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Mill Bay Homes Ltd

Supplementary Geotechnical Investigation

Cleggars Park
Lamphey
Pembrokeshire
SA71 5JY

Report No: 22.09.023a
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For and on behalf of ListersGeo, trading name of Listers Geotechnical Consultants Ltd

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SUPPLEMENTARY GEOTECHNICAL INVESTIGATION REPORT

INTRODUCTION

A Supplementary Geotechnical Investigation has been undertaken for a proposed residential development at Cleggars Park, Lamphey, Pembrokeshire, SA71 5JY. A Site Location Plan is provided in Appendix A. The Ordnance Survey National Grid reference for the approximate centre of the site is 201517, 199963.

Instructions to undertake the investigation were received from the client's structural engineer, Roger Casey Associates Ltd, in their email dated the 18th January 2023.

This report describes the work carried out by ListersGeo, the ground conditions encountered and discusses their implications with regard to the proposed development.

This report supplements a previous Ground Investigation Report prepared by ListersGeo, reference 22.09.023 and dated December 2022. This current report should be read in conjunction with the previous report for full details of the investigations undertaken at the site.

This report has been prepared for the sole use of the client and their professional advisors. This report shall not be relied upon by third parties without the express written authority of ListersGeo. If an unauthorised third-party comes into possession of this report, they must not rely on it and the authors owe them no duty of care and skill.

SCOPE OF THE INVESTIGATION

The previous Ground Investigation, reference 22.09.023 and dated December 2022, identified dissolution features in the underlying natural strata as a potential risk to the site. The scope of these supplementary works was to undertake a two phased investigation, involving geophysics followed by targeted boreholes, to allow a more detailed assessment of the risks posed by dissolution features at the site.

PROPOSALS

It is proposed to redevelop the site to accommodate a residential development of two storey houses and apartments, with an access road, driveways and gardens.

SITE INFORMATION AND WALKOVER SURVEY

As part of the previous Ground Investigation, reference 22.09.023 and dated December 2022, a walkover survey of the site and its immediate surrounds was undertaken. This revealed the following.

The site lies on the southern outskirts of Lamphey village in a predominantly agricultural area. It consists of two grassed fields that form an irregular shaped parcel of land and has overall dimensions of approximately 210m by 120m.

The site lies at the foot of a shallow north facing valley slope but is generally flat lying. However, there was a roughly circular depression in the ground surface in the central western area of the site and part of another depression straddling the eastern boundary and continuing into the neighbouring field. The channel is located in the eastern area of the southern field and is aligned roughly south to north, it slopes gently downwards to the north.

The site was bordered by:

Direction	Feature
North	Houses and gardens
East	A grass field
South	A grass field
West	Houses and gardens

There were trees and hedgerows along each of the site's boundaries.

At the time of the walkover there was no surface water on the site. However, it is our understanding that during wet weather water flows into the depression just beyond the eastern boundary and this area is prone to flooding during prolonged wet periods.

As part of this latest investigation an updated walkover was carried out on the 6th February 2023. No significant changes had occurred between the two dates.

PREVIOUS WORK

As noted above, a previous Ground Investigation was carried out at the site by ListersGeo, reference 22.09.023 and dated December 2022. The salient points relevant to this report are included here, but the full report should be referred to for more detail.

The published geology for the site shows bedrock of the Carboniferous age Black Rock Subgroup and Gully Oolite Formation across most of the site, with the northern area underlain by bedrock of the overlying Pembroke Limestone, which is also of Carboniferous age. Both the Black Rock Subgroup and Gully Oolite Formation and the Pembroke Limestone are described as mainly limestone, but with some interbeds of mainly mudstone. The area is known to be faulted, with the closest known fault just beyond the southwestern corner of the site.

The Envirocheck Report gave a 'High' Hazard Potential Rating for ground dissolution under the site and a site-specific Natural Cavities Database search commissioned from Stantec identified one known dissolution feature under the site. The location of this feature coincides with the surface depression noted in the central western area of the site.

The Initial Geotechnical Ground Model identified dissolution features as the most significant geotechnical risk for the site. Other geotechnical issues included the potential for variable strata, vegetation influence, should fine-grained soils with a volume change potential be present and surface flooding during wet periods.

