AgTEM$_4$™ towed transient electromagnetic cart.

GROUNDWATER IMAGING

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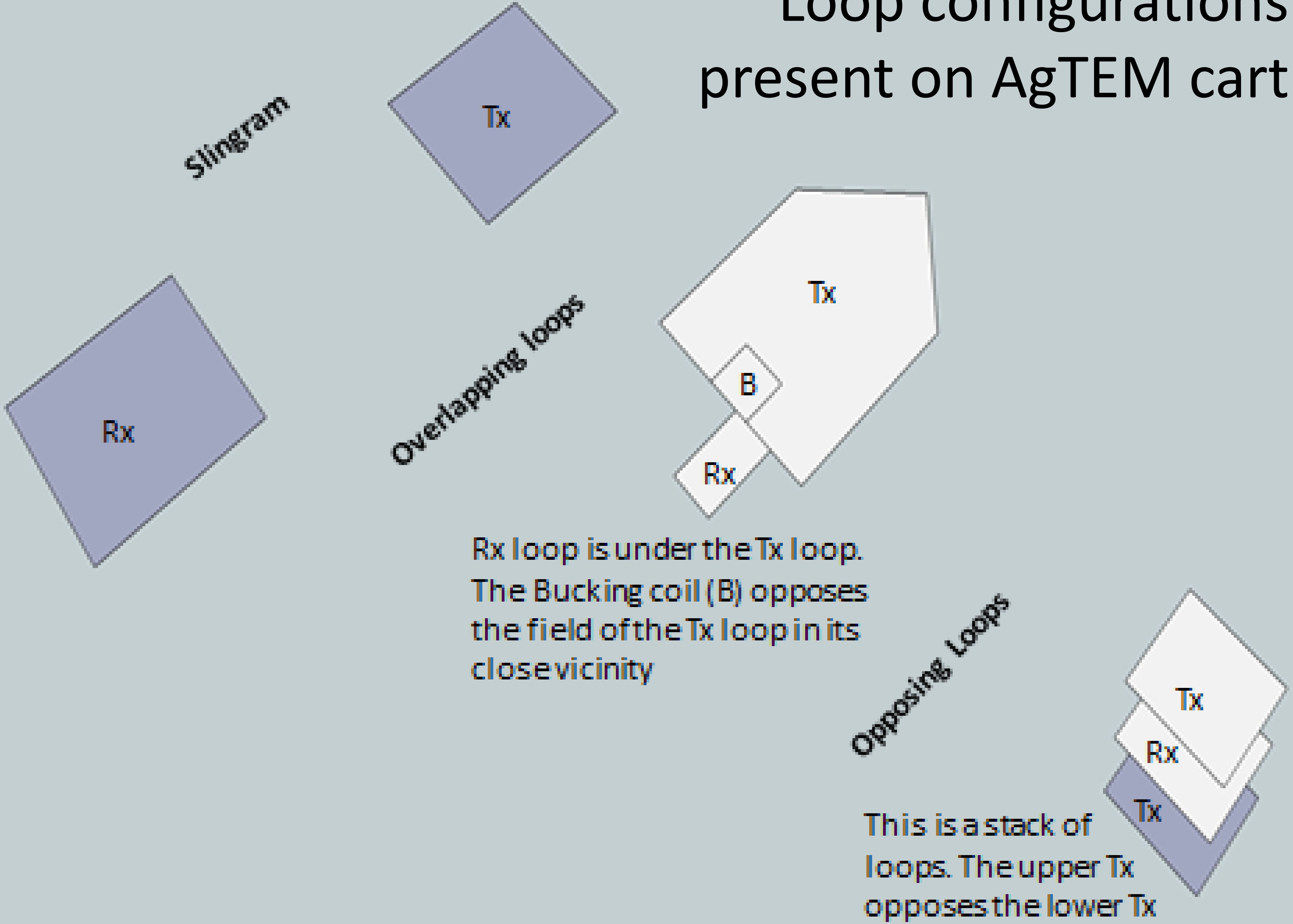
GROUNDWATER

Loop configurations present on AgTEM cart



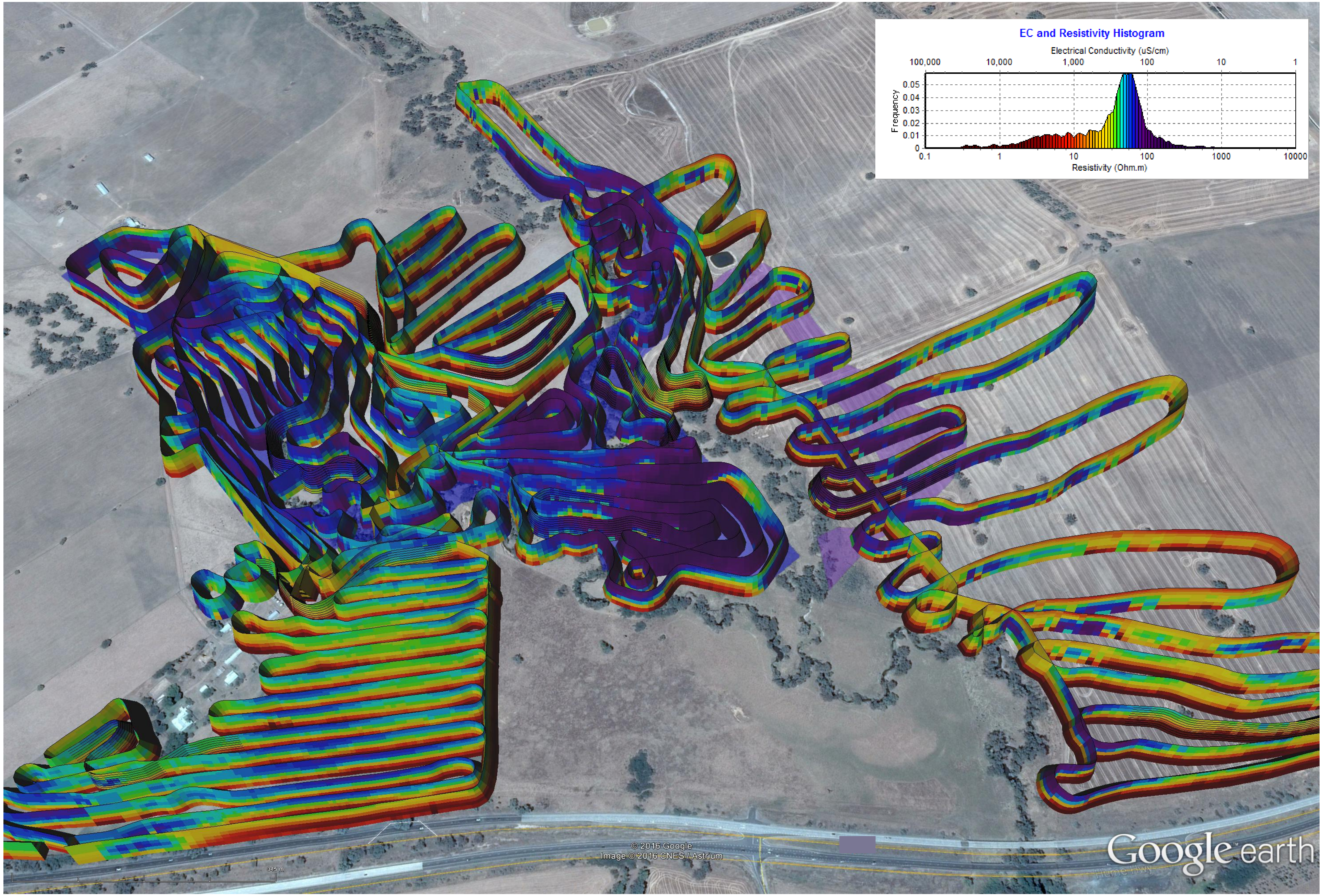
Slingram – towed slingram proved to be logistically difficult.

1st front-attached Slingram prototype.

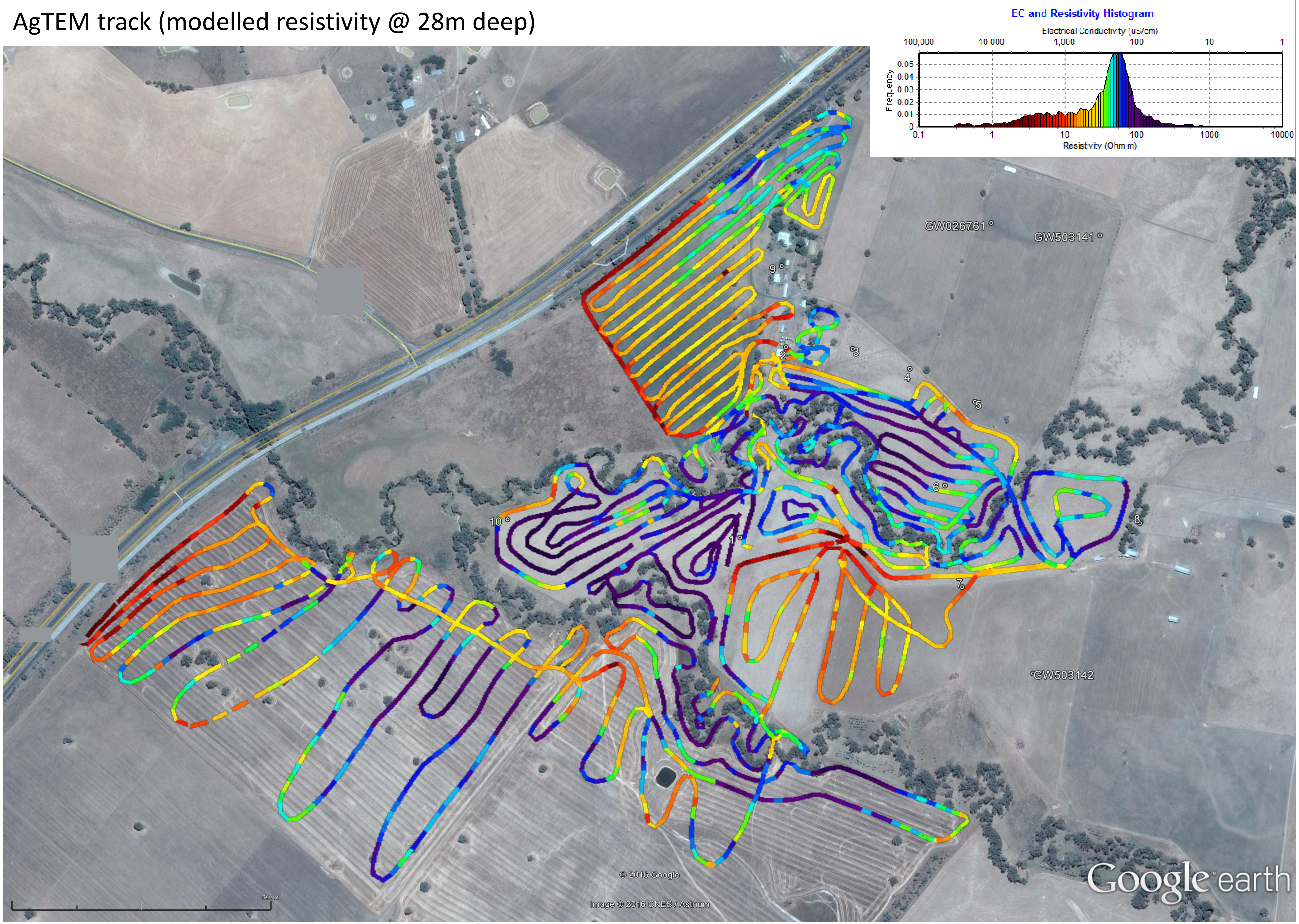
Vehicle coupling must be compensated.

A better design is under development.

