Andrew Trafford Geophysical Consultant

Interpretive report on the geophysical investigation, Drummin Bog, County Carlow

By

Andrew Trafford Geophysical Consultant

For

Drummin Bog Project

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Fuair an tionscnamh seo fóir-dheontas ó Coiste um Fhorbairt Pobail Aituil Cheatharlach, Clár Forbartha Tuaithe atá maoinithe ag Rialtas na hÉireann faoi Chlár Forbartha Tuaithe Éireann 2014-2020 agus ag Ciste Talamhaíochta na hEorpa d'Fhorbairt Tuaithe: infheistiú na hEorpa i Limistéir Tuaithe.

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Rialtas na hÉireann
Government of Ireland

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The European Agricultural Fund for Rural Development:
Europe investing in rural areas

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1 INTRODUCTION

This report documents the geophysical investigation carried out at Drummin Bog, County Carlow on behalf of the Drummin Bog Project. The main purpose of the work was to characterise the site with respect to peat distribution and shallow geology to provide background information that will be used in the planning and promotion of rehabilitation works planned for the bog.

Data were collected along a series of transects crossing the main part of the bog using the following geophysical techniques; Ground Penetrating Radar (GPR), Electrical Resistivity Tomography (ERT) and seismic refraction. By collecting several complimentary techniques and incorporating all available intrusive investigation data it is possible to produce a representative interpretation of the subsurface across the site.

The data clearly showed the peat distribution with the thickest peat soils present in a topographic low formed in the underlying geological formations. Clay and silts were deposited in this depression prior to the transition into ‘fen’ type organic soils with bog peats forming at a later date. The peat was found to have a maximum thickness of c. 5.7m towards the centre of the site.

The deeper geology was found to be dominated by crystalline granitic bedrock with weathered zones above. The bedrock was seen to shallow to the south in accordance with data from the Geological Survey Ireland. A zone interpreted as more granular till material was interpreted towards the eastern part of the site.

Interpretation of all data sets is presented as a series of drawings in Appendix A.

2 SITE LOCATION

Drummin Bog is located c. 1.5km south southeast of St Mullins in County Carlow. The site is c. 500m x 200m covering just over 7Ha with the ground cover being predominantly bog with scrub / woodland to the west northwest.

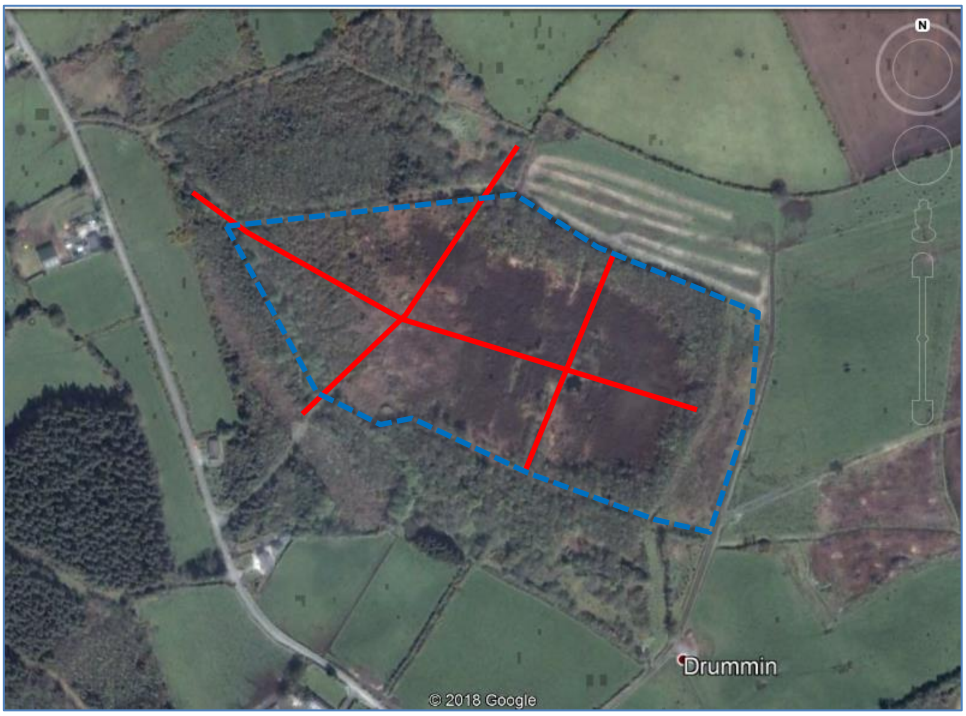


Figure 2.1: Location Map showing main test locations (red) and perimeter drain (blue)

2.1 SURVEY RATIONALE

The investigation approach taken consisted of the collection of several geophysical data sets to resolve different levels of geological information throughout the near surface. By using different geophysical methods measuring both mechanical and electrical properties, as well as correlation to all available intrusive information, it is possible to reduce the ambiguities in the final data interpretation. This investigation used three geophysical methods (detailed below) and correlation to window sampling and peat probing.

Ground Penetrating Radar (GPR) data were collected to resolve the peat thickness and internal layering. Electrical Resistivity Tomography (ERT) data were collected to provide a much deeper overview of the geological setting with regard to bedrock depth and soil/weathered rock distribution. Seismic Refraction data were used as a mechanical confirmation of the ERT bedrock interpretation.

All data sets were referenced to lidar data supplied by the client. Window sampling and Russian Augering data were also incorporated into the final interpretation.

3 FINDINGS

The detailed findings from the investigation have been presented in a series of 5 drawings, highlighting the resolved detail of both ‘deep’ geological and detailed peat thickness cross sections. The ‘deep’ cross sections (drawings 002, 003 and 004) are presented with a relative vertical scale of 1:1 whereas the detailed peat sections (drawing 005) are presented with a vertical exaggeration of x10 to enhance the resolved information.

Drawings:

- 18003-001 Location Map with peat thickness data
- 18003-002 Longitudinal geological cross section (ERT002 and ERT003)
- 18003-003 Transverse geological cross section (ERT001)
- 18003-004 Transverse geological cross section (ERT004)
- 18003-005 Detailed peat thickness cross sections

The findings from each element of the investigation are given below:

3.1 GROUND PENETRATING RADAR (GPR)

The peat thickness was interpreted as between 0 and c. 5.7m. Figure 3.1 shows the peat thickness distribution across the site. This peat thickness information is based on the interpretation of 7 GPR profiles across the site. It should be noted that this dataset is relatively sparse with a high level of interpolation across the site and should be used accordingly.

