Pacific Northwest NATIONAL LABORATORY

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Stratigraphic structure identification using electrical resistivity tomography (ERT) and seismic methods

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2023 Global Summit
on Environmental Remediation
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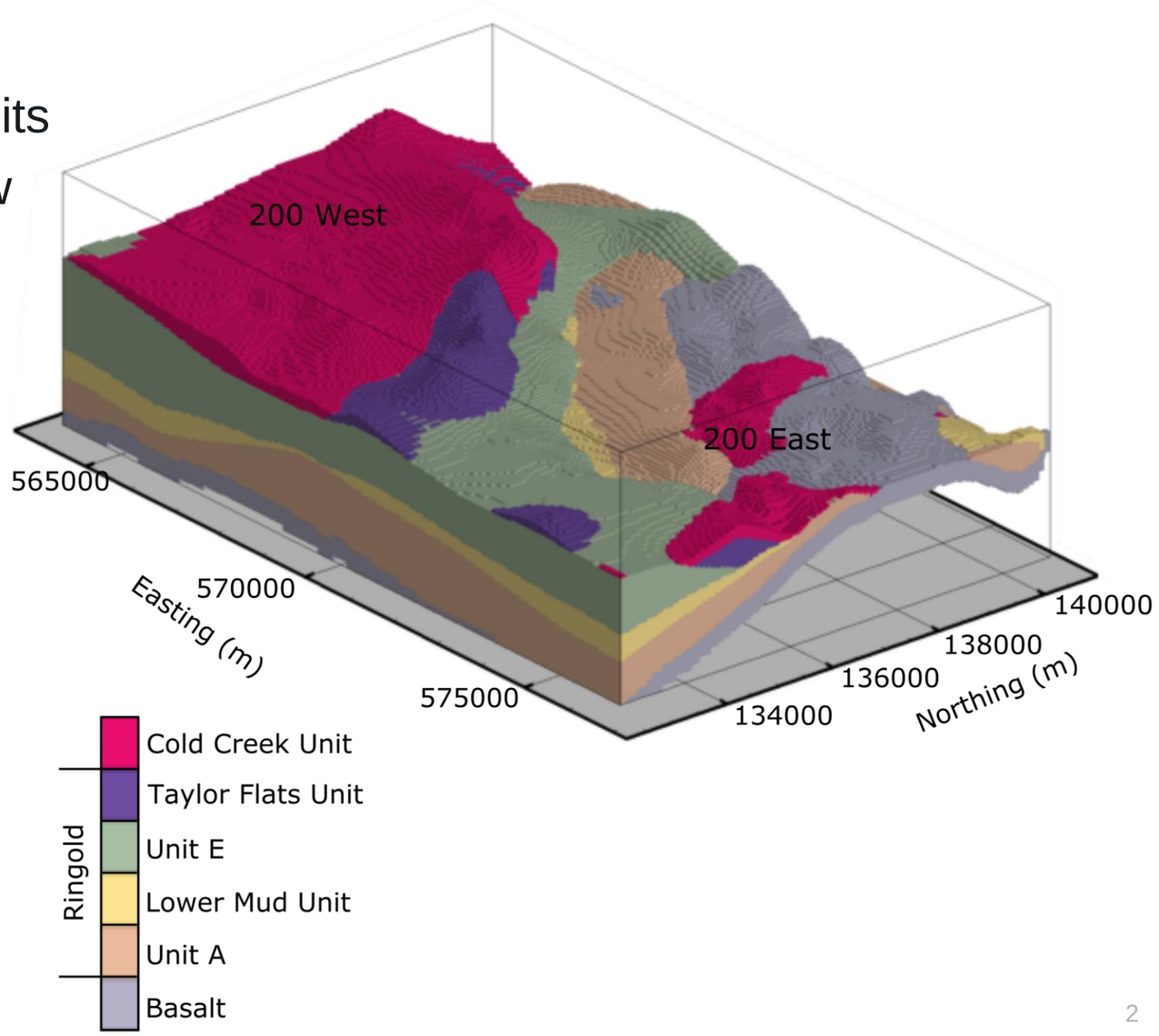
Hanford Site Geologic Framework Model

- Spatial arrangement of hydrostratigraphic units
- Foundation to understanding subsurface flow pathways
- Supports site management decisions
  - Flow and transport simulation models
  - Siting of new wells

Direct information

- Core samples, borehole sampling and logs, hydraulic testing
- New wells are costly
- Where to site new wells?



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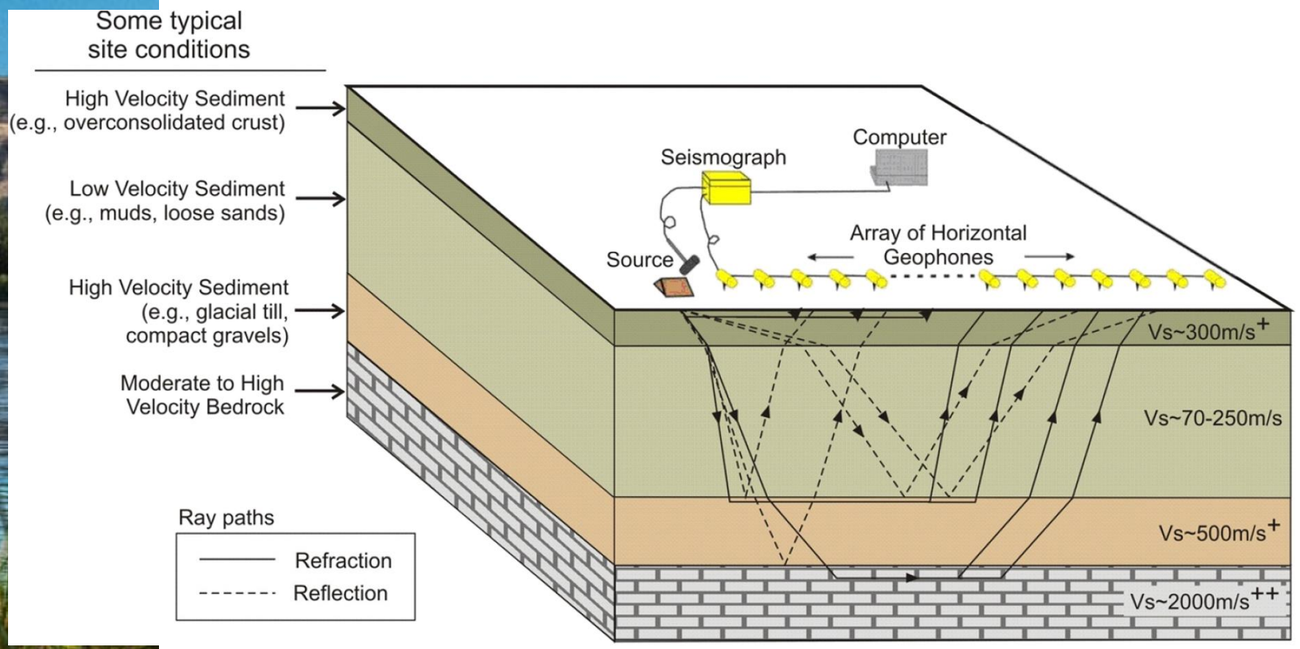
Geophysical Methods

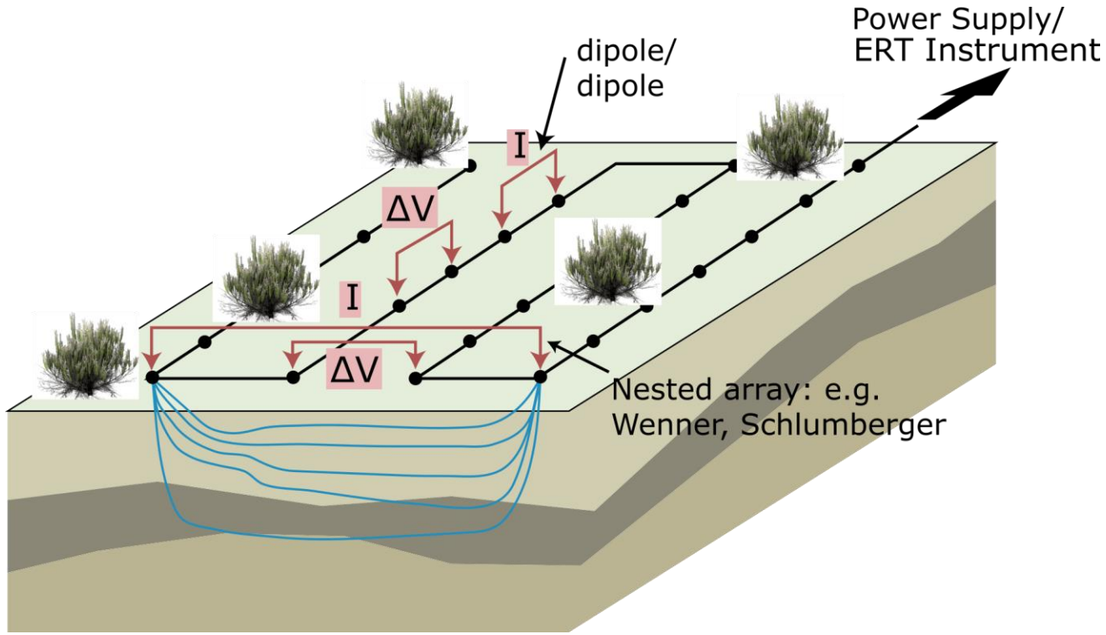
Seismic Reflection, Refraction



Hunter et al. (2015, 2022)

Seismic wave speeds vary depending on the density and the elastic properties of the material

Electrical Resistivity Tomography (ERT)



ERT depends on porosity, pore fluid conductivity, moisture contents, and lithology

Using these geophysical methods together provides multiple lines of evidence of stratigraphic structure

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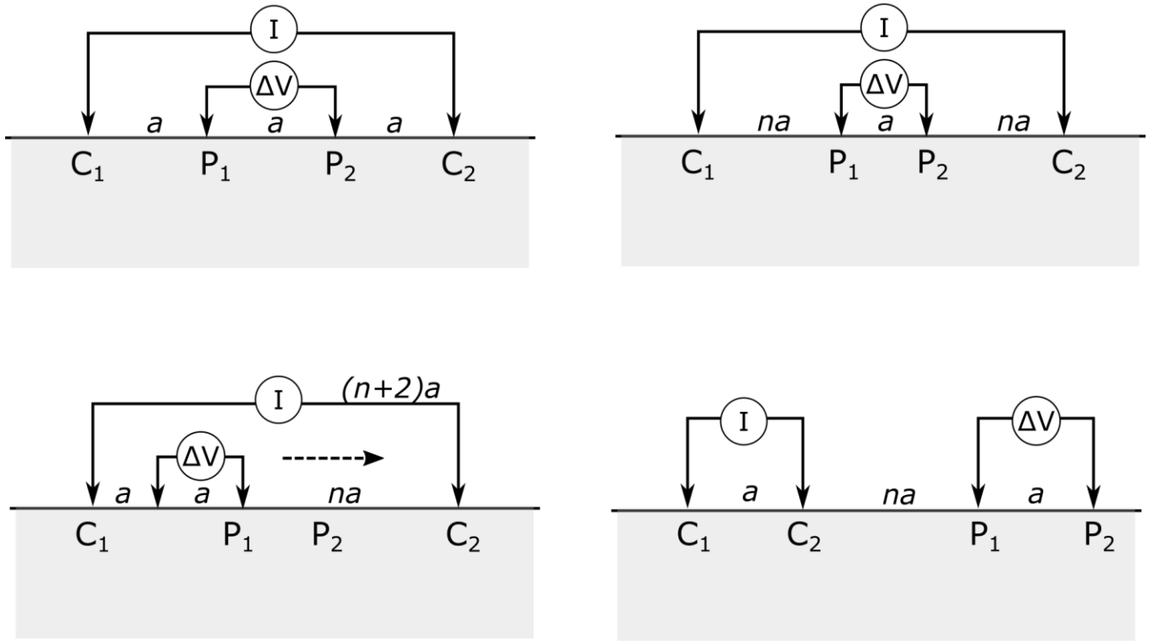
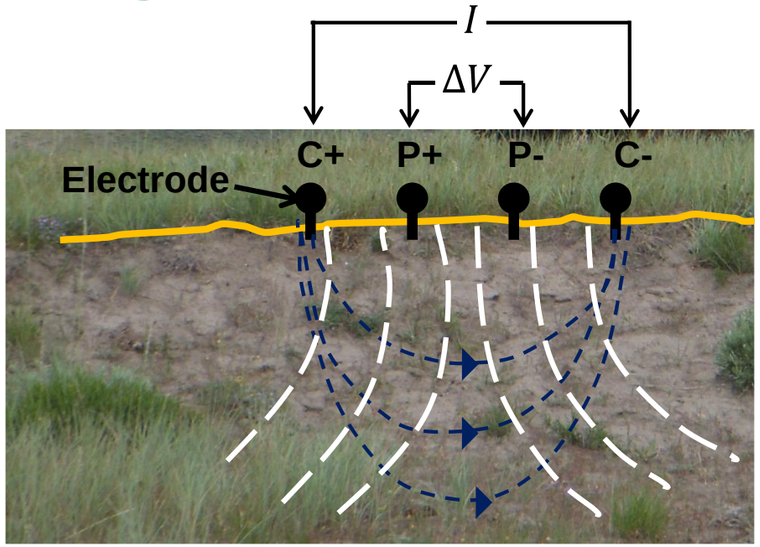
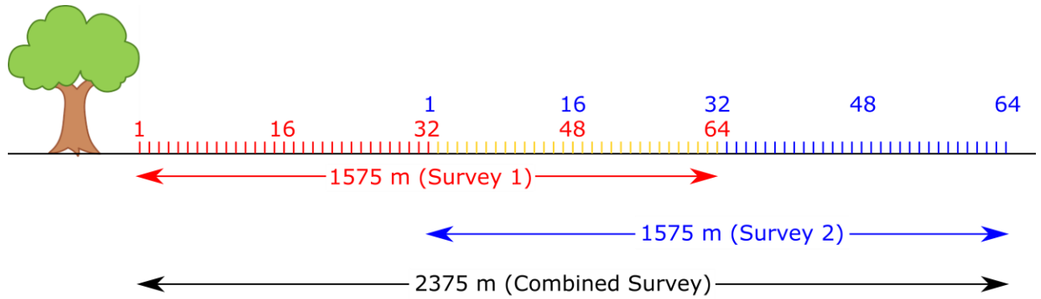
ERT Data Collection and Quality

