APPENDIX 7-5 BIOLOGICAL ASSESSMENT REPORTS (TMS ENVIRONMENT LTD)

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BIOLOGICAL ASSESSMENT OF SURFACE WATER QUALITY

FOR

LAGAN MATERIALS LTD
AGHAMORE
CO. SLIGO

Report Ref. 27815
TMS Environment Ltd
Issued: 30 October 2020

Prepared by: Nick Owen
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Approved by: Craig O'Connor
Craig O'Connor
Senior Consultant

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1.0 Introduction

TMS Environment Ltd has been requested by Lagan Materials Ltd to carry out a biological assessment of surface water quality in the vicinity of a discharge to surface water from their quarry at Aghamore, Co. Sligo.

The survey was conducted on 29 September 2020 by TMS Environment Ltd personnel. Samples were taken from both upstream and downstream of the discharge in accordance with the EPA Q-Rating Methodology and European Communities Environmental Objectives (Surface Waters) Regulations 2009 S.I. No. 272 of 2009.

2.0 Methodology

2.1 Monitoring Locations

Assessments were performed in the Aghamore Stream at a location upstream of the effluent discharge, adjacent to a culvert (SW1 – 54.234914, -8.451404). Sampling was also carried out at a location approximately 60 metres downstream of the effluent discharge (SW2 – 54.235660, -8.451522). The locations of the macroinvertebrate surveys are illustrated in Figure 1.

Figure 1: Location of biological assessments (SW1 and SW2) and effluent discharge, along the Aghamore Stream (denoted by blue arrow, indicating direction of flow).

The assessment locations chosen were selected on the basis of providing suitable locations to provide an adequate amount of benthic invertebrate specimens for assessment, as well as having reasonably comparable physical characteristics (substrate type, flow regime) to enable as close as possible a direct comparison between the upstream and downstream assemblages.

2.2 Sampling & Assessment

The water quality assessment was undertaken using the benthic macroinvertebrates as bioindicators. These are an excellent tool for water quality assessment as they exhibit differential responses to physical and chemical changes in their environment. Some macroinvertebrates are sensitive to pollution while others are tolerant. They provide a realistic record of the prevailing water quality conditions.

A range of physical (average depth and width, mesohabitat type and substrate composition) and chemical characteristics (dissolved oxygen, temperature, conductivity and pH) were determined on site using hand-held meters.

Two-minute kick samples and one minute stone wash samples were taken at each monitoring location. The sample nets were emptied and rinsed into a sorting tray for analysis. All macro-invertebrate specimens were isolated and identified to family or genus level in the field. Where individuals were not identifiable in the field, biological samples were taken and preserved in 70% alcohol solutions. These samples were brought to the laboratory of TMS Environment Ltd for analysis under a light microscope.

Identification of specimens was carried out to the level required for the EPA Q-Rating methodology (McGarrigle *et al*., 2002). Based on the relative abundance of each indicator group, a biotic index (Q Value) was determined in accordance with Tables 2 to 5 and the biological assessment procedure used by the Environmental Protection Agency (McGarrigle *et al*., 2002) and European Communities Environmental Objectives (Surface Waters) Regulations 2009 S.I. No. 272 of 2009.

3.0 Results

The sampling sites were relatively moderate flowing, clean and with little in-stream vegetation and similar water chemistries. These elements are summarised in Tables 1 and 2. The assemblages and Q-values applied are presented in Tables 3-5, with the basis for the Q-values applied included in Appendix I.

Location	Width (m)	Depth (cm)	Substrate	In-stream vegetation	Flow conditions
SW1	1.7	0.31	Gravel, sand, cobbles	None	Shallow, moderate exit slope
SW2	2.2	0.37	Gravel, cobbles, sand	None	Shallow, moderate riffle

Table 1. Physical characteristics of the two monitoring locations at the time of sampling.

Location	Temp. (°C)	DO (mg/l)	pH	EC (µS/cm @25°c)	BOD (mg/l)	Orthophos-phate (mg/l)	Total Phosphorus (mg/l)
SW1	13.6	9.20	7.18	97	1	0.02	<0.12
SW2	13.4	9.41	7.58	196	1	0.02	0.21

Table 2. Chemical characteristics of the two monitoring locations at the time of sampling.

Order / Group	Family	Genus	Q rating	SW1	SW2
Crustacea	Gammaridae	*Gammarus*	C	57	120
Trichoptera	Hydropsychidae	Indet.	C	15	5
	Rhyacophylidae	Indet.	C	10	0
Ephemeroptera	Baetidae	Indet.	B	8	0
	Heptageniidae	Indet.	A	5	6
Mollusca	Hyrobiidae	*Potamopyrgus*	C	16	12
	Lymnaeidae	Indet.	C	12	10
Hirudinea	Indet.	Indet.	C	3	1
Diptera	Simuliidae	Indet.	C	5	1
Oligochaeta	Indet.	Indet.	E	7	0

Table 3. Benthic invertebrate specimens determined for each sampling location. Indet. denotes indetermined.

Q-Value grouping	SW1	SW2
Total abundance	138	155
A	5	6
B	8	0
C	118	149
D	0	0
E	7	0
Percentage		
A	3.6	3.9
B	5.8	0
C	85.5	96.1
D	0	0
E	5.1	0
Number of Taxa		
A	1	1
B	1	0
C	7	6
D	0	0
E	1	0
Q-Rating	3-4	3-4

Table 4. The representation of each invertebrate group as separated by the Q-value system in each of the sampling sites, with assigned Q-rating at the bottom.

Biotic Index	Quality Status
Q5	Unpolluted Waters
Q4-5	
Q4	
Q3-4	Slightly Polluted Waters
Q3	Moderately Polluted Waters
Q2-3	
Q2	Seriously Polluted Waters
Q1-2	
Q1	

Table 5. Quality Standards for Rivers.

4.0 Discussion

Both of the substrates were relatively clean with cobble and coarse gravel available for invertebrates. Sites did have minor accumulations of fine sand and sediments and very few boulders were present. Flow velocity is slightly higher at the downstream location relative to the upstream site. Oxygen levels were within normal ranges (80-120%) for both locations.

The results of the macroinvertebrate surveys indicate a Q Value of 3-4, slightly polluted water (Table 5) at both SW1 and SW2. The assemblage upstream is slightly more diverse, but of a lower abundance than that observed downstream, but these variations are not significant enough to affect the Q-values applied. Specimens of the genus *Gammarus* are by far the most common organisms present, followed by Molluscs (Gastropods) and Trichopterids (Caddis flies).

The Q Value is the same upstream and downstream of the effluent discharge, therefore it can be inferred that the emissions from the quarry are not having a deleterious effect on the macroinvertebrate fauna in the Aghamore Stream. There is a slight difference in water chemistry, with the upstream site recording a slightly lower conductivity, pH, dissolved oxygen and Total Phosphorus relative to the downstream location. However, these differences do not appear to be having a significant impact on the macroinvertebrate faunal assemblage.

5.0 Conclusions

- The results of the macroinvertebrate surveys for this year (September 2020) indicate a Q Value of 3-4 for both the upstream monitoring location (SW1) and the downstream monitoring location (SW2) on the Aghamore Stream;

- As the Q Value is the same upstream and downstream of the quarry discharge, it is concluded that the discharge is not having a deleterious effect on the biological quality of the stream.

APPENDIX I

Criteria for Q-Value Application

Macroinvertebrates grouped according to their sensitivity to organic pollution

TAXA	Group A	Group B	Group C	Group D	Group E
	Sensitive	*Less Sensitive*	*Tolerant*	*Very Tolerant*	*Most Tolerant*
Plecoptera	All except *Leuctra* spp.	*Leuctra* spp.			
Ephemeroptera	Heptageniidae Siphlonuriidae *Ephemera danica*	Baetidae (excl. *Baetis rhodani*) Leptophlebidae	*Baetis rhodani* Caenidae Ephemerellidae		
Trichoptera		Cased spp.	Uncased spp.		
Odonata		All taxa			
Megaloptera				Sialidae	
Hemiptera		*Aphelocheirus aestivalis*	All except *A. aestivalis*		
Coleoptera			Coleoptera		
Diptera			Chironomidae (excl. *Chironomus* spp.) Simuliidae, Tipulidae		*Chironomus* spp. *Eristalis* sp.
Hydracarina			Hydracarina		
Crustacea			*Gammarus* spp. *Austropotamobius pallipes*	*Asellus* spp. *Crangonyx* spp.	
Gastropoda			Gastropoda (excl. *Lymnaea peregra* & *Physa* sp.)	*Lymnaea peregra* *Physa* sp.	
Lamellibranchiata	*Margaritifera margaritifera*		*Anodonta* spp.	Sphaeriidae	
Hirudinea			*Piscicola* sp.	All except *Piscicola* sp.	
Oligochaeta					Tubificidae
Platyhelminthes			All		

Biological Assessment of Water Quality in Eroding Reaches (Riffles & Glides) of Rivers and Streams*

Biotic Indices (Q Values) and typical associated macroinvertebrate community structure. See overleaf for details of the Faunal Groups.

Macroinvertebrate Faunal Groups**	Q5	Q4	Q3-4	Q3	Q2	Q1
Group A	At least 3 taxa well represented	At least 1 taxon in reasonable numbers	At least 1 taxon Few - Common	Absent	Absent	Absent
Group B	Few to Numerous	Few to Numerous	Few/Absent to Numerous	Few/Absent	Absent	Absent
Group C	Few	Common to Numerous *Baetis rhodani* often Abundant Others: never Excessive	Common to Excessive (usually Dominant or Excessive)	Dominant to Excessive	Few or Absent	Absent
Group D	Few or Absent	Few or Absent	Few/Absent to Common	Few/Absent to Common	Dominant to Excessive	Few or Absent
Group E	Few or Absent	Few or Absent	Few or Absent	Few or Absent	Few / Absent to Common	Dominant
Additional Qualifying Criteria						
***Cladophora* spp.** Abundance	Trace only or None	Moderate growths (if present)	May be Abundant to Excessive growths	May be Excessive growths	Few or Absent	None
Macrophytes (Typical abundance)	Normal growths or absent	Enhanced growths	May be Luxuriant growths	May be Excessive growths	Absent to Abundant	Present/Absent
Slime Growths (Sewage Fungus)	Never	Never	Trace or None	May be Abundant	May be Abundant	None
Dissolved Oxygen Saturation	Close to 100% at all times	80% - 120%	Fluctuates from < 80% to >120%	Very unstable. Potential fish-kills	Low (but > 20%)	Very low, sometimes zero
Substratum Siltation	None	May be light	May be light	May be considerable	Usually heavy	Usually very heavy and anaerobic

Note occurrence/abundance of groups in above table refers to <u>some</u> but not necessarily <u>all</u> of the constituents of the group. The Additional Qualifying Criteria apply in virtually all circumstances. Single specimens may be ignored. Seasonal and other relevant factors (i.e., drought, floods) must be taken into account.
* Macroinvertebrate criteria do not apply to rivers with mud, bedrock or sand substrata, very sluggish or torrential flow, head-water or high altitude streams and those affected by significant ground water input, excessive calcification, drainage, canalisation, culverting, marked shading etc.
** See Further Observations overleaf.

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BIOLOGICAL ASSESSMENT OF SURFACE WATER QUALITY

FOR

LAGAN MATERIALS LTD
AGHAMORE
CO. SLIGO

Report Ref. 27960
TMS Environment Ltd
Issued: 23 December 2020

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Senior Consultant

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1.0 Introduction

TMS Environment Ltd has been requested by Lagan Materials Ltd to carry out a biological assessment of surface water quality in the vicinity of their quarry at Aghamore, Co. Sligo.

There is a licenced discharge to surface water from the quarry to the Aghamore Stream (Trade Effluent Discharge Licence DL(W)139). There is also a discharge of surface water runoff from a concrete block yard within the processing area (but outside the proposed development site boundary) to the Aghamore Stream – this connection to the stream will be blocked off when operations recommence. The objective of this assessment is to sample upstream and downstream of both of these locations and identify changes in macroinvertebrate assemblages (if any).

The survey was conducted on 24 November 2020 by TMS Environment Ltd personnel. Samples were taken from both upstream and downstream of the facility in accordance with the EPA Q-Rating Methodology and European Communities Environmental Objectives (Surface Waters) Regulations 2009 S.I. No. 272 of 2009.

2.0 Methodology

2.1 Monitoring Locations

Assessments were performed in the Aghamore Stream at five locations: upstream and downstream of the yard drainage, upstream and downstream of the effluent discharge and at a bridge approximately 150m upstream of Lough Gill. The locations of the macroinvertebrate surveys are illustrated in Figure 1.

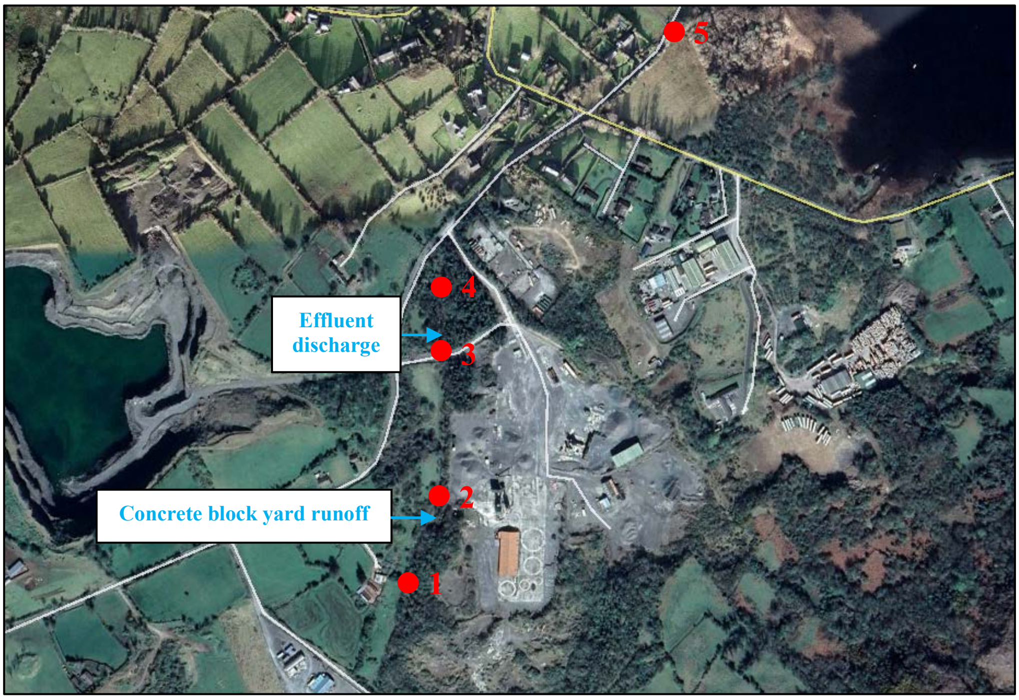

Figure 1: Location of biological assessments, yard drainage area and effluent discharge point, along the Aghamore Stream.

The assessment locations chosen were selected on the basis of providing suitable locations to provide an adequate amount of benthic invertebrate specimens for assessment, as well as having reasonably comparable physical characteristics (substrate type, flow regime) to enable as close as possible a direct comparison between the different meiofaunal assemblages.

Photographs of the selected monitoring locations are presented in Appendix I.

(It is important to note that biological assessments are normally conducted between the months of April – September, assessments conducted during the months October – March may give a less representative lower value due to the limited number of seasonal invertebrates.)

2.2 Sampling & Assessment

The water quality assessment was undertaken using the benthic macroinvertebrates as bioindicators. These are an excellent tool for water quality assessment as they exhibit differential responses to physical and chemical changes in their environment. Some macroinvertebrates are sensitive to pollution while others are tolerant. They provide a realistic record of the prevailing water quality conditions.

A range of physical (average depth and width, mesohabitat type and substrate composition) and chemical characteristics (dissolved oxygen, temperature, conductivity and pH) were determined on site using hand-held meters.

Two-minute kick samples and one-minute stone wash samples were taken at each monitoring location. The sample nets were emptied and rinsed into a sorting tray for analysis. All macro-invertebrate specimens were isolated and identified to family or genus level *in situ*. Where individuals were not identifiable in the field, biological samples were taken and preserved in 70% alcohol solutions. These samples were brought to the laboratory of TMS Environment Ltd for analysis under a light microscope.

Identification of specimens was carried out to the level required for the EPA Q-Rating methodology (McGarrigle *et al*., 2002). Based on the relative abundance of each indicator group, a biotic index (Q Value) was determined in accordance with Tables 2 to 5 and the biological assessment procedure used by the Environmental Protection Agency (McGarrigle *et al*., 2002) and European Communities Environmental Objectives (Surface Waters) Regulations 2009 S.I. No. 272 of 2009.

3.0 Results

The sampling sites were relatively moderate flowing, clean and with little in-stream vegetation and similar water chemistries. These elements are summarised in Tables 1-2. The assemblages and Q-values applied are presented in Tables 3-5, with the basis for the Q-values applied included in Appendix II.

Location	Width (m)	Depth (cm)	Substrate	In-stream vegetation	Flow conditions
1	2.7	0.67	Sand, silt gravel	None	Deep, slow flow, run
2	2.4	0.63	Sand, silt gravel	None	Deep, moderate flow, run
3	1.8	0.47	Gravel, sand, cobbles	None	Shallow, moderate exit slope
4	2.4	0.52	Gravel, cobbles, sand	None	Shallow, moderate riffle
5	1.9	0.55	Gravel, cobbles	None	Shallow, fast flow, riffle

Table 1. Physical characteristics of the monitoring locations at the time of sampling.

Location	Temp. (°C)	DO (mg/l)	pH	EC (µS/cm @25°c)	BOD (mg/l)	Orthophos-phate (mg/l)	Total Phosphorus (mg/l)
1	6.1	9.08	7.01	109	1.6	0.02	0.05
2	6.1	9.06	7.03	114	1.5	<0.02	0.02
3	6.3	9.17	7.05	112	1.2	<0.02	0.02
4	6.8	9.97	7.86	237	2.1	<0.02	<0.02
5	6.2	9.28	7.10	142	1.5	<0.02	<0.02

Table 2. Chemical characteristics of the monitoring locations at the time of sampling.

Order / Group	Family	Genus	Q value	1	2	3	4	5
Crustacea	Gammaridae	*Gammarus*	C	17	48	52	76	59
Trichoptera	Hydropsychidae	Indet.	C	1	6	7	4	8
	Rhyacophylidae	Indet.	C	2	1	0	2	3
Mollusca	Hyrobiidae	*Potamopyrgus*	C	15	6	7	3	11
	Lymnaeidae	Indet.	C	10	6	2	6	10
Hirudinea	Indet.	Indet.	C	5	2	3	1	1
Diptera	Simuliidae	Indet.	C	6	2	3	1	0
Oligochaeta	Indet.	Indet.	E	4	5	9	0	1

Table 3. Benthic invertebrate specimens determined for each monitoring location ('Indet.' denotes indetermined).

Q-Value grouping	1	2	3	4	5
Total abundance	60	76	83	93	93
A	0	0	0	0	0
B	0	0	0	0	0
C	56	71	74	93	92
D	0	0	0	0	0
E	4	5	9	0	1
Percentage					
A	0	0	0	0	0
B	0	0	0	0	0
C	93	93	89	100	99
D	0	0	0	0	0
E	7	7	11	0	1
Number of Taxa					
A	0	0	0	0	0
B	0	0	0	0	0
C	7	7	6	7	6
D	0	0	0	0	0
E	1	1	1	0	1
Q-Rating	Q3	Q3	Q3	Q3	Q3

Table 4. The representation of each invertebrate group as separated by the Q-value system in each of the monitoring locations, with assigned Q-rating at the bottom.

Biotic Index	Quality Status
Q5	Unpolluted Waters
Q4-5	
Q4	
Q3-4	Slightly Polluted Waters
Q3	Moderately Polluted Waters
Q2-3	
Q2	Seriously Polluted Waters
Q1-2	
Q1	

Table 5. Quality Standards for Rivers.

4.0 Discussion

All of the substrates were relatively clean with cobbles and / or coarse gravel available for invertebrates. Sites did have minor accumulations of fine sand and sediments and very few boulders were present. Flow velocity is higher at the downstream locations relative to the upstream sites. Oxygen levels were within normal ranges (i.e. >6.5-8mg/l) for all locations.

The results of the macroinvertebrate surveys indicate a Q Value of 3, moderately polluted water (Table 5) at all locations. The assemblages did not vary significantly between sampling locations, specimens of the genus *Gammarus* are by far the most common organisms present, followed by Molluscs (Gastropods) and Trichopterids (Caddis flies). The number of taxa present, and their diversity, is likely to be limited due to the time of year when this survey was conducted and it is probable that a survey conducted during the period April – September would produce Q ratings significantly higher than those obtained from this survey.

The Q Value applied is the same upstream and downstream of the yard drainage and the effluent discharge, therefore it can be inferred that the emissions from the quarry are not having a deleterious effect on the macroinvertebrate fauna in the Aghamore Stream.

There is a slight difference in water chemistry downstream of the effluent discharge, due to the mixing of the quarry discharge with the background stream water, however this does not appear to be having an impact on the macroinvertebrate faunal assemblage.

5.0 Conclusions

- The results of the macroinvertebrate surveys indicate a Q Value of 3 for all five monitoring locations on the Aghamore Stream (November 2020);

- The derived Q Values are most likely artificially lower than if the survey was done during April – September due to the absence of the more ephemeral components of the meiofaunal assemblage, which are unlikely to be present during the winter months;

- The derived Q Values are the same upstream and downstream of the runoff from the concrete block yard entering the stream, as well as the quarry effluent discharge entering the stream, therefore it can be inferred that the emissions from the quarry are not having a deleterious effect on the macroinvertebrate fauna in the Aghamore Stream.

APPENDIX I

Photographs of Monitoring Locations


Monitoring Location 1


Sampling Monitoring Location 1 (24/11/2020)

Monitoring Location 2

Sampling Monitoring Location 2 (24/11/2020)

Monitoring Location 3

Sampling Monitoring Location 3 (24/11/2020)


Monitoring Location 4


Sampling Monitoring Location 4 (24/11/2020)


Monitoring Location 5


Sampling Monitoring Location 5 (24/11/2020)

APPENDIX II

Criteria for Q-Value Application

Macroinvertebrates grouped according to their sensitivity to organic pollution

TAXA	Group A	Group B	Group C	Group D	Group E
	Sensitive	*Less Sensitive*	*Tolerant*	*Very Tolerant*	*Most Tolerant*
Plecoptera	All except *Leuctra* spp.	*Leuctra* spp.			
Ephemeroptera	Heptageniidae Siphlonuriidae *Ephemera danica*	Baetidae (excl. *Baetis rhodani*) Leptophlebidae	*Baetis rhodani* Caenidae Ephemerellidae		
Trichoptera		Cased spp.	Uncased spp.		
Odonata		All taxa			
Megaloptera				Sialidae	
Hemiptera		*Aphelocheirus aestivalis*	All except *A. aestivalis*		
Coleoptera			Coleoptera		
Diptera			Chironomidae (excl. *Chironomus* spp.) Simuliidae, Tipulidae		*Chironomus* spp. *Eristalis* sp.
Hydracarina			Hydracarina		
Crustacea			*Gammarus* spp. *Austropotamobius pallipes*	*Asellus* spp. *Crangonyx* spp.	
Gastropoda			Gastropoda (excl. *Lymnaea peregra* & *Physa* sp.)	*Lymnaea peregra* *Physa* sp.	
Lamellibranchiata	*Margaritifera margaritifera*		*Anodonta* spp.	Sphaeriidae	
Hirudinea			*Piscicola* sp.	All except *Piscicola* sp.	
Oligochaeta					Tubificidae
Platyhelminthes			All		

Biological Assessment of Water Quality in Eroding Reaches (Riffles & Glides) of Rivers and Streams*

Biotic Indices (Q Values) and typical associated macroinvertebrate community structure. See overleaf for details of the Faunal Groups.