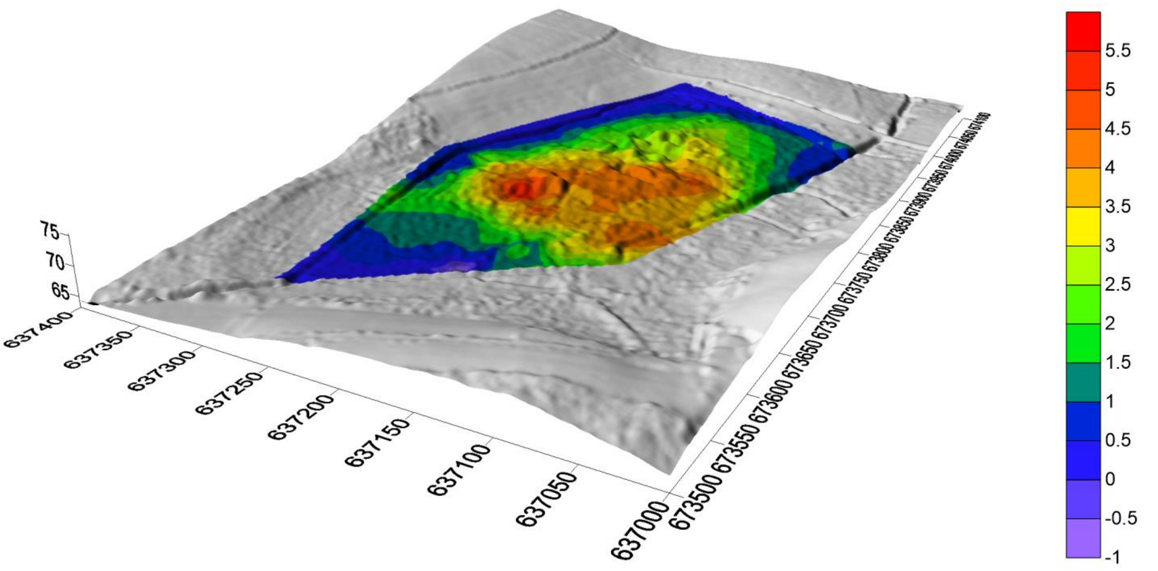


Figure 3.1: 3D view showing peat thickness distribution.

The GPR data when combined with the lidar data shows the greatest accumulations of peat/organic soils to be located within a topographic hollow formed within the underlying geological formations. The fen type peat is limited to the central part of the site, with underlying clay deposits, whereas the eastern limits appear to be underlain by more granular material.

It is recommended that additional Russian coring is carried out to further resolve the peat thickness distribution as well as better define the extent of the lower 'fen' type peat where appropriate.

The GPR data are presented as a thickness map and detailed cross sections in Appendix A. Drawings 18003-001 and 005.

One feature of interest with regard to the nature of the GPR data was the relatively low depth of penetration and the presence of a second internal layer associated with the more olive green 'fen' peat. The low depth of penetration is most likely due to an increased amount of inorganic silt material washed into the basin over time. This has the effect of increasing the conductivity of the peat and reducing the transmissivity of the GPR signals.

There was an increase in the depth of penetration using the 80MHz antenna compared to the 200MHz, as would be expected, and from this it was possible to resolve the full peat thickness. The internal boundary between the two peat layers was resolved with a reduced clarity than would normally be expected, due to the increased presence of silt/clay within the lower 'fen' soils.

Appendix B: Methodology gives a detailed description of the method.

3.2 ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT)

The ERT data is presented with the appropriate interpretation in Appendix A. Drawings 18003-002, 003 and 004.

ERT profiles were collected longitudinally along the centre line of the bog and transversely at two locations crossing the bog. Figure 2.1 shows the location of the ERT profiles. The profiles resolved data to a depth of c. 60m, providing information on the shallow peat/soil layers as well as the deeper weathered and competent bedrock.

The competent bedrock was seen to shallow significantly to the southern extent of the site. This information is consistent with the GSI bedrock mapping data for the area.

Figures 3.2 and 3.3 show 'fence' diagrams of the ERT profiles highlighting the spatial distribution of resistivity across the site. A simple overview of these data would be that the shallow blue zones (low resistivity) represent the distribution of the clay and thick peat deposits and the red zones (high resistivity) identify the presence of more resistive crystalline (granitic) bedrock.