Variety of measurements collected

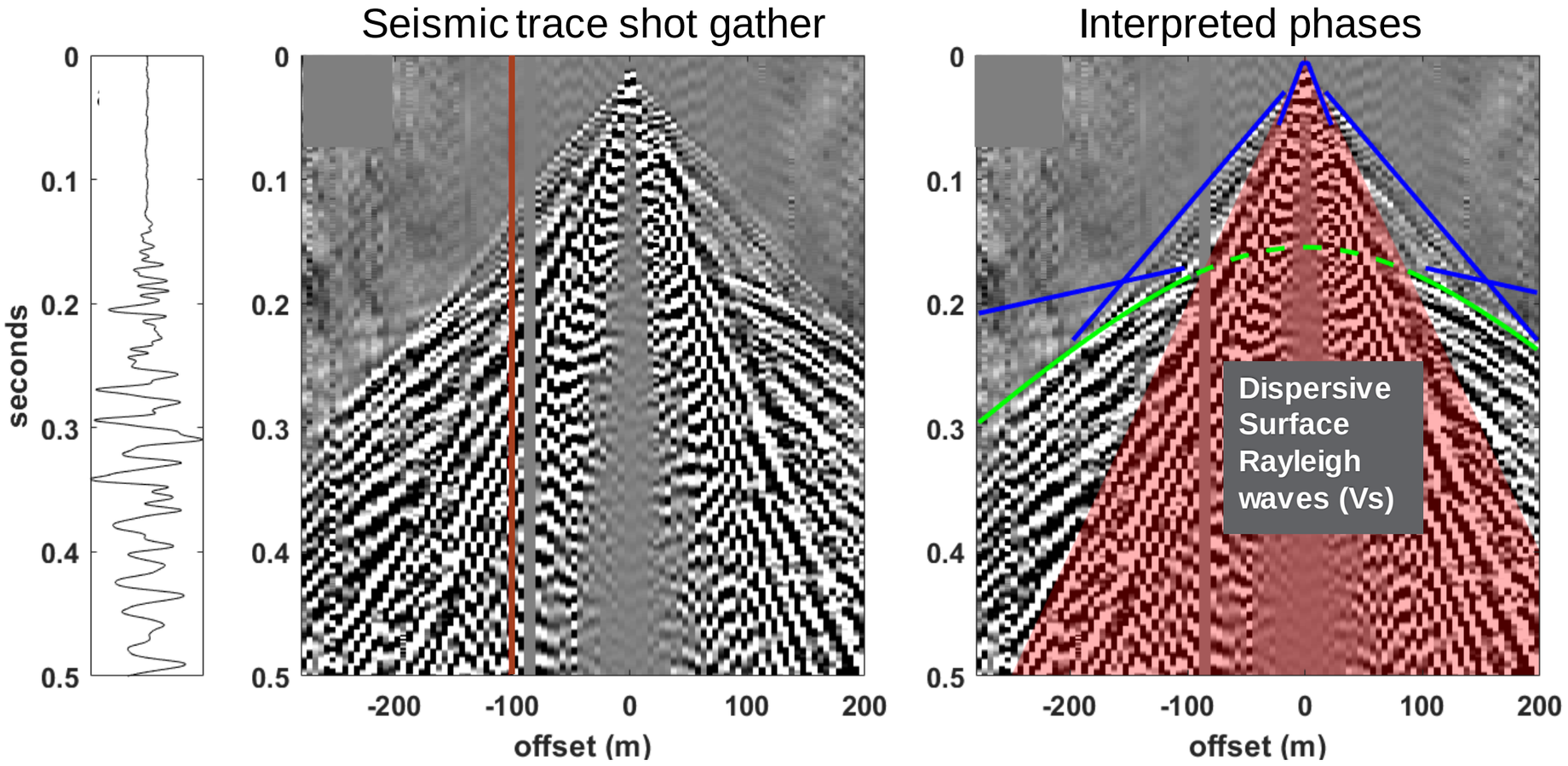






- Large and small electrode spacings provide higher resolution of shallow and deep features
- 64 electrodes @ 25 m electrode spacing; 96 electrodes @ 10 m spacing
- Datasets had high signal-to-noise ratio

Seismic Data



- Three interpreted phases from seismic data
- 5 m geophone spacing along 480 m cable
- Shorter and longer offsets collected for shallow and deeper resolution

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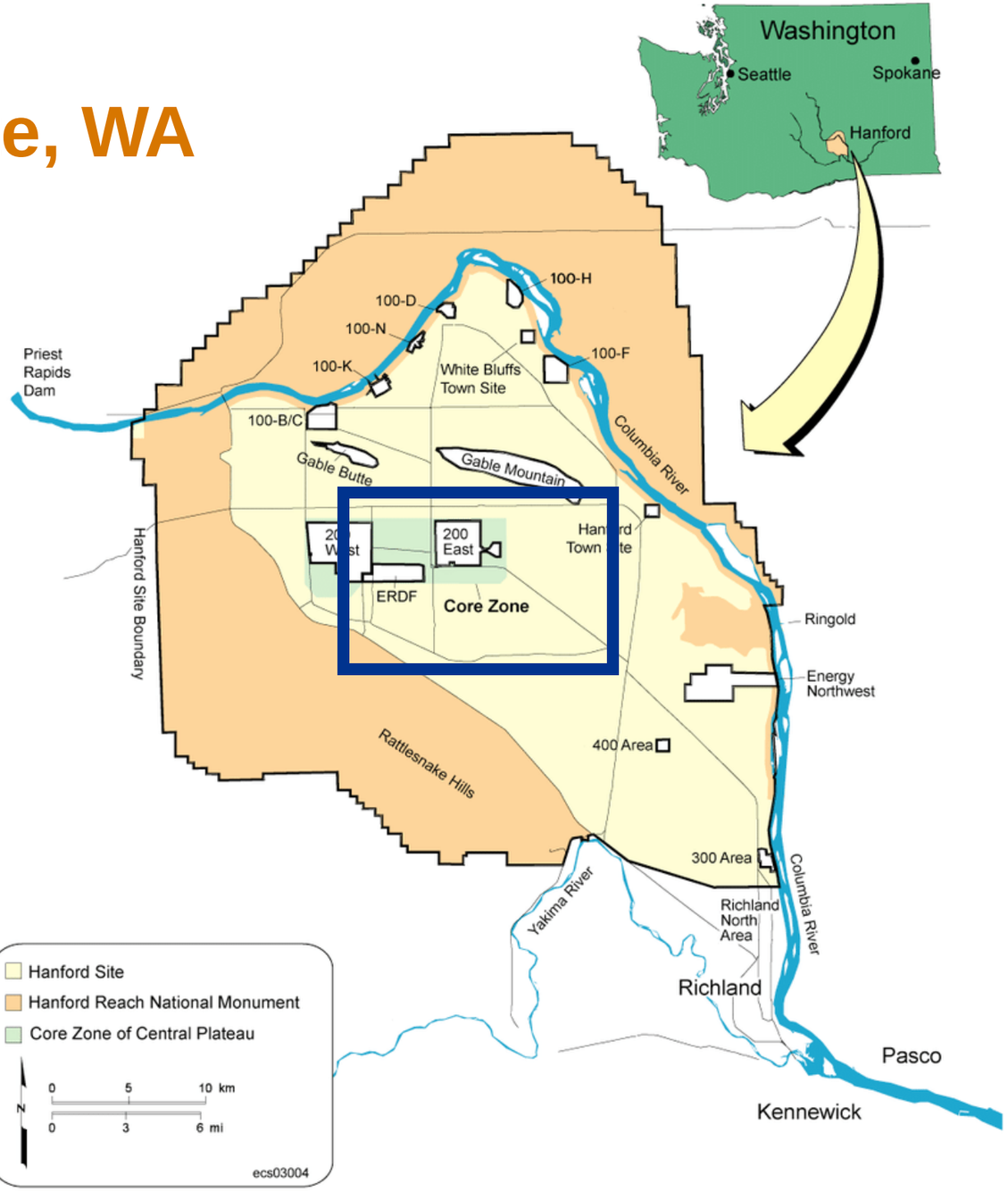
Hanford Site, WA

Geophysical investigations to investigate stratigraphic structure began with synthetic simulations and progressed to field studies



