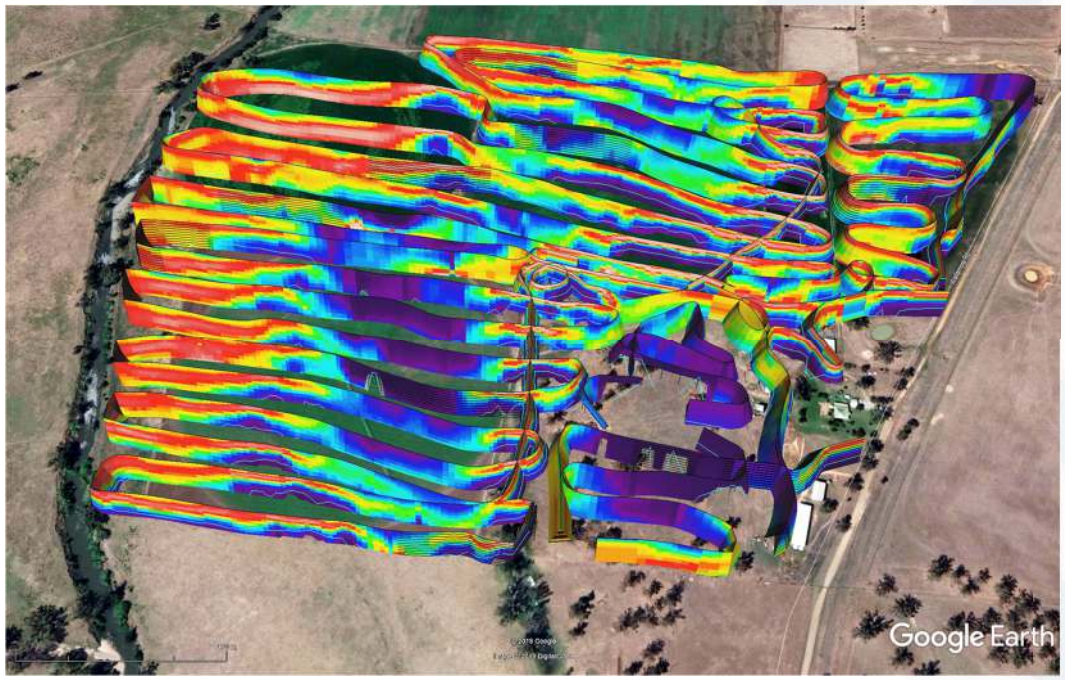
RAPID MAPPING OF AQUIFERS, WATER QUALITY, AND POTENTIAL RECHARGE SITES USING A TOWED CART TIME-DOMAIN ELECTROMAGNETIC INDUCTION SYSTEM: *A NEW TOOL FOR GROUNDWATER MANAGEMENT*

Doug Laymon, P.G., John Jansen, P.Gp, Ph.D. and David Allen, Ph.D.



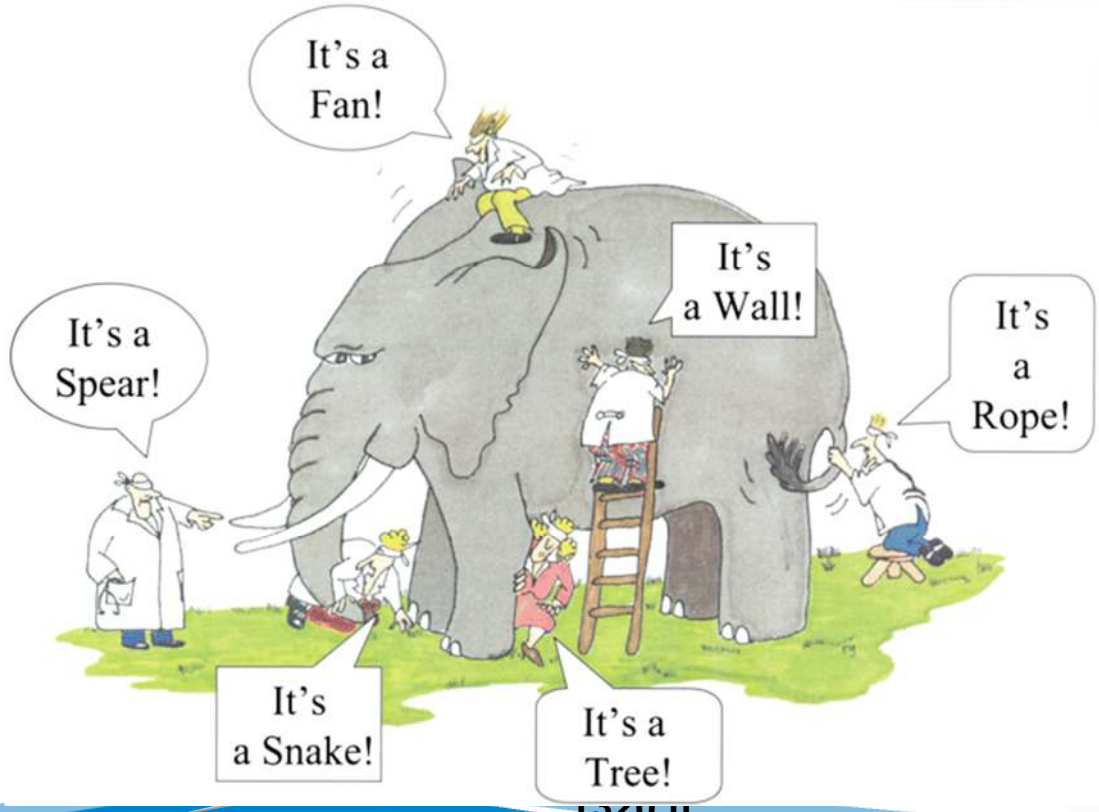
GROUNDWATER IMAGING

COLLIER GEOPHYSICS

COLLIER CONSULTING

AgTEM Wallaby by COLLIER GEOPHYSICS

Groundwater Studies are Grossly Under Sampled
The Classic "Blind Man and the Elephant" Problem



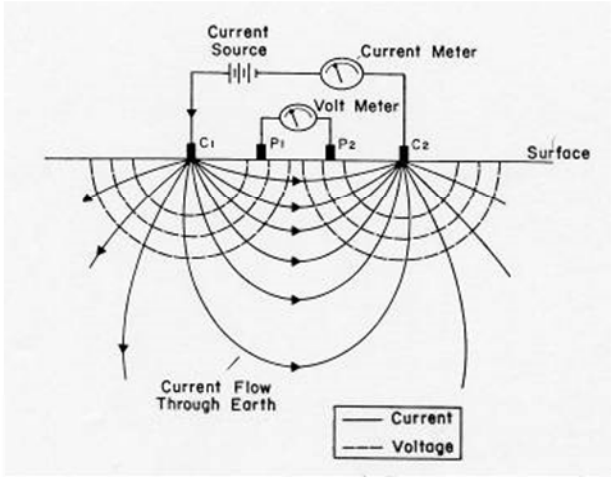
Assuming a 40-acre site, narrow target body, 50 ft. wide:

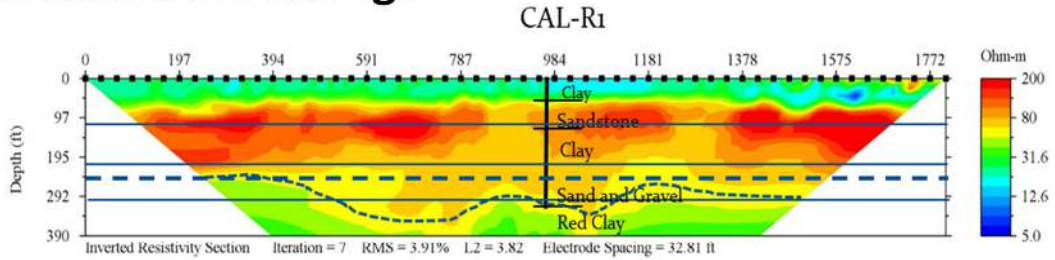
- **each boring has 4% probability of hitting target**
- **13 borings needed for 50/50 chance of hitting target**
- **Over 20 borings needed for 90% probability of hitting once**
- **Around 700 borings needed to map shape of feature to within +/- 50 ft.**
- **The result is an incomplete or misleading conceptual site model**

1320 ft.

Electrical Resistivity (ER)

- Current injected through two current electrodes.
- Voltage drop measured across potential electrodes.
- Electrode array is expanded to increase depth of penetration and moved to map lateral changes
- Resistivity of formation/fluids measured in ohm-meters (Ω-m).
- Modern systems use many electrodes with automated switching.

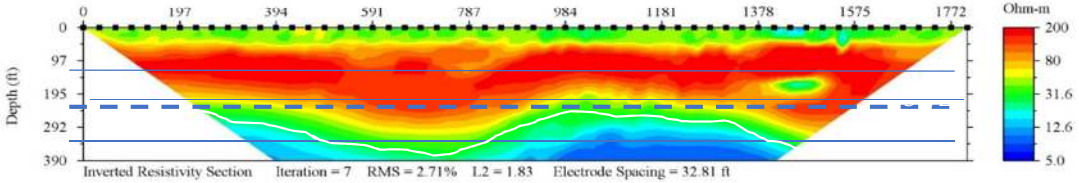




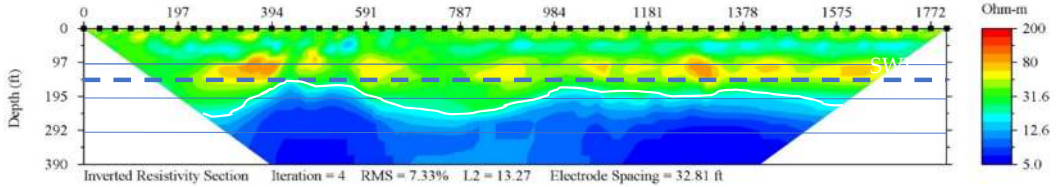
Ogallala Aquifer Channel, TX

Siting a Horizontal Well in Texas Panhandle

Typical East Side ERT Profile



Typical West Side ERT Profile



- Horizontal well location chosen
- 200 ft deep – 500 ft of screen – ~1,000 GPM

Correlation of Channel Trends

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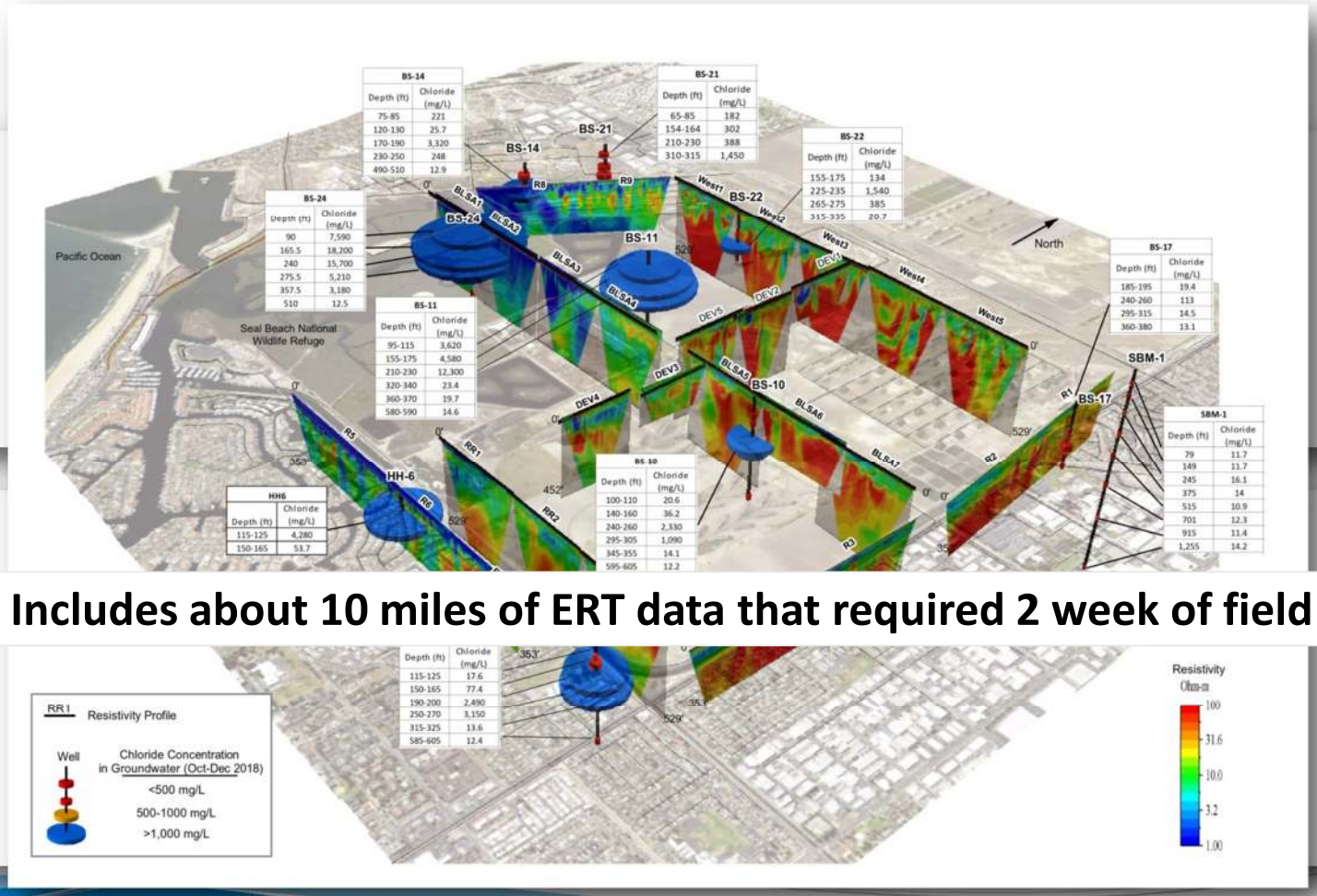
Mapping Salt Water Intrusion at the Seal Beach Naval Station



