



MEMORANDUM

To: Josh Denholm

Date: 28 Nov 2022

Copy:

From: Kelly Vaughan–Taylor, Kate Hine, Nick Direen and Bismah Akhtar

Subject: TH007– DHEM , EL 28/1988 Trial Harbour, Tasmania

Summary

Fender Geophysics conducted a DHEM survey of TH007 in March 2022. TH007 shows a broad response typical of a large source beyond the end of the hole. This response has been modelled using two south–west dipping plates called TH007_EOH_15S and TH007_EOH_50S. While both these models are large, they are only moderate conductors. While they may be massive sulphides, we cannot rule out that they are graphitic shale or possibly coastal seawater incursion. They do, however, appear to lie within the Cambrian serpentinite. The VTEM appears to be responding to the same zone, but for the VTEM the relevant models are called 'seawater.dxf' and 'background.dxf'.

The downhole results are in good agreement with results from the 2011 VTEM survey. The results also correlate well with the resistivity results from the 2022 PDIP in the same area.

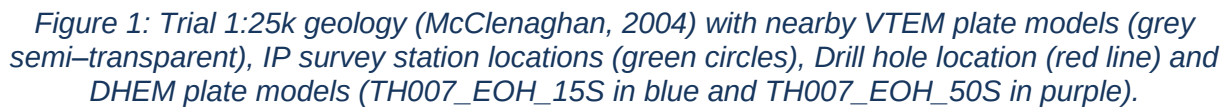


1 Introduction

In 2022, Fender Geophysics was commissioned by Avebury Mining Pty Ltd to conduct a down-hole electromagnetic (DHEM) survey on drillhole TH007 in EL 28/1988 at Trial Harbour, Tasmania. This project lies ~10km west of Zeehan, Tasmania, and about 5 km WSW of the Avebury mine. A Pole-Dipole Induced Polarisation (PDIP) survey was also carried out (Hine and Vaughan-Taylor, 2022); however, it is the DHEM results are the focus of this report. Importantly, as will be discussed later, the area was also covered with a helicopter-borne EM (VTEM) survey in 2011. This older dataset has direct relevance to the DHEM and was integrated into our DHEM modelling. The DHEM led to a more thorough review of all of the VTEM data (over 89 anomalies were identified in the VTEM data, and the results of the modelling of that data are reported in the accompanying Mitre_plate_model_summary.pptx).

While EL 28/1988 has many drillholes, particularly collared in units closer to the Avebury mine, this region has surprisingly little DHEM or surface EM. This is presumably not because the target isn't conductive: in the literature review stage of this project, we found a report by (Asten (1999) which showed that the Avebury NiS mineralisation gives a good response to EM, with estimated conductances of 2000S. Instead, most of the drillholes in the area appear to have been targeted on magnetic anomalies. Magnetite is associated with mineralisation (Newnham, 1999), but it is also extremely common in the serpentinites without significant sulphide mineralisation e.g. Leaman and Webster (2002).

TH007 was designed to test for massive Ni sulphide mineralisation hosted in the serpentinitised ultramafic rocks some 5km WSW of the Avebury deposit. This diamond drillhole was collared on a massive quartz body that is likely due to silicification of the fault contact between sedimentary units of the NPrz Crimson Creek Formation (€cwts) to the SW of the collar, and Cambrian serpentinitised dunite and harzburgite (€sd) to the NE of the collar (see Figure 1). Previous magnetic modelling by Mitre (Hine and Direen, 2021) shows the fault contact likely dips shallowly to the SW.





2 TH007 DHEM survey details

Date: 11–12 March 2022
Contractor: Fender Geophysics
Collar Location: 350197mE 5355905mN; 100mASL
Projection system: GDA94 MGA zone 55
Hole Azimuth, Dip, Depth: 360°, 70.0° TN, 278.4m
Tx Current: 56.1– 60.2A (Loop1) and 52.3– 56.4A (Loop2)
Components: AUV
Frequency: 1Hz
Transmitter: Modified Zonge ZT30
Receiver: DigiAtlantis
Probe: Digi–Atlantis #115
Stacks: 128 – 256
Surveyed Interval: 5–275.1m
Units: pT/A
Channels: 36 channels over the interval 0.087msec to 218.259msec
Loop: Loop1, 500x400m (see Direen (2022) **Error! Reference source not found.**)
Loop Corner Coordinates: 350128mE 5356223mN 82mASL; 350486mE 5356041mN 70mASL; 350259mE 5355568mN 80mASL; 349909mE 5355780mN 110mASL
Loop: Loop2, 400x400m (Figure 2)
Loop Corner Coordinates: 350128mE 5356223mN 82mASL; 350486mE 5356041mN 70mASL; 350311mE 5355689mN 95mASL; 349950mE 5355860mN 102mASL

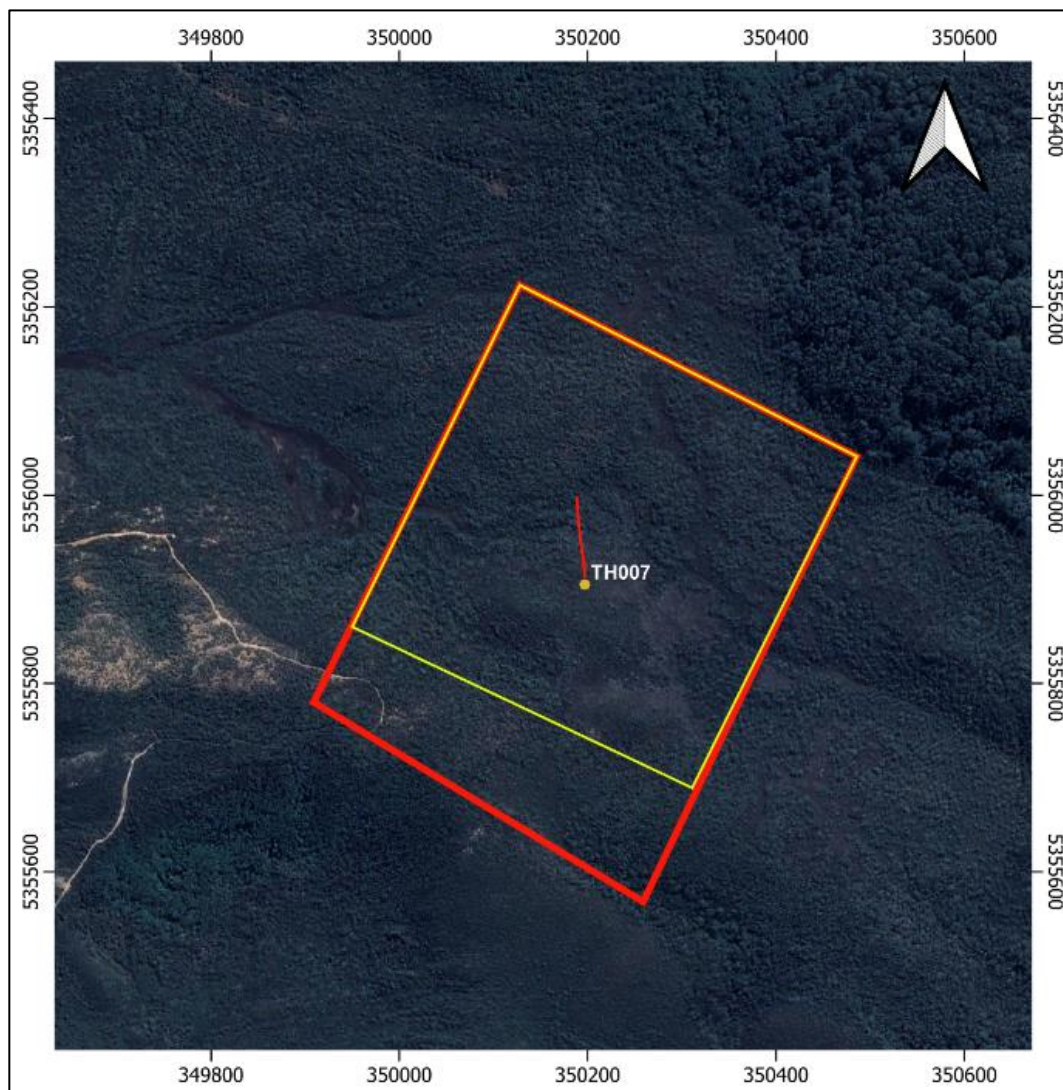


Figure 2: Map showing loops (Loop1 in red and Loop2 in yellow) and hole location.



3 DHEM data

The DHEM profiles are provided in Appendix 1.

Data from the first ~90m of the drill hole has been removed because they are inside steel casing (see Figure 3). DHEM cannot 'see' through metal casing or abandoned drill rods.

For both loops, the DHEM shows a broad response typical of a large source beyond the end of the hole.

- The axial A component is increasing in amplitude with depth, primarily in the early to mid-time channels (up to 17msec)
- The U component trends from positive toward a negative response, up to 17 msec.
- The V component is increasingly negative with depth.

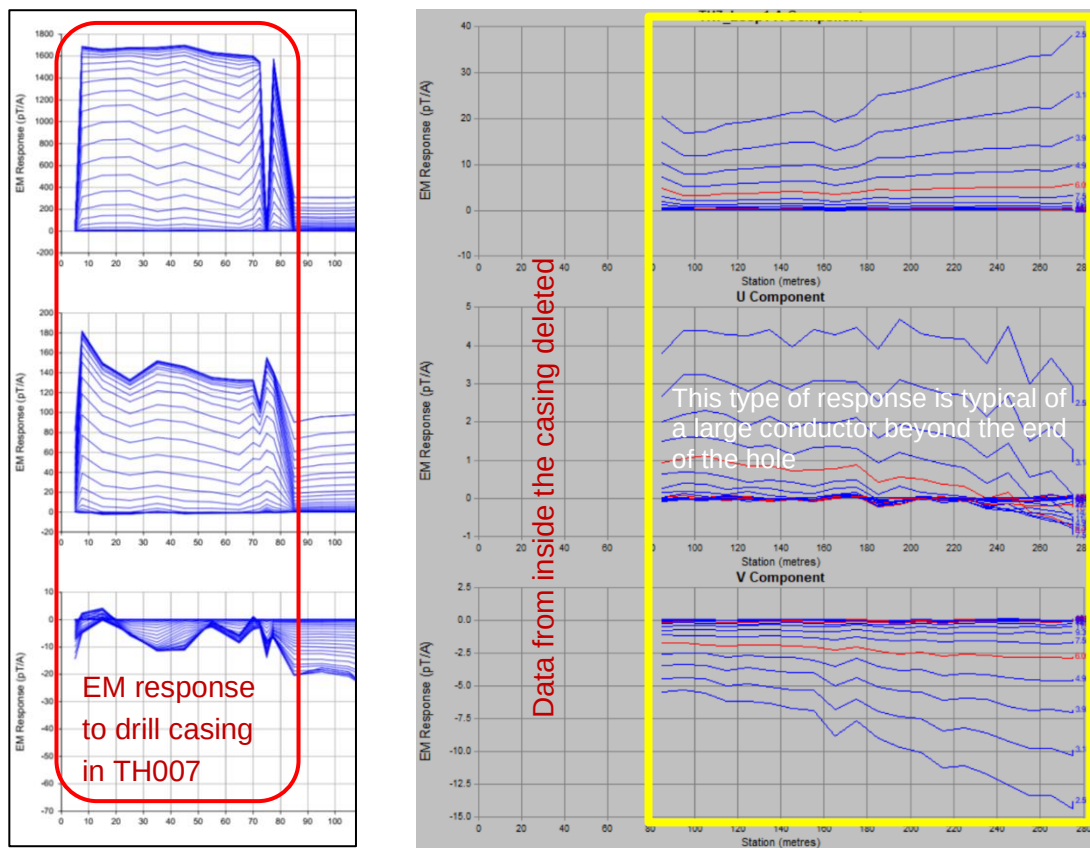


Figure 3: DHEM data from TH007 (Loop1). The red box highlights the strong EM response due to stuck steel casing in the hole.