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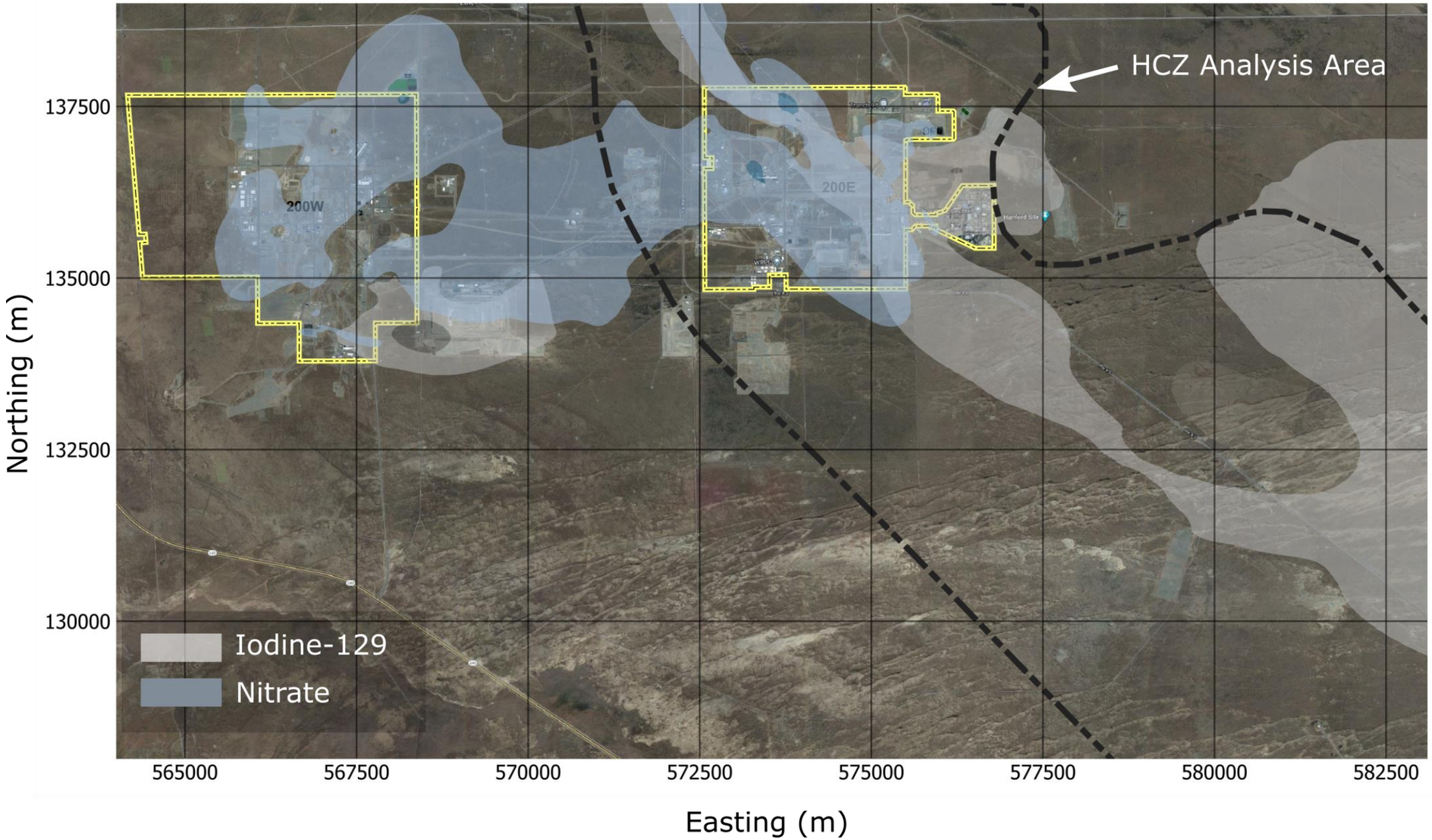
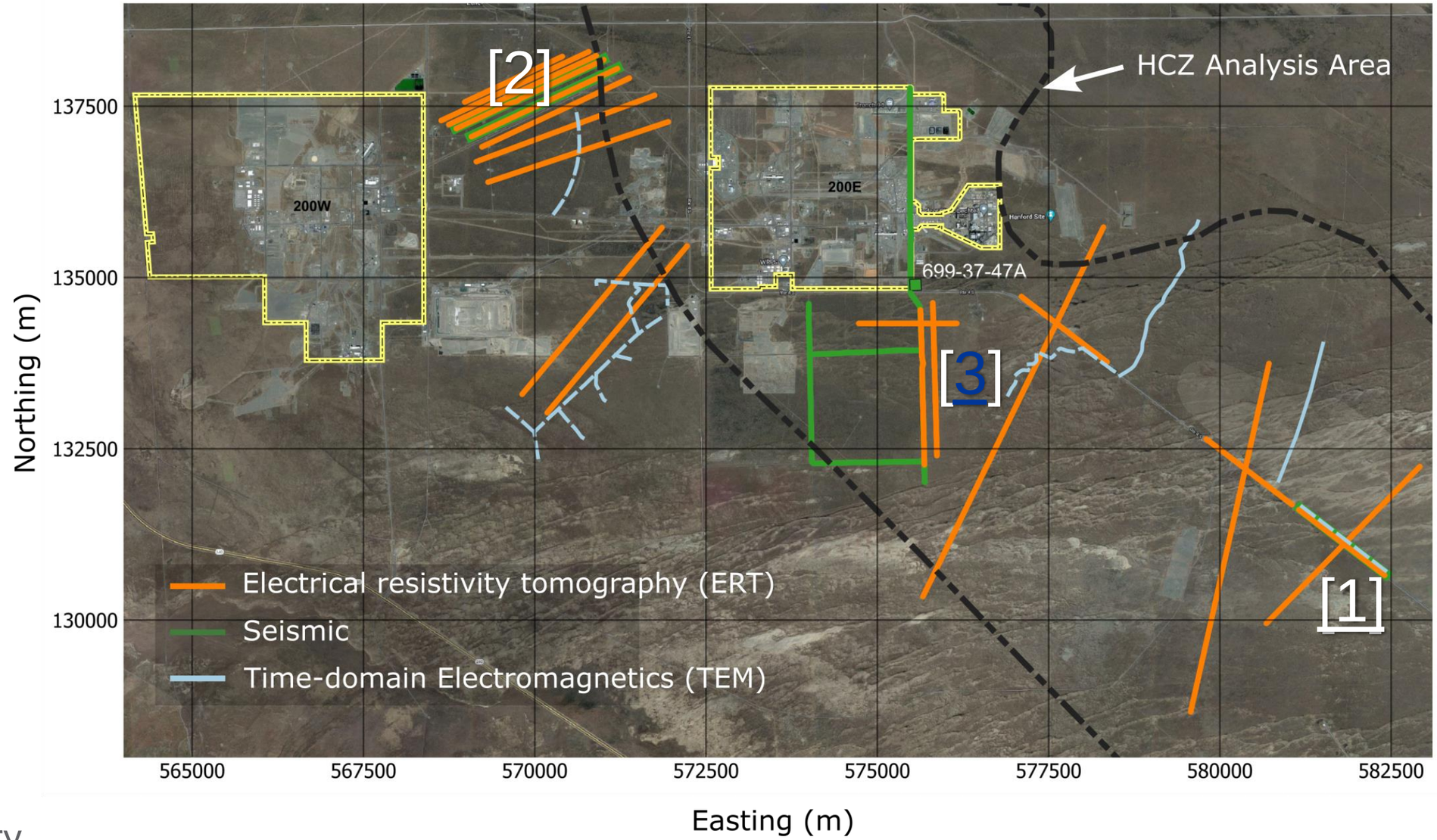
Plume maps and HCZ at Hanford



Stratigraphic Geophysical Investigations



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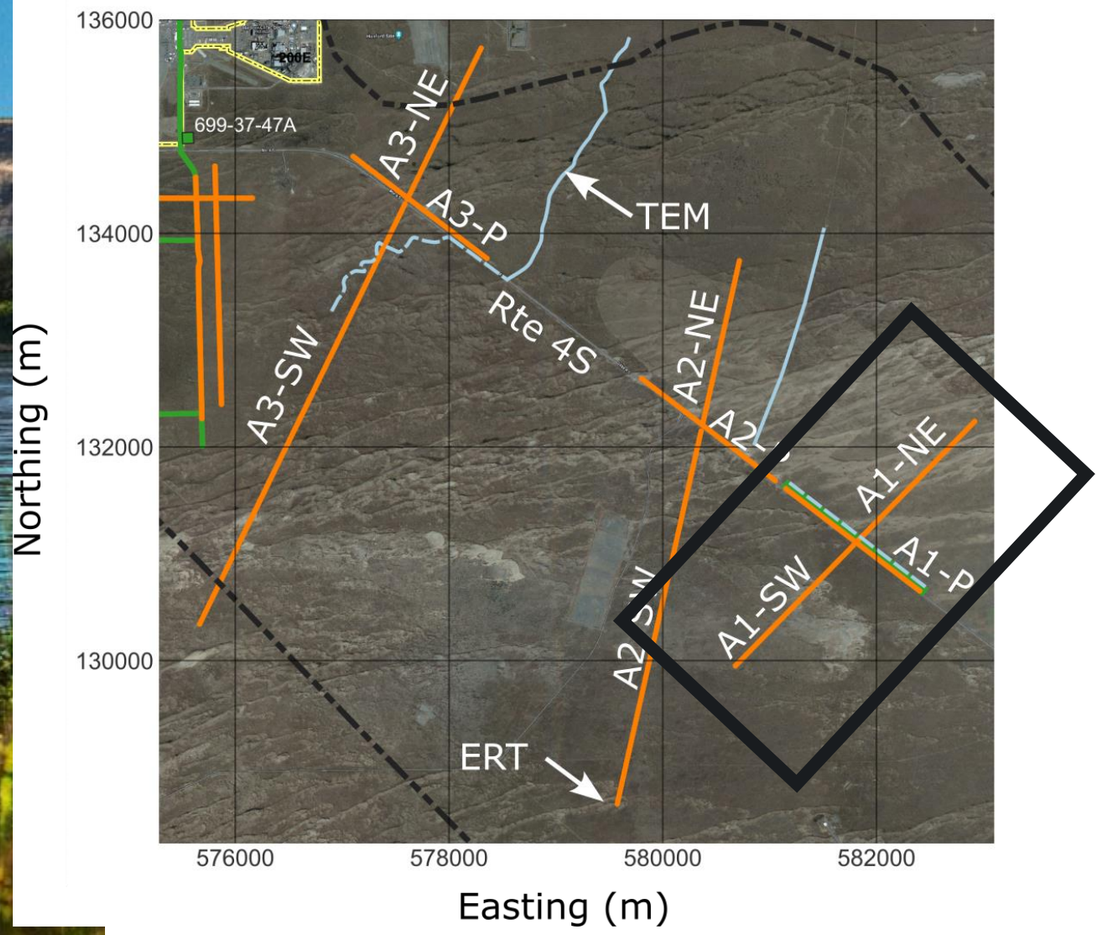
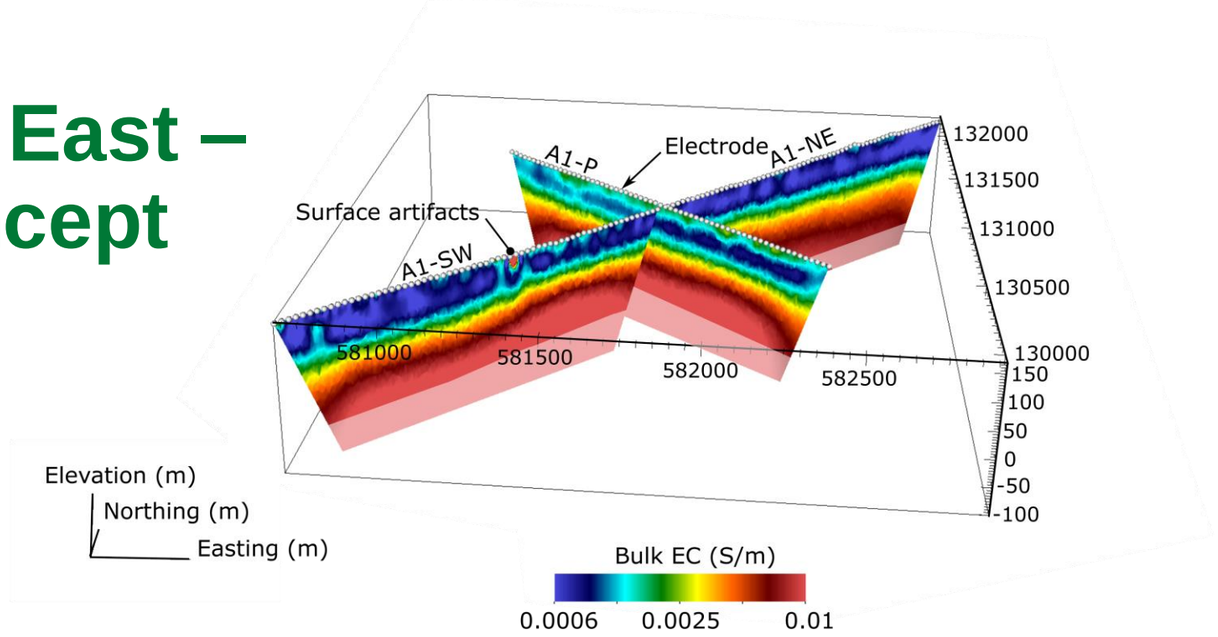
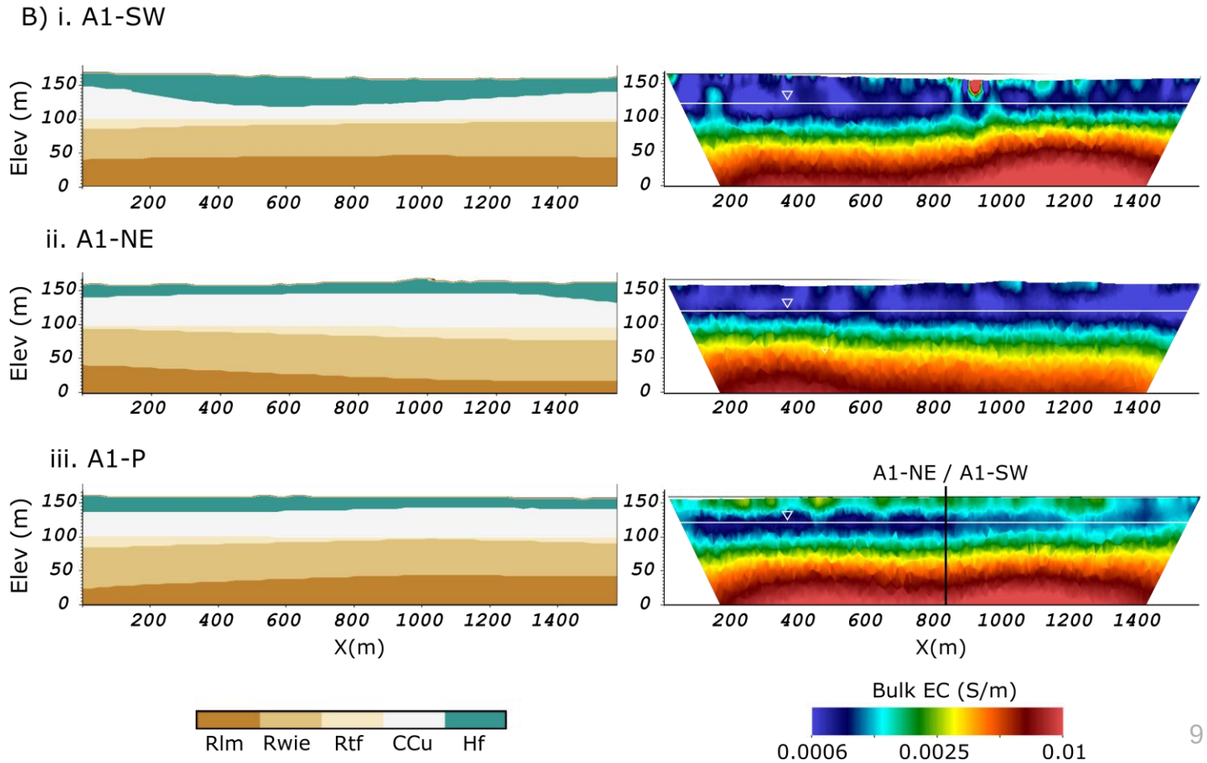
[1] Southeast of 200 East – Area 1: Proof of Concept







