areas with different water isotopes
  - Different recharge sources
- Clay Rich Aquifer area
  - “lightest” results
- Bedrock area
  - “heavier” results
- Irrigation Canal Recharge to south side
- Area north of Helena Valley Fault different

Ground Water Temperature

- Another "***Tracer***" for groundwater– snowmelt recharge cold
- Average water temperature 1-2°C above mean annual temperature (8°C)
- Ground water temperature increases with depth at ***Geothermal Gradient***
  - 1.8°C/100m (0.0055°C/ft) in "normal" areas (higher in volcanic locations)

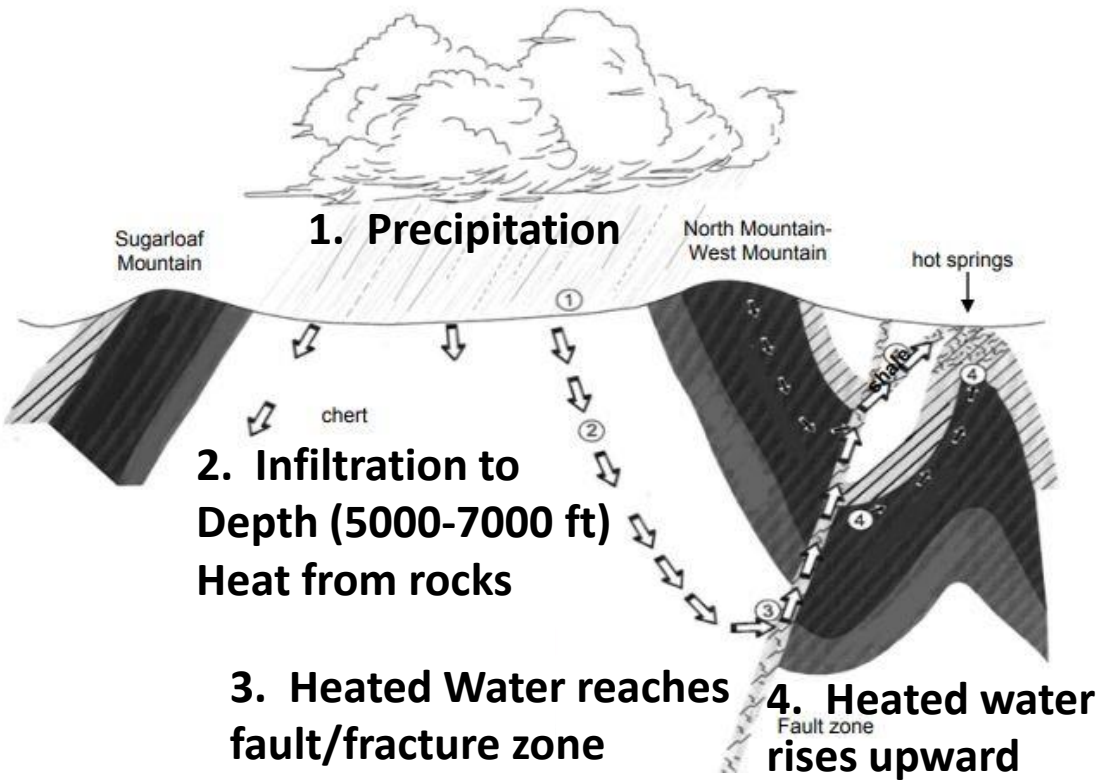
Geothermal Gradient

Ground Temperature Increases with Depth



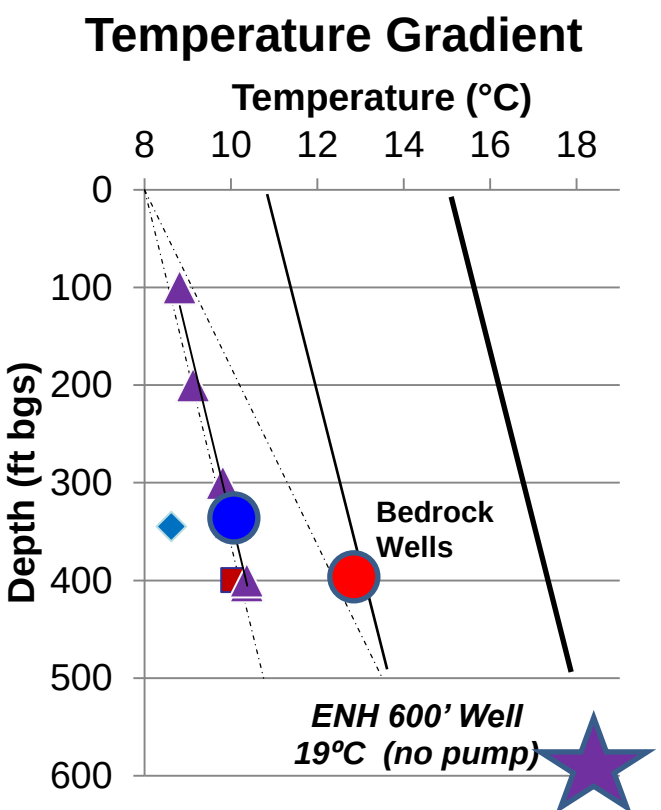
(Heath, 1983)

Hot Springs Formation
e.g. Broadwater Hot Springs

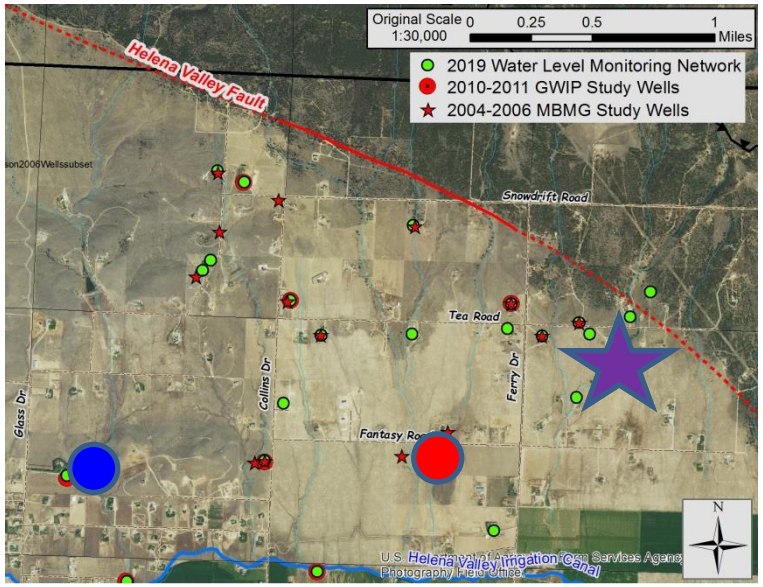


Study Area Ground Water Temperature

- Wells from North Hills, Scratchgravel Hills
  - Show “normal” geothermal gradient
  - Groundwater Temperature 8C at surface