Macroinvertebrate Faunal Groups**	Q5	Q4	Q3-4	Q3	Q2	Q1
Group A	At least 3 taxa well represented	At least 1 taxon in reasonable numbers	At least 1 taxon Few - Common	Absent	Absent	Absent
Group B	Few to Numerous	Few to Numerous	Few/Absent to Numerous	Few/Absent	Absent	Absent
Group C	Few	Common to Numerous *Baetis rhodani* often Abundant Others: never Excessive	Common to Excessive (usually Dominant or Excessive)	Dominant to Excessive	Few or Absent	Absent
Group D	Few or Absent	Few or Absent	Few/Absent to Common	Few/Absent to Common	Dominant to Excessive	Few or Absent
Group E	Few or Absent	Few or Absent	Few or Absent	Few or Absent	Few / Absent to Common	Dominant
Additional Qualifying Criteria						
***Cladophora* spp.** Abundance	Trace only or None	Moderate growths (if present)	May be Abundant to Excessive growths	May be Excessive growths	Few or Absent	None
Macrophytes (Typical abundance)	Normal growths or absent	Enhanced growths	May be Luxuriant growths	May be Excessive growths	Absent to Abundant	Present/Absent
Slime Growths (Sewage Fungus)	Never	Never	Trace or None	May be Abundant	May be Abundant	None
Dissolved Oxygen Saturation	Close to 100% at all times	80% - 120%	Fluctuates from < 80% to >120%	Very unstable. Potential fish-kills	Low (but > 20%)	Very low, sometimes zero
Substratum Siltation	None	May be light	May be light	May be considerable	Usually heavy	Usually very heavy and anaerobic

Note occurrence/abundance of groups in above table refers to <u>some</u> but not necessarily <u>all</u> of the constituents of the group. The Additional Qualifying Criteria apply in virtually all circumstances. Single specimens may be ignored. Seasonal and other relevant factors (i.e., drought, floods) must be taken into account.

* Macroinvertebrate criteria do not apply to rivers with mud, bedrock or sand substrata, very sluggish or torrential flow, head-water or high altitude streams and those affected by significant ground water input, excessive calcification, drainage, canalisation, culverting, marked shading etc.

** See Further Observations overleaf.

APPENDIX 7-6 GEOPHYSICAL INVESTIGATION REPORT (APEX GEOPHYSICS LTD)

AGP21007_01

REPORT ON THE GEOPHYSICAL INVESTIGATION AT AGHAMORE NEAR, CO. SLIGO FOR LAGAN ASPHALT

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5H FEBRUARY 2021

PRIVATE AND CONFIDENTIAL

THE FINDINGS OF THIS REPORT ARE THE RESULT OF A GEOPHYSICAL SURVEY USING NON-INVASIVE SURVEY TECHNIQUES CARRIED OUT AT THE GROUND SURFACE. INTERPRETATIONS CONTAINED IN THIS REPORT ARE DERIVED FROM A KNOWLEDGE OF THE GROUND CONDITIONS, THE GEOPHYSICAL RESPONSES OF GROUND MATERIALS AND THE EXPERIENCE OF THE AUTHOR. APEX GEOPHYSICS LTD. HAS PREPARED THIS REPORT IN LINE WITH BEST CURRENT PRACTICE AND WITH ALL REASONABLE SKILL, CARE AND DILIGENCE IN CONSIDERATION OF THE LIMITS IMPOSED BY THE SURVEY TECHNIQUES USED AND THE RESOURCES DEVOTED TO IT BY AGREEMENT WITH THE CLIENT. THE INTERPRETATIVE BASIS OF THE CONCLUSIONS CONTAINED IN THIS REPORT SHOULD BE TAKEN INTO ACCOUNT IN ANY FUTURE USE OF THIS REPORT.

PROJECT NUMBER	AGP21007		
AUTHOR	**CHECKED**	**REPORT STATUS**	**DATE**
EURGEOL PETER O'CONNOR P.GEO., M.SC (GEOPHYSICS), DIP. EIA MGT.	TONY LOMBARD M.SC (GEOPHYSICS)	V.01	5TH FEBRUARY 2021

CONTENTS

1. EXECUTIVE SUMMARY

APEX Geophysics Limited was requested by Lagan Asphalt to carry out a geophysical investigation at Aghamore Quarry in Co. Sligo. The survey was required to assist in the hydrogeological assessment of the quarry. The objectives of the investigation were to provide information on overburden type and thickness, to map the depth to bedrock and rock type, and to provide information presence of any possible faults, fissures, or karstic zones.

The survey area consists of the existing quarry (Area A) and land to the northeast (Area B). The quarry floor at an elevation of c. 20.8 mOD is currently flooded with an average water depth of 5.4 m. The topography of the land area ranges from 17 to 32 mOD. Part of the land to the northeast has been stripped.

The Geological Survey of Ireland (GSI) 1:100k Bedrock Geology map for the area indicates that the site is underlain by dark fine-grained cherty limestone of the Dartry Limestone Formation. The Teagasc soils map for the area indicates an area of till derived from metamorphic rock. The Dartry Limestone Formation is classified on the GSI map as a 'Regionally Important Aquifer - Karstified (conduit)'. The historical 6 inch sheet for the area shows northeast-southwest striking rock with a dip of 5° to the northwest.

Previous geophysical investigations have been carried out in 2017 and 2019 for resource assessment to the northwest of the quarry have indicated between 0.7 and 3.5 m of overburden over thin weathered limestone, over limestone. No major structural or karst features were apparent on these surveys.

The land based survey to the northeast consisted of EM ground conductivity readings, 4 ERT profiles and 2 seismic refraction profiles. The over water survey in the quarry consisted of 6 ERT profiles.

The geophysical data have outlined thin overburden (0 -2m m) across most of Area B, thickening to 2-5m in local pockets. The data indicate loose predominantly clayey gravel overburden. In the northwest of the Area B the overburden thicknesses increases significantly to at least 15m and data here are indicative of a stiff gravelly clay with cobbles and boulders (Zone 1).

The bedrock in area B has been interpreted as clean thin to medium bedded limestone with an upper weathered layer, over slightly weathered to fresh limestone. At the northwest end of Area B the bedrock resistivity decreases below an elevation of around 10 mOD and similar was observed during the 2019 survey to the west. A transition to more clay mineral rich or shaley limestone may occur at depth in this area (Zone 2). A localised increase in depth to bedrock at around 85m on ERT Profile R1 may be due to a possible karst doline (Point 3).

In Area A rock resistivities are relatively constant at 1500 – 7000 Ohm-m and there are no indications of major weathered zones or structural (fault, fissure) or karst features. No changes in properties with direction of profile were apparent in either Area A or B.

Further investigation should be considered to confirm the nature of the material in Zone 1, to investigate the transition to lower resistivity material in Zone 2 and to investigate the localised feature at point 3.

The geophysical report should be reviewed after the completion of any direct investigation.

2. INTRODUCTION

APEX Geophysics Limited was requested by Lagan Asphalt to carry out a geophysical investigation at Aghamore Quarry in Co. Sligo. The survey was required to assist in the hydrogeological assessment of the quarry. Part of the survey was land based and profiles were also recorded in the currently flooded quarry area.

2.1 Survey Objectives

The objectives of the investigation were to:

- Provide information on overburden type and thickness;
- Map depth to bedrock and rock type;
- Provide information on the presence of any possible faults, fissures, or karstic zones.

2.2 Site Background

The survey area is located in the townland of Aghamore Near which is approximately 2 km south of Sligo town centre (Fig. 2.1). It consists of the existing quarry (Area A - 4.2 ha) and land to the northeast currently in pasture (Area B - 5.1 ha). The quarry floor is currently flooded with the water level at -15.4 mOD at the time of survey and with a water depth of 5.4 m. The topography of the land to the northeast ranges from 17 to 32 mOD. Part of the land to the northeast has been stripped (Fig. 2.2).

Planning permission for the site has previously been awarded but was overturned on appeal. Further information is required on the ground conditions as part of the hydrogeological assessment for a new application.

Figure 2.1. Site location indicated by red boundary.

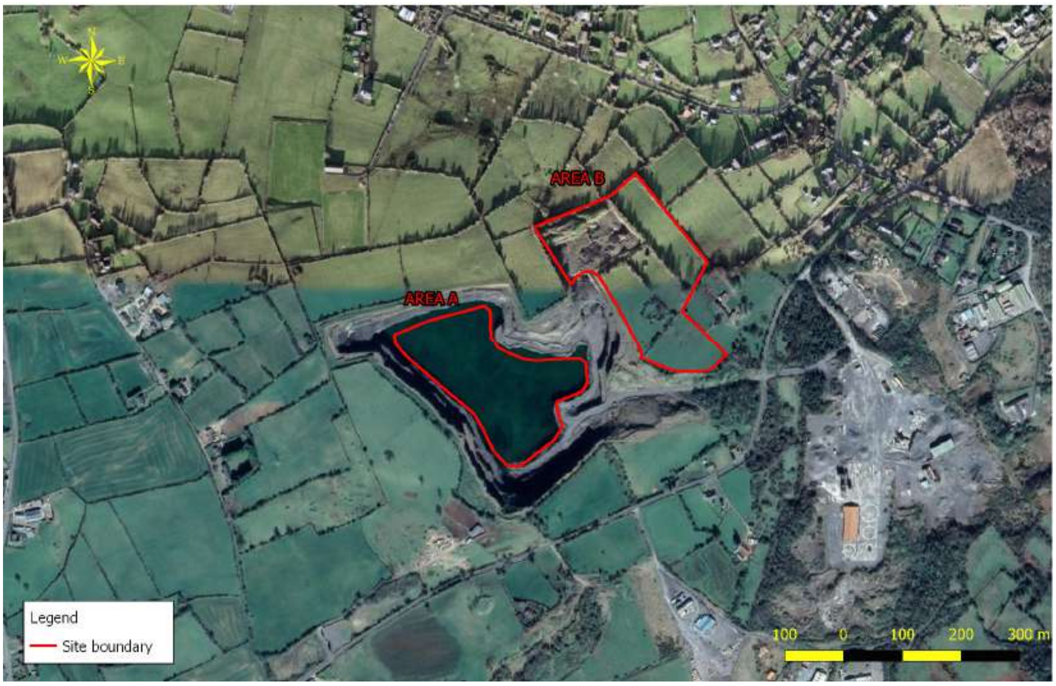

Figure 2.2. Aerial photo of site showing Area A (quarry) and Area B (land).

2.2.1 Geology

The Geological Survey of Ireland (GSI) 1:100k Bedrock Geology map for the area (Figure 2.3) indicates that the site is underlain by dark fine-grained cherty limestone of the Dartry Limestone Formation. The GSI karst database indicates a karst feature (spring) approximately 1200 m to the northeast of the site.

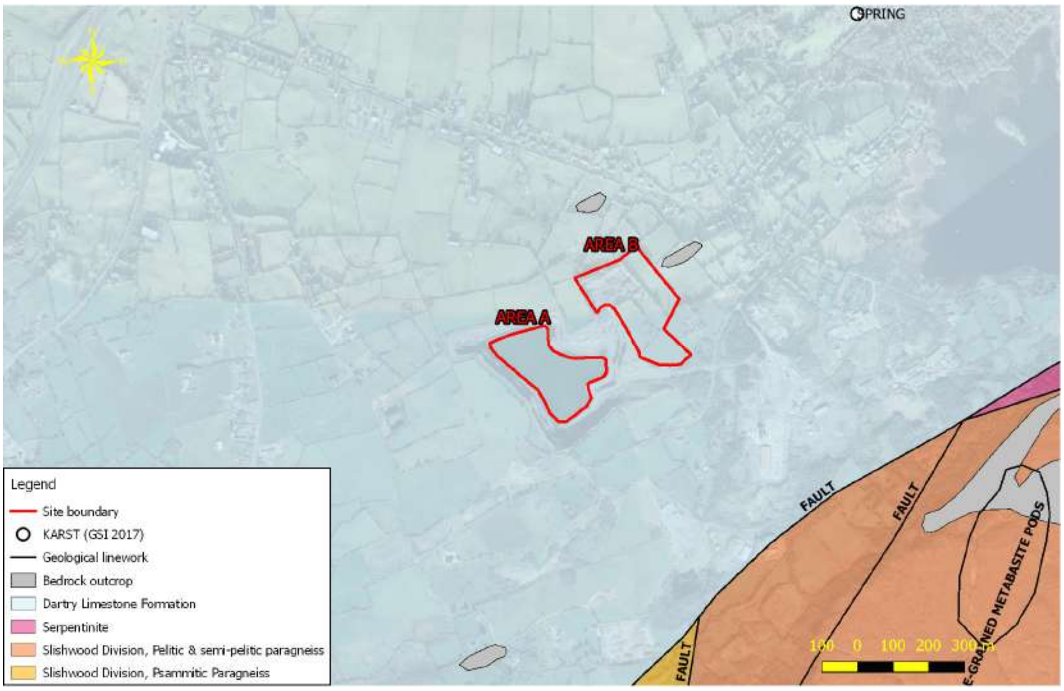

Figure 2.3. Geological map for the survey area (site marked in red).

2.2.2 Soils

The Teagasc soils map for the area (Fig. 2.4) indicates that the site is in an area of till derived from metamorphic rocks with subcropping/outcropping rock to the south and northeast of the site.

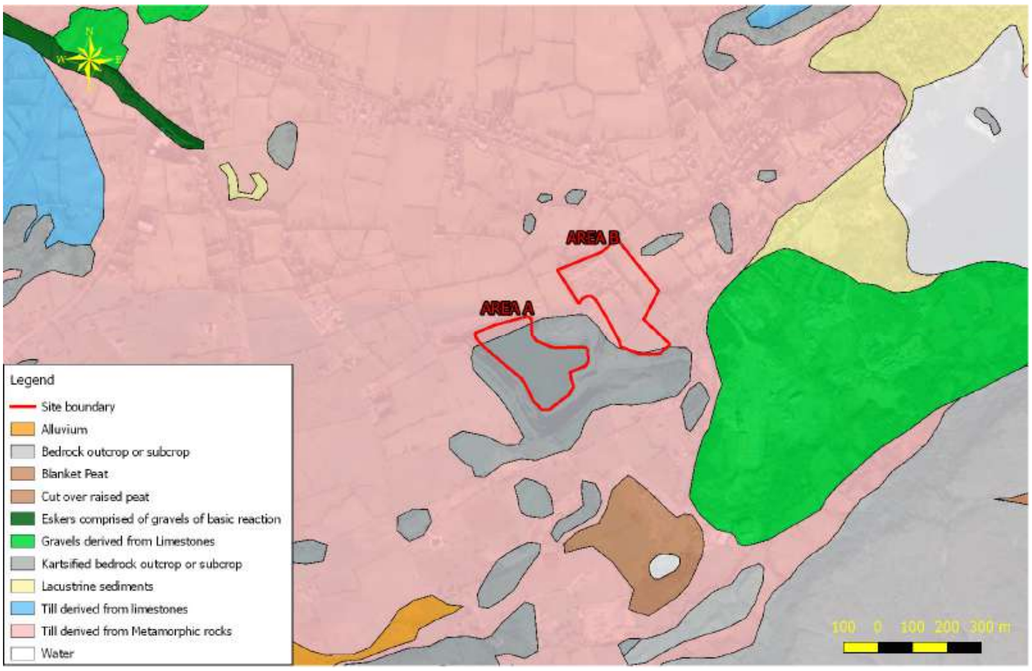

Figure 2.4: Teagasc soil map (site marked in red).

2.2.3 Groundwater

The Dartry Limestone Formation is classified as a 'Regionally Important Aquifer - Karstified (conduit)' (GSI).'

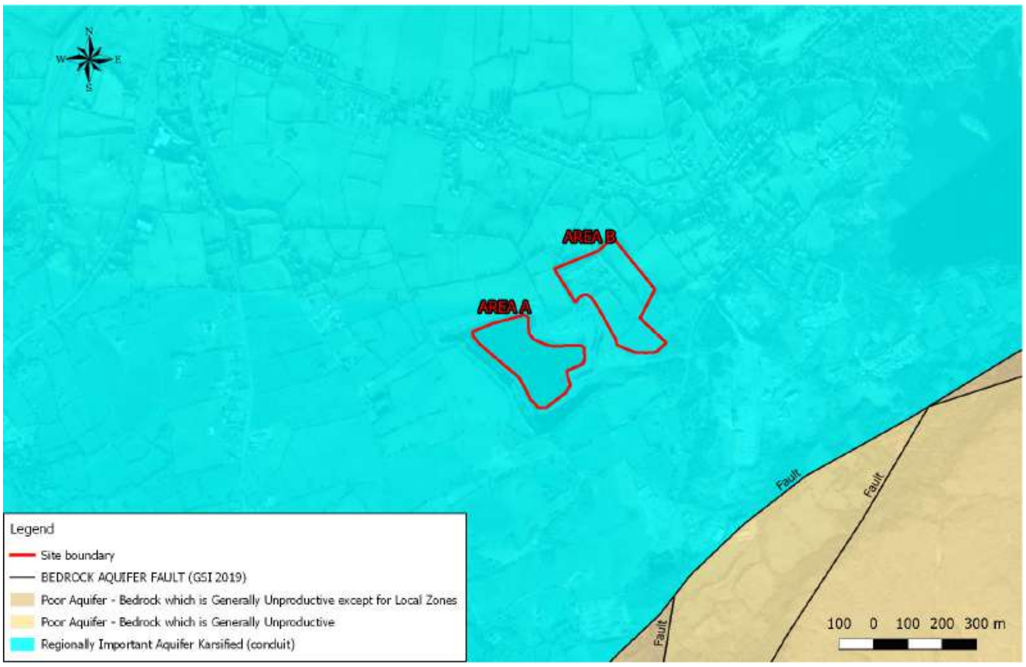

Fig 2.5: Bedrock aquifer (site marked in red).

The groundwater vulnerability rating for the site (Fig. 2.6) is classified as high to rock at surface..

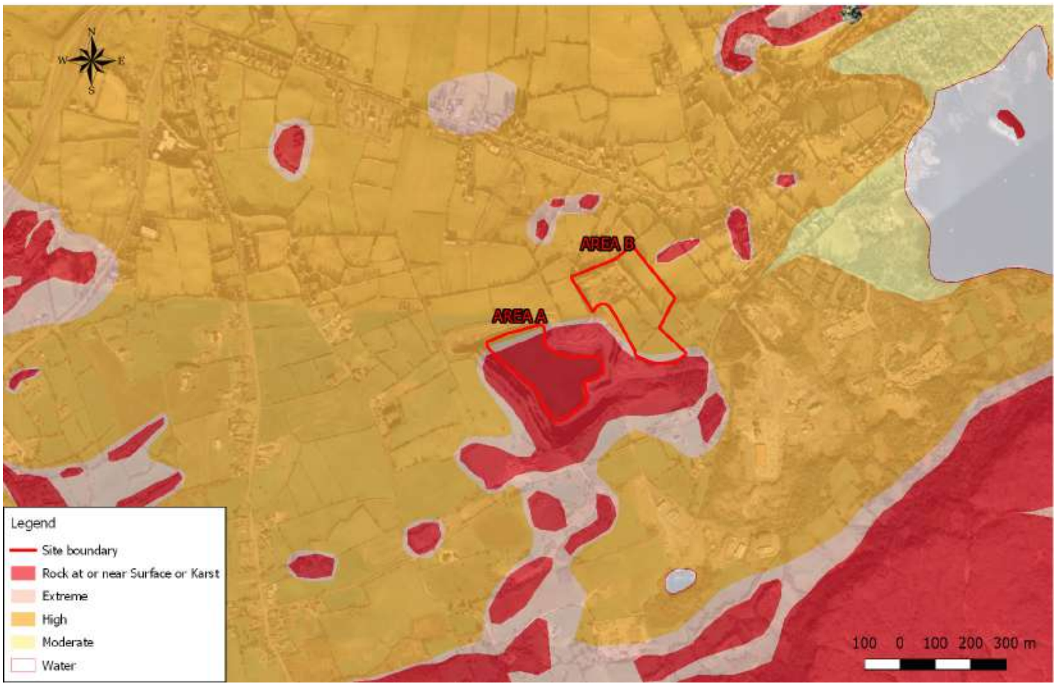

Fig 2.6. Groundwater vulnerability classification for the survey area (site marked in red).

2.2.4 Historical Data

The historical 6 inch sheet (Figure 2.7) for the area shows northeast-southwest striking rock outcropping northeast and north of the site. A geological boundary is shown running between Area A and Area B running approximately north to NNE. A dip of 5° to the northwest is shown. 'Drift' is mapped across the site.

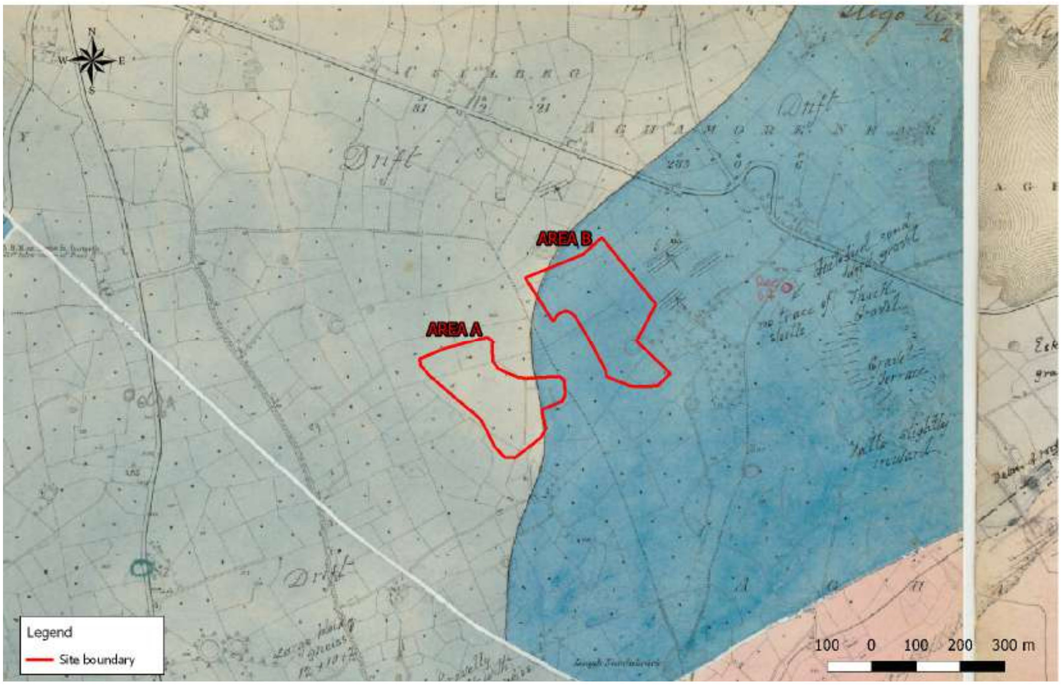

Fig 2.7: The historical 6 inch map (site marked in red).