Sixteen machine excavated trial pits, three continuous tube boreholes and two dynamic probe holes were formed across the site and on land just to the south between the 18th and 20th October 2022. The ground conditions encountered generally comprised Topsoil down to a typical depth of 0.3m over the Black Rock Subgroup and Gully Oolite Formation down to the base of the test locations at depths down to 6.0m. The Black Rock Subgroup and Gully Oolite Formation generally comprised firm medium strength brown slightly sandy clay, which contained some gravel and cobble sized siltstone lithorelicts, interbedded with medium strong fractured grey limestone. The presence, depth and thickness of the limestone was variable across the site, however many of the trial pits were terminated at 1.9m to 2.9m depth in rock quality limestone.

No groundwater strikes or seepages were encountered during the fieldworks, down to 6.0m depth, and both of the standpipe monitoring wells were recorded to be dry down to their bases at 3.0m depth at the subsequent monitoring visit.

Infiltration testing was carried out in the Black Rock Subgroup and Gully Oolite Formation strata at seven locations, at depths between 0.7m and 2.3m. The results of the testing indicate the shallower clay soils, down to 0.7m depth, have an infiltration rate of approximately 1.0 x 10^{-6}m/s, the deeper clay soils, down to approximately 2.2m depth, have an infiltration rate of approximately 6.5 x 10^{-7}m/s and the limestone has an infiltration rate between 1.1 x 10^{-6}m/s and 5.1 x 10^{-4}m/s. The variation in results from the limestone was considered likely to be related to the thickness of the limestone bed and the nature of its fracturing.

For areas of the site not affected by dissolution features, the Black Rock Subgroup and Gully Oolite Formation strata was considered to be suitable for convention shallow foundations at 1.0m depth. At this depth an allowable bearing pressure of 100kPa was considered suitable. However, to take account of the potential risks posed by dissolution features, it was recommended, unless further investigations to allow a more detailed assessment were carried out, all foundations should be reinforced and of ‘cruciform’ in nature. The potential for exclusions zones was also discussed. In addition, floor slabs should be suspended, and road design should include measures to mitigate the risk of dissolution features.

No further evidence of dissolution features was encountered during the intrusive works, however further investigation were recommended to allow a more detailed assessment of the risks and prior to finalisation of design for the substructures. These further works were recommended to take place over two phases, with the first phase comprising geophysics and the second phase targeted boreholes.

The objective of this latest investigation is to carry out the recommended supplementary works and subsequent more detailed assessment of the risks posed by dissolution features under the site.

EXPLORATION AND TESTING

The fieldworks were carried out over two phases, with the first phase comprising geophysical survey works over five days between the 6th and 10th February 2023, and the second phase comprising sonic boreholes over five days between the 1st March and 5th March 2023.

Phase 1

In view of the anticipated geology and the depth of information required, the Electrical Resistivity Imaging survey was designed to record continuous ground properties from ground level up to a maximum depth of 30m below ground level. This was dependant on the length of profile line available on the site. A total of fourteen electrical resistivity lines were formed across the site.

The survey area was set out to record electrical resistivity data measurements over lines of 160m length, with electrodes at 5.0m centres, when aligned west to east and 120m, with electrodes at 3.75m centres, when aligned north to south. A specialised computer system controlled each survey line measurement, mainly using varying sets of four electrodes in a Wenner system.

Phase 2

Taking account of the variable ground conditions and presence of hard rock, sonic boreholes were utilised to achieve deeper boreholes than would be possible using a standard cable percussive rig.

One of the boreholes, BH101, was targeted above the depression in the central area of the site, with the rest of the boreholes spread across the site to ensure wide coverage with which to allow a more detailed interpretation of the ERT data.

The positions and orientations of the geophysics survey lines and sonic boreholes formed during this latest investigation can be seen on the Exploratory Hole Location Plans in Appendix A.

Coordinates for exploratory positions have been extracted from freely available georeferenced on-line information and should be treated with an appropriate level of accuracy in the order of ±5m.

Engineering conclusions given in this report are based on data obtained from these sources, but it should be noted that variations, which affect these conclusions, may inevitably occur between and beyond the test locations. Also, water levels may vary seasonally and with other factors.

METHODOLOGY

Health and Safety

To minimise the dangers from/to buried services, prior to commencement of boring the proposed locations were scanned using a Cable Avoidance Tool. At the borehole locations, a service avoidance pit was dug, using hand tools, to a depth of around 1.2m below ground level (bgl). No buried services were encountered in the locations of the exploratory holes.