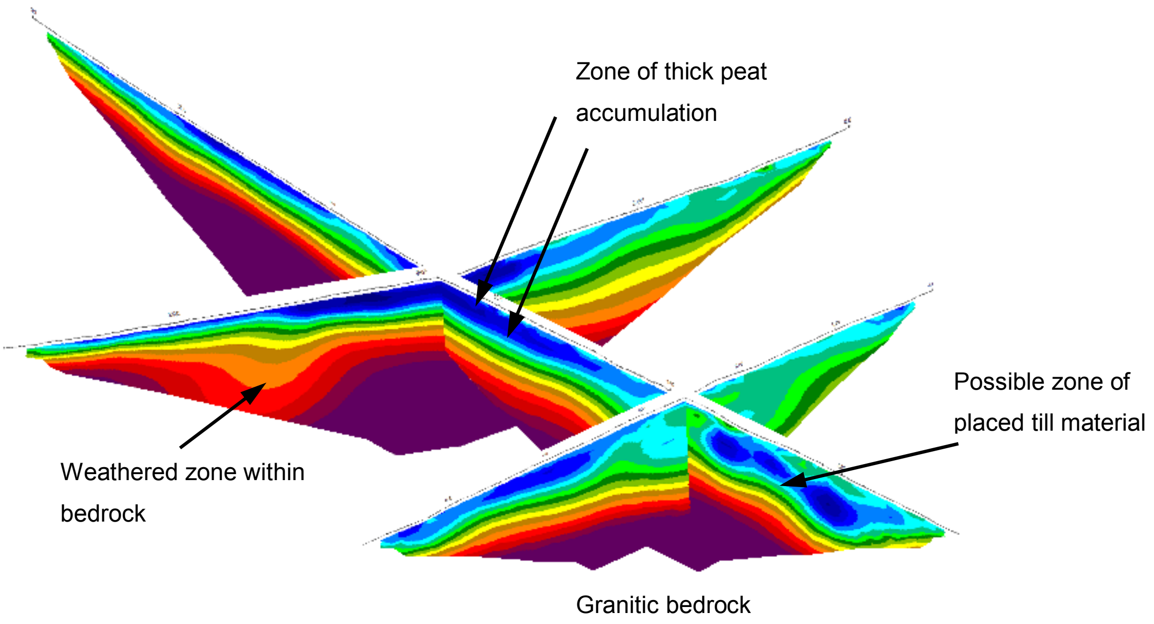


Figure 3.2 ERT fence diagram viewed from SE

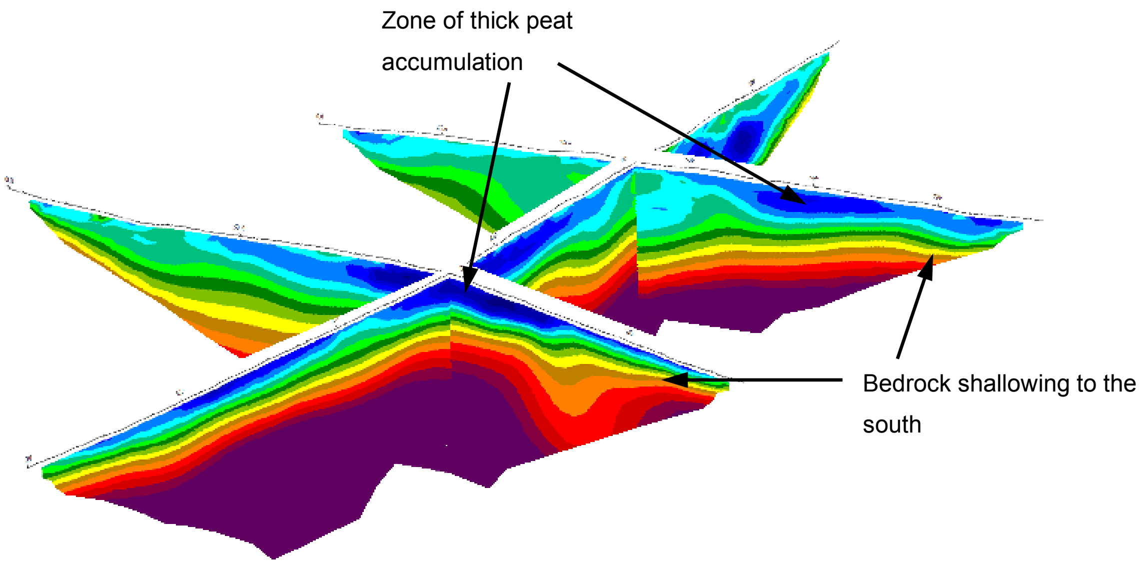


Figure 3.3 ERT fence diagram viewed from SW

The thickening of the peat and substrate layers is clearly identified from the ERT data and correspond to a topographic low within the underlying till / bedrock where the deposit of clays and silts were followed by the accumulation of the fen peat before transitioning into the shallower bog peat. The ERT data do not differentiate between the peat and underlying clay layers due to the resolution of the collected data.

An area interpreted as till forms a subtle topographic high beneath the peat to the NE of the site. This feature has been identified on profiles ERT03 and ERT04.

Appendix B: Methodology gives a detailed description of the method.

3.3 SEISMIC REFRACTION

Seismic data were collected at a selected number of locations in order to provide an independent mechanical calibration of the electrical ERT data collected across the site. The locations were chosen in areas of thin peat due to the negative effect of thick peat on signal data quality due to attenuation. Seismic profile was targeted on ERT cross sections, ERT001 and ERT002.

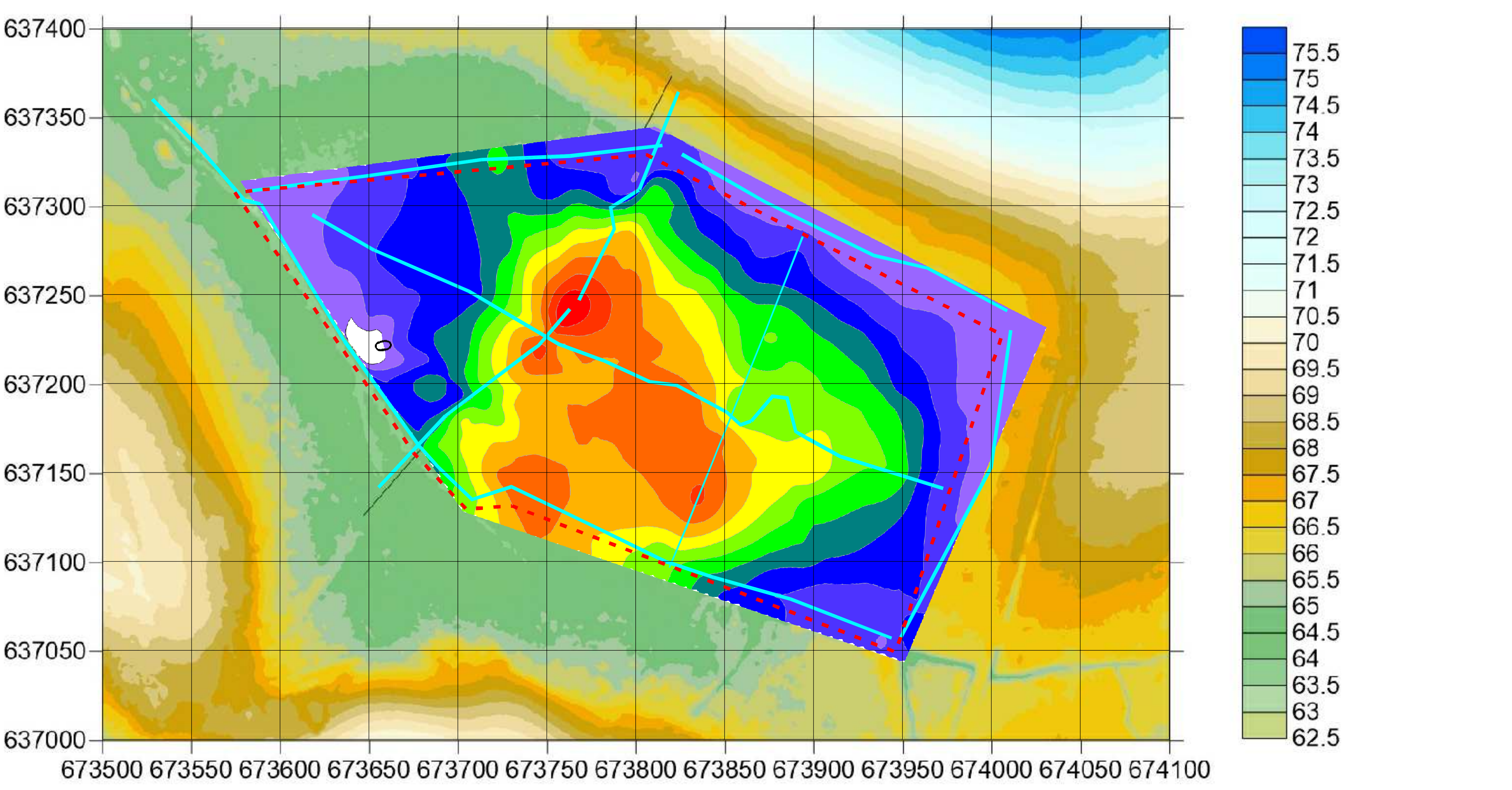
The seismic data resolved three layers at each of the three locations tested. These materials were seen to have very different mechanical properties. The layering comprised of a very soft upper peat/substrate layer (90 – 180 m/s), a soil / weathered bedrock layer (600 – 900 m/s) and more competent bedrock below (2900 – 5100 m/s).

Variations in bedrock velocities were consistent with resistivity values, with the areas of shallow competent bedrock towards the south having corresponding higher velocities compared to the more weathered bedrock to the north.

Appendix B: Methodology gives a detailed description of the method.