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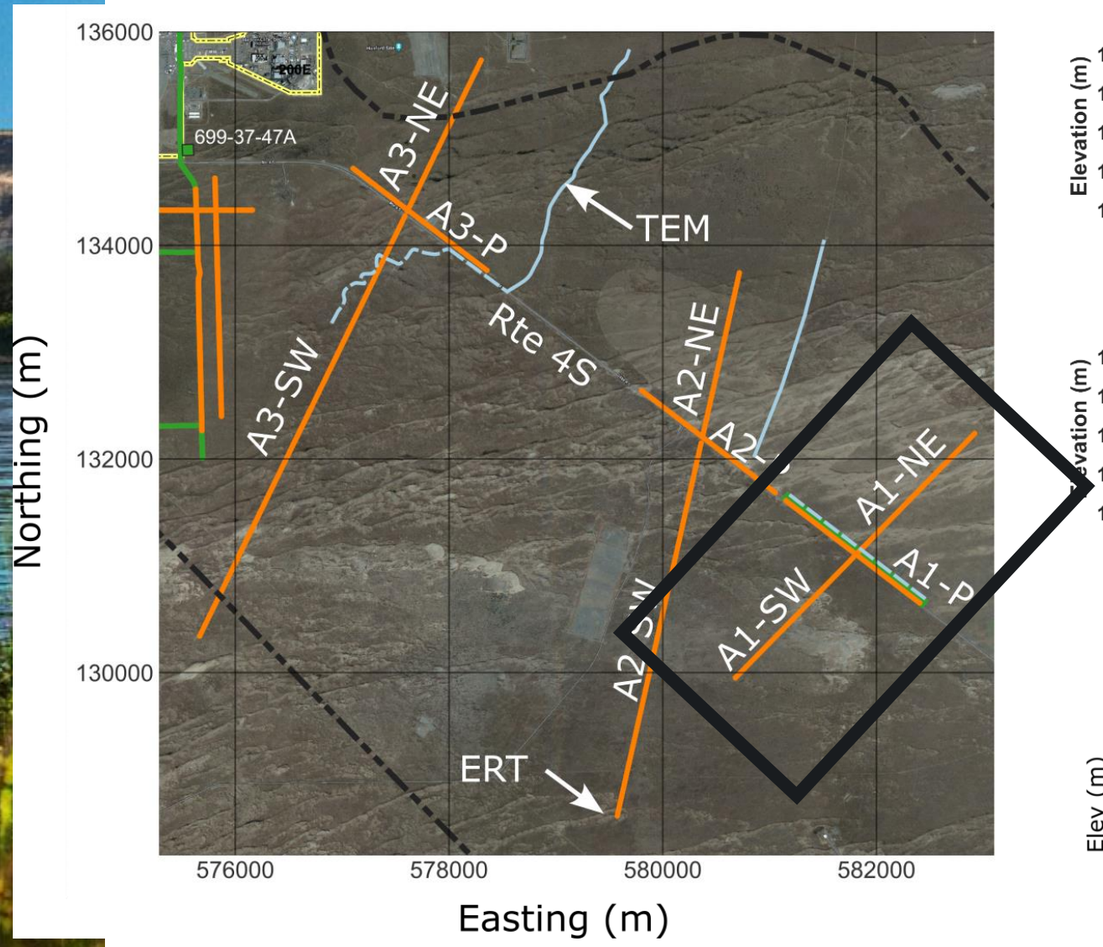
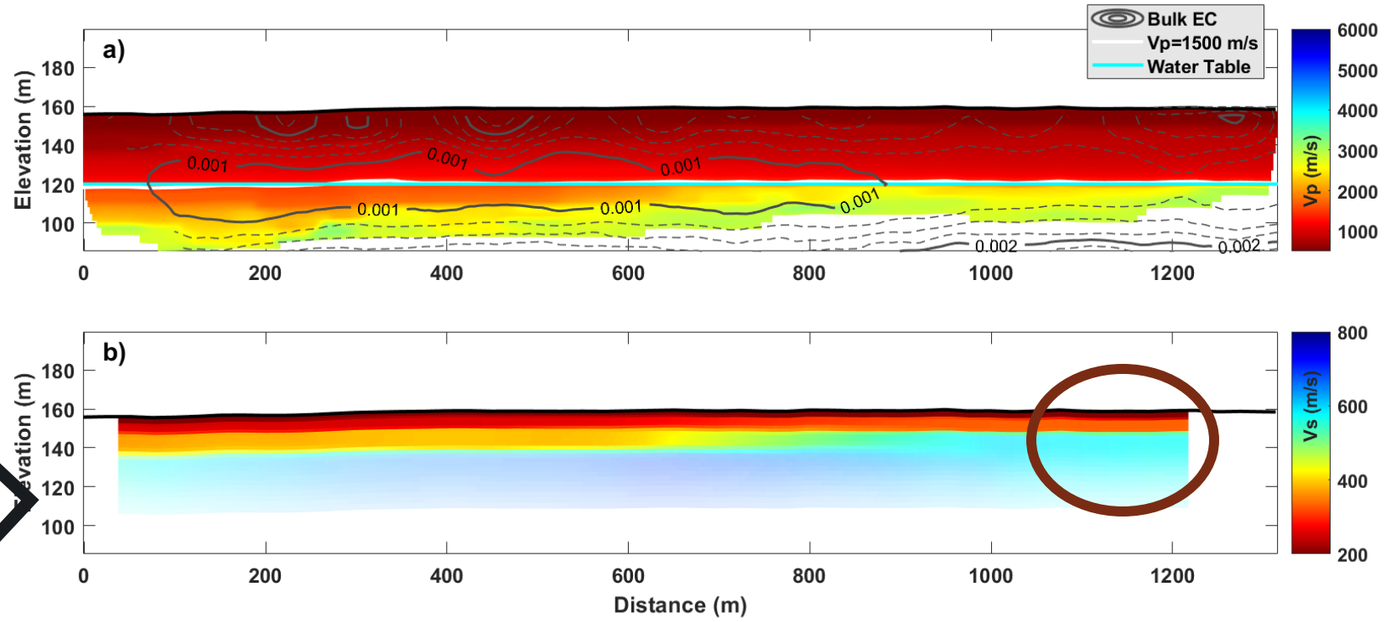
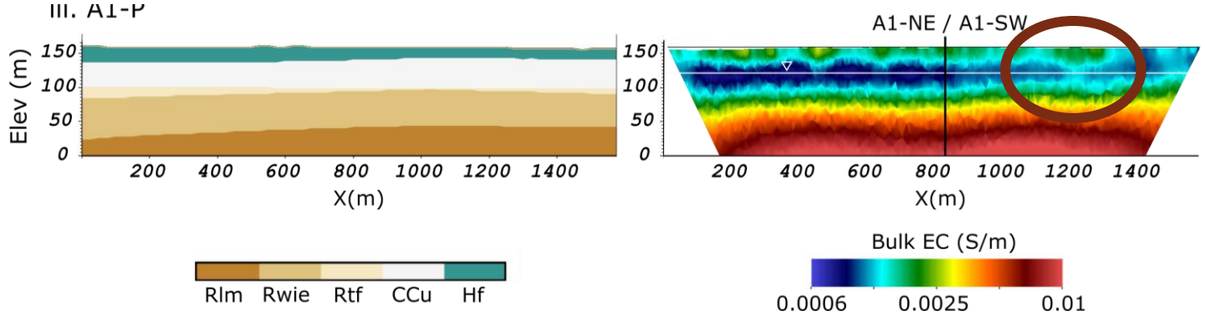
[1] Southeast of 200 East – Area 1







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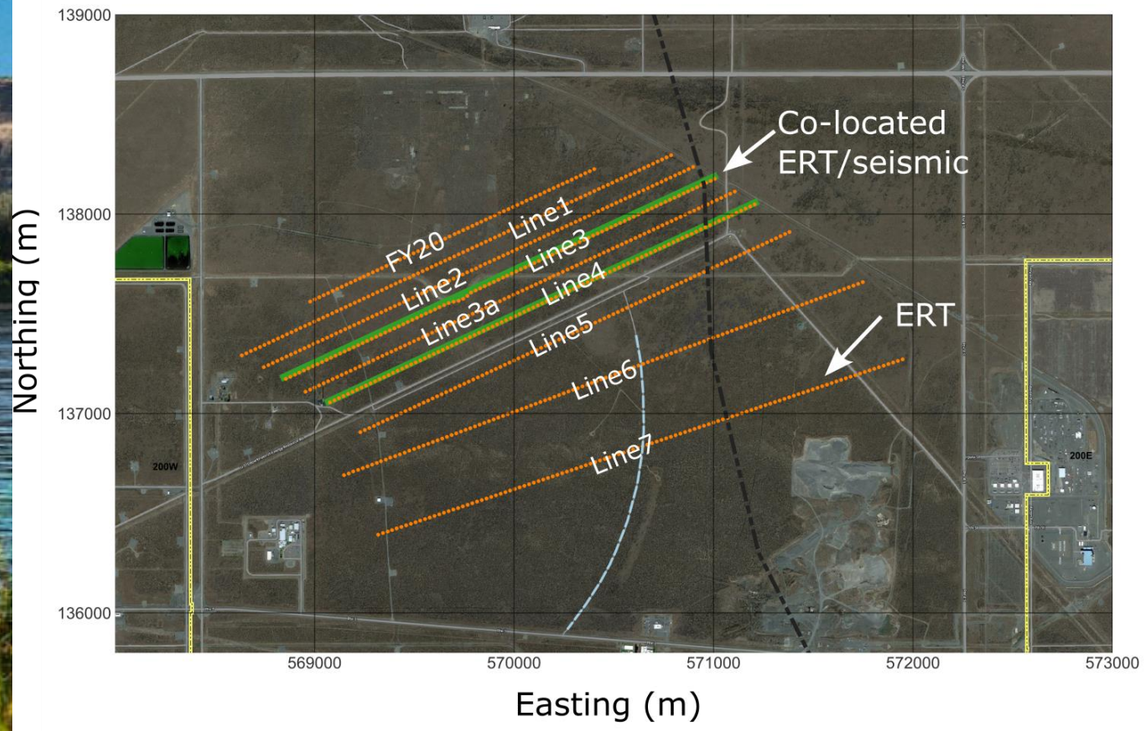
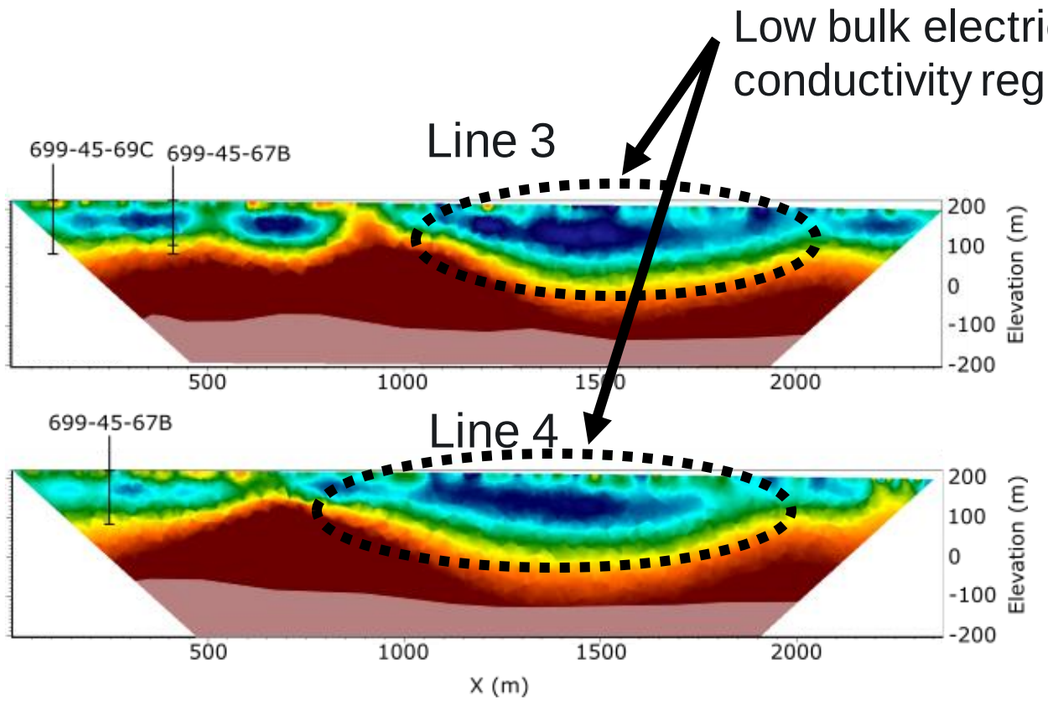
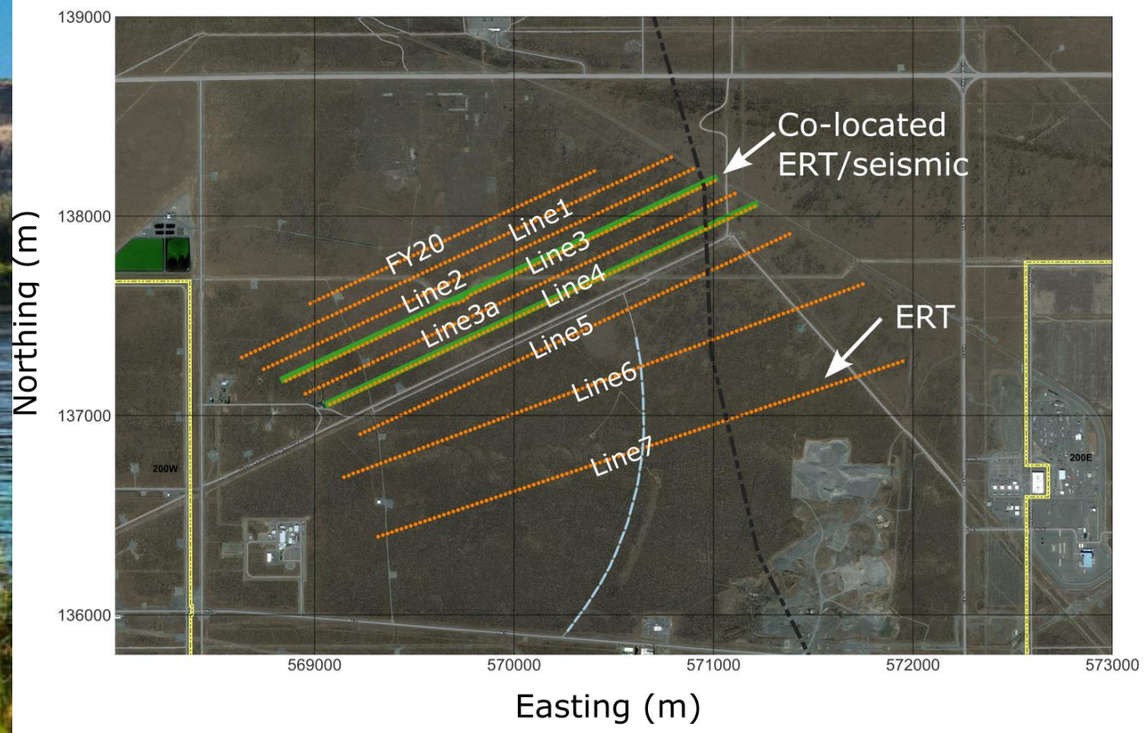
[2] Between 200 Areas