Electrical Resistivity Imaging

Measurements of the Electrical Resistivity variations of subsurface soils form a well-established geophysical technique for assessing the depth and thickness of strata, special variations in ground conditions and the geotechnical properties of ground materials.

Electrical Resistivity Imaging is a ground investigation technique that measures the electrical properties of soils and rocks within the target area at multiple discrete points both laterally and vertically along a linear alignment. A current is introduced into the ground sequentially through a series of metal electrodes which are inserted into the sub-soil. The current passing through the ground sets up a distribution of electrical potential within the soils and rocks along the survey alignment and the difference in electrical potential at each remaining electrode along the system length is measured and recorded. Using Ohm's law, the measured voltage at each receiving electrode is converted into a resistance for the ground between each electrode. A Wenner array formula was used for profiling this electric resistivity investigation.

These readings are then reconstructed in two-dimensions using specialist computer modelling software and complex mathematical algorithms to produce a pseudo-image of electrical contrast analogous to a vertical cross-section.

Limitations

It is important to note that the cross-section produced from the above surveys are not directly showing geological form but rather mapping relative changes and contrasts in ground impedance to current flow, electromagnetism and density. As such, specialist interpretation and engineering judgment is required to infer strata types, boundary positions and geological structures from the data and intrusive methods are recommended to provide further data to inform interpretation of the results.

Whilst the developments in modern Electrical Resistivity Imaging instruments have brought increased reliability and accuracy in measurement acquisition, the survey depth penetration is a direct function of the lateral survey array length and therefore overall imaging depth is typically restricted by usable site area.

Additionally, electrode spacing exerts a fundamental control on data resolution along the survey length and the purpose and needs of the investigation must be carefully assessed when selecting a site-specific survey methodology to yield optimum results. Multiple natural variables can affect the quality of data obtained including degree of saturation of the soils being tested, changes in salinity, void ratio and mineralogical variations as well as anthropogenic interference such as from existing structures and from ground loop-current induced into the soils by overhead high-voltage power lines.

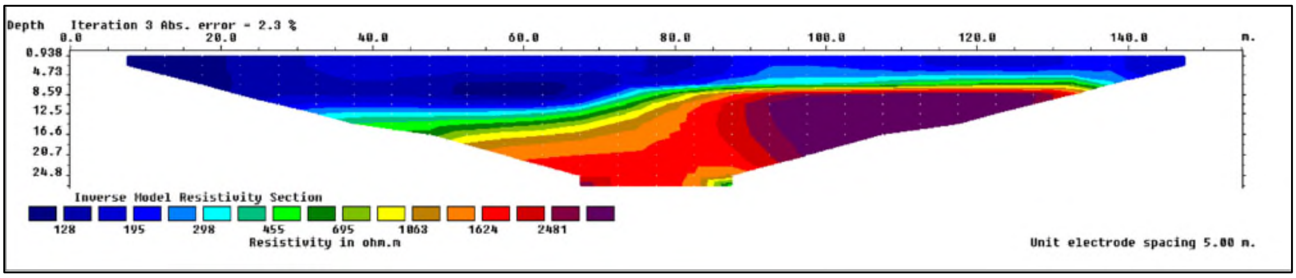
Exploratory Holes

Boreholes BH101 to BH105, were drilled utilising a sonic drilling rig, at a diameter of 100mm, down to depths ranging from 7.5m to 12.0m depth. The boreholes were advanced using a steel lined tube sampling system driven into the ground using sonic resonance techniques. A near continuous core sample was recovered for subsequent examination, sub-sampling and laboratory testing. Standard Penetration Tests (SPTs) were taken at 1.5m intervals.

