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An Analysis of Injected Water Quality in a Fractured Basalt Aquifer

Created and Presented by

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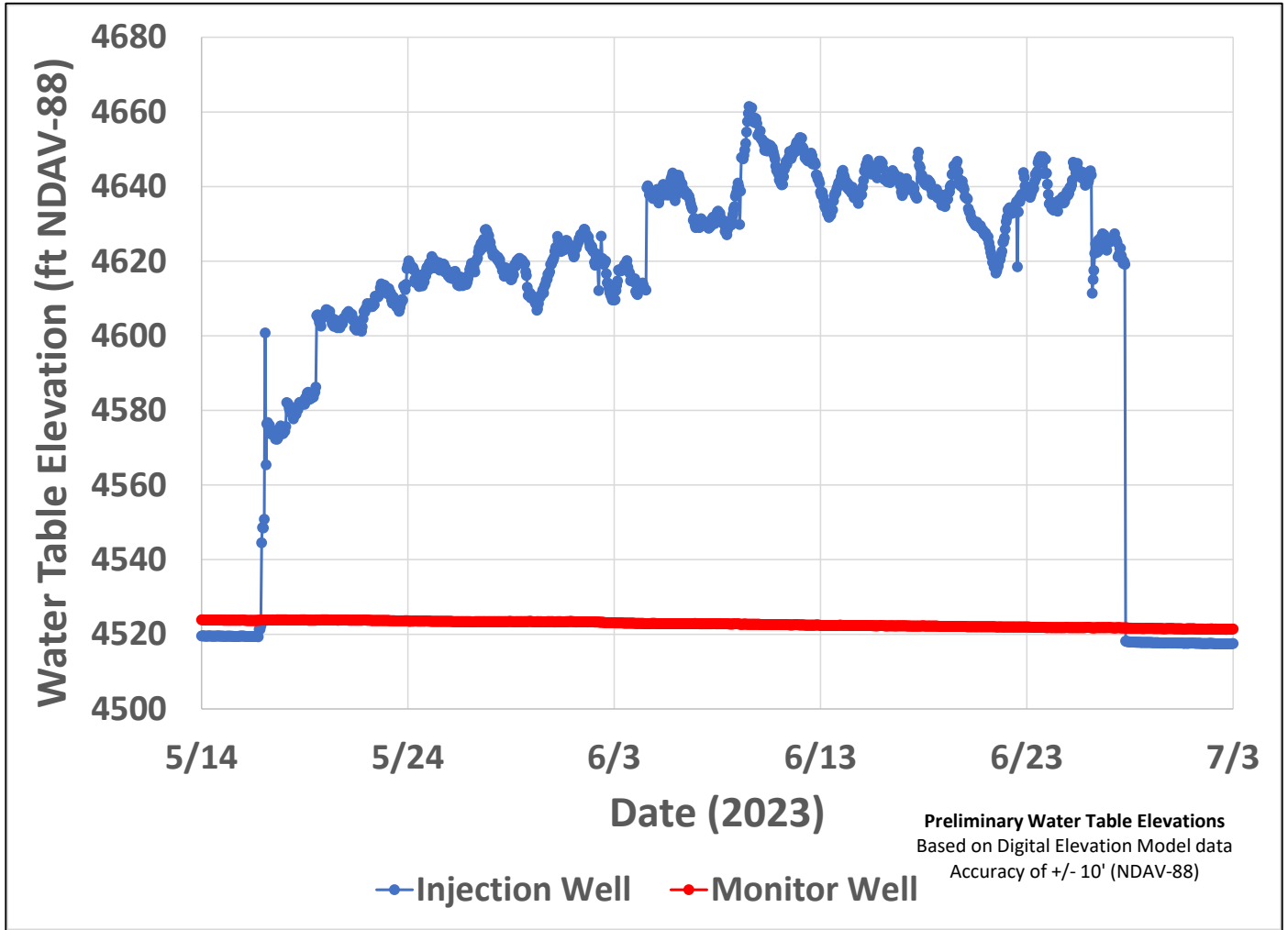
Regional Trend – [Lack of] Primary Constituents (aka Harmful Contaminants) in Surface Water

- **Large(st?) collection of water quality samples from canals across Eastern and Southern Idaho.**
- **Sample variously for 21 pesticides, 48 herbicides, 35 industrial byproducts, and 14 metals.**
  - **Vast majority = non-detect.**
- **Bacteria is the contaminant of concern in canal water.**

Background -- Preliminary Hydrologic Data



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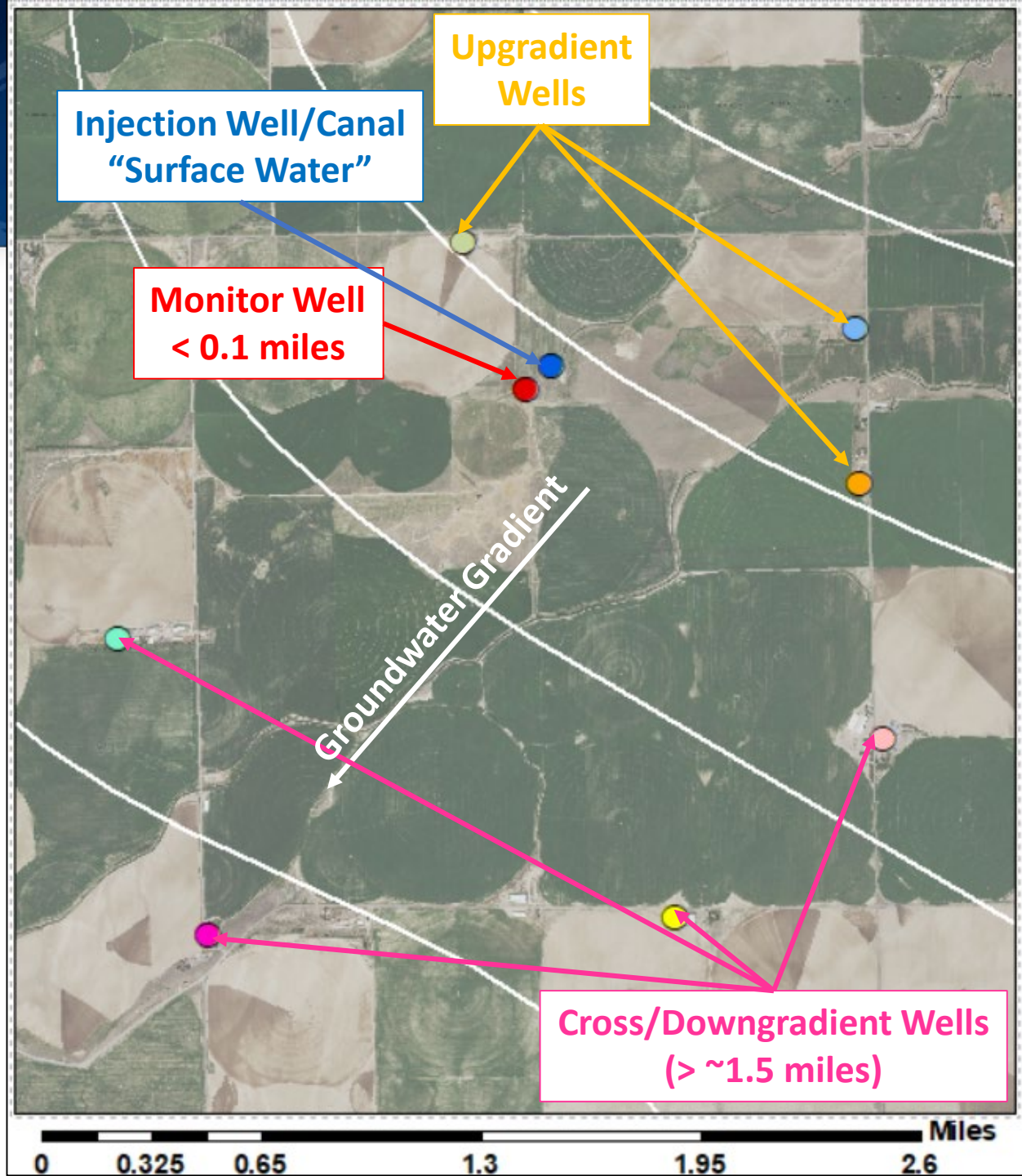
Sampling Network Overview