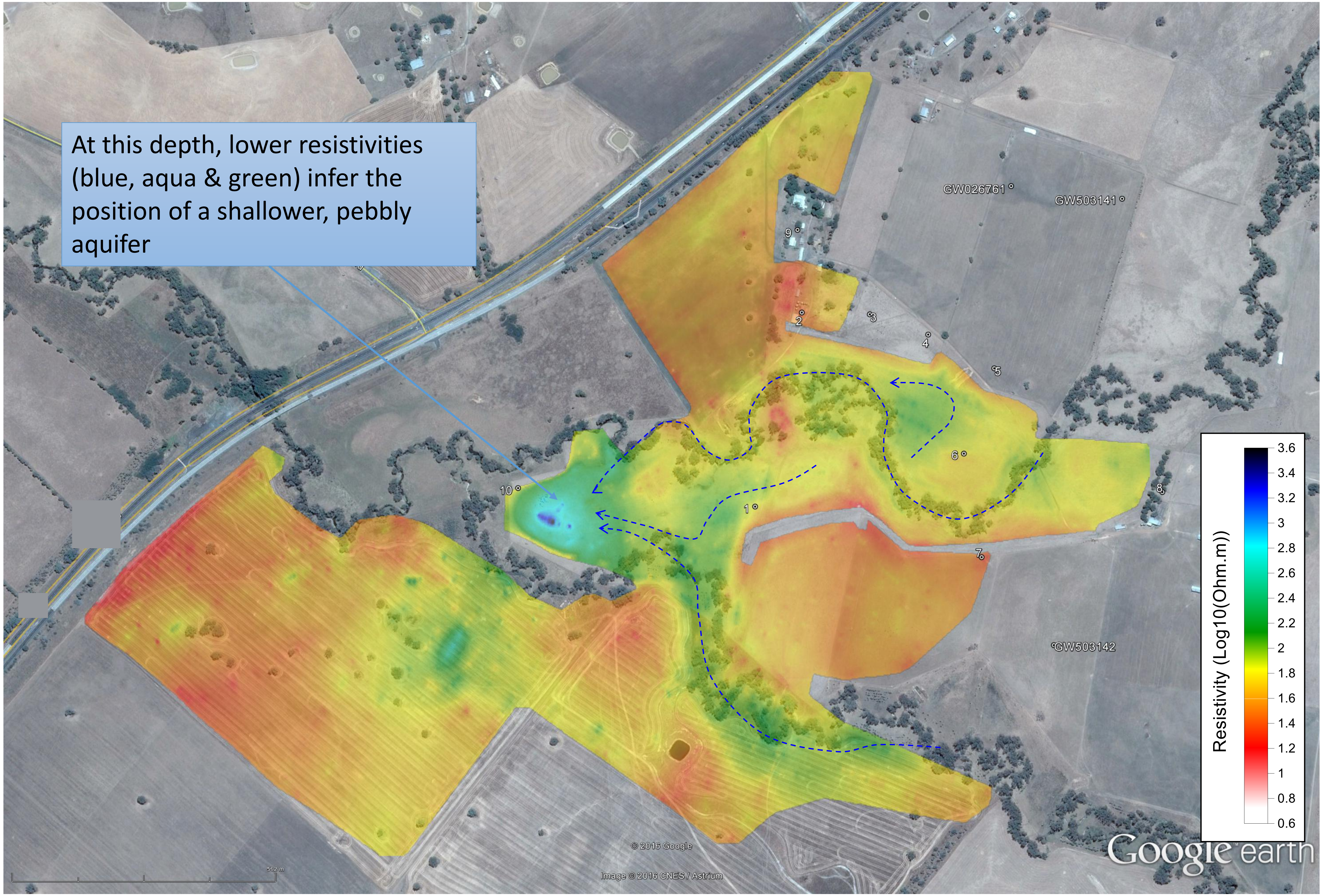
Modelled resistivity projected 50m up



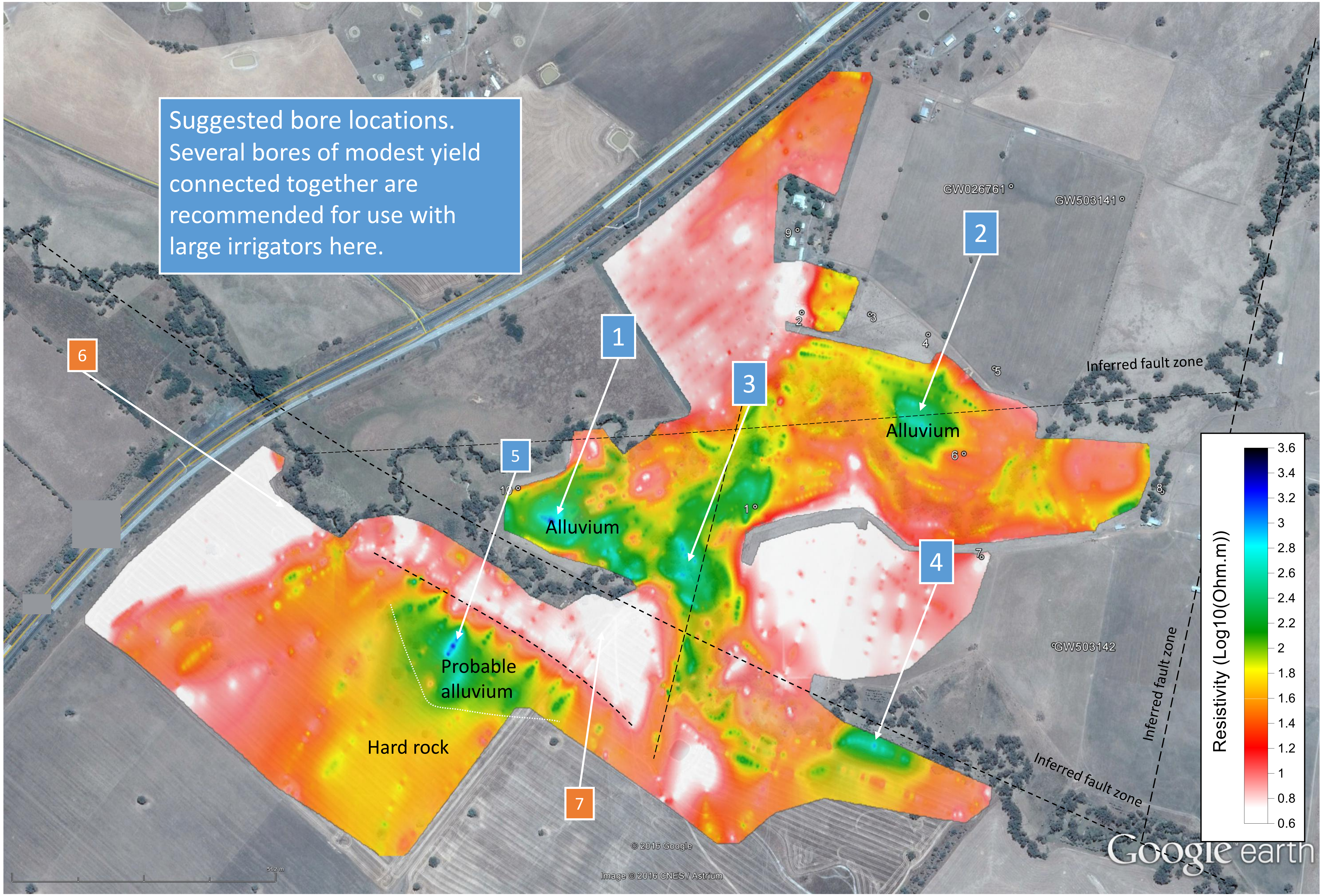
AgTEM track (modelled resistivity @ 28m deep)



