RPS

Dunkellin River and Aggard Stream Flood Relief Scheme

Response to Geological Survey of Ireland

Document Control Sheet

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INTRODUCTION

RPS was commissioned by Galway County Council in 2011 to prepare an Environmental Impact Statement (EIS) for the Dunkellin River and Aggard Stream Flood Relief Scheme, hereafter called the "scheme", in south County Galway. The Dunkellin River and the Aggard Stream form part of the Dunkellin Drainage District which was constructed in or around 1857 and Galway County Council has a statutory maintenance responsibility for these works.

The scheme was submitted to An Bord Pleanála (ABP) in October 2014 for planning approval in line with Section 175 of the Planning and Development Act 2000, as amended. In February 2015, the Board, in accordance with Section 175(5)(a) of the Planning and Development Act, 2000, as amended, requested further information in relation to the proposed development.

Item 7 of the Board's letter stated that, "*The applicant is invited to respond in detail to the written submissions made by parties including local residents, prescribed bodies and others.*"

The purpose of this document is to provide a response to the issues raised by the Geological Survey of Ireland (GSI) in their submission.

1 ITEM 1 – GEOLOGICAL HERITAGE SITES

1.1 Should you identify a Geological Heritage Site with buffer within your study area, please contact Sarah Gatley, head of the Geological Heritage and Planning Programme at sarah.gatley@gsi.ie, for further information and possible mitigation measures if applicable.

Response

No geological heritage areas have been identified within the study area.

2 ITEM 2 – DATA FOR GSI

2.1 As GSI's karst dataset is far from comprehensive due to important data gaps, GSI would welcome any complementary data collected during any EIA; data which would be added to the national database. If you wish to contribute data, please contact Camomile Hickey for details (caoimhe.hickey@gsi.ie).

Response

A site investigation programme was completed for the project by Priority Geotechnical Limited between April and July 2014. A copy of the site investigation report can be provided on request. The scope of work included the drilling of boreholes using cable percussion (20 No.) and rotary coring (32 No.), the excavation of trial pits (43 No.) and the completion of a geophysical survey. In situ and laboratory testing were completed to determine the geotechnical properties of the soils, subsoils and bedrock. The only karst feature identified during drilling was a shallow infilled cavity/ fracture feature at RC42 which was noted between 3.8m to 4.8m below ground level.

Karst Feature mapping was completed by RPS Senior Hydrogeologist Gerry Baker in April 2015. This included a desk based review of potential karst features identified from aerial photography and historical maps. A number of potential karst features which are not included in the existing GSI database were identified and subsequently visited on site.

The two most significant features identified from the desk study and confirmed on site, which may be worthwhile adding to the database, are the **Spring at Carranhally** and **Ephemeral Spring at Crinnage**. A detailed description of these features is provided below.

- **Spring at Carranhally - Grid Reference (ITM 542858-718662).**
  This is a large pool adjacent the Dunkellin River which overflows into the river, see **Images 1.1 to 1.3**. The overflow from the pool is significant, possibly up to 100l/s. It is possible that when the Dunkellin River is in flood the spring is engulfed but at lower flows it appears to be a discrete feature. The feature does not appear on the historical maps. The historical maps pre-arterial drainage indicate the feature was within the original river channel and may have functioned as an underwater discharge feature providing baseflow to the river. The historical maps post-arterial drainage show the narrower river channel but no clear spring is identified.

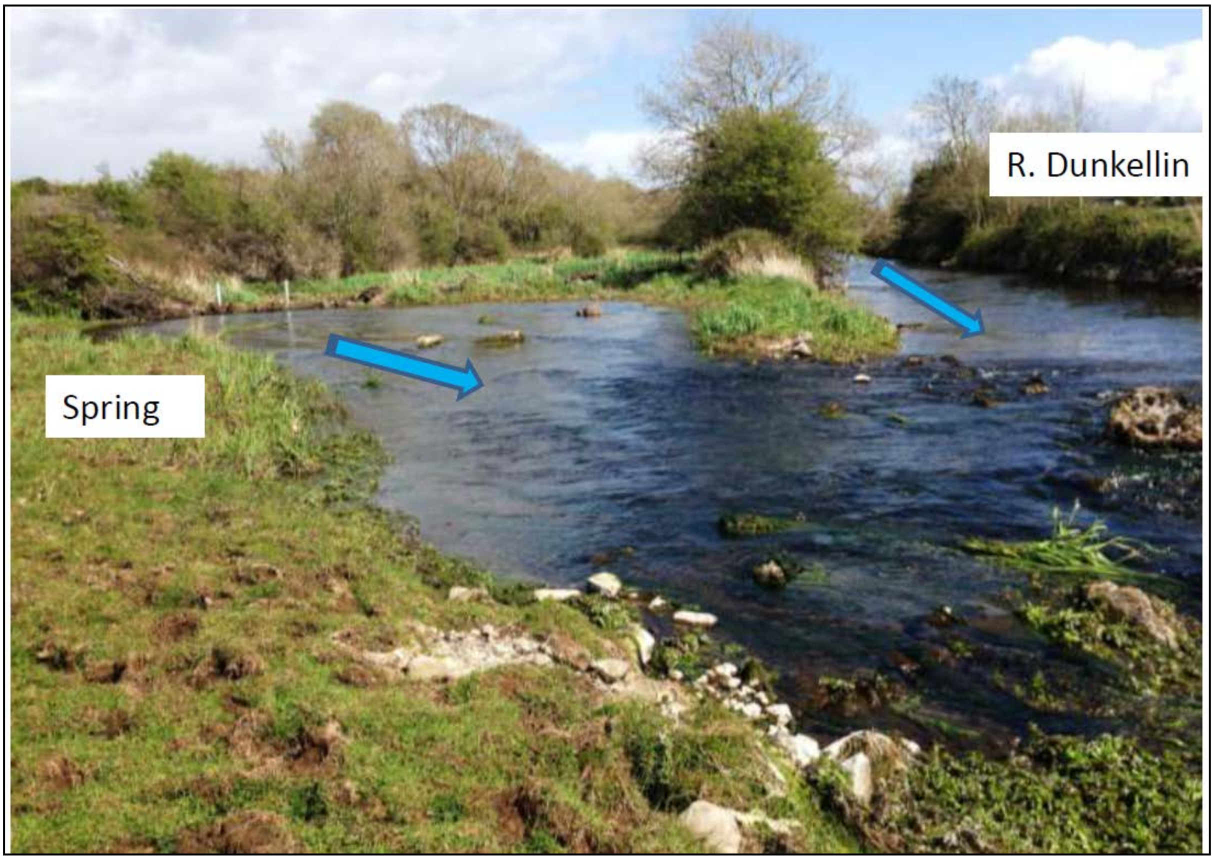

Image 1.1 - Spring at Carranhally looking upstream (Photo No. Img3655)

Image 1.2 - Spring at Carranhally looking downstream (Photo No. 3652)

Image 1.3 - Spring at Carranhally aerial photo and location of photographs.

- **Ephemeral Spring at Crinnage – Grid Reference (ITM 542858-718662).**

  This spring is shown on the historical mapping, current OSI mapping and aerial photos but is not in the GSI karst database, see **Images 1.4** and **1.6**. The spring channel is approximately one metre deep. The spring was dry during the site visit but it seemed clear from the depth of the channel, the sculpting and erosion patterns on the banks that there can be a considerable flow when the spring becomes active.

Image 1.4 - Spring at Crinnage - Location on Aerial Photograph

Image 1.5 - Spring at Upwelling Location, dry at time of site visit (28/04/2015)

Following the completion of the hydrogeological walkover some additional areas were defined for further investigation. A supplementary geophysical programme was developed to investigate the nature of the geological environment in these areas. The results of that geophysical survey are presented in **Appendix A**. The report highlights some clear anomalies in the geophysical survey that relate to karstifed bedrock.

The most significant anomaly relates to a feature identified along survey section R3 (grid reference ITM 543010 718816). The feature is an ephemeral pond surrounded by marshy land as shown in **Images 1.6 to 1.8**. The feature is shown on historical maps as a spring that originally flowed to the north to join the other springs at Killeely Beg before ultimately discharging back into the Dunkellin River further downstream. One of the other Killeely Beg springs to the north is noted in the GSI karst database (Feature No. 1421SWk066). It would appear the land and field boundary walls now prevent the spring from overflowing. As a result a pond is formed, the level of which would relate to the hydraulic head driving the original spring. This feature may in effect function hydraulically in a similar fashion to a small turlough.

Image 1.6 - Karst Feature at Killeely Beg

Image 1.7 - Pond within Karst Feature at Killeely Beg

Image 1.8 - Vegetation at Karst Feature at Killeely Beg

2.2 At a later stage, GSI would much appreciate a copy of reports detailing any site investigation carried out. The data would be added to GSI's national database of site investigation boreholes, implemented to provide a better service to the civil engineering sector. Data can be sent to Beatriz Mozo (beatriz.mozo@gsi.ie, 01-678 2795).

Response

The project geophysical survey reports are provided in **Appendix A**.