1.1 DHEM modelling

The TH007 DHEM response was modelled as two large conductors, [TH007_EOH_15S.dxf](#) and [TH007_EOH_50S.dxf](#). Both these models are dipping southwest. TH007_EOH_15S is 1000x300m (strike length by depth extent) and TH007_EOH_50S is 400x400m. While large, these models are only moderately conductive, 15S and 50S respectively. This type of large, strike extensive, moderate conductor could either be sulphides or graphitic shale. It has not been intersected by the drill hole. Figure 5 shows the models in 3D w.r.t. the drill hole.

Both models are well fitted to the EM response (see Figure 4) and lie about 100m beyond the end of TH007. However, the strike length/depth extent of both conductors are essentially unconstrained. In other words, they could be much bigger and still fit the data. The dip/strike is also only loosely constrained. It is probably 'not steep', but that is about all we can determine.

Overall, the size and shape of this EM anomaly suggests a large, moderate to weakly conductive, stratigraphic conductor such as graphitic shale or coastal seawater incursion into an aquifer, 50–100m beyond the end of TH007. There is a reasonable chance that extending TH007 would test the conductor, but we are not sure if this would be worthwhile given the above.

X	Y	Z	S
TH007_EOH_15S			
350569.47	5355840.12	-233.8094	15
349710.53	5356339.88	-122.1906	15
349575.79	5356150.72	-312.0972	15
350434.73	5355650.96	-423.7161	15
350569.47	5355840.12	-233.8094	15
TH007_EOH_50S			
350373.83	5356035.28	-125	50
350046.17	5356264.72	-125	50
349858.23	5355996.31	-354.4306	50
350185.89	5355766.88	-354.4306	50
350373.83	5356035.28	-125	50

Table 1: Corners of each plate model in MGA55 coordinates



TH007 DHEM MEMO

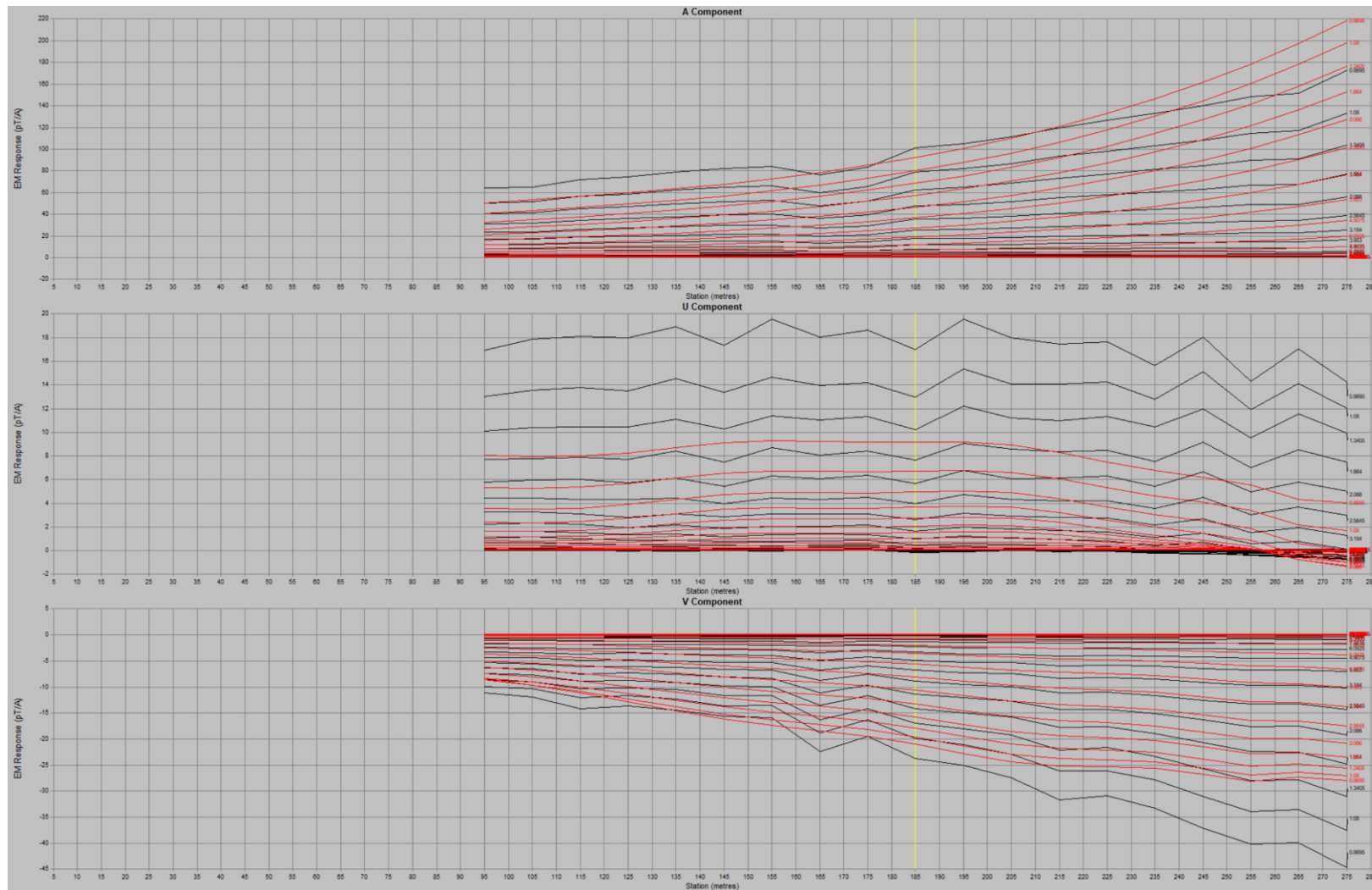


Figure 4: EM profiles show the actual EM response (black) and calculated EM response (red) for A, U and V component. Beginning of response has been deleted due to the response from the steel casing.

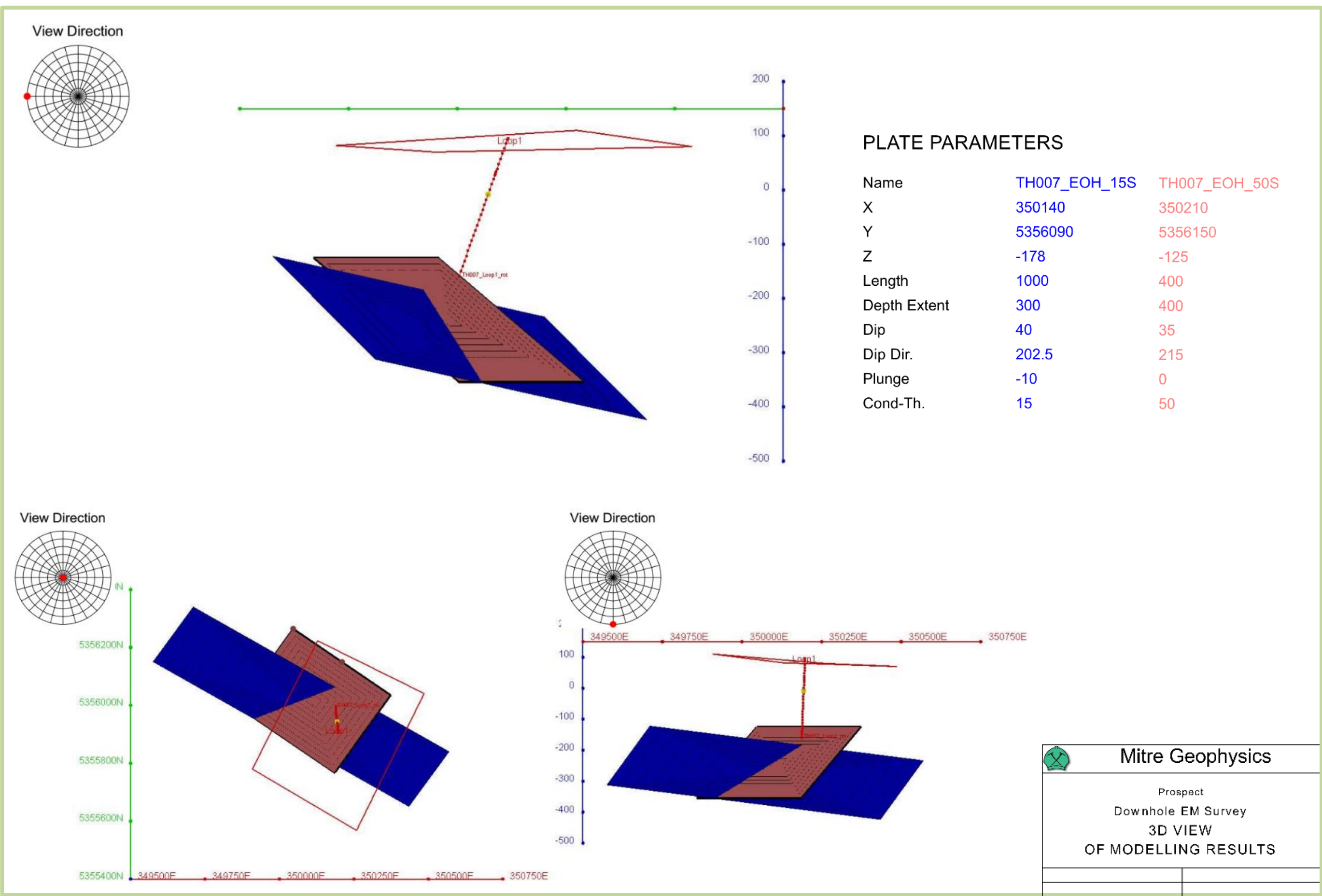


Figure 5: TH007 DHEM plate models for TH007_EOH_15S (blue) and TH007_EOH_50S (peach).



1.2 Comparison with the VTEM modelling

In 2011, Geotech Airborne flew a VTEM survey in the Avebury area (see figure below) (Geotech Airborne Pty Ltd., 2011). Mitre Geophysics reviewed this data in 2022, identifying and modelling 89 anomalies (see Mitre_plate_model_summary.pptx).