GEOPHYSICAL RESULTS

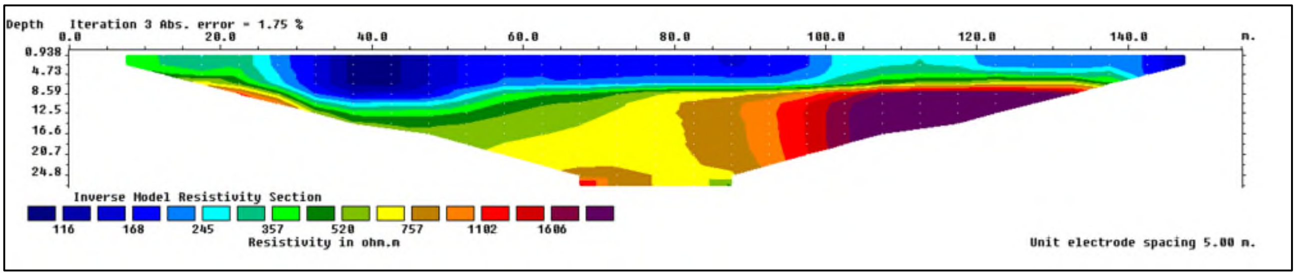
Line 1-1

Line 1-1 was orientated roughly west to east close to the southern boundary of the site. The results, shown below, record low resistivity results, below approximately 200ohm.m, down to depths between approximately 6.5m to 12.5m, over higher resistivity results, up to approximately 2,750ohm.m. The lower resistivity strata were encountered to greater depths across the western half of the site, with the highest resistivity results below approximately 8.5m depth across the eastern area.



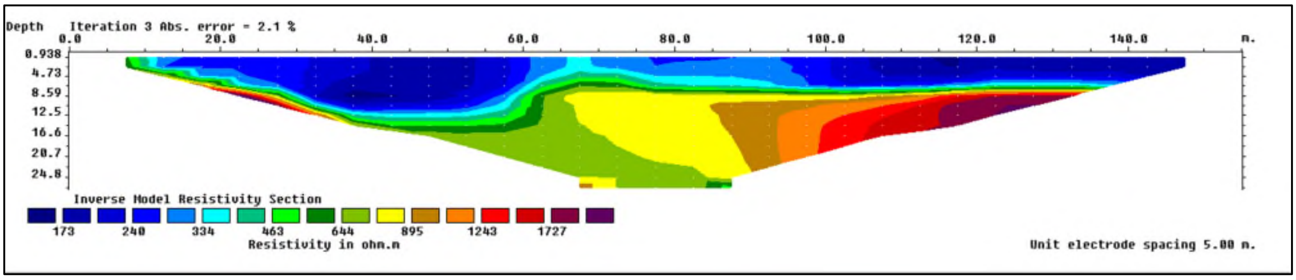
Line 2-2

Line 2 was orientated roughly west to east across the southern area of the site. It recorded lower resistivity results, below approximately 350ohm.m, down to approximately 7.0m to 10.0m, over higher resistivity results, up to approximately 1,900ohm.m. The lower resistivity strata were encountered to greater depths across the western half of the site, with the highest resistivity results below approximately 8.0m depth across the eastern area of the line.



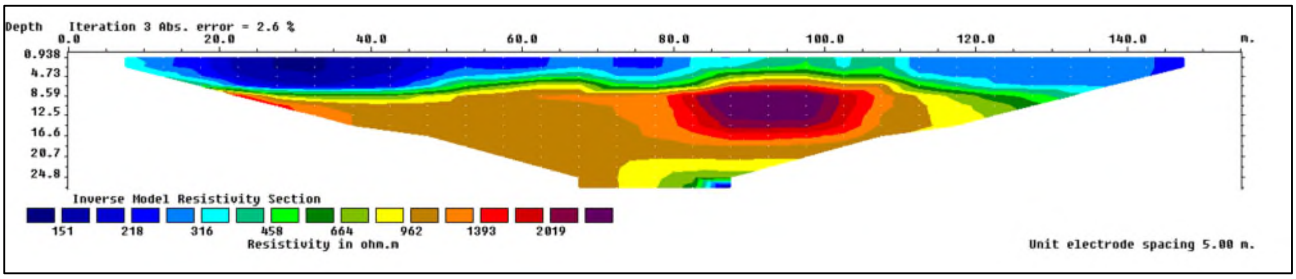
Line 3-3

Line 3 was orientated roughly west to east across the central area of the site and was located above the depression noted in the central area of the site previously. It recorded lower resistivity results, below approximately 350ohm.m, down to depths between approximately 7.0m and 12.0m. The lower resistivity strata were encountered to greater depths across the western half of the site, with the highest resistivity results below approximately 8.0m depth across the eastern area of the line.