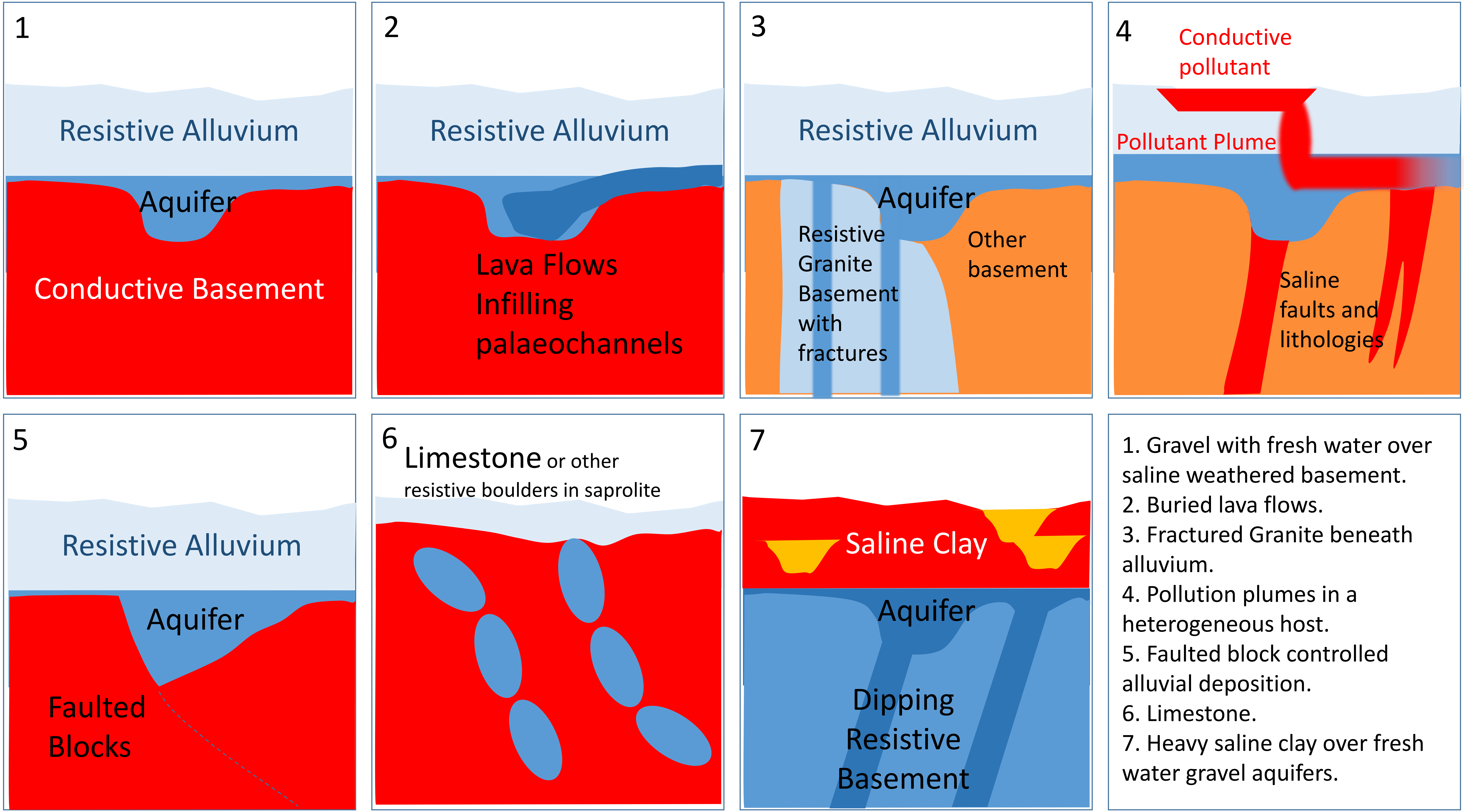
Modelled Resistivity at 20m deep



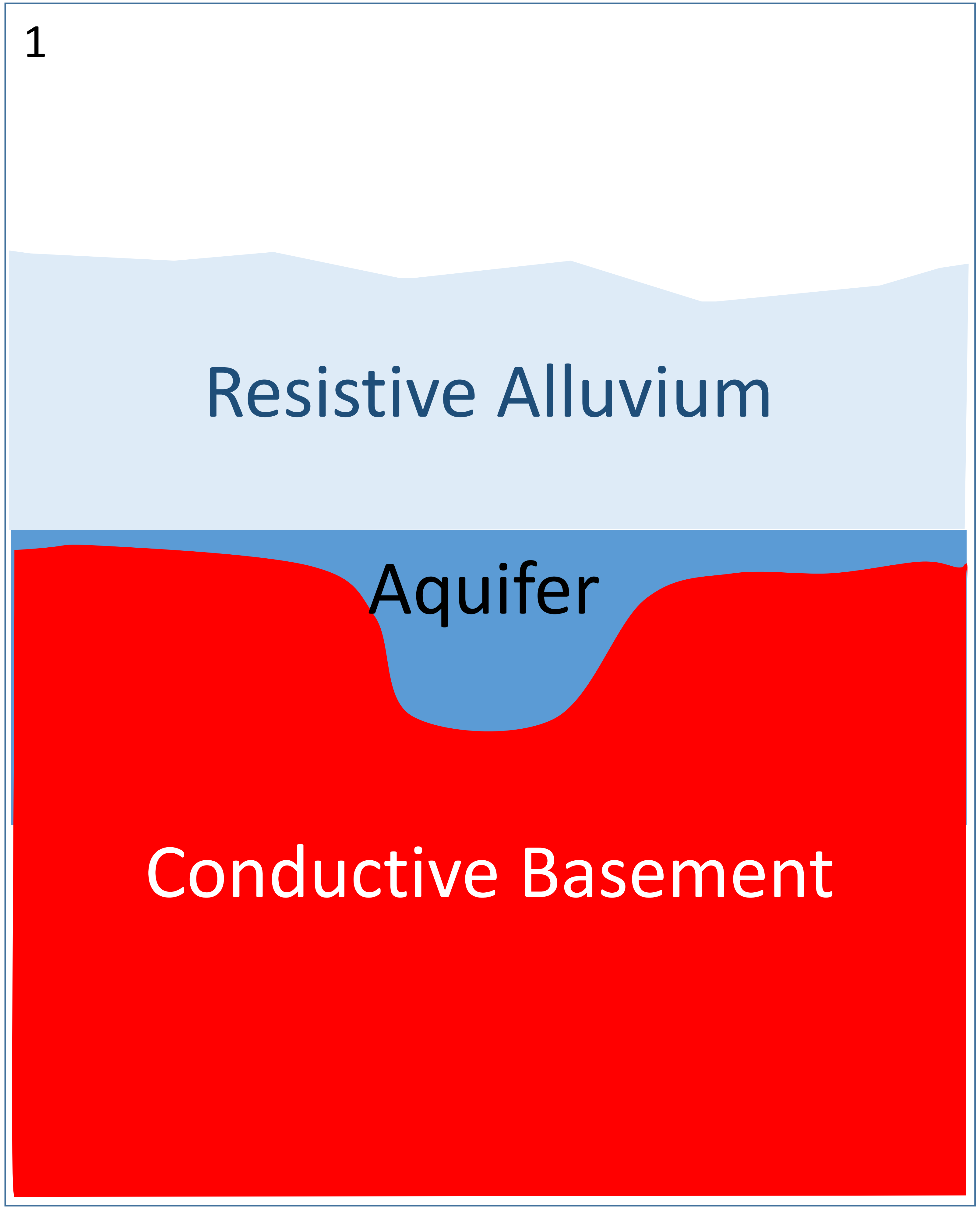
Modelled Resistivity 32 to 64m deep

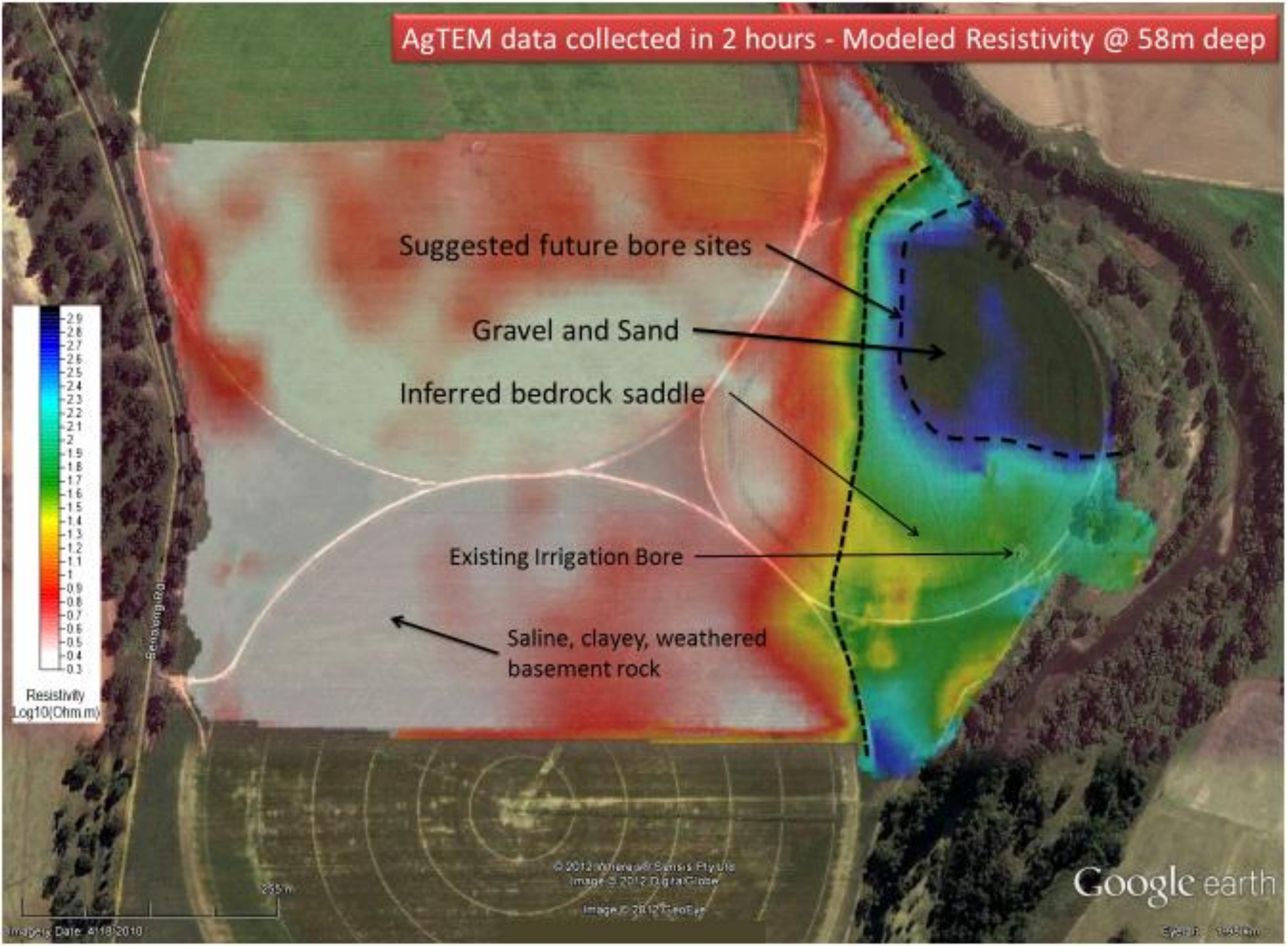


Some interpretation scenarios

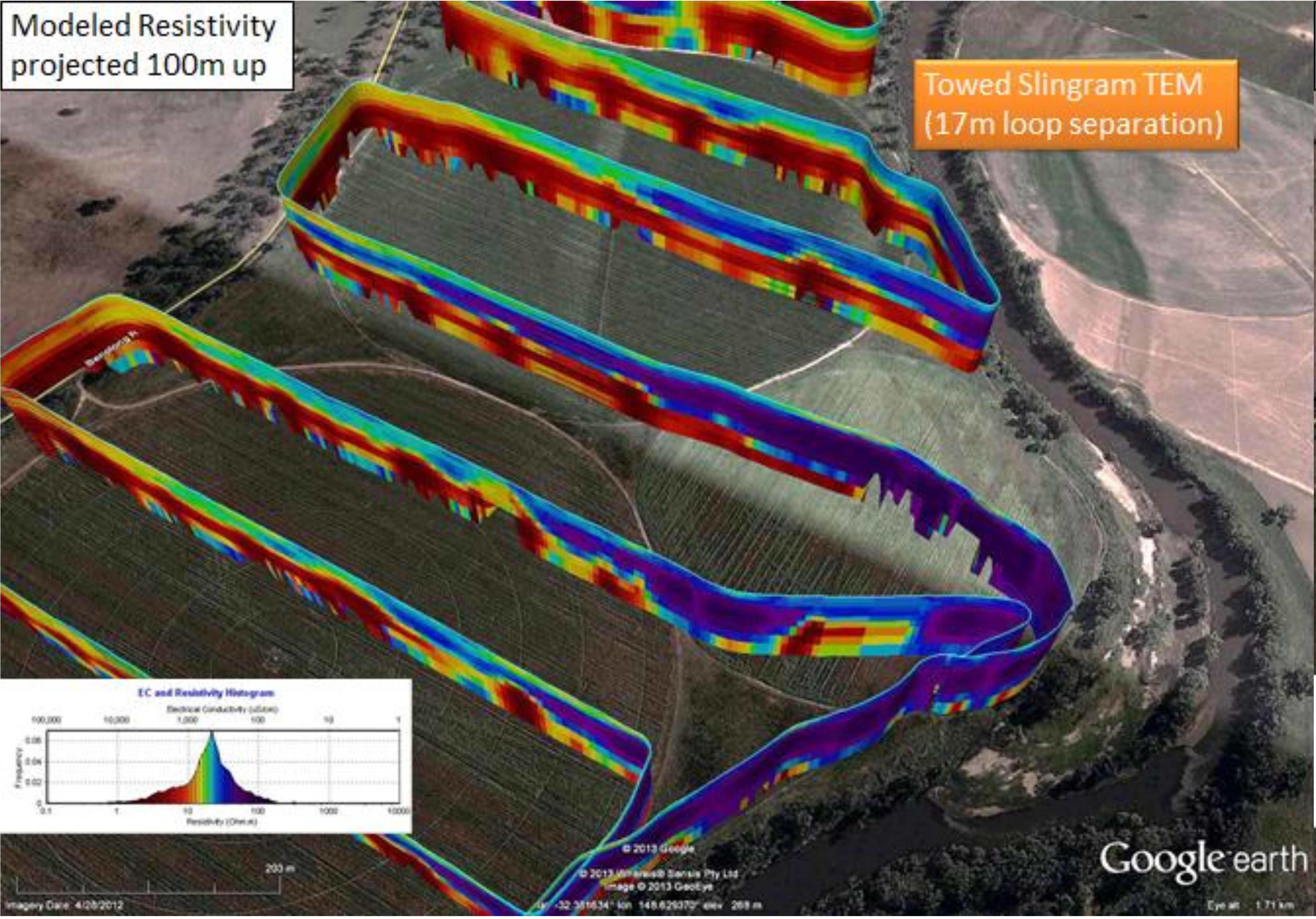


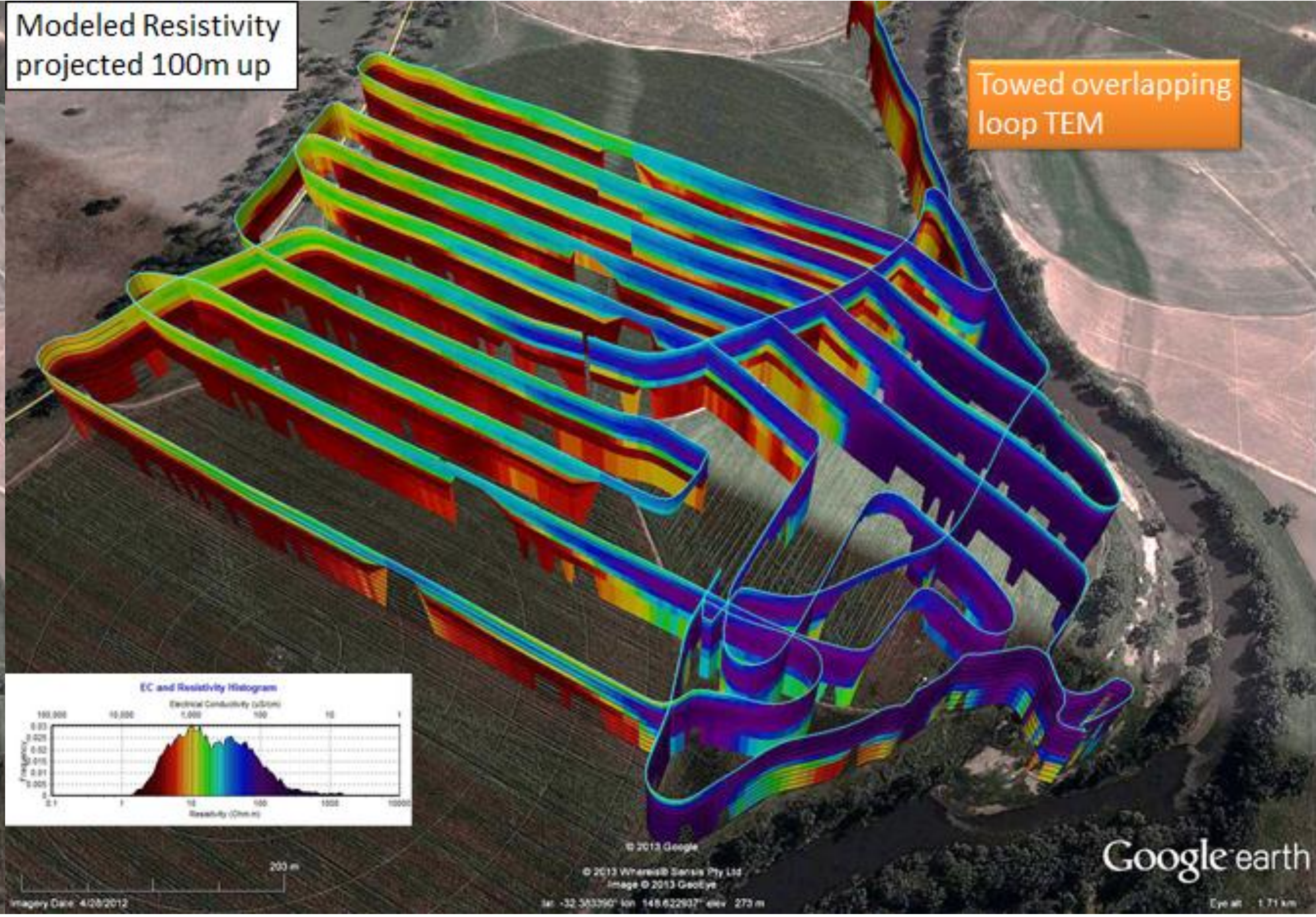
1. Gravel with fresh water over saline weathered basement.
2. Buried lava flows.
3. Fractured Granite beneath alluvium.
4. Pollution plumes in a heterogeneous host.
5. Faulted block controlled alluvial deposition.
6. Limestone.
7. Heavy saline clay over fresh water gravel aquifers.