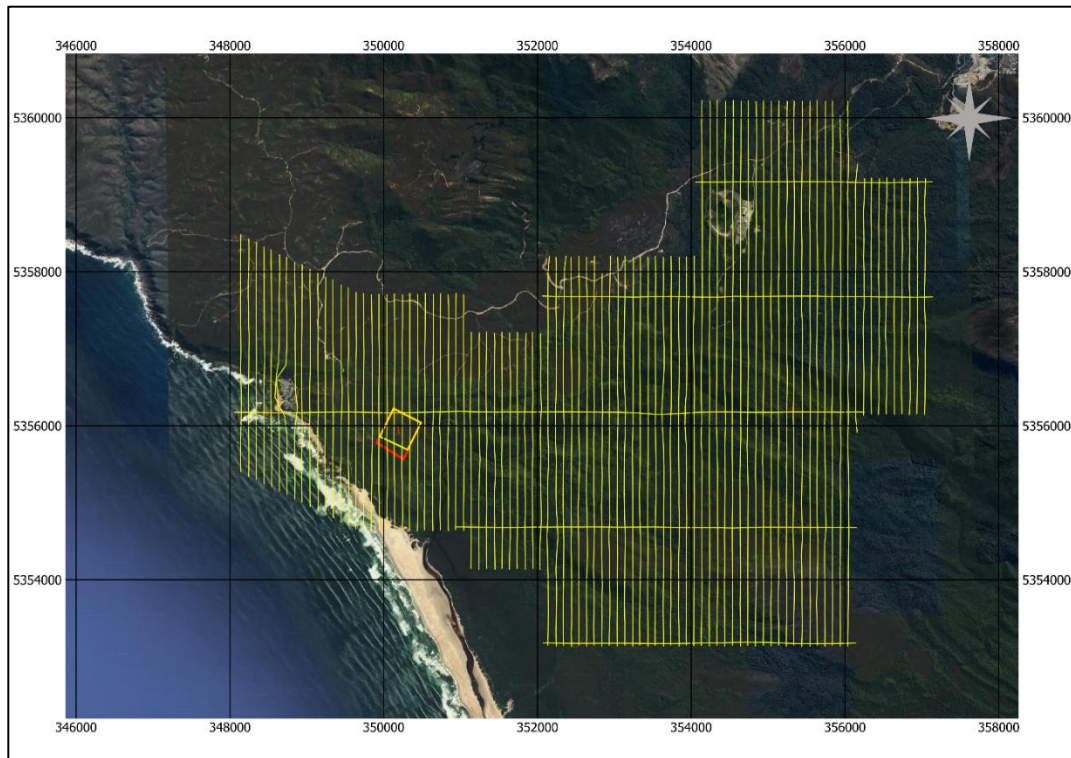


Figure 6: Flight path for Avebury 2011 VTEM survey. Also depicts DHEM TH007 loop 1 (red) and loop 2 (yellow).

Of these conductors, several overlap the DHEM models (see Figure 7). The two most relevant are “Background.dxf” and “seawater.dxf” (the latter may be mis-named because, in hindsight, there is currently no definitive reason to conclude that it is seawater). There is excellent agreement between TH007_EOH_50S.dxf and the VTEM “seawater.dxf” model (at least as much as can be expected from older airborne EM and modern DHEM). There is also good agreement between TH007_EOH_15S and “Background.dxf”. The differences between the models are as expected given the different resolutions of downhole and airborne EM. Note that, because neither survey has completely mapped the anomalies (for the VTEM they were too deep, and for the DHEM, the hole was too short), even by incorporating the VTEM, the orientation and size of these sources is only very loosely defined.

In the VTEM modelling, “seawater.dxf” was thought, originally, to reflect saltwater incursion into an aquifer beneath Trial Harbour. Such anomalies are relatively common in coastal areas, and can penetrate up to 10km inland e.g. (Annetts et al., 2017; Gilgallon and McGivern, 2018; Siemon et al., 2001; Viezzoli et al., 2010). However, this concept is only one possibility, because the source was too deep to be well resolved. It is of note that the DHEM suggests a more discrete conductor rather than the broad diffuse response identified by the AEM.



Note that there is a third, very small, shallow conductor detected in the VTEM near the collar of TH007. The model for this is C46_L210_100S.dxf. The drill rods / casing, which adversely affected the first 95m of data, prevented any chance of the DHEM detecting this conductor.

Logging of TH007 did note 1–5% sulphides in three intervals between 96–120 m, which comprised vein pyrrhotite–pentlandite + magnetite (96–100m), pyrrhotite blebs (102–110m) and blebby pyrrhotite + vein magnetite (111–122m); although no in-hole conductor appears to have been detected, it is conceivable that the shallow VTEM conductor may be related to these sulphides.

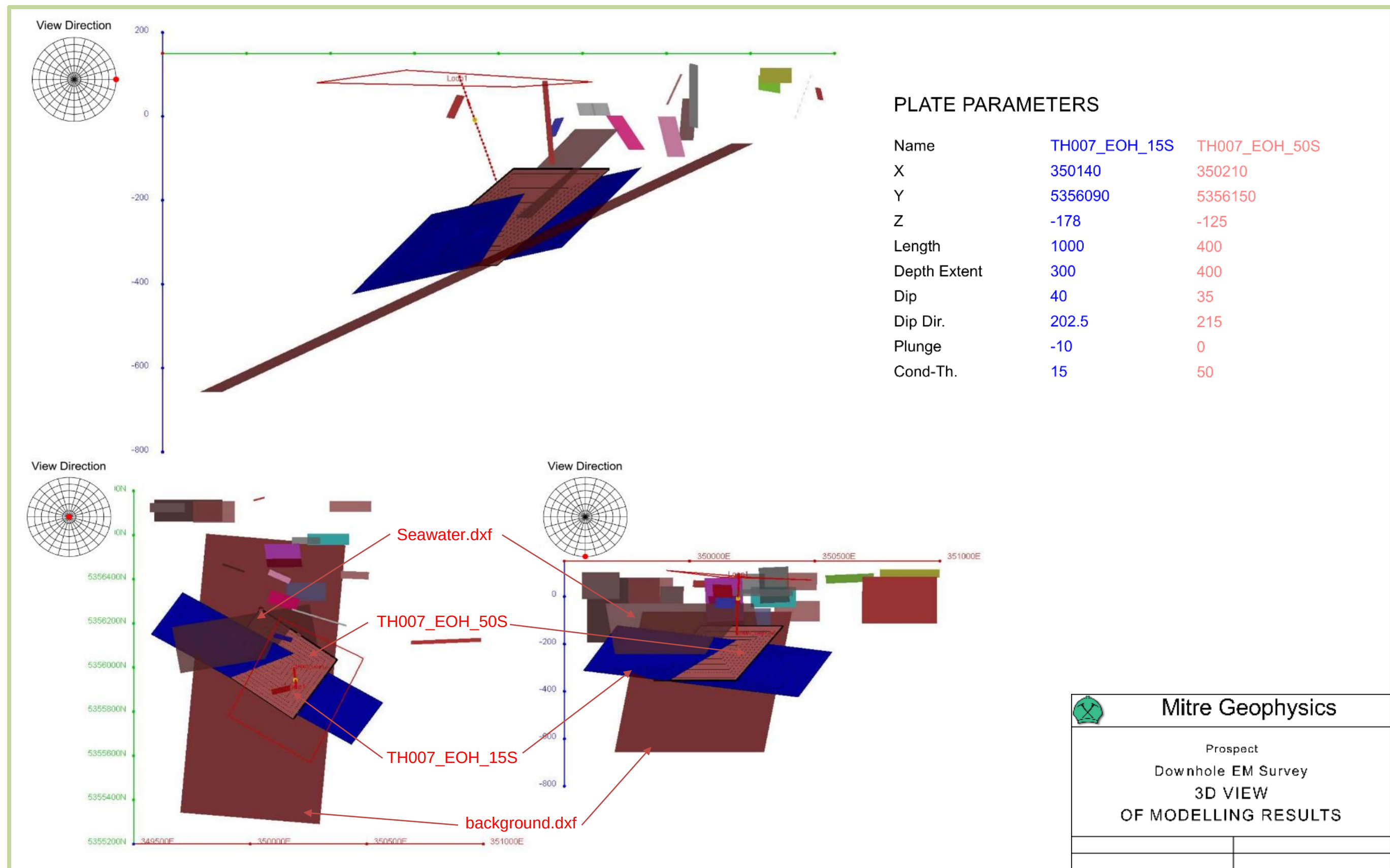


Figure 7: TH007 DHEM and 2011 Avebury VTEM plate models.



1.3 Comparisaton with pole–dipole IP results

The 2022 PDIP survey (Hine and Vaughan-Taylor, 2022) comprised four SSW–NNE oriented lines of 1100m to 1200m length. Line 1200E passes through the collar position of TH007.

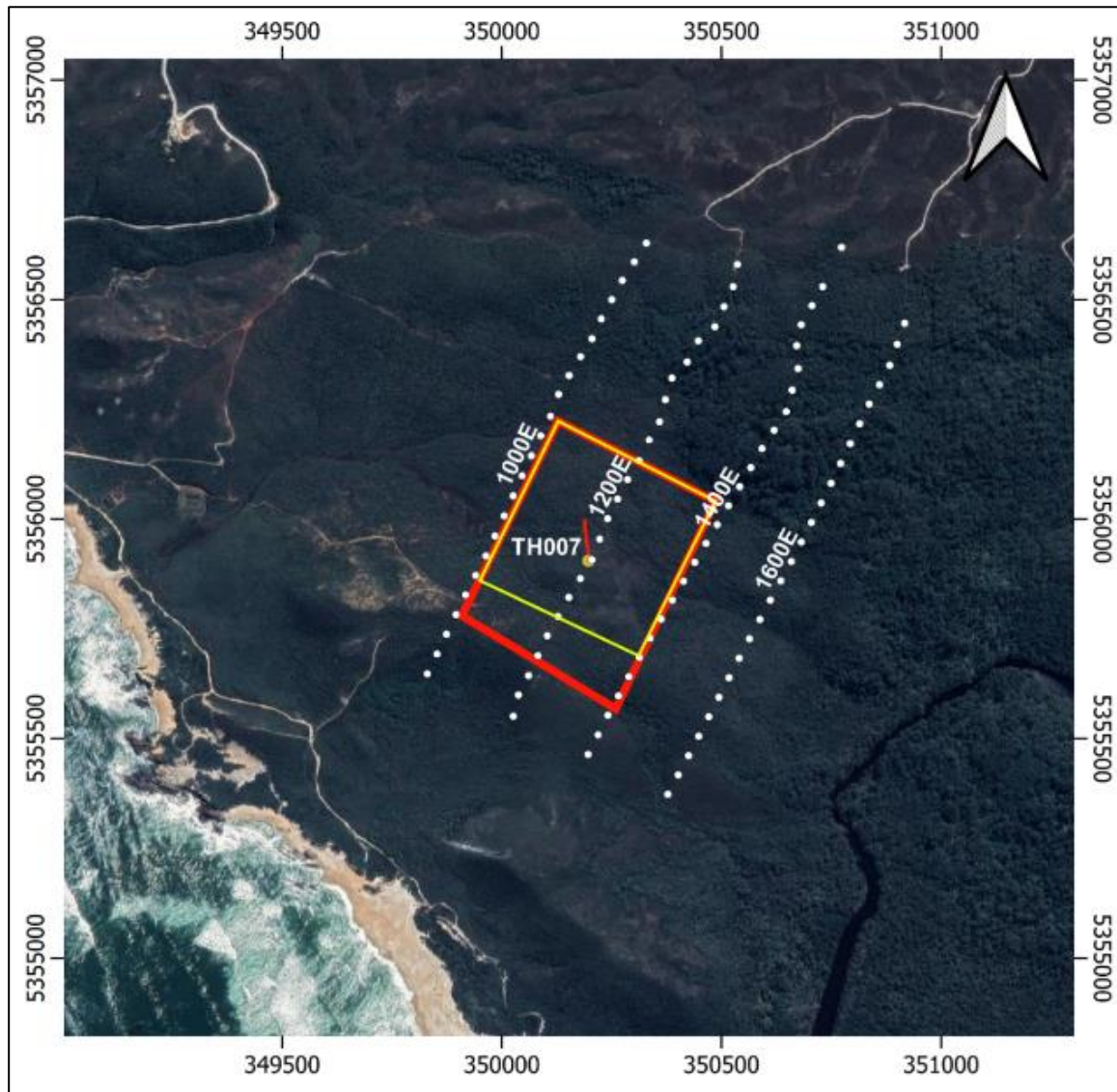


Figure 8: PDIP survey stations (white dots). Also included is TH007 drill hole (red line) and corresponding DHEM loops (Loop1=red, Loop2=yellow)

The DC resistivity results show low resistivity zones (note that low resistivity = high conductivity) that correlate well with the VTEM and DHEM models (see Figure 9). The two plates of relevance to this report, TH007_EOH_15S, TH007_EOH_50S (and their VTEM model equivalents, “Background.dxf” and “seawater.dxf”) are a <10 ohm.m low resistivity zone on line 1000E and 1200E at 5356200mN, at about 200–300m below surface. Unfortunately, DC resistivity has very low resolution at depth, and thus is unable to indicate which of the various EM models is more accurate.