4 APPENDIX A: DRAWINGS

FIGURE 1: LOCATION MAP - Digital Elevation Model with Peat Thickness



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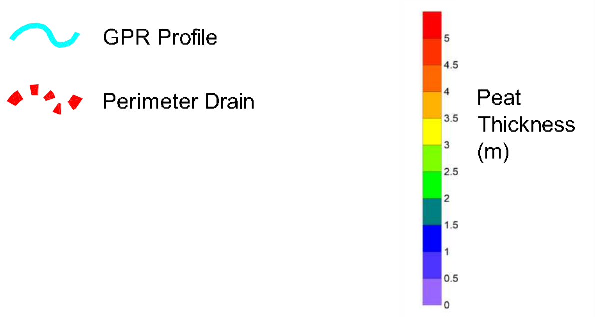

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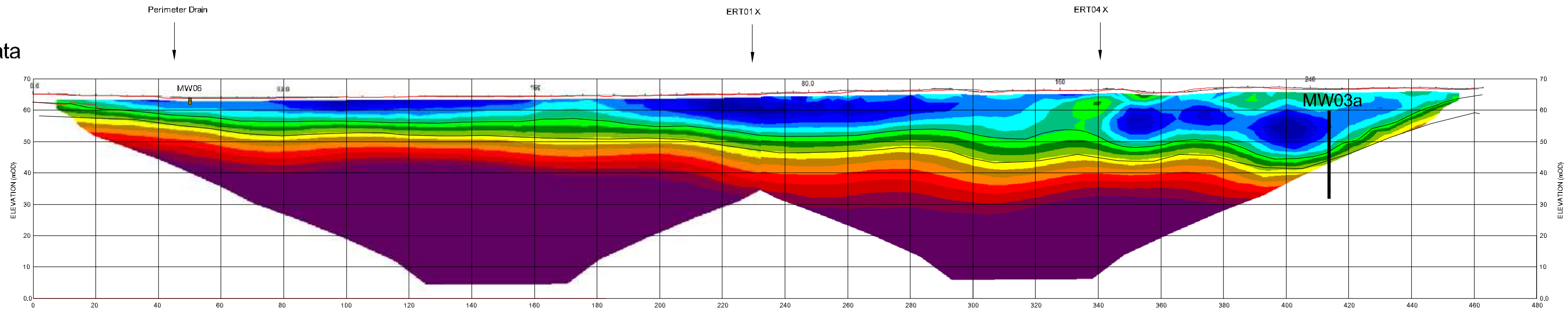
Scale:	NTS
Date:	20/04/20
Drawing No:	TRAFF-DWG-18003-001

Andrew Trafford
Geophysical Consultant
Andrew Trafford Pgeol MEngSc BSc
M: 089 705 3344
E: andrew.trafford@atgeoconsultant.ie

FIGURE 1: LONGITUDINAL ERT PROFILE (ERT02 & 03)

ERT Data



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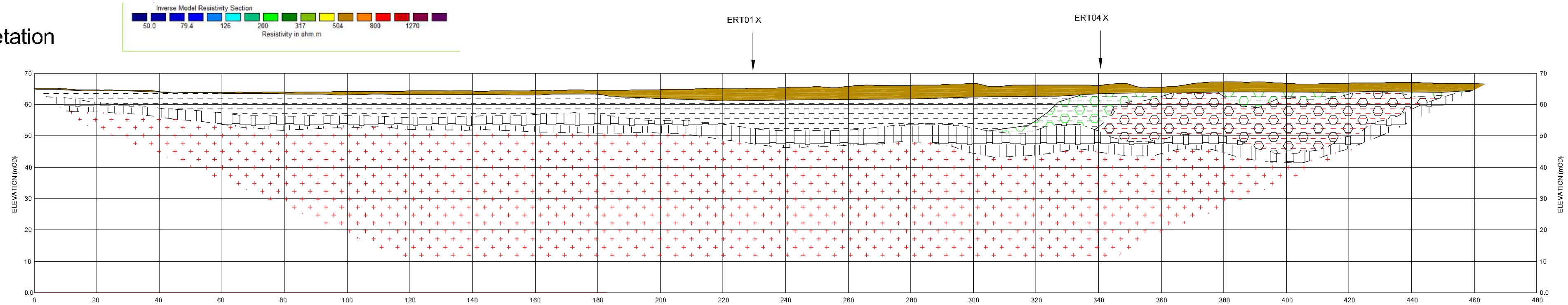
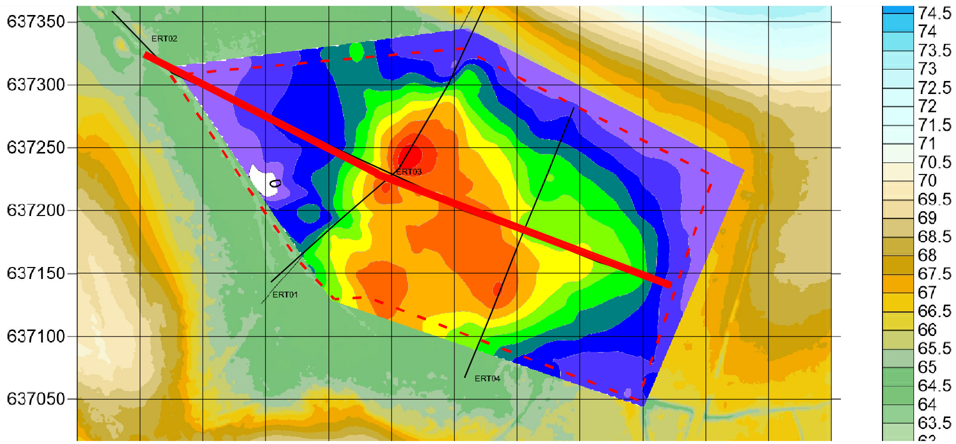


FIGURE 2: LOCATION MAP - Digital Elevation Model



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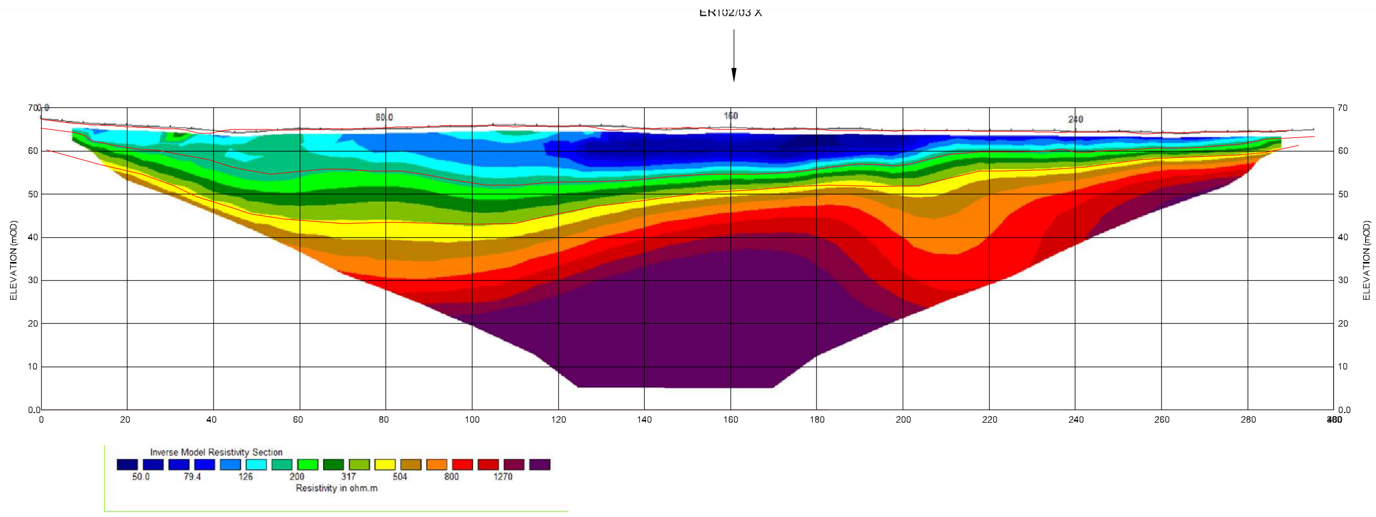
Drawing No:	TRAFF-DWG-18003-002