This Survey Includes about 10 miles of ERT data that required 2 week of field time

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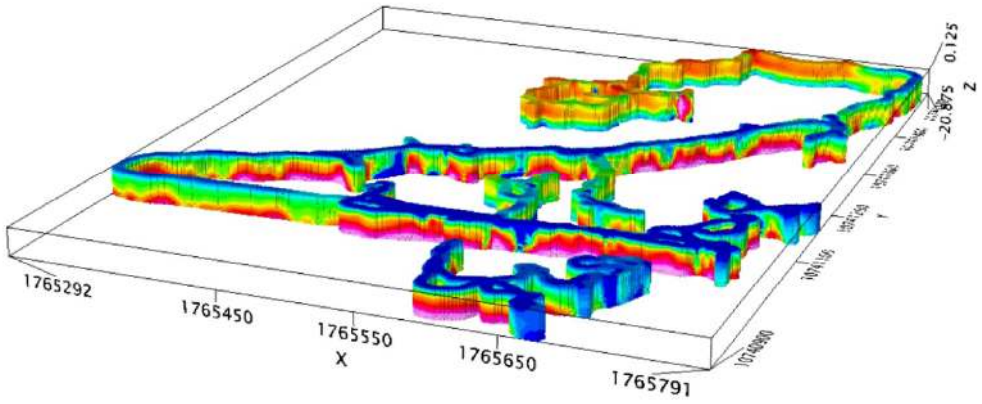
Mapping 3D Conductivity/Resistivity Using FDEM



Fast and effective, but limited to about 20 to 30 feet

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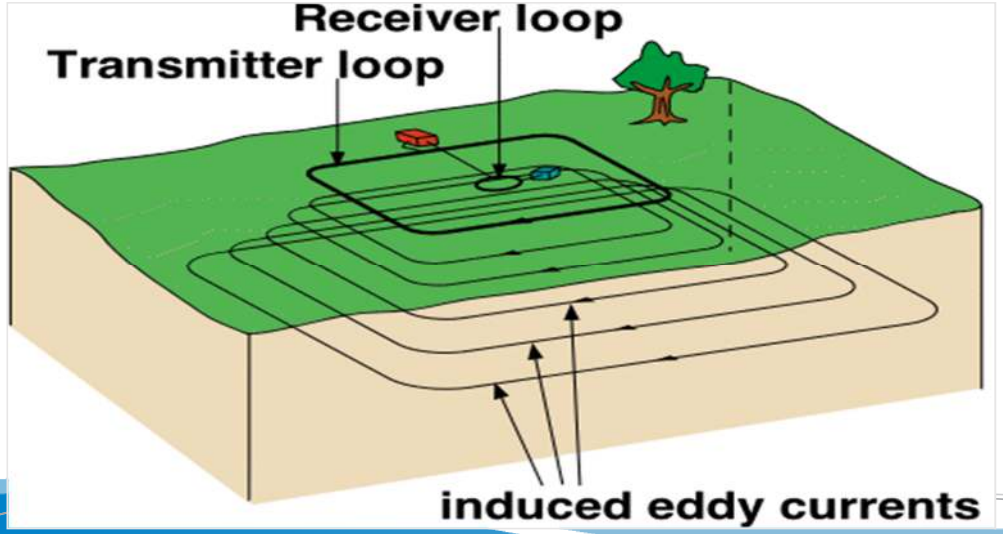
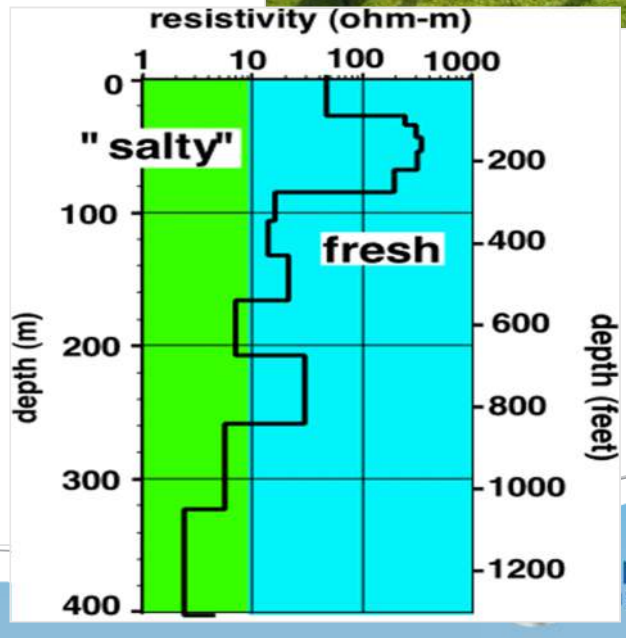
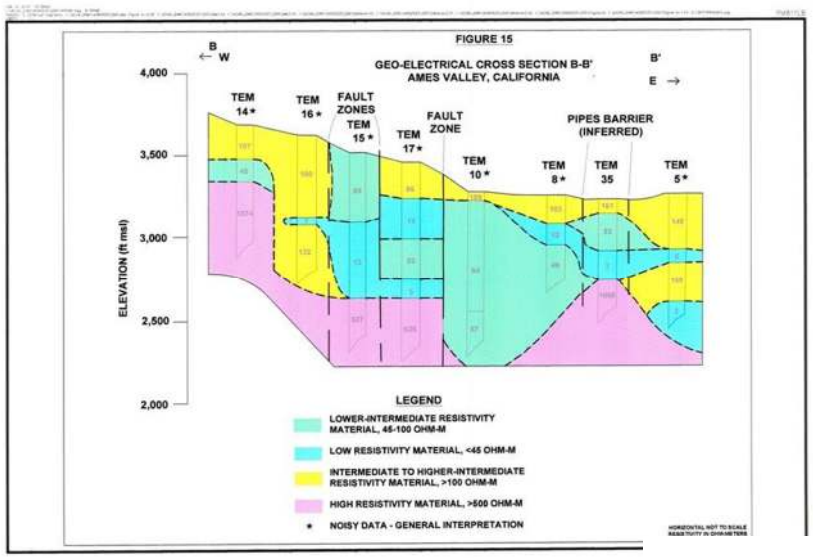
Time Domain (TEM)