These conductors do not, however, appear to generate a chargeability response on the two IP lines over them, namely line 1000E or 1200E. Graphitic shales and massive sulphides with disseminated haloes generally produce chargeability anomalies as well as conductivity anomalies. One explanation is that at 300m below surface, the conductors are indeed sea water; alternatively, the sulphide zone may be massive but does not have a big enough disseminated halo to be detected as a chargeable anomaly at this depth.

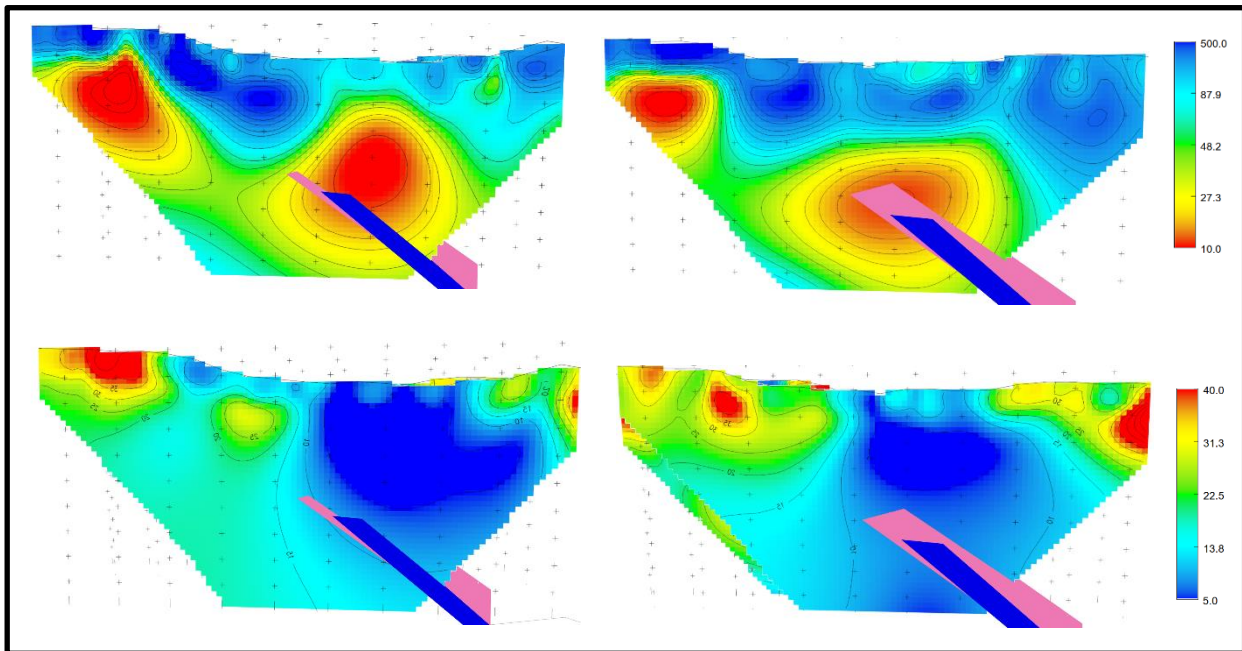


Figure 9: The DHEM conductors show a good correlation with a low resistivity (top– 1000E, 1200E) but no real chargeability anomaly (bottom– 1000E, 1200E). It is not clear if this is because they are too deep to be resolved or that the source is actually seawater.

The most impressive correlation is between the VTEM models and DC resistivity on the northern (and shallower) side of the IP survey. The VTEM plate models for Anomaly 34, 40 and 41 clearly coincide with strong, steeply dipping, low resistivity zones. Examples of this are shown in Figure 10 and Figure 11. Line 1600E is probably the clearest, with a very strong, narrow, vertical low resistivity zone coinciding exactly with VTEM model A34_L280_80S.

The correlation between VTEM models and chargeability is not so clear cut. We suspect that the chargeability model is being influenced by sources outside the survey area i.e. ‘end of line’ anomalies, particularly along the southern edge of the survey area, and also at the northern end of lines 1600E and 1400E. Lines 1600E and 1400E also show responses that, in our opinion, look like they are from sources to the north or east of the survey area. They do not correlate with the VTEM, and they also do not correlate with the resistivity. This type of ‘high res, high charge’ typically indicates off-line effects contaminating the edges of the model.

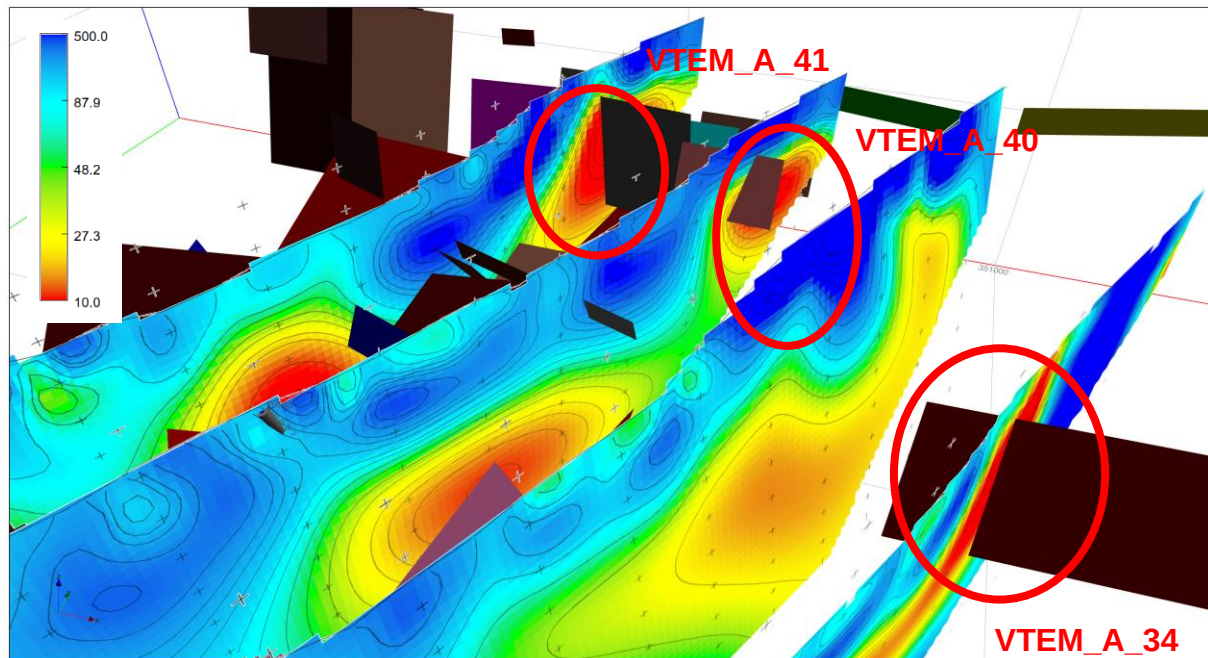


Figure 10: Areas of excellent correlation between the VTEM models and DC resistivity models. The VTEM conductors are clearly also strong low resistivity zones. This is unsurprising (since resistivity and conductivity are inversely correlated).

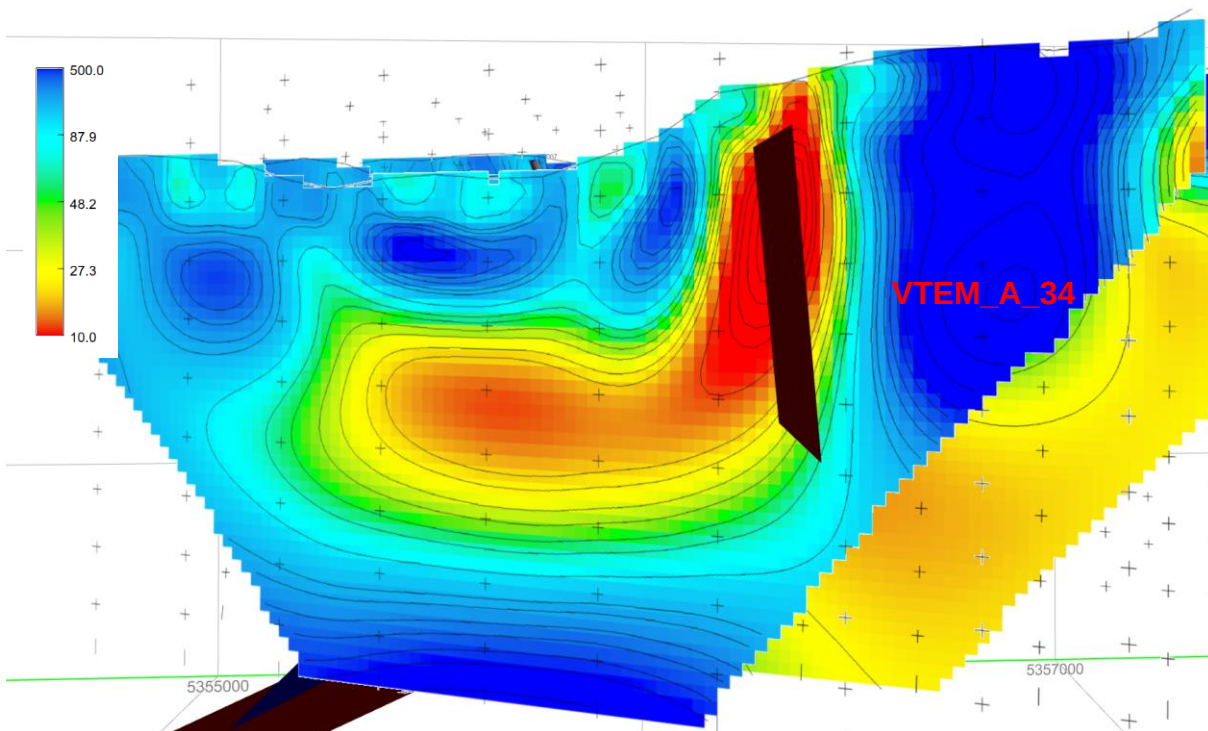


Figure 11: Line 1600 DC resistivity model and VTEM plate conductor A34_L280_80S.