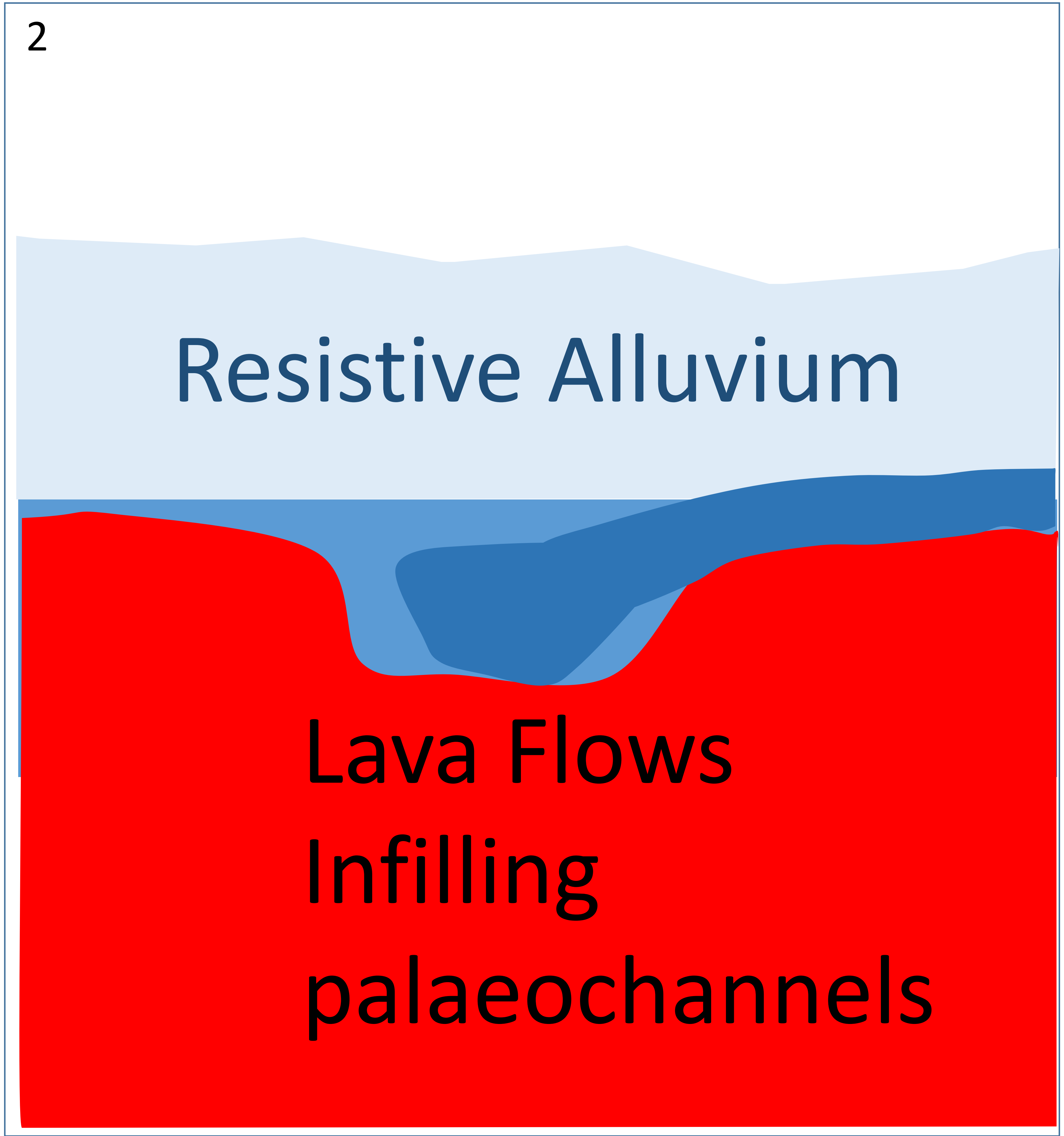

1
Resistive Alluvium
Aquifer
Conductive Basement

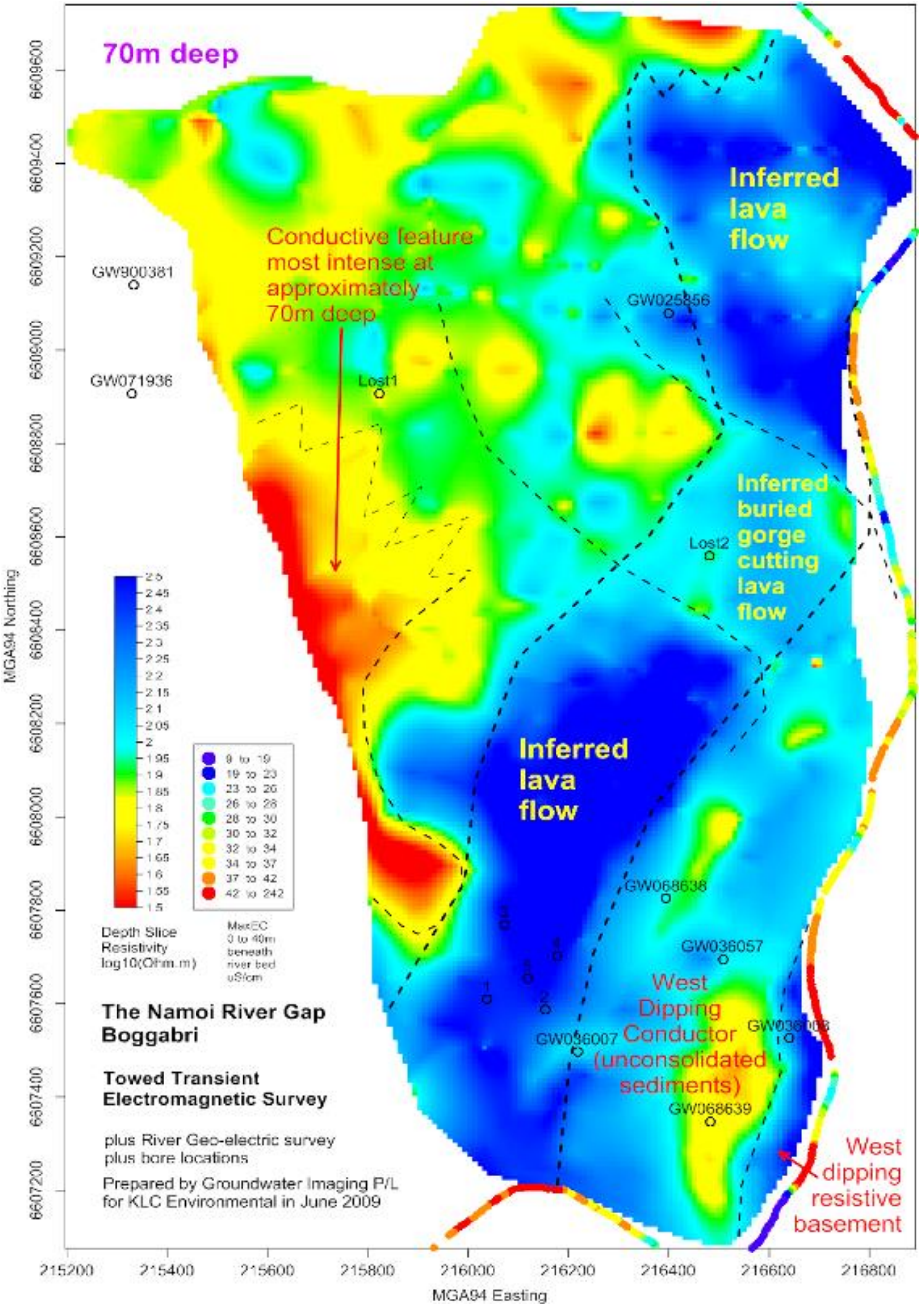


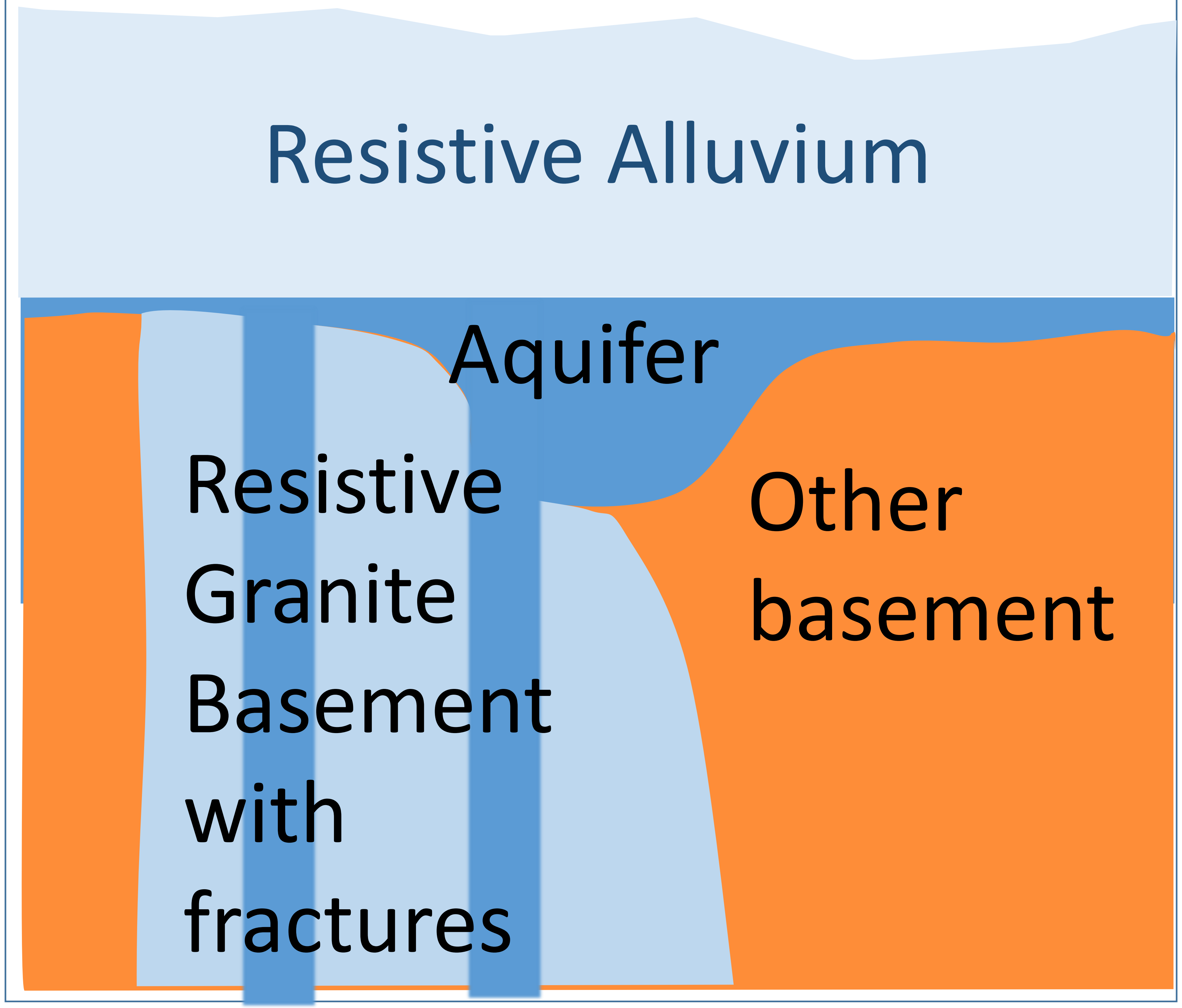
AgTEM data collected in 2 hours - Modeled Resistivity @ 58m deep
Suggested future bore sites
Gravel and Sand
Inferred bedrock saddle
Existing Irrigation Bore
Saline, clayey, weathered basement rock
Resistivity Log10(Ohm.m)
Google earth

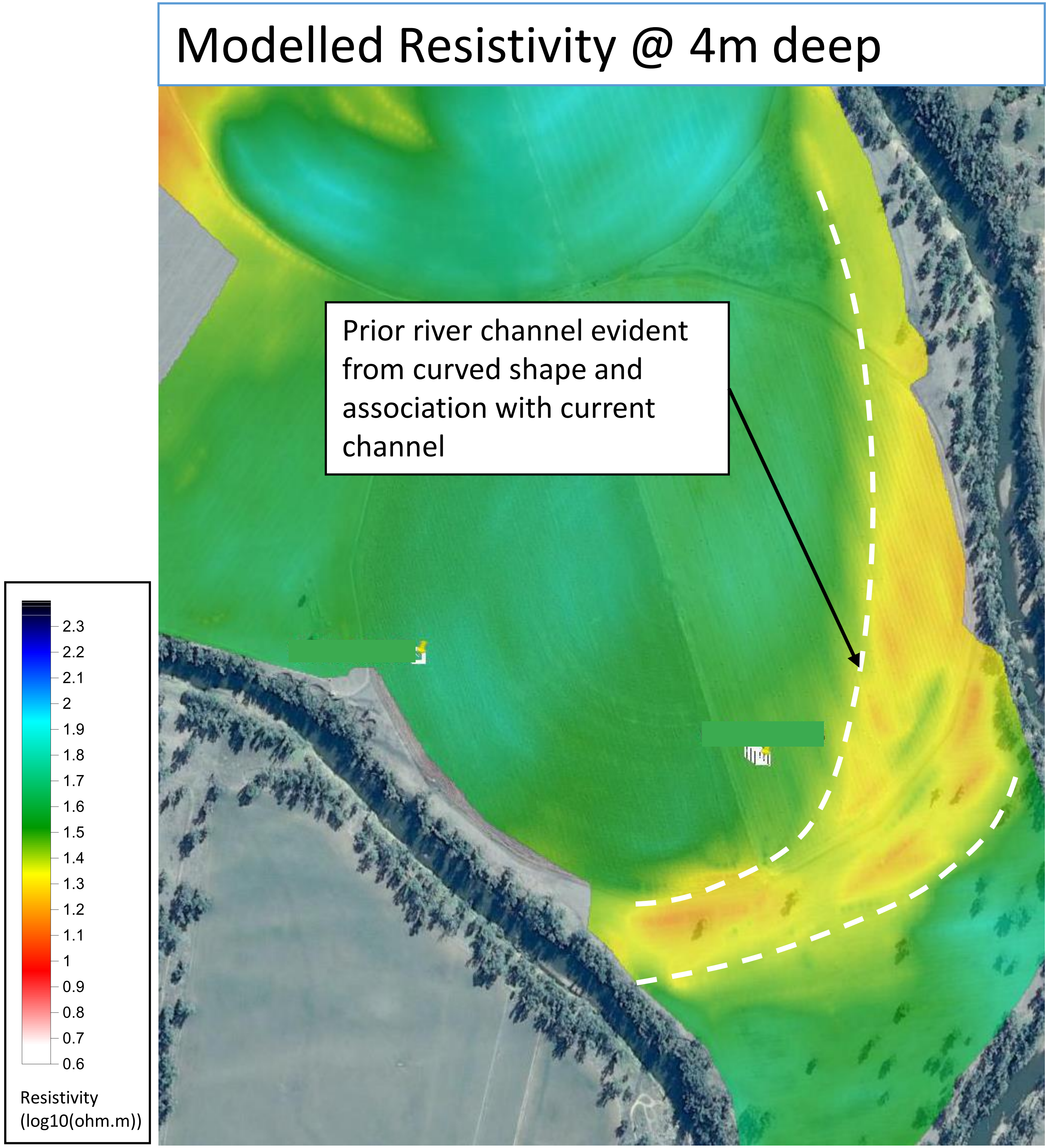

Modeled Resistivity
projected 100m up
Towed Slingram TEM
(17m loop separation)
EC and Resistivity Histogram
Google earth

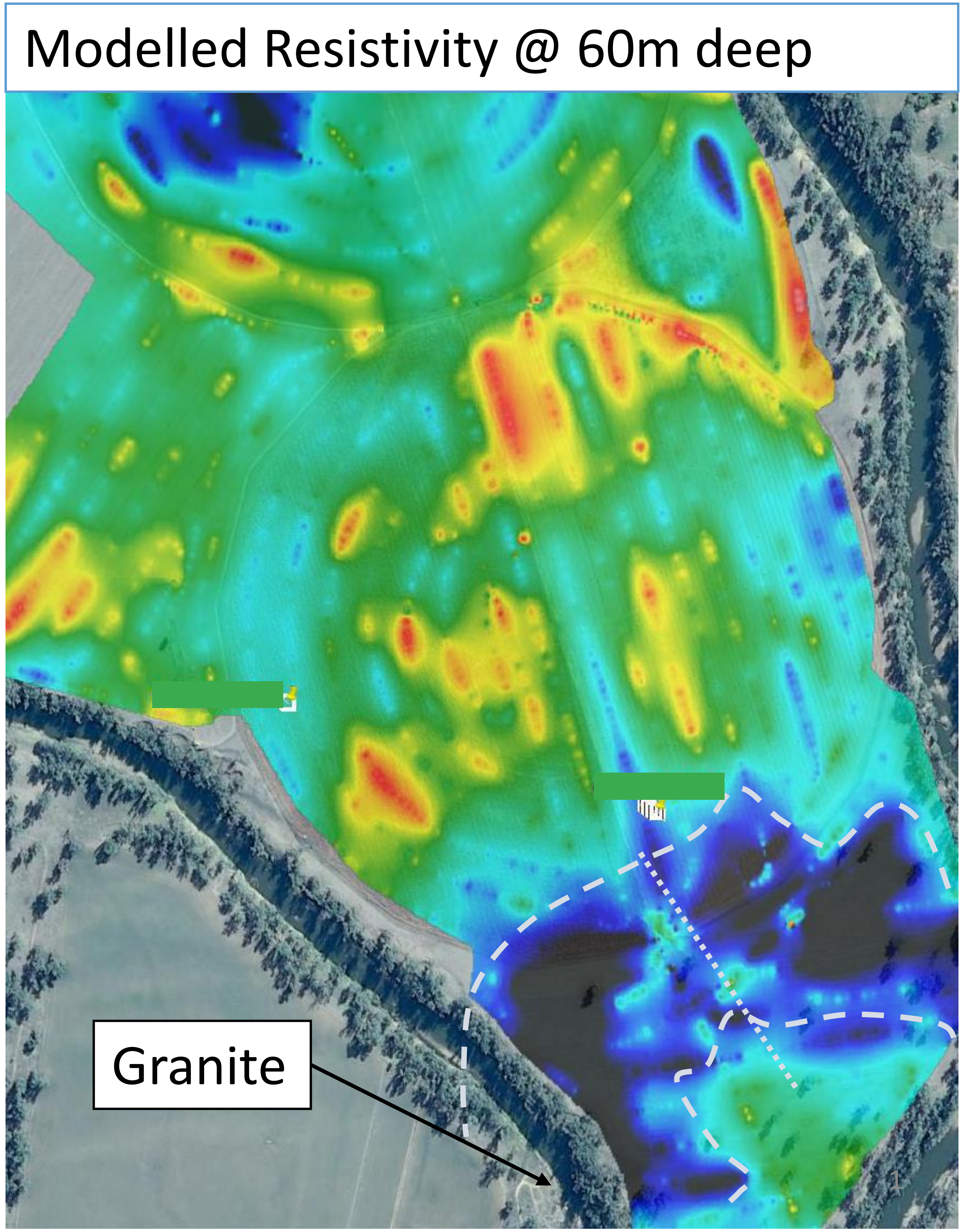

Modeled Resistivity
projected 100m up
Towed overlapping
loop TEM
EC and Resistivity Histogram
Google earth

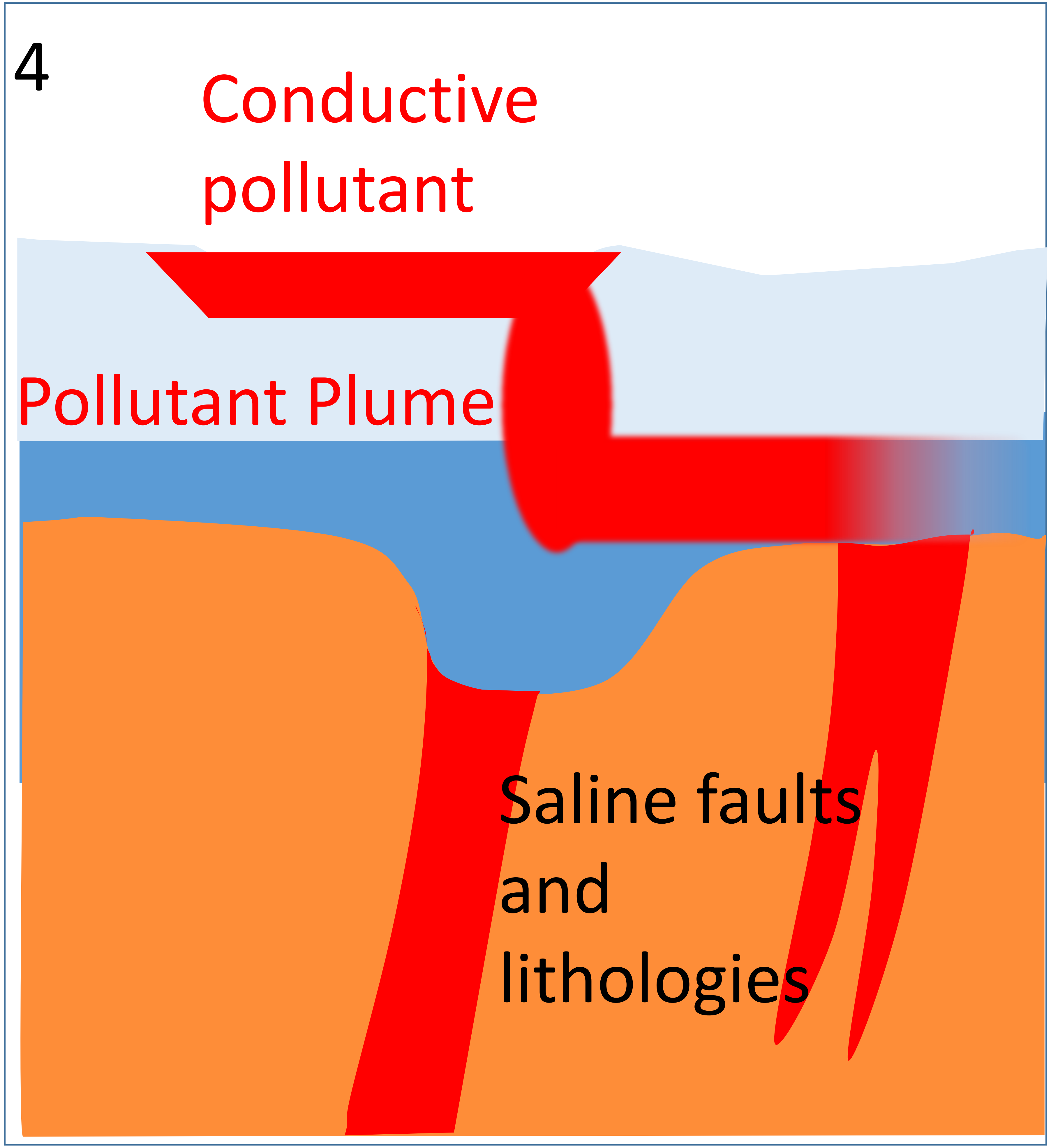

2
Resistive Alluvium
Lava Flows
Infilling
palaeochannels


70m deep
Inferred lava flow
Conductive feature most intense at approximately 70m deep
GW900381
GW025856
GW071936
Lost1
Inferred buried gorge cutting lava flow
Lost2
Inferred lava flow
GW068638
GW036057
West Dipping Conductor (unconsolidated sediments)
GW036007
GW036008
GW068639
West dipping resistive basement
Depth Slice Resistivity log10(Ohm.m)
MaxEC 0 to 40m beneath river bed uS/cm
The Namoi River Gap Boggabri
Towed Transient Electromagnetic Survey
plus River Geo-electric survey
plus bore locations
Prepared by Groundwater Imaging P/L for KLC Environmental in June 2009
MGA94 Easting
MGA94 Northing


Resistive Alluvium
Aquifer
Resistive Granite Basement with fractures
Other basement