Well Location



Warm water means recharge from depth, like hot springs

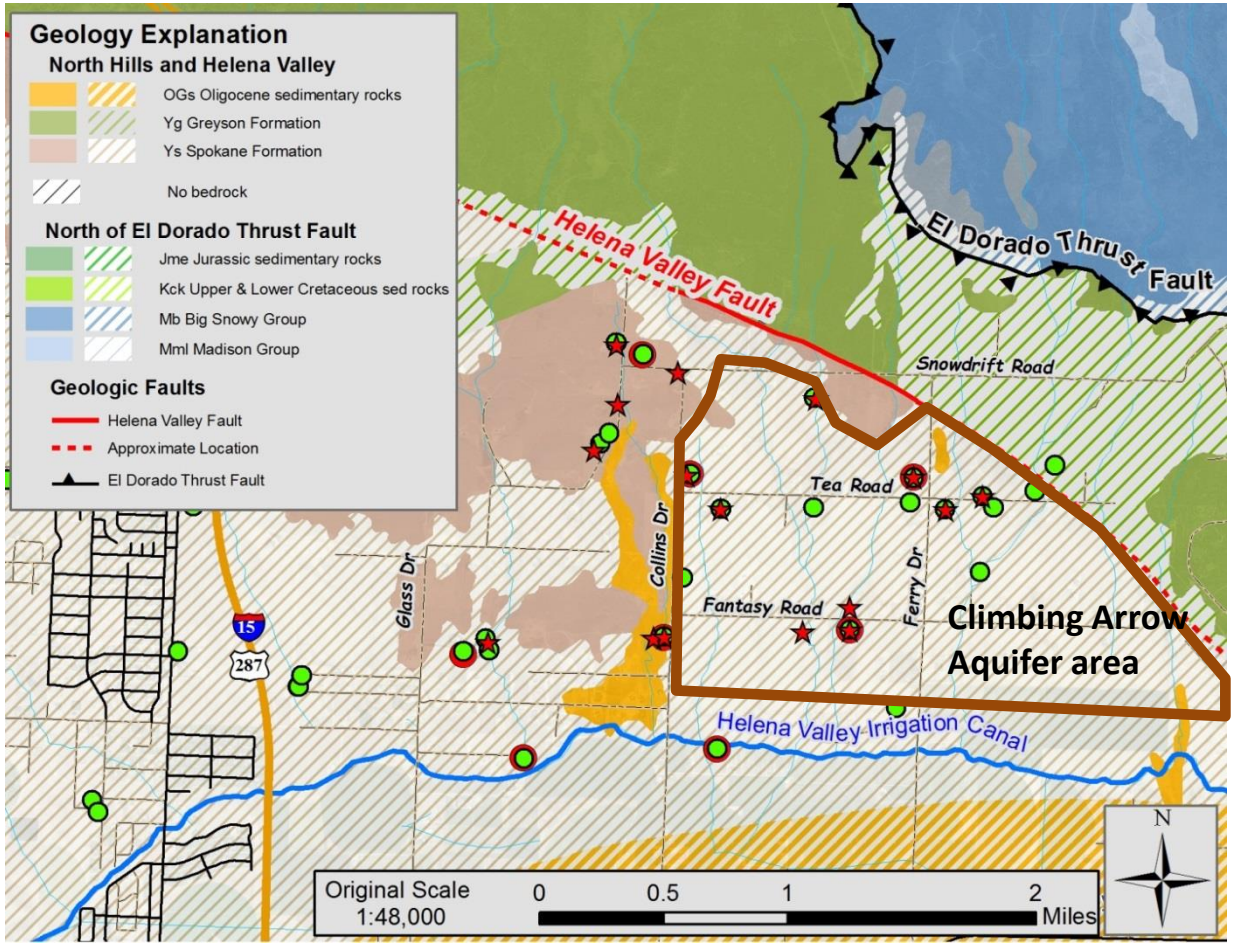
“Bedrock” Wells – Local Recharge; Mixed Recharge gives cooler temps

Groundwater Temperature Conclusions

- Warm/heated water shows upwelling of groundwater
  - Recharge from below, not above
  - East side of Study Area
    - Bedrock waters beneath Climbing Arrow unit
- "Cool"/normal temperature water in bedrock
  - Local recharge from precipitation
- Separate Factors influence water in different areas
- Anecdotally hear of warm/hot waters near and north of Helena Valley Fault
  - Local groundwater system separate