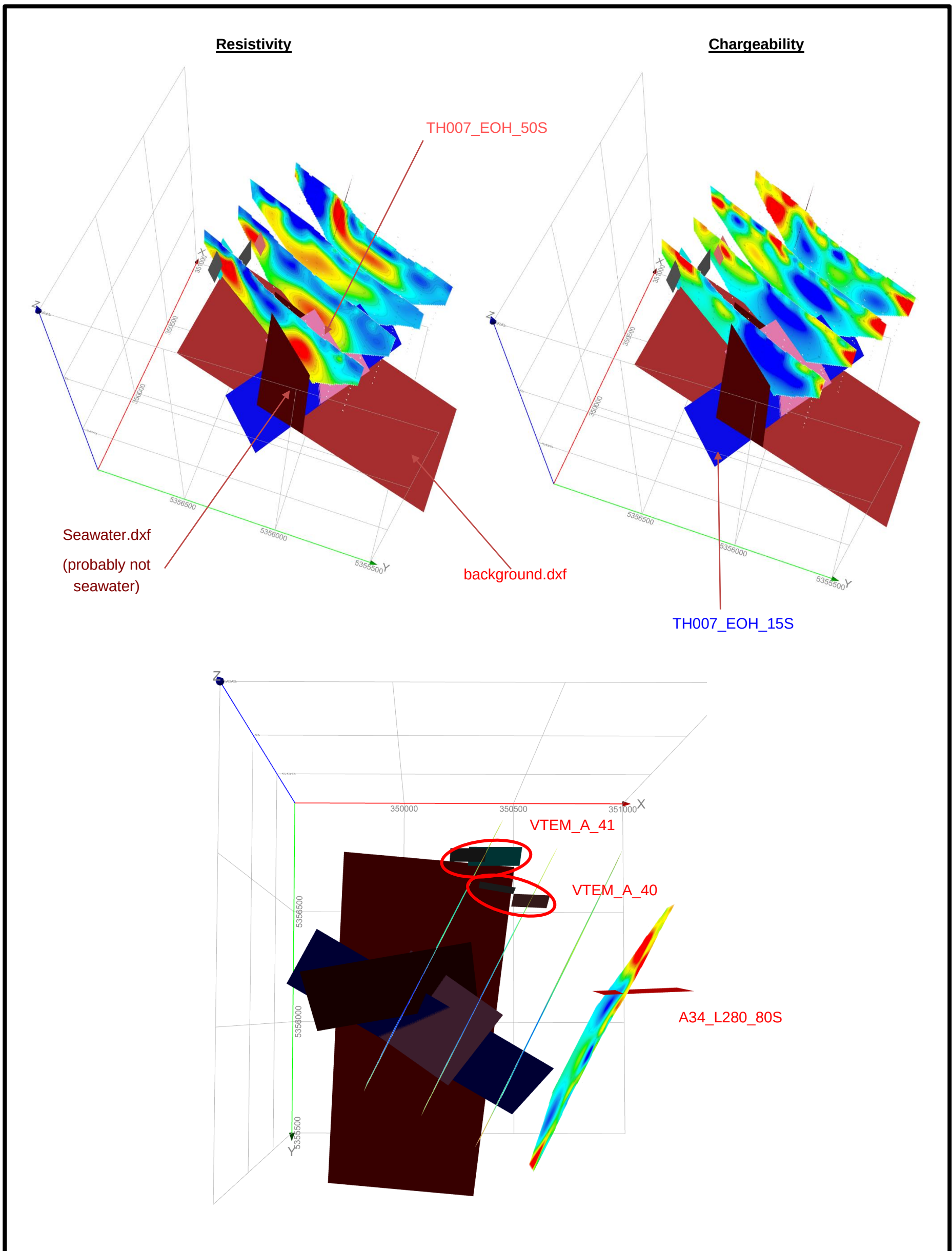


Figure 12: Resistivity and chargeability 2D profiles. VTEM and TH007 DHEM plate models are also included.



1.4 Comparison to previous magnetic modelling

Plates from the VTEM and DHEM were also compared to the results from modelling the Cambrian serpentinised ultramafic – Crimson Creek Formation contact (Hine and Direen, 2021), and are depicted in Figure 13 below. This shows the main “seawater” conductors (red and brown plates) mostly have an overall dip consistent with the contacts of the serpentinite body. The exception is the red plate which appears to cut across the contact.

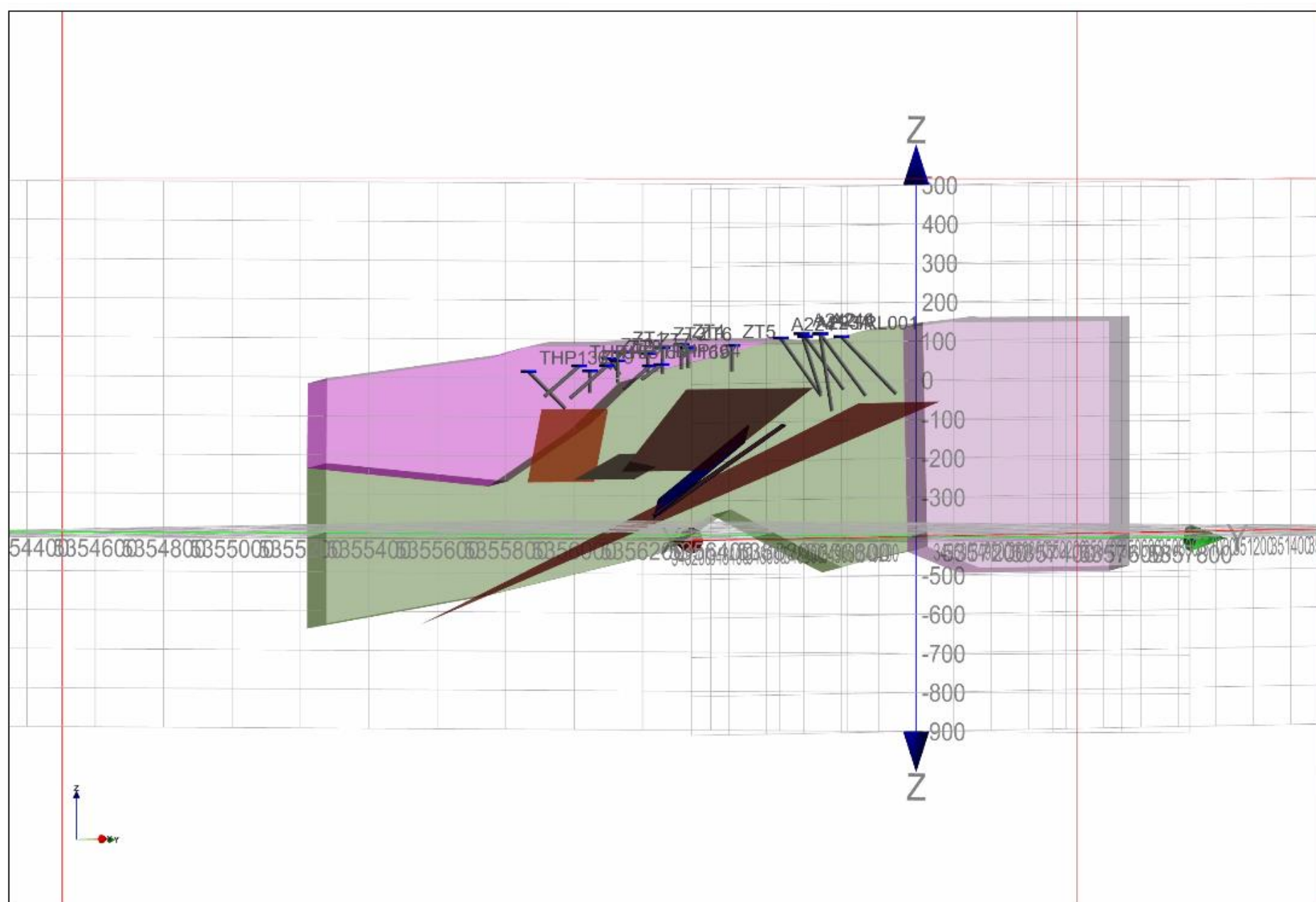


Figure 13: View WNW through model on IP line 1200 E intersecting TH007. Pink body is modelled Crimson Creek Formation, Olive body is the Cambrian serpentinite. Drillholes also shown – all miss the modelled conductive plates, mostly due to being too shallow.



4 Conclusions and Recommendations

The DHEM survey of TH007 shows a broad response typical of a large source beyond the end of the hole. To fit this response, two large conductors were required. Both are dipping moderately to the southwest with weak to moderate conductance (15S and 50S). They are about 50–100m beyond the end of the hole. The DHEM conductors agree with the VTEM conductors in this area: the location and geometry of the DHEM model plates are within the margins of error of the “Background.dxf” and “seawater.dxf” VTEM plates. None of the modelled plates has been penetrated by any of the existing drilling, which is mostly too shallow to test the plates modelled (see Figure 13).

We cannot tell from the EM data alone whether the source of the two main DHEM features is graphitic shale (less likely, as they seem to be within the serpentinite body from the magnetic modelling); massive sulphides; or sea water incursion into aquifer horizons in the serpentinite, perhaps controlled by shear zones parallel to the upper and lower contacts. If the VTEM models are closer to the physical truth, then the conductor may ‘connect’ through to the Denali area in the north, where sulphides have been intersected. The DC resistivity, however, shows no indication that the deep conductive zones are connected to surface. The lack of chargeability anomaly for the conductor is also not definitive: it could either be due to compact massive sulphides lacking a disseminated sulphide halo (less likely, given observations in the drill log from TH007); or it could be due to seawater incursion originating beneath the Trial Harbour and infiltrating into shear-zone controlled aquifers to the east. This possibility could be tested if there are sufficiently deep water monitoring bores near Remine that are measuring the salinity of the inland aquifers: if the seawater wedge is not penetrating far inland from the coast, the “seawater.dxf” conductor may in fact be due to massive sulphides.

Note that the conductors are all defined with Z = absolute elevation w.r.t. sea level, not depth below surface.