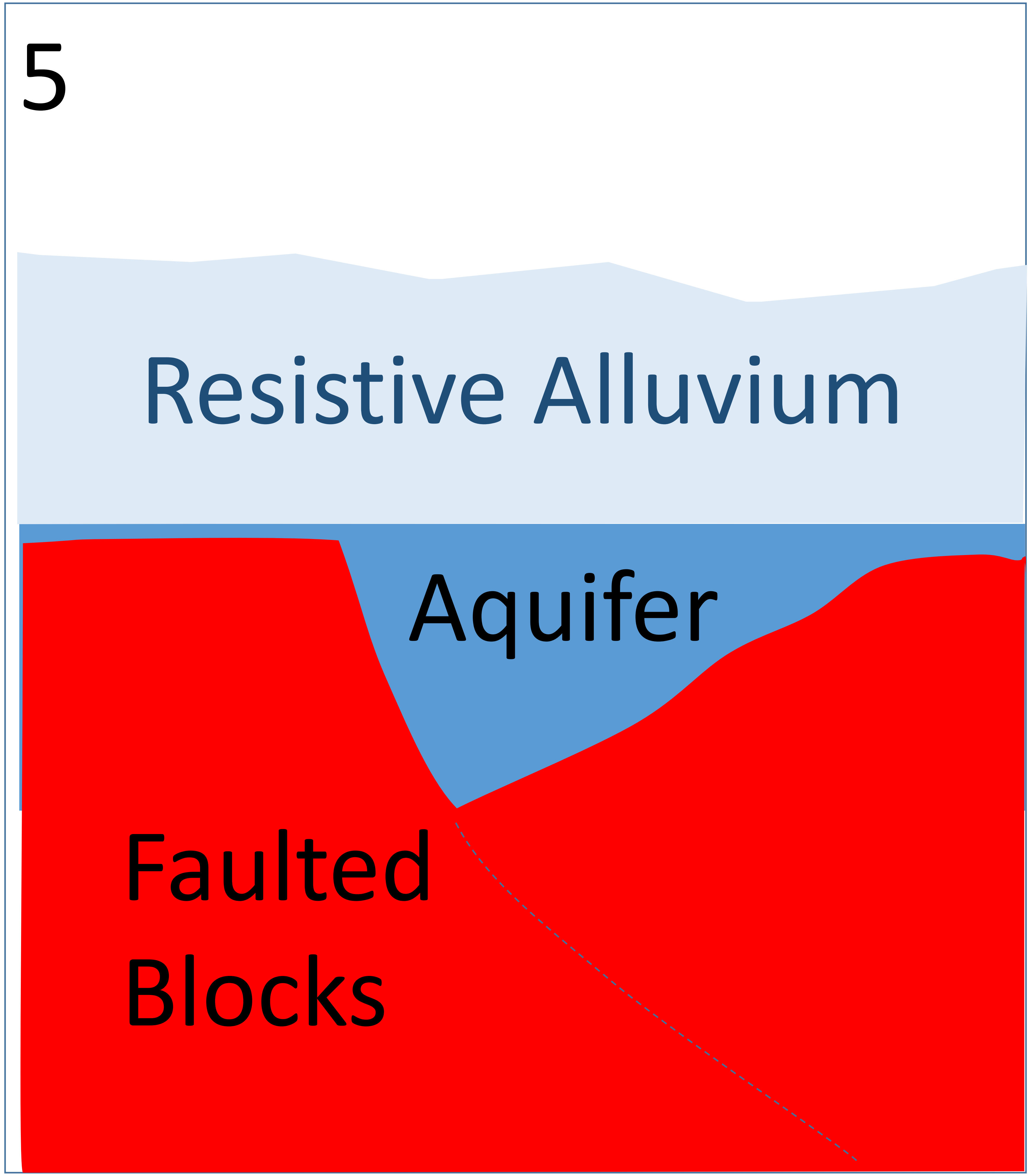

Modelled Resistivity @ 4m deep
Prior river channel evident from curved shape and association with current channel
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Resistivity (log10(ohm.m))

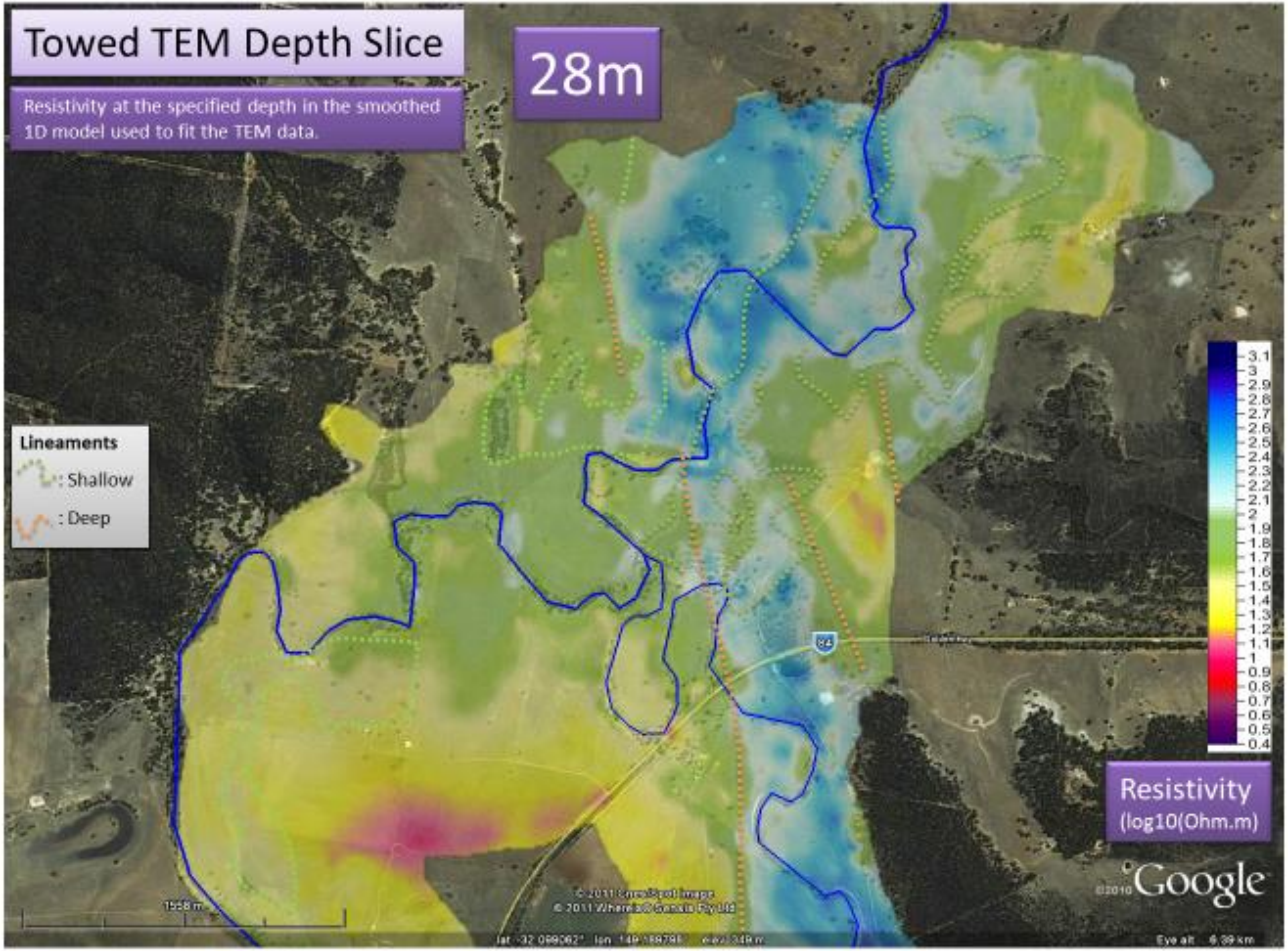

Modelled Resistivity @ 60m deep
Granite


4
Conductive pollutant
Pollutant Plume
Saline faults and lithologies

Conductive pollutant case studies

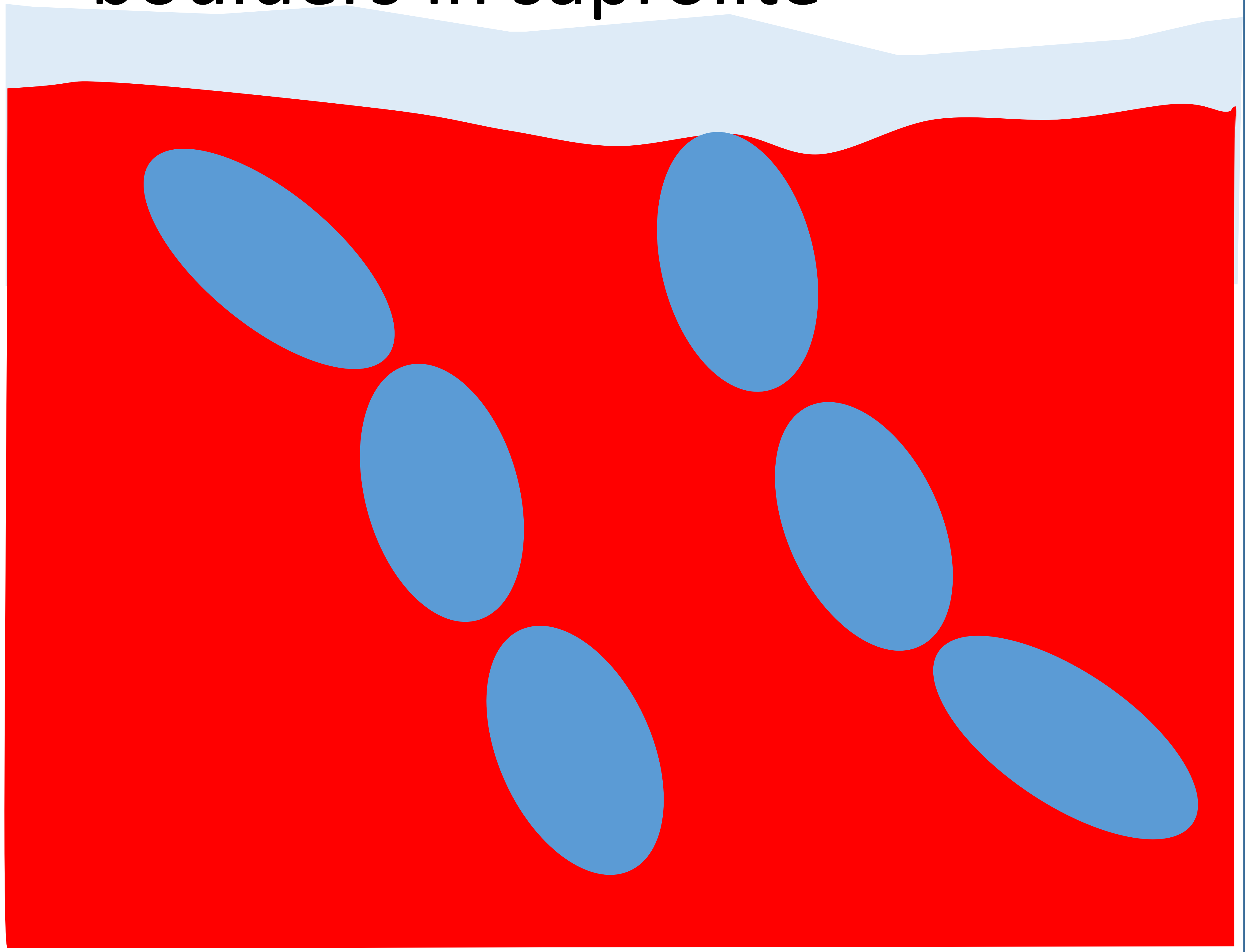
- Pollution plumes are revealed superbly
- Clients usually are in trouble when pollution plumes are revealed superbly
- Polluted groundwater tends to prefer to take paths of least resistance which often are the very same paths being taken by natural sources of saline groundwater. Where this is not identified by studying more widely and in more detail, project opponents can mistake, accidentally, on purpose, or in-advertently the source of saline pollution.
- 3D Detail can be essential to the client’s case.


5
Resistive Alluvium
Aquifer
Faulted
Blocks

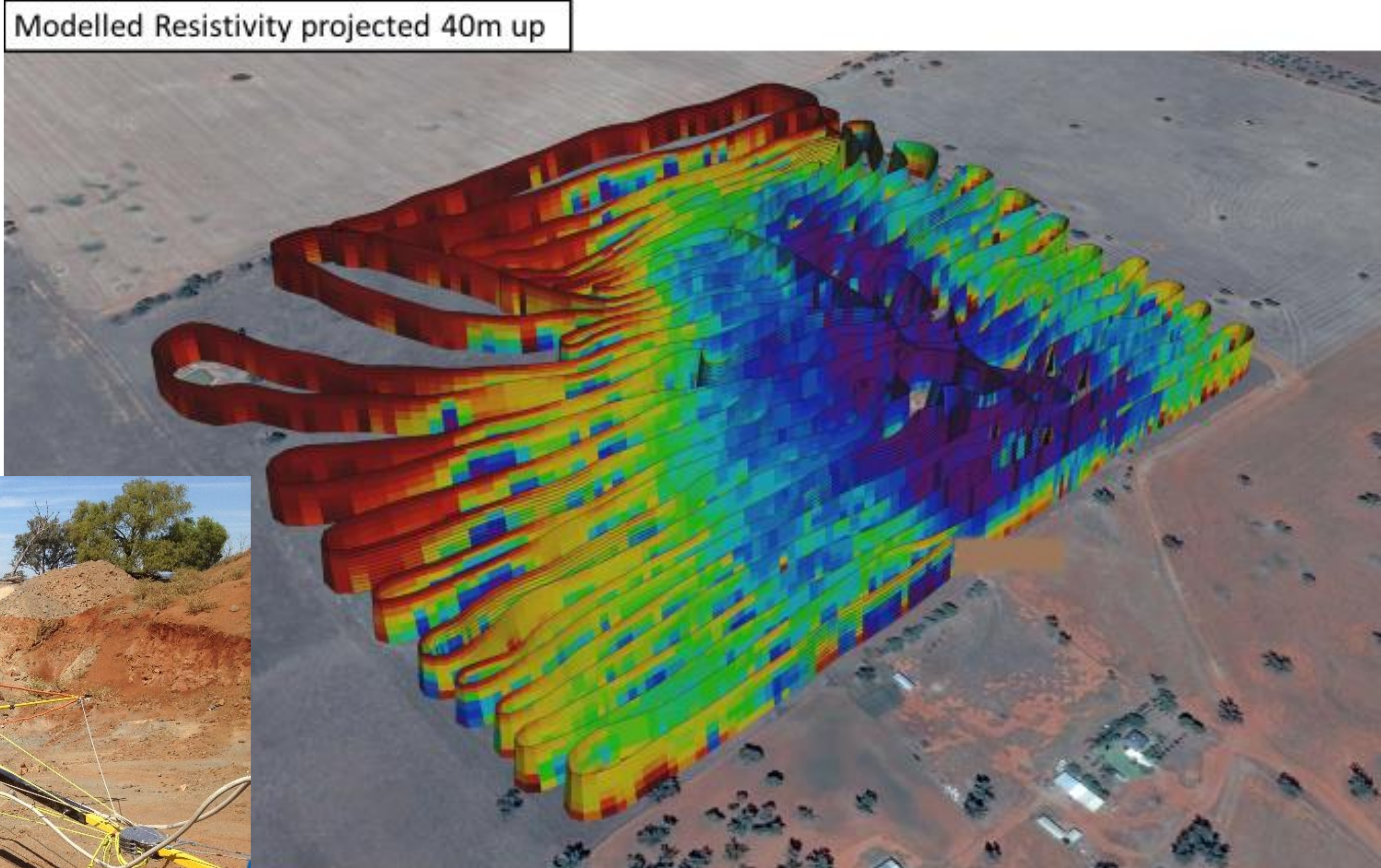

Towed TEM Depth Slice
28m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
©2010 Google