Legend

- Injection Well/Canal
- Monitor Well
- Winder Well
- Snarr NE Well
- Mickelsen Well
- Messenger Well
- J Evans Well
- Snarr Well
- B Evans Well
- 50 ft Groundwater Contours



Experiment Overview

- **Probably about 900 AF of operational spill injected from May 16 – June 27, 2023.**
  - **Started fast, slowed down over time.**
- **87 total samples,**
  - **Eight surface water samples,**
  - **Eight wells sampled 9+ times.**
- **All samples analyzed for major ions, bacteria, select metals, and nitrate.**
  - **Chloride is the ion of focus here.**
  - **Bacteria is the contaminant of focus.**

Injection Well

~0.09 Miles

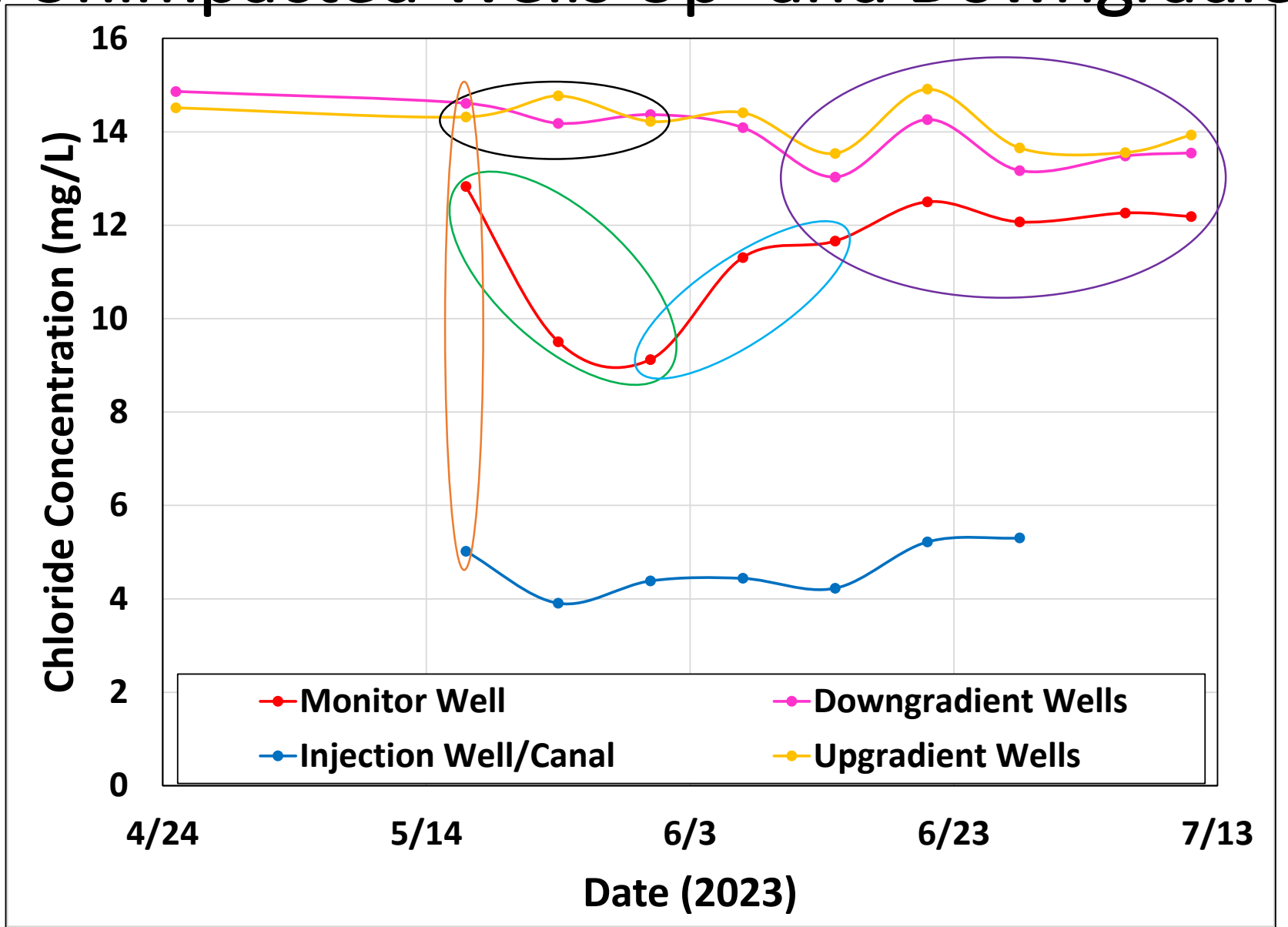
Monitor Well

Both wells completed in fractured basalt aquifer, ~255' below ground surface into the deeper of two water tables.