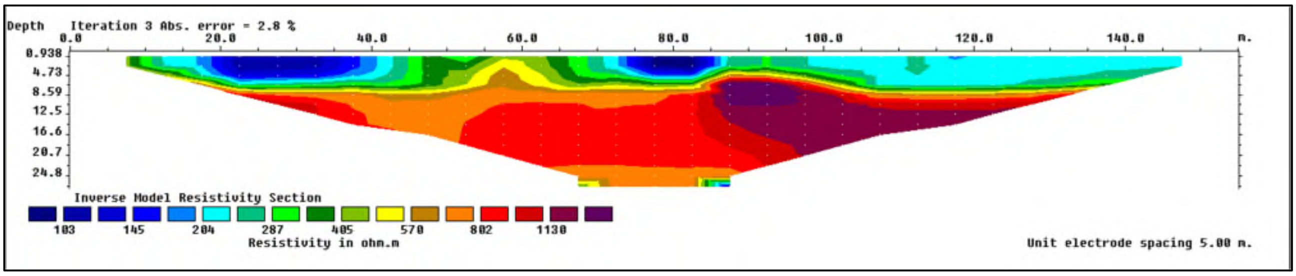
Line 4-4

Line 4-4 was orientated roughly west to east across the northern half of the site. It records lower resistivity results, below approximately 450ohm.m, down to depths ranging from approximately 4.5m to 9.0m, above higher resistivity results, up to approximately 2,300ohm.m. The lower resistivity strata were encountered to greater depths across the western and eastern areas of the line, with the highest resistivity results below approximately 8.0m depth across the central eastern area of the line.



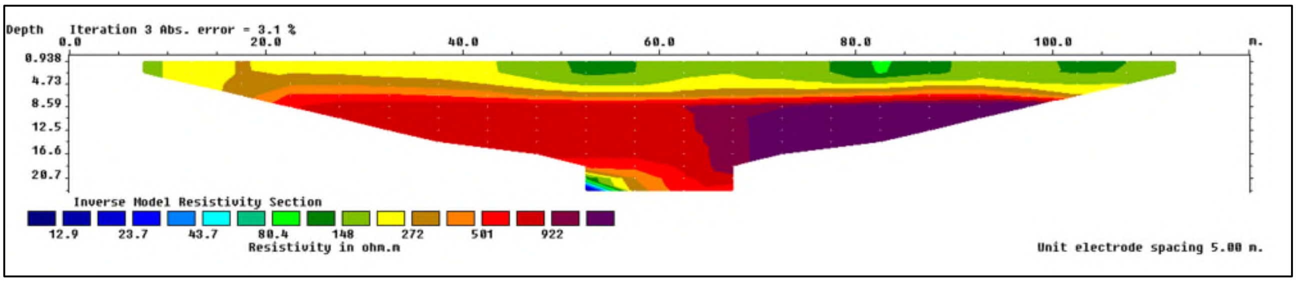
Line 5-5

Line 5-5 was orientated roughly west to east close to the northern boundary of the site. It recorded lower resistivity results, below approximately 400ohm.m, down to approximately 7.5m depth, above higher resistivity results, up to approximately 1,400ohm.m. The highest resistivity results were recorded below approximately 5.0m depth across the eastern area of the line.



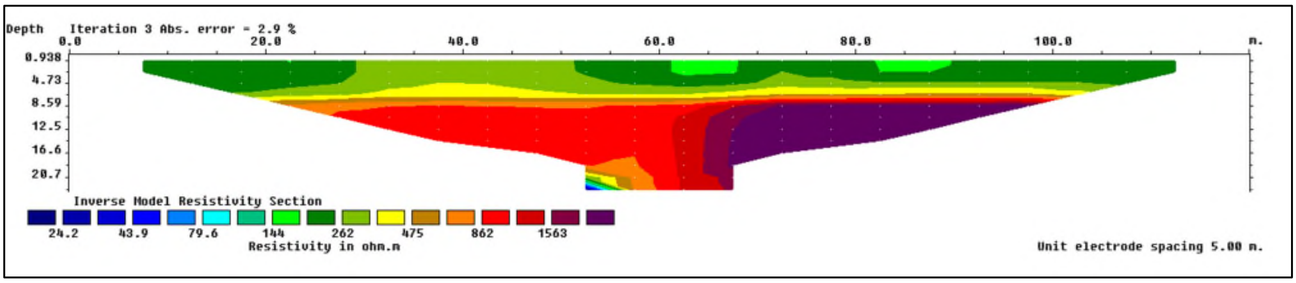
Line 6-6

Line 6-6 was orientated roughly north to south close to the western boundary of the site. It records lower resistivity results, below approximately 300ohm.m, down to approximately 6.5m, above higher resistivity results, up to approximately 1,300ohm.m. The highest resistivity results were below approximately 7.0m depth across the southern area of the line.