2.3 Previous Investigation

Previous geophysical investigations have been carried out in the lands to the northwest of the quarry in 2017 and 2019 (Apex Geoservices Ltd., 2017, 2019). The surveys indicated, between 0.7 and 3.5 m of overburden material over a thin layer of highly to moderately weathered limestone, over slightly weathered to fresh limestone to depths of at least 25m bgl (c. 5 mOD). A decrease in resistivity at around 10 mOD was noted at the eastern end of the 2019 survey.

Some monitoring well and rotary core information was also provided by the client as part of the 2019 survey.

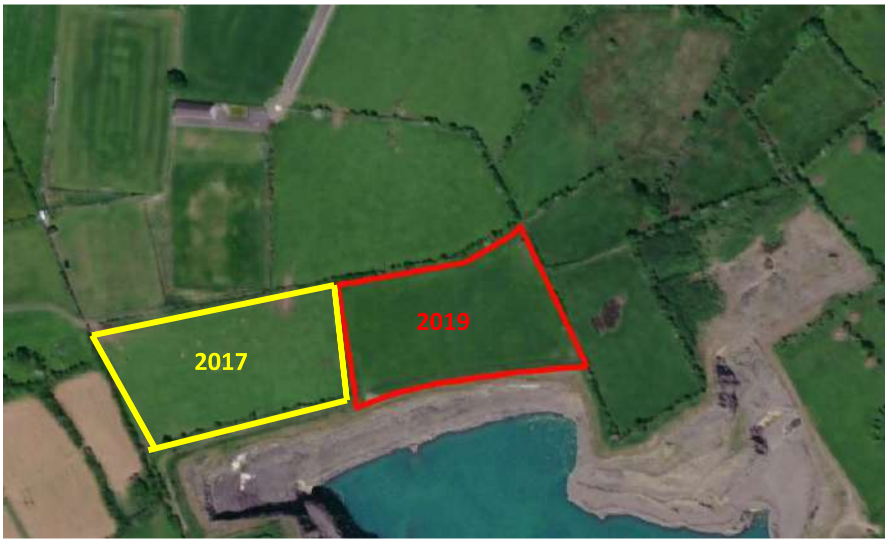

Figure 2.8. Aerial photo of site showing 2017 and 2019 surveys

2.4 Survey Rationale

The investigation consisted of reconnaissance EM ground conductivity mapping with follow-up 2D Electrical Resistivity Tomography (ERT) and Seismic Refraction profiling:

EM ground conductivity mapping operates on the principle of inducing currents in conductive substrata and measuring the resultant secondary electro-magnetic field. The strength of this secondary EM field is calibrated to give apparent ground conductivity in milliSiemens/metre (mS/m). This technique will provide information on the shallow (0-6m below ground level) variation of the superficial deposits and outline the shallow bedrock.

ERT images the resistivity of the materials in the subsurface along a profile to produce a cross-section showing the variation in resistivity with depth, depending on the length of the profile. Each cross--section will be interpreted to determine the material type along the profile at increasing depth, based on the typical resistivities returned for Irish ground materials.

Seismic Refraction profiling measures the velocity of refracted seismic waves through the overburden and rock material and allows an assessment of the thickness and quality of the materials present to be made. Stiffer and stronger materials usually have higher seismic velocities while soft, loose or fractured materials have lower velocities. Readings are taken using geophones connected via multi-core cable to a seismograph. This method should allow us to profile the depth to the top of the bedrock, along profiles across the site.

As with all geophysical methods the results are based on indirect readings of the subsurface properties. The effectiveness of the proposed approach will be affected by variations in the ground properties. By combining a number of techniques it is possible to provide a higher quality interpretation and reduce any ambiguities which may otherwise exist. Further information on the detailed methodology of each geophysical method employed in this investigation is given in **APPENDIX A: DETAILED GEOPHYSICAL METHODOLOGY**.

Fig. 2.9 Exposed overburden in the northwest of Area B

Fig. 2.10 Floating electrode ERT survey Area A.

3. RESULTS

The land based survey to the northeast was carried out on the 21st-22nd January 2021 involving the collection of EM ground conductivity readings, 4 ERT profiles and 2 seismic refraction profiles. The over water survey in the quarry was carried out on the 25th - 27th January 2021 and consisted of 6 ERT profiles. Profile locations were laid out as received from SLR/TMS. The Survey locations are indicated on Drawing AGP21007_01 (Appendix C).

3.1 EM Ground Conductivity Mapping

The EM ground conductivity results (Drawing AGP21007_02, Appendix C) are indicative of the bulk conductivity of the ground materials from 0-6.0m bgl. The recorded conductivity values ranged from 0.5 to 10 mS/m and have been generally interpreted in conjunction with the ERT and seismic data as follows:

Conductivity (mS/m)	Interpretation
0.5 - 2.0	Overburden thickness < 2m over limestone
2.0 – 3.0	Localised pockets of overburden thickness 2-5 m
3.0 – 10.0	Thick overburden (>5m)

3.2 ERT

Ten ERT Profiles (R1 to R10) have been acquired across the site. The resistivity values have been interpreted on the following basis.

Resistivity (Ohm-m)	Interpretation
20 - 40	WATER column in quarry
150 - 500	Predominantly clayey GRAVEL overburden
50 -250	Gravelly CLAY with cobbles and boulders (Boulder Clay)
250 - 1125	Weathered LIMESTONE (subcrop), possible shaley LIMESTONE at depth
1125-7000	Slightly weathered to fresh LIMESTONE

3.3 Seismic refraction profiling

Two seismic refraction spreads were recorded across the site (S1-S2). The seismic refraction data indicated three velocity layers that have been interpreted on the following basis:

Layer	Seismic Velocity (m/s)	Average Seismic Velocity (m/s)	Interpretation	Stiffness/ Rock Quality
1	200 - 400	300	Overburden	Soft-/Loose
2	1000 -1400	1300	Highly-Moderately Weathered Rock (S1) Gravelly Silty CLAY with cobbles/boulders (S2)	Poor Stiff
3	3100-4200	3700	Slightly Weathered – fresh thinly bedded LIMESTONE	Fair - Good

3.4 Discussion

The ERT results have been interpreted in conjunction with the seismic and EM ground conductivity datasets.

Overburden – Area B

The geophysical data have outlined thin overburden (0 -2m m) across most of Area B, thickening to 2-5m in local pockets in the southwest. The resistivity and seismic values indicate loose predominantly clayey gravel with possible highly weathered/fractured rock at base.

In the northwest of the Area B the overburden thicknesses increases significantly to at least 15m and possibly greater (see Drawing AGP21007_03 and profiles R1, R3 and R4). The resistivity and seismic values here are indicative of a stiff gravelly clay and cobbles and boulders are visible where exposed (Fig. 2.9). This area has been marked **Zone** 1 on Drawing AGP21007_03 and drilling should be considered to confirm the thickness and nature of the sediment fill. Seismic spread S2 indicates a minimum thickness of 15m over possible rock but the rock level may be deeper.

Bedrock – Area B

The bedrock has been interpreted as clean (1125 – 7000 Ohm-m), thin to medium bedded limestone with an upper weathered layer 1-4m thick, over slightly weathered to fresh limestone. Seismic velocities of the bedrock are slightly lower than average at 3000 to 4200 m/s mainly due to the thin-medium bedding and some jointing.

At the northwest end of Area B the bedrock resistivity on profiles R1, R3 and R4 decreases to less than 1000 Ohm-m below a depth of around 10 mOD. This area extends around 50m southeast of Zone 1 and has been marked **Zone 2** on Drawing AGP21007_03. A similar feature was observed at the eastern end of the profiles recorded during the 2019 survey (green dashed line on Drawing AGP21007_03) and may indicate a transition to more clay mineral rich or shaley limestone at depth in this area. Alternatively it may be associated with weathering and clay infill at the edge of the thick sediment filled channel in Zone 1. Investigation to establish the nature of the material in Zone 2 is recommended.

A localised increase in depth to bedrock occurs at around 85m on ERT Profile R1 (marked point **3** on Drawing AGP21007_03) and bedrock seismic velocities in the vicinity are relatively low. This feature should be investigated to check for a possible karst doline (point 3). Resistivity values on R2 which runs approximately E-W are similar to those recorded on NW-SE trending profile R1, R3 and R4 and do not show any major change with direction.

Bedrock – Area A

The bedrock in Area A was investigated using ERT profiles recorded by the floating electrode method. Water level was -15.4 mOD and the average water depth was 5.4 m allowing bedrock resistivity to be measured between -20.8 mOD and – 60 mOD on NW-SE profiles R5, R6 and R7, and between -20.8 mOD and – 50 mOD on NE-SW profiles R8, R9 and R10).

Rock resistivities on both the NW-SE profiles (R5, R6, R7) and the NE-SW profiles (R8, R9 and R10) are relatively constant at 1500 – 7000 Ohm-m and there are no indications of major weathered zones or structural (fault, fissure) or karst features. Some lower values occur immediately beneath the water column but these are mainly due to smoothing of the sharp transition between water and rock, also associated with relaxation and near surface opening of joints on the quarry floor in the upper 1-3m.

4. RECOMMENDATIONS

Further investigation should be considered to:

- Confirm the nature of the material in Zone 1.
- Investigate the transition to lower resistivity material in Zone 2.
- Investigate the localised feature at point 3.

The geophysical report should be reviewed after the completion of any direct investigation.

REFERENCES

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APPENDIX A: DETAILED GEOPHYSICAL METHODOLOGY

A combination of geophysical techniques was used to provide a high quality interpretation and reduce any ambiguities, which may otherwise exist.

EM Ground Conductivity Mapping

Principles

This is an electromagnetic technique used to investigate lateral variations in overburden material and to assist with the indication of the depth to bedrock. This method operates on the principle of inducing currents in conductive substrata and measuring the resultant secondary electro-magnetic field. The strength of this secondary EM field is calibrated to give apparent ground conductivity in milliSiemens/metre (mS/m). Readings over material such as organic waste and peat give high conductivity values while readings over dry materials with low clay mineral content such as gravels, limestone or quartzite give low readings. The EM31 survey technique determines the apparent conductivity of the different overburden layers from 0-6m bgl depending on the dipole mode used.

Data collection

The EM31 equipment used was a GF CMD-4 conductivity meter equipped with data logger. This instrument features a real time graphic display of the previous 20 measurement points to monitor data quality and results. Conductivity and in-phase values were recorded across the site. Local conditions and variations were recorded.

Data processing

The conductivity and in-phase field readings were downloaded, contoured and plotted using the SURFER 12 program (Golden Software, 2015). Data which was affected by metallic objects was removed. Assignation of material types and possible anomaly sources was carried out, with cross-reference to other data.

Electrical Resistivity Tomography (ERT)

Electrical Resistivity Tomography was carried out to provide information on lateral variations in the overburden material as well as on the underlying overburden and bedrock.

Principles

This surveying technique makes use of the Wenner resistivity array. The 2D-resistivity profiling method records a large number of resistivity readings in order to map lateral and vertical changes in material types. This method involves the use of electrodes connected to a resistivity meter, using computer software to control the process of data collection and storage.

Data Collection

Profiles were recorded using a Tigre resistivity meter, imaging software, two 32 takeout multicore cables and up to 64 stainless steel electrodes. Saline solution was used at the electrode/ground interface in order to gain a good electrical contact required for the technique to work effectively. The recorded data were processed and viewed immediately after surveying.

For the overwater survey floating electrodes were used with the cable anchored at either end of the line. Water depths were taken at intervals along each line.

Data Processing
The field readings were stored in computer files and inverted using the RES2DINV package (Geotomo Software, 2006) with up to 5 iterations of the measured data carried out for each profile to obtain a 2D-depth model of the resistivities. The overwater resistivity data was inverted using the standard smooth inversion with some damping of the rock resistivity values.

The inverted 2D resistivity models and corresponding interpreted geology are displayed on the accompanying drawings alongside the processed seismic sections. Profiles have been contoured using the same contour intervals and colour codes. Distance is indicated along the horizontal axis of the profiles.

Seismic Refraction Profiling

Principles
This method measures the velocity of refracted seismic waves through the overburden and rock material and allows an assessment of the thickness and quality of the materials present to be made. Stiffer and stronger materials usually have higher seismic velocities while soft, loose or fractured materials have lower velocities.

Seismic profiling measures the p-wave velocity (Vp) of refracted seismic waves through the overburden and rock material and allows an assessment of the thickness and quality of the materials present to be made. Stiffer and stronger materials usually have higher Vp velocities while soft, loose or fractured materials have lower Vp velocities. Readings are taken using geophones connected via multi-core cable to a seismograph.

Data Collection
A Geode high resolution 24 channel digital seismograph, 24 10HZ vertical geophones and a 10 kg hammer were used to provide first break information, with a 24 take-out cable. Equipment was carried and operated by a two-person crew.

Readings are taken using geophones connected via multi-core cable to a seismograph. The depth of resolution of soil/bedrock boundaries is determined by the length of the seismic spread, typically the depth of resolution is about one third the length of the profile (eg. 69m profile ~23m depth, 33m profile ~ 11m depth).

Data Processing
First break picking in digital format was carried out using the FIRSTPIX software program to construct p-wave (Vp) traveltime plots for each spread. Velocity phases were selected from these plots using the GREMIX software program and were used to calculate the thickness of individual velocity units. Topographic data were input. Material types were assigned and estimation made of material properties. The processed seismic data are displayed in Appendix A.

GREMIX interprets seismic refraction data as a laterally varying layered earth structure. It incorporates the slope-intercept method, parts of the Plus-Minus Method of Hagedoorn (1959), Time-Delay Method, and features the Generalized Reciprocal Method (GRM) of Palmer (1980). Up to four layers can be mapped; one deduced from direct arrivals and three deduced from refractions. Phantoming of all possible travel time pairs can be carried out by adjusting reciprocal times of off shots.

Approximate errors for Vp velocities are estimated to be +/- 10%. Errors for the calculated layer thicknesses are of the order of +/-20%. Possible errors due to the "hidden layer" and "velocity inversion" effects may also occur (Soske, 1959).

Spatial Relocation

All the geophysical investigation locations were acquired using a Trimble Geo 7X high-accuracy GNSS handheld system using the settings listed below. This system allows collection of GPS data with c.20mm accuracy.

Projection:	Irish Transverse Mercator
Datum:	Ordnance
Coordinate units:	Meters
Altitude units:	Meters
Survey altitude reference:	MSL
Geoid model:	Republic of Ireland

Water depths were measured by the sonar depth monitor on the survey boat and confirmed by manual depth sounding. The surface water level was measured using the GPS. Water depths average around 5.4 m apart from some localised areas where water depths were up to 1m shallower.

APPENDIX B: SEISMIC PLATES

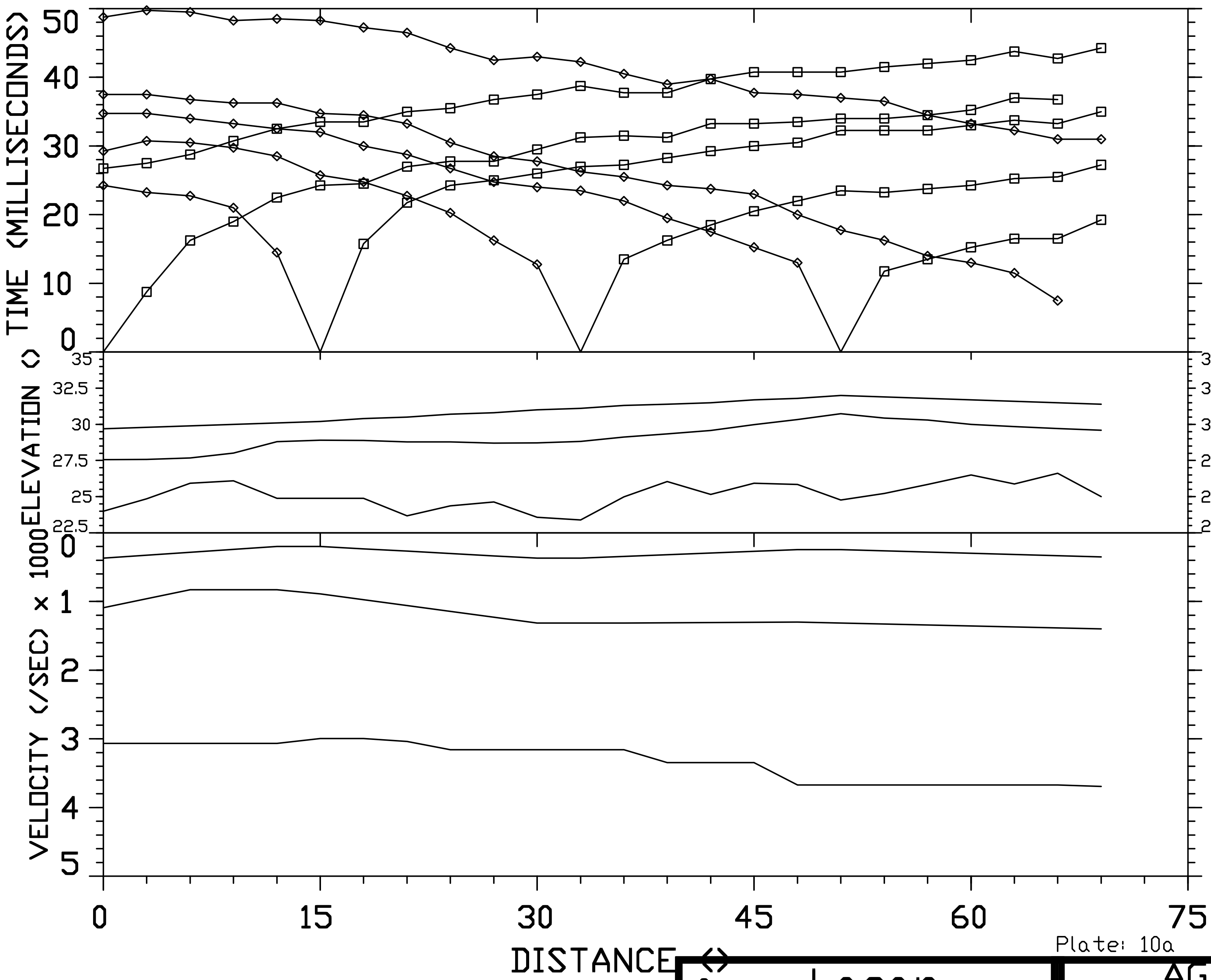
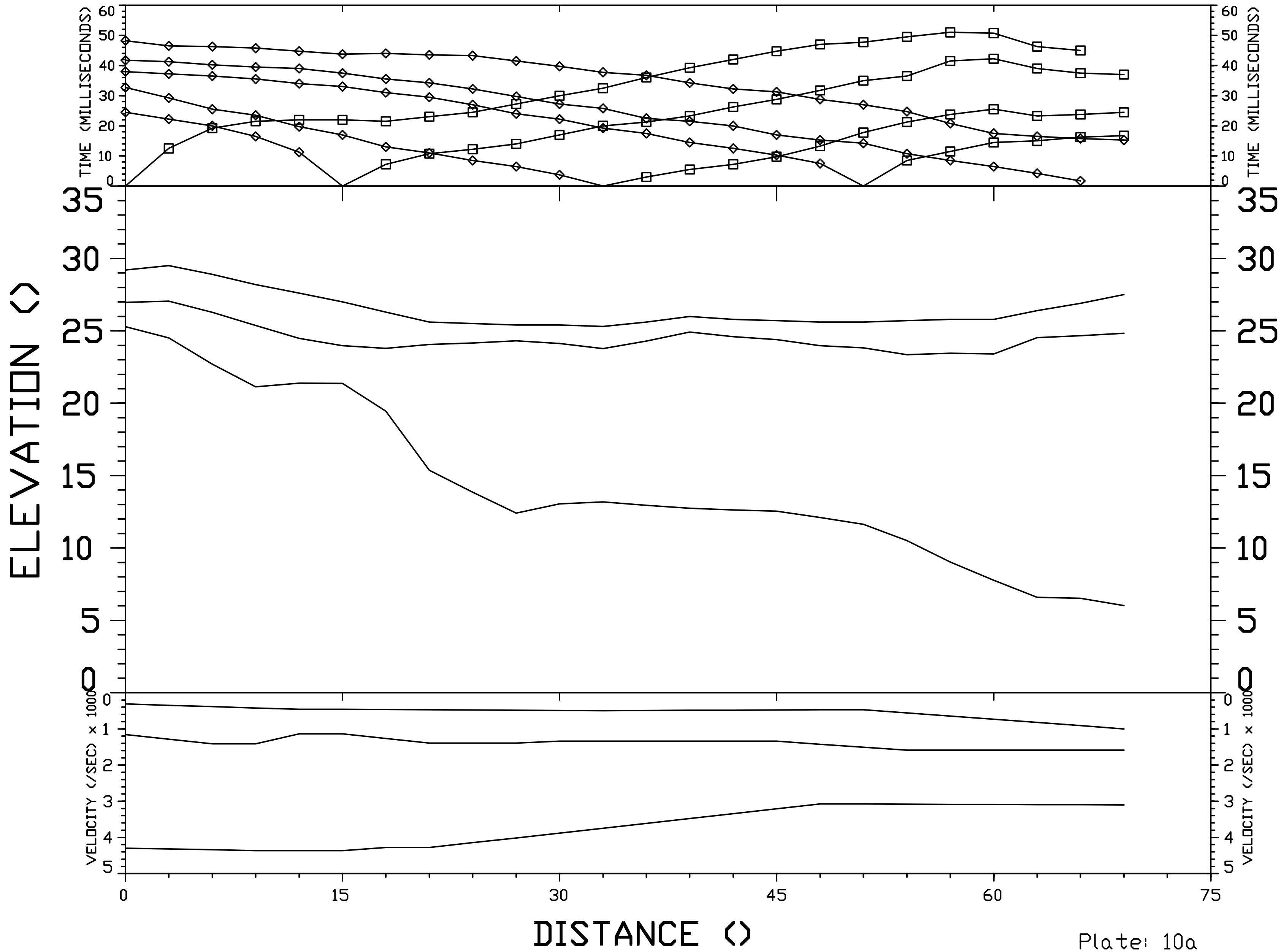


Plate: 10a

for: Lagan	AGP21007
by: APEX Geophysics Ltd.	Sligo SLIGO
Data SetS1 · Date: 22\01\21	
Equipment: Geode · Spread: S1	Azimuth:



for: Lagan	AGP21007
by: APEX Geophysics Ltd.	Sligo SLIGO
Data SetS2 / Date: 22\01\21	
Equipment: Geode / Spread: S2	Azimuth:

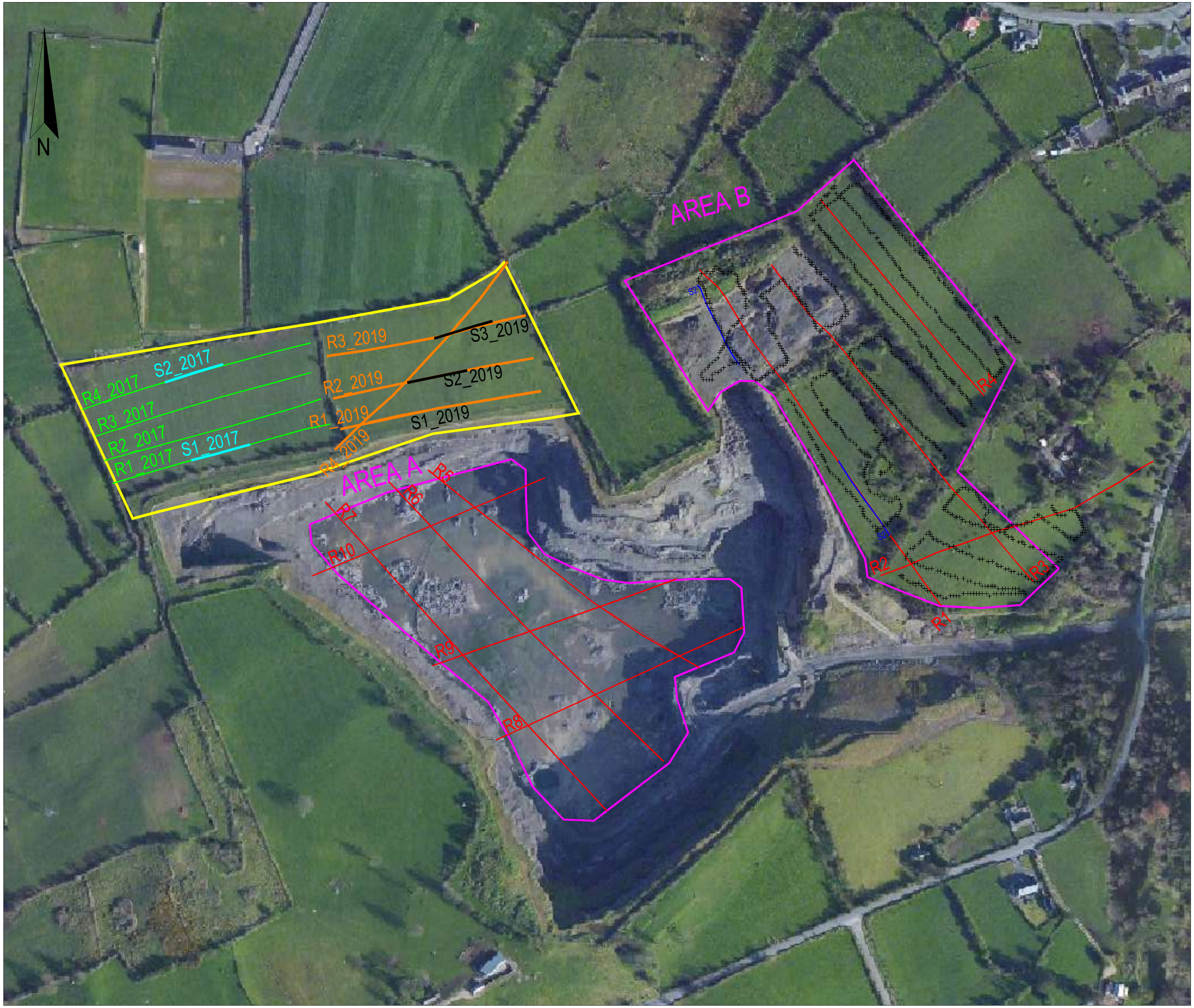
APPENDIX C: DRAWINGS

The information derived from the geophysical investigation is presented in the following drawings:

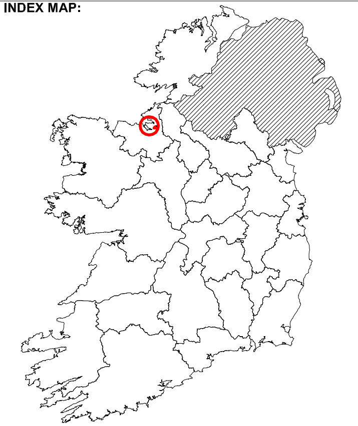
AGP21007_01	Geophysical Survey Locations	1:4000	@ A4
AGP21007_02	EM Conductivity Contours (mS/m)	1:4000	@ A4
AGP21007_03	Summary Interpretation Map	1:4000	@ A4
AGP21007_R1	Results & Interpretation – ERT Profile R1 and seismic Profiles S1 and S2	1:1500	@ A4
AGP21007_R2	Results & Interpretation – ERT Profile R2	1: 1500	@ A4
AGP21007_R3	Results & Interpretation – ERT Profile R3	1: 1500	@ A4
AGP21007_R4	Results & Interpretation – ERT Profile R4	1: 1500	@ A4
AGP21007_R5	Results & Interpretation – ERT Profile R5	1: 1500	@ A4
AGP21007_R6	Results & Interpretation – ERT Profile R6	1: 1500	@ A4
AGP21007_R7	Results & Interpretation – ERT Profile R7	1: 1500	@ A4
AGP21007_R8	Results & Interpretation – ERT Profile R8	1: 1500	@ A4
AGP21007_R9	Results & Interpretation – ERT Profile R9	1: 1500	@ A4
AGP21007_R10	Results & Interpretation – ERT Profile R10	1: 1500	@ A4

GEOPHYSICAL SURVEY LOCATIONS

SCALE 1:4000



INDEX MAP:



LEGEND:

- Site
- EM conductivity/gravity station
- 2D resistivity profile - 2021
- Seismic refraction profile - 2021
- Previous Surveys
- 2D resistivity profile - 2019
- Seismic refraction profile - 2019
- 2D resistivity profile - 2017
- Seismic refraction profile - 2017

The information displayed here is to be used in conjunction with AGP21007_01 Report on the Geophysical Investigation at Aghamore, Sligo for Lagan Asphalt Ltd., APEX Geophysics Ltd. 5th February 2021.

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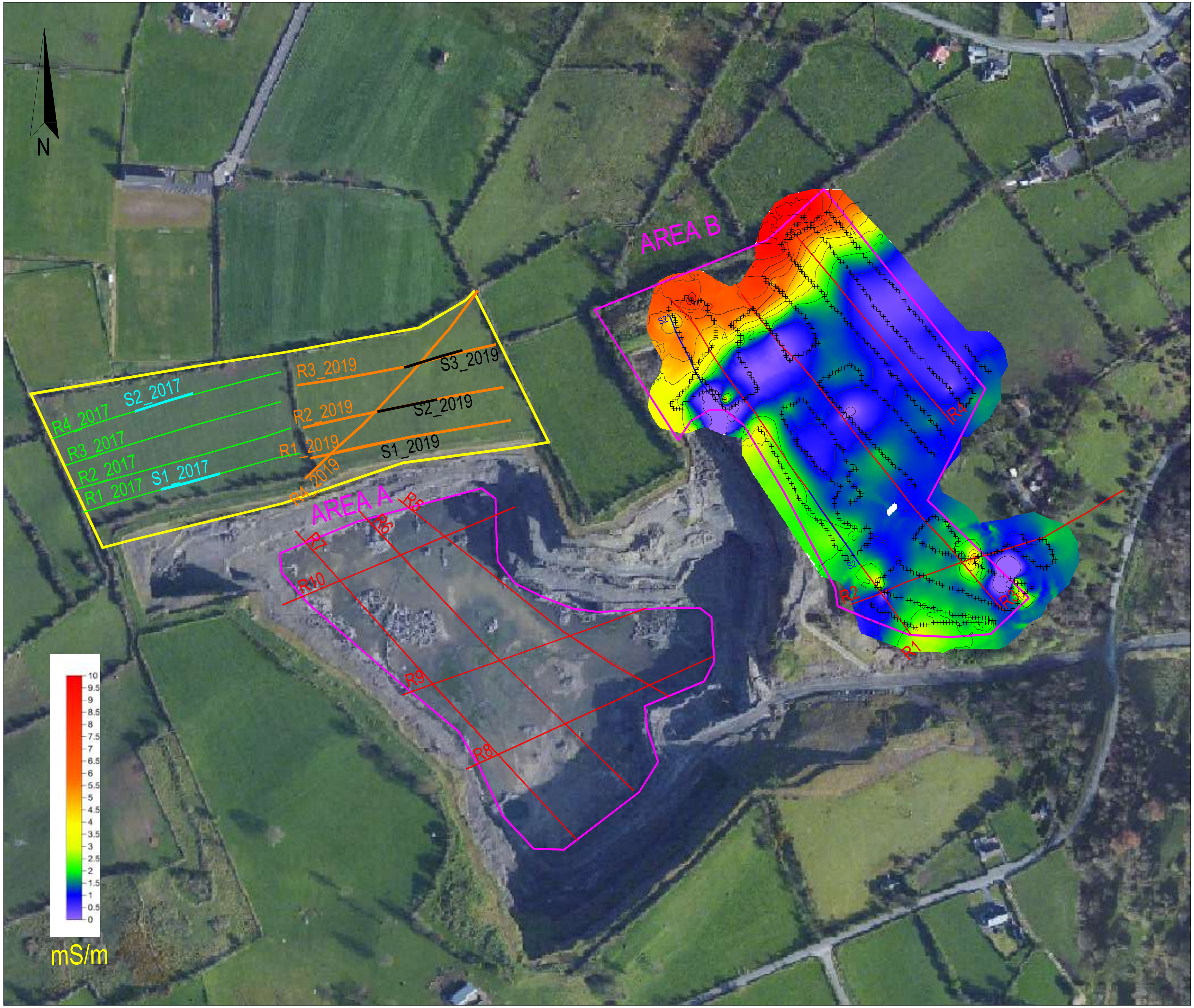
PROJECT:	AGHAMORE GEOPHYSICAL SURVEY
CLIENT.:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_01
SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

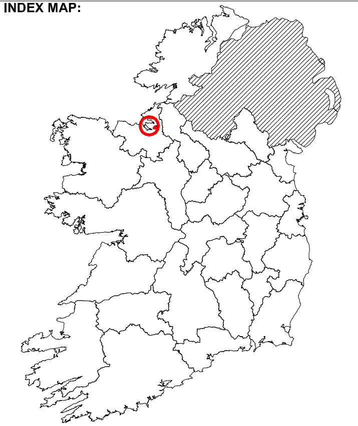
Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

EM GROUND CONDUCTIVITY (mS/m)

SCALE 1:4000



INDEX MAP:



LEGEND:

- Site
- \+ EM conductivity/gravity station
- R1 2D resistivity profile - 2021
- S1 Seismic refraction profile - 2021
- R1 2D resistivity profile - 2019
- S1 Seismic refraction profile - 2019
- R1 2D resistivity profile - 2017
- S1 Seismic refraction profile - 2017

The information displayed here is to be used in conjunction with AGP21007_01 Report on the Geophysical Investigation at Aghamore, Sligo for Lagan Asphalt Ltd., APEX Geophysics Ltd. 5th February 2021.

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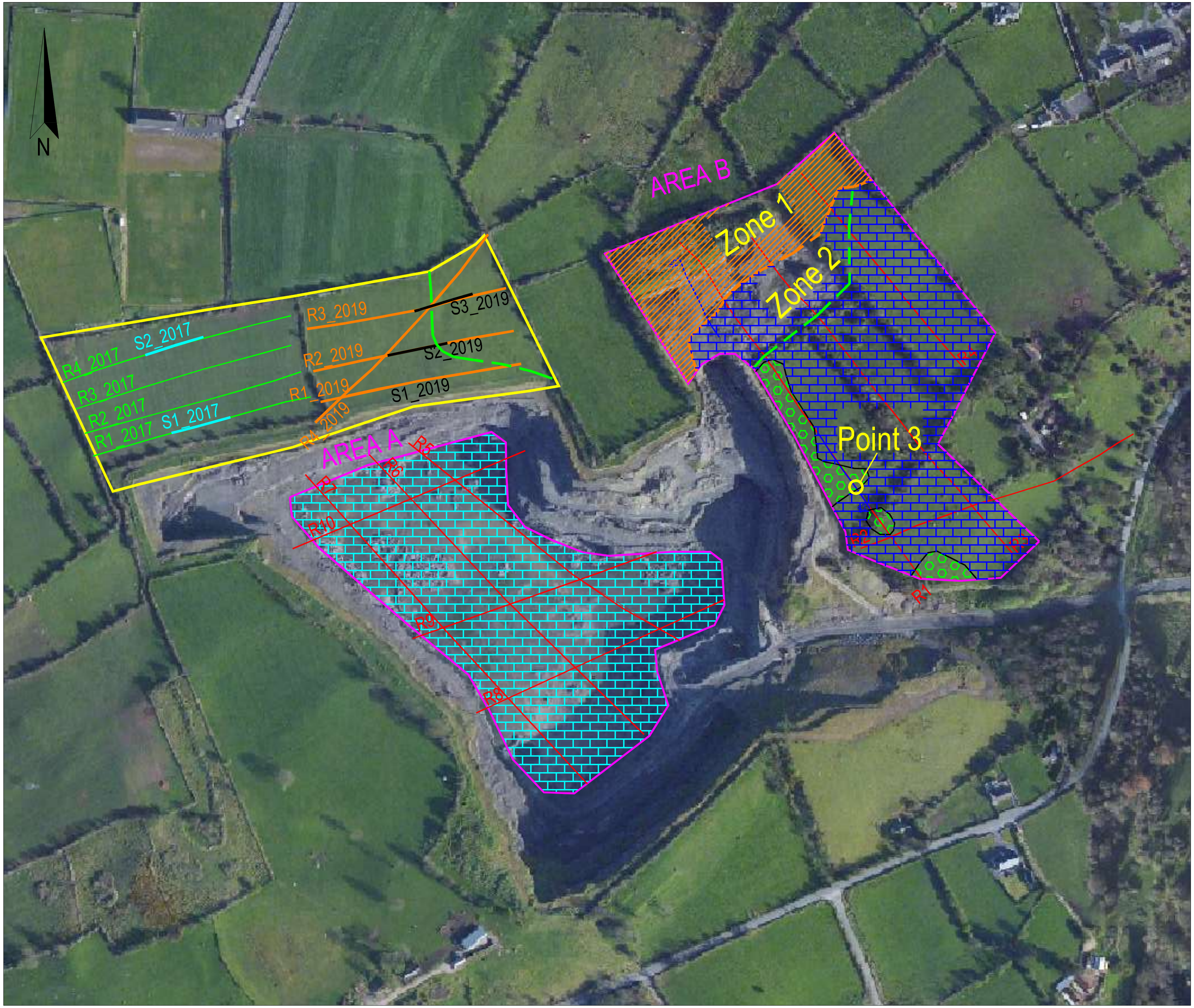
PROJECT:	AGHAMORE GEOPHYSICAL SURVEY
CLIENT.:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_02
SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

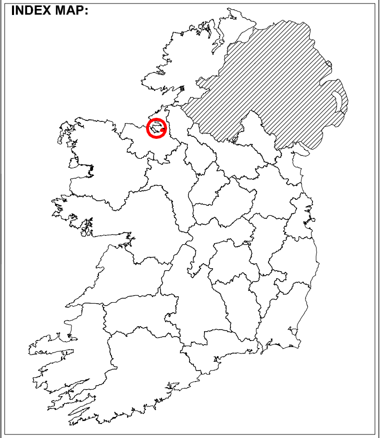
Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

SUMMARY INTERPRETATION MAP

SCALE 1:4000



INDEX MAP:



LEGEND:

- Survey area A and B - 2021
- Localised overburden thickening
- Fresh LIMESTONE 25 to -30 mOD
- Fresh LIMESTONE -20 to -60 mOD
- Thick Gravelly CLAY (Boulder Clay)
- Area of low resistivity below 10 mOD
- R1 2D resistivity profile - 2021
- S1 Seismic refraction profile - 2021
- R1 2D resistivity profile - 2019
- S1 Seismic refraction profile - 2019
- R1 2D resistivity profile - 2017
- S1 Seismic refraction profile - 2017

The information displayed here is to be used in conjunction with AGP21007_01 Report on the Geophysical Investigation at Aghamore, Sligo for Lagan Asphalt Ltd., APEX Geophysics Ltd. 5th February 2021.

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PROJECT:	AGHAMORE GEOPHYSICAL SURVEY
CLIENT.:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_03
SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

ERT PROFILE R1 AND SEISMIC PROFILES S1 AND S2

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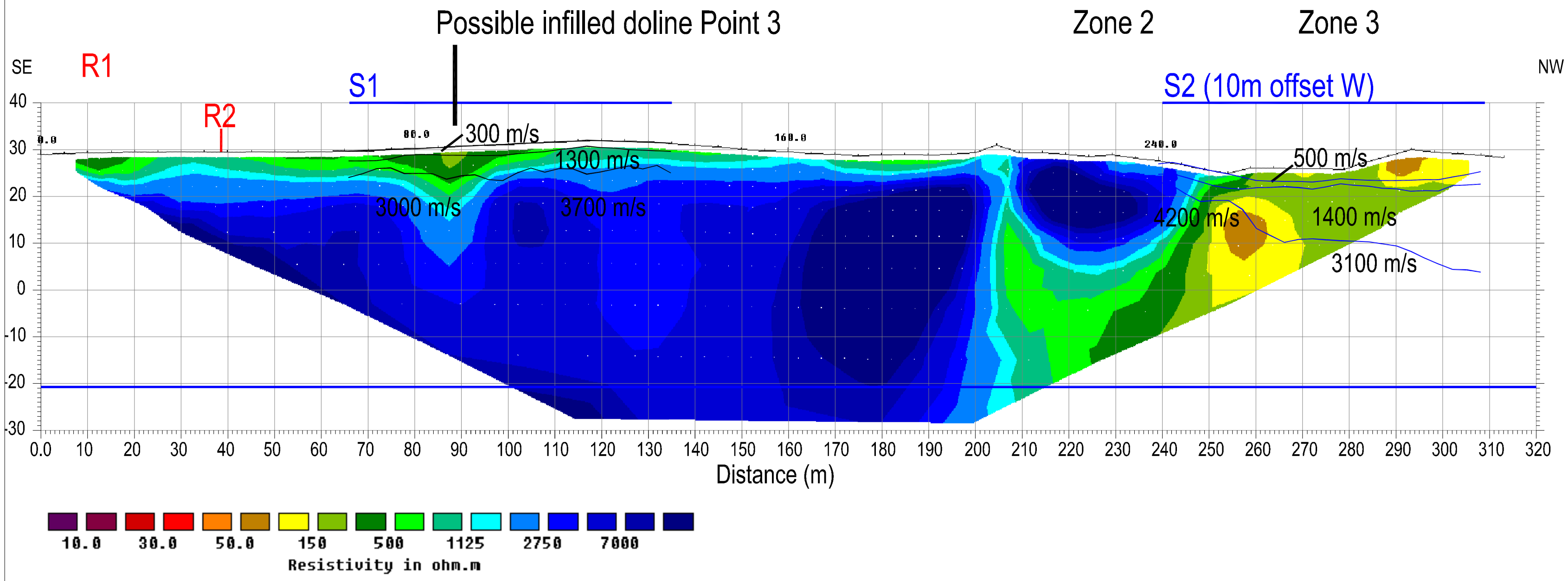

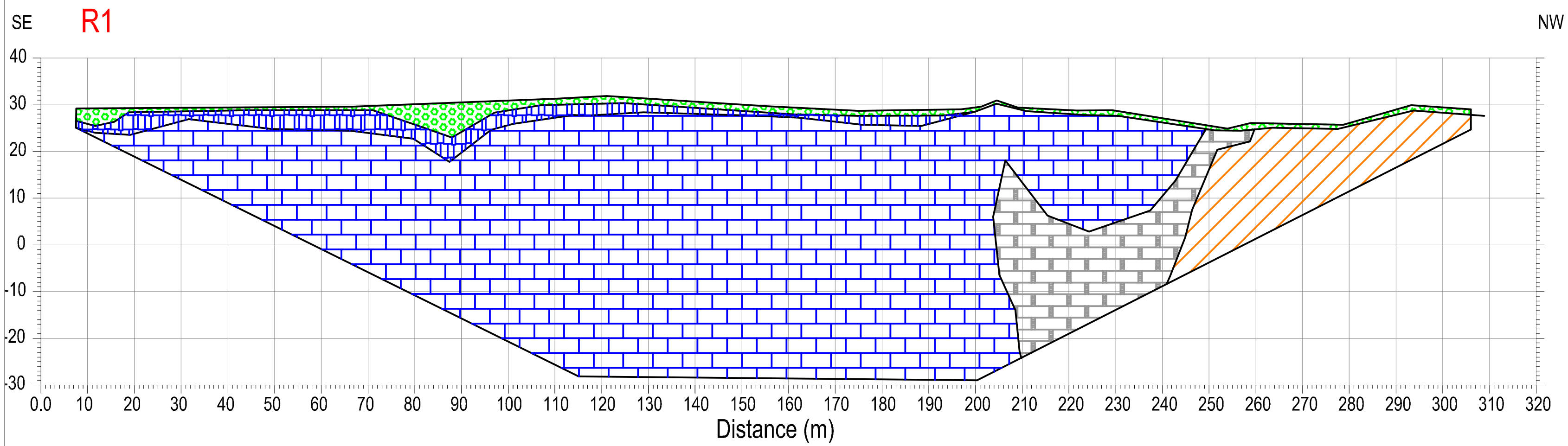

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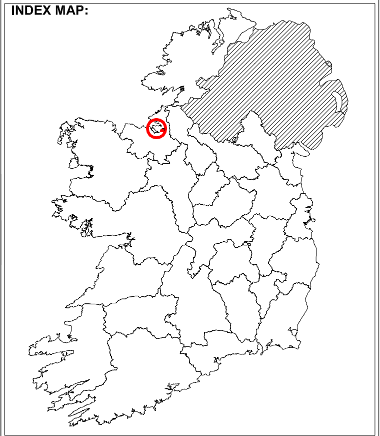

LEGEND:

- Clayey SAND/GRAVEL
- Weathered Rock
- possible shaley Limestone
- Gravelly CLAY (Boulder Clay) to >15m
- LIMESTONE (Land Survey)
- LIMESTONE (Over water survey)
- WATER COLUMN
- OPEN JOINTS
- SEISMIC LAYER, VELOCITY
- WATER LEVEL IN QUARRY (at time of survey)