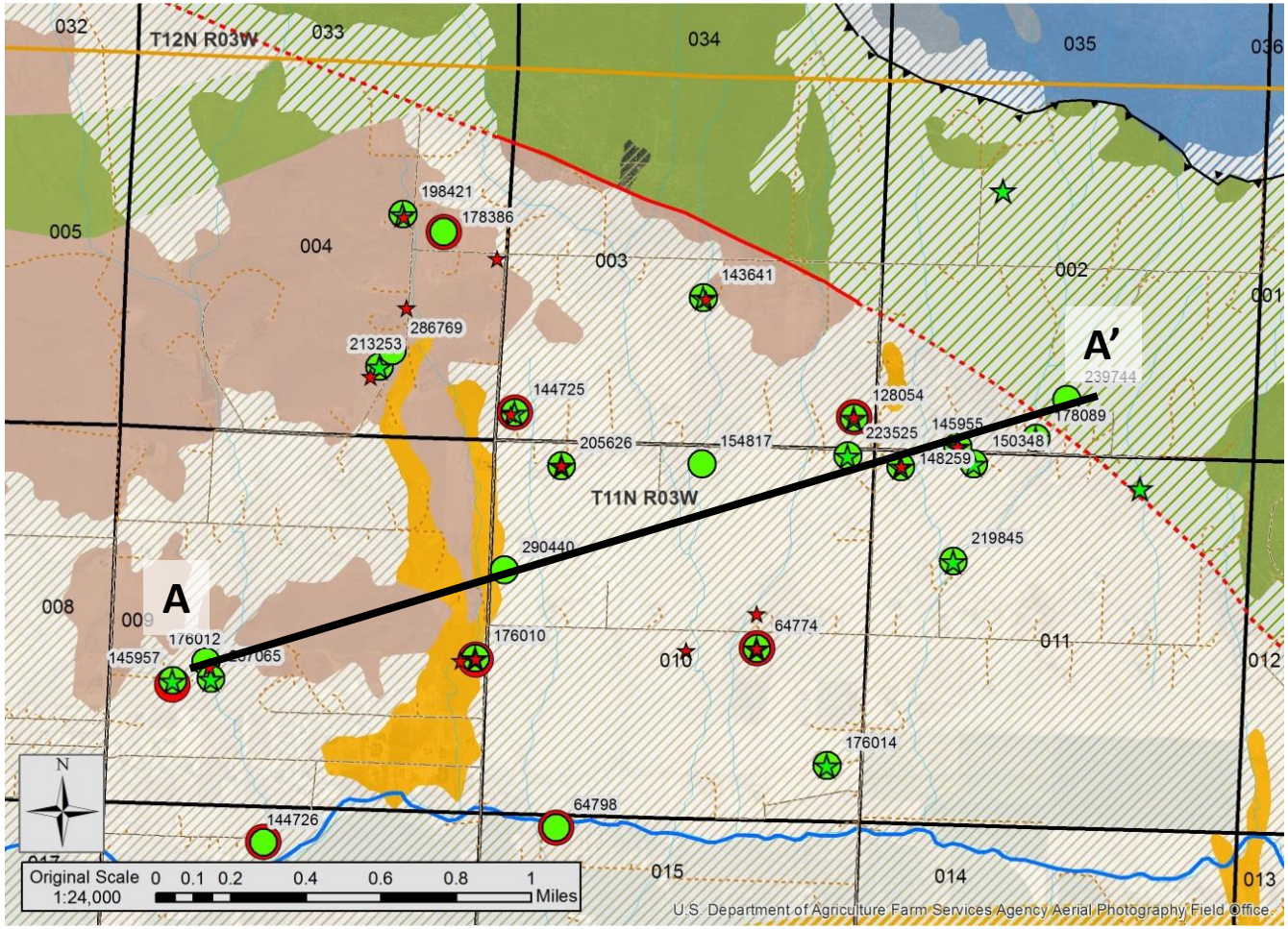
Aquifer Delineation and Geology

- Geology determines aquifer properties
  - **Yield**
- Ogs – Tertiary
  - Climbing Arrow Fm
    - Clay rich
    - Sand seams
    - Low yields
  - BEDROCK present beneath Climbing Arrow Fm
- Bedrock
  - Fracture flow
  - Variable Yields

