Direct River Water To Groundwater Recharge Experiments to Elucidate Mass Transport Mechanisms of Uranium

Kendyl Hoss, Rakiba Sultana, Cullen Meurer, Jiyan Hatami, Aaron Tigar, Raymond Johnson, Charles Paradis

UWM UNIVERSITY of WISCONSIN MILWAUKEE

Abstract

The concentration of uranium in groundwater at a former mill tailings site located on the floodplain of the Little Wind River in Riverton, Wyoming persists above levels as predicted by a site-wide reactive transport model. It was hypothesized that the mass transfer of immobile uranium in the solid phase to mobile uranium in the aqueous phase was occurring during periods of river water to groundwater recharge, via dissolution of uranium-bearing sulfate evaporites, and contributing to persistent levels of uranium.

To test this hypothesis, a 100-gallon solution of tracer-amended river water was injected into a single well and was tracked over several weeks in two down-gradient transects of observation wells. Dilution-adjusted breakthrough curves will be analyzed to determine if uranium was mobilized from the solid- to the aqueous-phase.

Background

Milling activities at a former uranium mill site near Riverton, Wyoming contaminated the shallow groundwater beneath and downgradient of the site.

Groundwater modeling predicted that natural flushing would agree with pertinent groundwater protection standards by the year 2098. A decade of groundwater monitoring indicated that contaminant concentrations were declining steadily, which confirmed the conceptual site model.

However, local flooding in 2010 mobilized contaminants that traveled downgradient from the Riverton site and resulted in a dramatic increase in groundwater contaminant concentrations. This observation indicated that the original conceptual site model was inadequate to explain site conditions and needed to be refined.

Methods and Materials

Figure 1. Experimental well gallery at the Saint Steven's Mission Area.