APPENDIX A

Geophysical Survey

Dunkellin River Flood Relief Scheme

County Galway

Geophysical Survey 2015

Report Status: Final

MGX Project Number:5945

MGX File Ref: 5945d-005.doc

22nd June 2015

Confidential Report To:

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Minerex Geophysics Limited

Subsurface Geophysical Investigations

EXECUTIVE SUMMARY

1. Minerex Geophysics Ltd. (MGX) carried out a geophysical survey in 2014 for the Dunkellin River Flood Relief Scheme consisting of seismic refraction (p-wave) surveying. The main objectives of the survey were to determine the ground conditions, estimate the depth to rock and establish the overburden thickness (MGX 2014).
2. The current 2015 survey consisted of 2D-Resistivity and EM31 Ground Conductivity. The main objective of this survey was to check for the presence of karst features at selected zones along the Dunkellin River and on some land areas that are intended for depositing and spreading geological material gained form the river channel widening.
3. The locations for the survey were first selected after a desk study and walk over by the hydrogeologist for the scheme. The main targets were areas where possible karst features are existing or may be found. During the survey the results were processed and discussed among the team and some further locations were checked.
4. The precious seismic refraction survey results modelled the ground with four layers that represent the transition from soft/loose overburden to strong rock. Layers 3 (Weathered broken rock) and layers 4 (strong fresh rock) will mainly require breaking and blasting for removal, though some rock of layer 3 may be removed by ripping. Results from the direct ground investigation were available report and had been added to the sections where relevant to the geophysical survey.
5. Generally the resistivity values are very high and indicate a clean limestone as the bedrock type. In the survey areas investigated by conductivity and resistivity survey there are relatively few anomalies typical for karst features in the limestone. Most areas do not show anomalies that indicate karstification, faults, fracture zone or thick weathered rock.
6. R3 has the strongest anomalous resistivity and conductivity values of the entire survey. There is a notable karstified rock and clay-water infilled zone on this profile.
7. Some resistivity profiles (R8, R9) show weak anomalies interpreted as near-surface shallow slightly karstified and weathered rock. The localised extent can be seen in the vertical resistivity and horizontal conductivity data.
8. The individual profiles and areas are discussed in details in chapter 4.

CONTENTS

List of Tables, Maps and Figures:

1. INTRODUCTION

1.1 Background

Minerex Geophysics Ltd. (MGX) carried out two geophysical surveys for the Dunkellin River Flood Relief Scheme in 2014 and 2015. The first survey consisted of seismic refraction (p-wave) measurements in water and on land (MGX 2014). The second survey was done by using 2D-Resistivity and EM31 Ground Conductivity measurements.

The second survey had the main objective to locate karst zones/features or thick weathered rock zones. The survey was employed at locations where such features may exist based on existing ground investigation data, a desk study or a walk over by the project hydrogeologist.

The main construction objective is the removal of overburden and rock for the deepening of the river in Craughwell and for the widening of the river channel west of the Rinn Bridge towards the N18 near Kilcolgan. It is intended to spread the geological material gained from excavations on fields. The survey intention was to check for the presence of karst features in order to prevent a possible collapse of ground, subsidence of spread material and possible changing of the ground water flow regime.

1.2 Objectives

The main objectives of the geophysical survey were:

- To check for the presence of karst zones/features in the subsurface
- To check for layers of thick weathered rock
- To determine areas of anomalous rock

1.3 Site Description

The survey areas are located along the Craughwell River and Dunkellin River between Craughwell and the N18 near Kilcolgan. Most survey profiles (R1, R2 and R5 to R10) are close to the river though some (R3, R4, R5a, R8a and R9a) are further away in fields that are intended for spreading material.

1.4 Geology

The bedrock geological map of Galway Bay (GSI, 2003) indicates that the survey area is underlain by Carboniferous lithologies, Visean Limestone and Burren Formation. The Visean Limestone is described as an undifferentiated limestone and the Burren Formation as pale grey clean skeletal limestone. Both formations can be karstified and show a ‘limestone pavement’ (Epikarst) weathering pattern near the surface of the rock.

1.5 Report

This report includes the results and interpretation of the geophysical survey. Plans and tables are included to illustrate the results of the survey. More detailed descriptions of geophysical methods and measurements can be found in GSEG (2002), Milsom (1989) and Reynolds (1997).

The client provided maps of the site and the digital version were used as the background map in this report. Elevations were surveyed and are included in the vertical sections.

The interpretative nature and the non-invasive survey methods must be taken into account when considering the results of this survey and Minerex Geophysics Limited, while using appropriate practice to execute, interpret and present the data, give no guarantees in relation to the existing subsurface.

2. GEOPHYSICAL SURVEY

2.1 Methodology

The methodology consisted of 2D-Resistivity Profiles and EM31 Ground Conductivity.

The survey locations are indicated on the overview plan (Plan 1) and on the individual plans 3a – 3g.

All geophysical surveys are acquired, processed and reported in accordance with British Standards BS 5930:1999 +A2:2010 'Code of Practice for Site Investigations'.

2.2 EM31 Ground Conductivity

The EM31 ground conductivity survey was carried out over the areas indicated in Plan 1 on lines nominally 10 m apart. Along each line a reading of ground conductivity was taken every second while walking along, thereby resulting in a survey grid of nominally 10 x 2 m. The locations were measured with a sub-meter accuracy SERES DGPS system attached to the EM31 and all data was jointly stored in a data logger. The conductivity meter was a GEONICS EM31 with Allegro data logger and NAV31 data acquisition software. The instrument was checked at a base station, the readings were stable and no drift occurred.

The conductivity is typical for certain geological material types. Dry and clean Sand/Gravel and most clean limestone rock types have relatively low conductivities while peat, clay and clay-rich rock types (mudstone, shale) have high conductivities.

EM31 ground conductivity determines the bulk conductivity of the subsurface over a typical depth between 0 and 6 m bgl. and over a radius of approx. 5m around the instrument. When looking for clay, silt and water infill within rock occurring at relatively shallow depth the EM31 can find anomalous rock zones with a vertical extent of approx. 3m. The measurements are disturbed by metal and other conductive objects within the range of the instrument and therefore no geological interpretations can be made in the vicinity of such man-made objects. Either readings were not taken near sources of interference in the first place or notes were taken by the operator in order to remove these during processing or to account for these in the interpretation.

The combined survey area has a size of 22.45 ha.

2.3 2D-Resistivity

2D-Resistivity profiles were surveyed with electrode spacing of 5m, up to 64 electrodes per set-up and a maximum length of 315m per set-up. The longest of the 13 profiles was 475 m long. The readings were taken with a Tigre Resistivity Meter, Imager Cables, stainless steel electrodes, laptop and ImagerPro acquisition software.

During 2D-Resistivity surveying data is acquired in the form of linear profiles using a suite of metal electrodes. A current is injected into the ground via a pair of electrodes while a potential difference is measured across a second pair of electrodes. This allows for the recording of the apparent resistivity in a two-dimensional arrangement below the profile. The data is inverted after the survey to obtain a model of subsurface resistivities. The generated model resistivity values and their spatial distribution can then be related to typical values for different geological materials.

2D-Resistivity has proven zones of anomalous rock/karstified rock with lateral extents of 5 m and more.

The combined length of all survey profiles was 3890 m.

2.4 Site Work

The data acquisition was carried out between the 2nd and 18th of June 2015. The weather conditions were variable throughout the acquisition period. Health and safety standards were adhered to at all times.

The locations and elevations were surveyed with a TRIMBLE RTK-GPS to accuracy < 0.02m.

3. RESULTS AND INTERPRETATION

The interpretation of geophysical data was carried out utilising the known response of geophysical measurements, typical physical parameters for subsurface features that may underlay the site, and the experience of the authors.

3.1 EM31 Ground Conductivity

The EM31 ground conductivity values were merged into one data file for each survey area and contoured and gridded with the SURFER contouring package. The contours are created by gridding and interpolation and care must be taken when using the data. The contour maps are overlaid over the location and base maps (Plans 3a – 3g) and the values in milliSiemens/metre (mS/m) are indicated on the colour scale bar.

With the exception of the westernmost survey at R1 all other EM31 areas have the same colour scale (1-15 mS/m). Only the survey at the centre of profile R1 has a doubled scale (1-30 mS/m) because the range of values is much larger.

The EM31 values for ground conductivity indicate the conductivity to a depth of approx. 6m. Therefore the values indicate the material type over an area at a shallow level. Low conductivities indicate either shallow bedrock or dry sandy and gravely overburden while higher conductivities indicate thicker overburden, shallow zones of bedrock karstification and clay-rich overburden. Very high or very low conductivities indicate noise from man-made metal objects and are ignored in the interpretation. High interference typically occurs along field boundaries and fences and close to the railway line and bridges.

The colour scale is designed such that the colours indicate certain geological material types. Blue colours indicate shallow bedrock, thin overburden and generally an absence of anomalous ground conditions.

Green colours indicate an increase in overburden thickness because there are more clay minerals contained within the soil and subsoil matrix. Yellow to red indicates thick overburden with clay-rich material. These area can contain anomalies with relevance to karst features as solution voids in shallow bedrock can be filled with clay and other products that increase the conductivity.

3.2 2D-Resistivity Profiles

The 2D-Resistivity data was positioned and inverted with the RES2DINV inversion package. Overlapping profiles were concatenated for a joint inversion. The programme uses a smoothness constrained least-squares inversion method to produce a 2D model of the subsurface model resistivities from the recorded apparent resistivity values. Three variations of the least squares method are available and for this project the Jacobian Matrix was recalculated for the first three iterations, then a Quasi-Newton approximation was used for subsequent iterations. Each dataset was inverted using seven iterations resulting in a typical RMS error of < 5.0%. The resulting models were colour contoured with the same resistivity scale for all profiles and they are displayed as cross sections (Plans 3a – 3g).

The resistivities cover a range typical for materials from clay overburden to clean limestone bedrock. Low resistivity values (<400 Ohmm with red – yellow colours) typically indicate presence of clay and water in the overburden or within fractured rock. Medium values (400 – 1200 Ohmm with green colours) show sand/gravel/boulders rather than clay in the overburden and weathered limestone bedrock. High resistivities (> 1200 Ohmm) indicate bedrock type like clean limestone.

Generally the resistivity values are very high and indicate a clean limestone as the bedrock type. Clean limestone is liable to karstification and is known to be highly karstified in many places like County Galway. In the survey area there are relatively few anomalies typical for karst features in the limestone.

