Lifting the fog of aquifer heterogeneity: An airborne electromagnetic survey of the High Plains Aquifer in Northwest Kansas

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Governor's Conference on the Future of Water in Kansas

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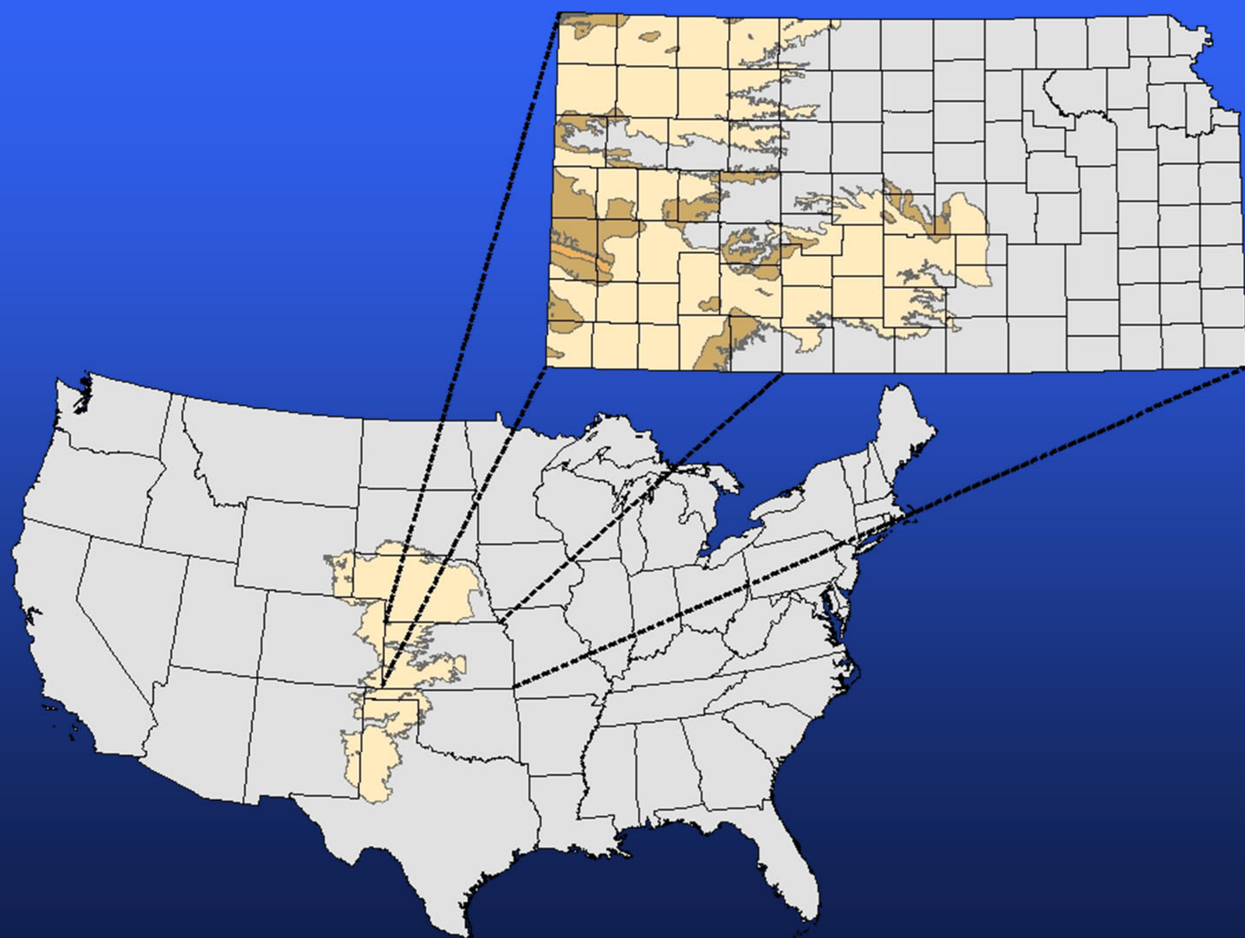
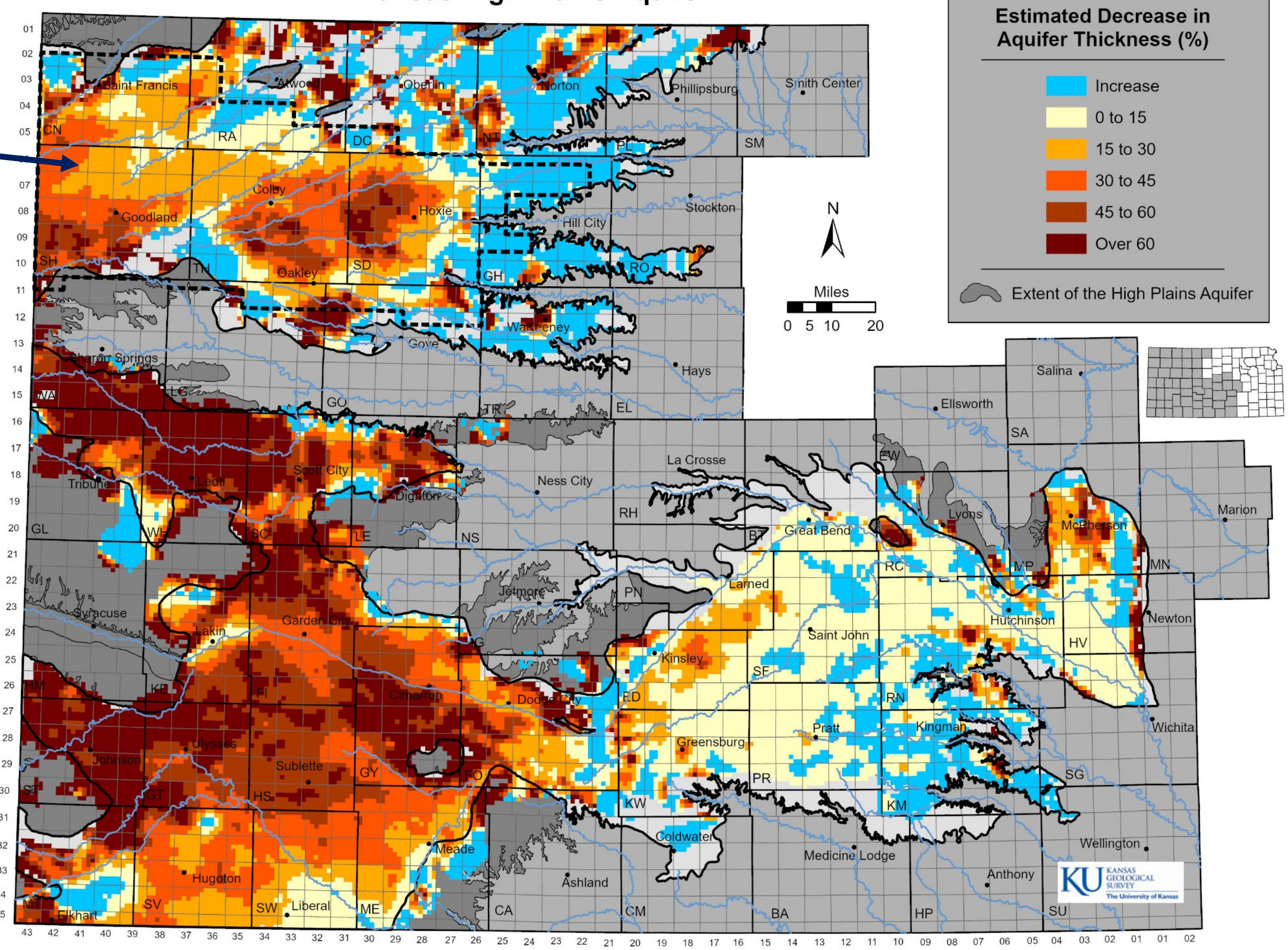
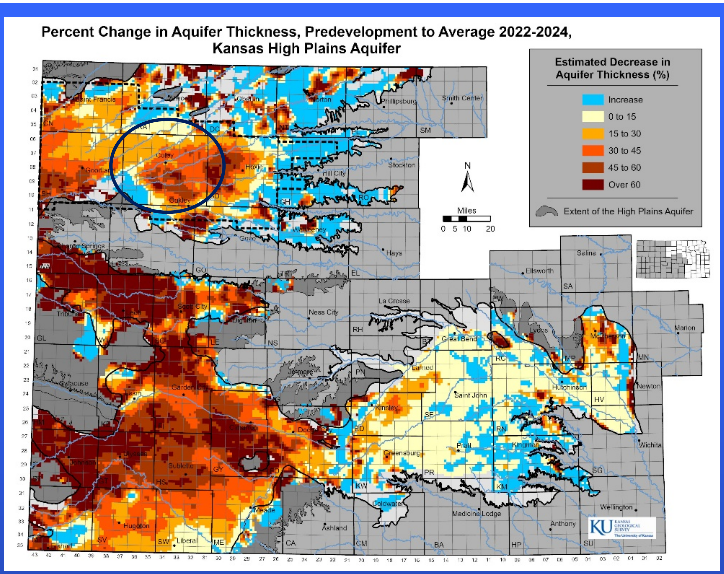
The High Plains Aquifer