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PROJECT:	AGHAMORE GEOPHYSICAL SURVEY
CLIENT.:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_R1
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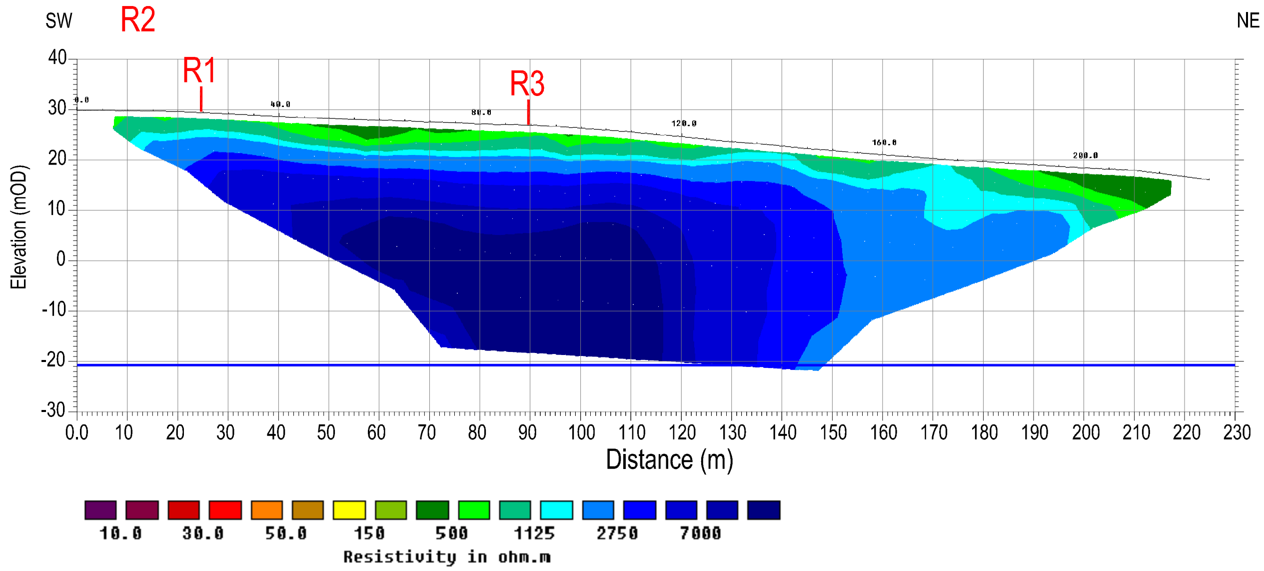

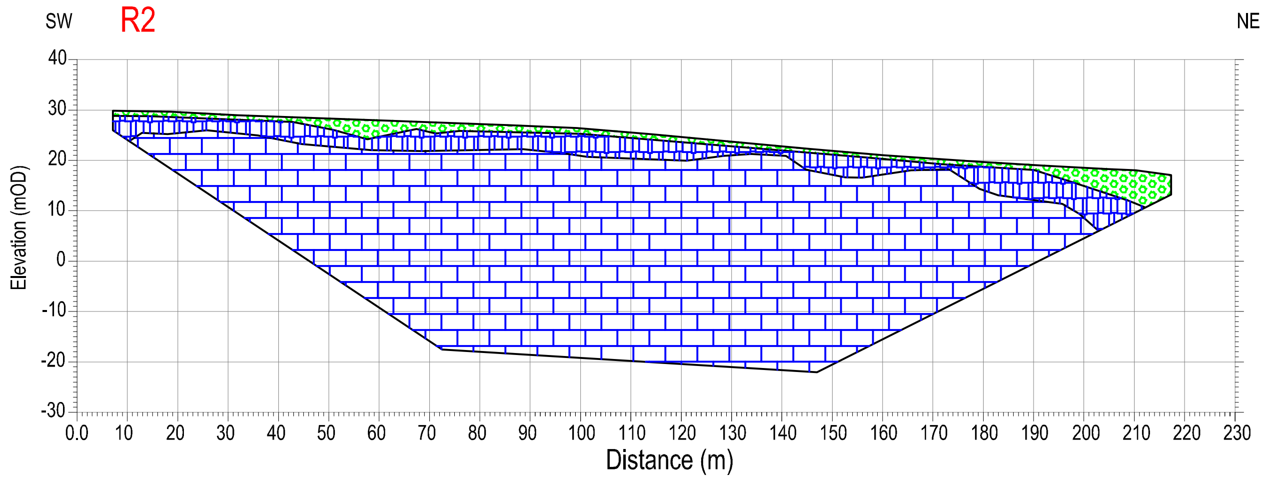

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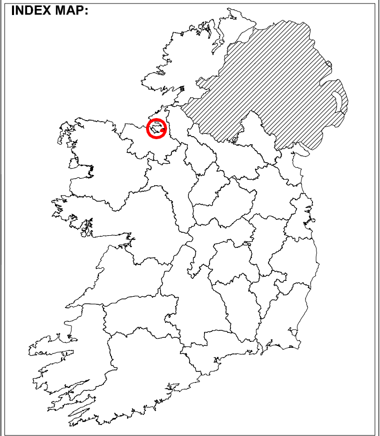

LEGEND:

- Clayey SAND/GRAVEL
- Weathered Rock
- possible shaley Limestone
- Gravelly CLAY (Boulder Clay) to >15m
- LIMESTONE (Land Survey)
- LIMESTONE (Over water survey)
- WATER COLUMN
- OPEN JOINTS
- SEISMIC LAYER, VELOCITY
- WATER LEVEL IN QUARRY (at time of survey)

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No	05-02-2021	POC	TL

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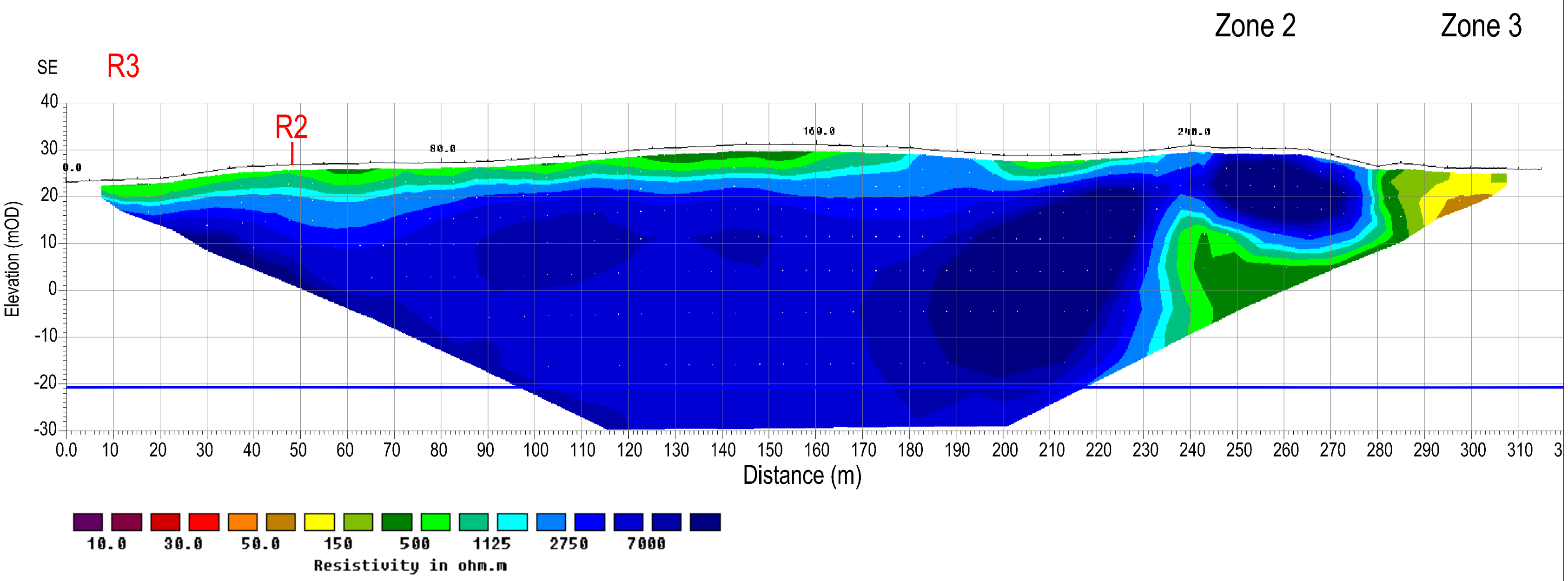

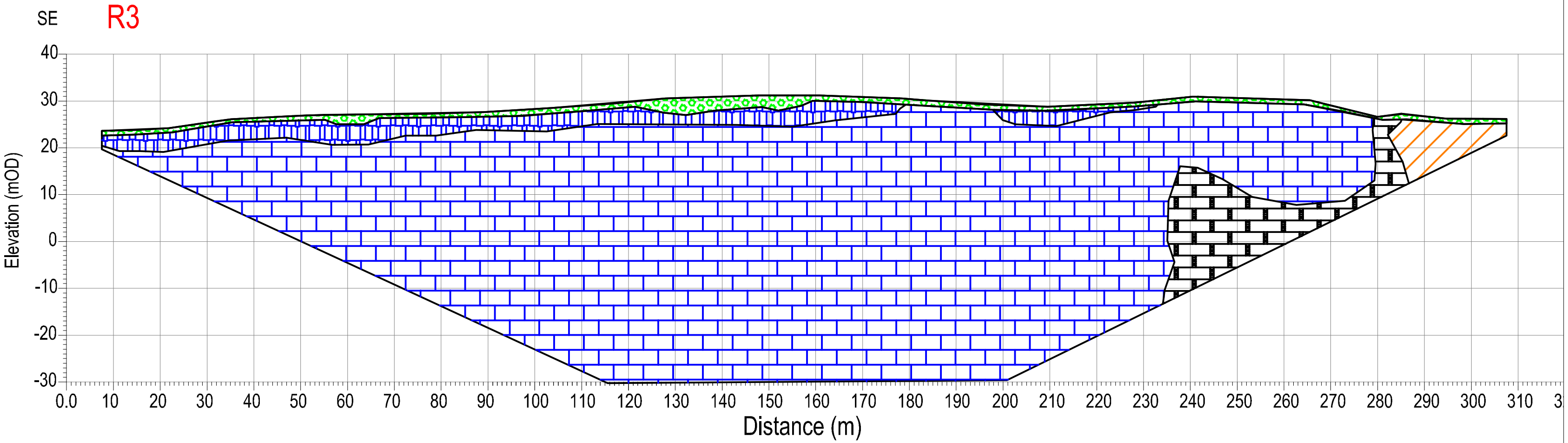

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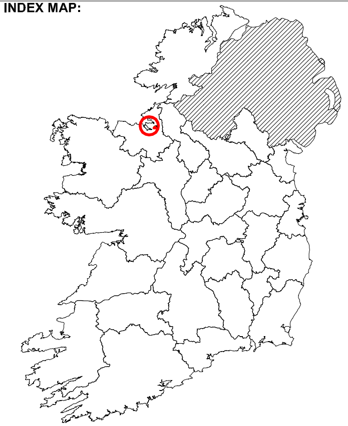

LEGEND:

- Clayey SAND/GRAVEL
- Weathered Rock
- possible shaley Limestone
- Gravelly CLAY (Boulder Clay) to >15m
- LIMESTONE (Land Survey)
- LIMESTONE (Over water survey)
- WATER COLUMN
- OPEN JOINTS
- SEISMIC LAYER, VELOCITY
- WATER LEVEL IN QUARRY (at time of survey)

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DATE:	05-02-2021

Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

ERT PROFILE R4

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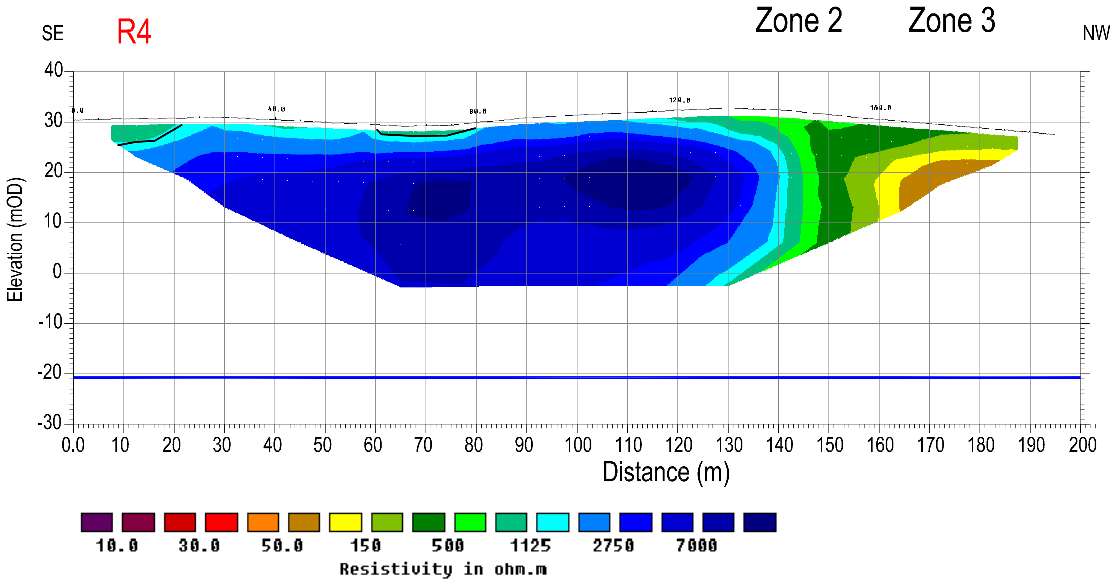

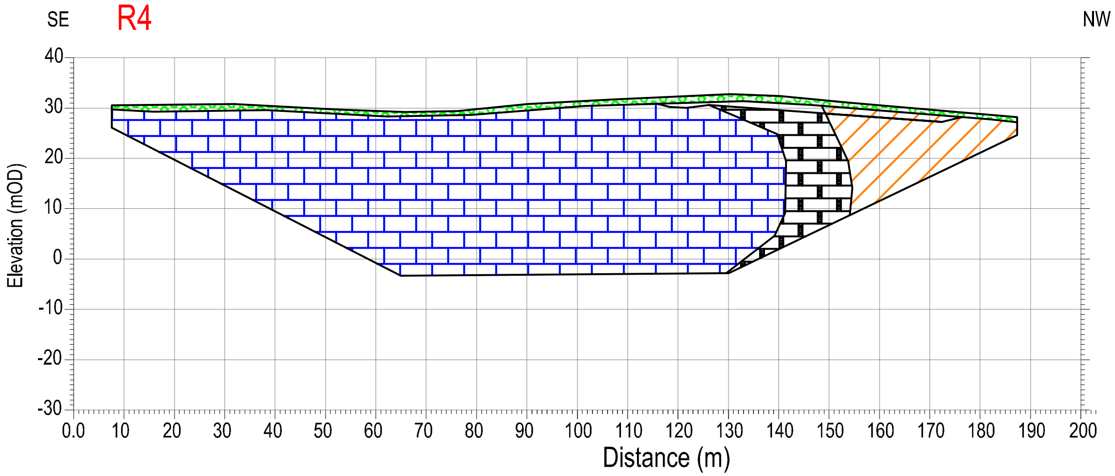

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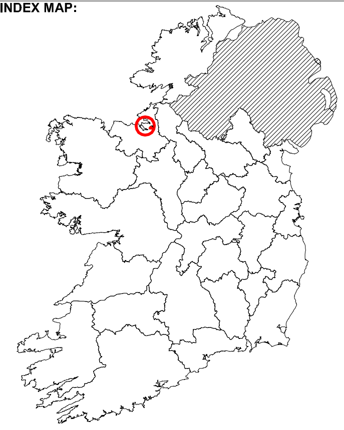

LEGEND:

- Clayey SAND/GRAVEL
- Weathered Rock
- possible shaley Limestone
- Gravelly CLAY (Boulder Clay) to >15m
- LIMESTONE (Land Survey)
- LIMESTONE (Over water survey)
- WATER COLUMN
- OPEN JOINTS
- SEISMIC LAYER, VELOCITY
- WATER LEVEL IN QUARRY (at time of survey)

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SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

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No	05-02-2021	POC	TL

ERT PROFILE R5

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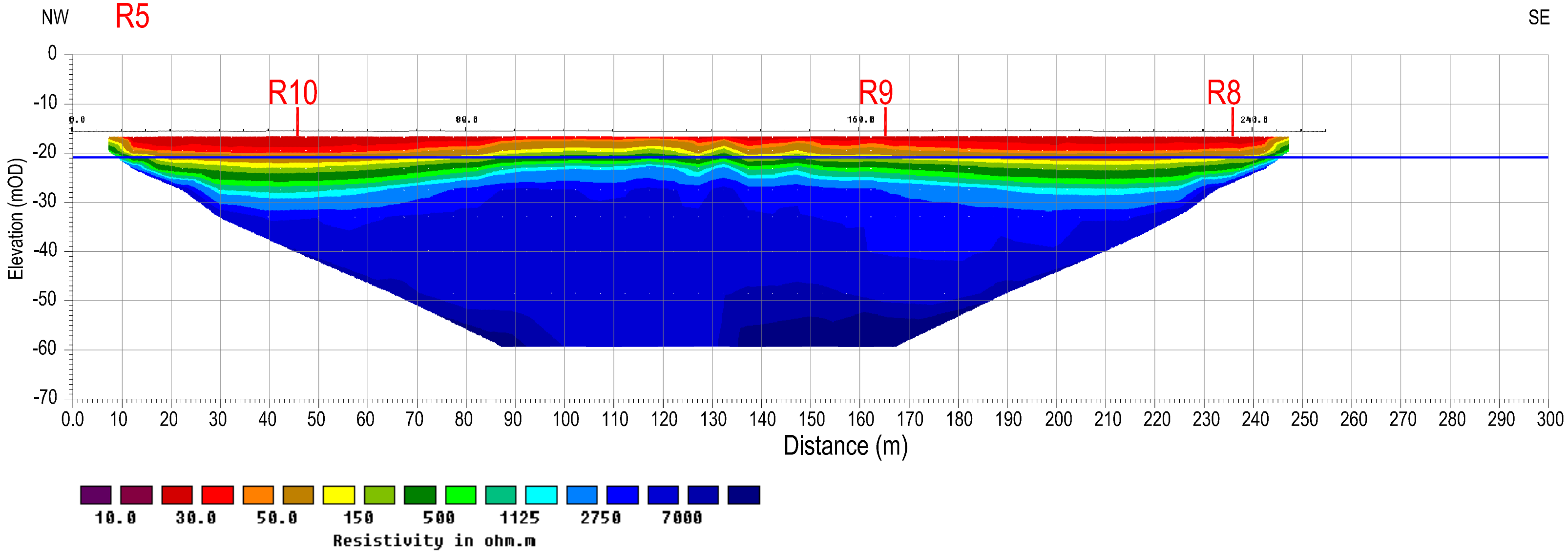

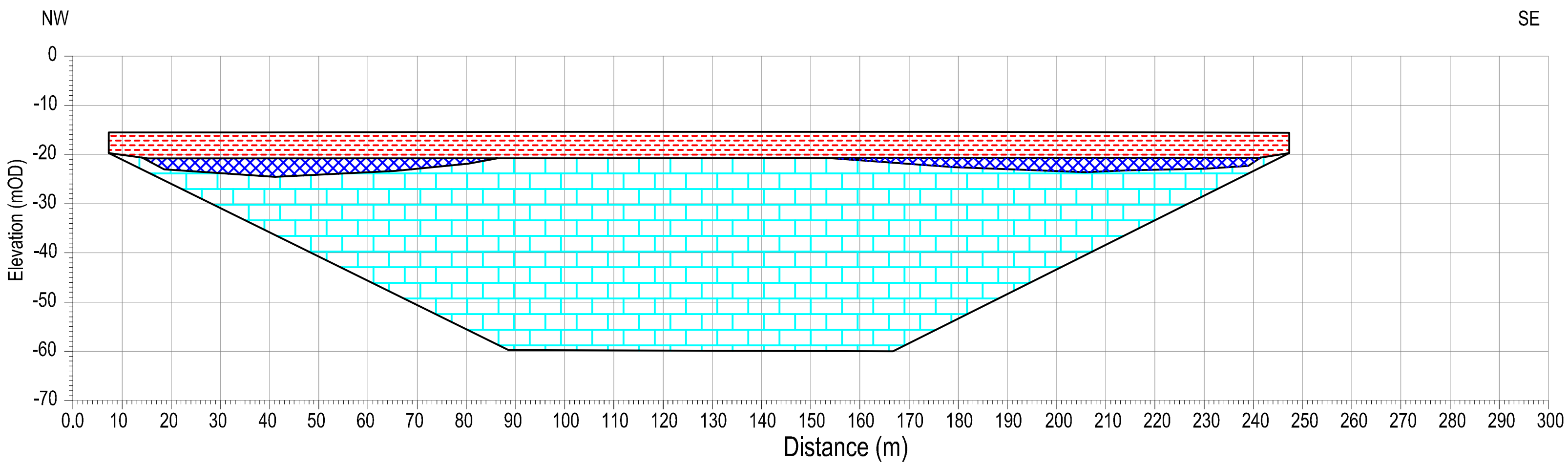

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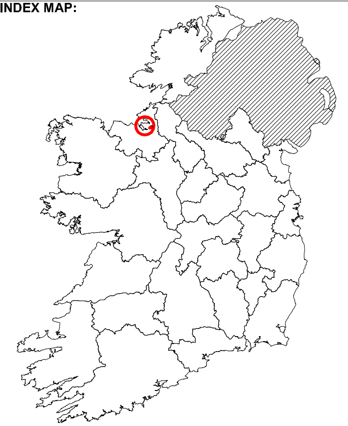

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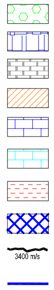

- Clayey SAND/GRAVEL
- Weathered Rock
- possible shaley Limestone
- Gravelly CLAY (Boulder Clay) to >15m
- LIMESTONE (Land Survey)
- LIMESTONE (Over water survey)
- WATER COLUMN
- OPEN JOINTS
- SEISMIC LAYER, VELOCITY
- WATER LEVEL IN QUARRY (at time of survey)