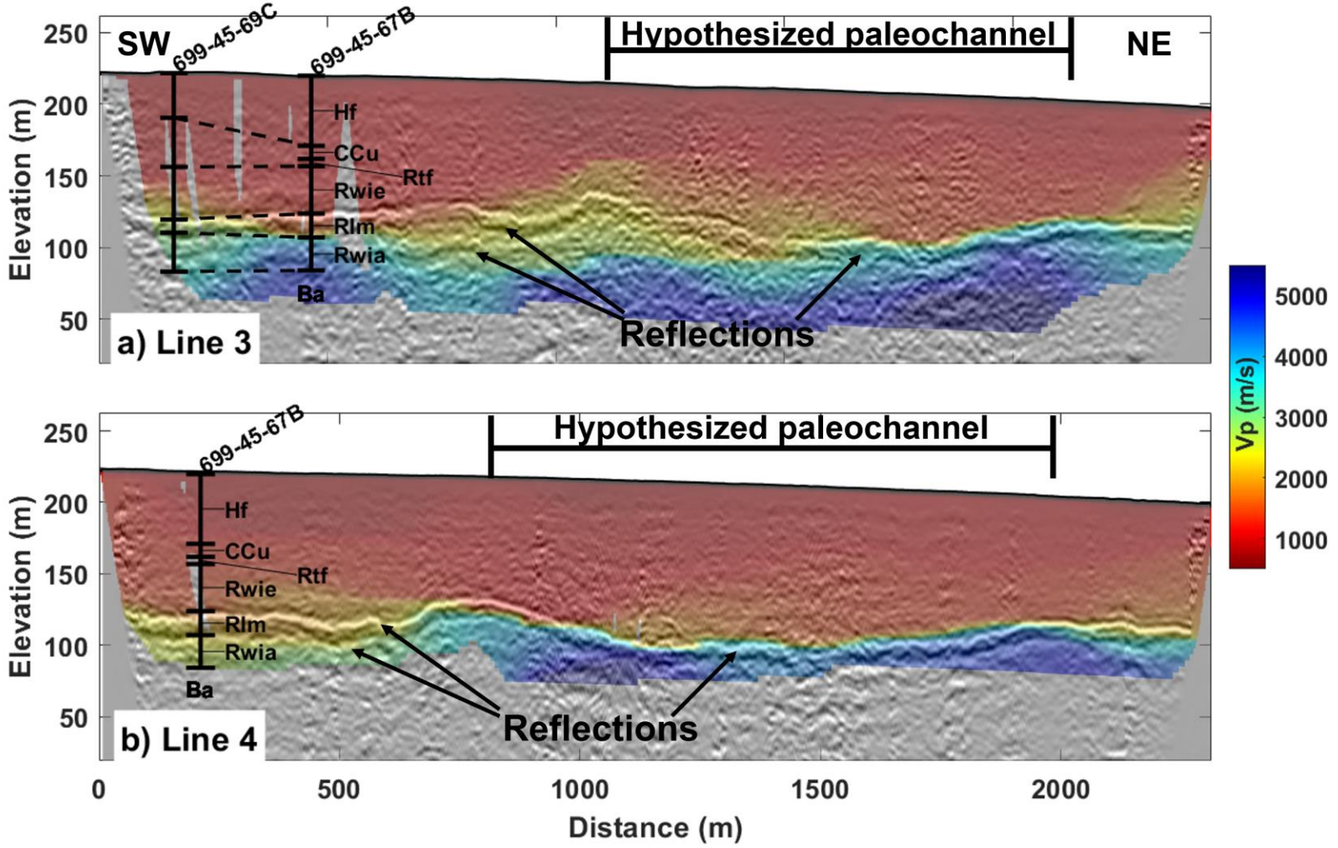




- Low bulk electrical conductivity region is channel-like in shape
- Located within an area where there is a suspected high transmissive area (e.g. paleochannel)
- ERT provides 1st line of evidence of stratigraphic structure - **Few wells to verify**

[2] Seismic Reflection and Refraction Tomography





- Compressional wave (Vp) (colored image) contrasts match well with locations of reflections
- Shallower resolution (shorter offsets) of features compared to ERT
- Channel like feature on NE side of line

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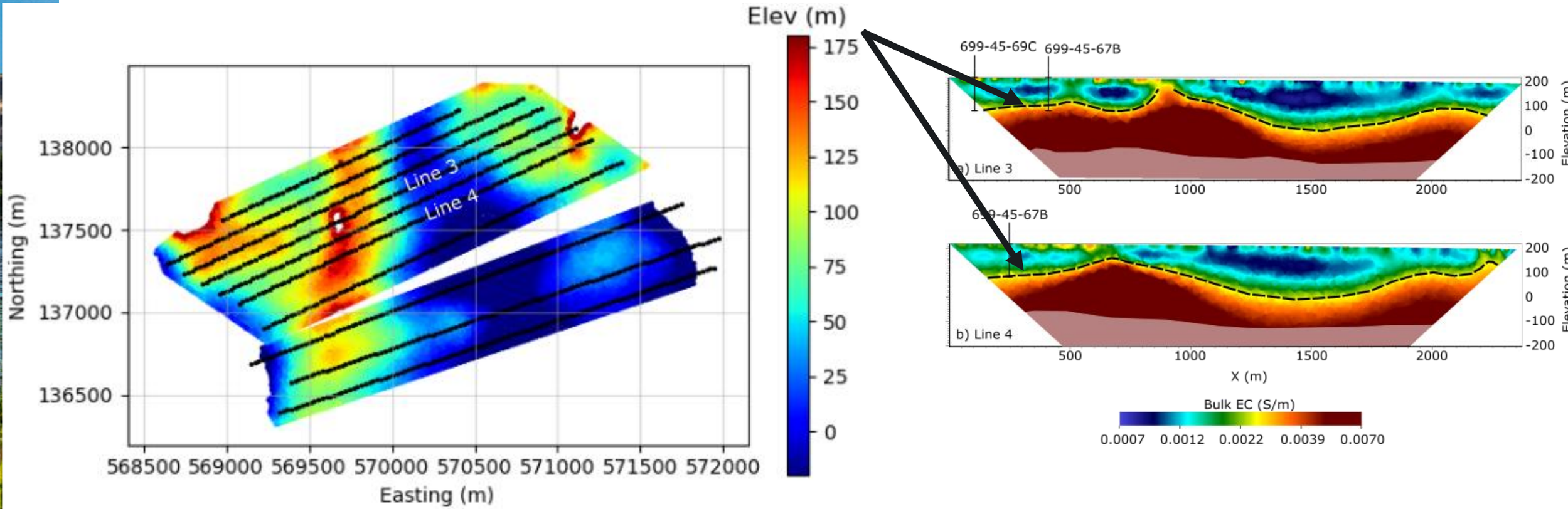
[2] Between 200 Areas - Quasi-3D ERT Inversion

Elevation where bulk EC = 0.0025 S/m



- Geophysics has helped provide a first line of evidence of subsurface structure
- Need a better understanding of electrical properties vs. hydraulic properties

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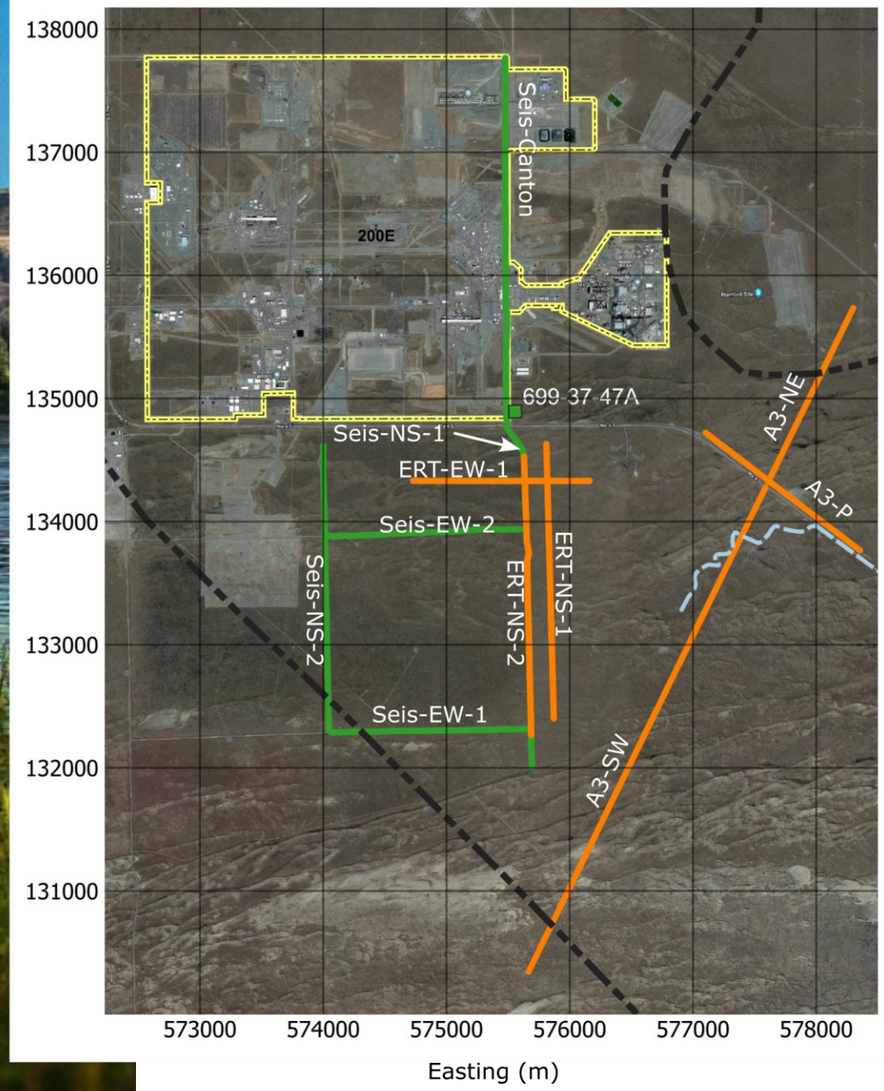
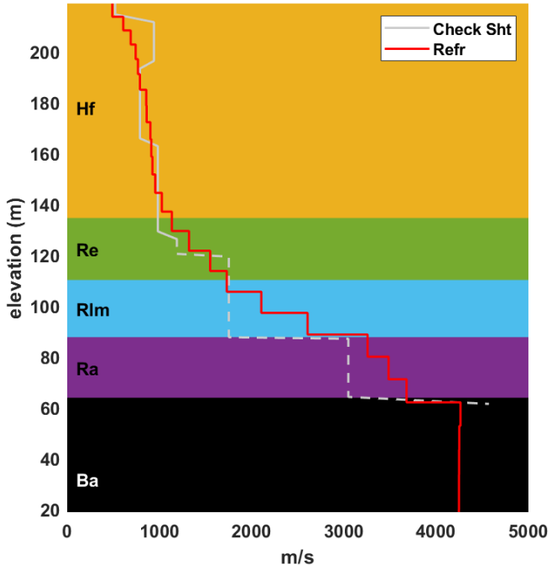
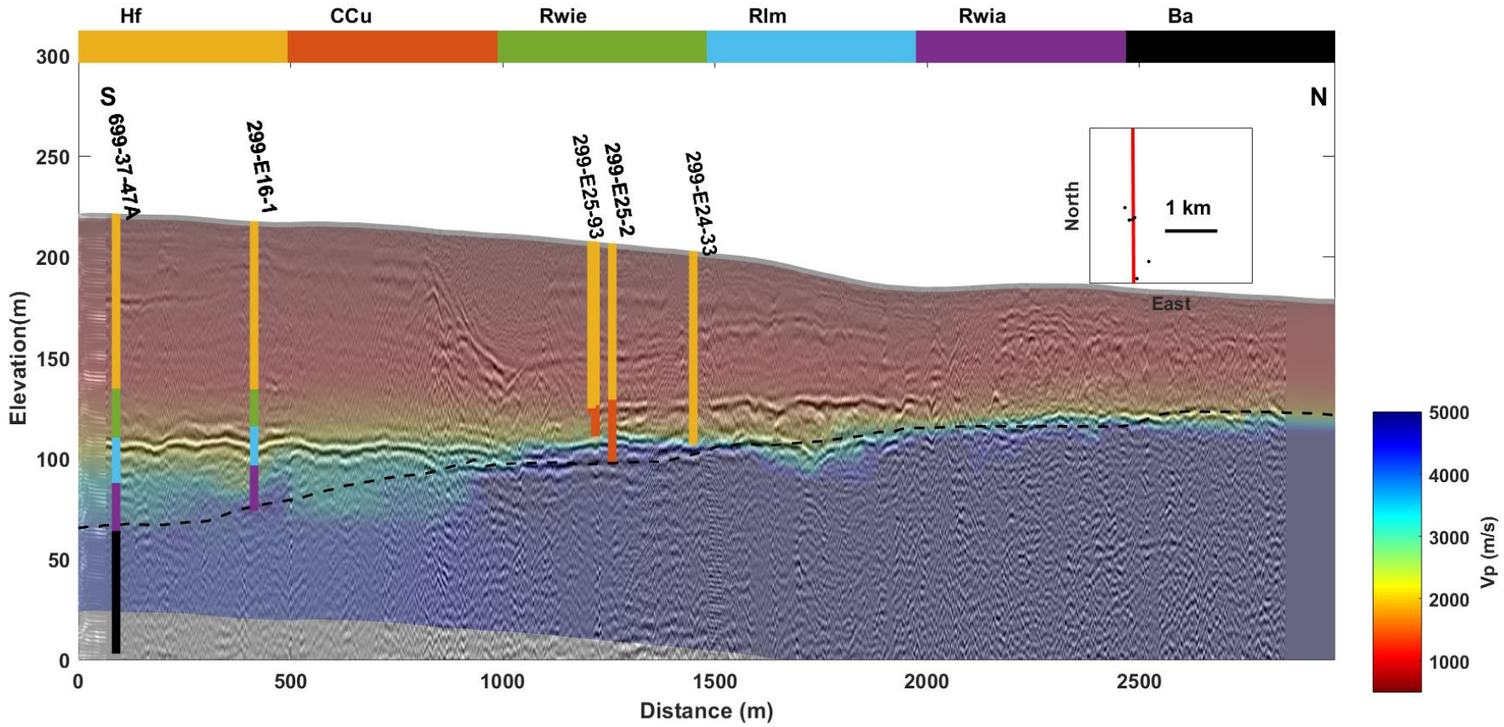
[3] South and within 200 East Area