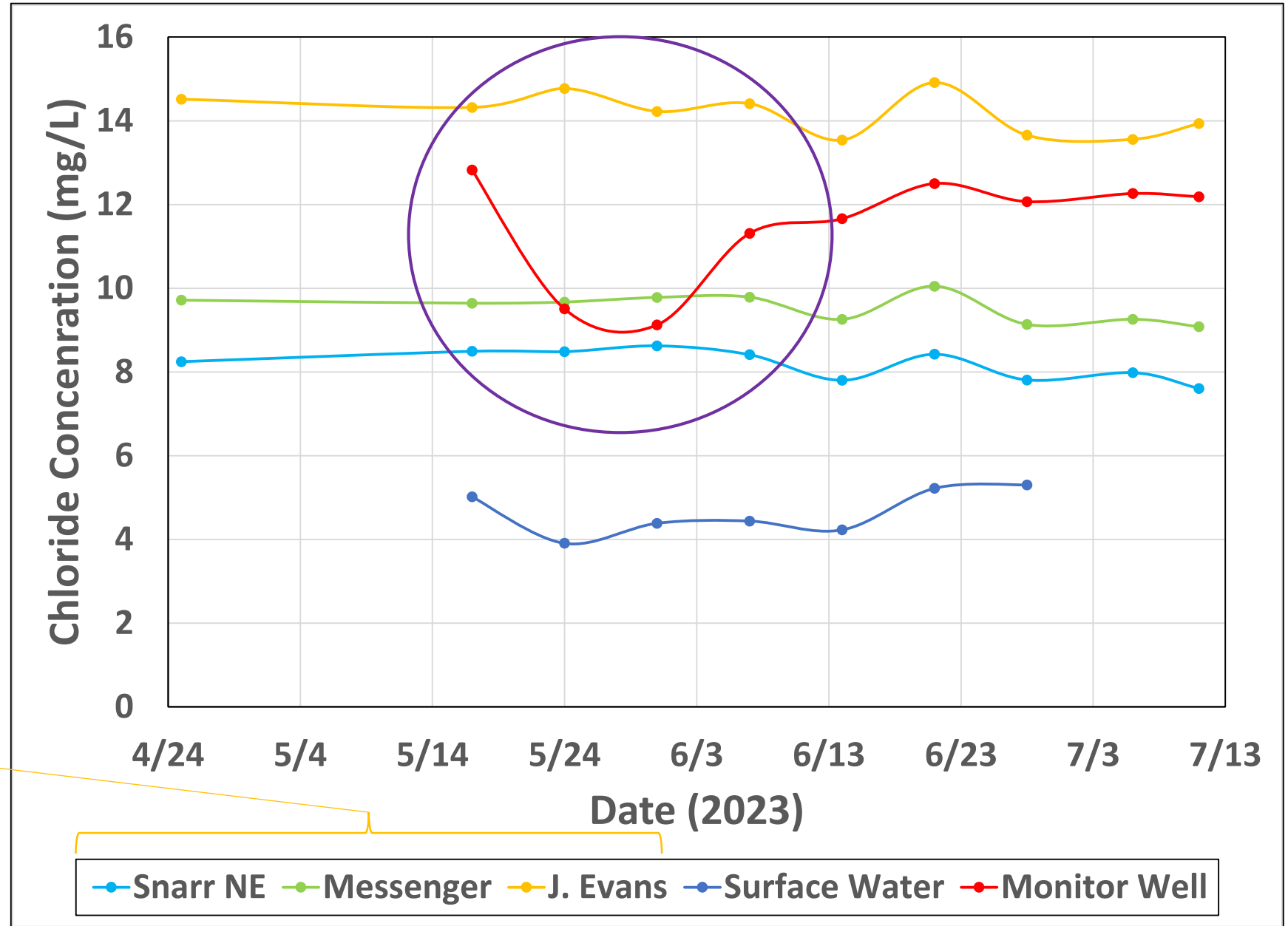
Travel time from Injection Well to Monitor Well is approximately 3.5 days*.

* Appendix A

Chloride Concentrations in Monitor Well, Injected Water, and Unimpacted Wells Up- and Downgradient