Andrew Trafford
Geophysical Consultant

Andrew Trafford Pgeol MEngSc BSc
M: 089 705 3344
E: andrew.trafford@atgeoconsultant.ie

FIGURE 1: TRANSVERSE ERT PROFILE (ERT01)

ERT Data



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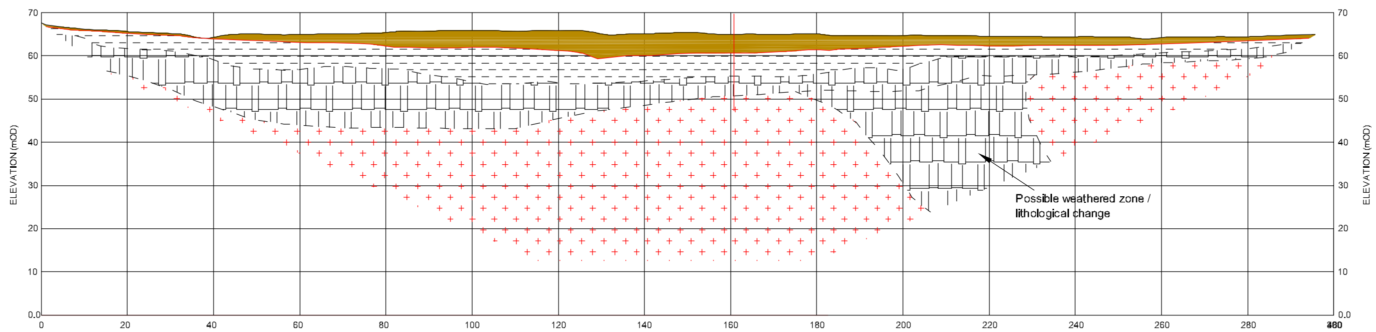
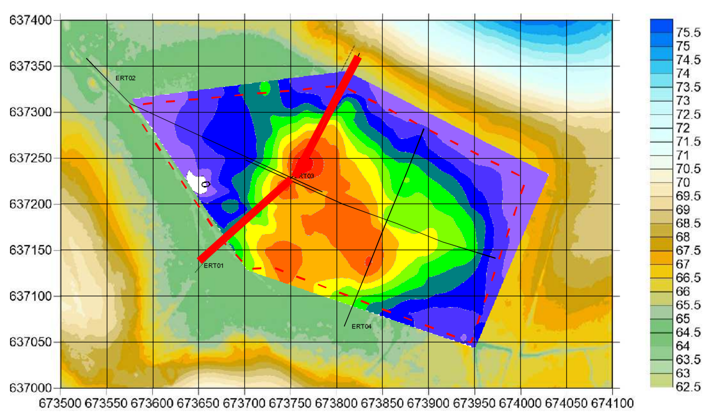


FIGURE 2: LOCATION MAP - Digital Elevation Model



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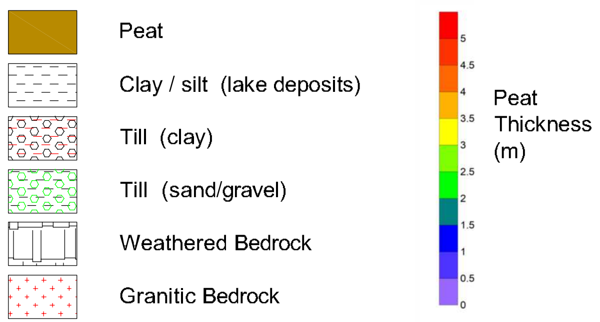

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Andrew Trafford
Geophysical Consultant

Andrew Trafford Pgeol MEngSc BSc
M: 089 705 3344
E: andrew.trafford@atgeoconsultant.ie

FIGURE 1: TRANSVERSE ERT PROFILES

ERT Data

Interpretation

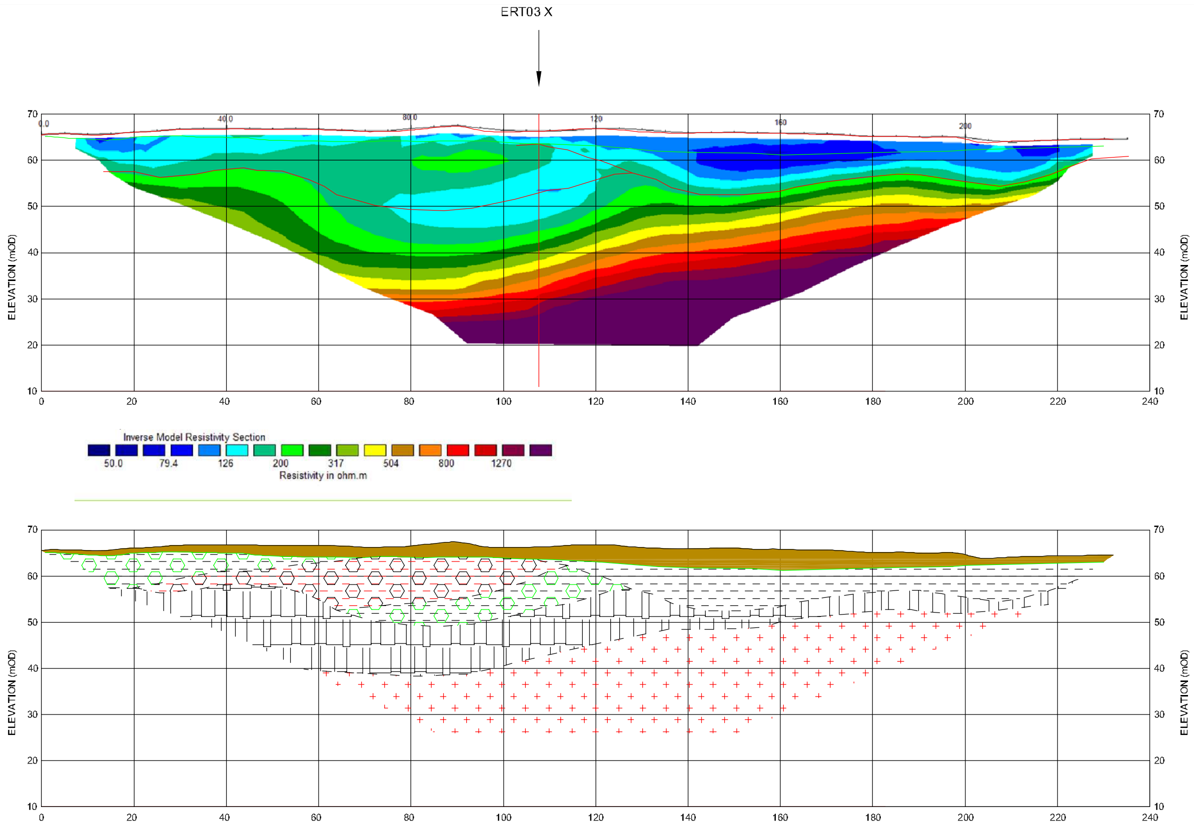
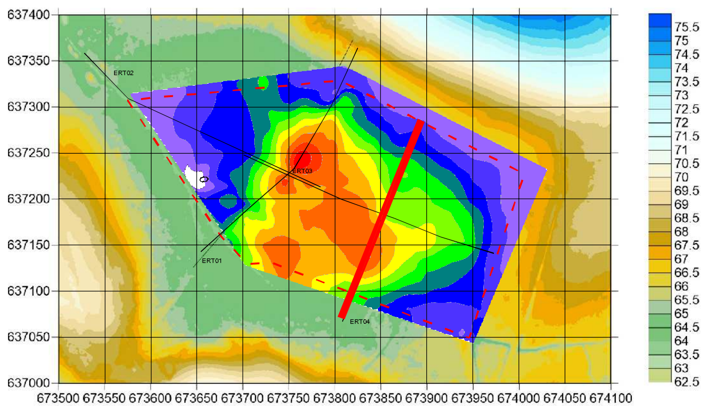