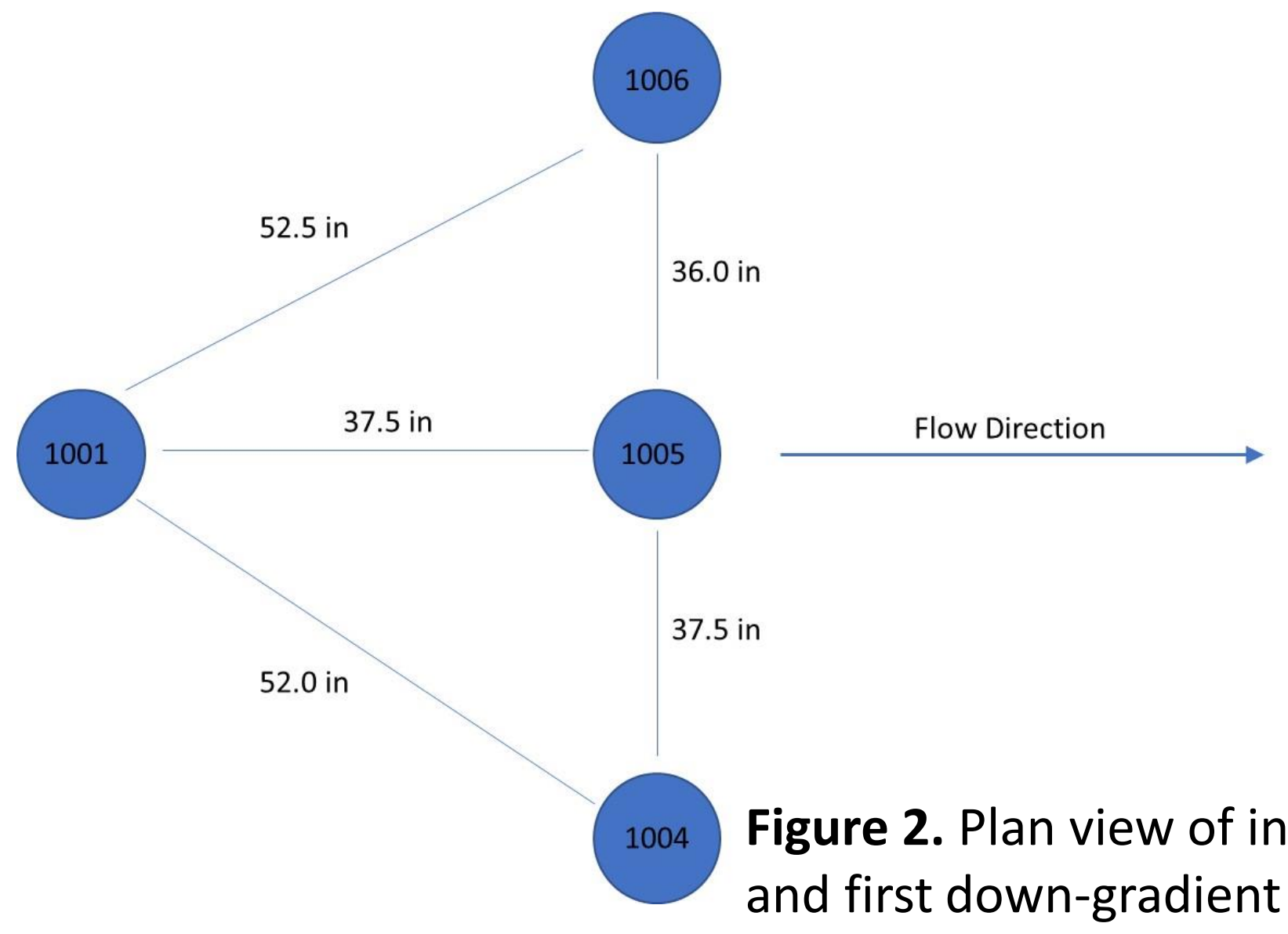

Figure 2. Plan view of injection well 1001 and first down-gradient transect.

$$C_e^{r'}(\mathrm{t}) = \left(\frac{[C_e^c(\mathrm{t}) - C_a^c]}{[C_i^c - C_a^c]}\right)[C_i^r - C_a^r] + C_a^r$$

Equation 1. The expected concentration of a reactive analyte due to dilution between the injection and aquifer fluids during the extraction phase.

$$\bar{R} = \frac{\int_0^t C_e^r(t)dt}{\int_0^t C_e^{r'}(t)dt}$$

Equation 2. Recovery factor of the reactive analyte during the extraction phase.