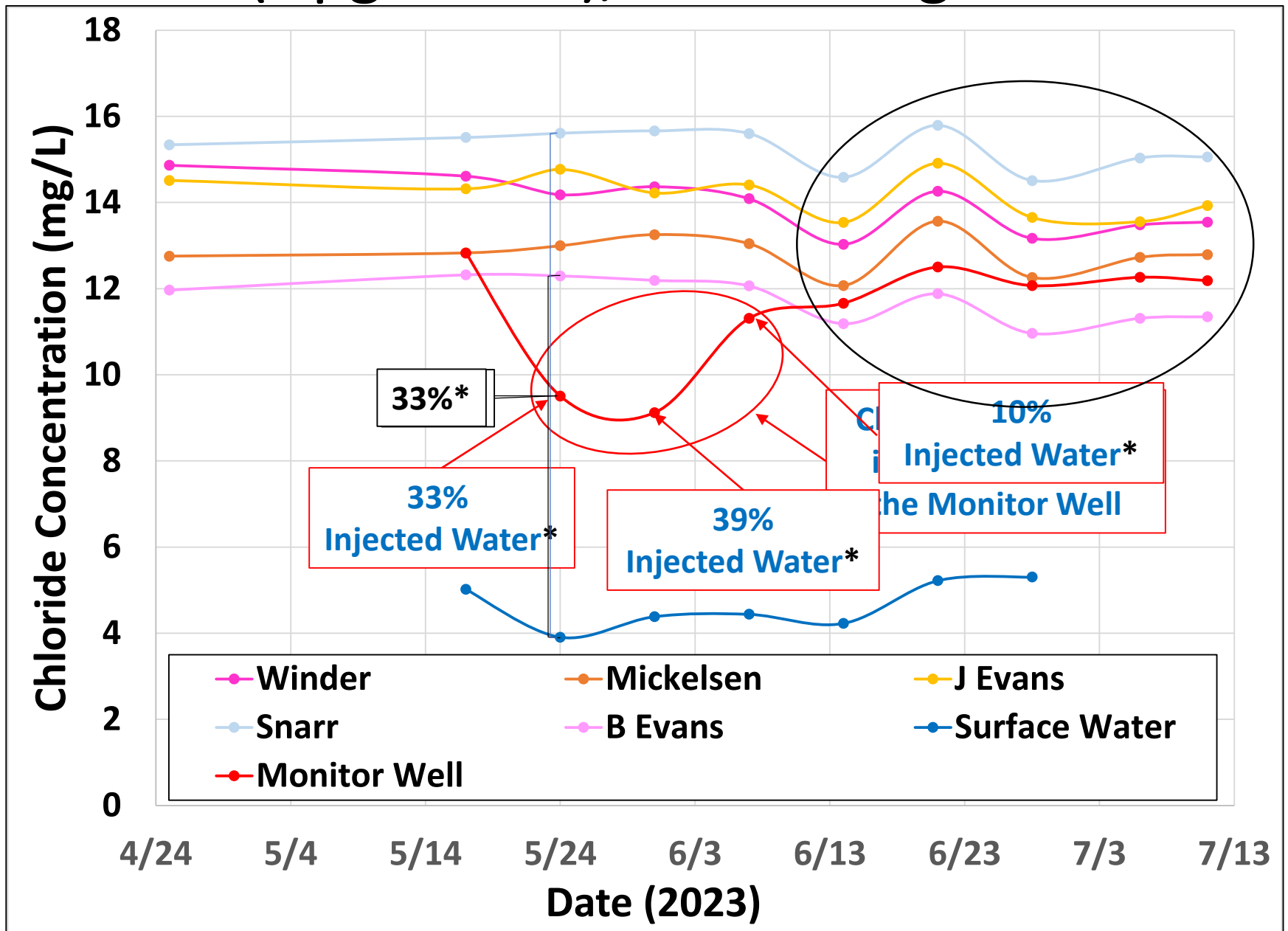


Chloride Concentrations in Surface Water, Monitor Well, and Upgradient Wells



Upgradient Wells

Chloride Concentrations in Surface Water, Monitor Well, J Evans (Upgradient), and Downgradient Wells



*Appendix B

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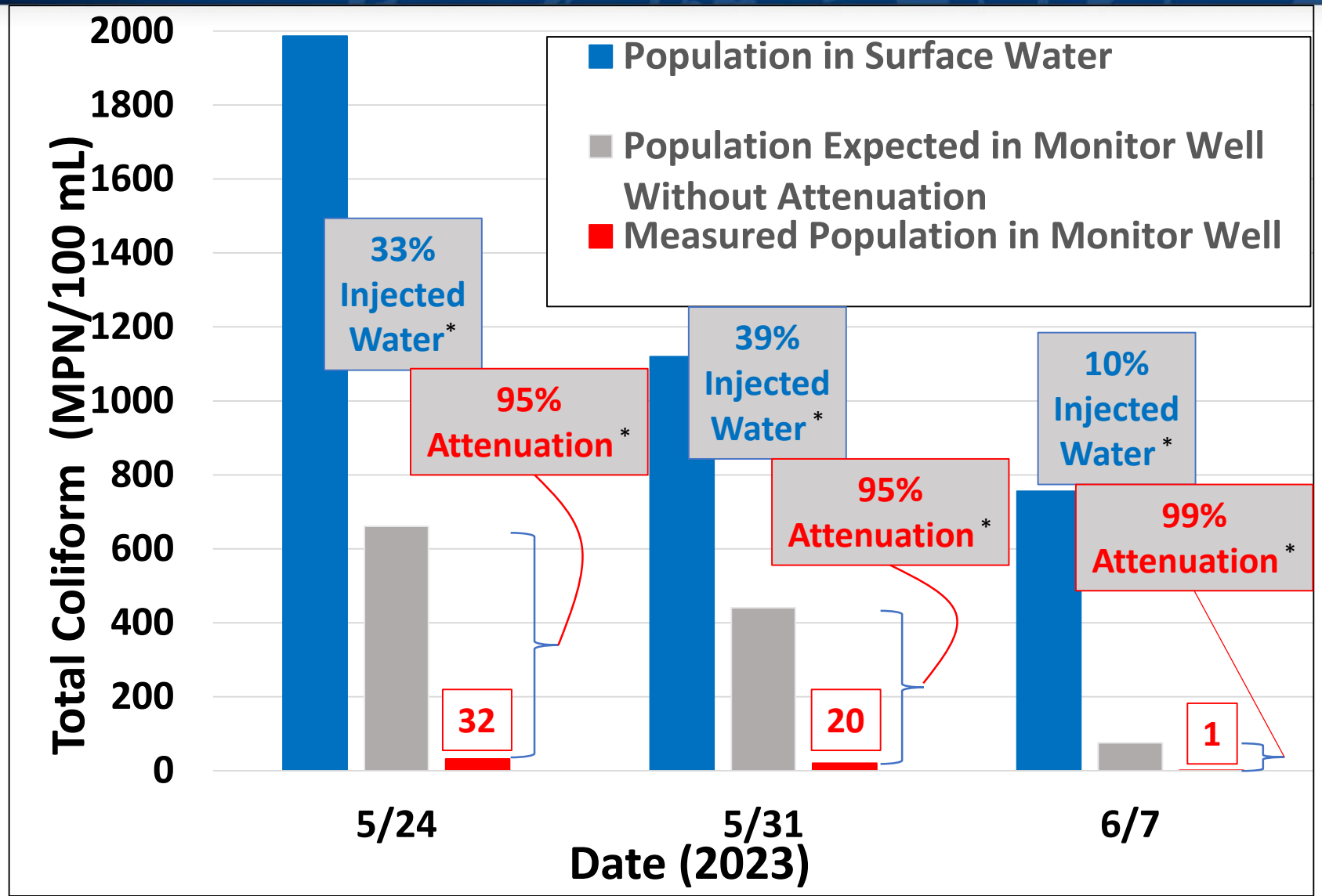
Total Coliform Human Health Standard is 1 MPN/100 ml (IDAPA 58.01.11)