Groundwater Management District #4 (GMD4)

Percent Change in Aquifer Thickness, Predevelopment to Average 2022-2024, Kansas High Plains Aquifer





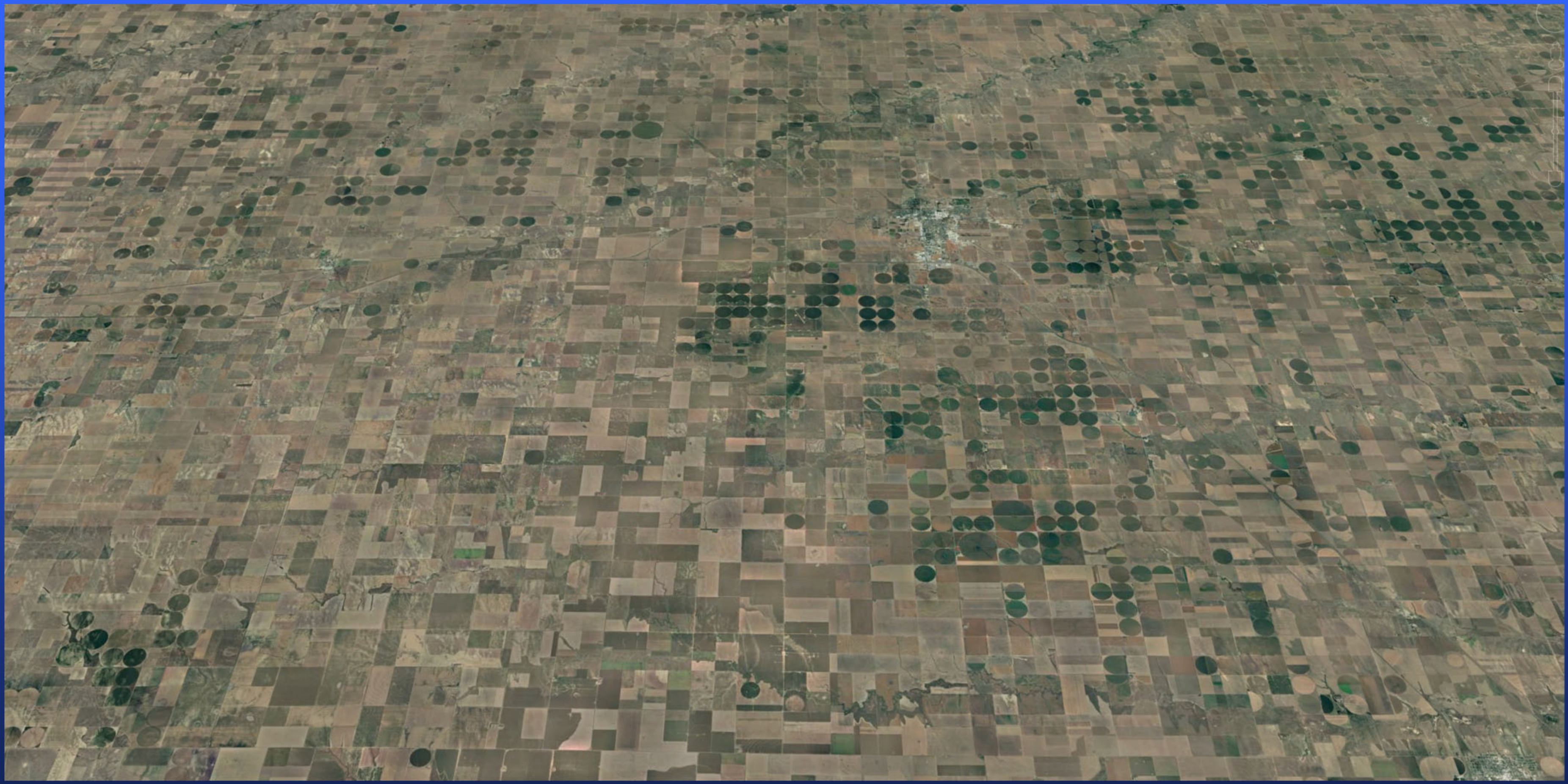
Only one option over the next few to several decades:

Pumping reductions with modifications of agricultural practices (Butler and Whittemore, 2024)

Key Question - How much does pumping need to be reduced?
- **We have pumping and water-level data.**
  - **reliable predictions on the GMD to county scale.**
- **Need better information on the hydrostratigraphic framework.**
  - **focus of this presentation**