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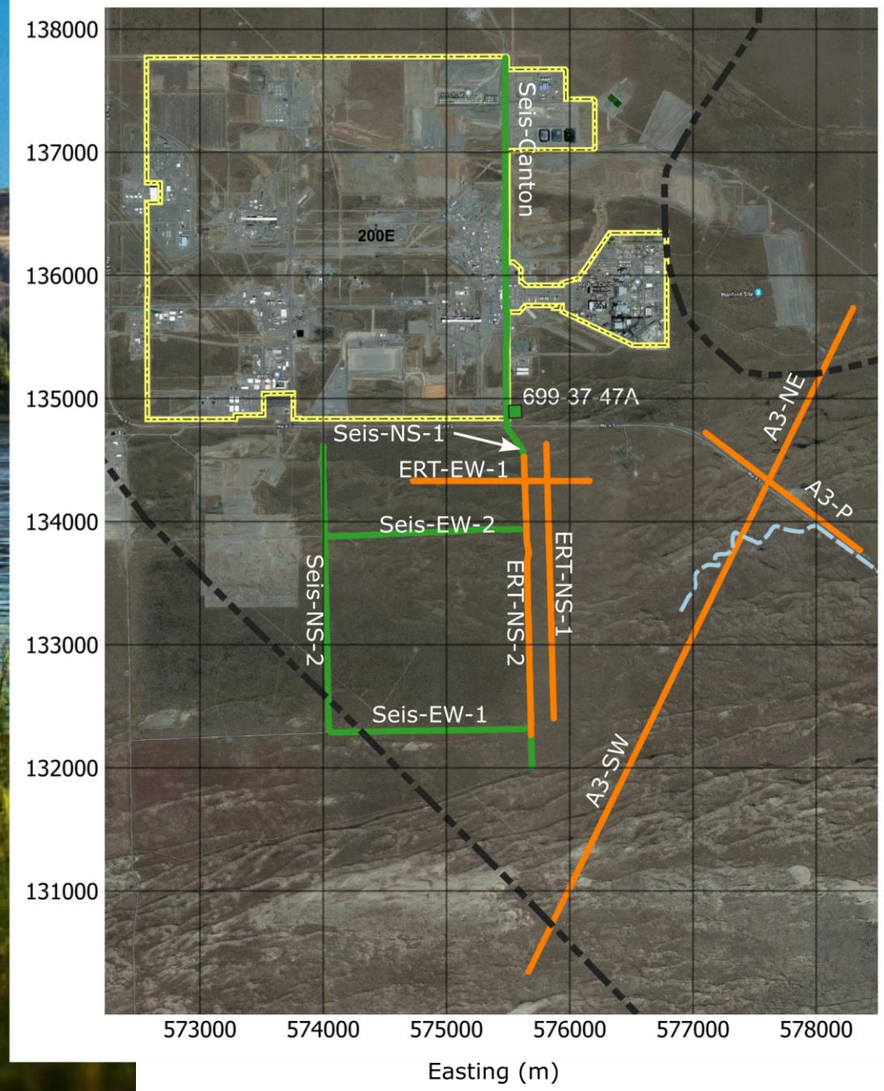
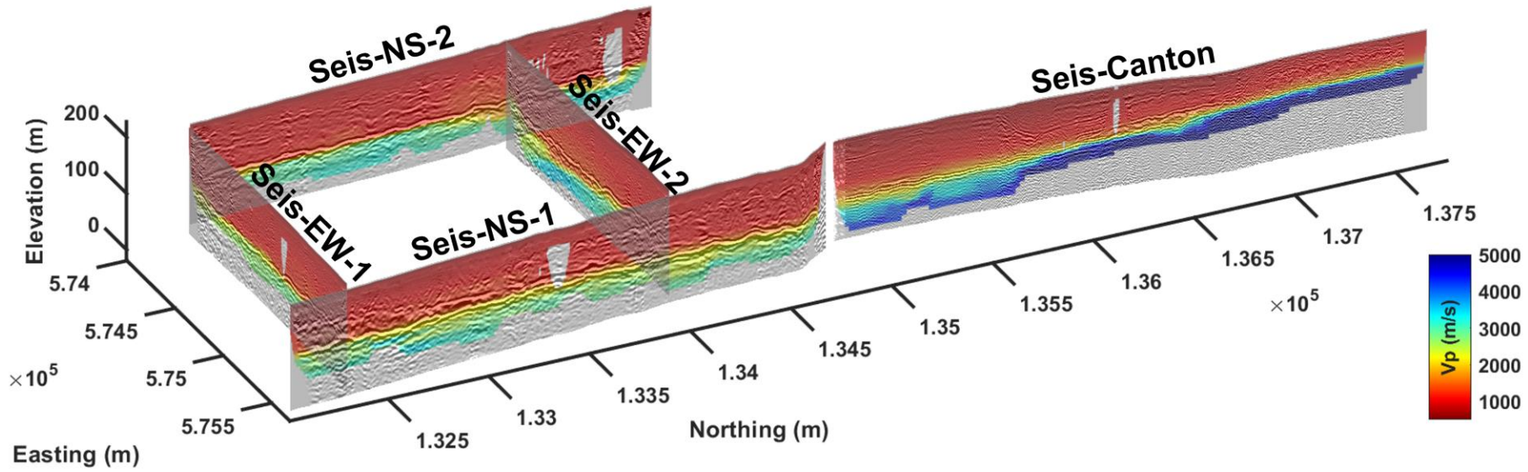
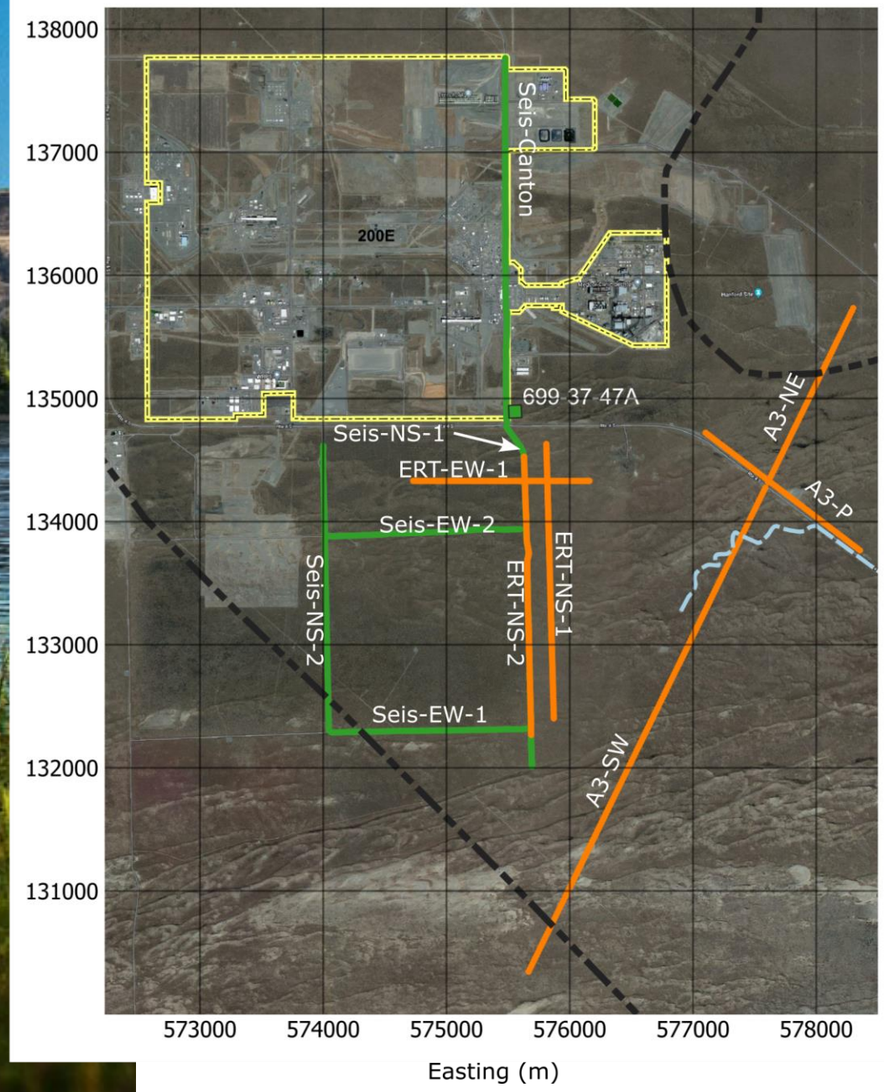