Where low to medium values occur at depth within the high resistivity limestone they indicate karstification, faulting or fracturing of the limestone. The void space is filled with clay, silt and weathering products and water saturated. All of these material lower the resistivities when present within the limestone.

3.3 Relation with previous Seismic Survey

The 2D-Resistivity Images are overlaid with the seismic survey and the data can be jointly interpreted. The seismic refraction method determines the strength/stiffness/rock quality through the seismic velocity while resistivities and conductivities depend on the material and mineral composition of the ground. Therefore resistivity/conductivity is more diagnostic for karst features, especially where these are infilled with clay and water.

At R7 the overburden is very shallow as indicated by both methods towards the slight rise in the east.

Good correlations can be seen at R8 where the seismic surface layers thicken in the west, and also the resistivities show some smaller anomalies here.

At R9 at around 120 m the seismic interpreted layers indicated some thick weathering of rock and the resistivities mirror this trend with green colours and mid-range resistivities indicating thicker weathered rock.

The seismic interpretation follow generally the resistivity values in terms of thicker/thinner overburden. Only at R10 there is a larger difference which can be explained by the seismic profile having been in the river while the R10 was offset on land.

4. CONCLUSIONS

Several areas along the Dunkellin River were investigated by resistivity and conductivity survey and the conclusions and results can be summarised by areas:

R1 is the furthest profile to the west and sea along the Dunkellin River and overburden sediments are containing clay deposited in the flood plain. The overburden is characterised by the lowest resistivities and highest conductivities of the survey. The overburden thickness is approx. 3 – 5m. At the centre of R1 the lowest resistivities stretch to a depth of around 10m. The seismic layers continue relatively horizontal, therefore it is interpreted that the rock near its surface has been karstified and weathered but that it is filled quite tightly with clay and other products. The anomalous zone is also reflected on the EM31 conductivity but it is limited to a roughly rectangular zone. At depth the resistivities are very high indicating the continuous high quality limestone.

The conductivity between area R1 and R2 was done around rotary corehole RC42 which showed an area of clay infill of a cavity/fracture between 3.8 and 4.8m. This type of anomaly is also expected at the location of R1 as discussed in the previous paragraph. The EM31 conductivities show that RC42 is located at the edge of high conductivities that stretch along the river but get smaller at a larger distance from the river. The zone continues west and south-west.

R2 is located along a small contributory river and shows increasing resistivity values from northwest to southeast. This is also reflected in the ground conductivities which decrease away from the Dunkellin River. Anomalous conditions here are interpreted to consist of clay and water rich overburden near the river rather than karstification. At depth the resistivities are very high indicating the continuous high quality limestone.

R3 and R4 are located north of the river in a wider area marked for land spreading. There is a spring located close to the river. R3 shows the strongest anomalous resistivities measured anywhere during this survey. A shallow red area between 50 and 150 m shows clay rich and saturated overburden. This area is in a small depression which is not used for pasture, unlike all surrounding fields. A deep red zone exists at 40 – 70 m with a depth of 8 – 18 m. This is a typical anomaly for a clay and water infilled area and karstified rock. Two weaker zones exist within the rock at 170 and 260 m along the profile. R4 shows thin overburden, no anomalies and at depth the resistivities are very high indicating the continuous high quality limestone. The EM31 ground conductivities indicate the outline of the depression on R3 but otherwise there is shallow rock all over this survey area.

R5 is in an area of small visible karst features looking like pools where the water drains away. The resistivities and ground conductivities only show small medium anomalies and all those are occurring close to the surface with no indications at larger depths.

R6, R7 and R9a all indicate shallow overburden and no anomalous ground either at shallow or large depth.

R8 and R9 indicate some small isolated locally anomalous resistivities and conductivities that do not stretch deeper than 10 – 15m. These weak anomalies typical for slightly karstified and weathered rock in the vertical resistivity data are mirrored in the lateral EM31 ground conductivities.

R10 resistivities indicate slightly anomalous conditions towards both ends of the profiles. At the western end this likely due to clay rich overburden at the extreme profile end. At the eastern end the medium resistivities stretch into the rock. The EM31 ground conductivity covers a wider area to the northeast from the end of R10 and the anomalous zone gains higher conductivities close to the river. This features is likely a weathered/karstified rock zone that terminates in the Northeast at the Dunkellin River.

5. REFERENCES

1. **GSEG 2002.** Geophysics in Engineering Investigations. Geological Society Engineering Geology Special Publication 19, London, 2002.
2. **GSI, 1995.** Geology of Galway Bay. Geological Survey of Ireland 1995.
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4. **Milsom, 1989.** Field Geophysics. John Wiley and Sons.
5. **Reynolds, 1997.** An Introduction to Applied and Environmental Geophysics. John Wiley and Son.

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CLIENT	Priority Geotechnical Ltd
PROJECT	Dunkellin River Flood Relief Geophysical Survey 2015
TITLE	Plan 1: Overview Plan

SCALE:	1:10000 @ A1
PROJECT:	5945
DRAWN:	JC
DATE:	22/06/2015
MGX FILE:	5945d_Plans.dwg
STATUS:	Final

LEGEND: **Geophysical Survey Locations:**

S1	Seismic Refraction Profile
R1	2D-Resistivity Profile
	EM-31 Ground Conductivity
	Proposed Material Depositing

Locations are in ITM, Elevations are in mOD (Malin Head)

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CLIENT	Priority Geotechnical Ltd
PROJECT	Dunkellin River Flood Relief Geophysical Survey 2015
TITLE	Plan 3a: 2D-Resistivity Models and Ground Conductivity Contour Maps

SCALE:	Hor 1:1000 @ A1, Ver 1:200, VE x 5
PROJECT:	5945
DRAWN:	JC
DATE:	22/06/2015
MGX FILE:	5945d_Plans.dwg
STATUS:	Final

LEGEND: **Geophysical Survey Locations:**

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Locations are in ITM, Elevations are in mOD (Malin Head)

Geothechnical Survey Locations:

BH01	Borehole Location
RC01	Rotary Core Location
TP01	Trial Pit Location

Layers and Interpretation from Seismic Refraction Model:

1800 Seismic Velocity in m/s

Layers from Seismic Refraction Model:
- Ground Land Surface/Top of Layer 1 (300-500 m/s) Soft/loose Topsoil/Overburden
- River Bottom and Top of Layer 2 (1500 m/s) Saturated Overburden
- Top of Layer 2 (1100 - 1500 m/s) Firm - Stiff/Dense Overburden
- Top of Layer 3 (2100-2200 m/s) Weathered Broken Rock
- Top of Layer 4 (4400-4800 km/s) Strong Fresh Rock

Legend for Abbreviated Borehole Logs:

RC01	Borehole location
(8mN)	Distance >5m and direction from line
OB	Overburden
WLST	Weathered Limestone
LST	Limestone

2D-Resistivity Model Values:

Resistivities (Ohmm) for 2D-Resistivity Model

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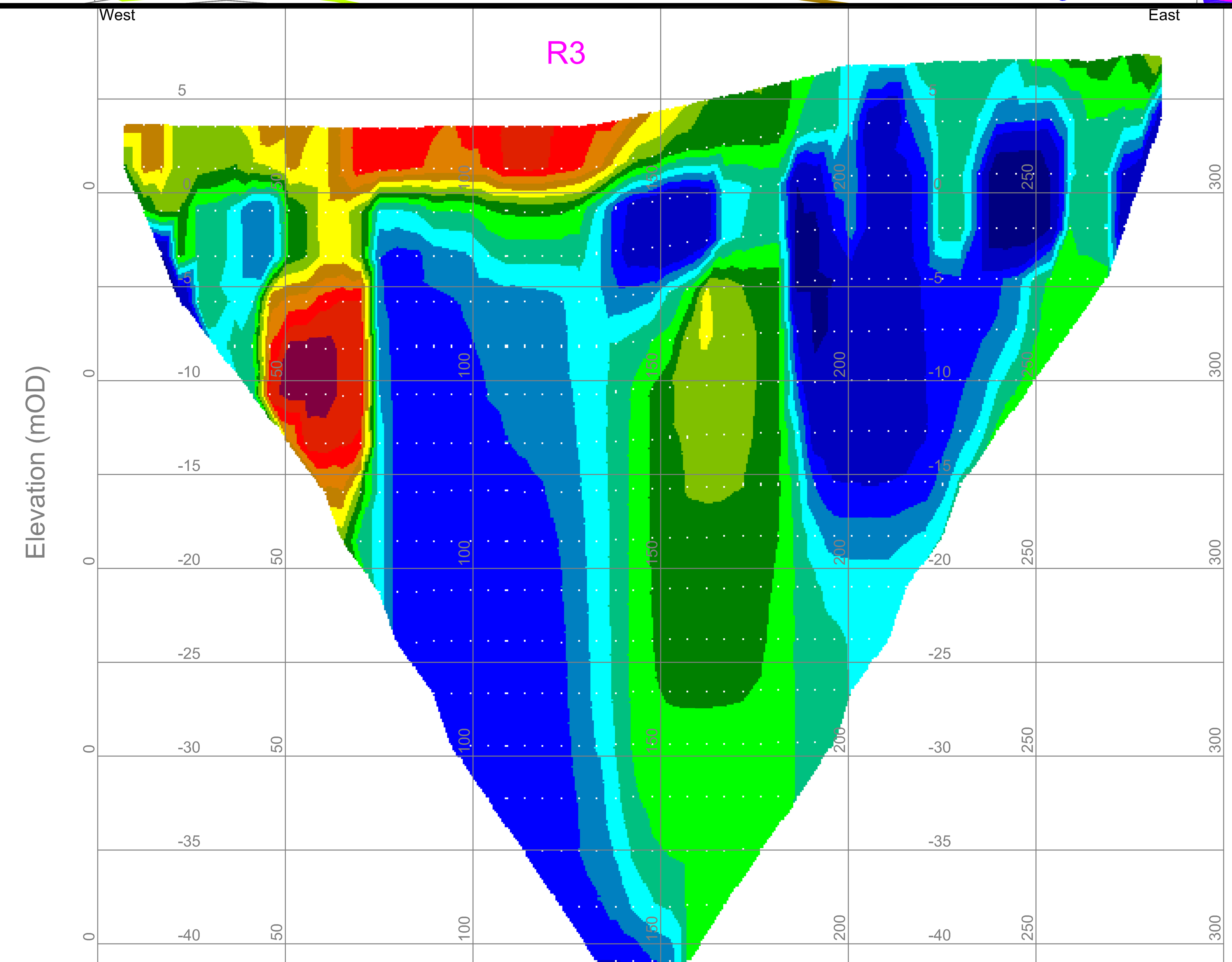