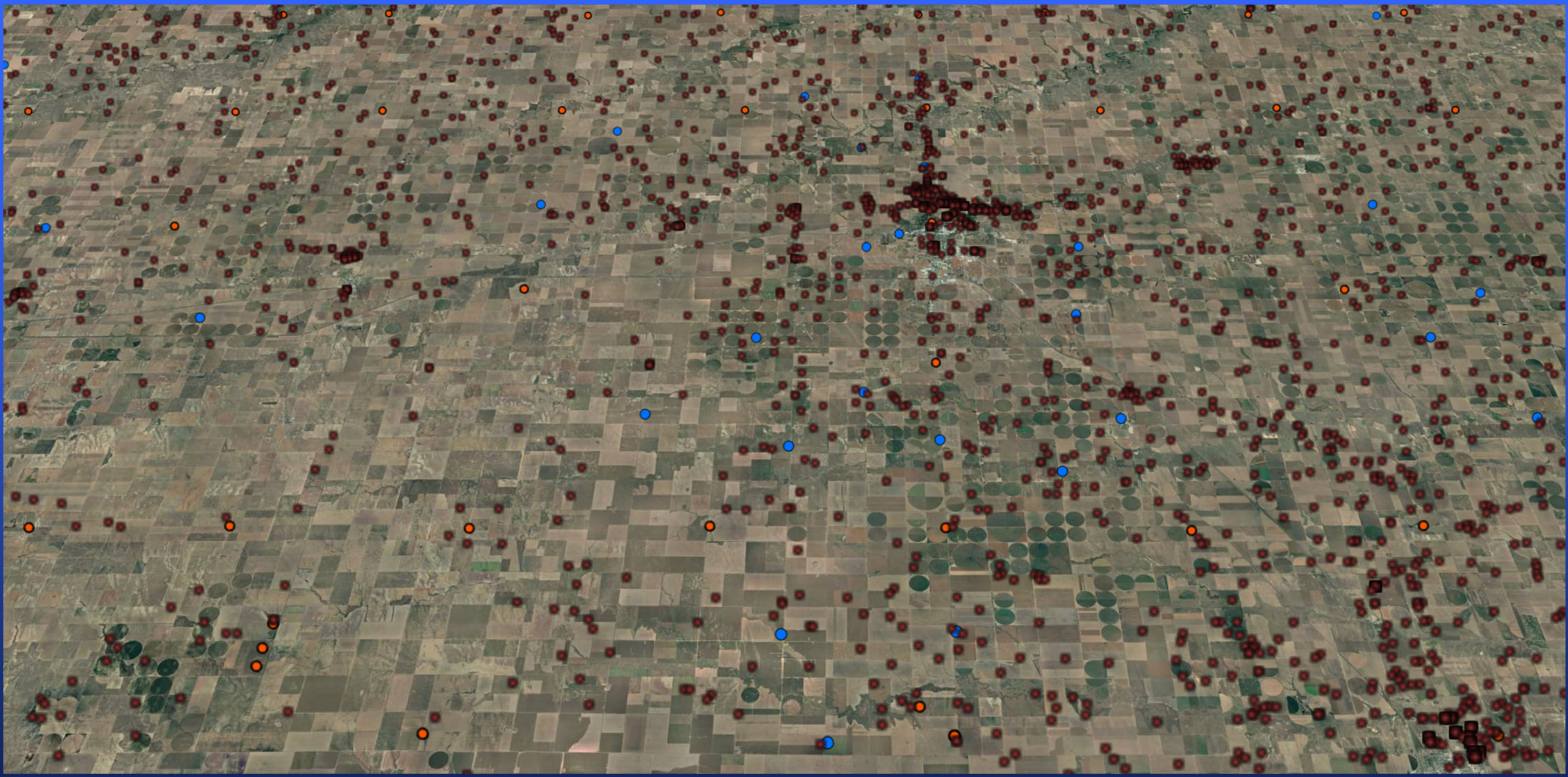
Distribution of Pumping Wells

Aquifer Heterogeneity on the Regional Scale



Discontinuity of transmissive zones – see Butler et al. (2013)

Hydrogeologic Framework – KGS and USGS Test Holes



Incorporation of data from drillers' logs – > 5,000 wells in GMD4

Airborne Electromagnetic (AEM) Survey

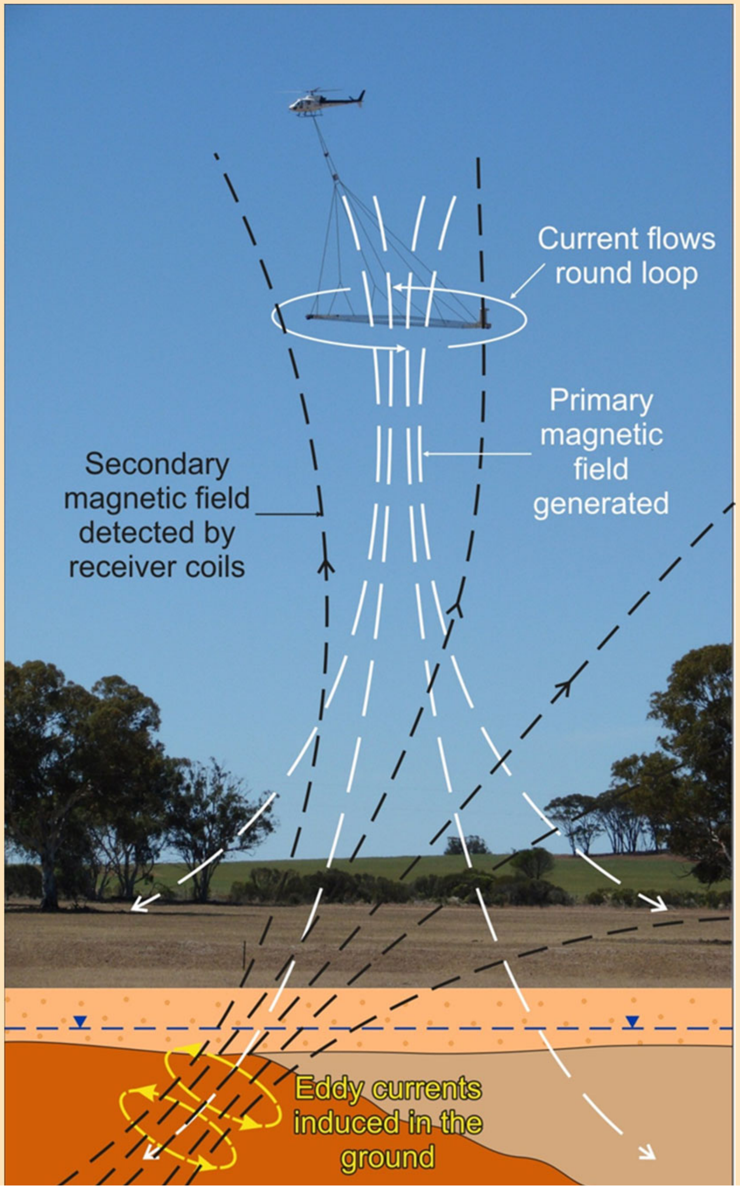
How AEM works:

The transmitter fires discrete electromagnetic pulses that generate a primary magnetic field.