*Appendix B

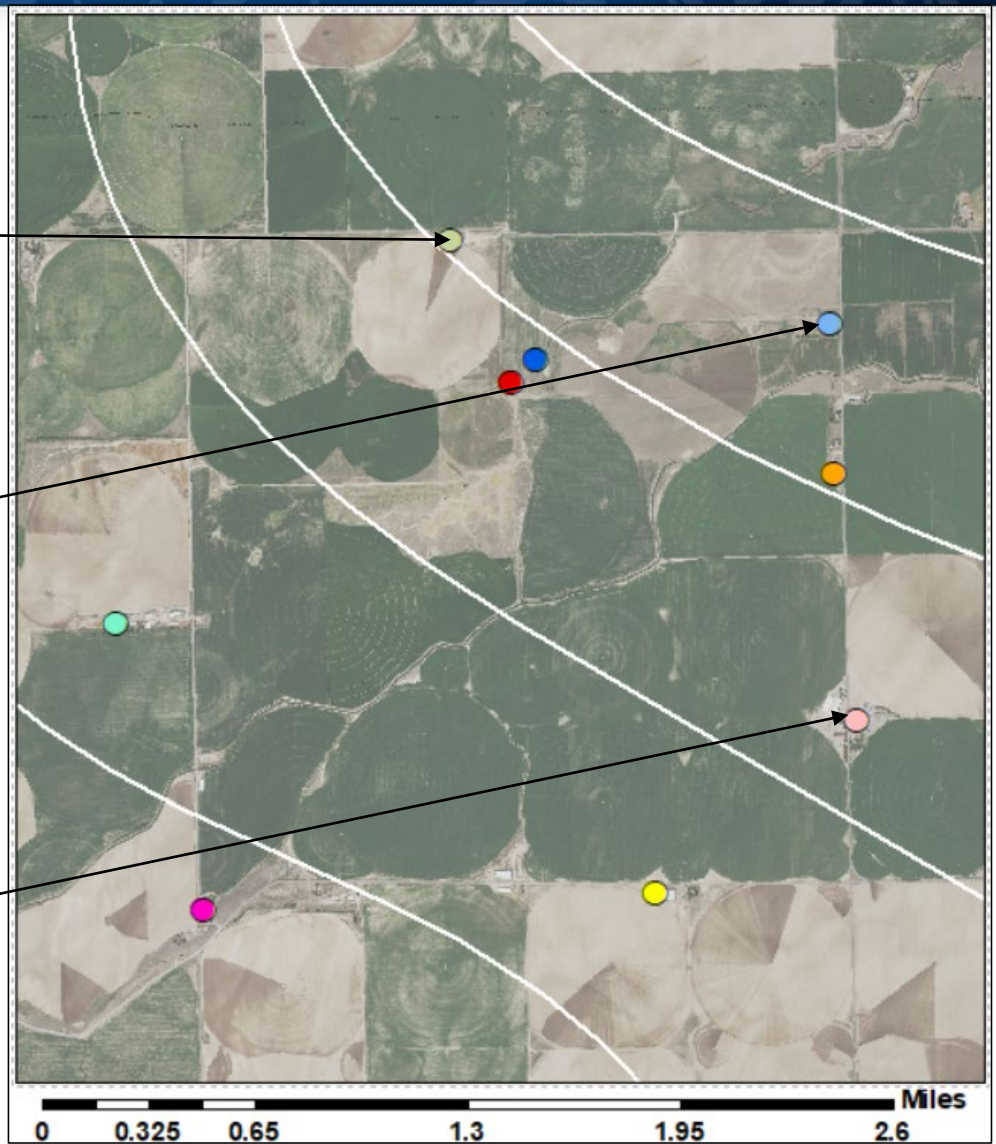
Bacteria (Total Coliform)