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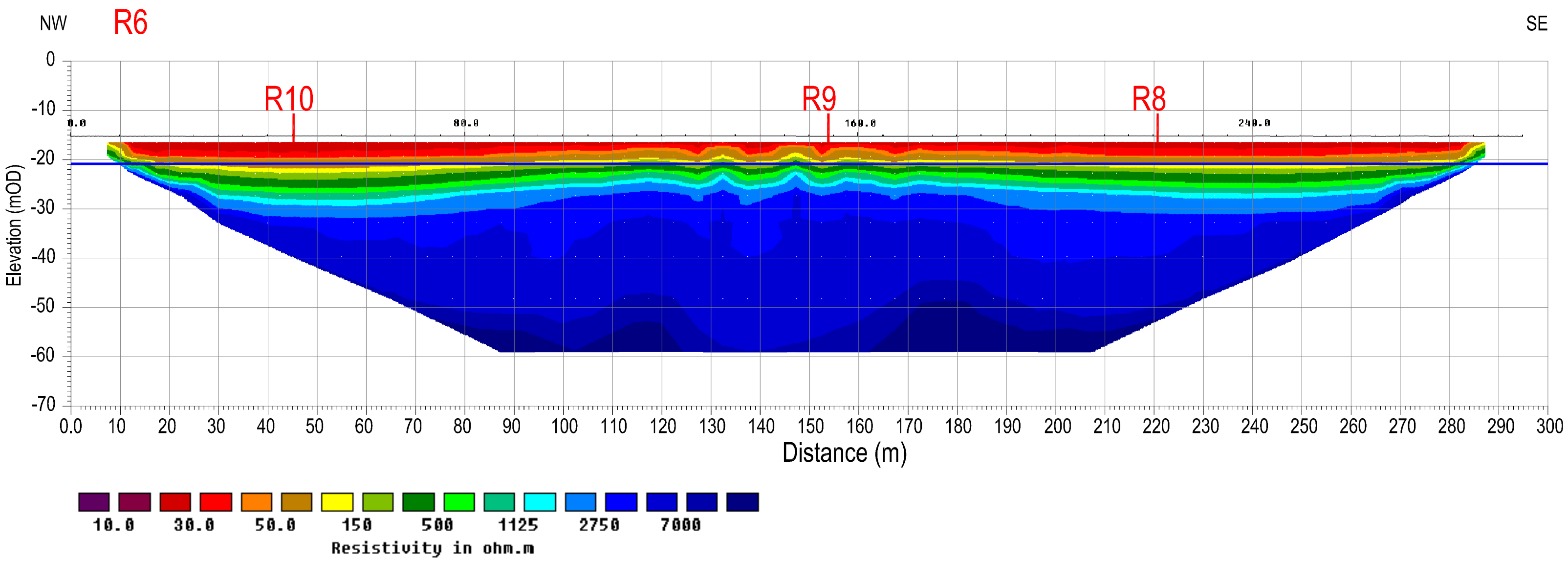
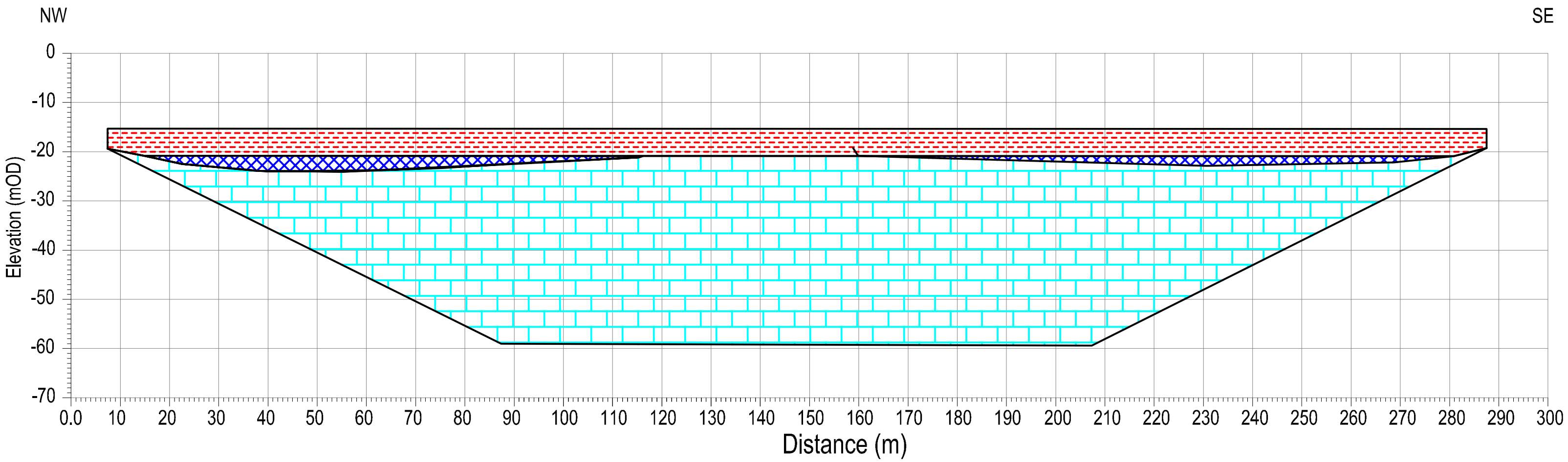
PROJECT:	AGHAMORE GEOPHYSICAL SURVEY
CLIENT.:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_R5
SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

ERT PROFILE R6

SCALE 1:1500





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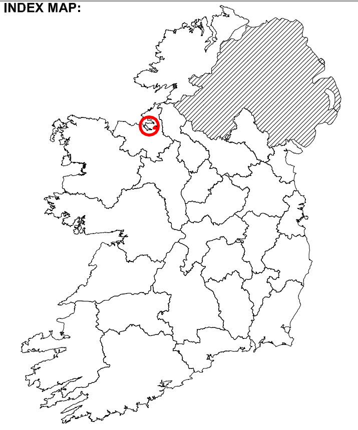

LEGEND:

- Clayey SAND/GRAVEL
- Weathered Rock
- possible shaley Limestone
- Gravelly CLAY (Boulder Clay) to >15m
- LIMESTONE (Land Survey)
- LIMESTONE (Over water survey)
- WATER COLUMN
- OPEN JOINTS
- 3400 m/s SEISMIC LAYER, VELOCITY
- WATER LEVEL IN QUARRY (at time of survey)

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CLIENT.:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_R6
SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

ERT PROFILE R7

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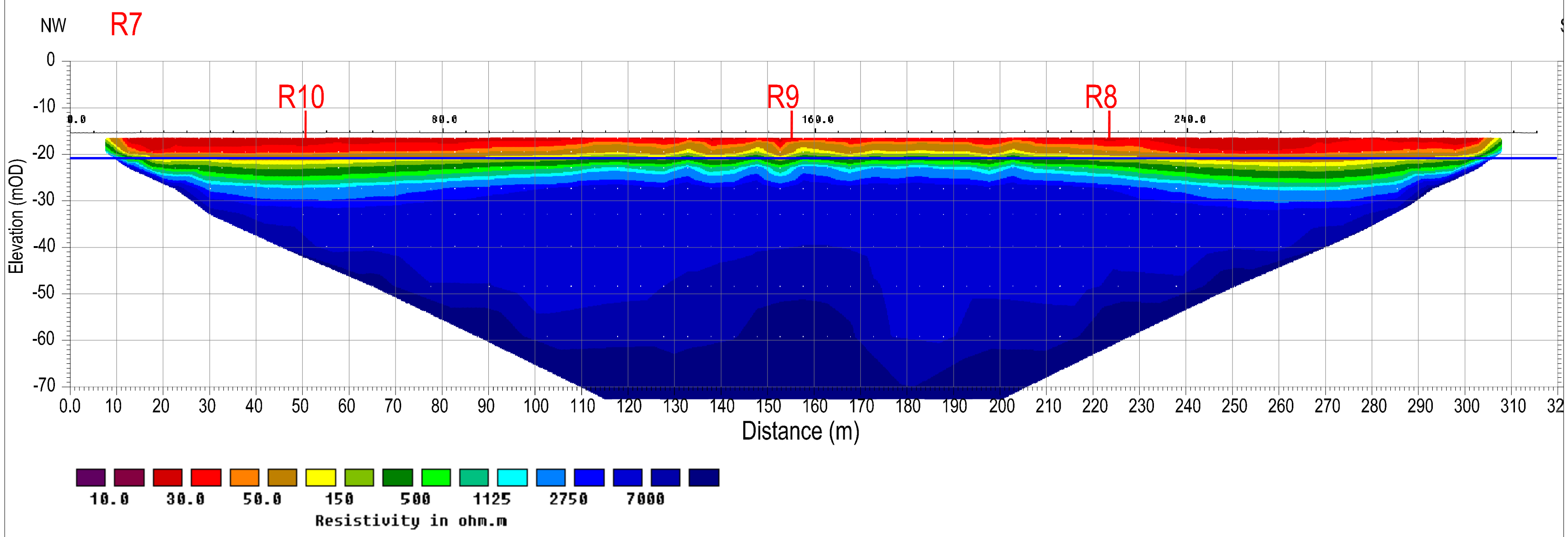

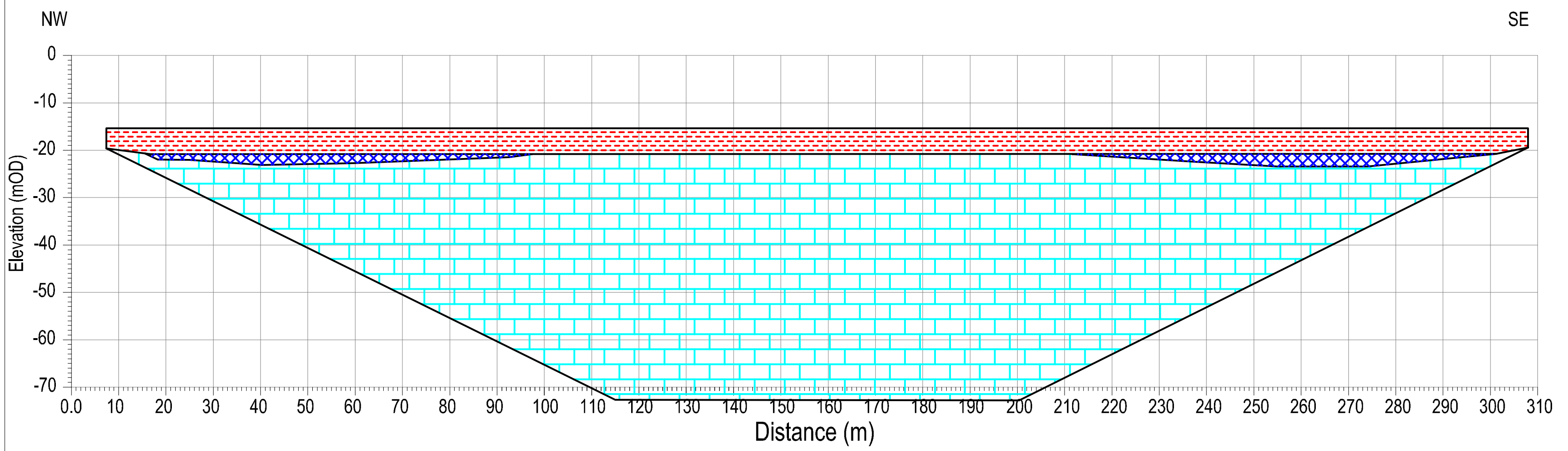

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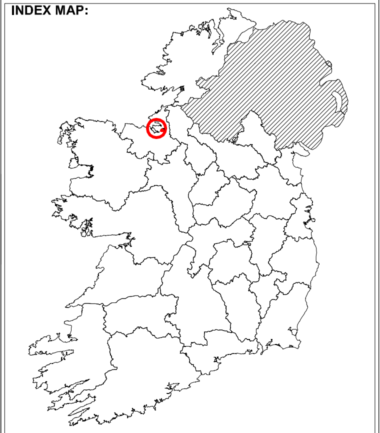

LEGEND:

- Clayey SAND/GRAVEL
- Weathered Rock
- possible shaley Limestone
- Gravelly CLAY (Boulder Clay) to >15m
- LIMESTONE (Land Survey)
- LIMESTONE (Over water survey)
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- OPEN JOINTS
- SEISMIC LAYER, VELOCITY
- WATER LEVEL IN QUARRY (at time of survey)

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CLIENT.:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_R7
SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

ERT PROFILE R8

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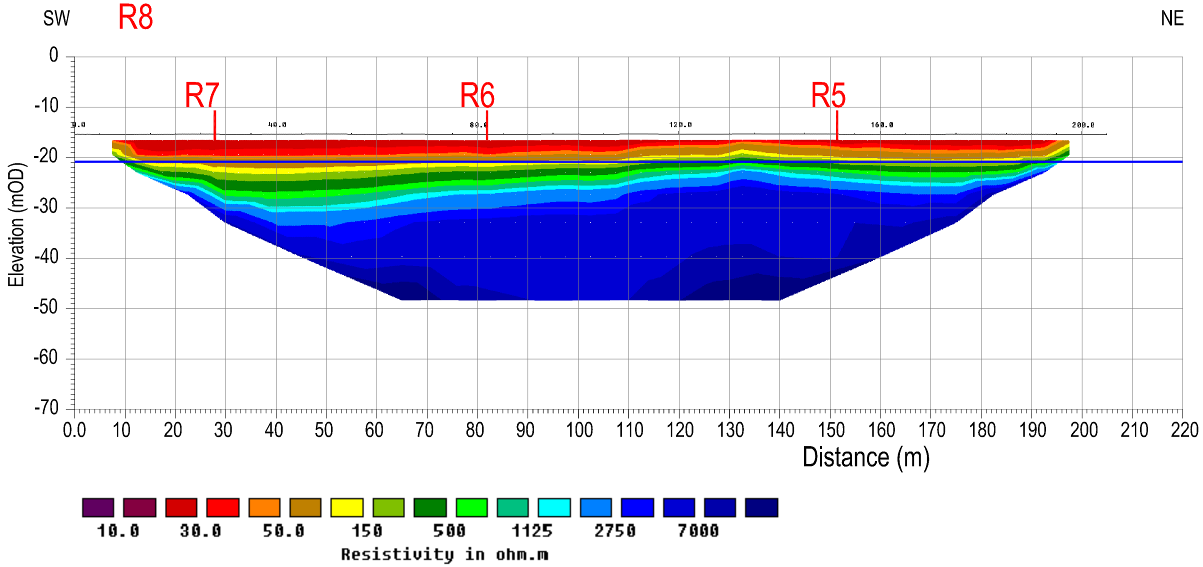

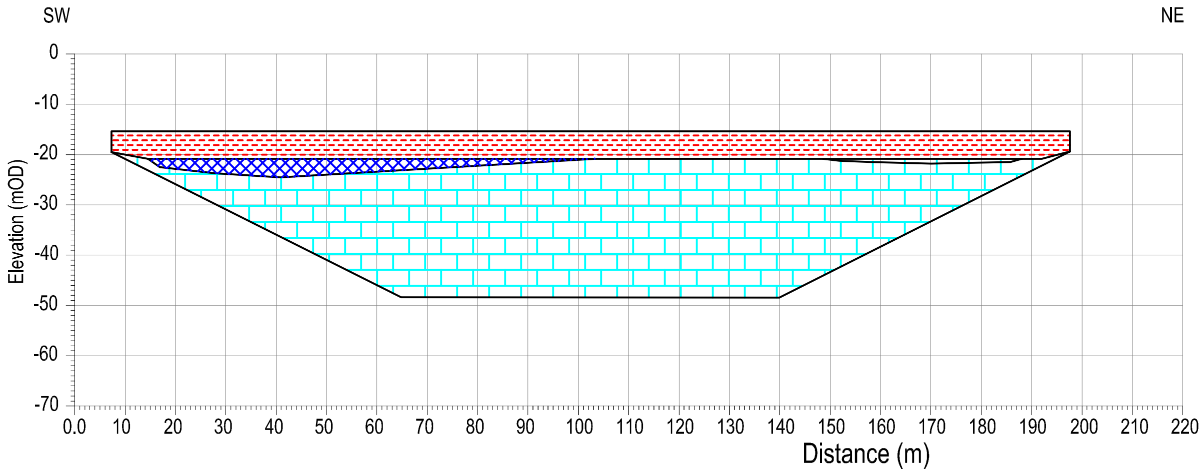

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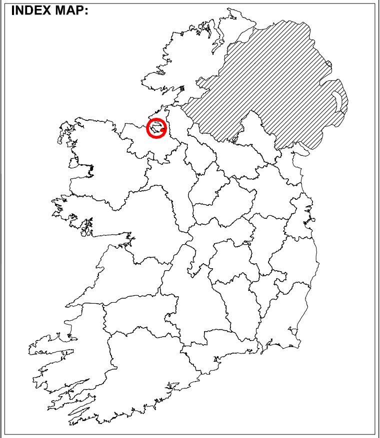

LEGEND:

- Clayey SAND/GRAVEL
- Weathered Rock
- possible shaley Limestone
- Gravelly CLAY (Boulder Clay) to >15m
- LIMESTONE (Land Survey)
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CLIENT:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_R8
SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

ERT PROFILE R9

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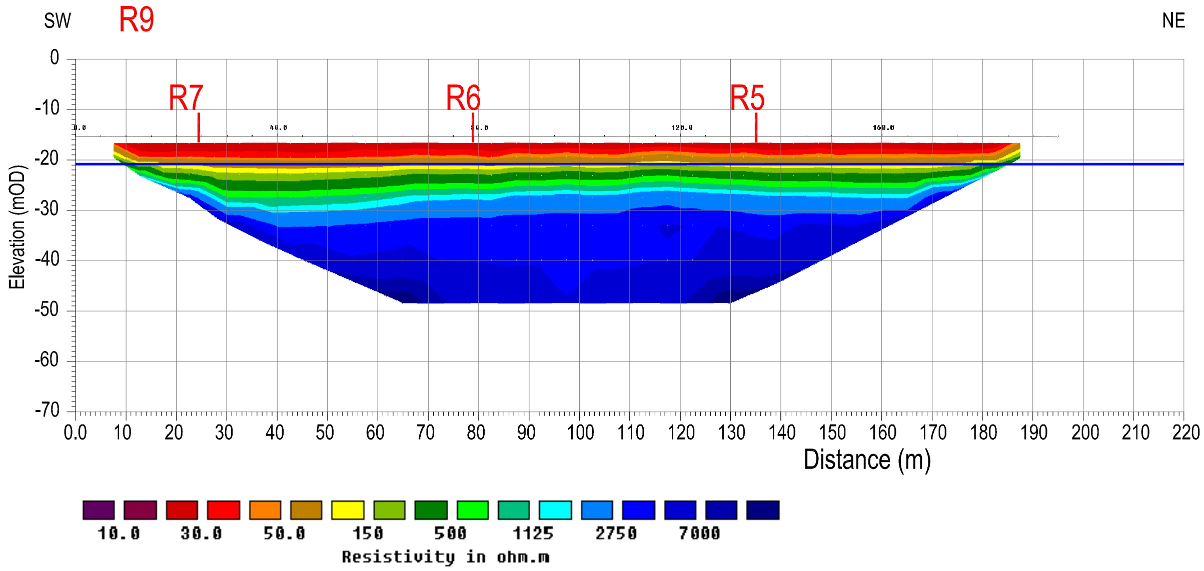

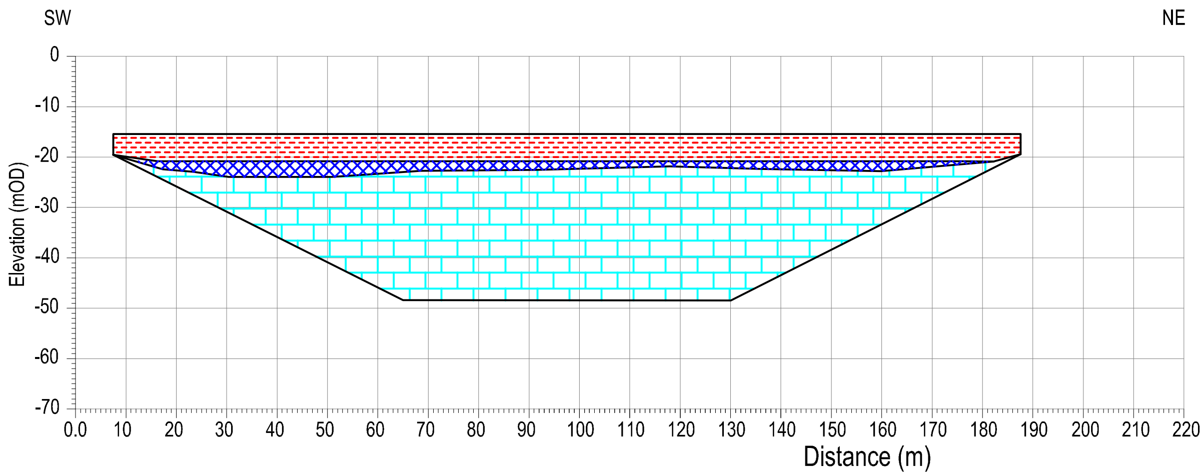

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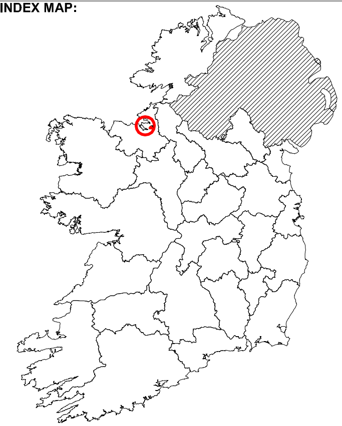

LEGEND:

- Clayey SAND/GRAVEL
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- possible shaley Limestone
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- LIMESTONE (Over water survey)
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CLIENT.:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_R9
SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

ERT PROFILE R10

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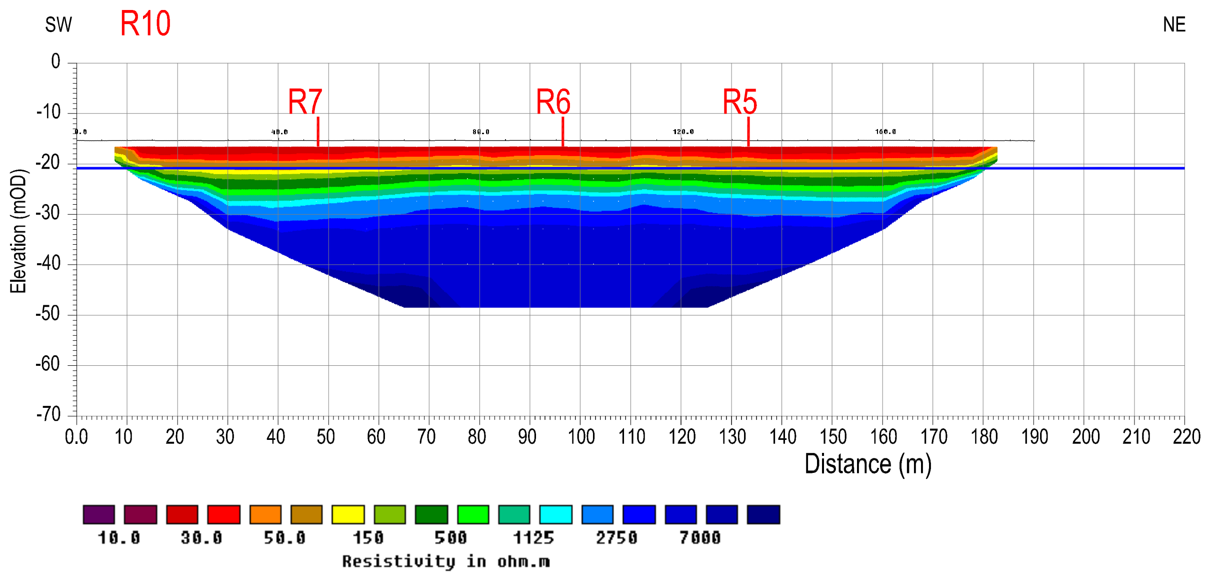