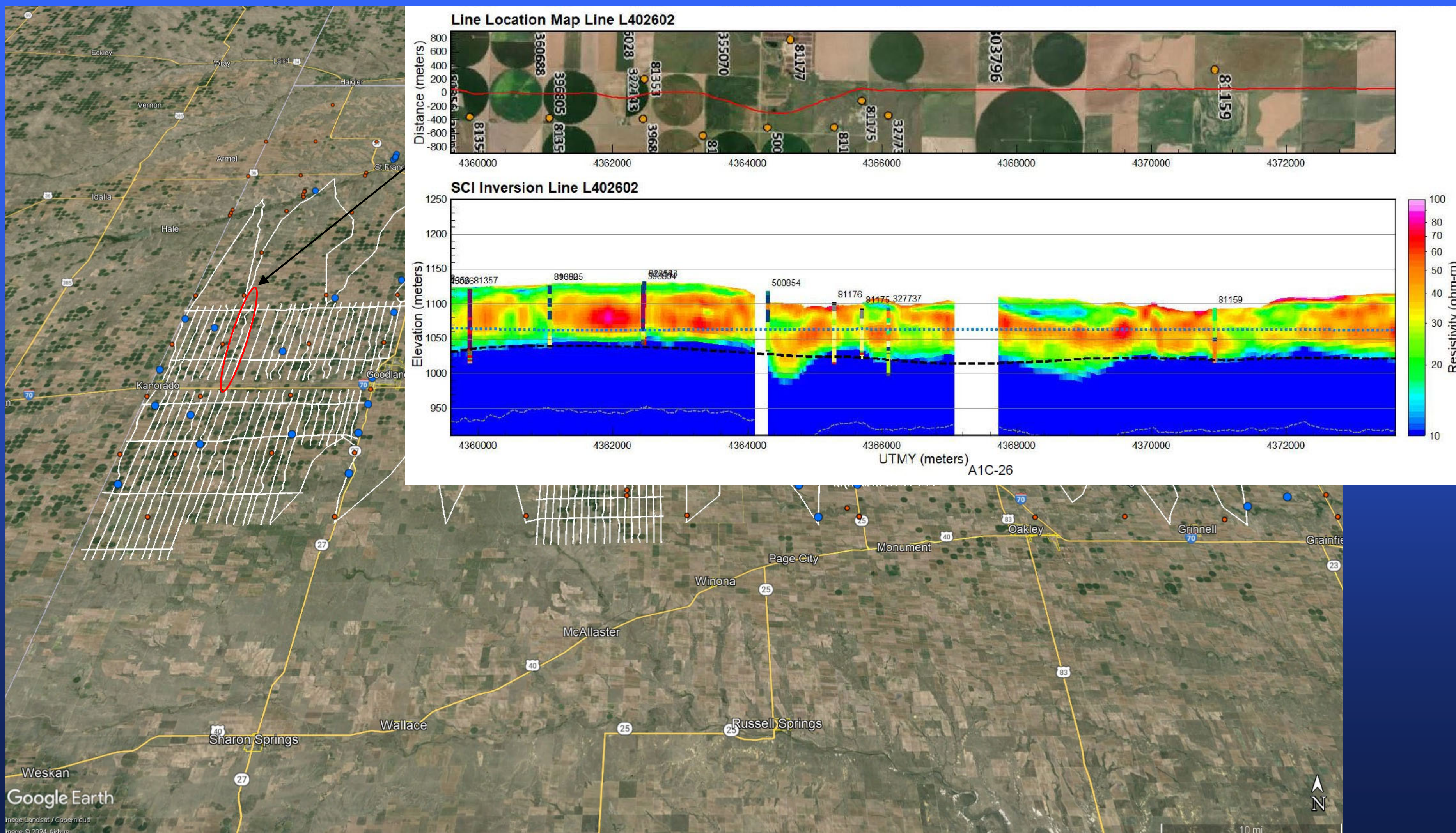
The pulses induce eddy currents in the subsurface that generate a secondary magnetic field, i.e. the "response".

The receiver "listens" for this response – we are measuring this secondary magnetic field.

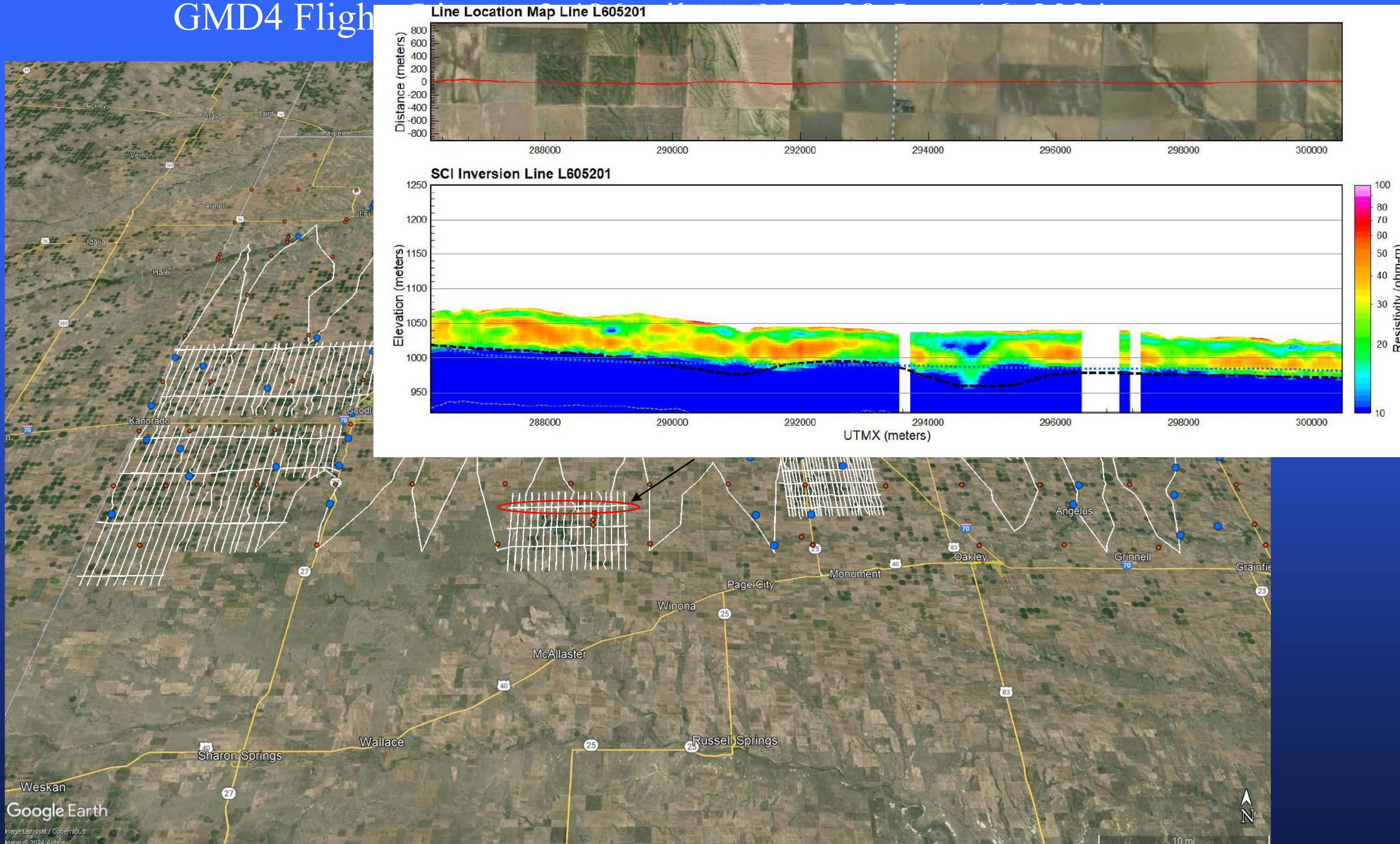
This measurement provides information on electrical resistivities in the subsurface. Sands and gravels have higher resistivities, while clays and shale bedrock have lower resistivities.