Unlikely Sourced from Injectate

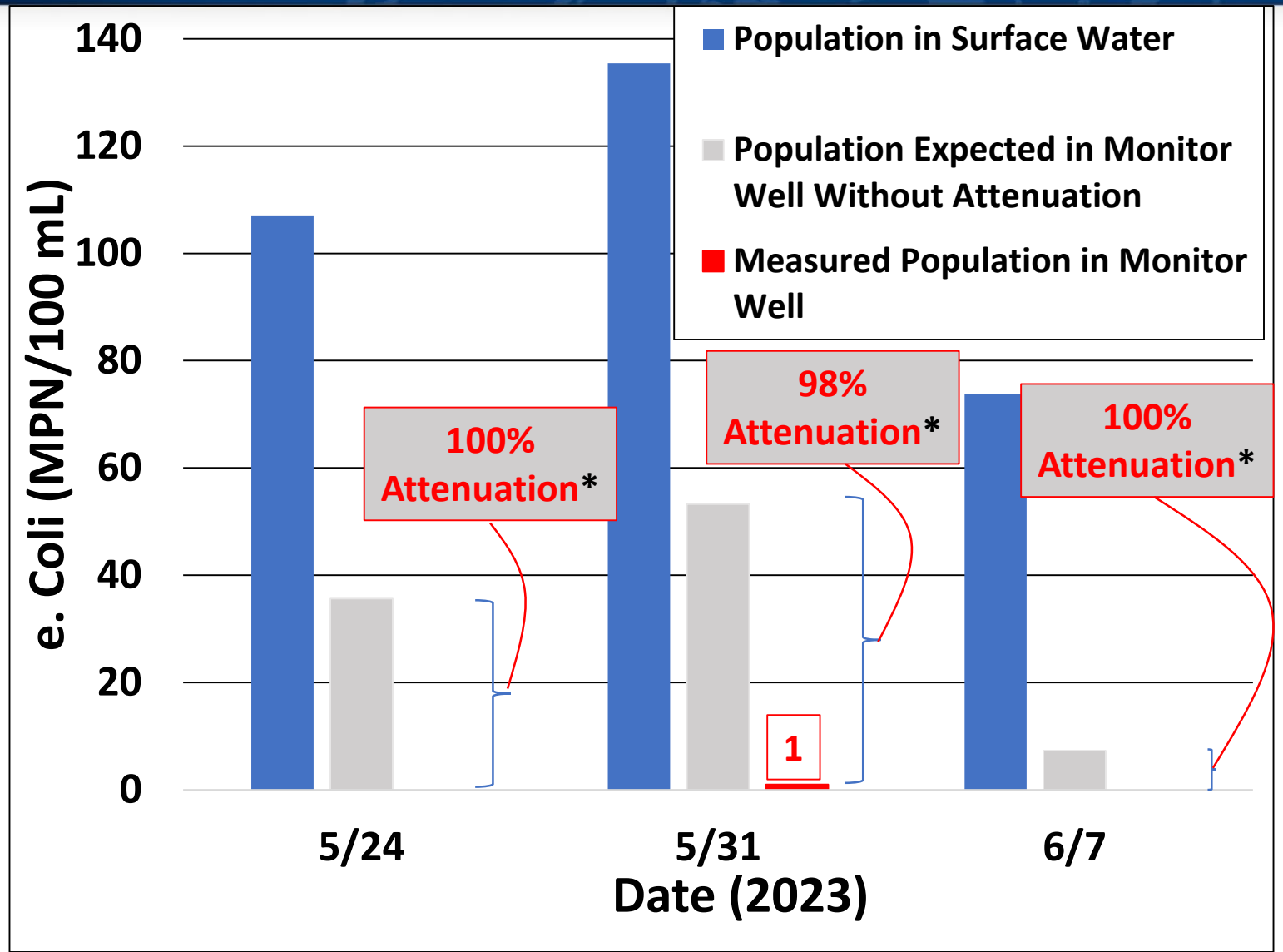
Messenger Well
5/17 – 11 MPN/100 mL

Snarr NE Well
6/28 – 1 MPN/100 mL
7/6 – 2 MPN/100 mL

B Evans Well
6/14 – 1 MPN/100 mL

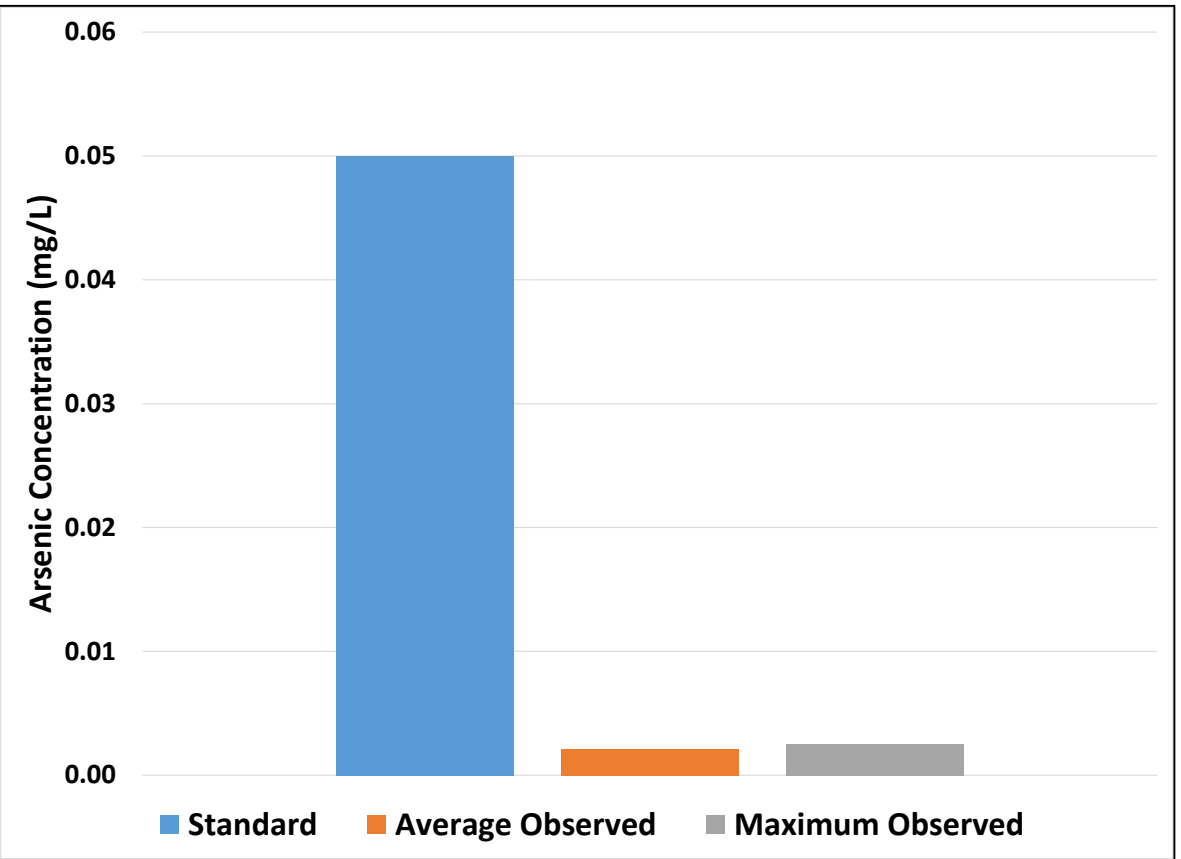


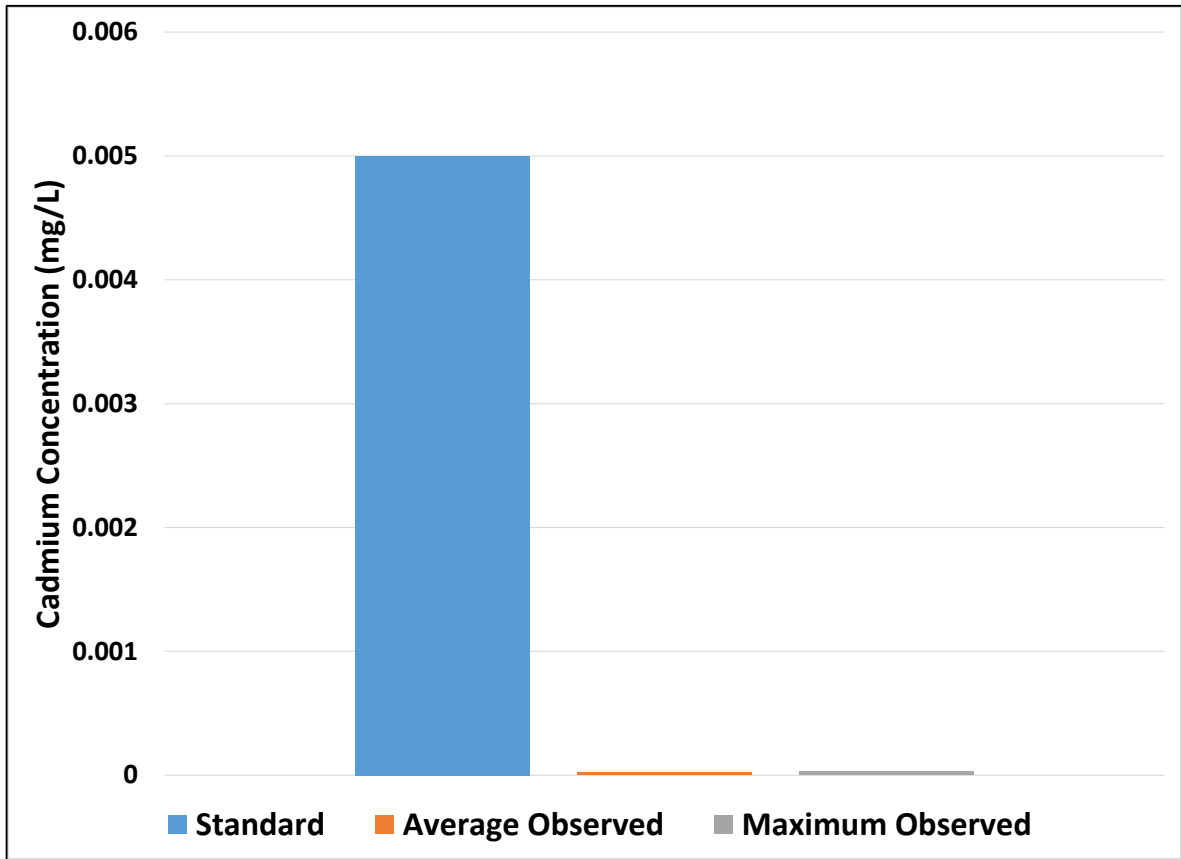
e. Coli
Human Health
Standard is
< 1 MPN/100 ml
(IDAPA 58.01.11)