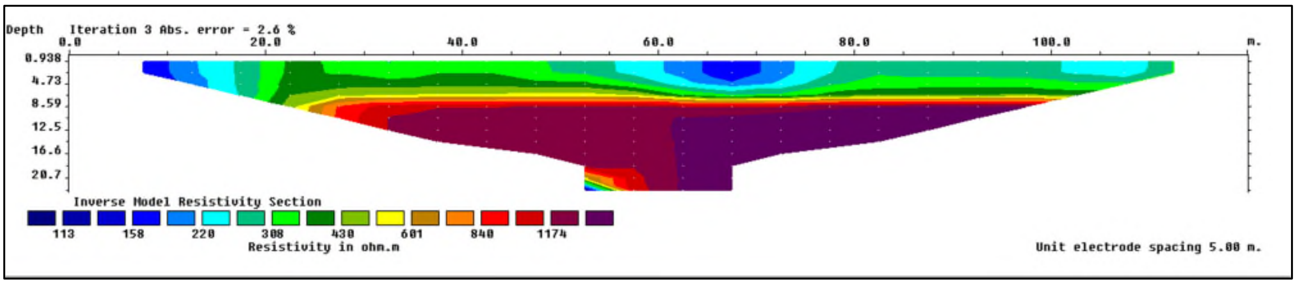
Line 7-7

Line 7-7 was orientated roughly north to south across the eastern area of the site. It recorded lower resistivity results, below approximately 300ohm.m, down to approximately 6.0m depth, above higher resistivity results, up to approximately 2,000ohm.m. The highest resistivity results were recorded across the southern area of the line.



Line 8-8

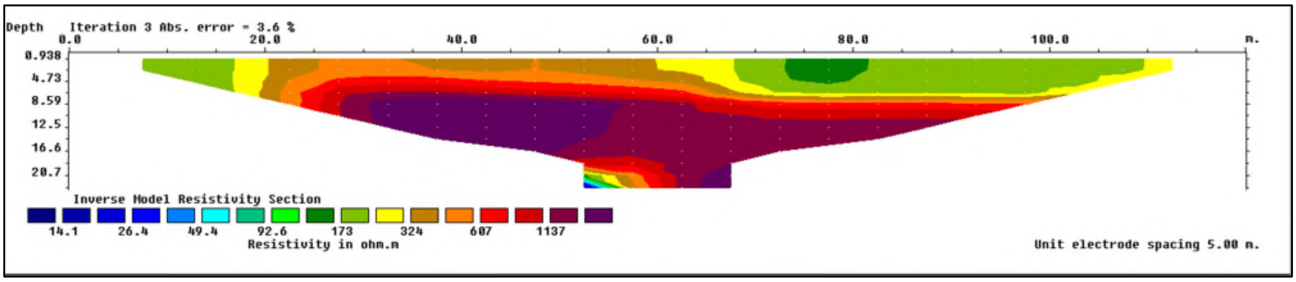
Line 8-8 was orientated roughly north to south across the central western area of the site. It recorded lower resistivity results, below approximately 430ohm.m, down to approximately 6.0m depth, above higher resistivity results, up to approximately 1,5000ohm.m. The highest resistivity results were recorded across the southern area of the line.



Line 9-9

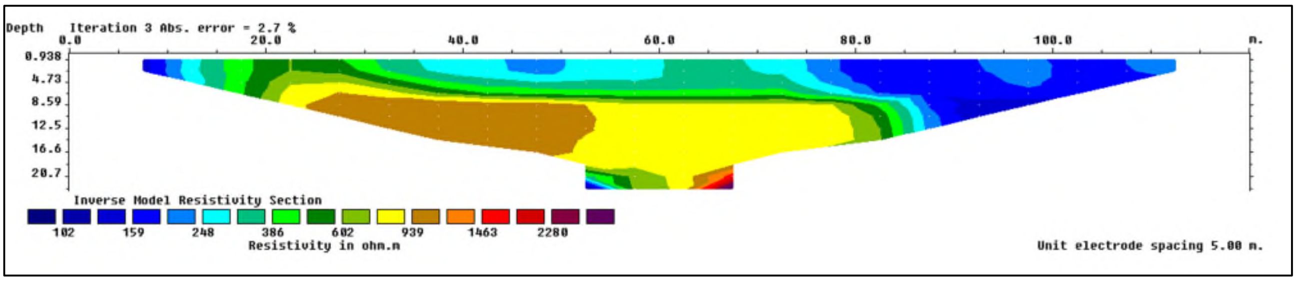
Line 9-9 was orientated roughly north to south across the central area of the site and was located above the depression in the central area of the site. It recorded lower resistivity results, below approximately