GMD4 Flights Lines – 2,486 miles – May 28-June 16, 2024



GMD4 Fligh



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Page City
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McAllaster
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Sharon Springs
Russell Springs
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Image © 2024 Airbus
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Line Location Map Line L605201
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SCI Inversion Line L605201
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UTMX (meters)
Resistivity (ohm-m)
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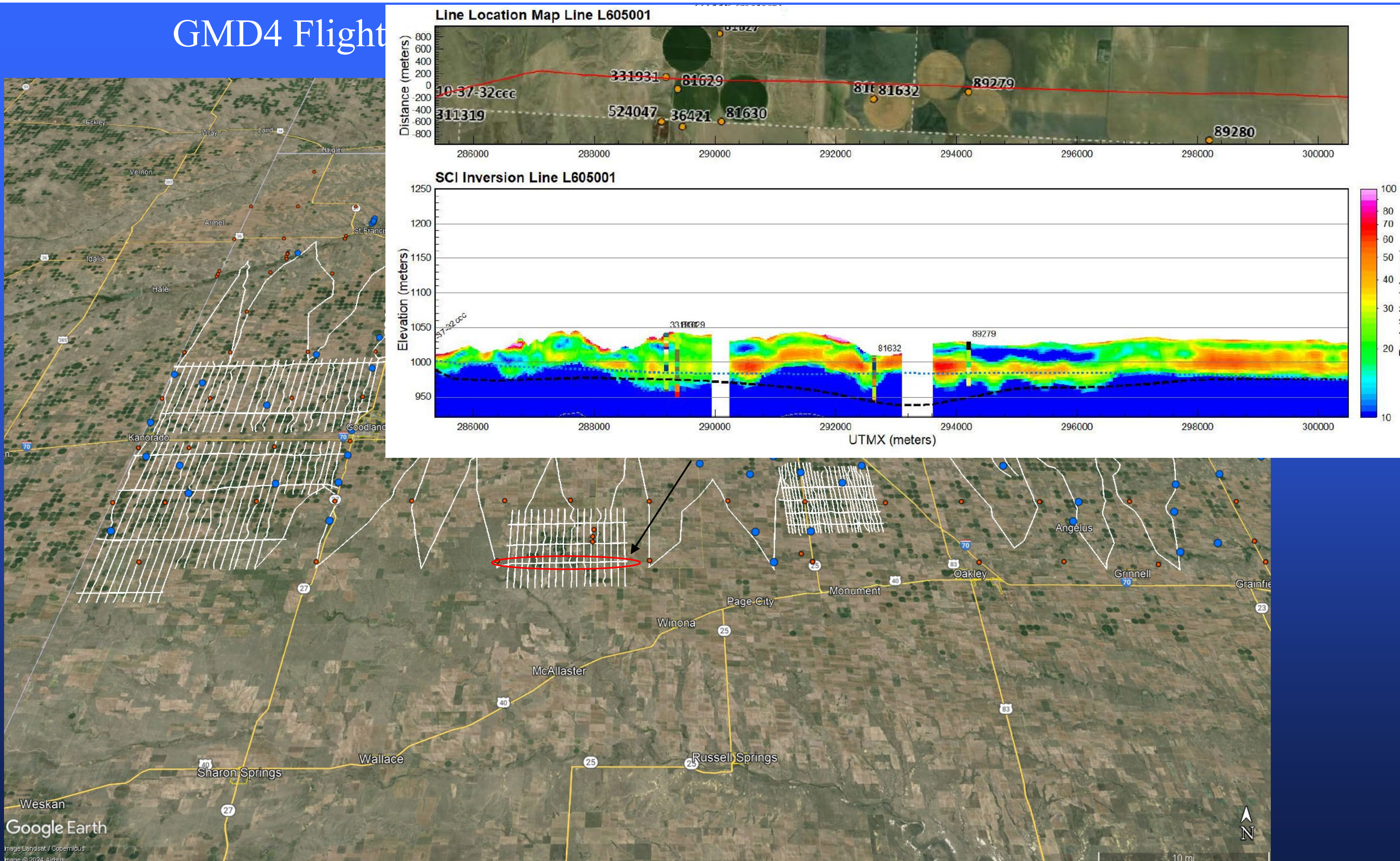
GMD4 Flight