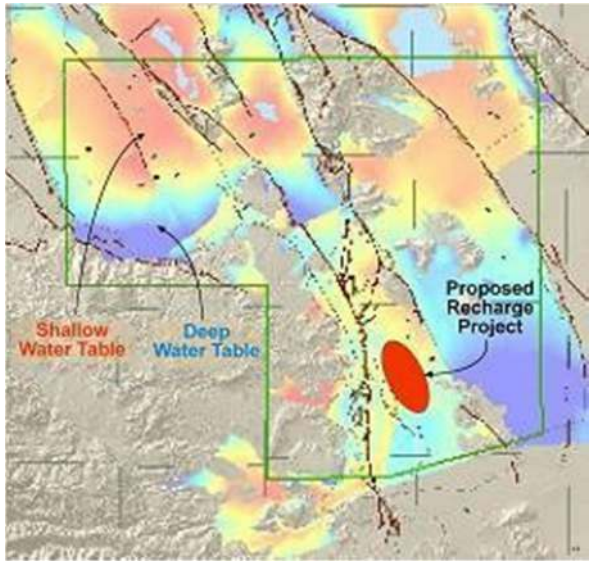
- Transmitter loop on surface (10 to 100 m per side)
- Current cut off nearly instantaneously
- Creates broad frequency EM pulse
- Vertical propagation of pulse induces eddy currents in conductive units (such as saline water)
- Receiver measures magnetic field from eddy currents over time
- Data modeled into layered system





TEM Soundings Along Profile Lines





Mapping Faults in California Basin to Site Recharge Ponds

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Airborne TEM for Regional Mapping

- Some systems developed specifically for groundwater studies (SkyTEM)
- 40 mph – 50 to 100 ft off the ground
- Up to 700 ft depth
- High production rate
- Cost efficient for large areas (tens of thousands of acres)
- Vertical and lateral resolution not as good as land systems
- No need to access the ground
- Strong correlation - resistivity to hydrogeology
- Expensive for small to medium size sites

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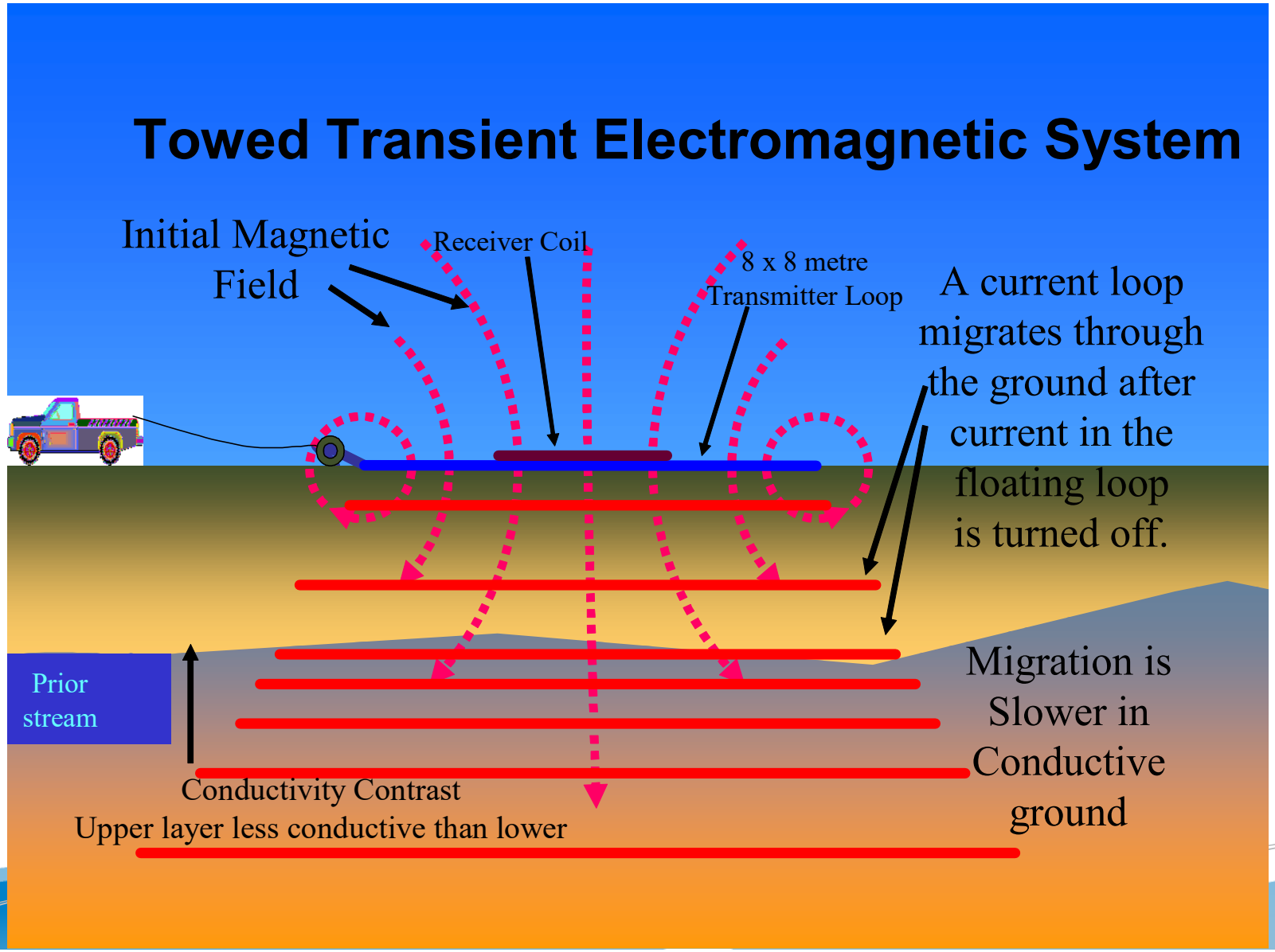
Towed Transient Electromagnetic System



Portable TDEM Systems

tTEM system: Penetration ~200 ft

AgTEM system: Penetration ~300 ft

Slingram AgTEM

AquaTEM

Towed, walking and floating platforms available

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AgTEM Portable TDEM System

- Nearly continuous TEM data to ~300 feet at ~5 mph
- 6 x 7 meter, 1 to 5 turn Tx loop on flexible booms for deep targets
- 2 smaller Tx loops in cart for shallow targets
- Rx coil either coincident (on cart) or offset in front of tow vehicle
- Map sand and gravel, bedrock fracture zones, confining units, depth to bedrock, saline water…….