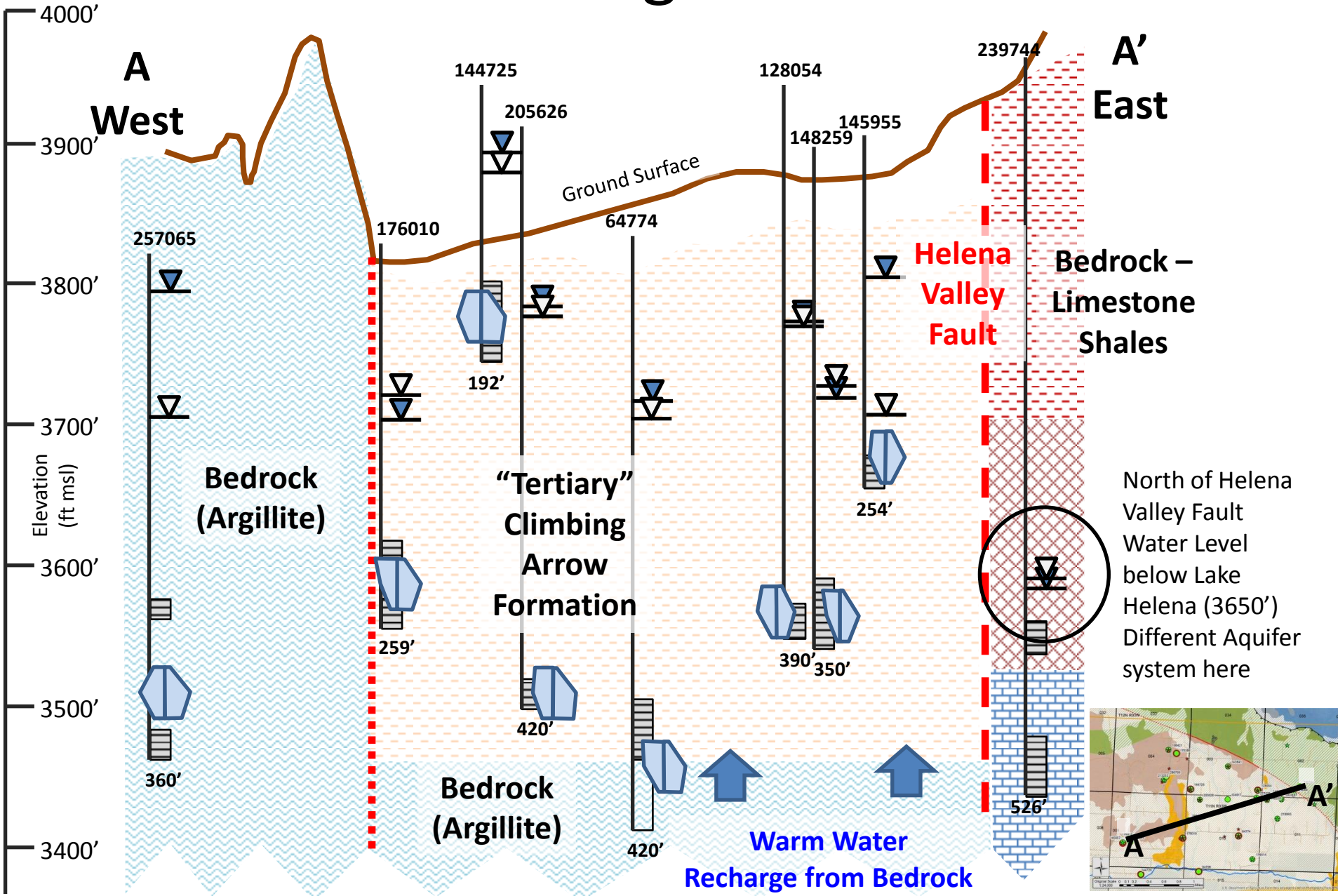


(Same map we saw before)