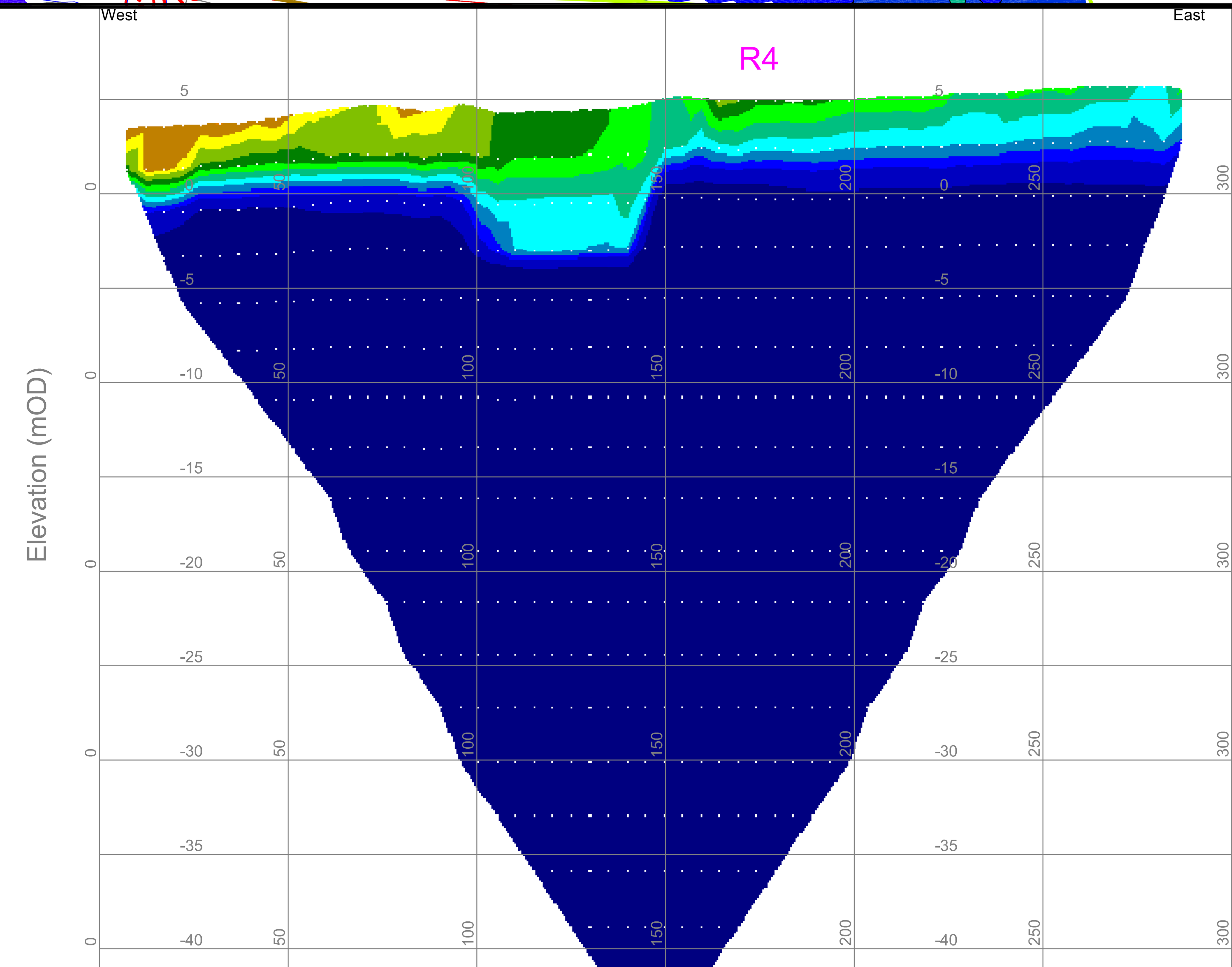

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CLIENT	Priority Geotechnical Ltd
PROJECT	Dunkellin River Flood Relief Geophysical Survey 2015
TITLE	Plan 3b: 2D-Resistivity Models and Ground Conductivity Contour Maps

SCALE:	Hor 1:1000 @ A1, Ver 1:200, VE x 5
PROJECT:	5945
DRAWN:	JC
DATE:	22/06/2015
MGX FILE:	5945d_Plans.dwg
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LEGEND: **Geophysical Survey Locations:**

- S1 — Seismic Refraction Profile
- R1 — 2D-Resistivity Profile
- EM-31 Ground Conductivity
- Proposed Material Depositing

Locations are in ITM, Elevations are in mOD (Malin Head)

Geothechnical Survey Locations:

- BH01 — Borehole Location
- RC01 — Rotary Core Location
- TP01 — Trial Pit Location

Layers and Interpretation from Seismic Refraction Model:

- *1800* — Seismic Velocity in m/s
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50.0 100 200 400 800 1600 3200 6400

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CLIENT	Priority Geotechnical Ltd
PROJECT	Dunkellin River Flood Relief Geophysical Survey 2015
TITLE	Plan 3c: 2D-Resistivity Models and Ground Conductivity Contour Maps

SCALE:	Hor 1:1000 @ A1, Ver 1:200, VE x 5
PROJECT:	5945
DRAWN:	JC
DATE:	22/06/2015
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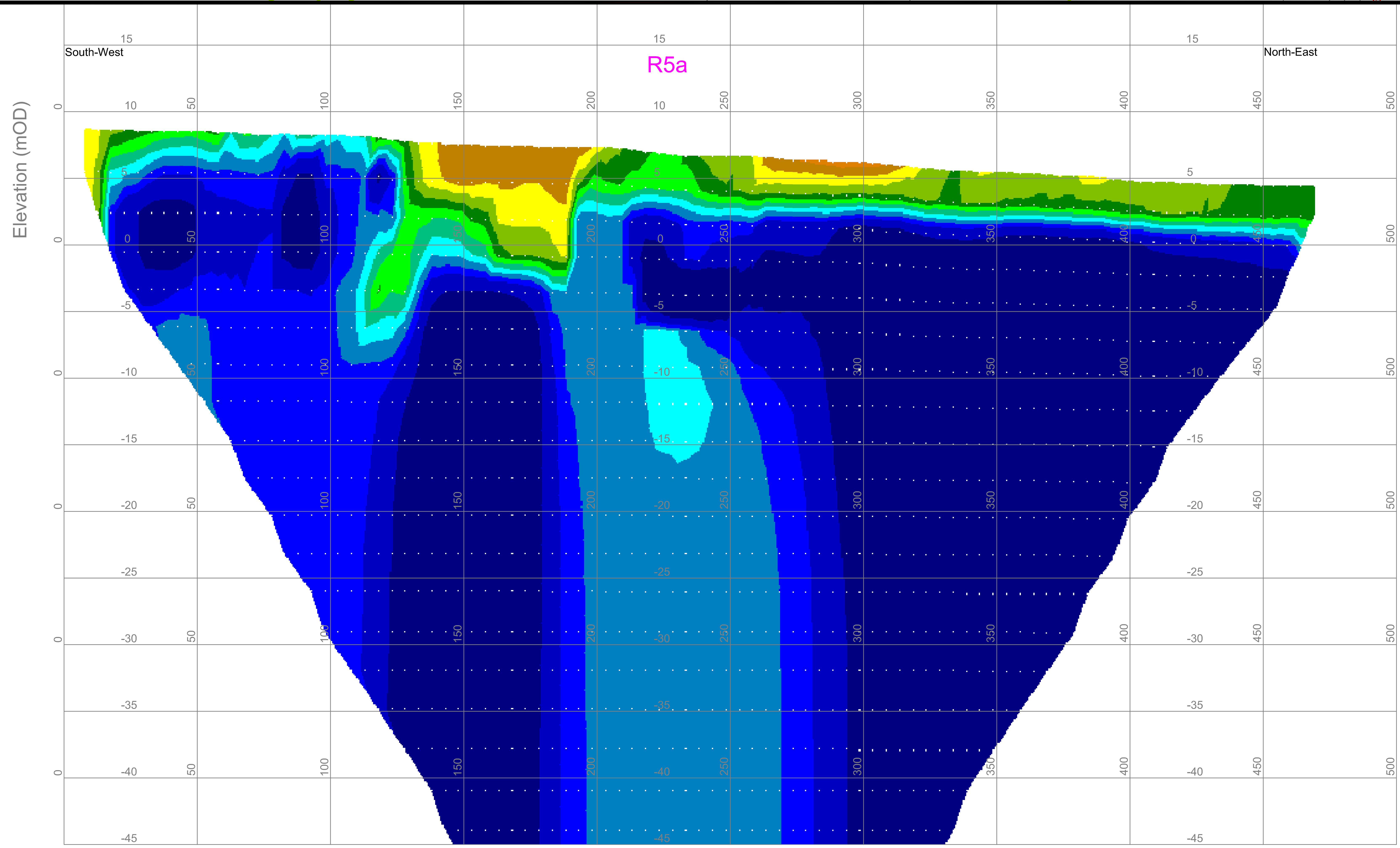
Resistivities (Ohmm) for 2D-Resistivity Model