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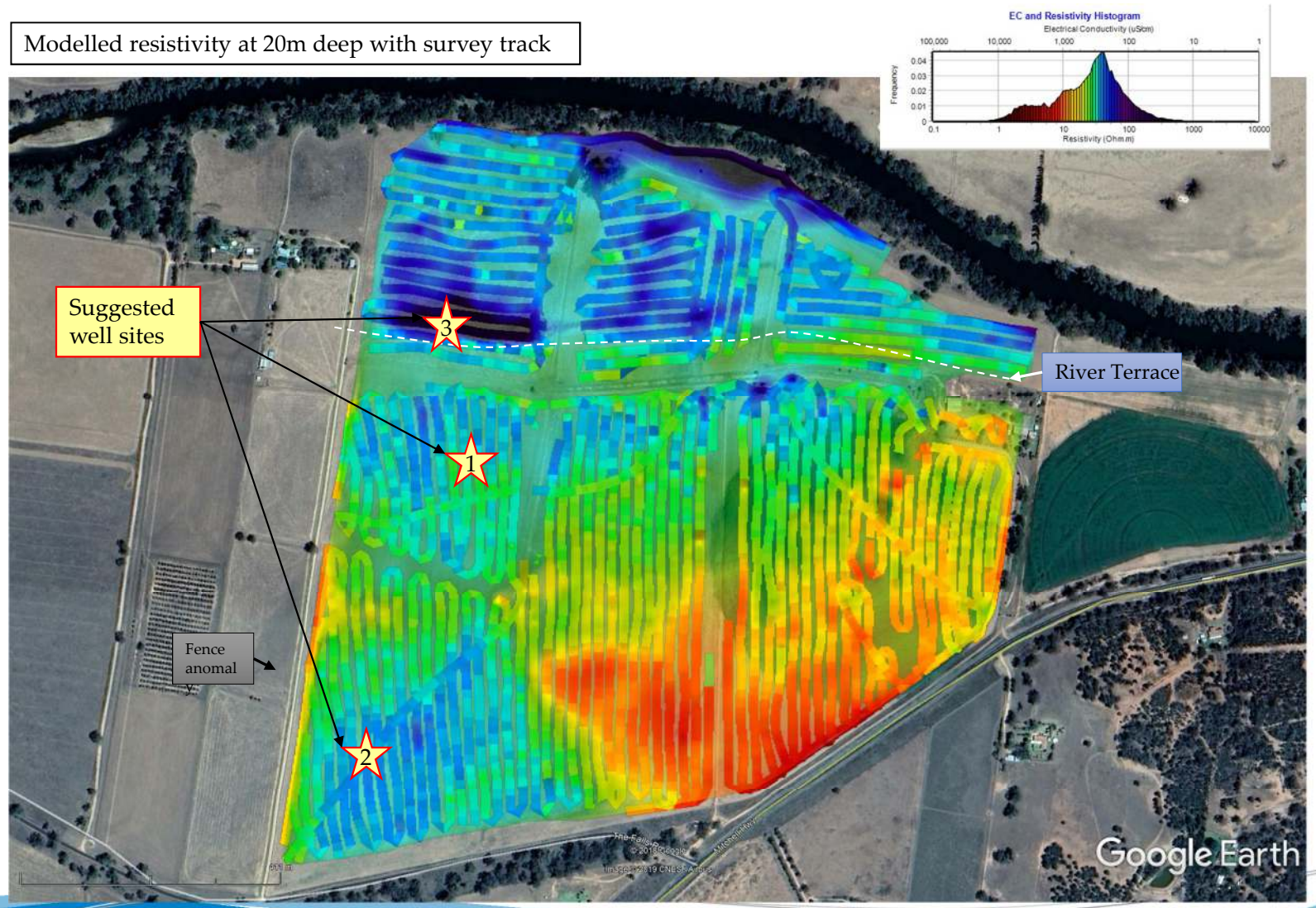
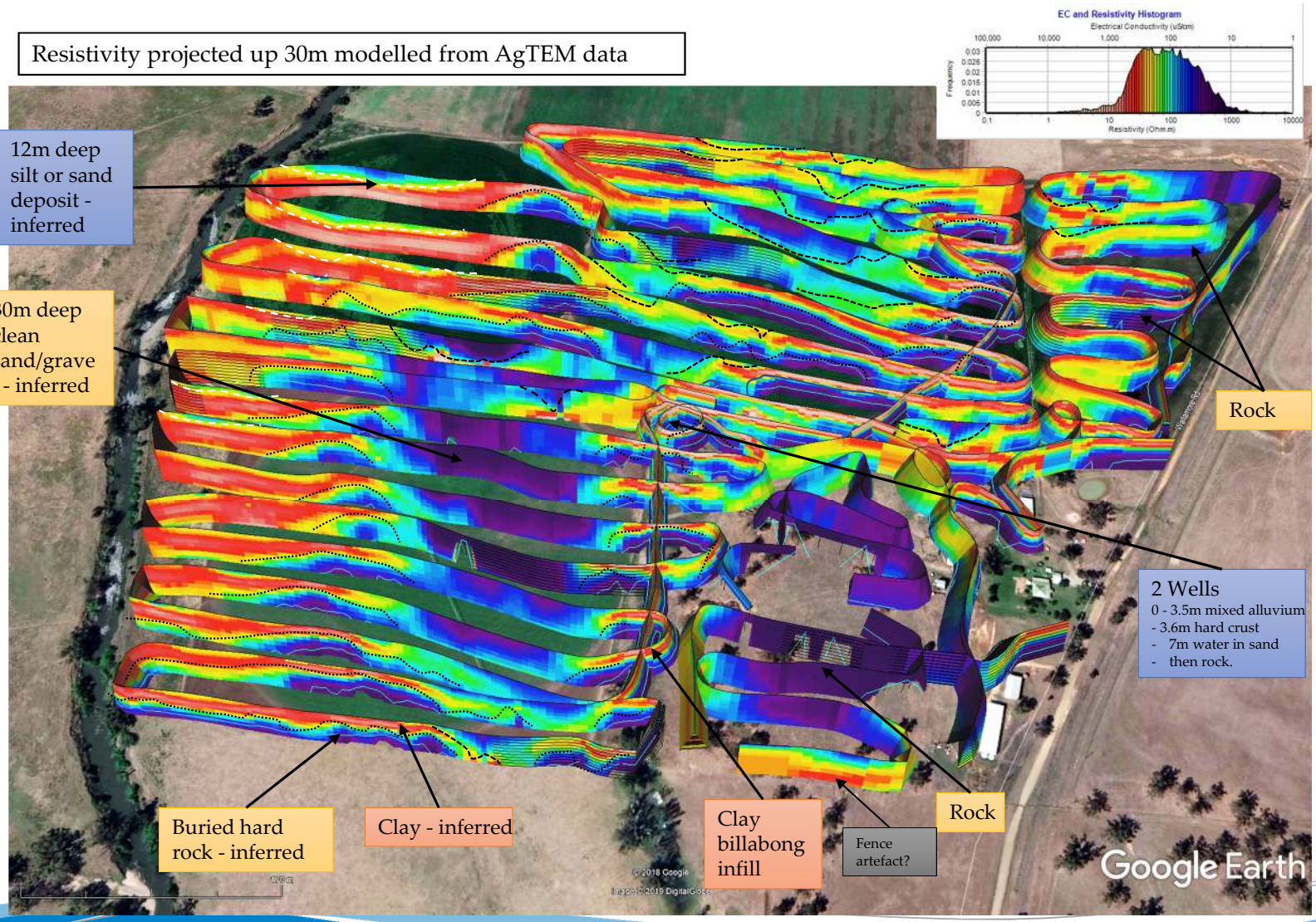
GROUNDWATER