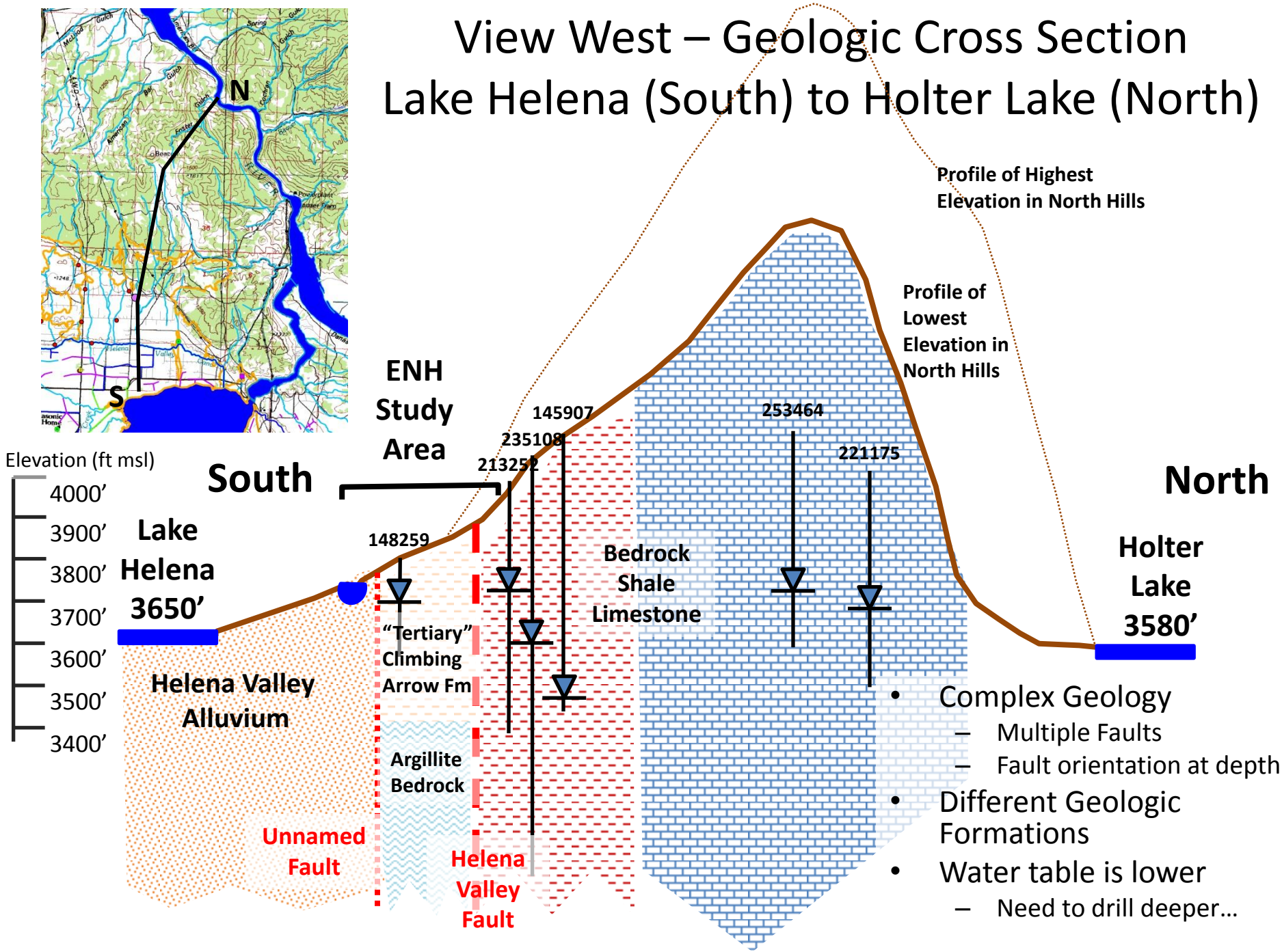
Geologic Cross Section A-A’
West – East



View North – Geologic Cross Section A-A’



View West – Geologic Cross Section
Lake Helena (South) to Holter Lake (North)