Line Location Map Line L605001
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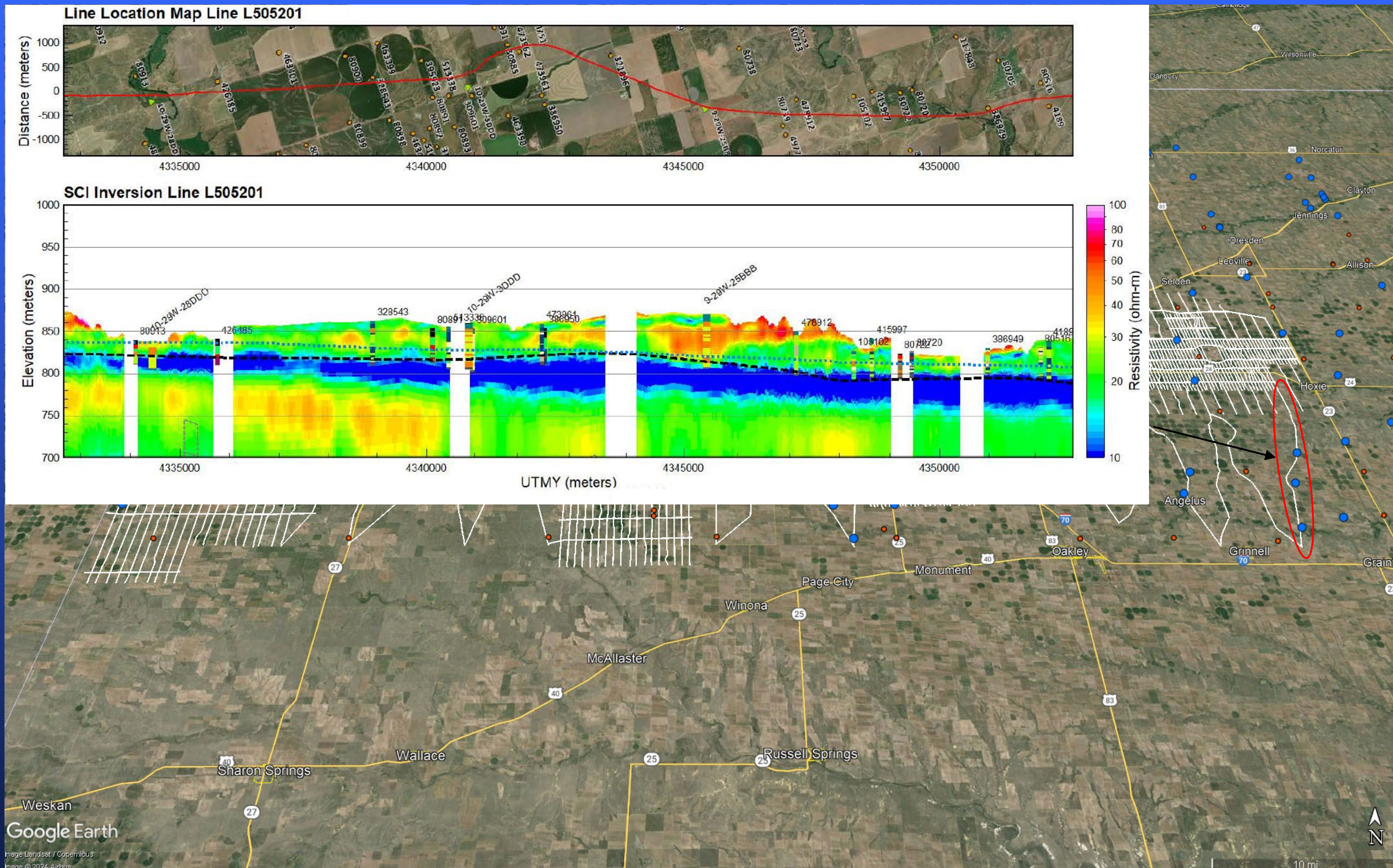
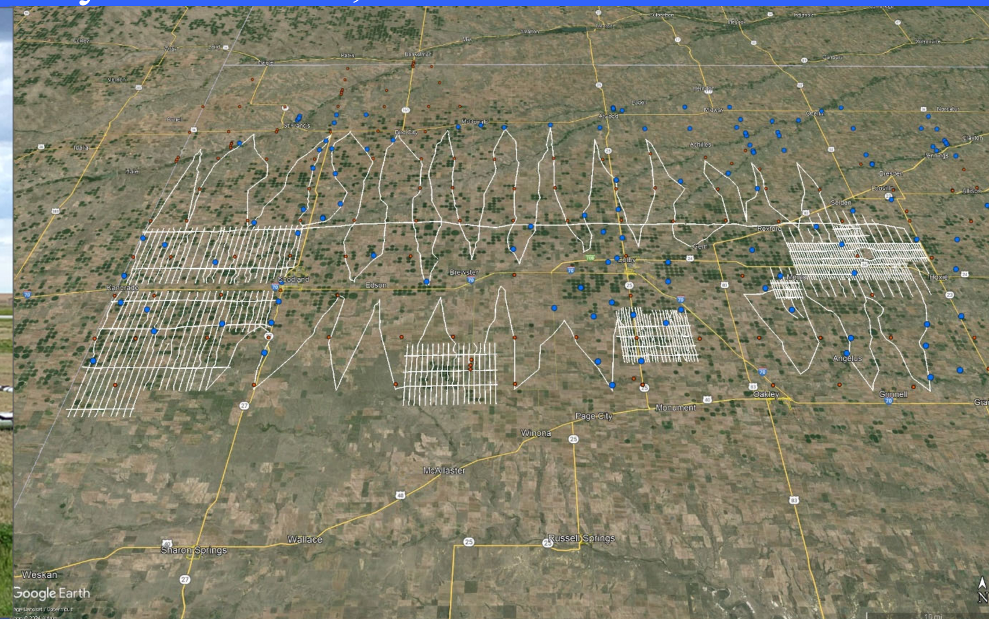


AEM Survey of GMD4 – May 28-June 16, 2024



Strengths of Airborne Electromagnetic Surveys:

- Near-continuous record (≈85 ft separation) of electrical resistivity in the subsurface.
- Provides important insights into the distribution of pumping wells in GMD4.
- Enhances the design of groundwater conservation areas (Orduna Alegria et al., 2024).

Major Challenge – Transformation of electrical resistivity to lithologic type.

ACKNOWLEDGMENTS

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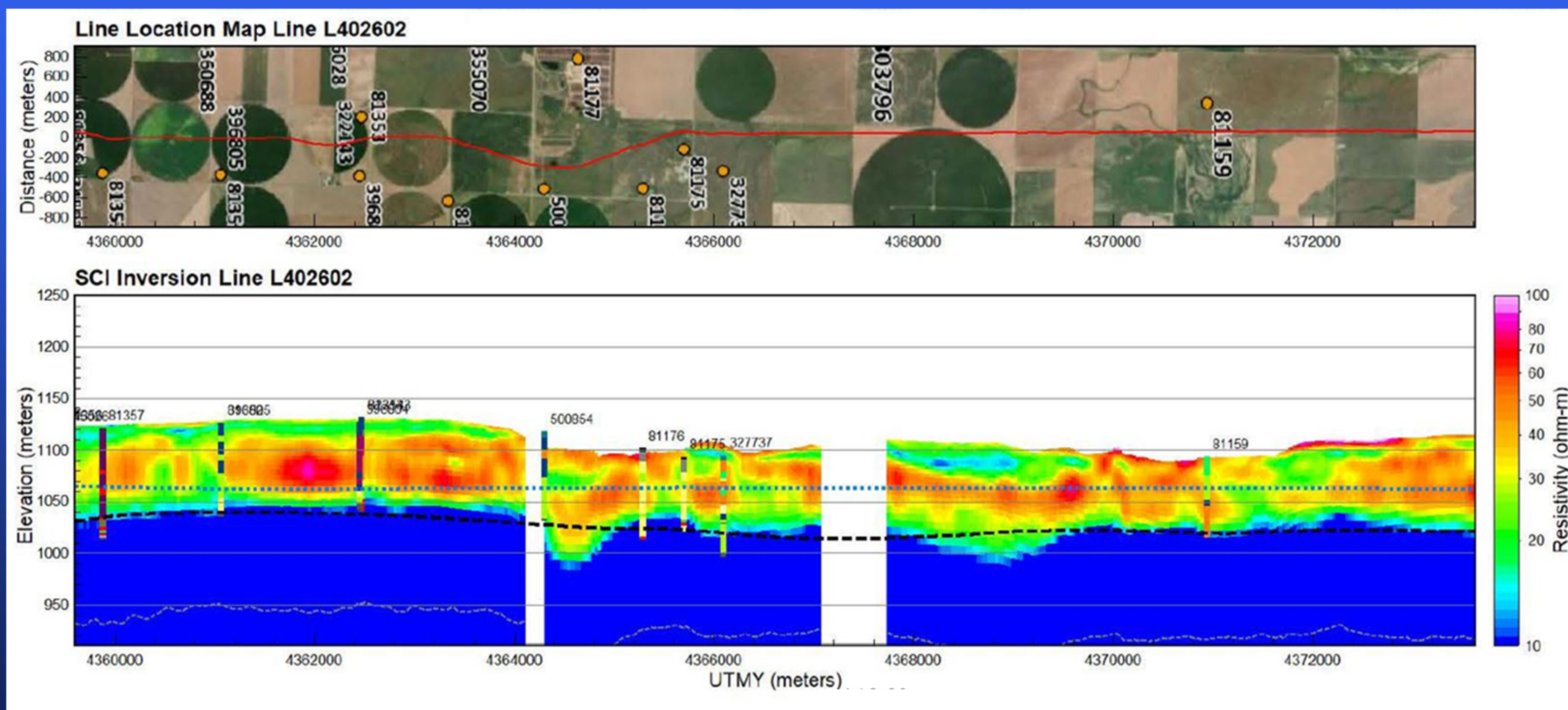