50.0 100 200 400 800 1600 3200 6400



Minerex Geophysics Limited Unit F4, Maynooth Business Campus Maynooth, Co. Kildare Tel. (01) 6510030 Fax. (01) 6510033 Email: info@mgx.ie Web: www.mgx.ie	CLIENT	Priority Geotechnical Ltd	
	PROJECT	Dunkellin River Flood Relief Geophysical Survey 2015	
	TITLE	Plan 3d: 2D-Resistivity Models and Ground Conductivity Contour Maps	

SCALE:	Hor 1:1000 @ A1, Ver 1:200, VE x 5
PROJECT:	5945
DRAWN:	JC
DATE:	22/06/2015
MGX FILE:	5945d_Plans.dwg
STATUS:	Final

LEGEND: **Geophysical Survey Locations:**

- S1 — Seismic Refraction Profile
- R1 — 2D-Resistivity Profile
- EM-31 Ground Conductivity
- Proposed Material Depositing

Locations are in ITM, Elevations are in mOD (Malin Head)

Geothechnical Survey Locations:

- BH01 — Borehole Location
- RC01 — Rotary Core Location
- TP01 — Trial Pit Location

Layers and Interpretation from Seismic Refraction Model:

- **1800** — Seismic Velocity in m/s
- Layers from Seismic Refraction Model:
- Ground Land Surface/Top of Layer 1 (300-500 m/s) Soft/loose Topsoil/Overburden
- River Bottom and Top of Layer 2 (1500 m/s) Saturated Overburden
- Top of Layer 2 (1100 - 1500 m/s) Firm - Stiff/Dense Overburden
- Top of Layer 3 (2100-2200 m/s) Weathered Broken Rock
- Top of Layer 4 (4400-4800 km/s) Strong Fresh Rock

Legend for Abbreviated Borehole Logs:

RC01	Borehole location
(8mN)	Distance >5m and direction from line
OB	Overburden
WLST	Weathered Limestone
LST	Limestone

2D-Resistivity Model Values:

Resistivities (Ohmm) for 2D-Resistivity Model

50.0 100 200 400 800 1600 3200 6400

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CLIENT	Priority Geotechnical Ltd
PROJECT	Dunkellin River Flood Relief Geophysical Survey 2015
TITLE	Plan 3e: 2D-Resistivity Models and Ground Conductivity Contour Maps

SCALE:	Hor 1:1000 @ A1, Ver 1:200, VE x 5
PROJECT:	5945
DRAWN:	JC
DATE:	22/06/2015
MGX FILE:	5945d_Plans.dwg
STATUS:	Final

LEGEND: Geophysical Survey Locations:

- S1 — Seismic Refraction Profile
- R1 — 2D-Resistivity Profile
- EM-31 Ground Conductivity
- Proposed Material Depositing

Locations are in ITM, Elevations are in mOD (Malin Head)

Geothechnical Survey Locations:

- BH01 — Borehole Location
- RC01 — Rotary Core Location
- TP01 — Trial Pit Location

Layers and Interpretation from Seismic Refraction Model:

- **1800** Seismic Velocity in m/s
- Layers from Seismic Refraction Model:
- Ground Land Surface/Top of Layer 1 (300-500 m/s) Soft/loose Topsoil/Overburden
- River Bottom and Top of Layer 2 (1500 m/s) Saturated Overburden
- Top of Layer 2 (1100 - 1500 m/s) Firm - Stiff/Dense Overburden
- Top of Layer 3 (2100-2200 m/s) Weathered Broken Rock
- Top of Layer 4 (4400-4800 km/s) Strong Fresh Rock

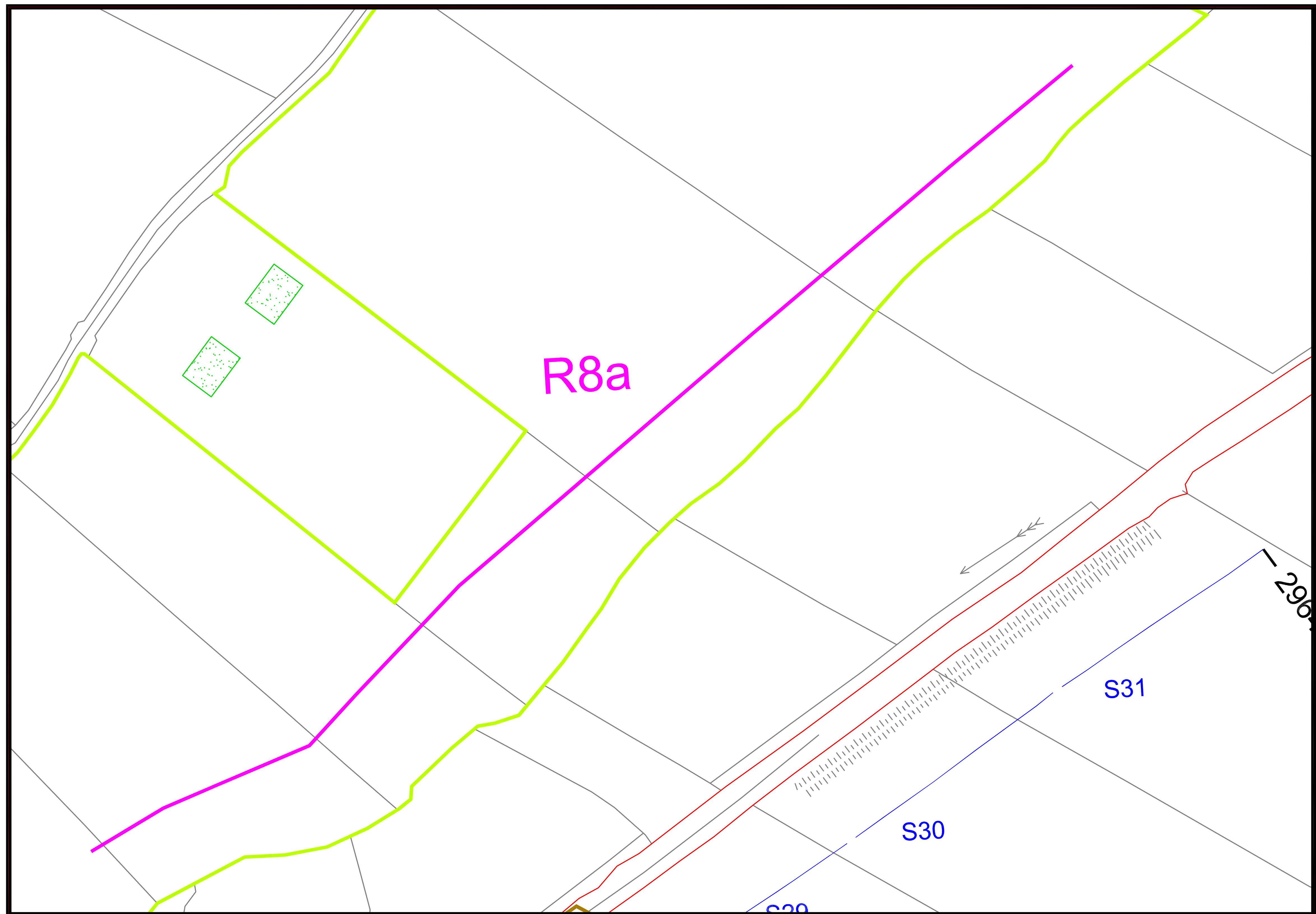
Legend for Abbreviated Borehole Logs:

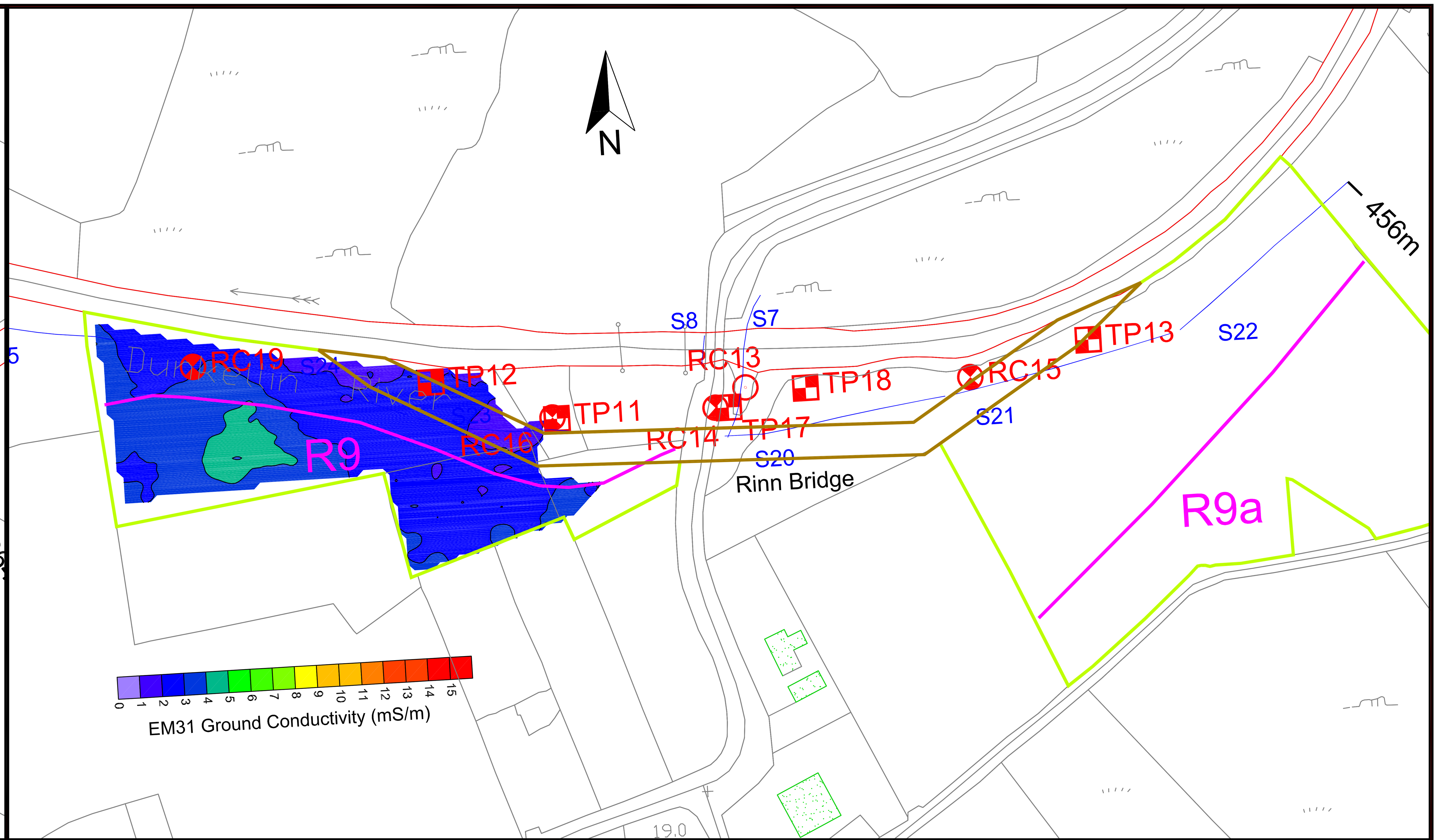
RC01	Borehole location
(8mN)	Distance >5m and direction from line
OB	Overburden
WLST	Weathered Limestone
LST	Limestone