Modelled resistivity at 20m deep with survey track



Resistivity projected up 30m modelled from AgTEM data



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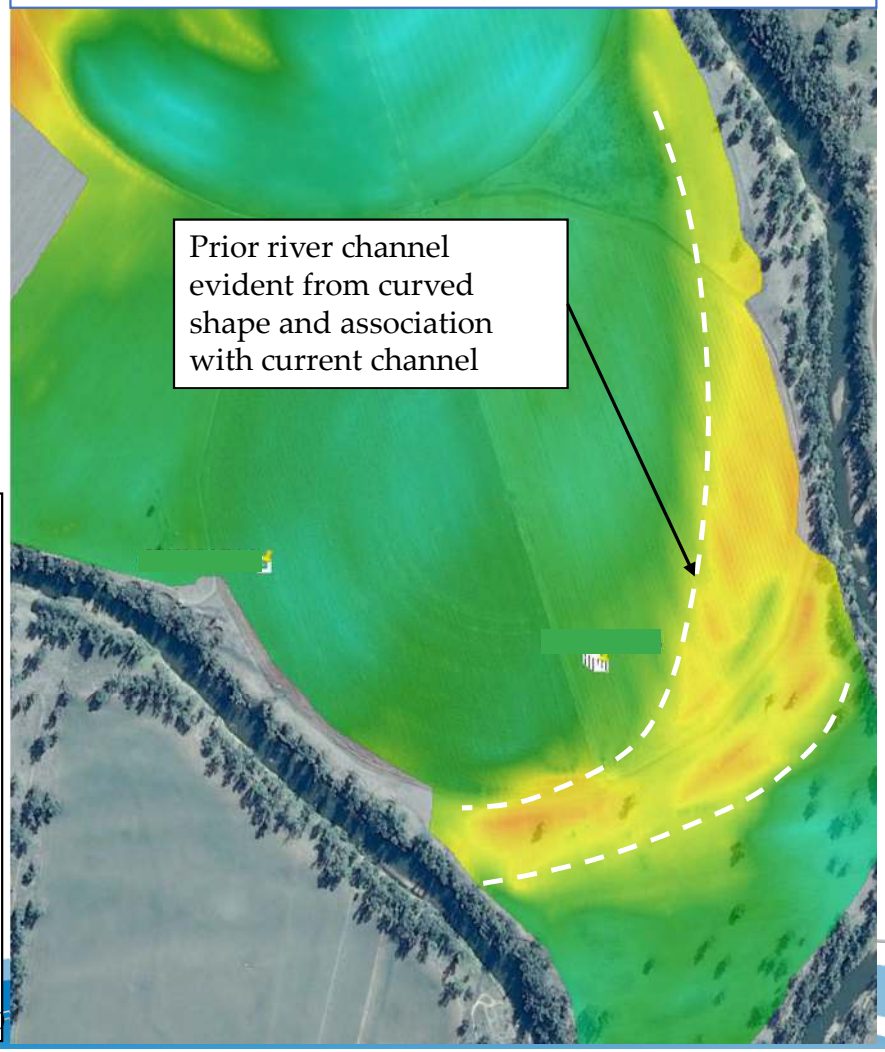
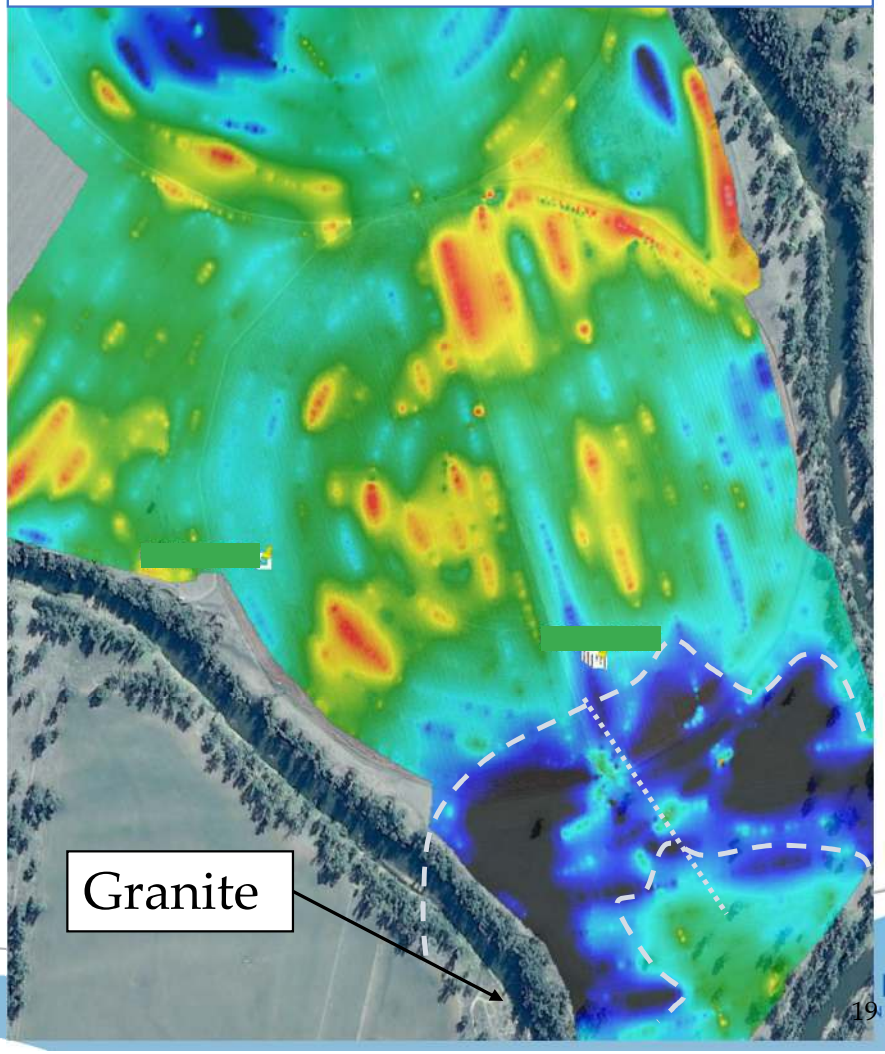
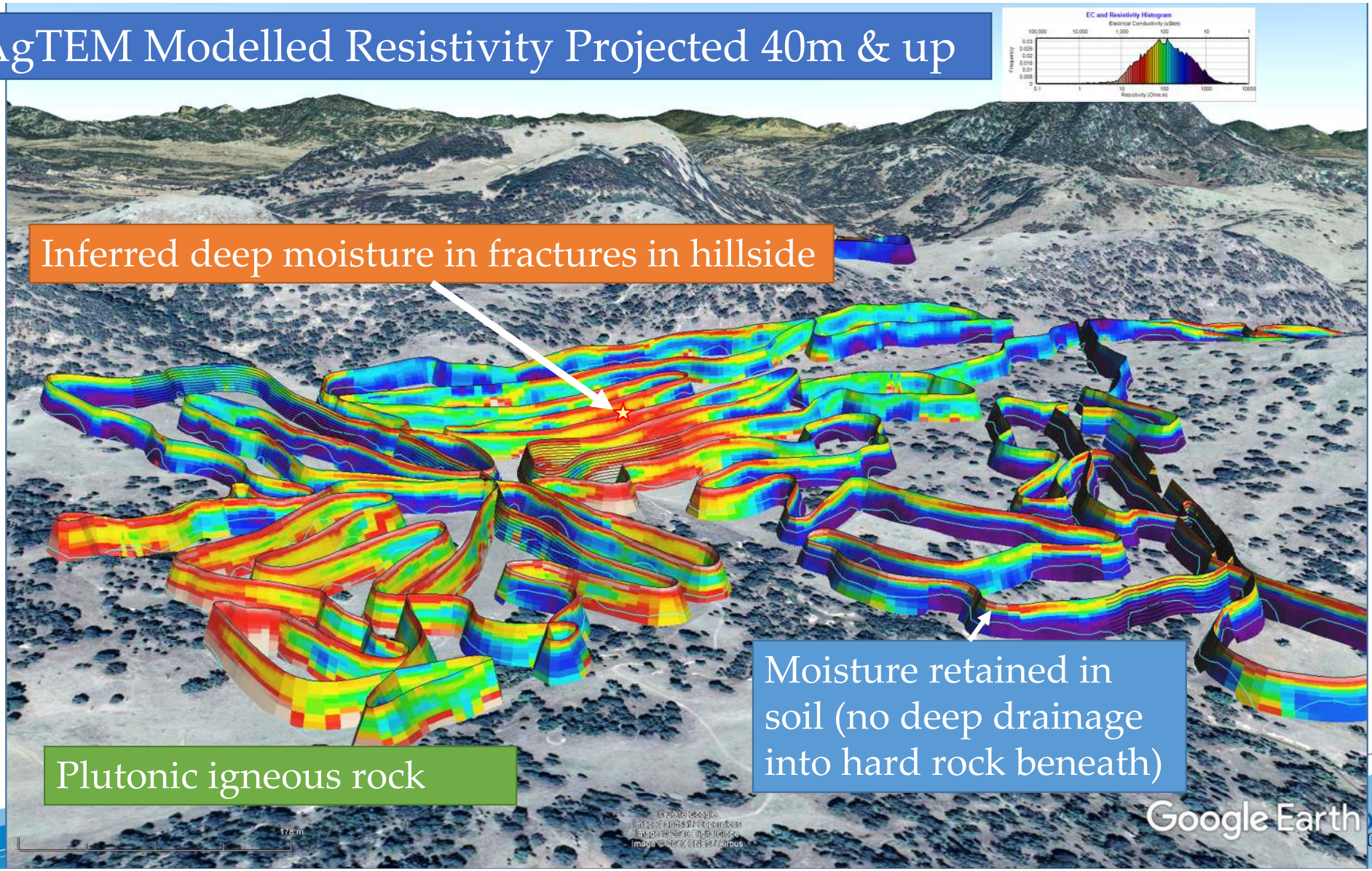
Modelled Resistivity @ 4m deep