5 References

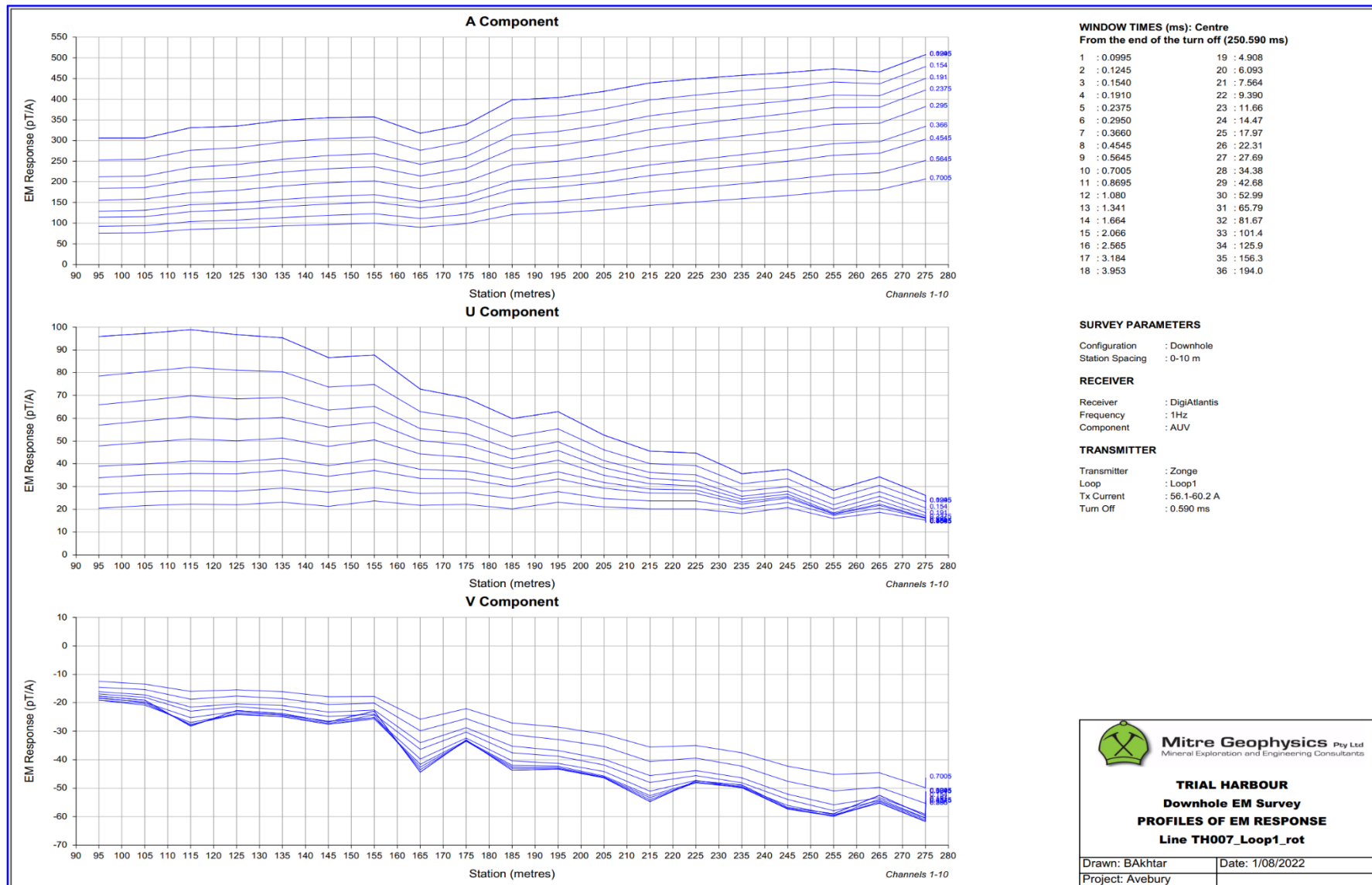
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APPENDIX 1: PROFILES