Co-located ERT along Seis-NS-1

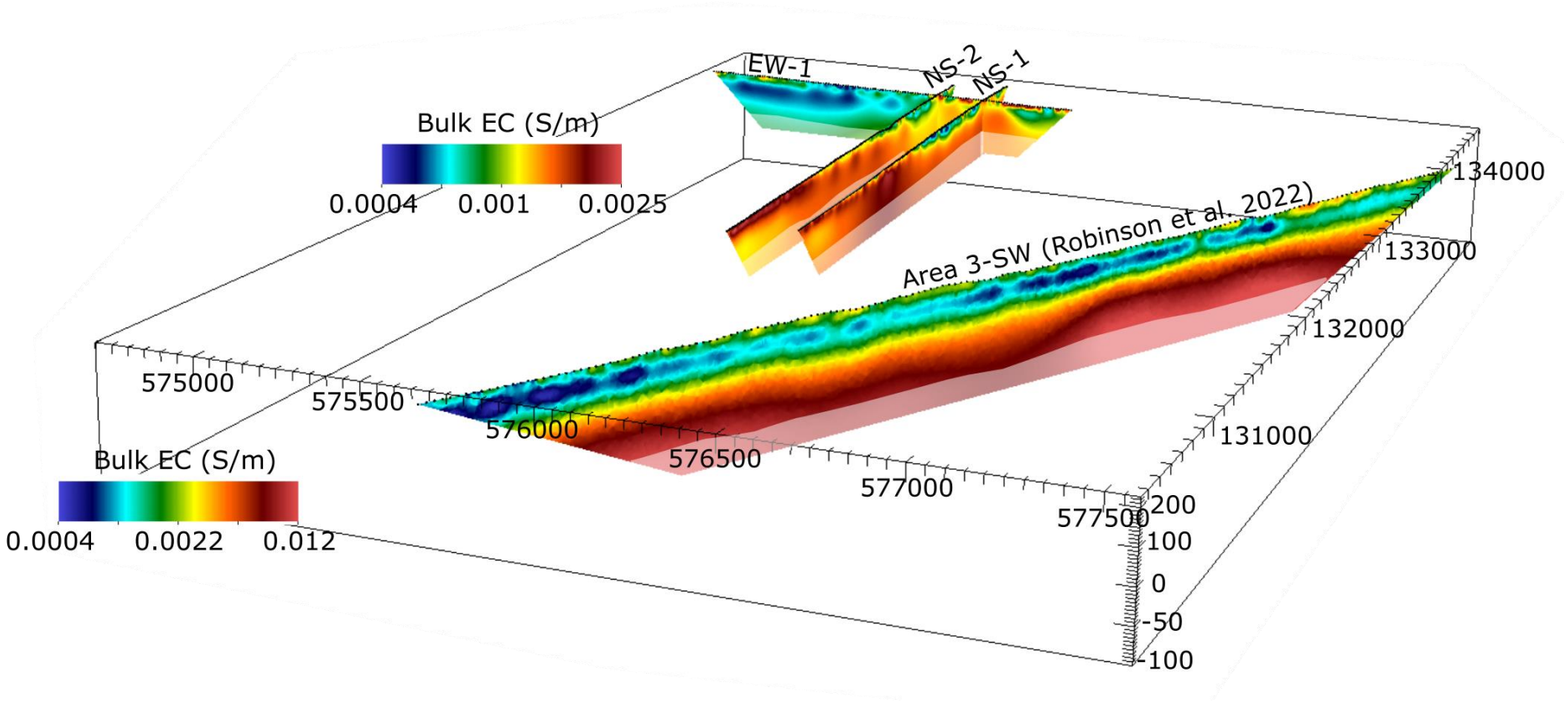


- Coarse-grained, unconsolidated materials commonly exhibit lower Vp compared to more cemented and stiffer finer-grained material
- Seismic reflections can occur at stratigraphic contacts or incised channels.

[3] South and within 200 East Area



Co-located seismic along NS-2



Coarser grained materials can exhibit higher bulk electrical conductivity (EC) but the site-specific relationship between hydraulic and EC needs to be studied

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Summary

- Surface geophysical methods are helping to provide stratigraphic information on the Hanford Site
  - First line of evidence
  - Site new wells
  - Provide better spatial understanding of transitions
- Ground truthing through well observations can better guide interpretations (seismic)
- We still have work to do to understand the relationship between geophysical properties and hydraulic properties

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Thank you!
Questions?

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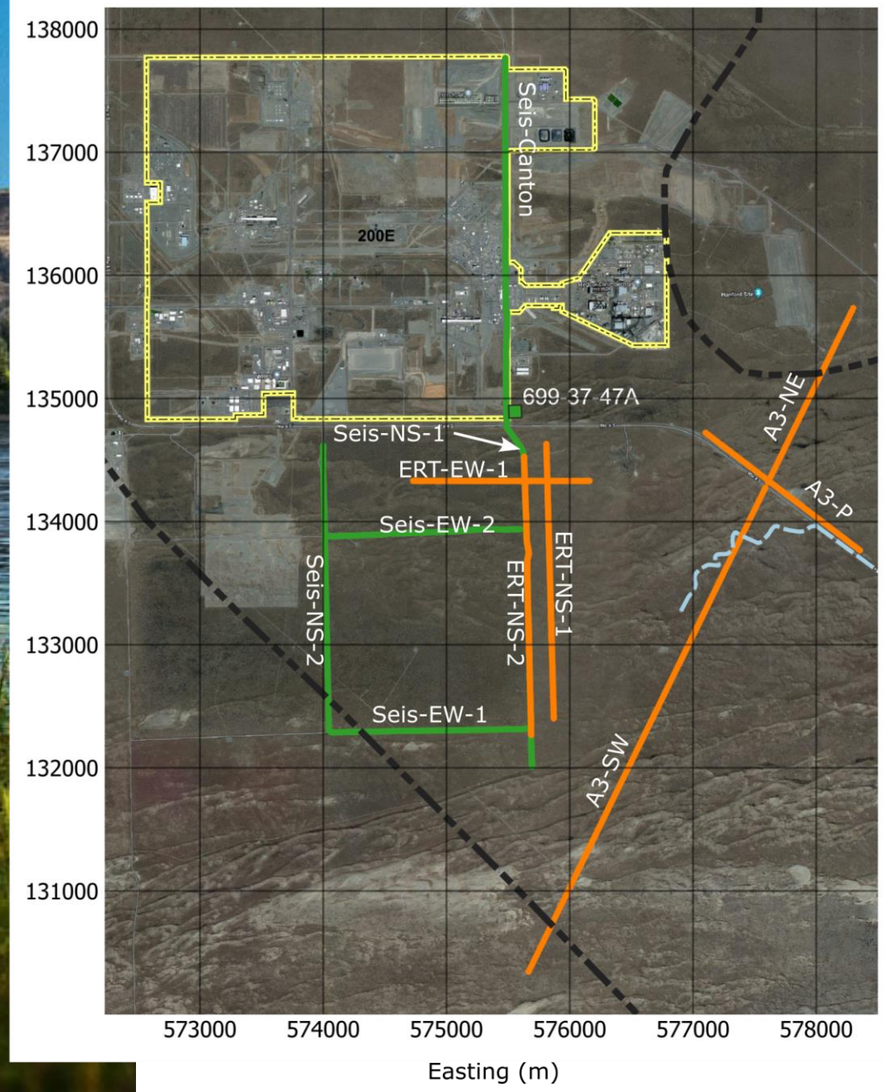
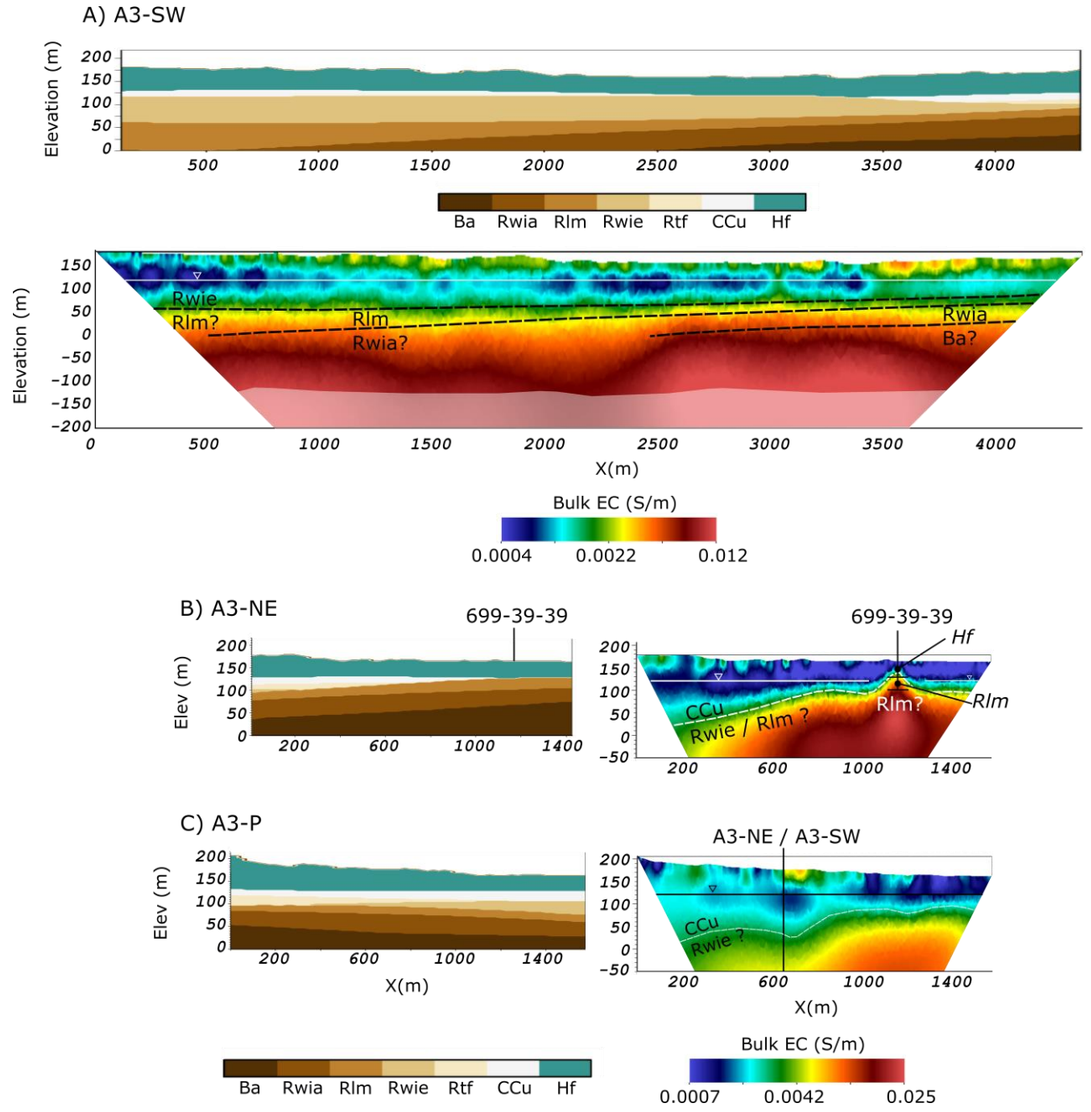
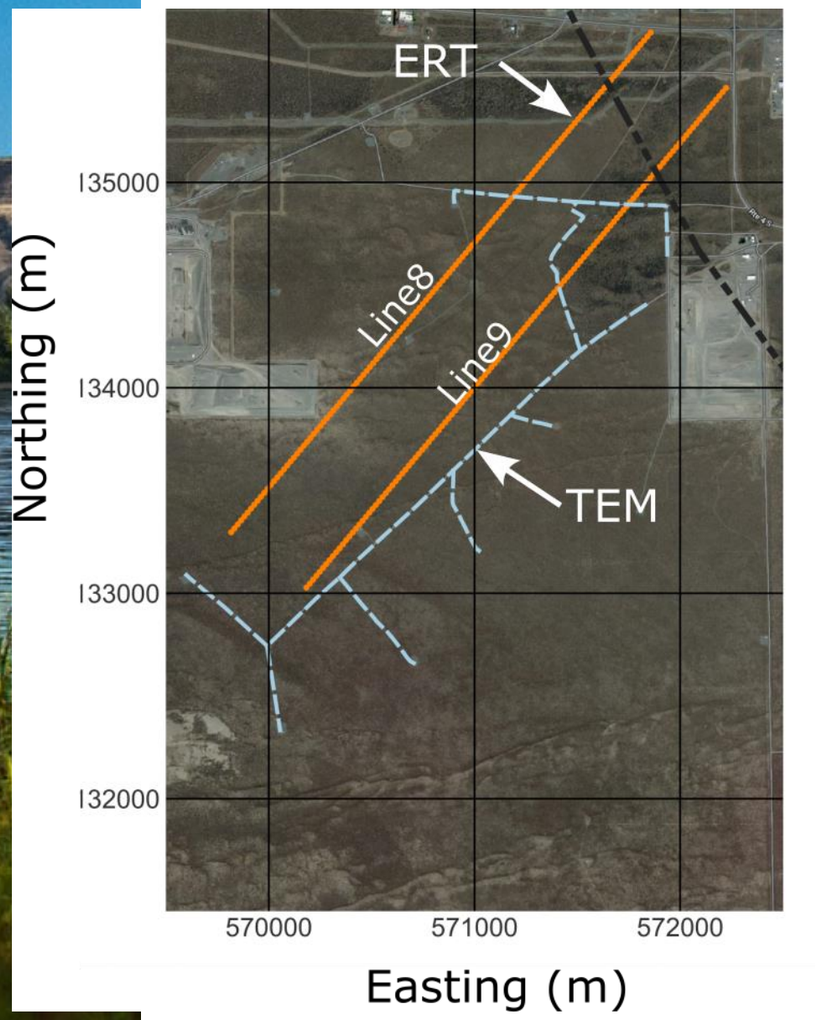
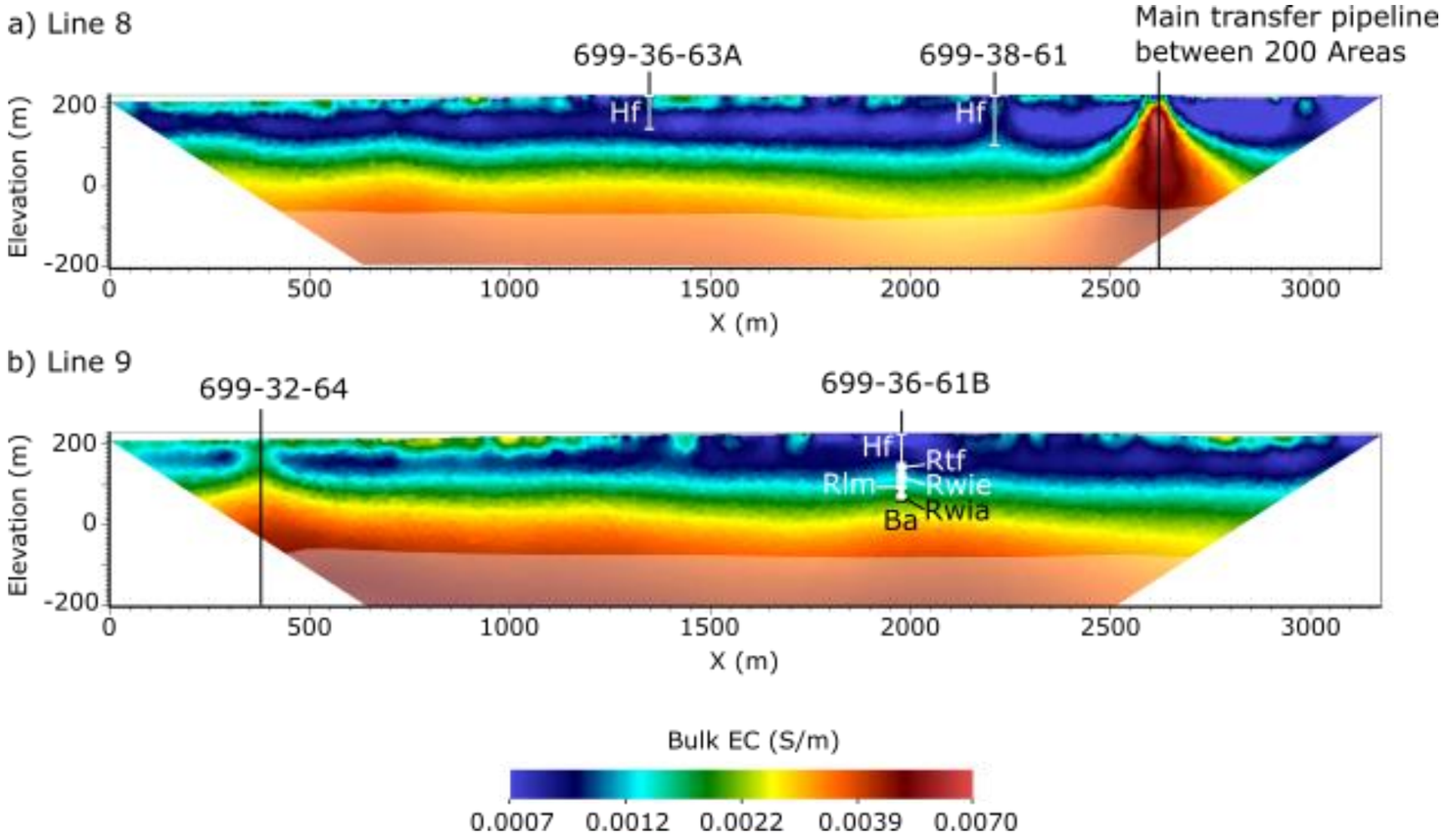
[3] South and within 200 East Area