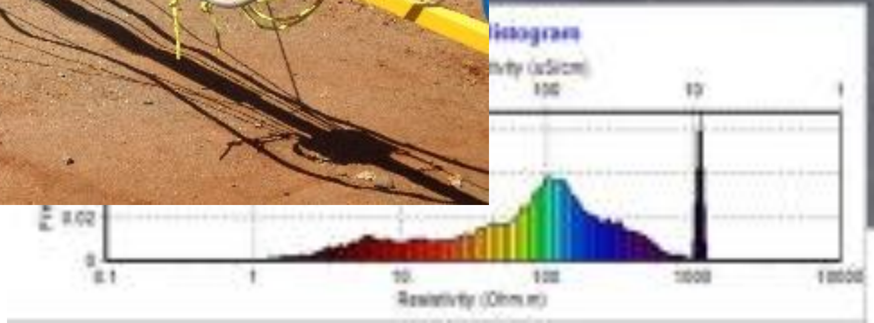
6

Limestone or other resistive boulders in saprolite



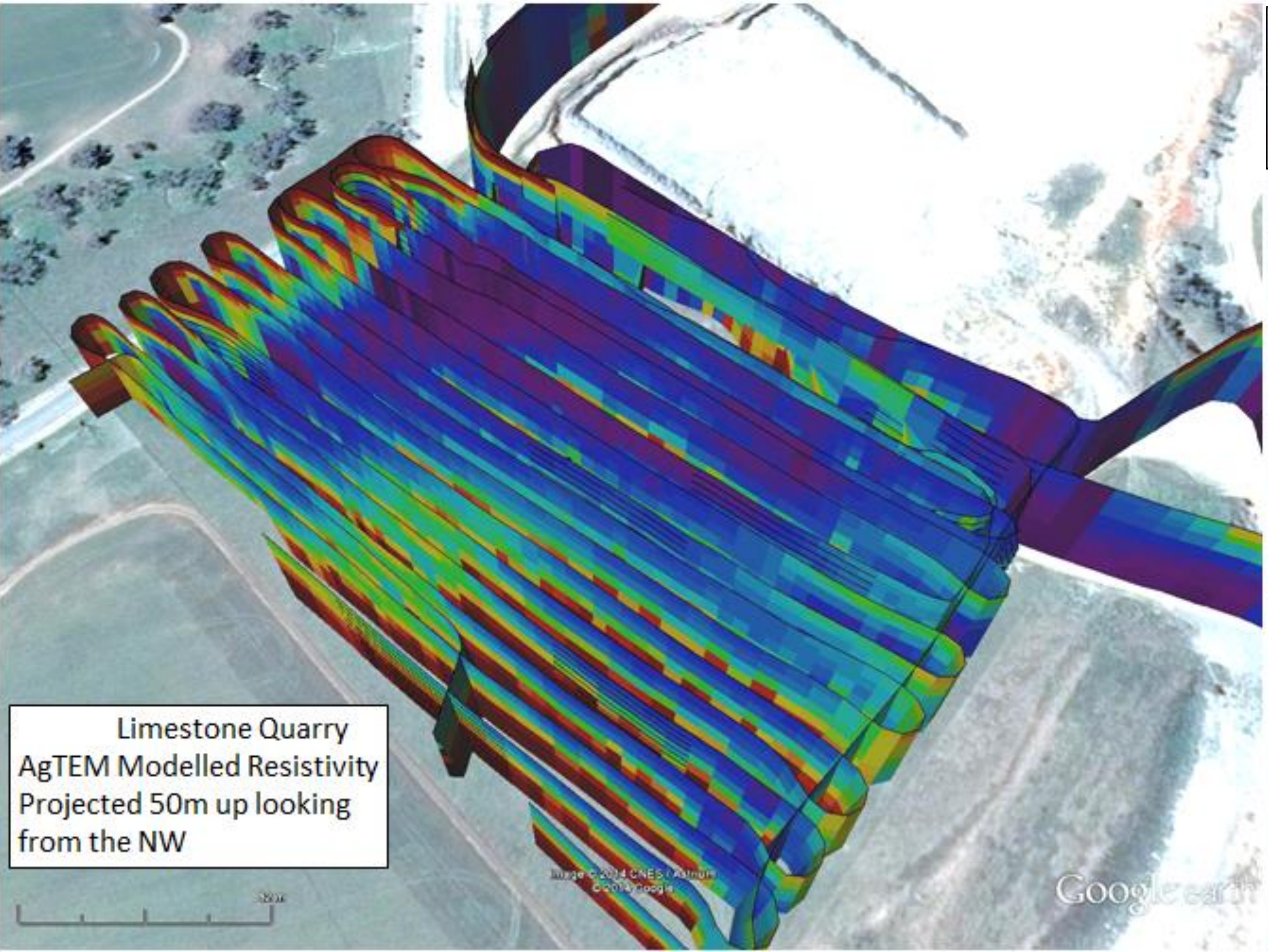
Gabbrodiorite dimension stone quarry

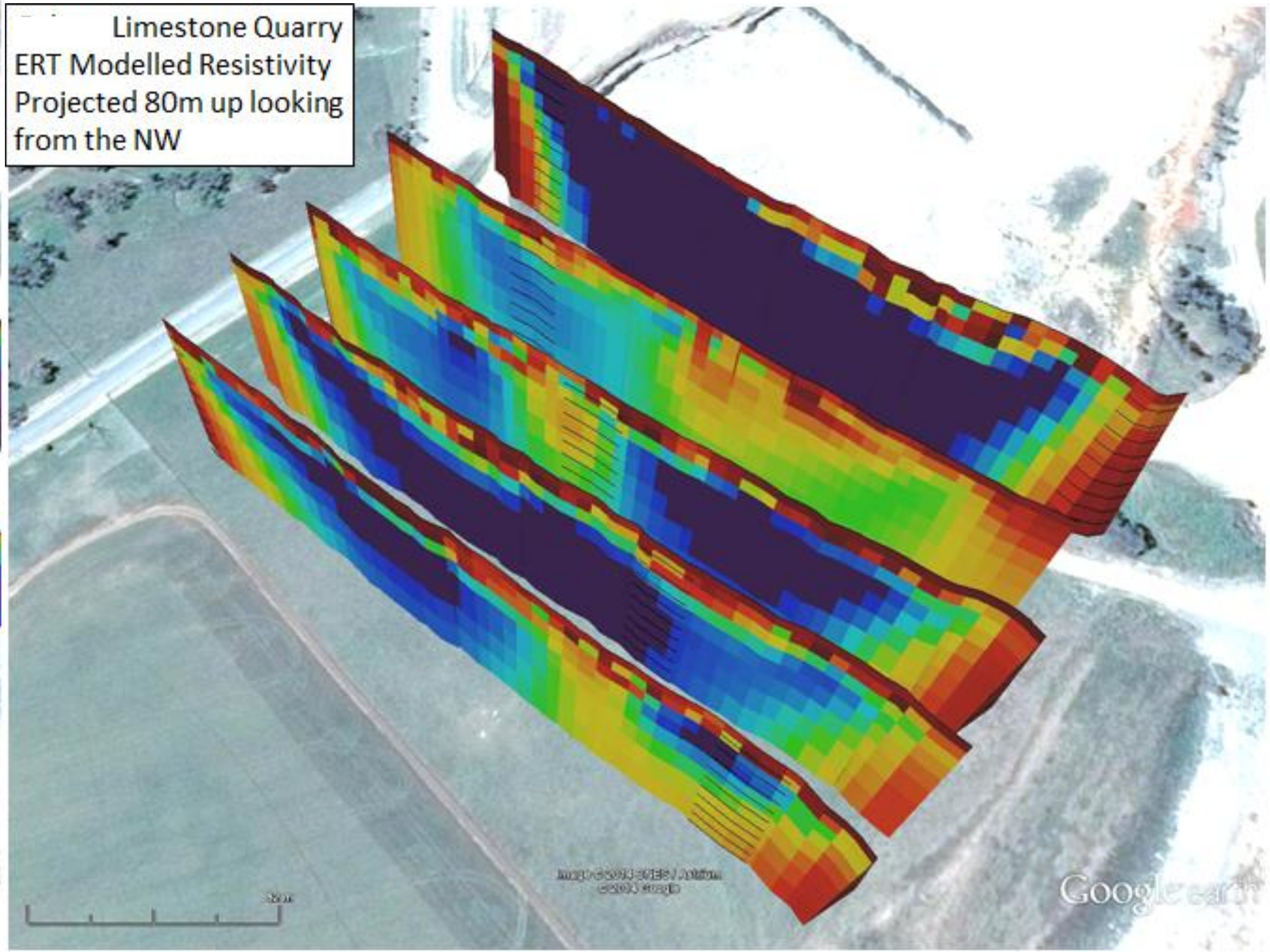




Limestone quarry blast pattern optimization

Three techniques were compared at one limestone quarry. AgTEM data provided the most detail at least cost. Ground penetrating radar could not effectively penetrate beyond 1m at this site. AgTEM arrives on site – is set up in less than 2 hours and surveys.

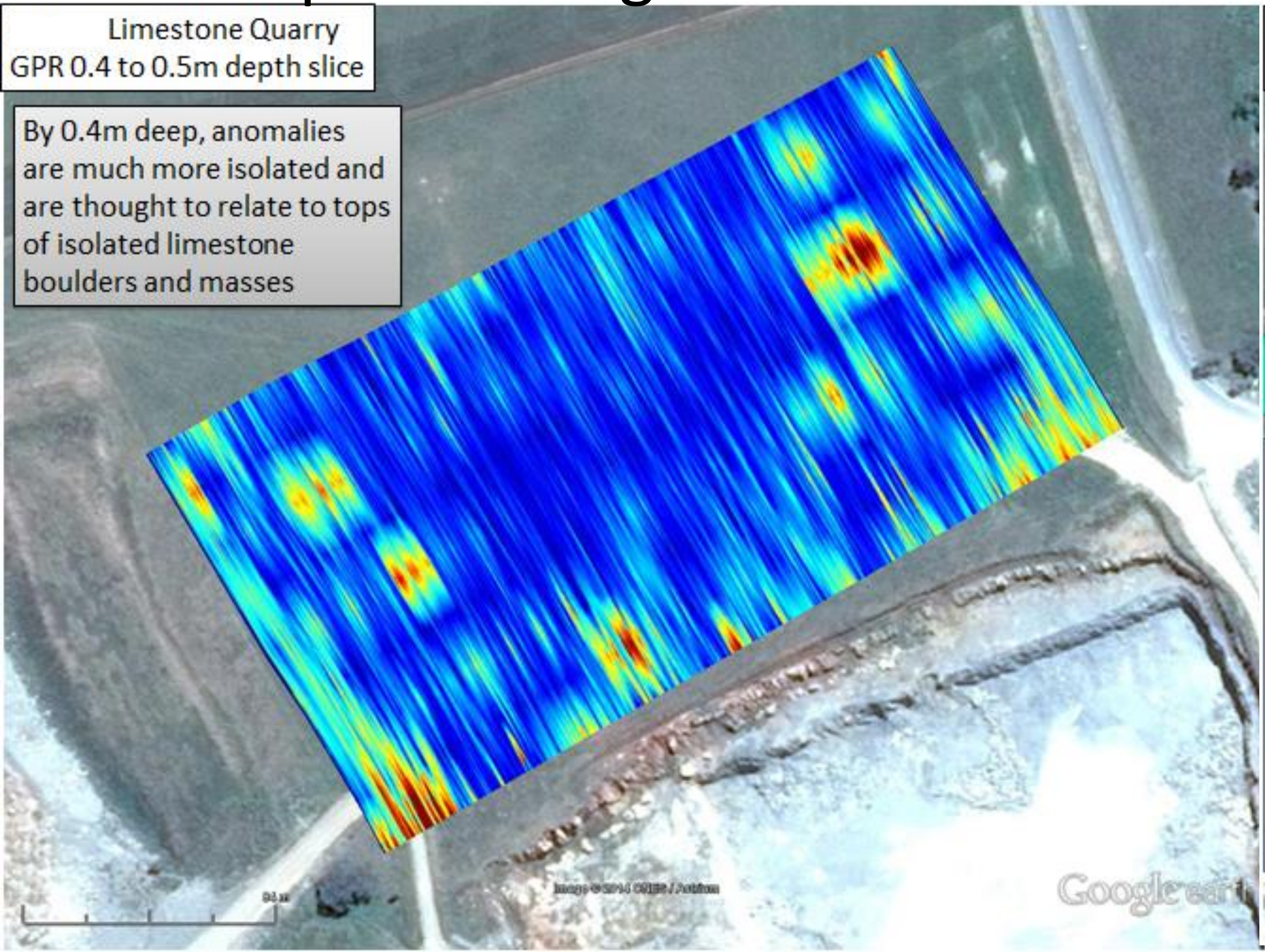




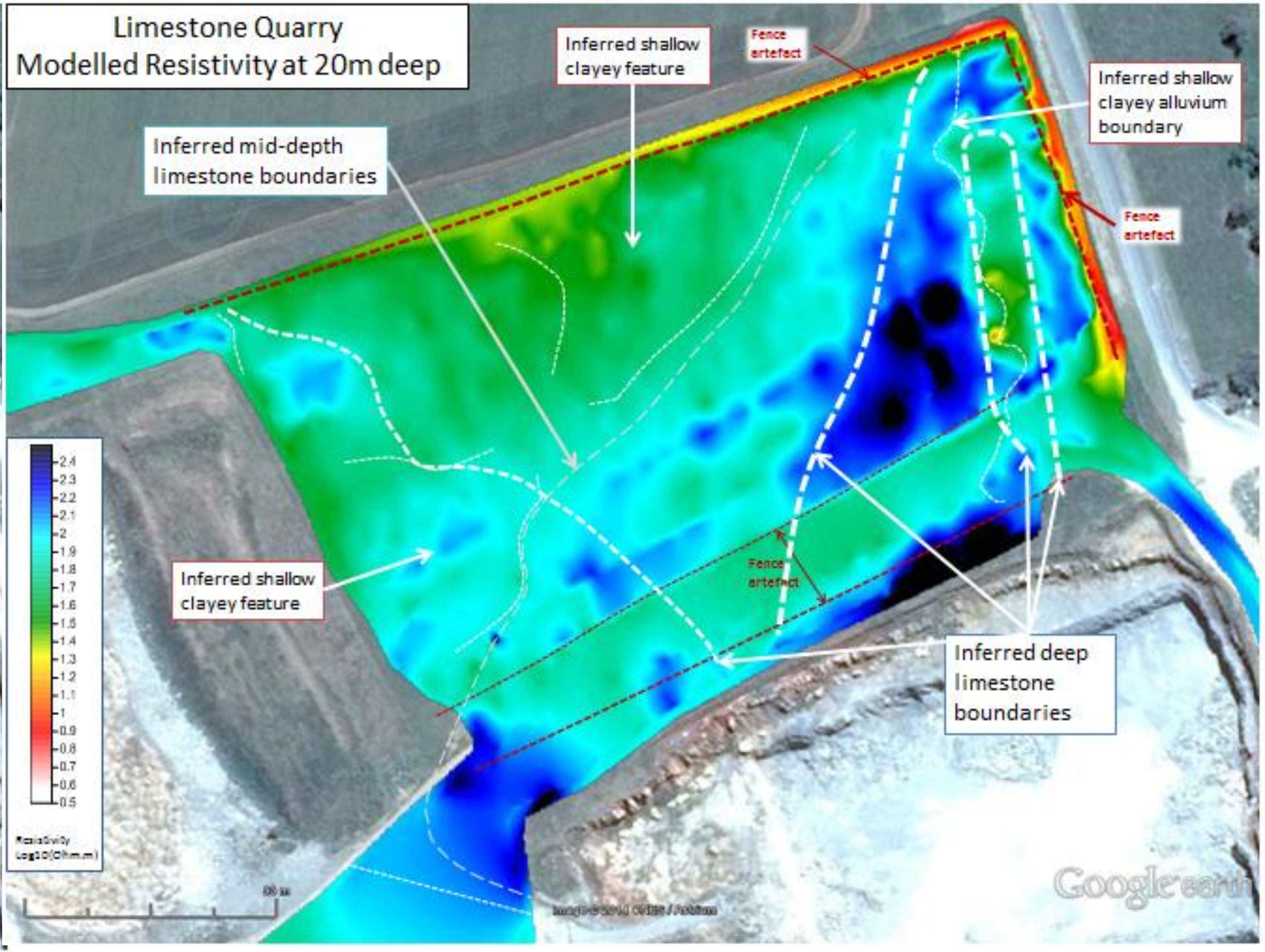
Limestone quarry blast pattern optimization

Soil and rock moisture content and salinity are generally related to rock competency and soil properties. These properties are strongly proportional to earth electrical resistivity which is mapped, in 3D by AgTEM cart.