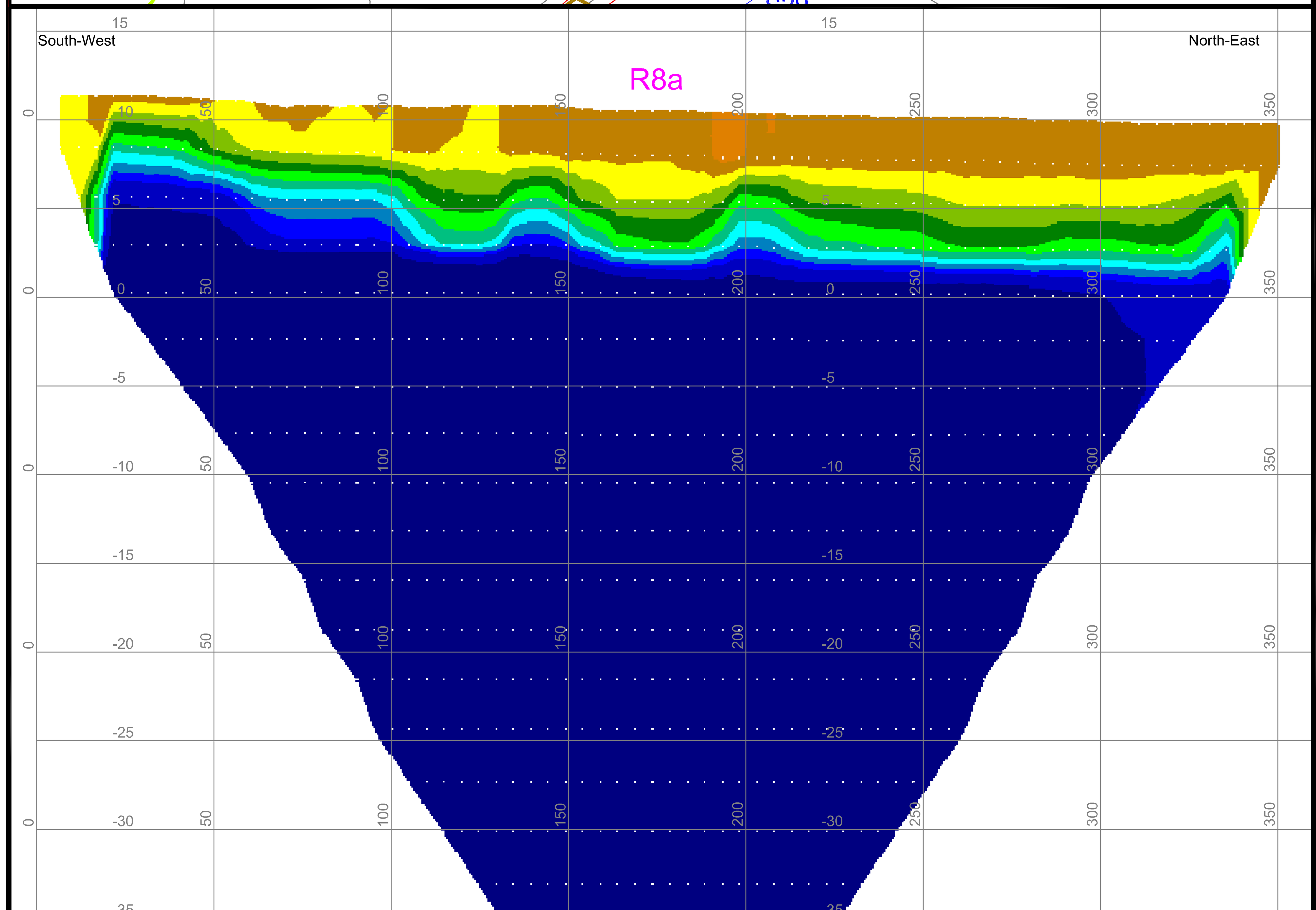
2D-Resistivity Model Values:

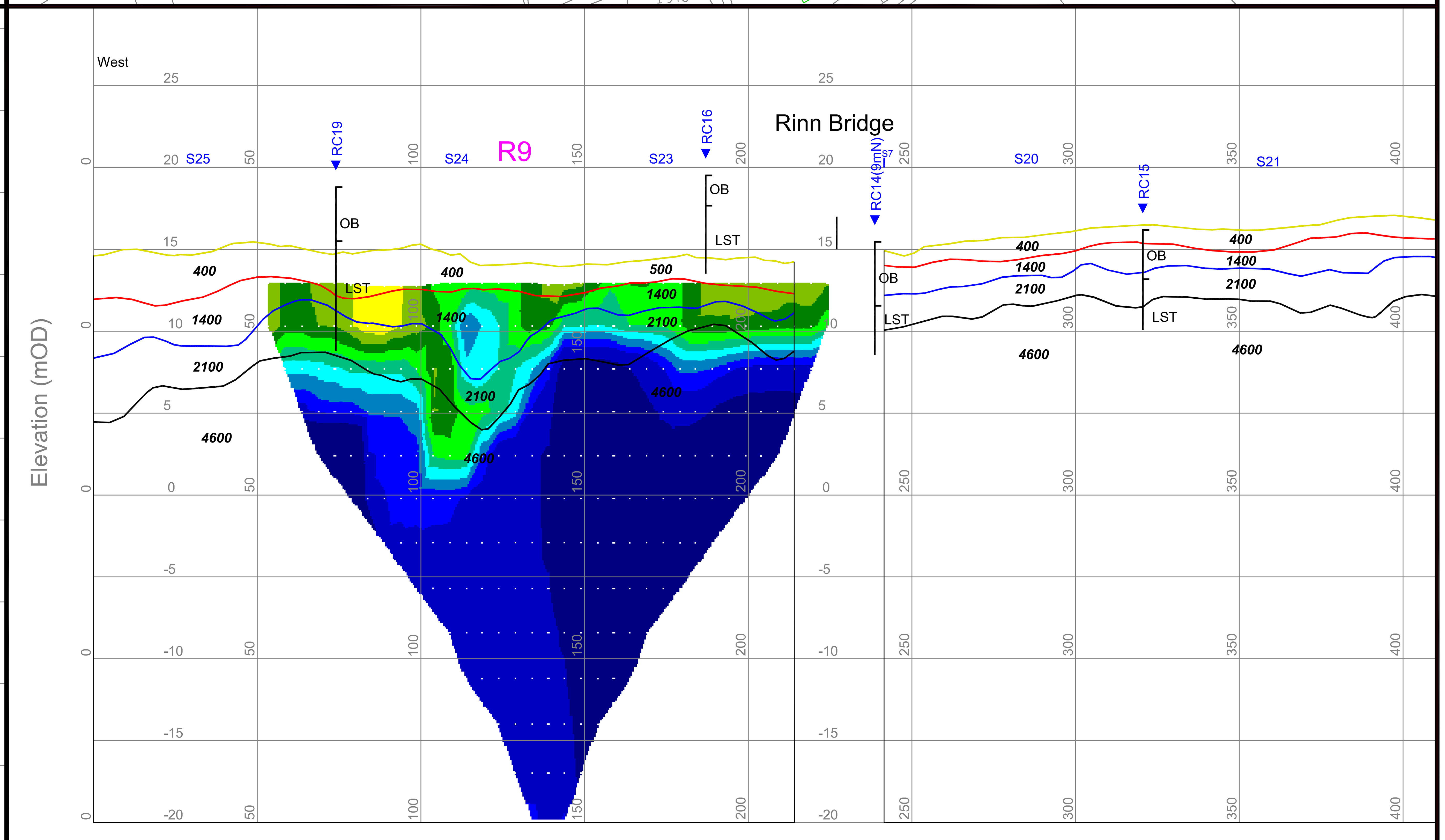
Resistivities (Ohmm) for 2D-Resistivity Model