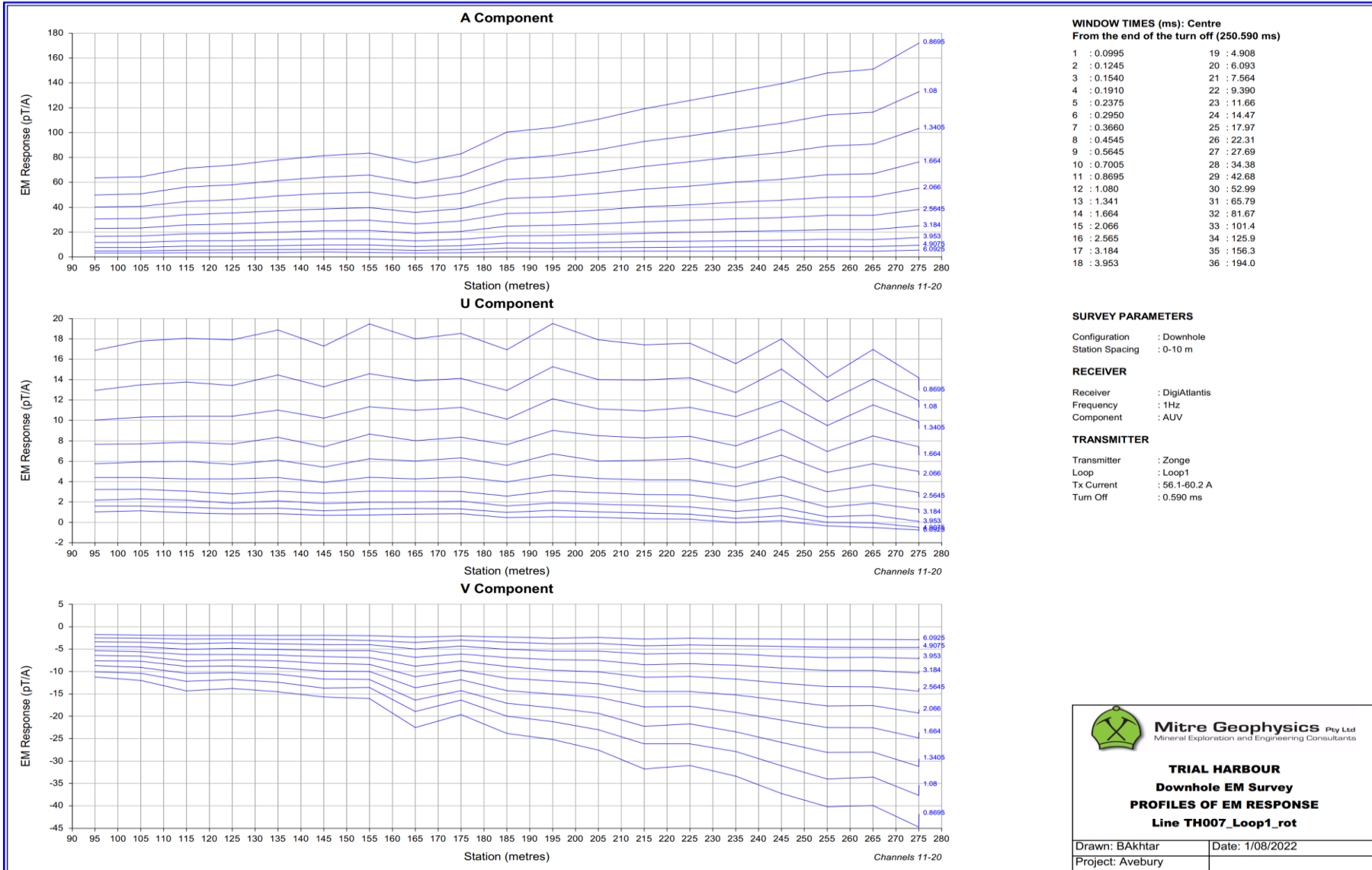


TH007 DHEM MEMO



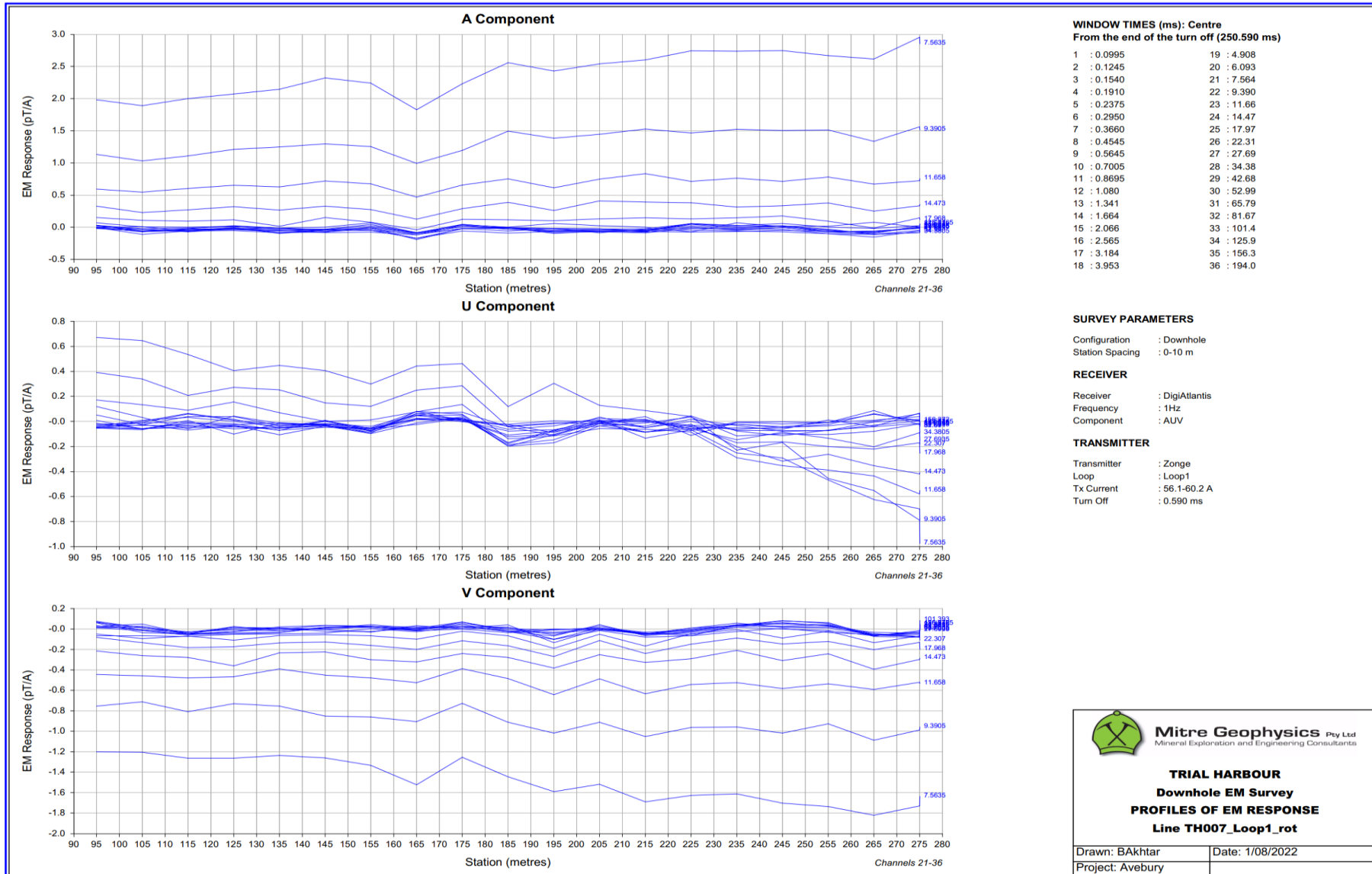


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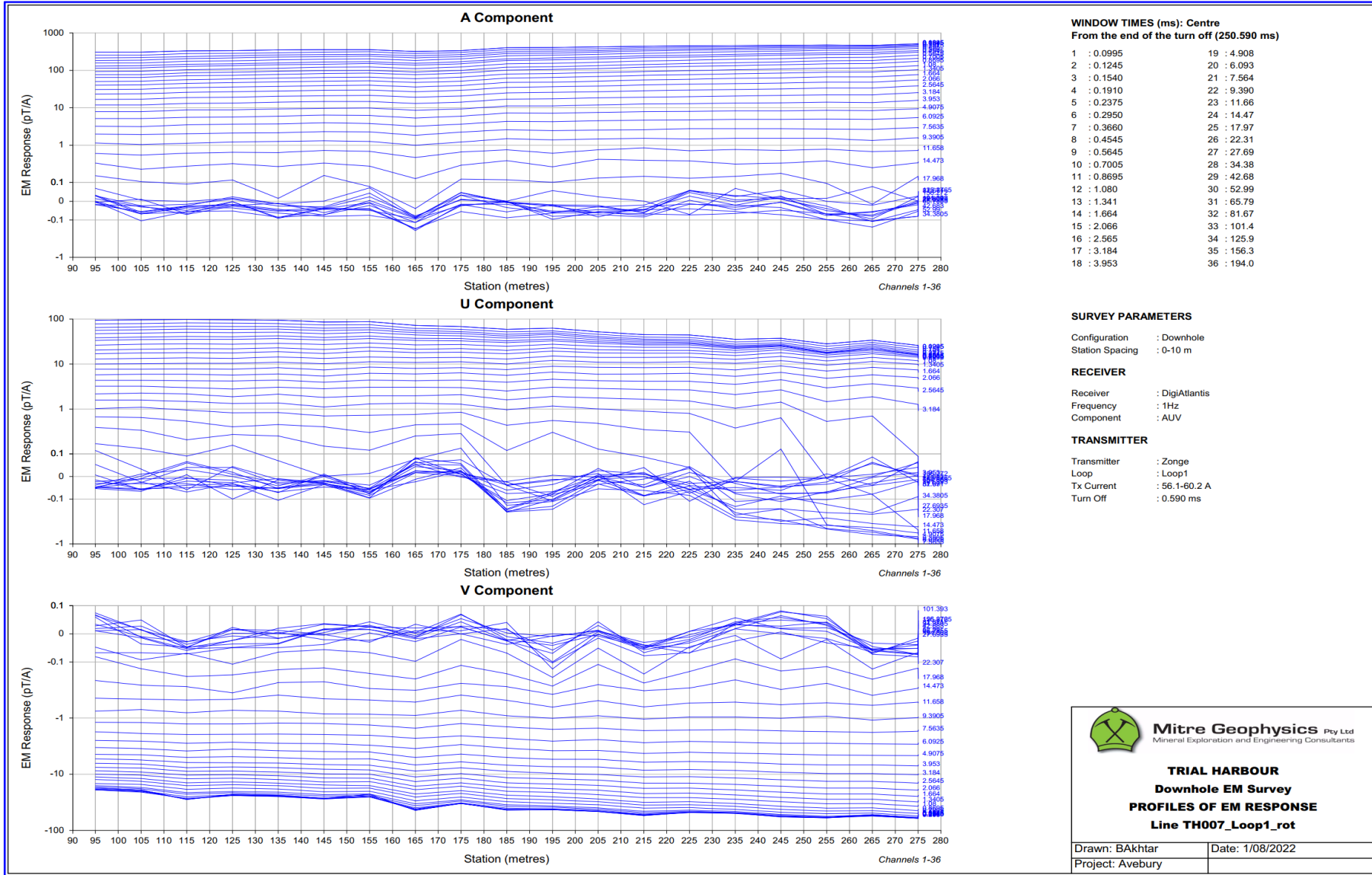


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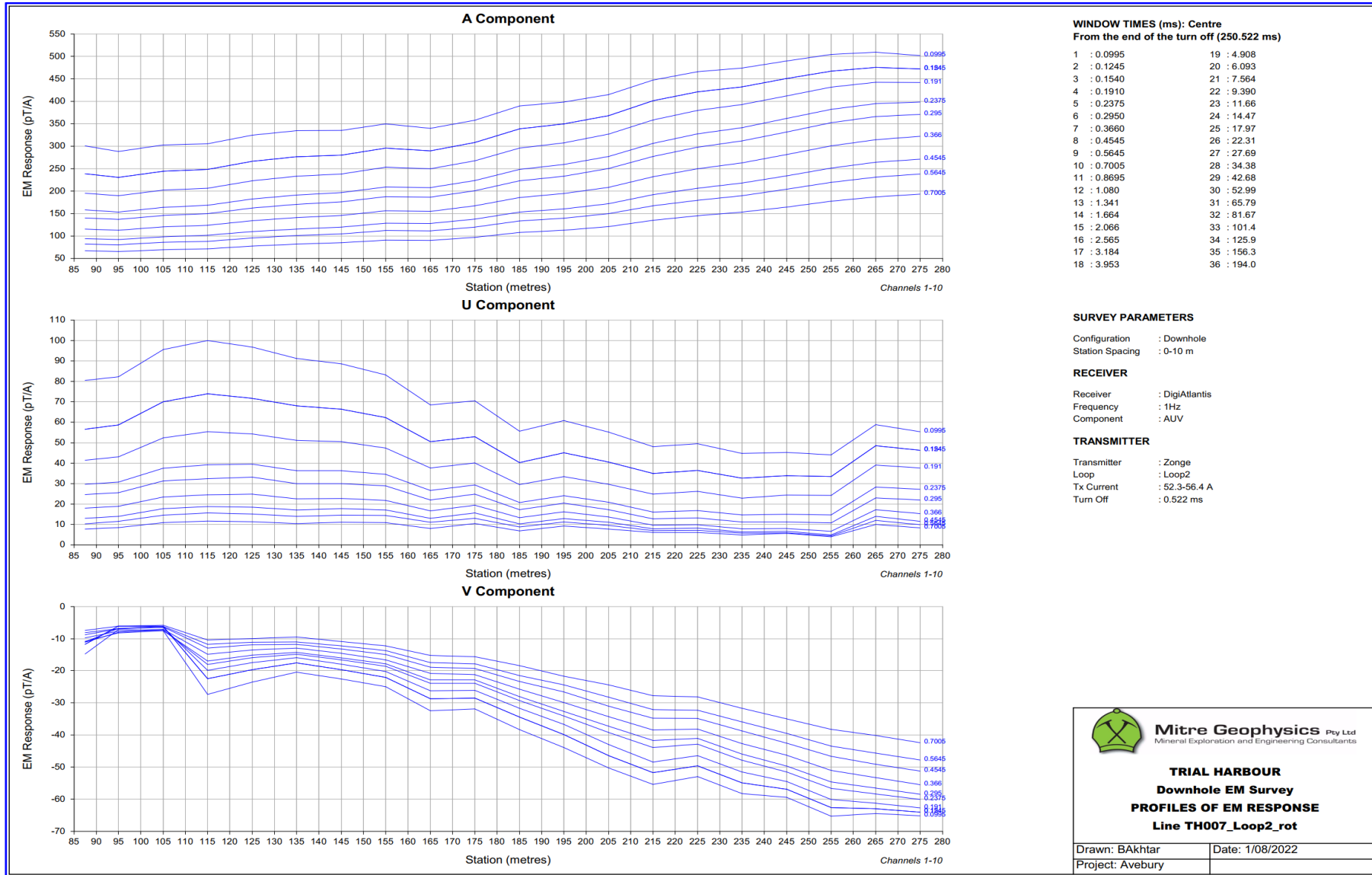


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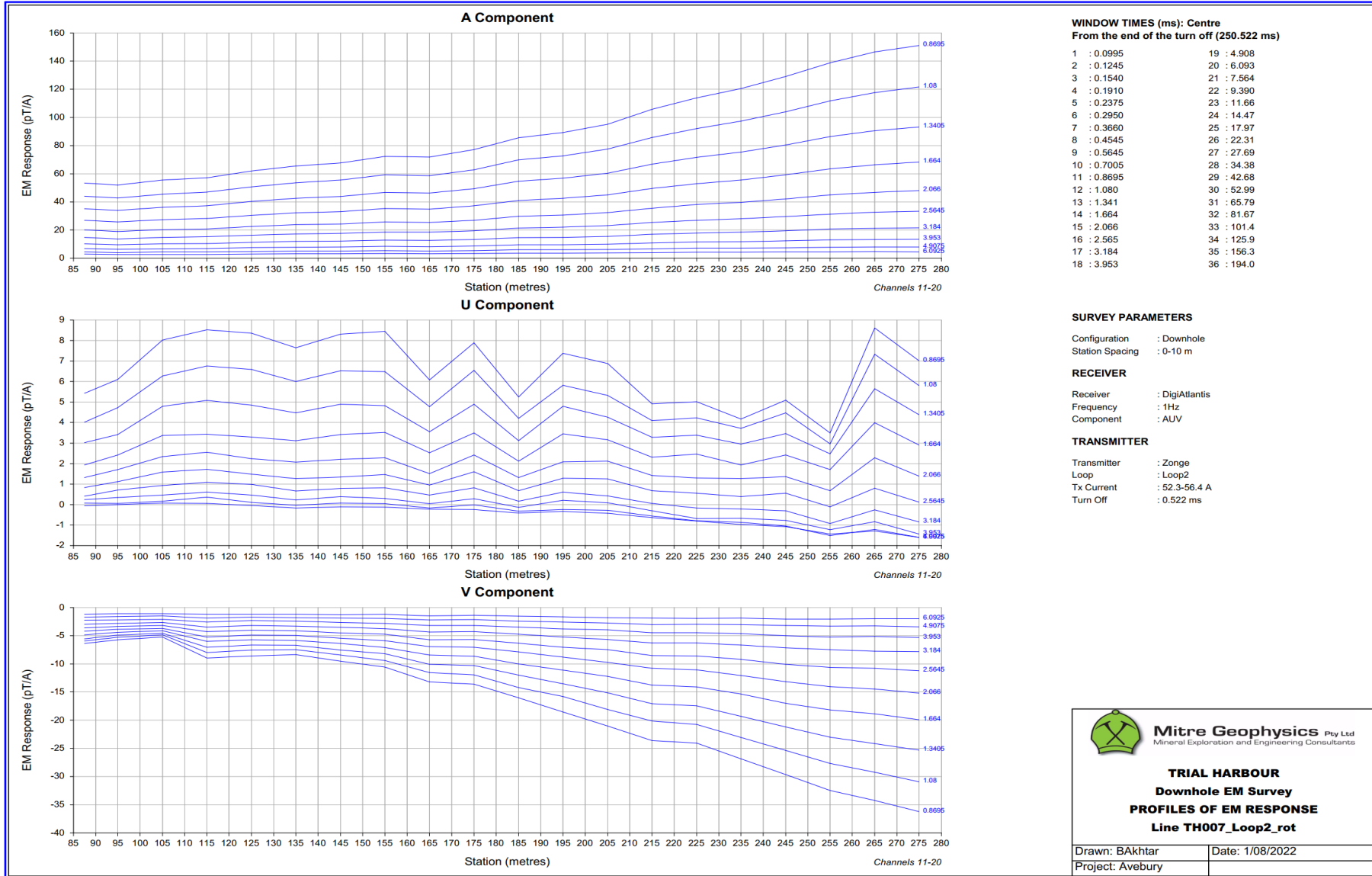