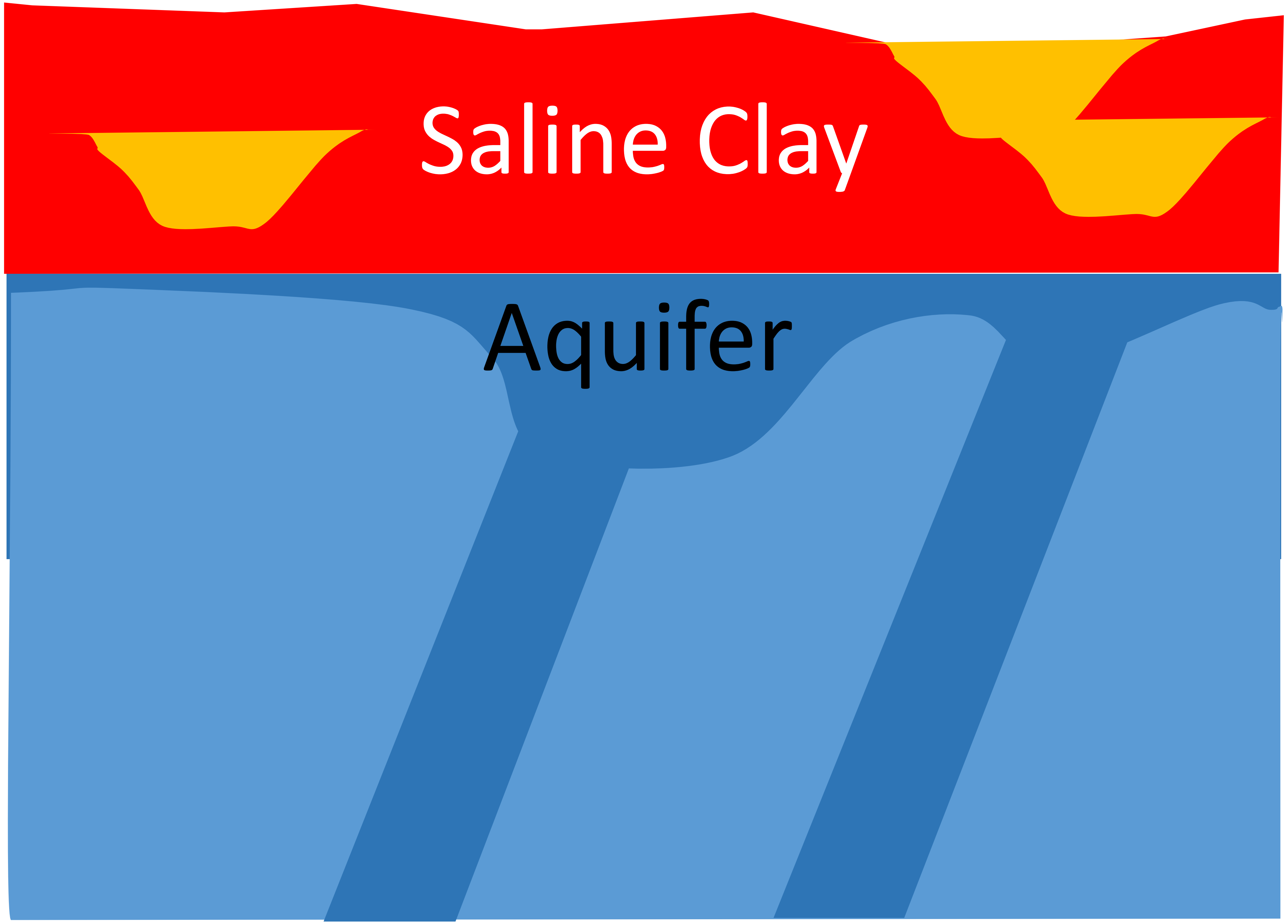
Ground penetrating Radar 250MHz

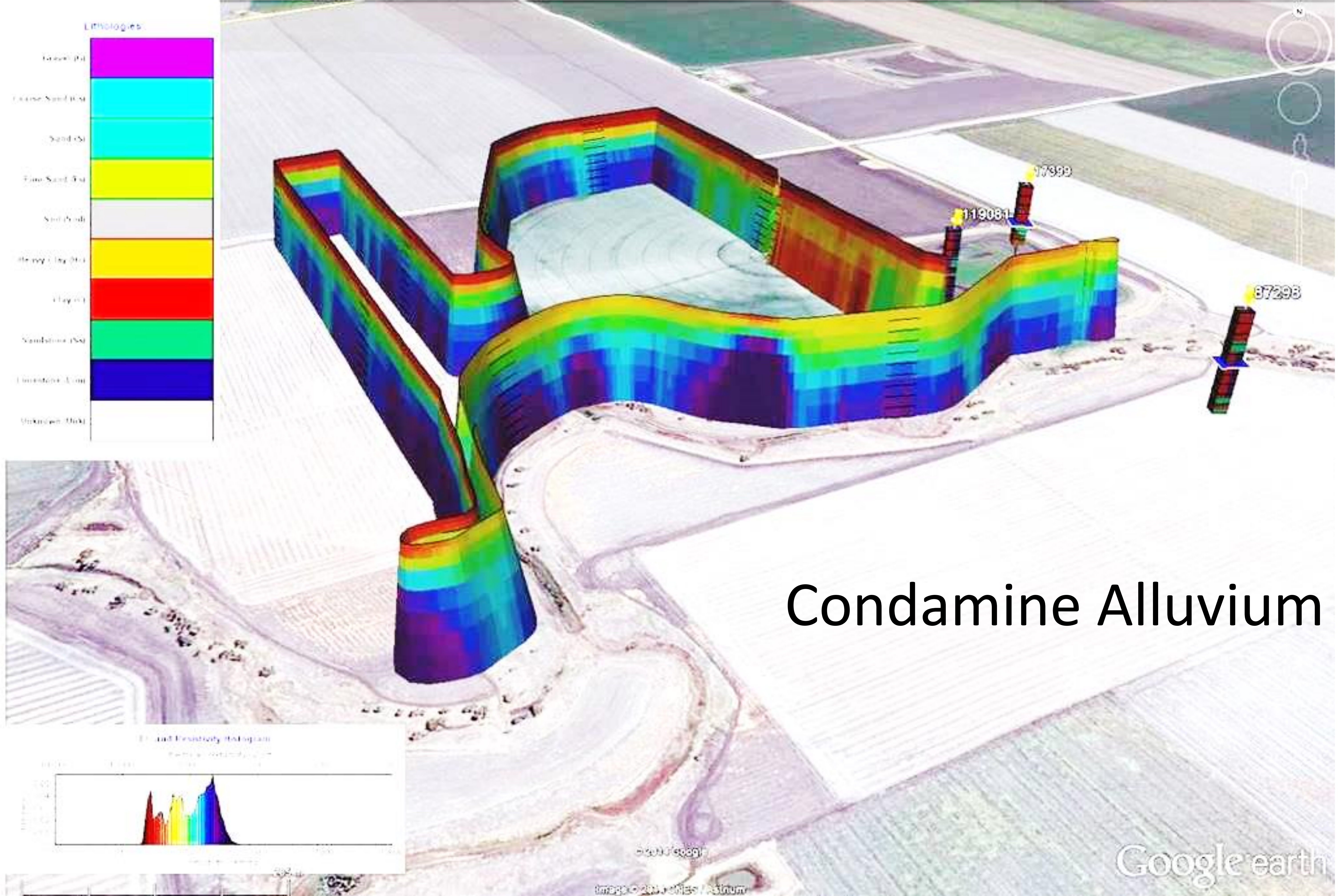


AgTEM Single Turn Transmitter Loop



7





Condamine Alluvium

Logistical challenges

Booms held rigidly in position yield and retract, rebounding elastically when released.


GROUNDWATER

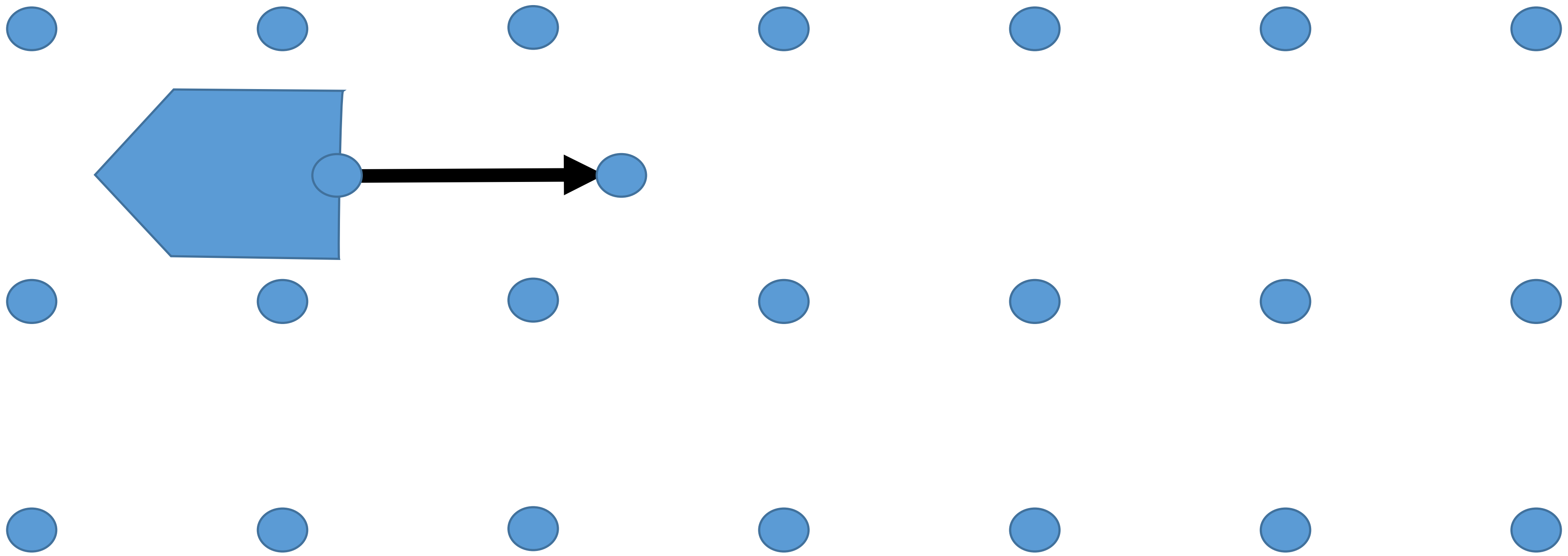

GROUNDWATER
BN 30 NZ

For optimal coupling with deep conductors.
AgTEM 3D Geological mapping & Mineral Exploration

High power focused mobile TEM transmitter
3 component enhancement is feasible.