50.0 100 200 400 800 1600 3200 6400









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CLIENT	Priority Geotechnical Ltd
PROJECT	Dunkellin River Flood Relief Geophysical Survey 2015
TITLE	Plan 3f: 2D-Resistivity Models and Ground Conductivity Contour Maps

SCALE:	Hor 1:1000 @ A1, Ver 1:200, VE x 5
PROJECT:	5945
DRAWN:	JC
DATE:	22/06/2015
MGX FILE:	5945d_Plans.dwg
STATUS:	Final

LEGEND: **Geophysical Survey Locations:**

S1	Seismic Refraction Profile
R1	2D-Resistivity Profile
	EM-31 Ground Conductivity
	Proposed Material Depositing

Locations are in ITM, Elevations are in mOD (Malin Head)

Geothechnical Survey Locations:

BH01	Borehole Location
RC01	Rotary Core Location
TP01	Trial Pit Location

Layers and Interpretation from Seismic Refraction Model:

1800 Seismic Velocity in m/s

Layers from Seismic Refraction Model:

- Ground Land Surface/Top of Layer 1 (300-500 m/s) Soft/loose Topsoil/Overburden
- River Bottom and Top of Layer 2 (1500 m/s) Saturated Overburden
- Top of Layer 2 (1100 - 1500 m/s) Firm - Stiff/Dense Overburden
- Top of Layer 3 (2100-2200 m/s) Weathered Broken Rock
- Top of Layer 4 (4400-4800 km/s) Strong Fresh Rock

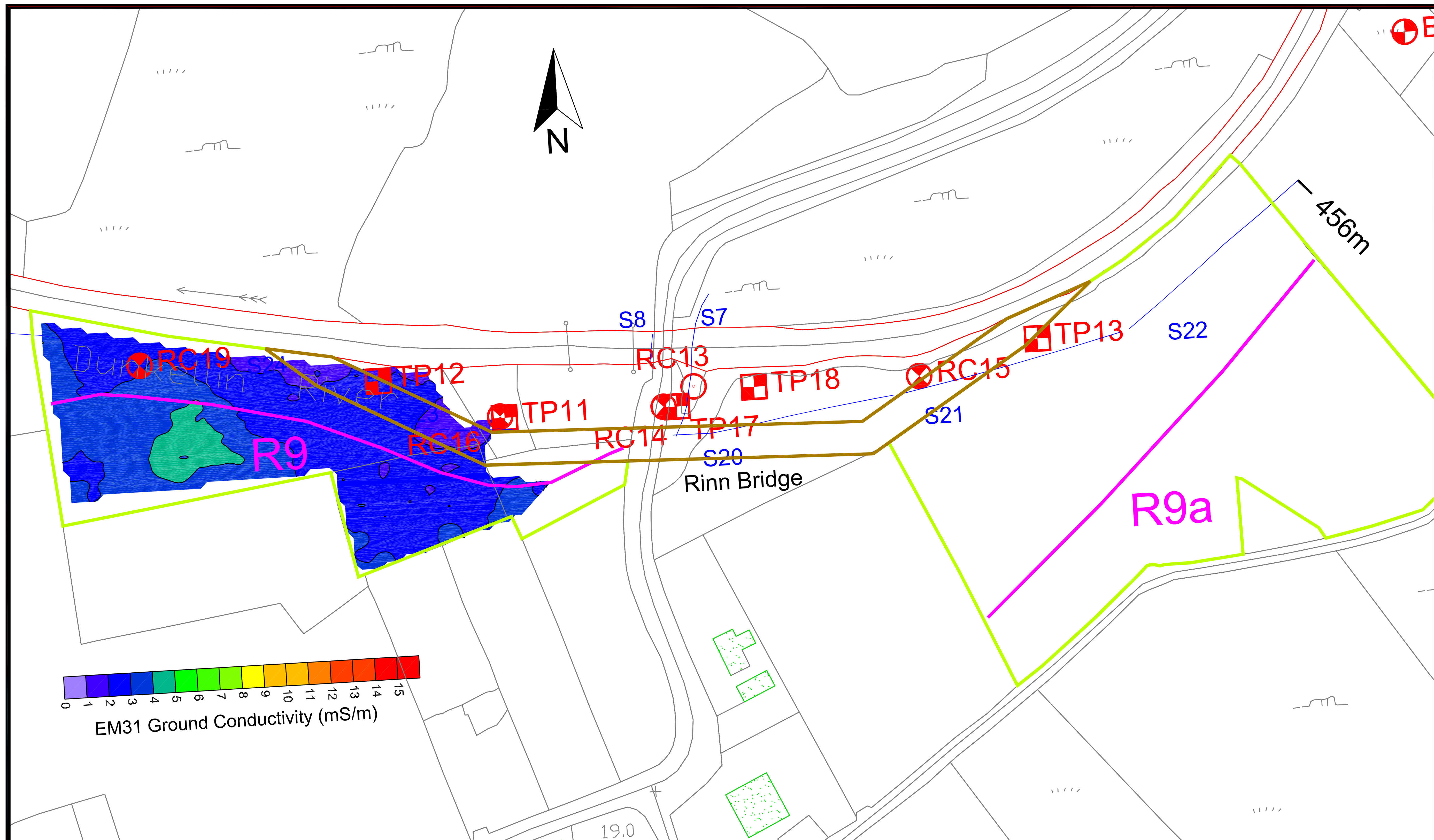
Legend for Abbreviated Borehole Logs:

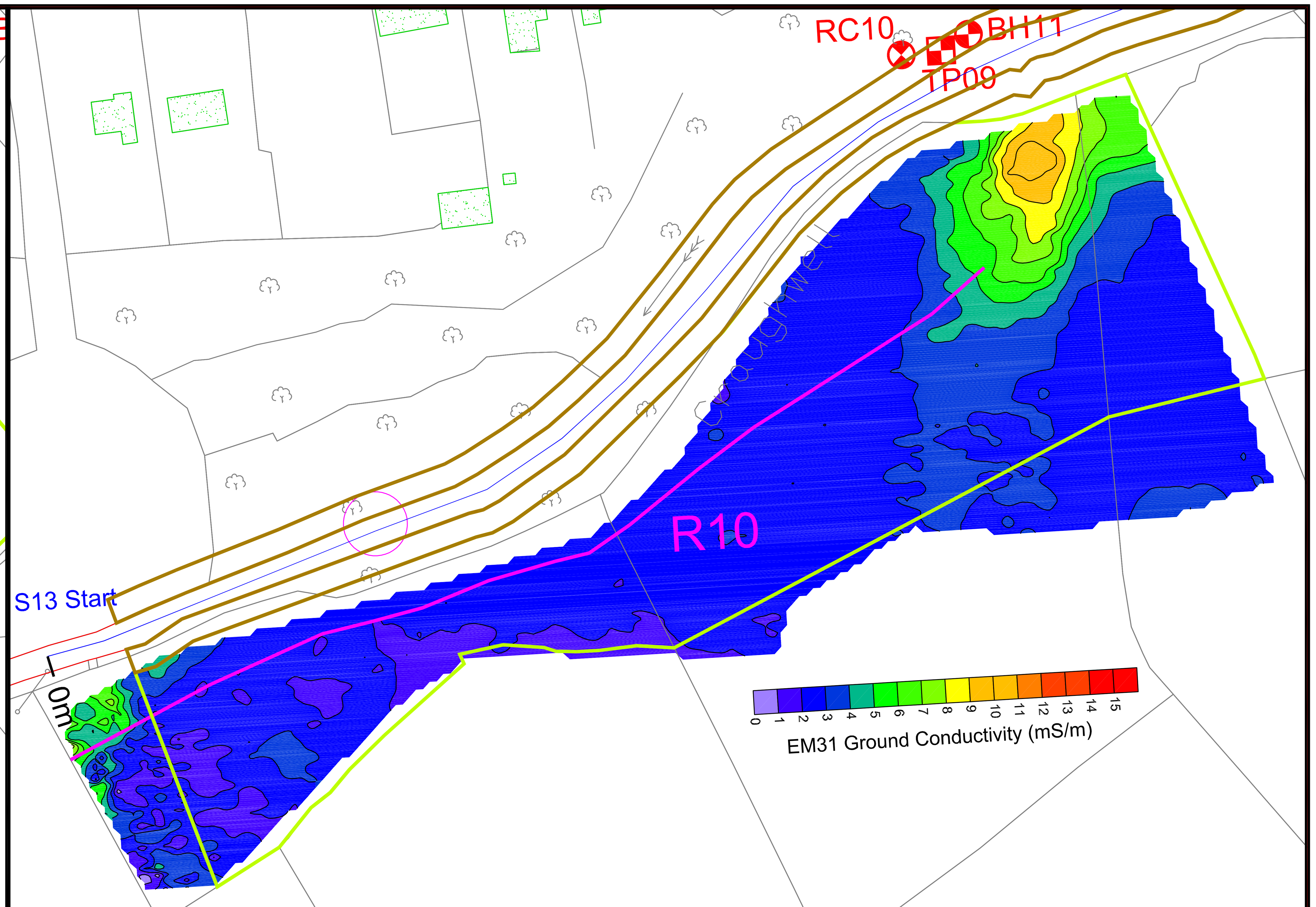
RC01	Borehole location
(8mN)	Distance >5m and direction from line
OB	Overburden
WLST	Weathered Limestone
LST	Limestone