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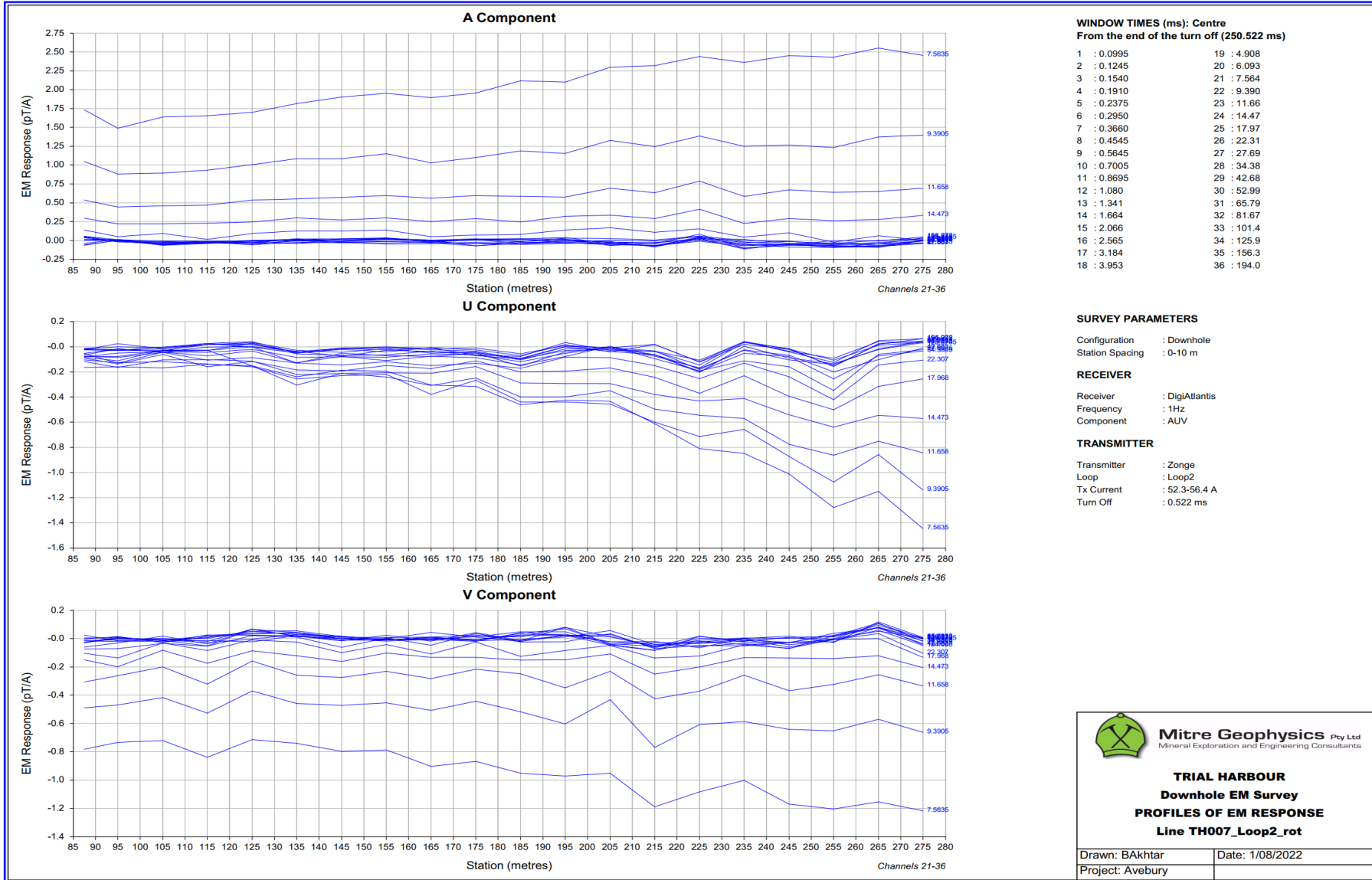


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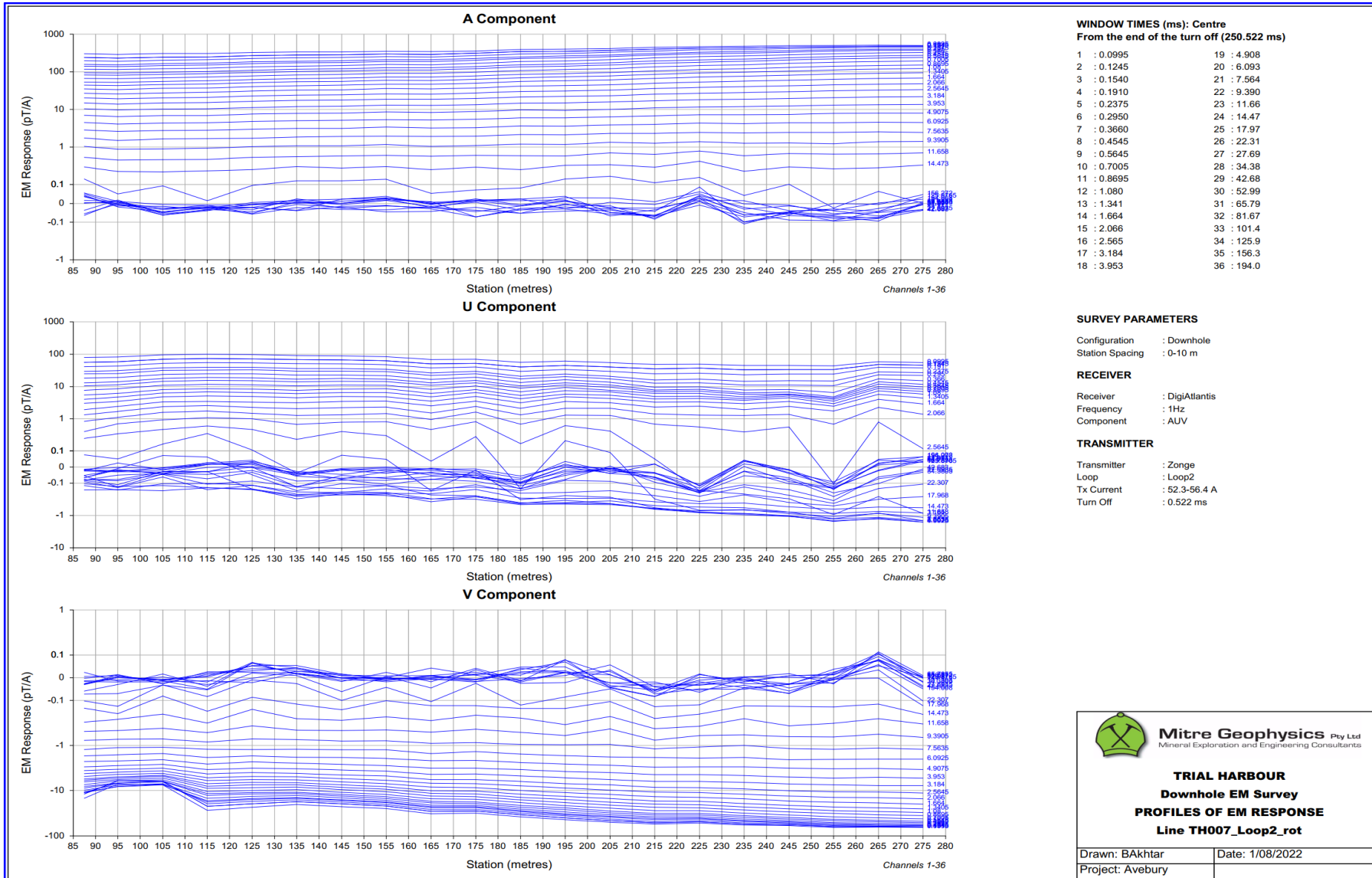


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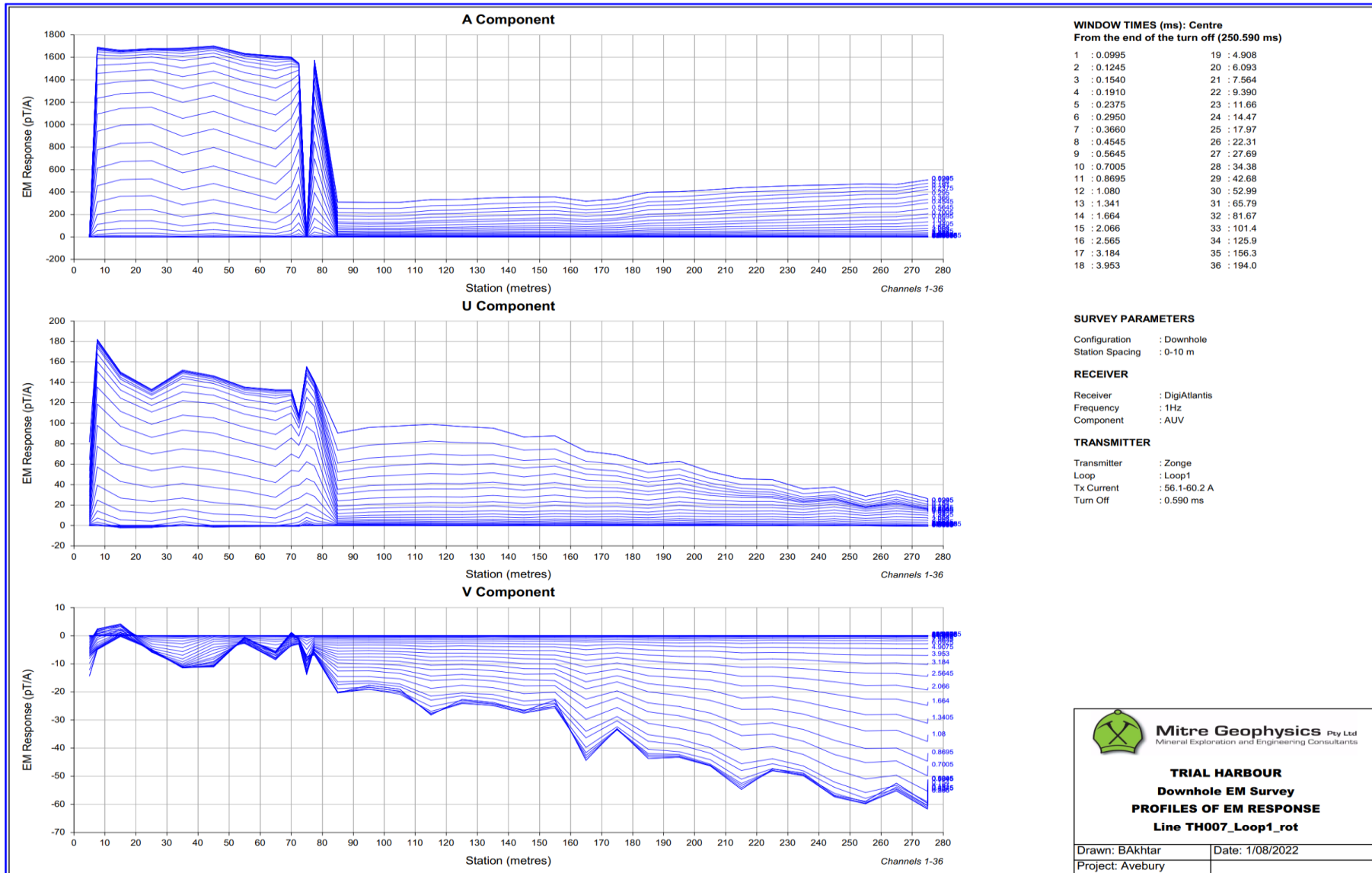


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