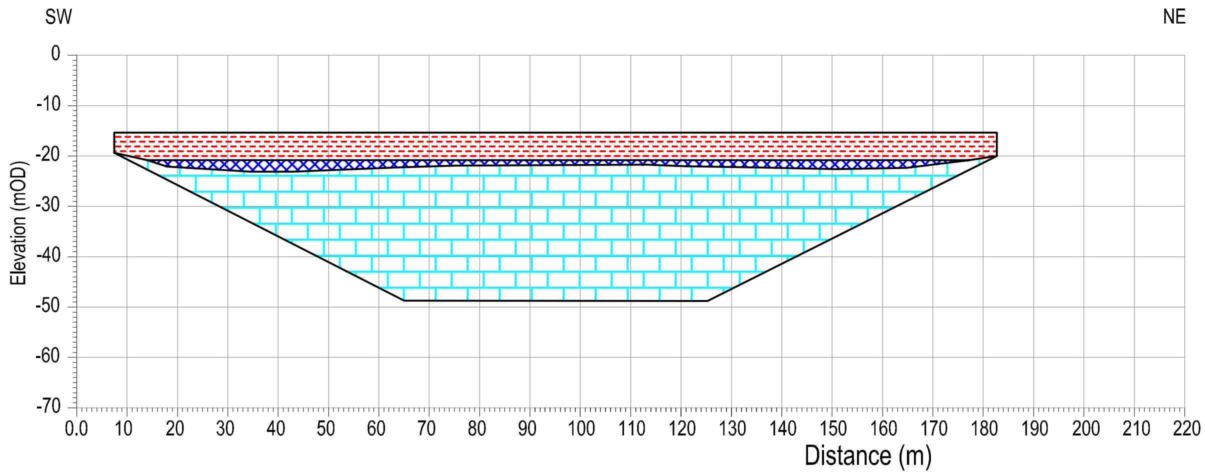

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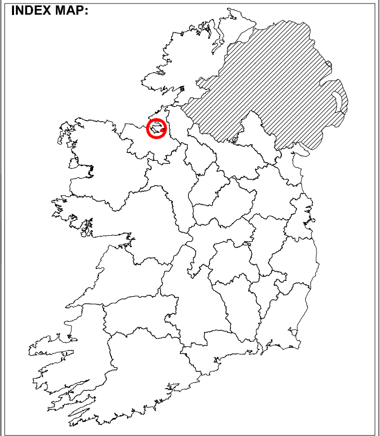

LEGEND:

- Clayey SAND/GRAVEL
- Weathered Rock
- possible shaley Limestone
- Gravelly CLAY (Boulder Clay) to >15m
- LIMESTONE (Land Survey)
- LIMESTONE (Over water survey)
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- OPEN JOINTS
- SEISMIC LAYER, VELOCITY
- WATER LEVEL IN QUARRY (at time of survey)

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CLIENT.:	LAGAN ASPHALT LTD
DRAWING NO:	AGP21007_R10
SCALE:	AS INDICATED @ A4
DATE:	05-02-2021

Version:	Date:	Drawn By:	Checked:
No	05-02-2021	POC	TL

APPENDIX D: ERT PROFILES FROM 2017 SURVEY

FIGURE 1: ERT & Seismic Profile Data

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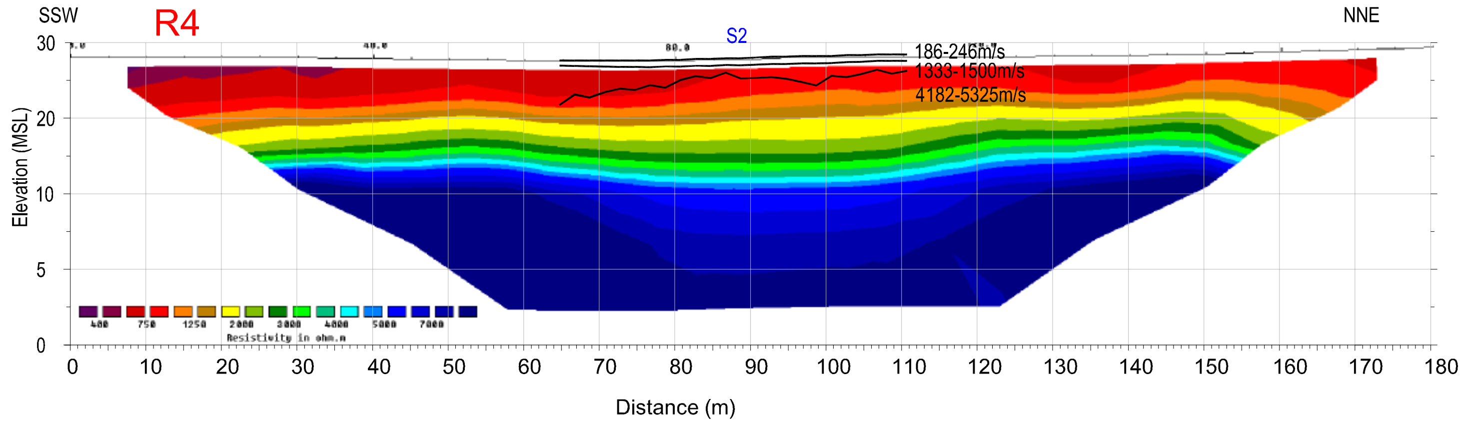

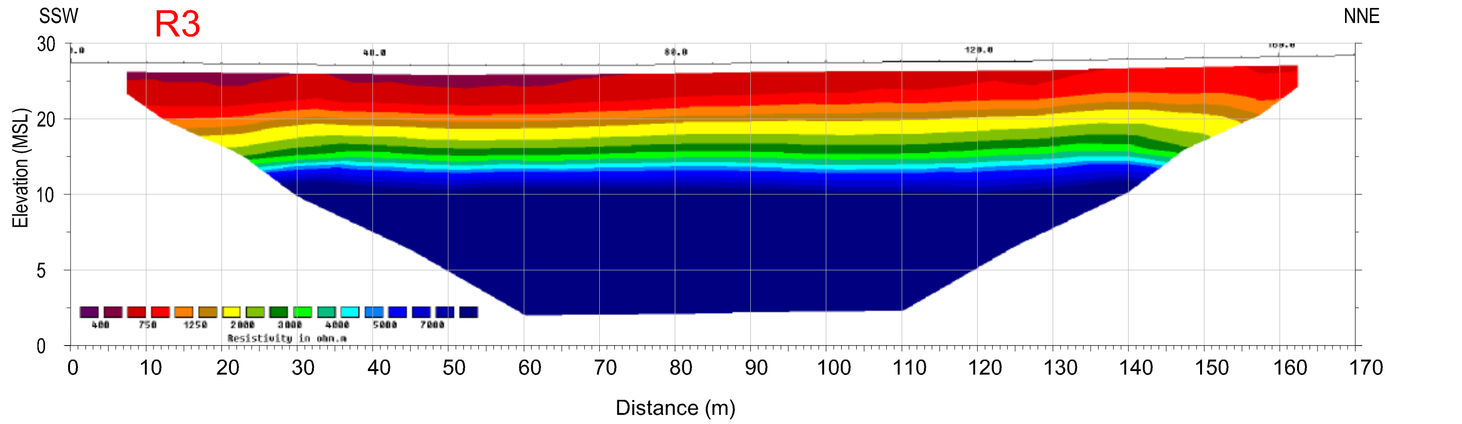

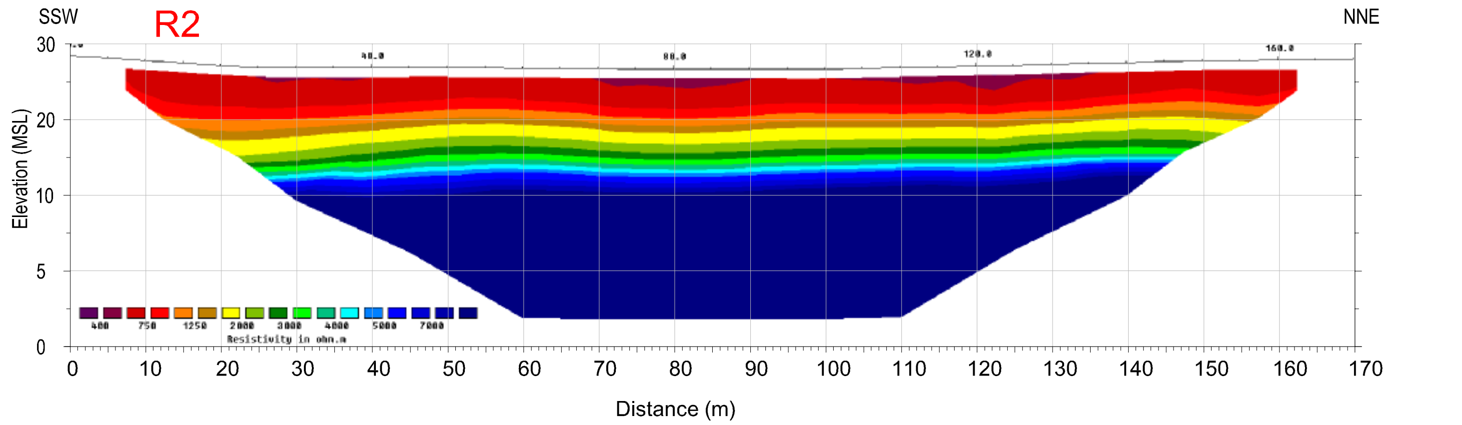

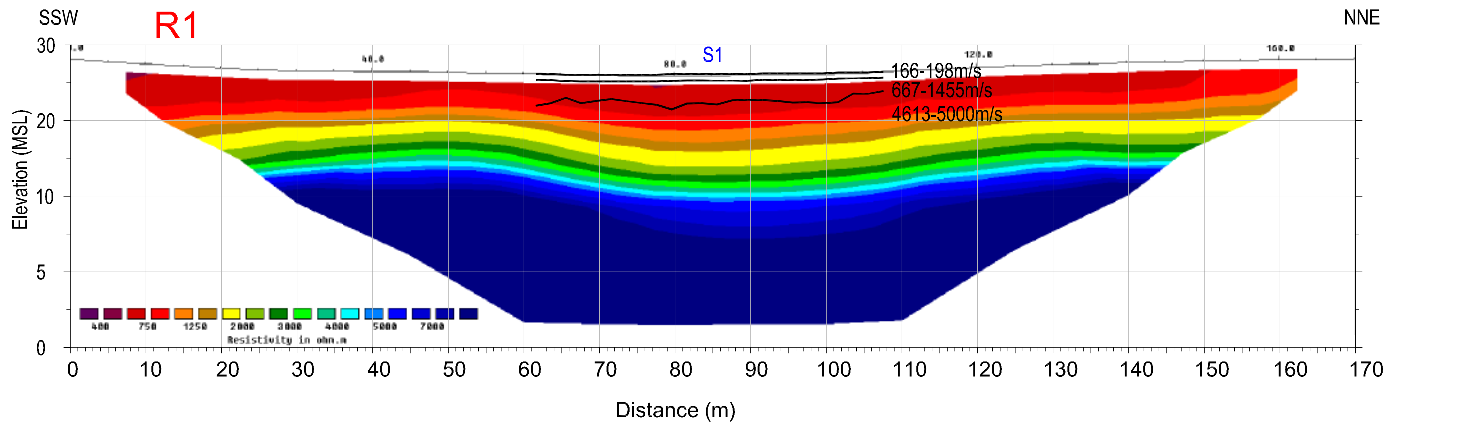

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www.apexgeoservices.co.uk

INDEX MAP:

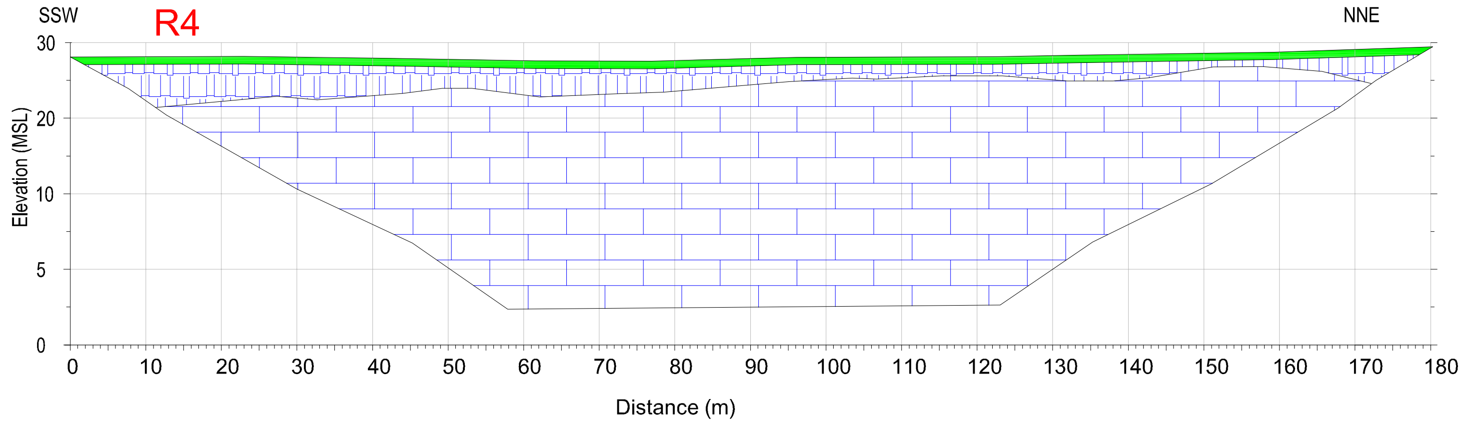
LEGEND:

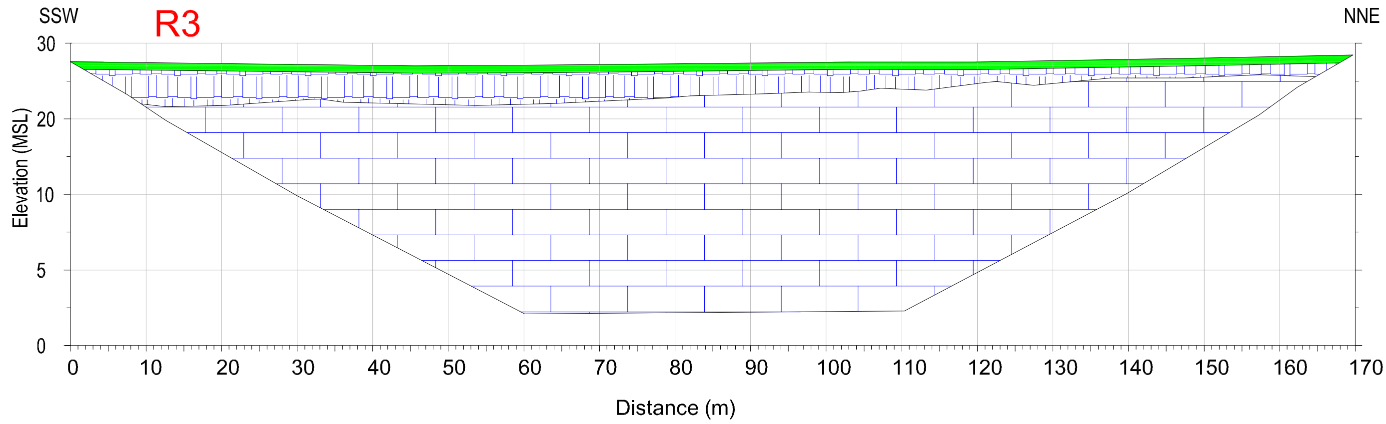
- Seismic refraction layer with interpreted P-wave velocity (1254-1288 m/s)
- Overburden
- Weathered LIMESTONE
- LIMESTONE
- PBH1 Proposed borehole
- PTP1 Proposed trial pit

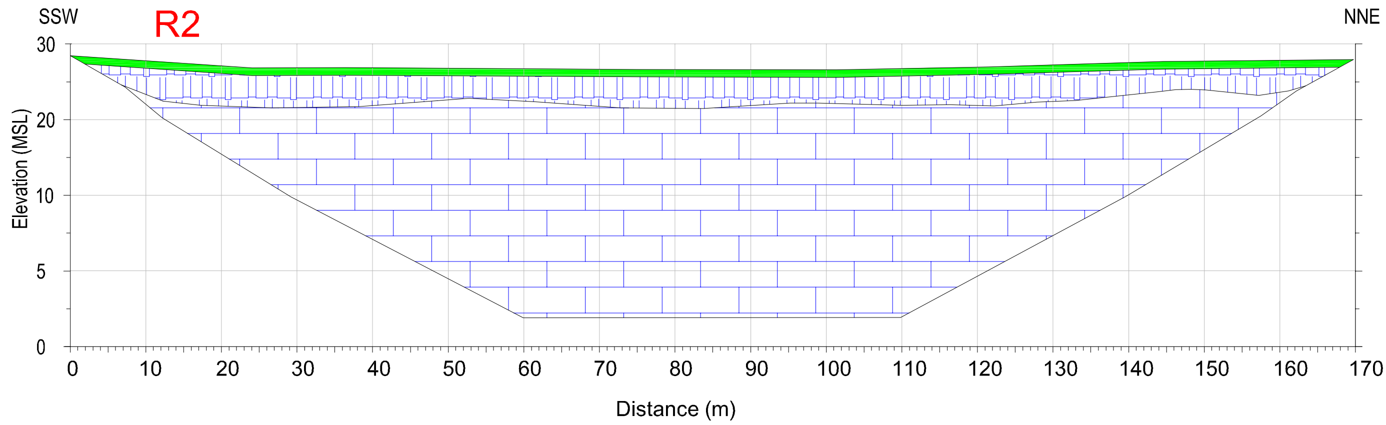
PROJECT:	SLIGO QUARRY GEOPHYSICAL SURVEY		
CLIENT.:	LAGAN ASPHALT		
DRAWING NO:	AGL17164_03		
SCALE:	AS INDICATED @ A1		
DATE:	12-10-2017		
Version:	Date:	Drawn By:	Checked:
01	12-10-2017	YOC	POC

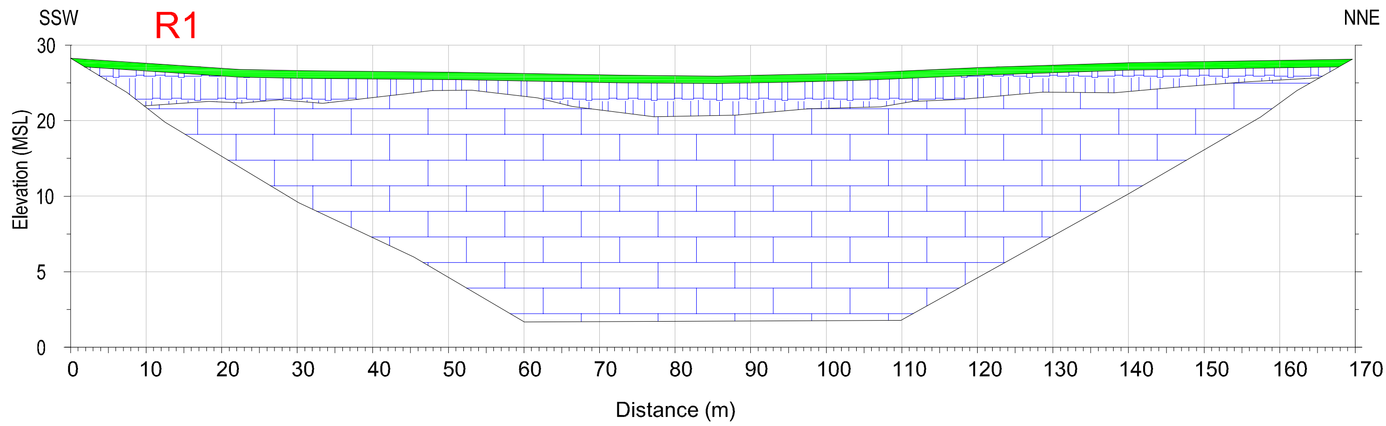
FIGURE 1: ERT & Seismic Profile Geological Interpretation

SCALE 1:1000









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INDEX MAP:

LEGEND:

- 1254-1288 m/s — Seismic refraction layer with interpreted P-wave velocity
- Overburden
- Weathered LIMESTONE
- LIMESTONE
- PBH1 — Proposed borehole
- PTP1 — Proposed trial pit

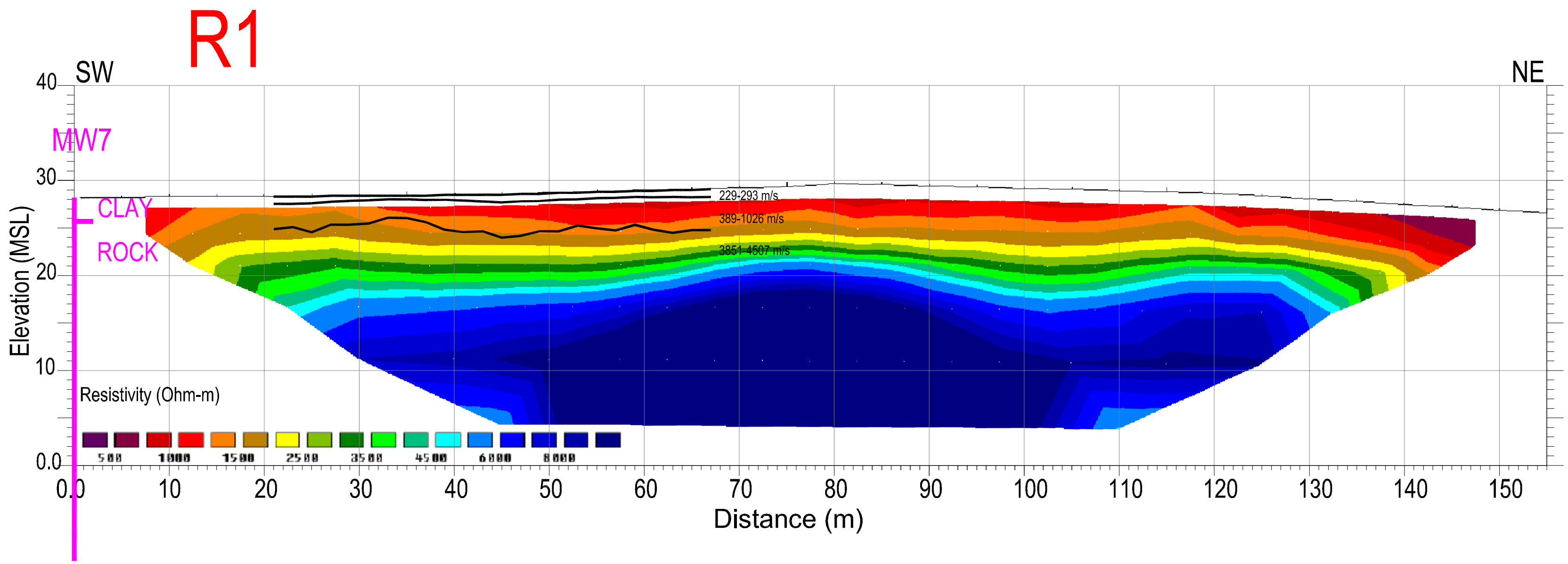
PROJECT:	SLIGO QUARRY GEOPHYSICAL SURVEY
CLIENT.:	LAGAN ASPHALT
DRAWING NO:	AGL17164_04
SCALE:	AS INDICATED @ A1
DATE:	12-10-2017