SELECTED REFERENCES

Butler, J.J., Jr., R.L. Stotler, D.O. Whittemore, and E.C. Reboulet, Interpretation of water-level changes in the High Plains aquifer in western Kansas, *Groundwater*, 51(2), 2013.

Butler, J.J., Jr., and D.O. Whittemore, Groundwater depletion reduces drought resiliency, *Nature Water*, 2, doi: 10.1038/s44221-023-00185-3, 2024.

Orduna Alegria, M.E., S. Zipper,….., J.J. Butler, Jr., Unlocking aquifer sustainability through irrigator-driven groundwater conservation, *Nature Sustainability*, doi:10.1038/s41893-024-01437-0, 2024.

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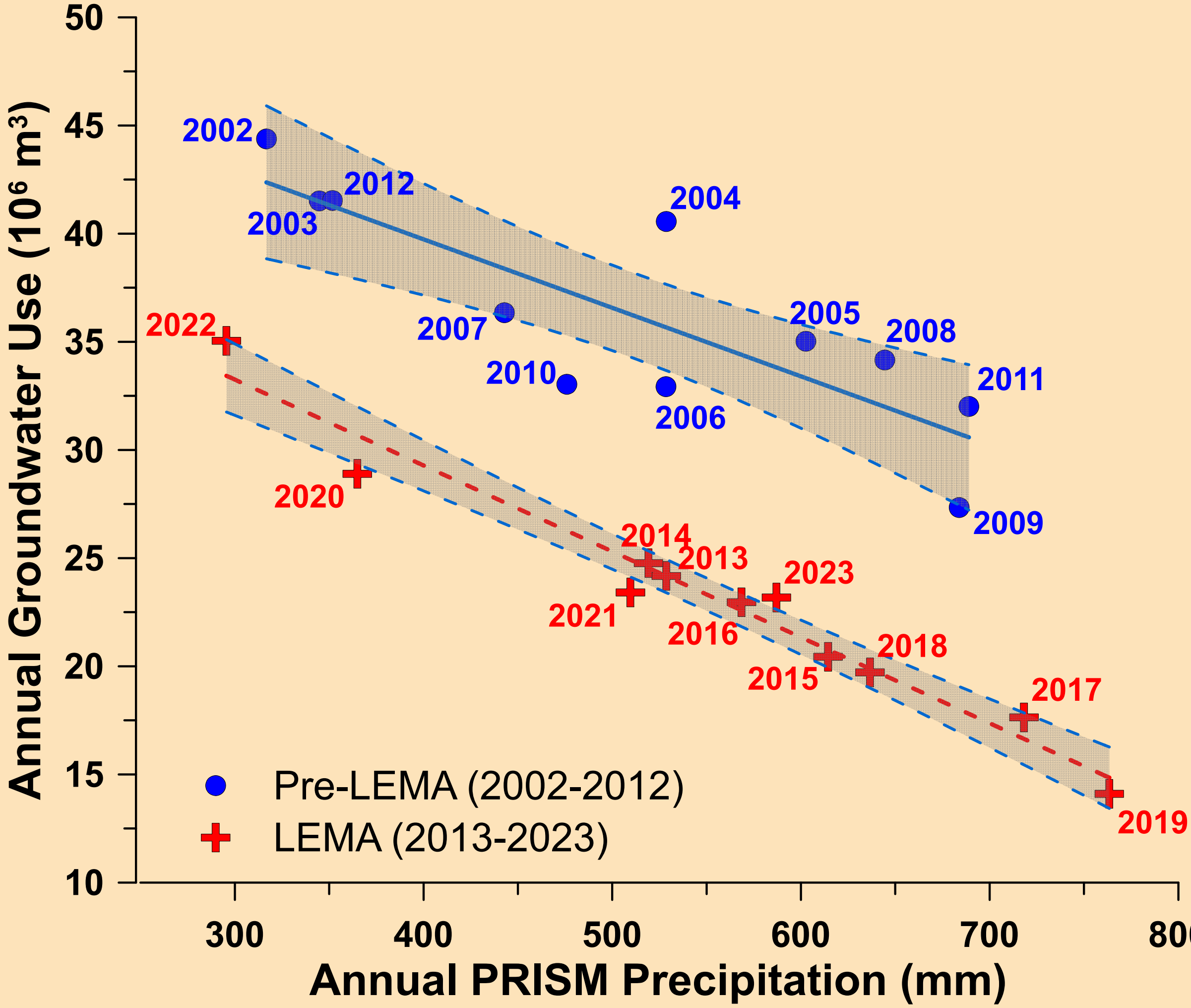
[redacted]

Sheridan-6 Local Enhanced Management Area (LEMA)