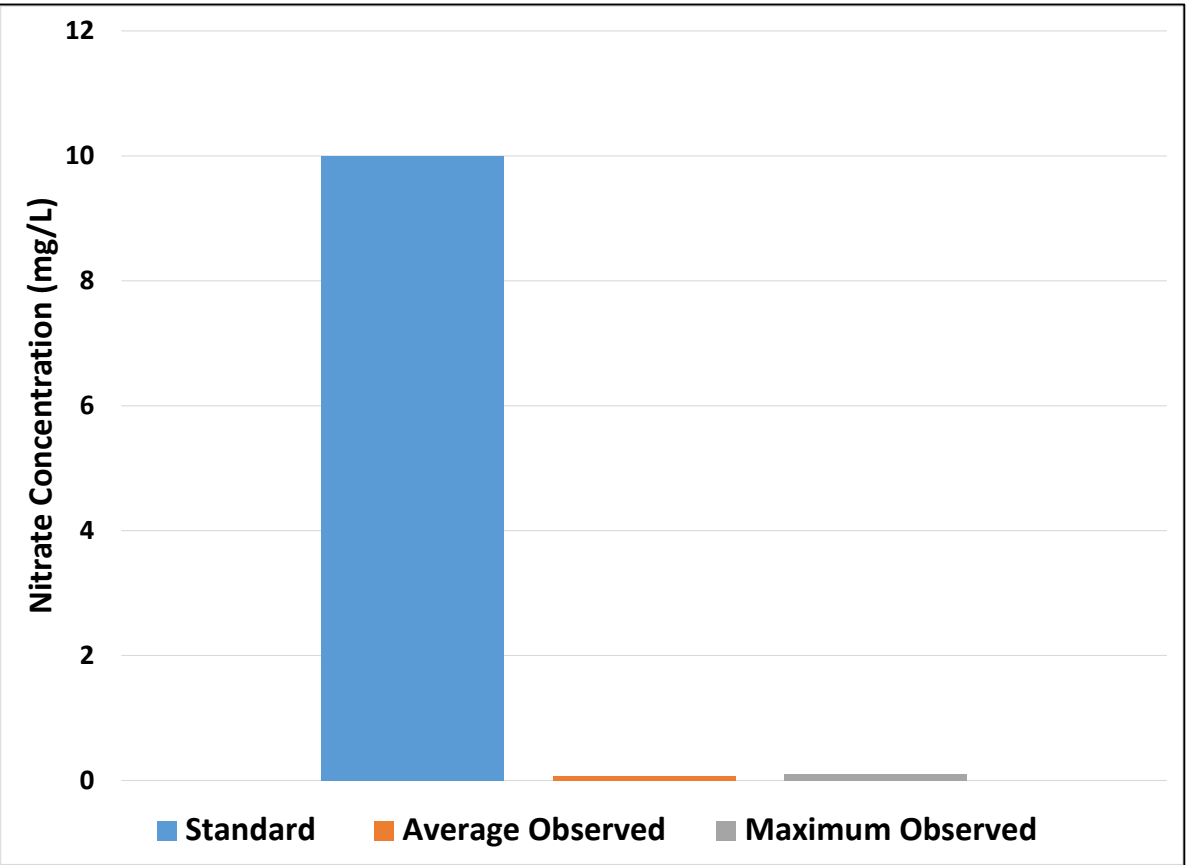
*Appendix B

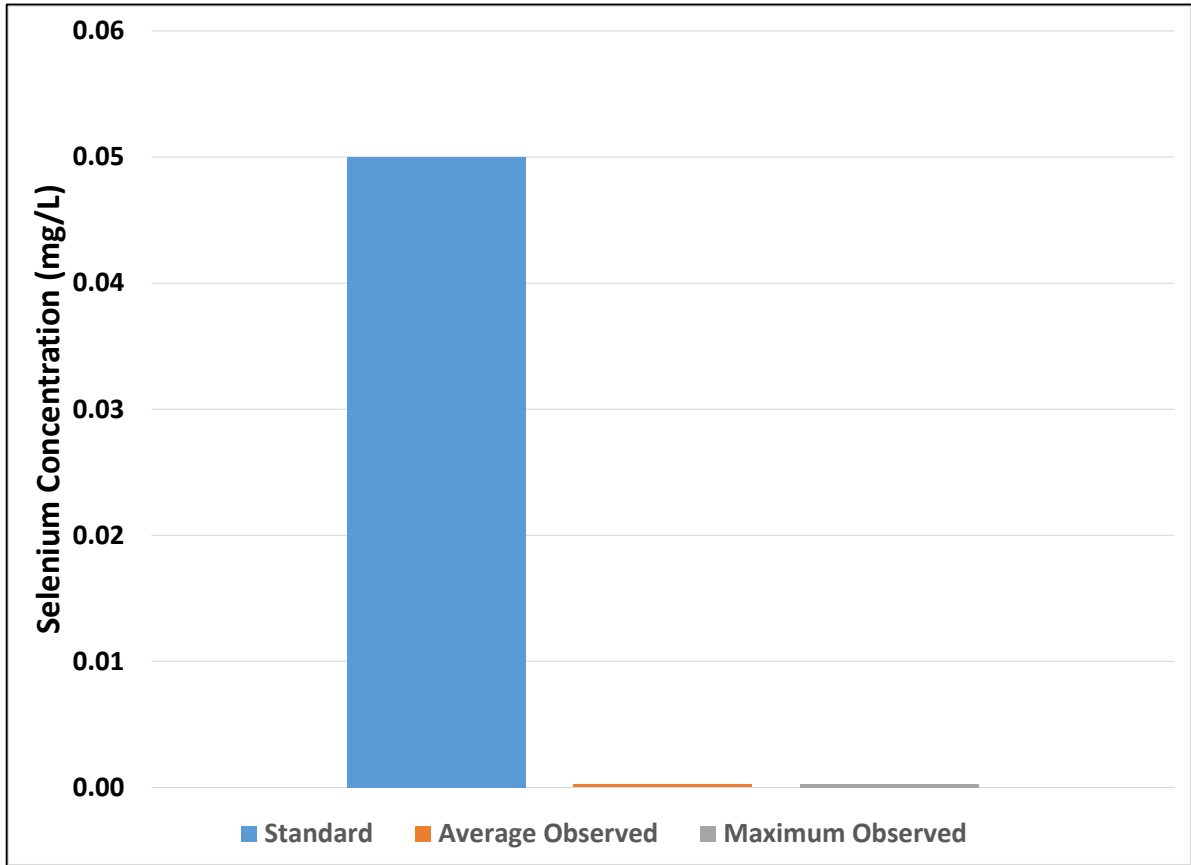
Concentration of Additional Contaminants in Surface Water