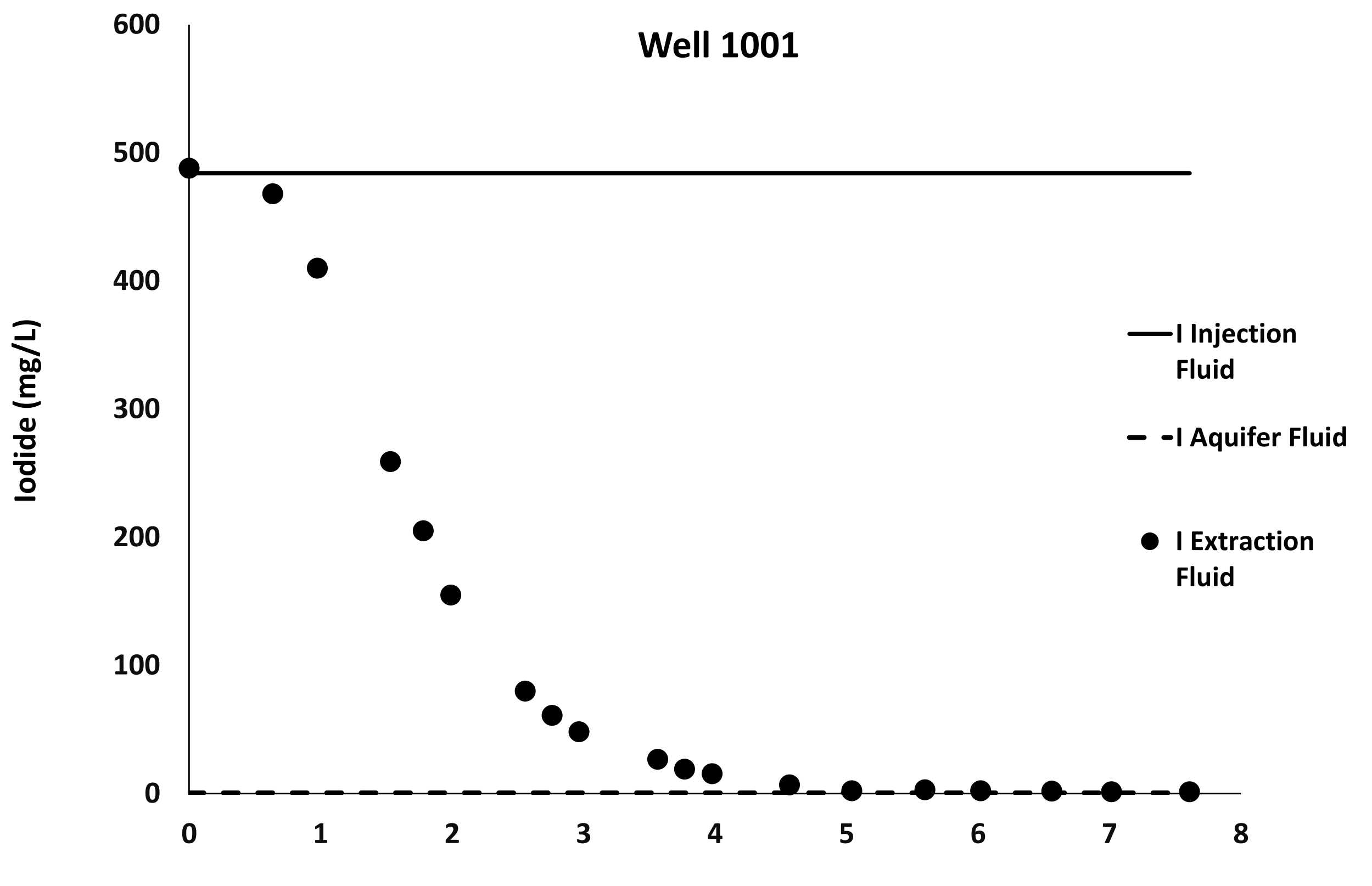

Figure 3. Breakthrough curve of Iodide (non-reactive tracer) in injection well 1001.