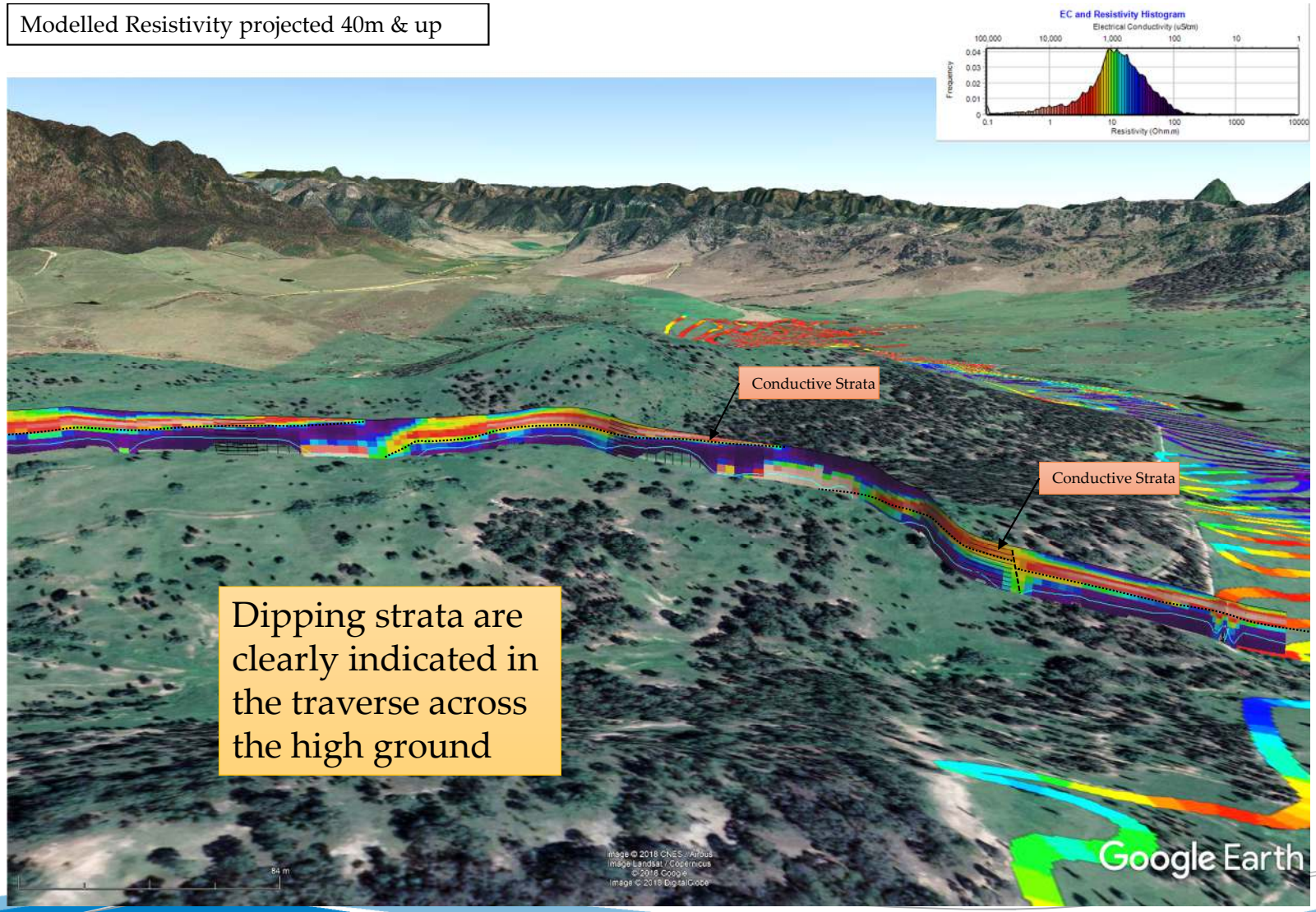
Modelled Resistivity @ 60m deep



AgTEM Modelled Resistivity Projected 40m & up



Modelled Resistivity projected 40m & up



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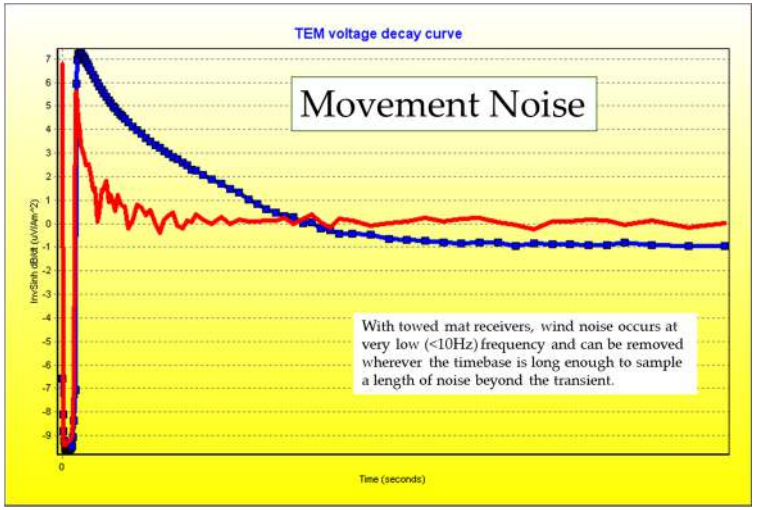
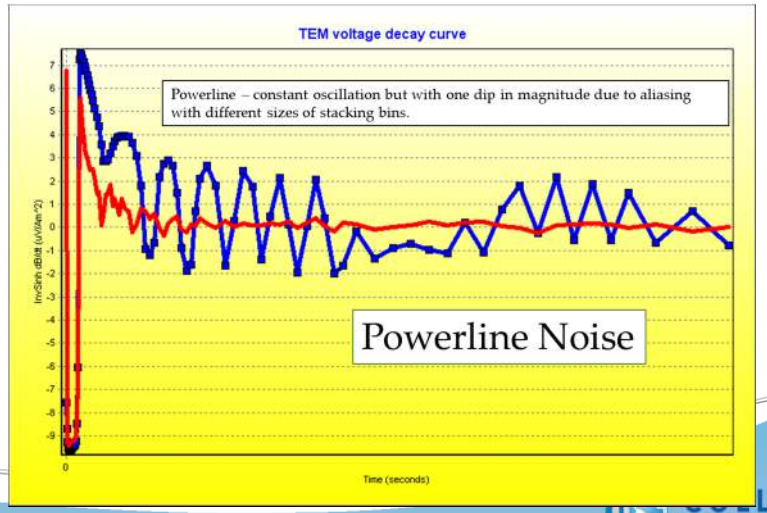
Noise and Unwanted Signals

- Buried utilities
- Power Lines
- Steel Post Fences
- Buried Metal
- Movement Noise

High sampling density allows more noise to be filtered out of data





What AgTEM Will Deliver:

- Rapid acquisition of subsurface geologic information in the range of tens of miles/day
- Much more vivid images of aquifers, bedrock and water quality
- 3D data that can be imported into geologic or groundwater model software with some site-specific transforms
- Map channel sands, clay confining units, depth to bedrock, fracture zones and more
- Rapid identification of freshwater targets
- Detailed mapping of brackish or saline zones
- Better noise identification and correction/removal due to higher data repetition
- Better site models and more successful groundwater projects
- Discarding inaccurate site models that were impeding progress
- Easily shipped and transportable between multiple sites
- Available for surveys in the US and North America in the Fall of 2021
- Not suitable for highly developed sites

Thank You

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AgTEM Wallaby by COLLIER GEOPHYSICS

GROUNDWATER IMAGING

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