FIGURE 2: LOCATION MAP - Digital Elevation Model



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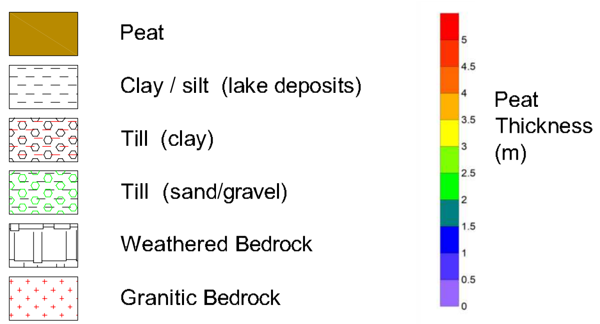

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Andrew Trafford
Geophysical Consultant

Andrew Trafford Pgeol MEngSc BSc
M: 089 705 3344
E: andrew.trafford@atgeoconsultant.ie

FIGURE 1: LONGITUDINALGPR PROFILE (ERT 02 & 03)

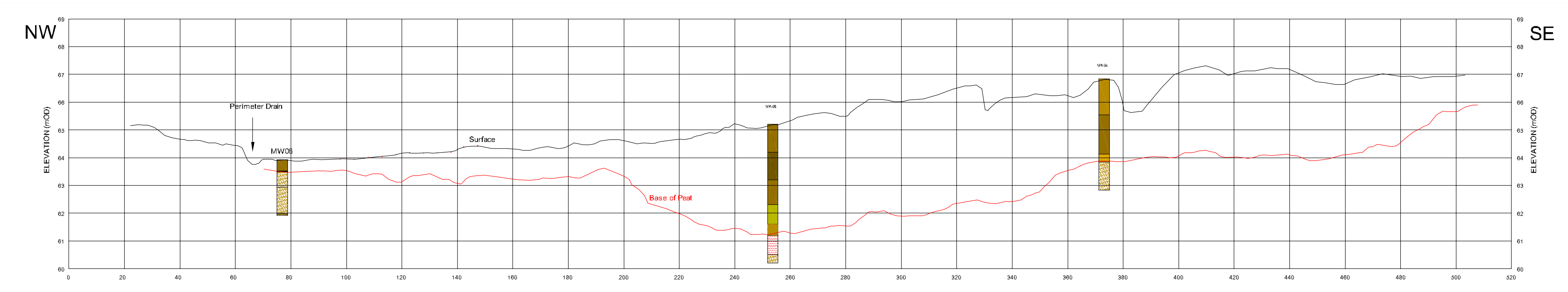
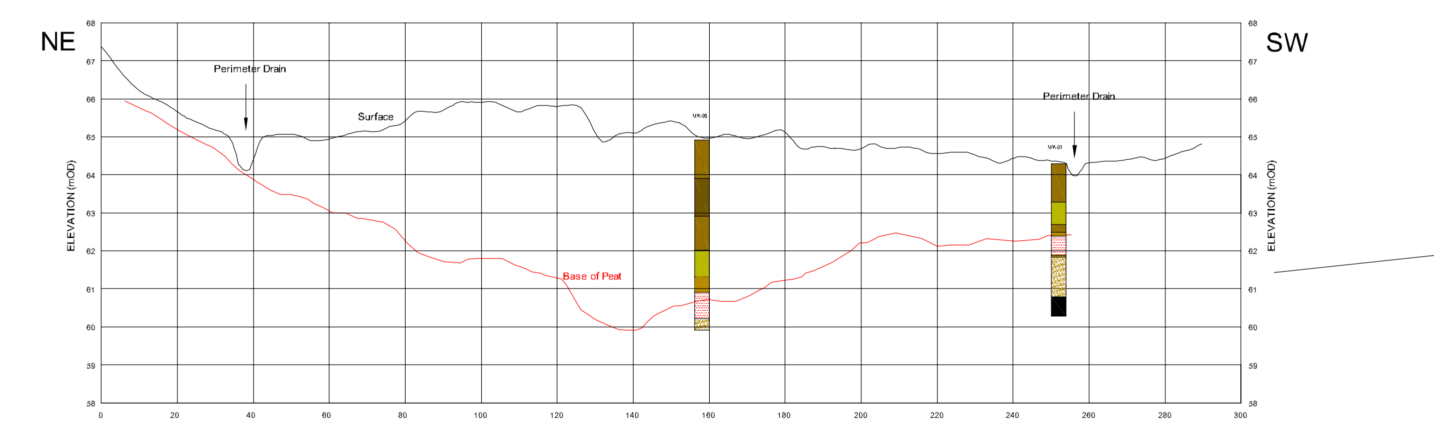


FIGURE 2:TRANSVERSE GPR PROFILE (ERT01)



LOCATION MAP

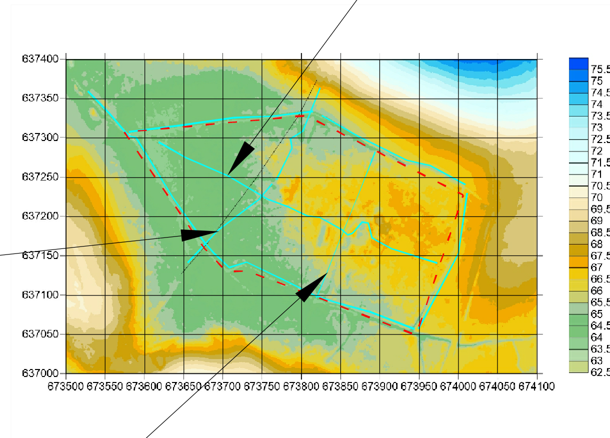
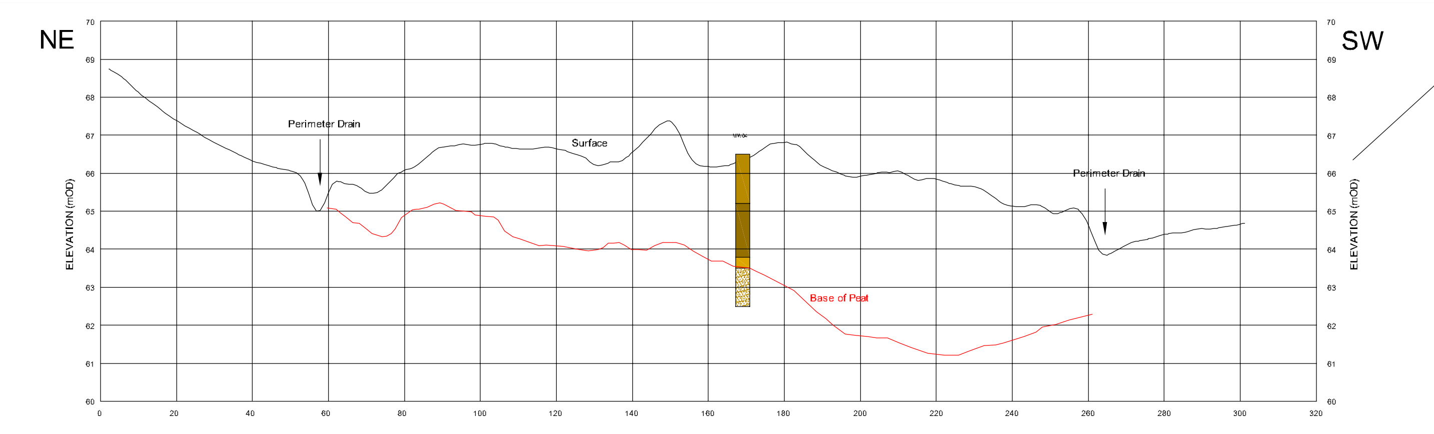