450ohm.m, down to depths ranging from approximately 2.5m to 7.0m, above higher resistivity results, up to approximately 1,500ohm.m. The lower resistivity strata were encountered to greater depths across the southern area of the line, with the highest resistivity results below approximately 7.0m depth across the central northern area of the line.



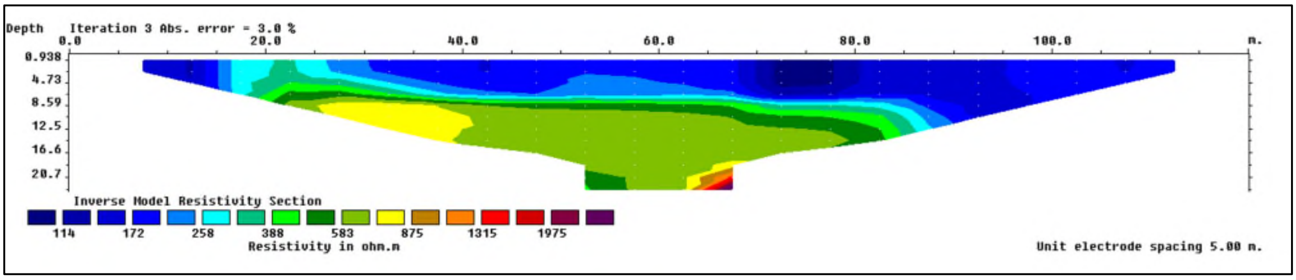
Line 10-10

Line 10-10 was orientated roughly north to south across the central area of the site. It recorded lower resistivity results, below approximately 450ohm.m, down to approximately 7.0m across most of the line, but down to below 10.0m depth in the southern area of the line, above higher resistivity results, up to approximately 1,200ohm.m. As noted above, the lower resistivity strata were encountered to greater depths across the southern area of the line, with the highest resistivity results below approximately 7.0m depth across the central northern area of the line.



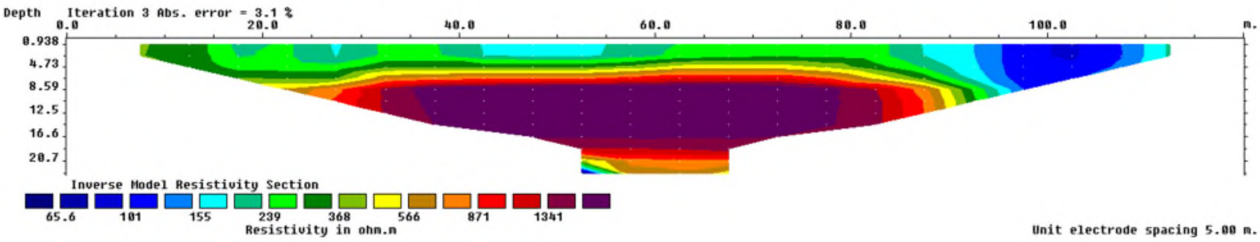
Line 11-11

Line 11-11 was orientated roughly north to south across the central area of the site. It recorded lower resistivity results, below approximately 400ohm.m, down to approximately 6.0m across most of the line, but down to below 10.0m depth in the southern area of the line, above higher resistivity results, up to approximately 900ohm.m. As noted above, the lower resistivity strata were encountered to greater depths across the southern area of the line, with the highest resistivity results below approximately 7.0m depth in the northern area of the line.