+

Distributed and/or independently mobile receivers oriented and located



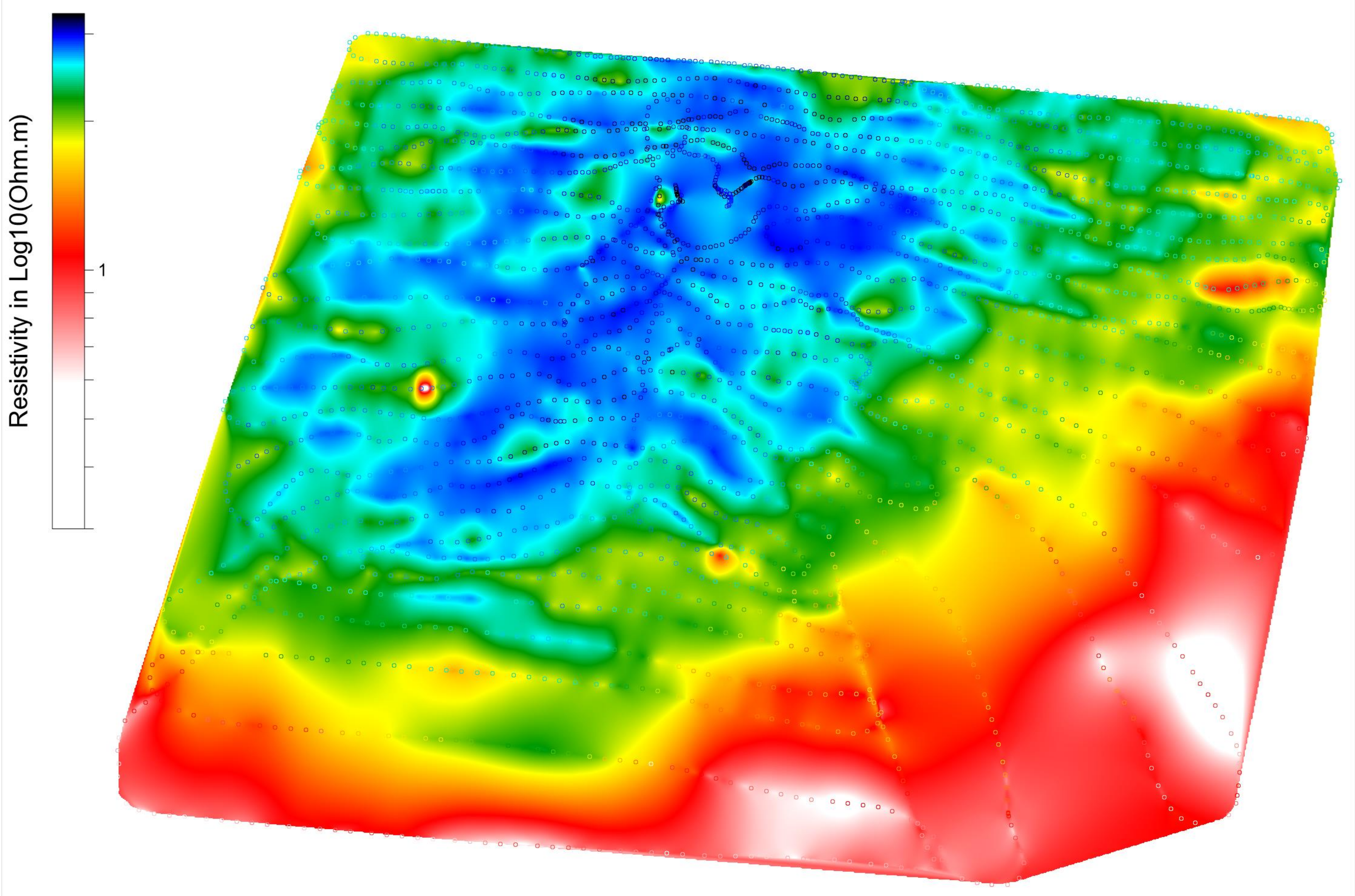
+ 3D Inversion. conductivity and IP

Conclusions

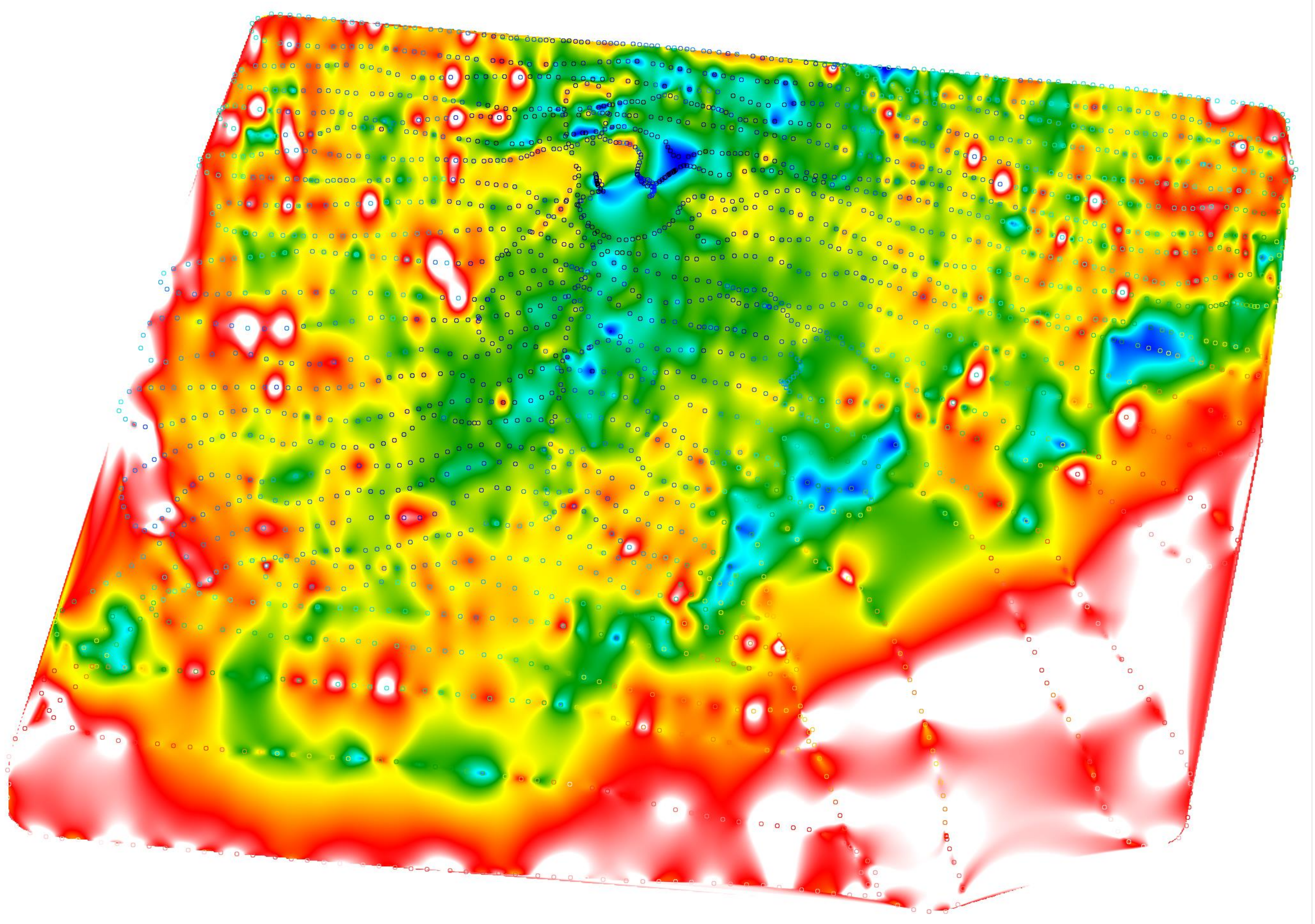
- Textbook examples of resistivity images of aquifers may make hydro-geophysics look easy but in practice ambiguity and complexity is usually encountered.
- The best way to resolve ambiguity and complexity is to collect data in more detail over a wider area.
- Assuming a simple groundwater conceptual model and conducting just enough geophysics to detect geology fitting that model is fraught with danger. It is better to obtain detailed geophysics.
- Designing a ground-based mobile TEM system is not as easy as it may seem.

Comparison of Nulled Rx and Slingram data

Modelled Resistivity at 36m deep at a resistive site. Line spacing is 20m



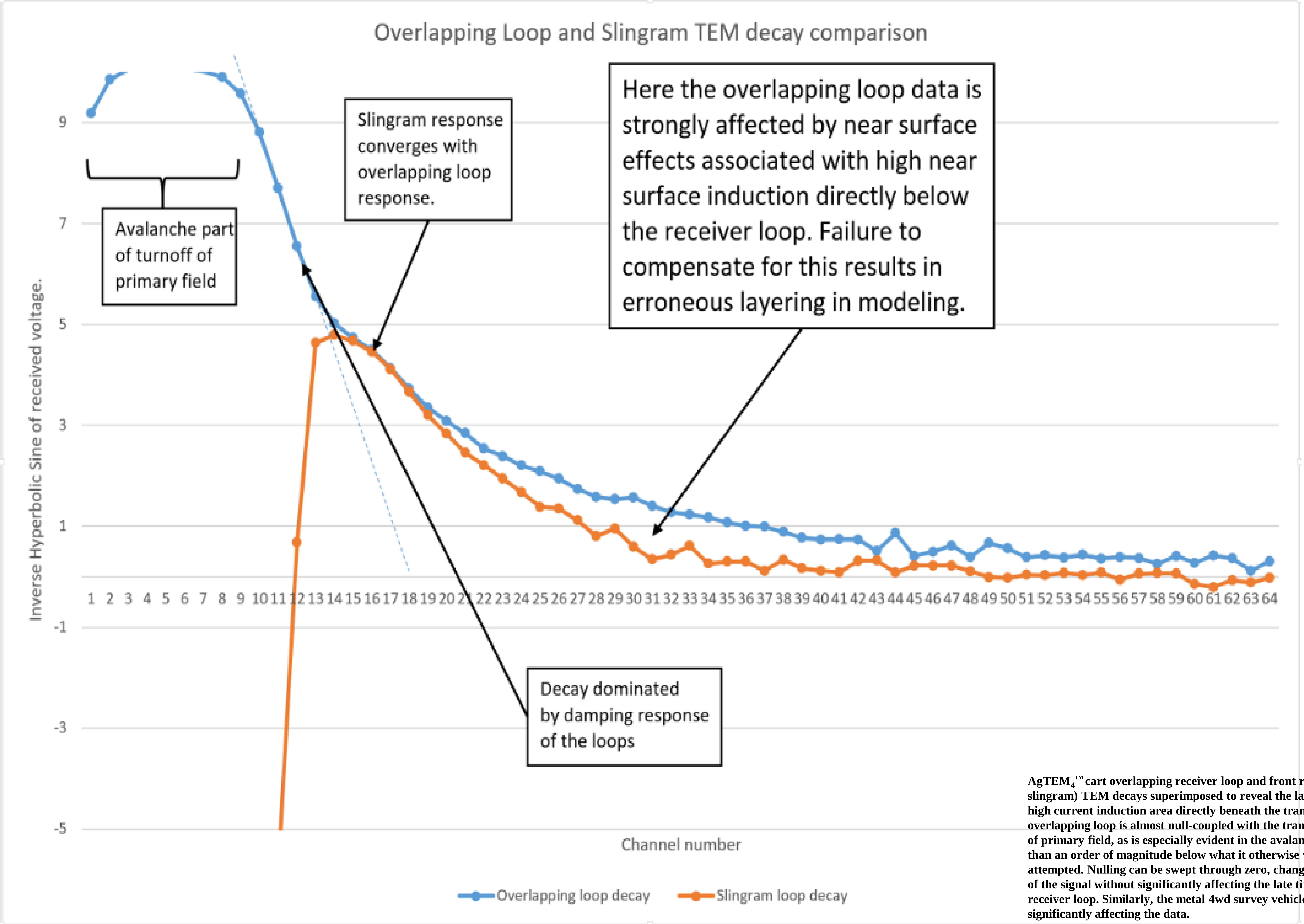
Slingram Data – 18m Tx-Rx separation



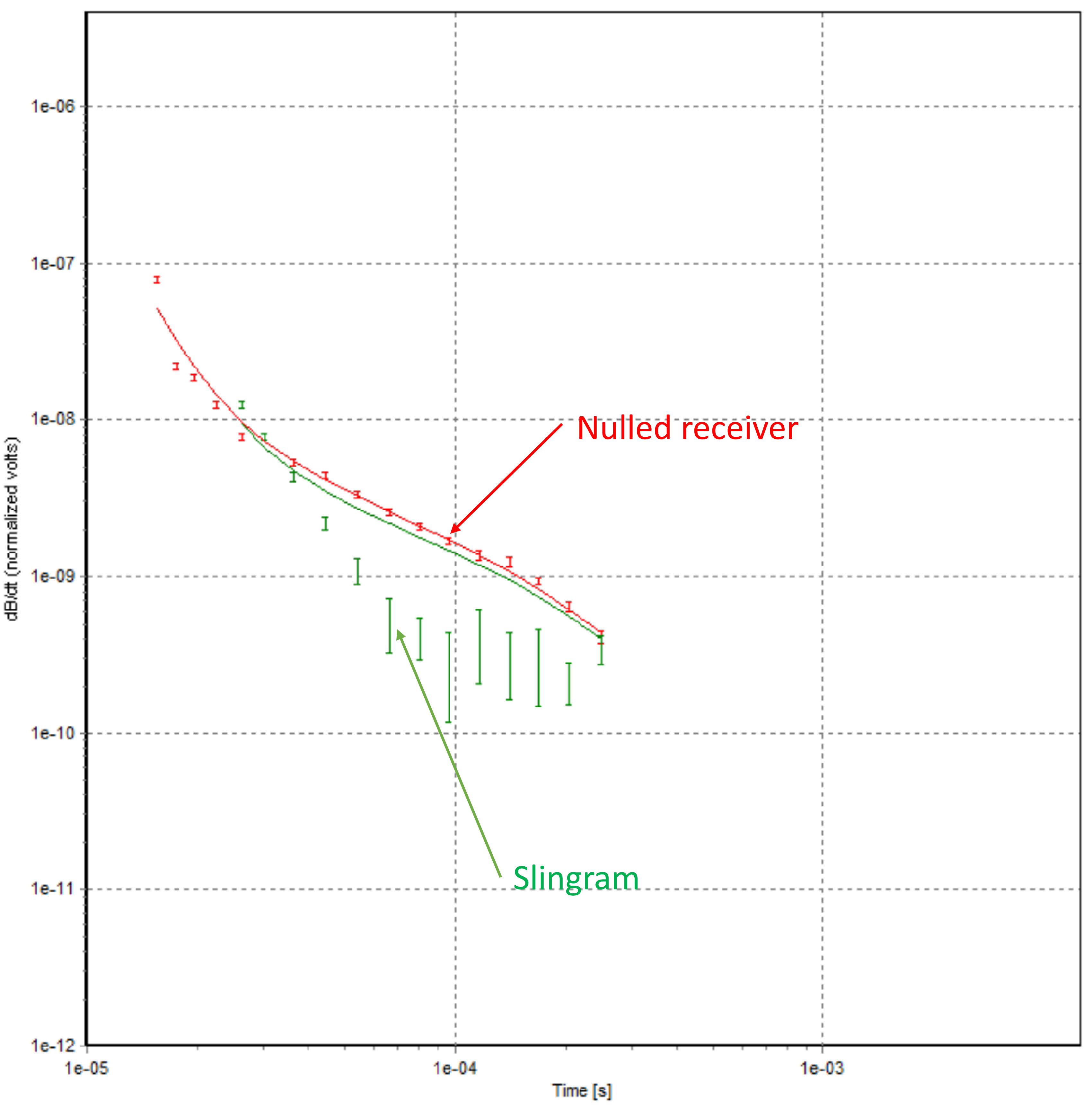
In-loop data – 6 x 6m tx loop

Gabbodiorite dimension stone quarry

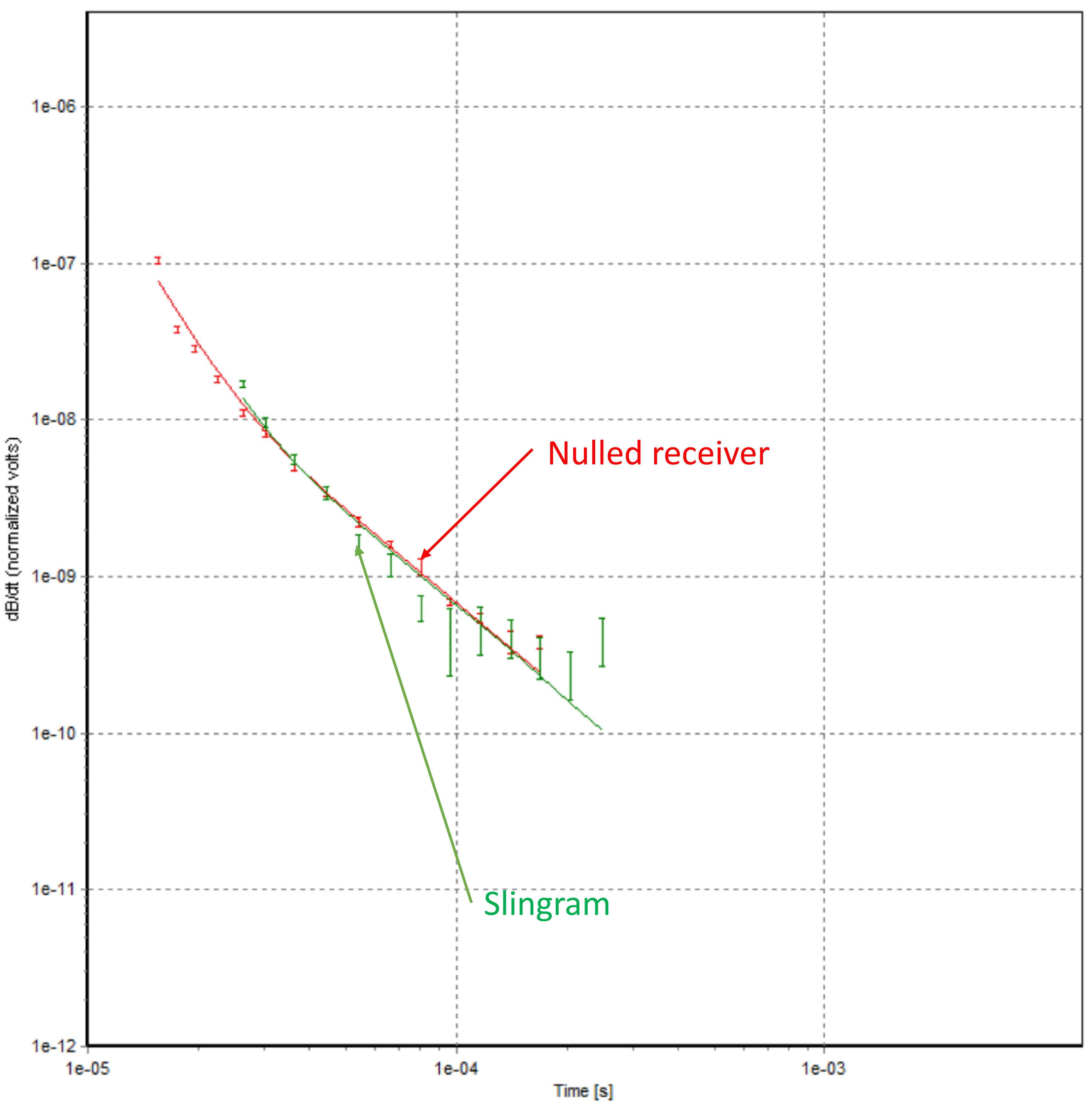
Signal contribution distribution is very different between slingram, which lacks shallow contribution, and nulled-Rx, which has very focused and intense shallow contribution.



AgTEM$_4$™ cart overlapping receiver loop and front receiver loop (17m separation slingram) TEM decays superimposed to reveal the late time effects of behaviour in the high current induction area directly beneath the transmitter loop. Note that the overlapping loop is almost null-coupled with the transmitter loop so that direct pickup of primary field, as is especially evident in the avalanche portion of the decay, is more than an order of magnitude below what it otherwise would be if null-coupling was not attempted. Nulling can be swept through zero, changing the sign of the avalanche part of the signal without significantly affecting the late time data detected by either receiver loop. Similarly, the metal 4wd survey vehicle can be removed without significantly affecting the data.



Nulled receiver
Slingram
dB/dt (normalized volts)
1e-06
1e-07
1e-08
1e-09
1e-10
1e-11
1e-12
1e-05
1e-04
1e-03
Time [s]



Nulled receiver
Slingram
dB/dt (normalized volts)
1e-06
1e-07
1e-08
1e-09
1e-10
1e-11
1e-12
1e-05
1e-04
1e-03
Time [s]


BN 30 NZ


BN 30 NZ