FIGURE 3: TRANSVERSE GPR PROFILE (ERT04)



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Project Name:	Drummin Bog Geophysical Investigation
Scale:	NTS
Date:	20/04/20
Drawing No:	TRAFF-DWG-18003-005

Andrew Trafford
Geophysical Consultant

Andrew Trafford Pgeol MEngSc BSc
M: 089 705 3344
E: andrew.trafford@atgeoconsultant.ie

5 APPENDIX B: METHODOLOGY

5.1 GROUND PENETRATING RADAR (GPR)

GPR involves the transmission of high frequency radio waves into the subsurface and recording the reflected waveforms (Figure 3.30 below). The method has proved highly effective in the determination of peat thickness and distribution due to the consistency of peat with regard to the transmission velocity of radio waves. The radio frequency velocity through peat is c. 0.035m/ns, which is very close to that of pure water (0.03m/ns) as might be expected due to the very high water contents found in many peat soils.

The method involves the collection of a 2D cross section through the peat. The data can be collected in either point or continuous mode.

Point mode involves the collection of multiple readings at incremental distances along the transect at given distances. Systems such as the Multi Low Frequency antenna (Figure 5.3) operate in this mode. The benefit of this type of system is that the input frequency can be altered depending on the depth of encountered peat and also the data quality can be increased by stacking of multiple readings. The data collected in this way often resolves layer detail within the peat that would not normally be possible using a continuous mode system. The method has the disadvantage of being relatively slow compared to data collected in continuous mode.

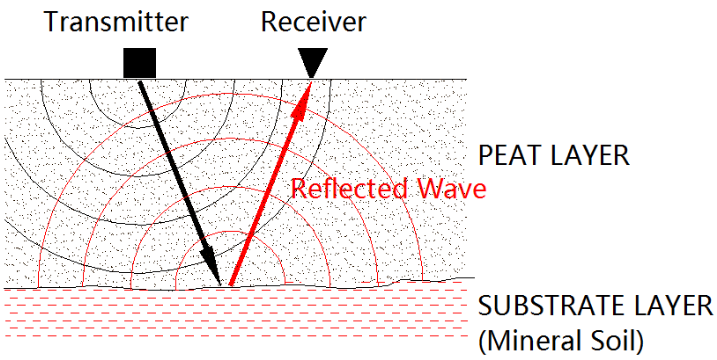


Figure 5.1: Schematic of GPR technique.

Figure 5.2: GSSI SIR 3000 system being operated with hand dragged 250MHz antenna.

Continuous mode (as shown in Figure 5.2) normally utilises an Electronic Distance Measuring (EDM) wheel which controls the triggering of the system. The antenna can therefore be dragged continually across the surface, either on foot or by the use of a survey vehicle, in order to rapidly collect 2D cross section. The frequency of antenna used in this way is normally limited to 100 to 200MHz compared to the lower frequencies used in the point mode systems. This can result in a loss of penetration and reduced resolution of the peat base. Commercial systems normally operate in continuous mode due to the increased acquisition rates that are possible.

Figure 5.3: GSSI Multi Low Frequency antenna in operation at 80MHz.

By linking the output from the GPR system to accurate elevation data it is possible to generate accurate sub peat elevation maps for use in slope stability assessments.

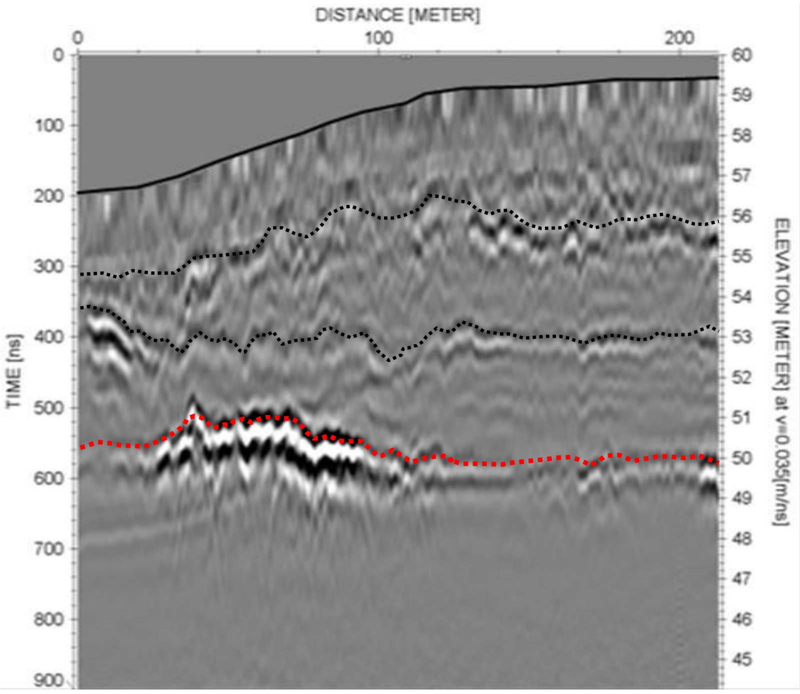


Figure 5.4: Example topographically corrected GPR profile (80MHz) from raised bog showing peat base (red) and internal boundaries (black). Data example Clara bog, Offaly.

5.2 SEISMIC REFRACTION

Seismic Refraction/Transmission is used routinely in engineering geophysical investigations for the assessment of both soils and bedrock. A brief description of the method is given below.

Seismic refraction utilises the refraction of seismic waves on geologic layers and rock/soil units in order to characterize the subsurface geologic conditions and geologic structure. Seismic waves travel at different velocities depending on the nature of the soil/rock forming the subsurface and refraction of these waves occurs where different velocity layers are encountered. The method generally relies on increasing velocity with depth.