255 km^2
199 pumping wells

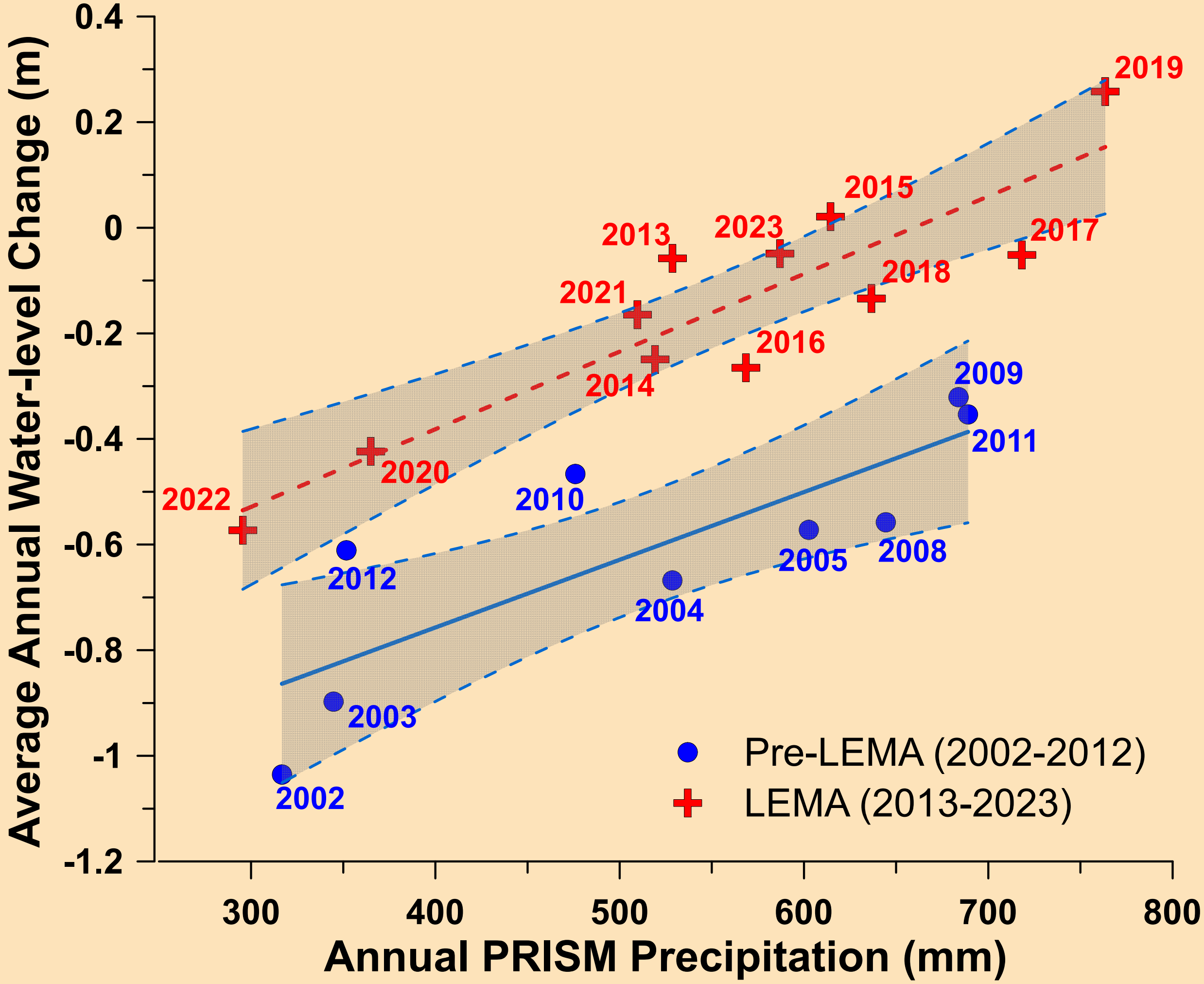


≈ 32% reduction in pumping for similar climatic conditions. (Whittemore et al., 2023)

≈ 63% reduction in water-level decline rate for similar climatic conditions (Butler et al., 2023)

Sheridan-6 LEMA

7 to 11 wells



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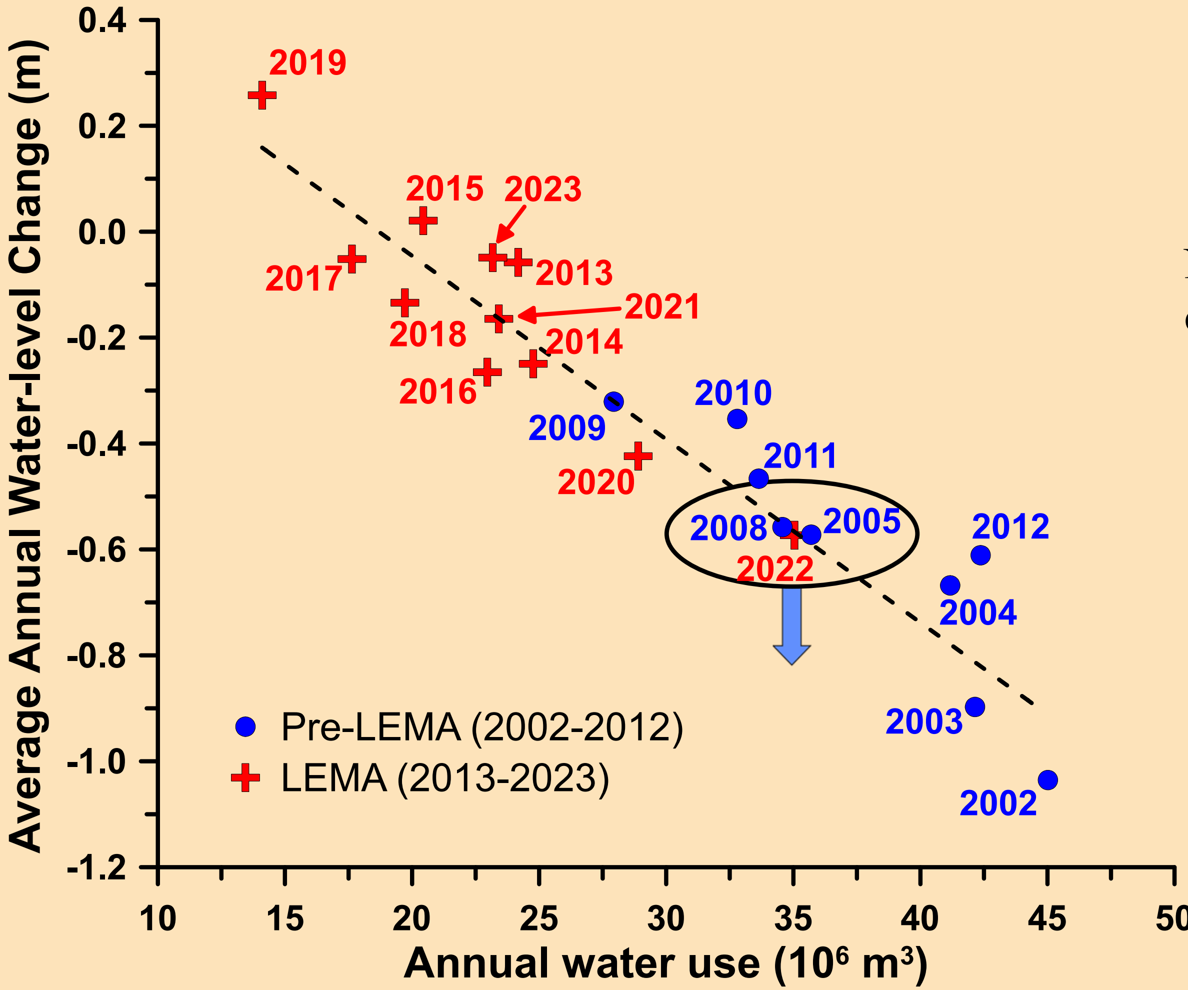

Net Inflow has remained near constant since 2002.

after Butler et al. (2023)