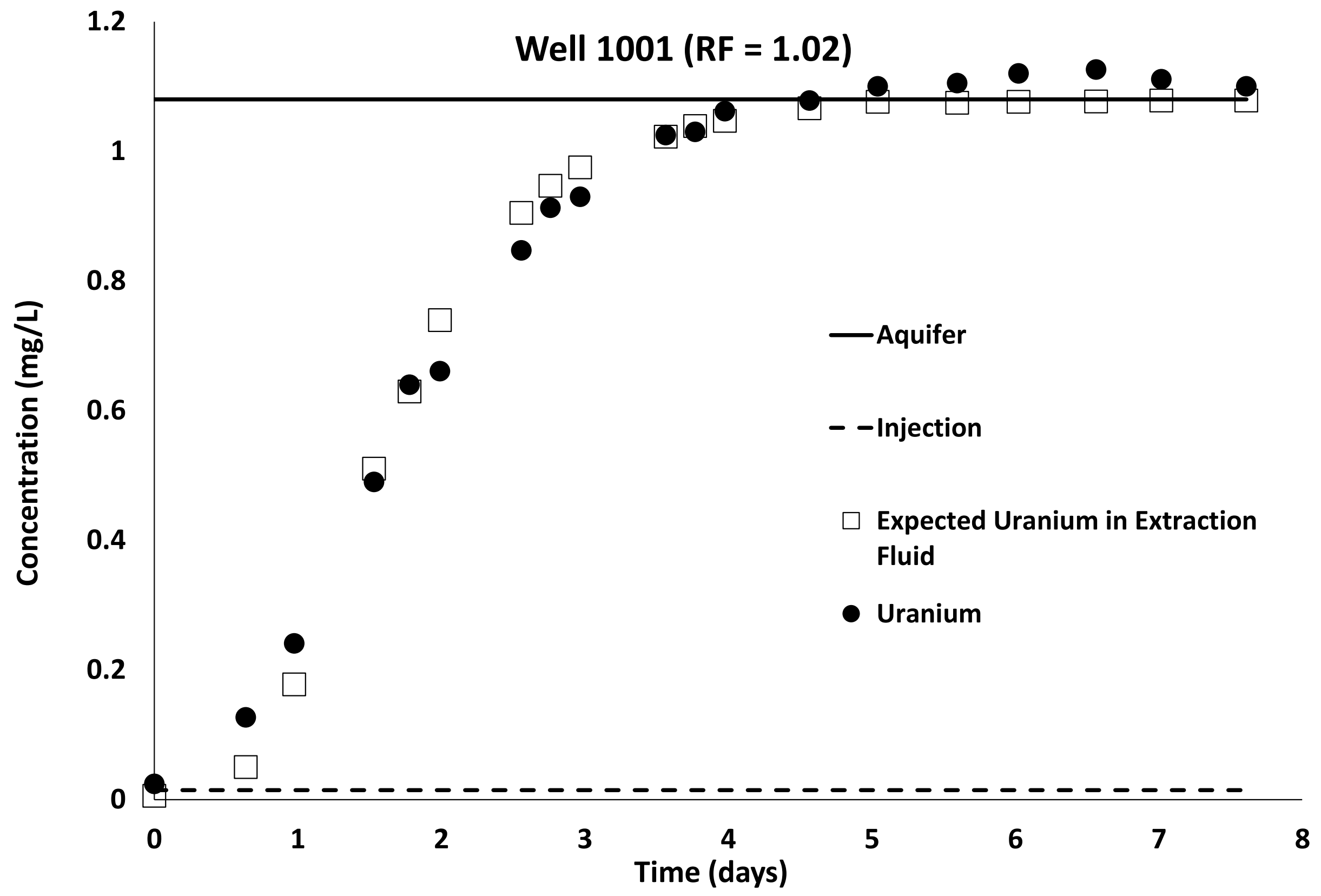

Figure 4. Concentration of Uranium during the extraction phase in injection well 1001.