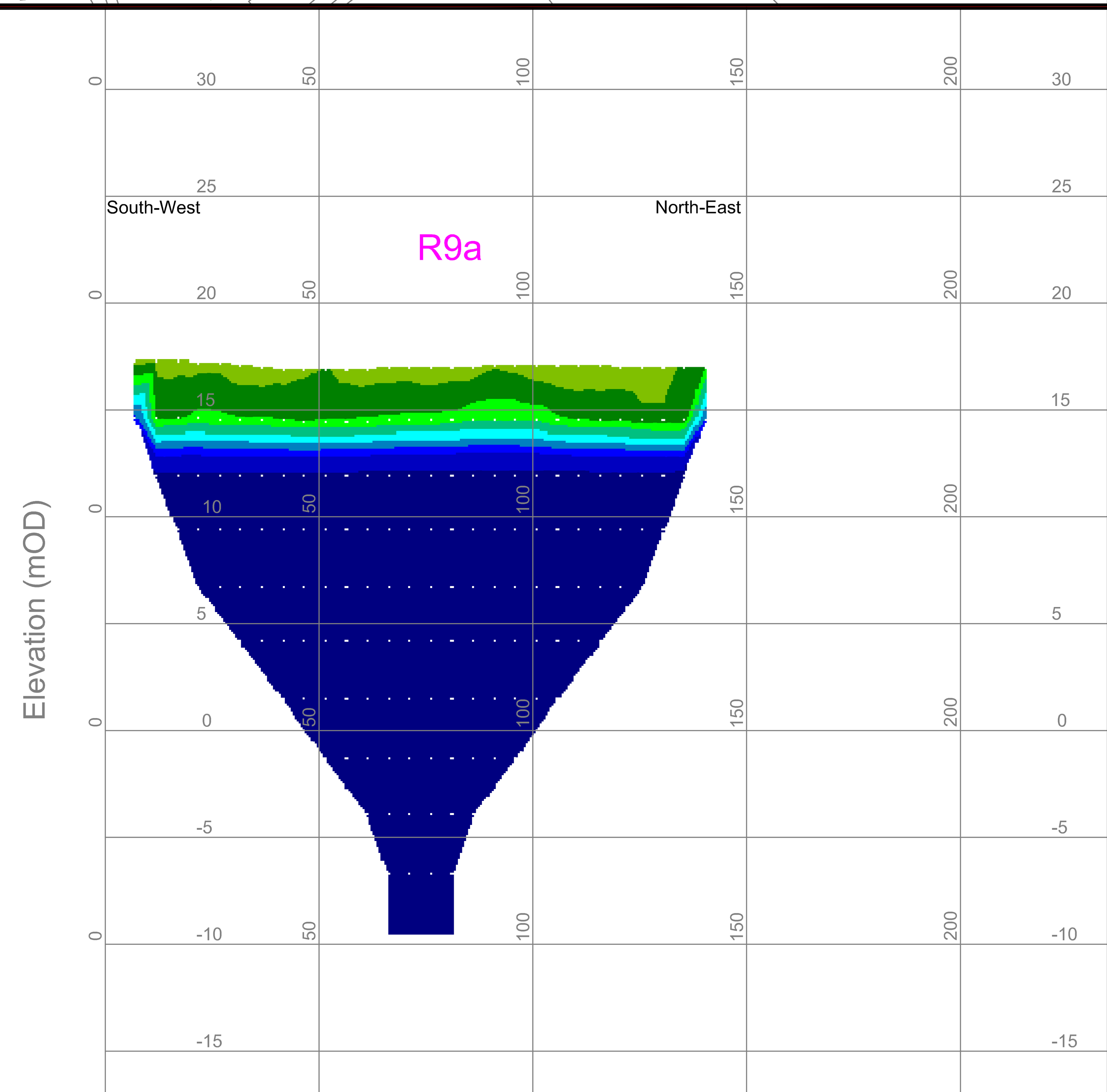
2D-Resistivity Model Values:

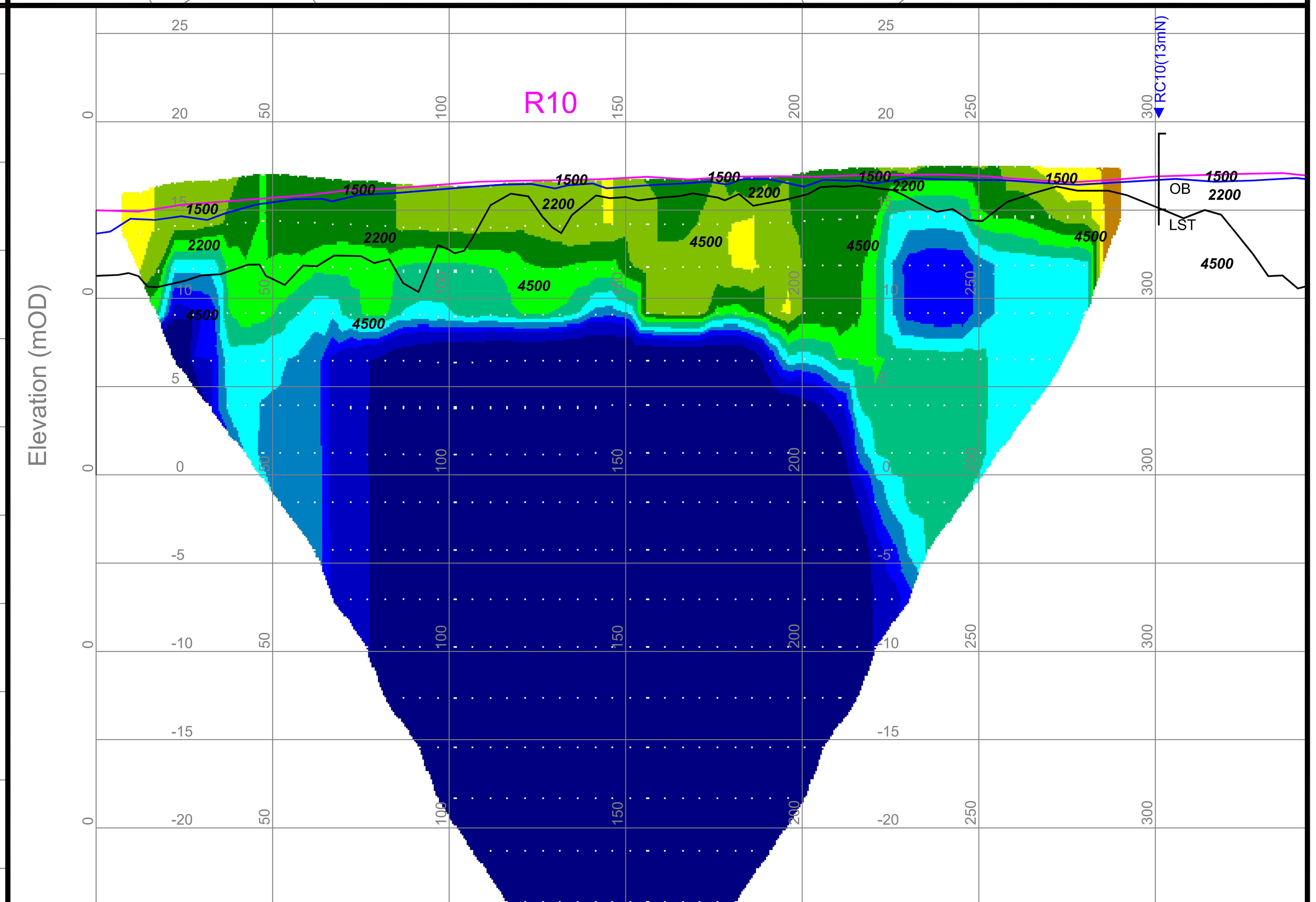
Resistivities (Ohmm) for 2D-Resistivity Model

50.0 100 200 400 800 1600 3200 6400









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CLIENT	Priority Geotechnical Ltd	SCALE:	Hor 1:1000 @ A1, Ver 1:200, VE x 5
PROJECT	Dunkellin River Flood Relief Geophysical Survey 2015	PROJECT:	5945
		DRAWN:	JC
		DATE:	22/06/2015
TITLE	Plan 3g: 2D-Resistivity Models and Ground Conductivity Contour Maps	MGX FILE:	5945d_Plans.dwg
		STATUS:	Final

LEGEND: Geophysical Survey Locations:

S1	Seismic Refraction Profile
R1	2D-Resistivity Profile
	EM-31 Ground Conductivity
	Proposed Material Depositing

Locations are in ITM, Elevations are in mOD (Malin Head)

Geothechnical Survey Locations:

BH01	Borehole Location
RC01	Rotary Core Location
TP01	Trial Pit Location

Layers and Interpretation from Seismic Refraction Model:

1800	Seismic Velocity in m/s
	Layers from Seismic Refraction Model:
	Ground Land Surface/Top of Layer 1 (300-500 m/s) Soft/loose Topsoil/Overburden
	River Bottom and Top of Layer 2 (1500 m/s) Saturated Overburden
	Top of Layer 2 (1100 - 1500 m/s) Firm - Stiff/Dense Overburden
	Top of Layer 3 (2100-2200 m/s) Weathered Broken Rock
	Top of Layer 4 (4400-4800 km/s) Strong Fresh Rock

Legend for Abbreviated Borehole Logs:

RC01	Borehole location
(8mN)	Distance >5m and direction from line
OB	Overburden
WLST	Weathered Limestone
LST	Limestone

2D-Resistivity Model Values:

Resistivities (Ohmm) for 2D-Resistivity Model

50.0 100 200 400 800 1600 3200 6400

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CLIENT	Priority Geotechnical Ltd
PROJECT	Dunkellin River Flood Relief Geophysical Survey
TITLE	Plan 3: EM31 Ground Conductivity

SCALE:	1:2000 @ A1
PROJECT:	5825
DRAWN:	JC
DATE:	31/07/2014
MGX FILE:	5825f_Plans.dwg
STATUS:	Final

LEGEND: Geophysical Survey Locations:

- S1 Seismic Refraction Profile
- R1 2D-Resistivity Profile

Locations are in ITM, Elevations are in mOD (Malin Head)