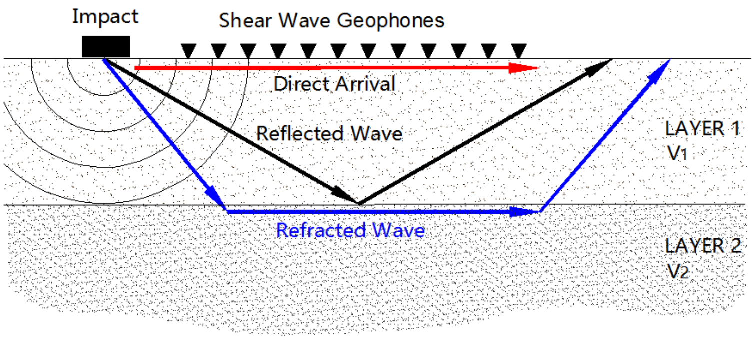


Figure 5.5 Schematic representation of Seismic Refraction Technique.

The data were collected using a Geometrix Geode seismograph with 24 vertically orientated geophones arranged in a linear array at 1.5 to 2m geophone spacing. The seismic source was generated using a sledgehammer strike on a plate at the ground surface.

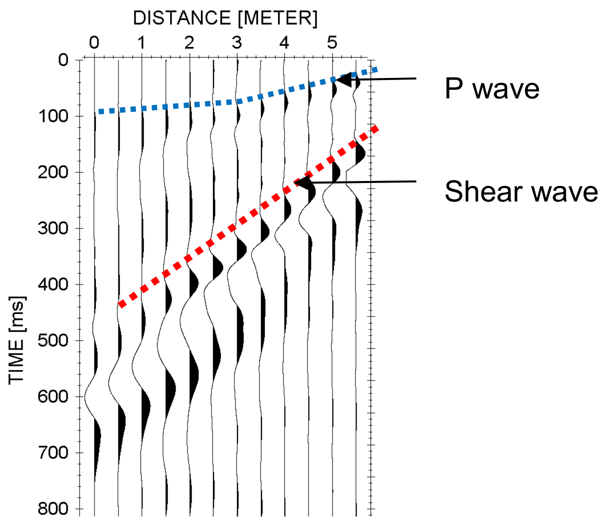


Figure 5.6: Example seismic record showing P wave and S wave arrivals.

5.3 ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT)

ERT is an electromagnetic method that involves passing low frequency alternating current into the ground and measuring the resultant potential field. The technique utilises pairs of current and potential electrodes inserted into the ground (Figure 3.34 below). By measuring the potential at a given input current it is possible to measure the apparent resistivity of the sub surface.

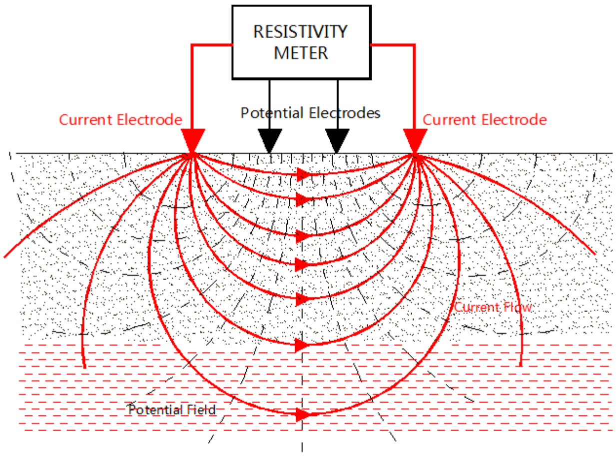
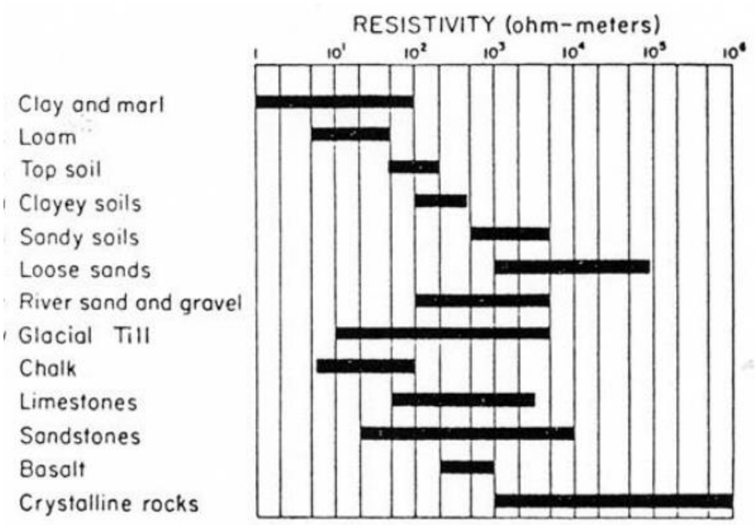


Figure 5.7: Schematic of Wenner Array Electrical Resistivity Tomography technique.



The field setup for the technique involved the use of multi core cables connecting up to 60 electrodes to a field acquisition computer. The data were processed in the field to give preliminary results and to assess the data quality.

By using different electrode spacing in pre specified arrays, the technique can be used to build up a tomographic cross section of resistivity to considerable depths. For the use in investigating shallow sites a tightly spaced array of electrodes (typically less than 3m spacing) is used to give the resolution required in the upper layers. Figure 3.35 below shows an example of an ERT profile from Ballinafagh Bog collected using the Wenner Array with electrode spacing of 2.5m.

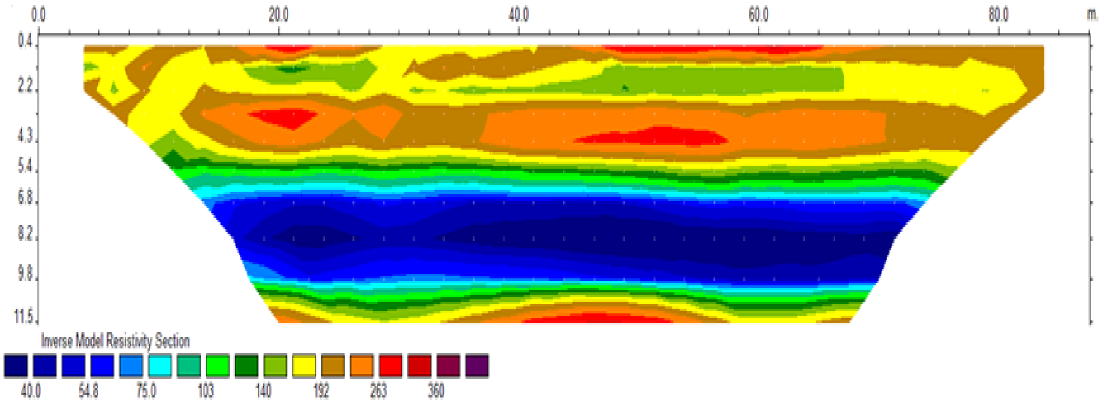


Figure 5.8: Example ERT profile showing peat layering (0-6m) and underlying clay deposits (blue).

The main factors affecting the resistivity of the ground are the clay content and the pore water present within the material under investigation. Increases clay content results in a reduced resistivity (increased conductivity).

The pore water chemistry for ‘pure’ peat soils is generally the controlling factor.

More detailed information on the ERT technique and methodology can be found in Reynolds (1997).