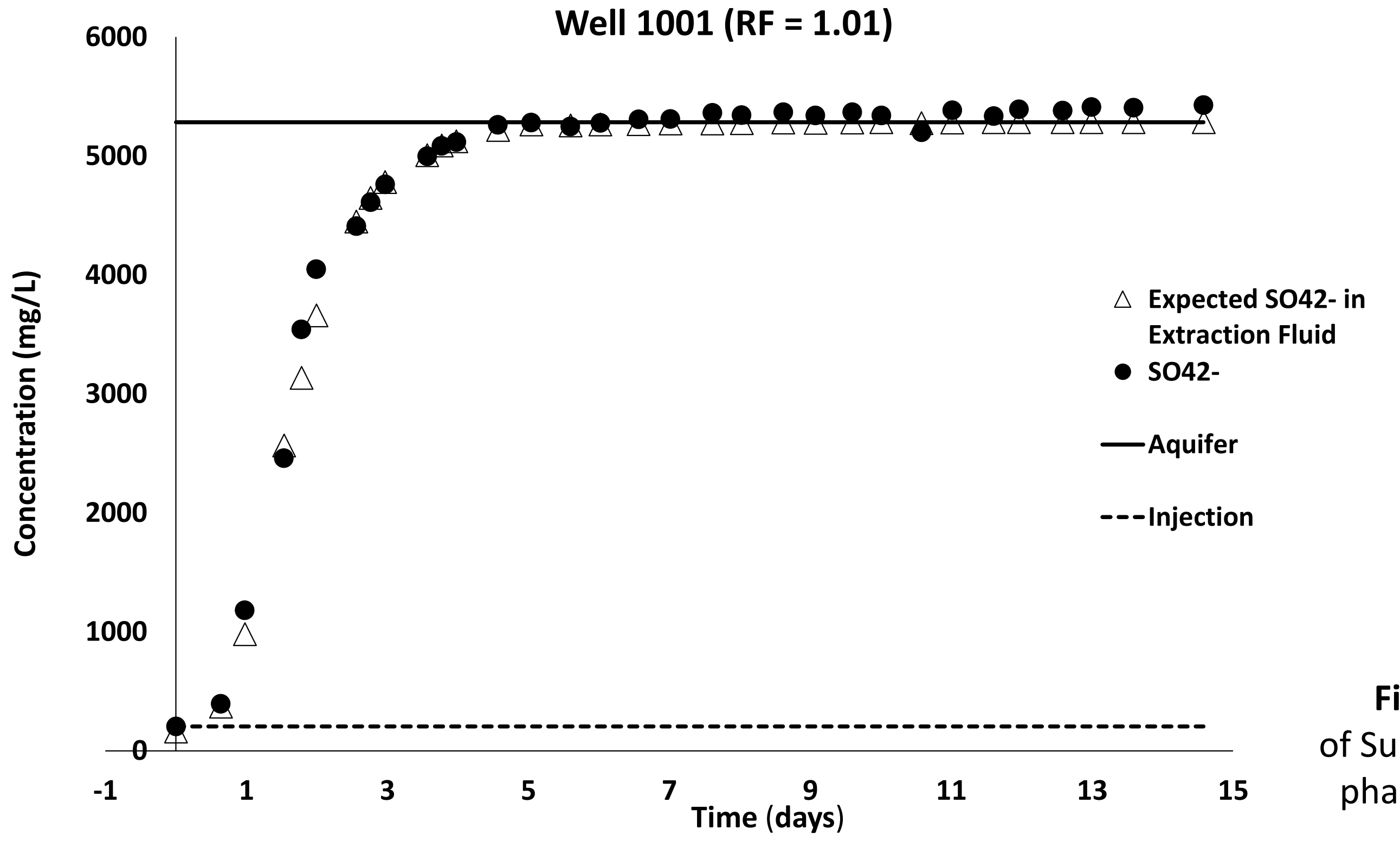

Figure 5. Concentration of Sulfate during the extraction phase in injection well 1001.

Results & Discussion

The recovery factor will tell us that if it is greater than 1 there is a net addition, less than 1 there is a net removal, or equal to 1 there is no change of the reactive analyte during the extraction phase.

The measured concentration of uranium was similar to the expected concentration of uranium for well 1001. This resulted in a recovery factor of nearly one which indicates that no net addition or removal of uranium from the aquifer to the extraction fluid occurred for well 1001.

The measured concentration of sulfate was similar to the expected concentration of sulfate for well 1001. This resulted in a recovery factor of nearly one which indicates that no net addition or removal of sulfate from the aquifer to the extraction fluid occurred for well 1001.

Conclusions & Future Directions

The measured concentration of uranium and sulfate did not exceed the expected concentrations of each, respectively. This indicates that there was no net addition or removal of each analyte from the aquifer to the extraction fluid. This does not support the hypothesis that a responsible mechanism, dissolution, mobilized each analyte in the saturated zone from the solid to aqueous phase in the injection well.

To create and analyze dilution-adjusted breakthrough curves of the downgradient wells.

To model breakthrough curves using a simple numerical approach (finite-difference) to characterize advection, dispersion, and possible source terms, e.g., desorption, re-oxidation, matrix diffusion, of uranium.

References

1. Charles J. Paradis, et al., Journal of Contaminant Hydrology, https://doi.org/10.1016/j.jconhyd.2019.103581
2. Charles J. Paradis, et al., NGWA, https://doi.org/10.1111/gwat.12770
3. Dam W. L., Campbell S., Johnson R. H., et al., *Refining the site conceptual model at a former uranium mill site in Riverton, Wyoming, USA.* Environmental Earth Sciences; Heidelberg Volume 74, Issue 10, (2015): 7255-7265. DOI:10.1007/s12665-015-4706-y.

Acknowledgements

I would like to express a sincere thank you to the Department of Energy, specifically Raymond Johnson and Aaron Tigar, for providing the necessary funds and materials to conduct this research. I also thank my advisor Dr. Charles Paradis for the continuous support of my study and research. I thank my fellow lab members, Cullen Meuer, Jiyan Hatami, and Rakiba Sultana, for also going out to the field site and collecting the necessary data.

© Poster Template by Genigraphics® 1.800.790.4001 www.genigraphics.com