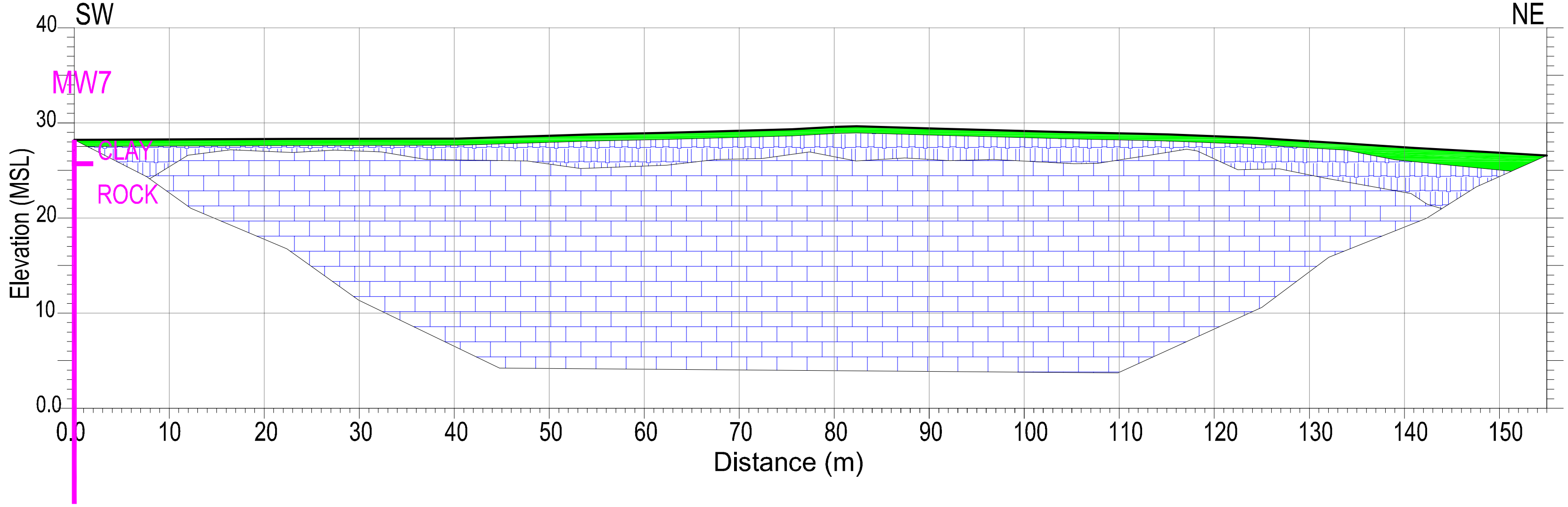
Version:	Date:	Drawn By:	Checked:
01	12-10-2017	YOC	POC

APPENDIX E: ERT PROFILES FROM 2019 SURVEY

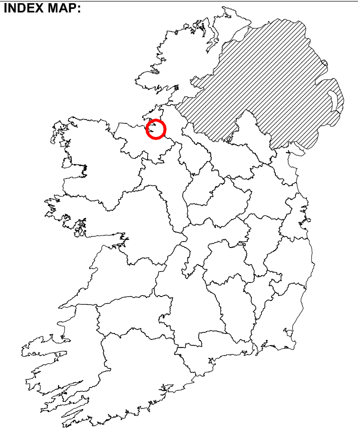
FIGURE 1: RESULTS & INTERPRETATION - ERT R1 & S1

SCALE 1:750





INDEX MAP:



LEGEND:

1254-1288 m/s — Seismic refraction layer with interpreted P-wave velocity

Overburden

Weathered LIMESTONE

LIMESTONE

PBH1 — Proposed borehole

The information displayed here is to be used in conjunction with Report AGP19223_01 Report on the Geophysical Investigation at Carnamaddoo, Co. Sligo for Lagan Group, APEX Geophysics Ltd. November 2019

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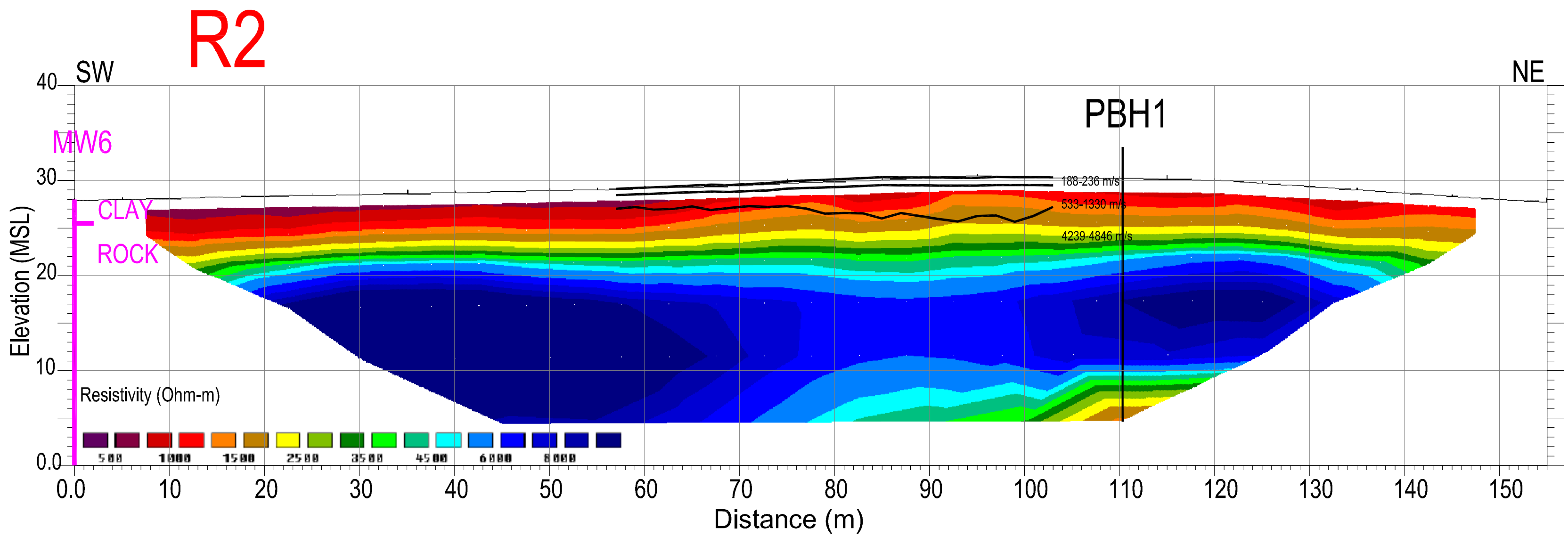
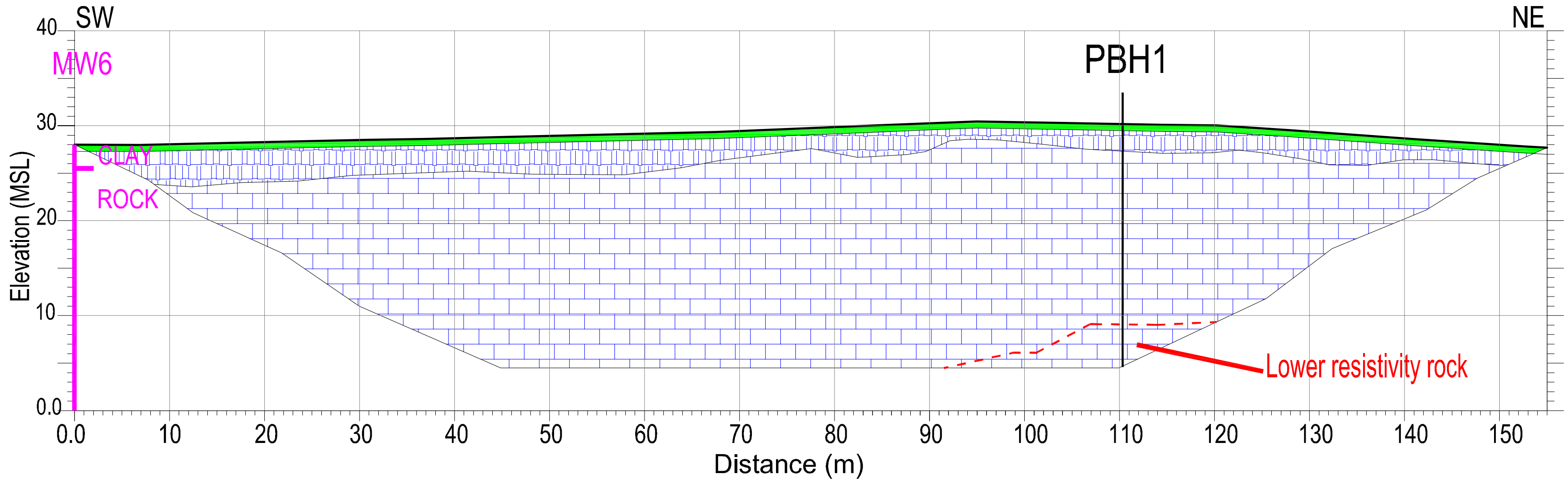
PROJECT:	CARNAMADDOO QUARRY GEOPHYSICAL SURVEY
CLIENT.:	LAGAN GROUP
DRAWING NO:	AGP19223_R1
SCALE:	AS INDICATED @ A4
DATE:	20-11-2019

Version:	Date:	Drawn By:	Checked:
01	20-11-2019	YOC	POC

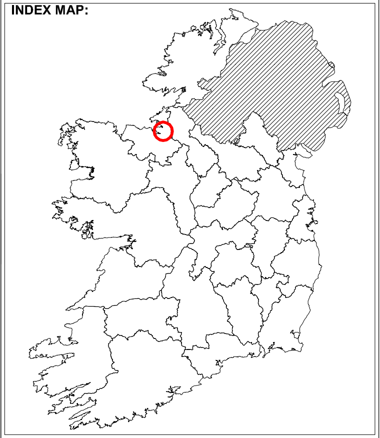
FIGURE 1: RESULTS & INTERPRETATION - ERT R2 & S2

SCALE 1:750





INDEX MAP:



LEGEND:

1254-1288 m/s — Seismic refraction layer with interpreted P-wave velocity

Overburden

Weathered LIMESTONE

LIMESTONE

PBH1 — Proposed borehole

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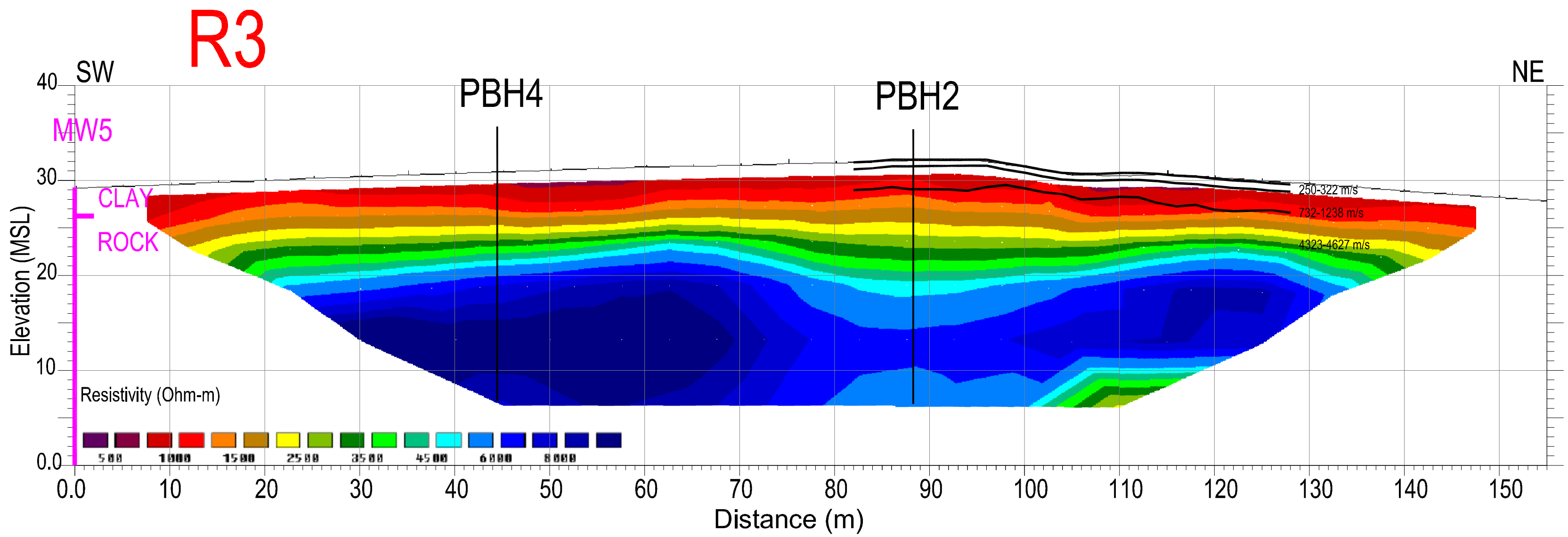
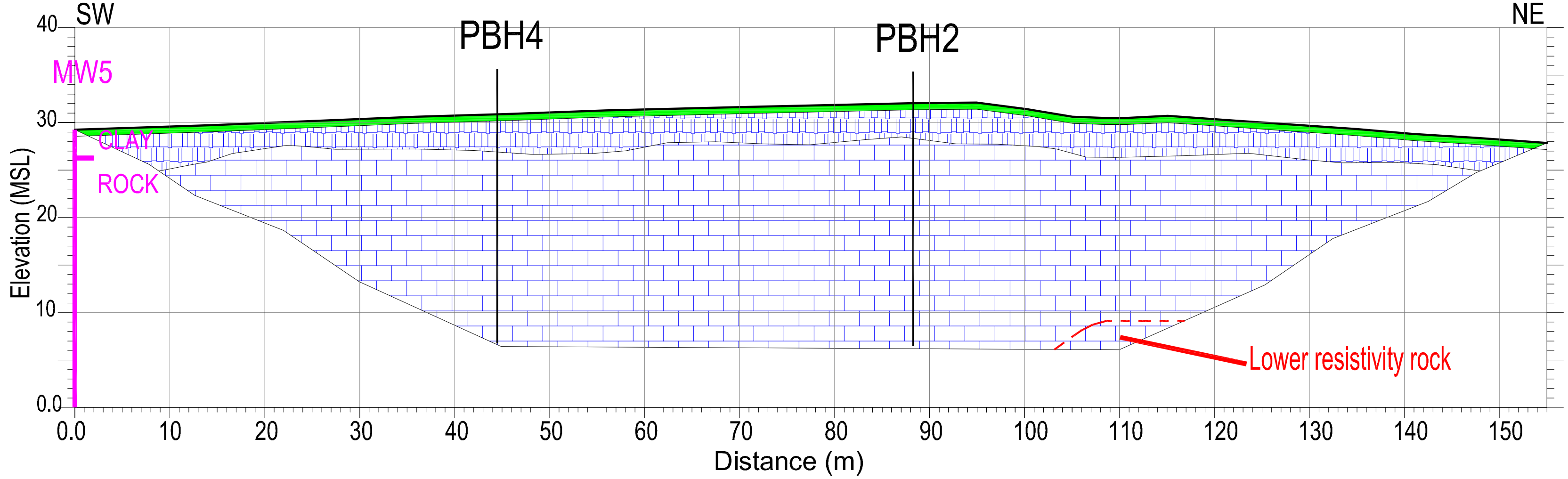
PROJECT:	CARNAMADDOO QUARRY GEOPHYSICAL SURVEY
CLIENT.:	LAGAN GROUP
DRAWING NO:	AGP19223_R2
SCALE:	AS INDICATED @ A4
DATE:	20-11-2019

Version:	Date:	Drawn By:	Checked:
01	20-11-2019	YOC	POC

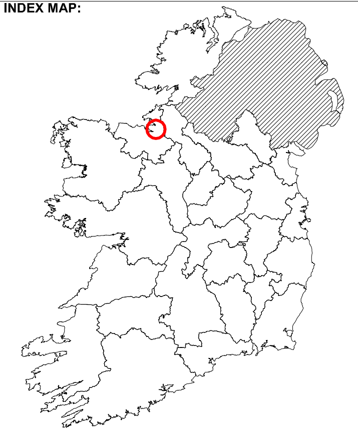
FIGURE 1: RESULTS & INTERPRETATION - ERT R3 & S3

SCALE 1:750





INDEX MAP:



LEGEND:

Seismic refraction layer with interpreted P-wave velocity (1254-1288 m/s)

Overburden

Weathered LIMESTONE

LIMESTONE

PBH1 Proposed borehole

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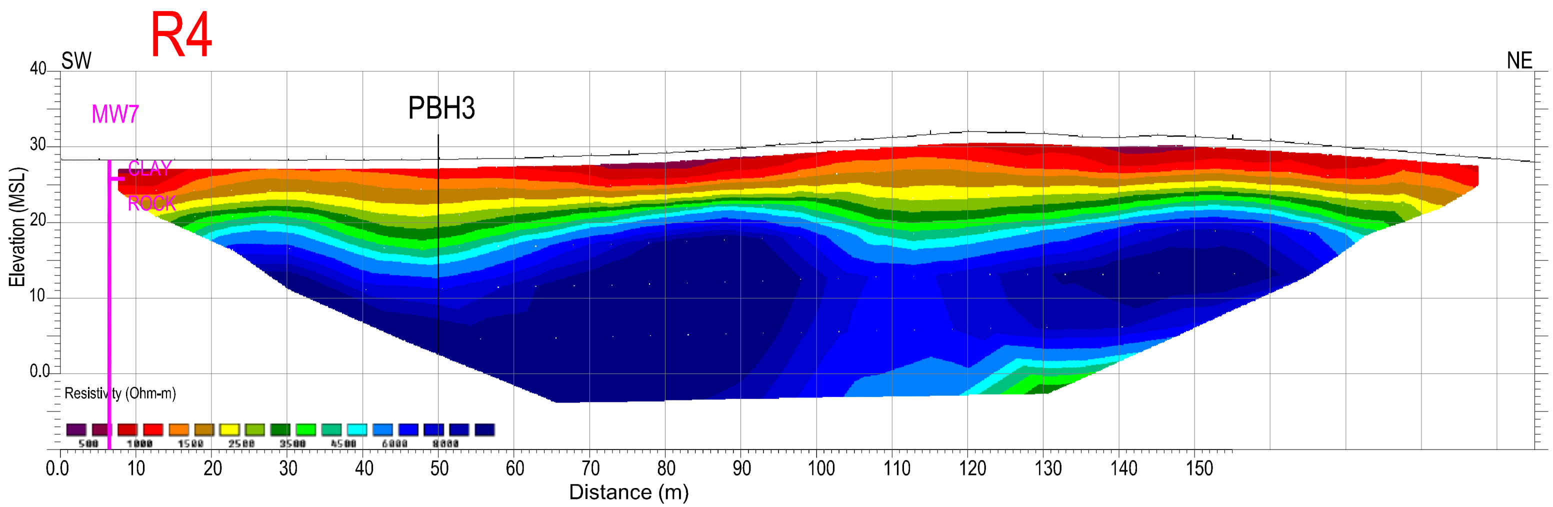
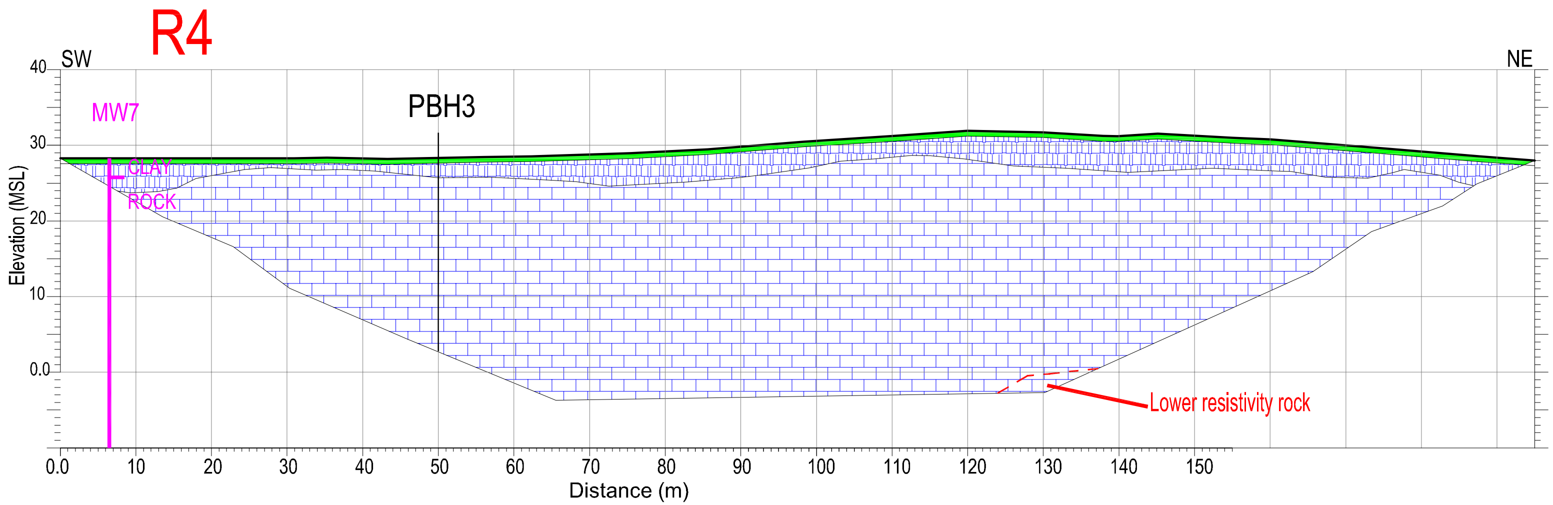
PROJECT:	CARNAMADDOO QUARRY GEOPHYSICAL SURVEY
CLIENT.:	LAGAN GROUP
DRAWING NO:	AGP19223_R3
SCALE:	AS INDICATED @ A4
DATE:	20-11-2019

Version:	Date:	Drawn By:	Checked:
01	20-11-2019	YOC	POC

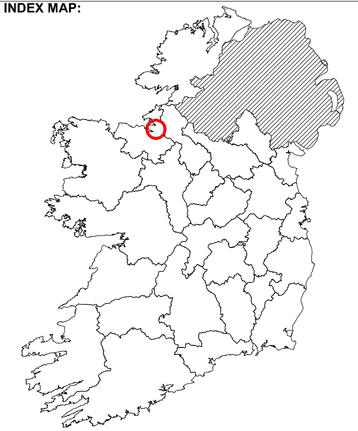
FIGURE 1: RESULTS & INTERPRETATION - ERT R4

SCALE 1:1000





INDEX MAP:



LEGEND:

- 1254-1288 m/s — Seismic refraction layer with interpreted P-wave velocity
- Overburden
- Weathered LIMESTONE
- LIMESTONE
- PBH1 — Proposed borehole

The information displayed here is to be used in conjunction with Report AGP19223_01 Report on the Geophysical Investigation at Carnamaddoo, Co. Sligo for Lagan Group, APEX Geophysics Ltd. November 2019

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PROJECT:	CARNAMADDOO QUARRY GEOPHYSICAL SURVEY
CLIENT.:	LAGAN GROUP
DRAWING NO:	AGP19223_R4
SCALE:	AS INDICATED @ A4
DATE:	20-11-2019

Version:	Date:	Drawn By:	Checked:
01	20-11-2019	YOC	POC