[2] Between 200 Areas (southeast)





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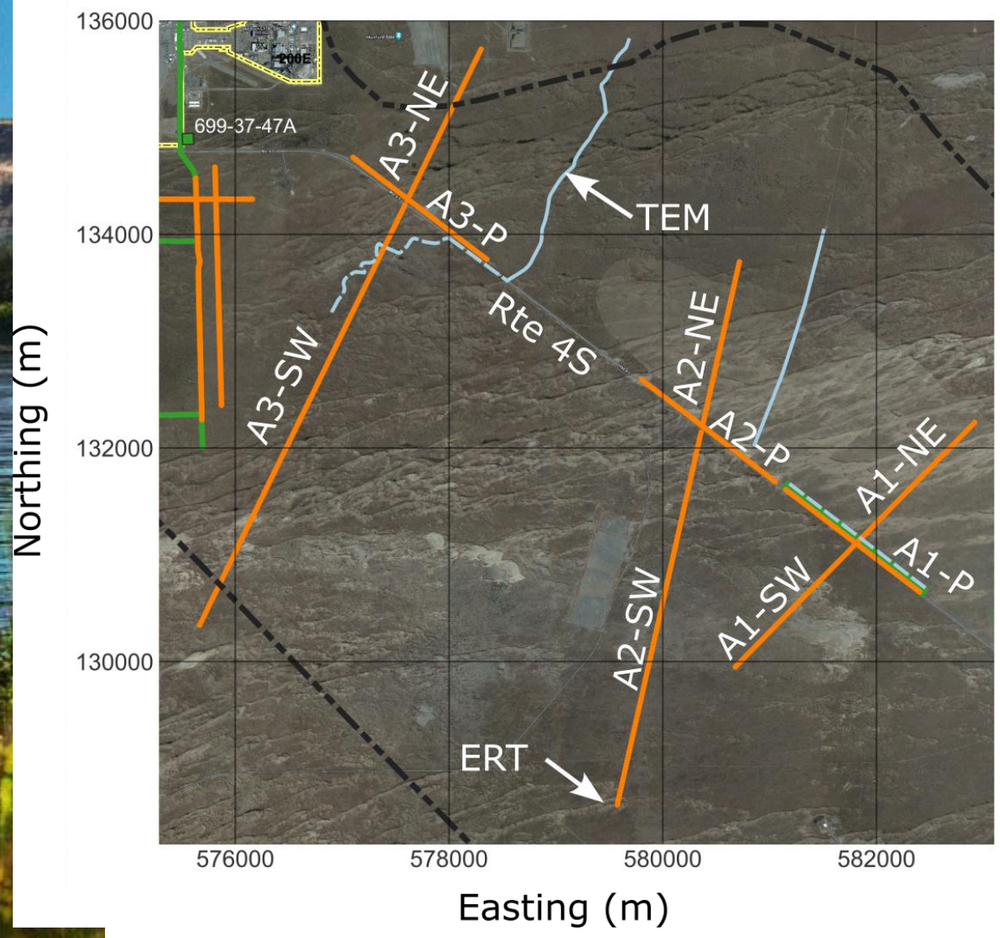
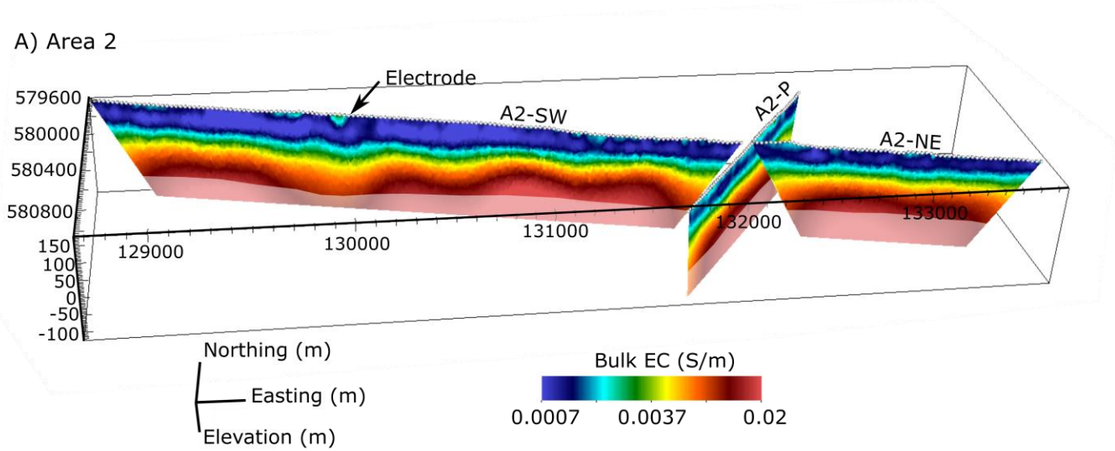
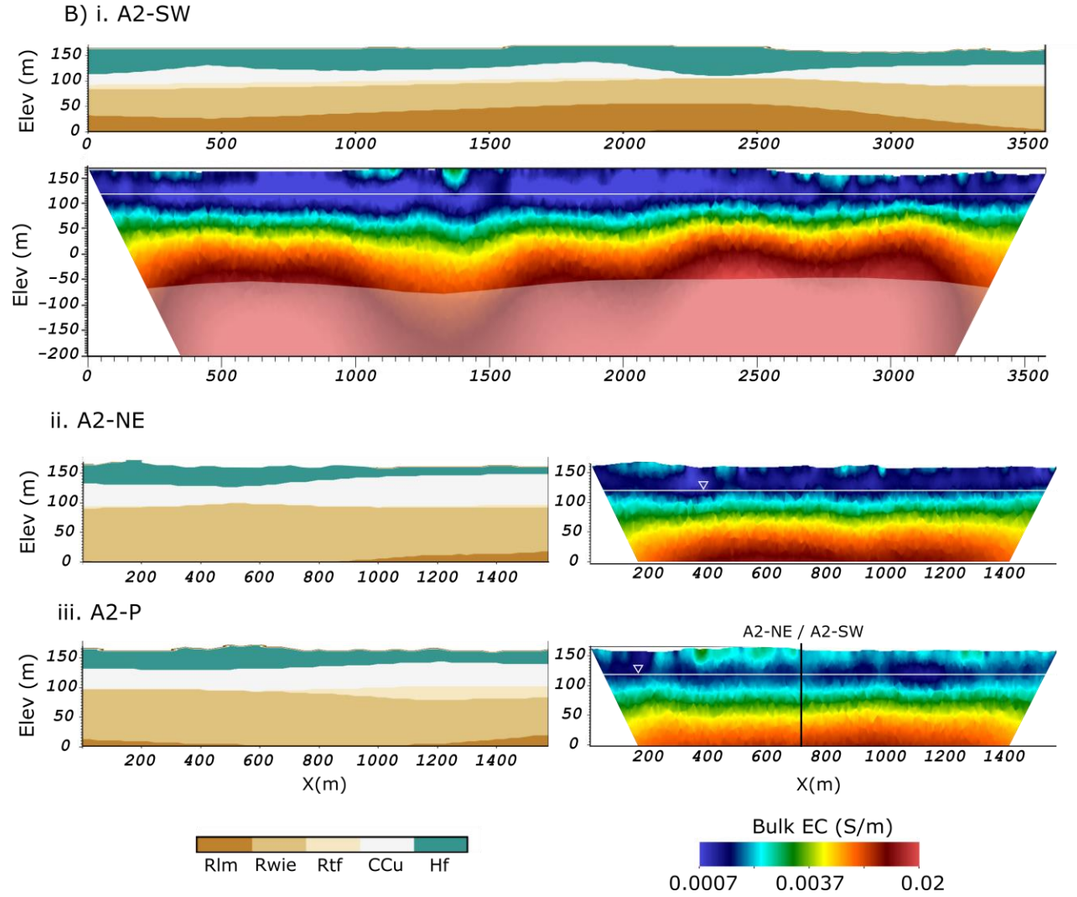
[1] Southeast of 200 East – Area 2







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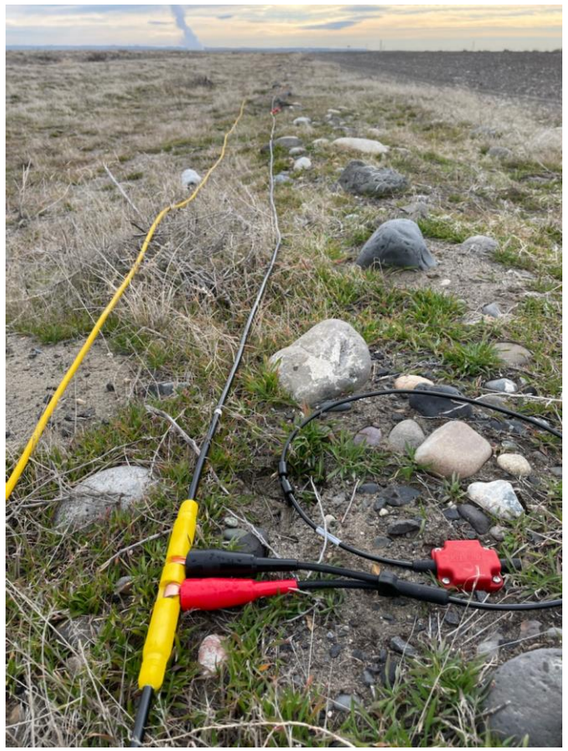
Seismic and ERT and Field Application

ERT and Seismic Imaging
Identifying stratigraphic structure



DOI = depth of investigation

ERT: Larger electrode spacing = Deeper DOI with lower resolution of features

Seismic: Deeper DOI with data collection from larger offsets

These geophysical methods are likely to see large contrasts in geological properties; thinner layers or small textural contrasts will not be resolved