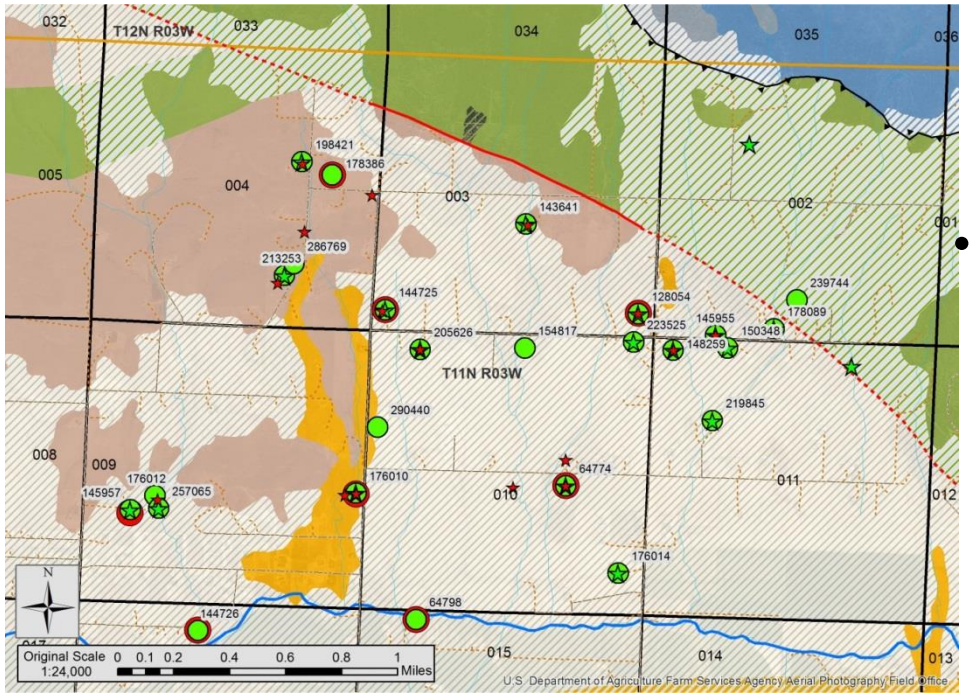


- Complex Geology
  - Multiple Faults
  - Fault orientation at depth
- Different Geologic Formations
- Water table is lower
  - Need to drill deeper…

Summary of Data Conclusions

- Water Levels
  - No Depletion Observed
    - Some declining water levels from storage
- Water Chemistry and Isotopes
  - Differences in Study Area
  - Different in bedrock/deep/clay-rich aquifer
- Water Temperature
  - Local Recharge into Bedrock
  - Clay-Rich sequence, “deep” aquifer recharge (warm waters)
- Geology – Different Aquifer Systems
  - Bedrock Aquifers – recharge locally
  - Clay rich aquifers – warm water, recharge from base
  - **Helena Valley Fault** separates aquifer types
    - Little Data, Deep groundwater north of fault

Conceptual Model of Hydrologic System



- Bedrock Aquifers surrounding "Tertiary" Aquifer
  - Tertiary clay-rich Climbing Arrow Formation
    - Poor yields, recharge from base to deep
  - Surface recharge to bedrock, shallow Tertiary aquifers
  - Recharge to Tertiary Aquifers from bedrock across fault
- Yields and Depletion
  - Bedrock provides best yields, may need to drill to depth
  - Depletion not observed
    - Would see break in slope of declining water level wells
- Groundwater Divide not at Drainage Divide
  - Aligns with some of Helena Valley Fault / Complex System
  - Flow appears to Align with "Tertiary Channel) to northeast
    - Water Quality, Isotopes similar
    - Recharge to Clay-rich sediments upward from base

Conclusions

- Climbing Arrow Formation major local aquifer
  - Poor aquifer, low yields, recharge
- Groundwater available at depth in bedrock in East North Hills
  - Area South of Helena Valley Fault
  - Water much deeper, but still available in bedrock

- (Temporary) Controlled Ground Water Area
  - No basis to develop, water levels stable
  - No need to determine/propose boundaries

- Next Steps
  - Continue WL monitoring program at selected locations
  - Looking for Resident wells to monitor (& Sample) North of Helena Valley Fault

Questions/Discussion?