Concentration of Additional Contaminants in Surface Water





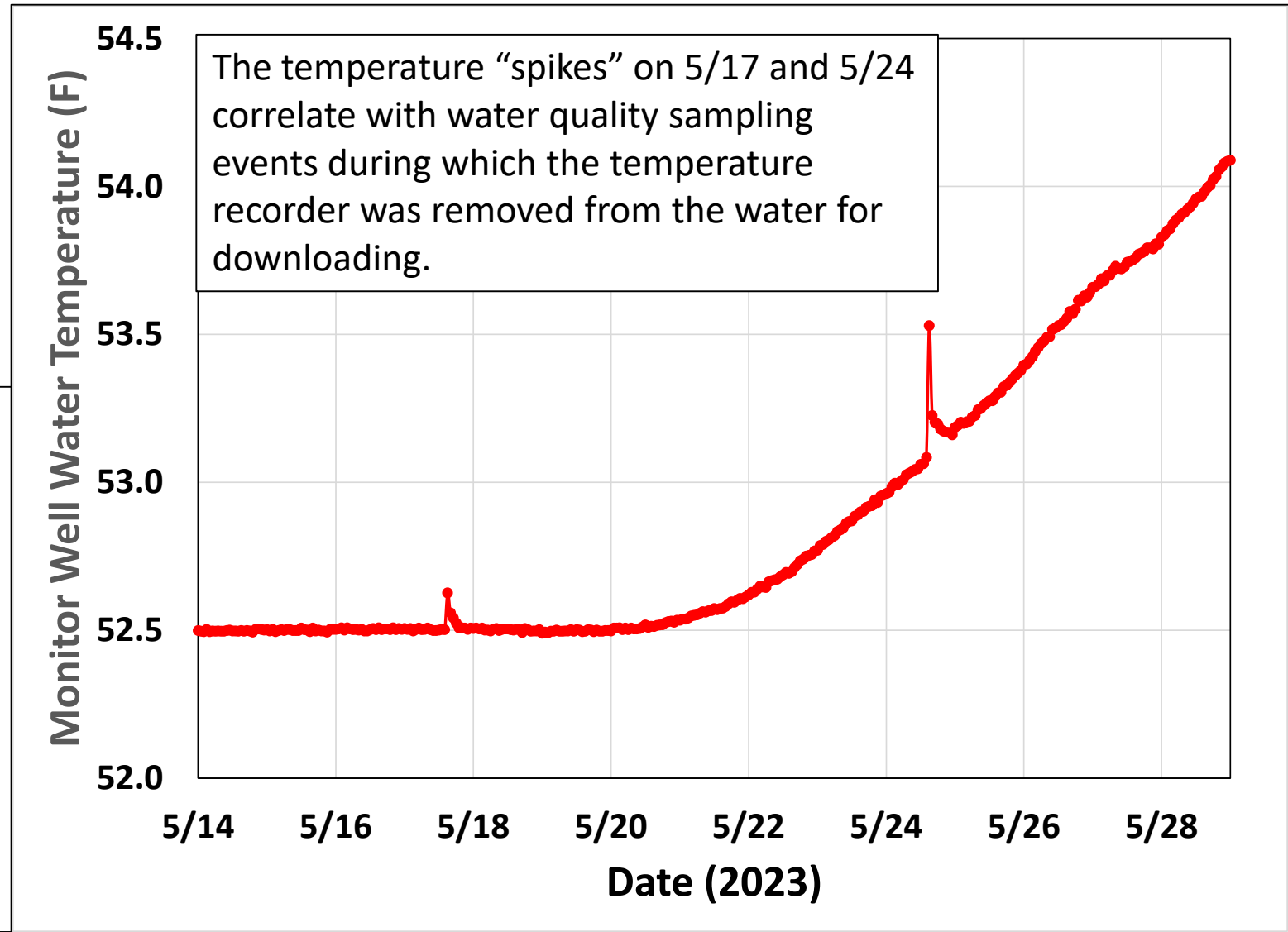
Conclusions

- **Lack of primary constituents (aka “harmful contaminants”) is a regional trend.**
- **Primary contaminant of concern in injectate is bacteria.**
- **Bacteria populations apparently rapidly attenuate below ground.**

Appendix A – Monitor Well Temperature Data

Water temperature in the Monitor Well was stable over the course of the 263 days of available data (not shown) prior to the increase in temperature which correlated with the arrival of infiltrated water around Midnight on May 20, 2023, approximately 3.5 days after the injection test began.

Increases in temperature were observed in all wells in the network over the 10 sampling events (not shown), yet hydrologic and chemical evidence do not support this rise in Temperature, correlated with the injection Event, with the arrival of injected water. Instead, the thermal shock to the closed system of introducing fluid with a different temperature perhaps diffused at least through the extent of the sampling network. This is an observation worthy of further study.



Appendix B – Mixing Excess Bacteria Concentrations

Equation 1: $Y = ([Cl^-]_{mw} - [Cl^-]_{bew}) / ([Cl^-]_{i/sw} - [Cl^-]_{bew})$

Where $Cl^-_{\text{mw, ww, and i/sw}}$ are the chloride concentration in the Monitor Well, B Evans Well, and Injected/Surface Water and
Y = Mixing Fraction, or % of Injected/Surface Water in the Monitor Well sample.

Equation 2: $\text{Bacteria}_{\text{Expected}} = Y * \text{Bacteria}_{/sw}$

Where Bacteria_{mw} = the expected population of bacteria in sample were no attenuation to occur, assuming all bacteria in the Monitor Well was due to mixing with ambient groundwater. The B Evans well was used as ambient groundwater because it had the lowest chloride concentration in the chemically unimpacted well, which in turn predicted the lowest percentage of injected water in the Monitor Well sample, and subsequently the lowest bacteria expected.

Equation 3: $\text{Bacteria Attenuation Percentage} = 1 - (\text{Bacteria}_{\text{Expected}} / \text{Bacteria}_{i/sw}) * 100$

Because the result is hypothetical, travel time to the injection well was 3.5 days, and samples were taken weekly, the concentration of bacteria in the injection/surface water sample and monitor well sample collected on the same day were used.

Appendix – Sulfate/Chloride Ratio – All Samples

Chloride concentrations in the Winder Well decreased (towards those of the Injection Well/Canal) between 5/17 and 5/24 [Slide 7].

However, the sulfate/chloride ratios in samples from the Winder Well increased (away from those of the Injection Well/Canal) between 5/17 and 5/24.

Increases in sulfate/chloride ratios between 5/17 and 5/24 are also observed in the chemically unimpacted and upgradient Snarr and Messenger Wells.

The Winder Well is likely not chemically impacted by injected water but rather the fluctuation in chloride concentrations observed Between 5/17 and 5/24 is a result of natural variability.