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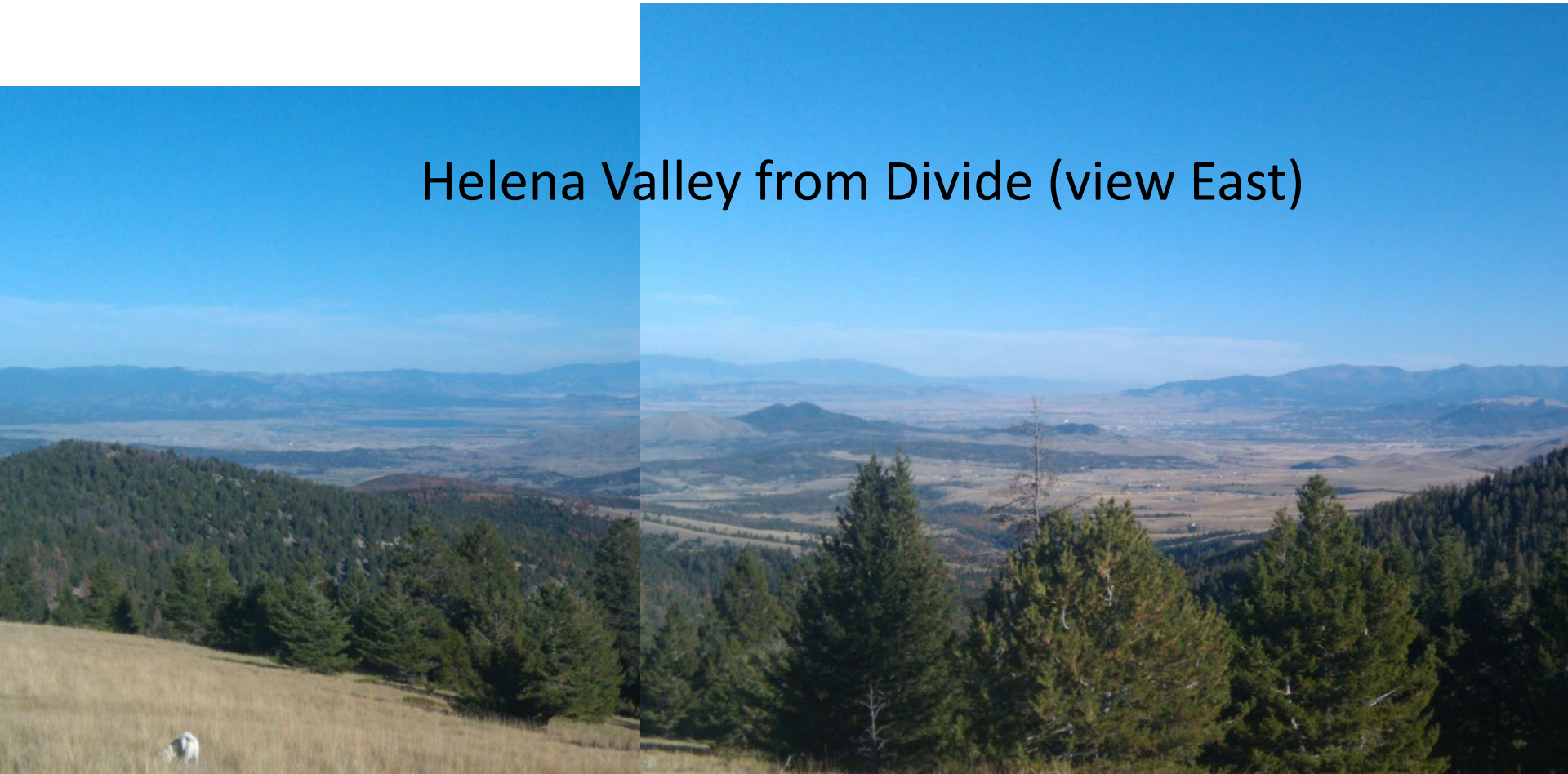
Project Report (est. Dec 2019) will be available at http://www.lccountymt.gov/health/water.html