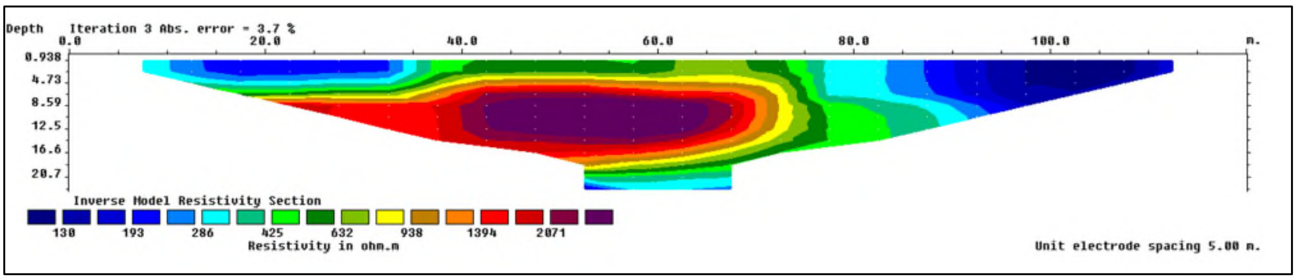
Line 12-12

Line 12-12 was orientated roughly north to south across the central eastern area of the site. It recorded lower resistivity results, below approximately 370ohm.m, down to approximately 5.0m across most of the line, but down to below 9.0m depth in the southern area of the line, above higher resistivity results, up to approximately 1,850ohm.m. As noted above, the lower resistivity strata were encountered to greater depths across the southern area of the line, with the highest resistivity results below approximately 7.0m depth across the central area of the line.



Line 13-13

Line 13-13 was orientated roughly north to south across the eastern half of the site. It recorded lower resistivity results, below approximately 425ohm.m, down to approximately 5.0m across the northern area and below 10.0m across the southern area. Across the central area resistivity results between approximately 500ohm.m and 750ohm.m were recorded down to approximately 3.5m depth. Below approximately 5.0m and 3.5m across the northern and central areas respectively, higher resistivity results, up to approximately 2,500ohm.m were recorded, with the highest resistivity results below approximately 7.0m depth in the central area of the line.



Line 14-14

Line 14-14 was orientated roughly north to south close to the eastern boundary of the site. Unfortunately, the results for this line did not download correctly, and therefore there is no meaningful data for line 14-14.

ERT Summary

Drawings showing the results of the ERT at four separate depths (3.0m, 6.0m, 9.0m and 12.0m) are provided in Appendix A and discussed below.

<u>3.0m Depth</u>

The results were all below 500ohm.m, with the lowest results, <200ohm.m, being recorded across the southern half of the site and in the northwestern quadrant.

<u>6.0m Depth</u>

The results were mainly between 200ohm.m and 1,000ohm.m, except for a zone close to the southern boundary, which were <200ohm.m and an area in the central eastern area where results >1,000ohm.m were recorded.

<u>9.0m Depth</u>

Results below 200ohm.m were recorded in a thin zone close to the southern boundary, with results between 200ohm.m and 1,000ohm.m across approximately half of the rest of the site. An area across the centre of the site recorded results between 1,000 and 1,500ohm.m, with results above 1,500ohm.m recorded across the central eastern area.

<u>12.0m Depth</u>

Results between 1,000ohm.m and 1,500ohm.m were recorded across most of the site, with an area in the southeastern quadrant recording results generally between 200ohm.m and 500ohm.m, and an area in the centre east of the site recording results above 1,500ohm.m.

Summary

The low resistivity results, below approximately 500ohm.m, are considered likely to represent more weathered clay soils, with relatively high moisture contents. The higher resistivity results, approximately greater than 1,000ohm.m, are considered to represent less weathered siltstone and/or limestone, with the highest readings, approximately greater than 1,500ohm.m, representative of highly fractured rock.

No obvious evidence of dissolution features was recorded by the ERT, including below the depression in the central western area of the site. However, at each depth analysed the results varied quite widely, indicating the likely presence of underground structures, such as faulting. See the Geotechnical Conclusions section later in this report for our interpretation of the findings.

GROUND CONDITIONS

The intrusive works carried out as part of this latest investigation revealed Topsoil over bedrock of the Black Rock Subgroup and Gully Oolite Formation and further details of the relative disposition of each stratum are given below.

TOPSOIL

Topsoil was encountered at each location from ground level down to 0.3m depth. It generally comprised brown slightly sandy slightly organic clay.

BLACK ROCK SUBGROUP AND GULLY OOLITE FORMATION

Black Rock Subgroup and Gully Oolite Formation was encountered beneath the Topsoil down to the base of the boreholes at depths between 7.5m and 12.0m. It generally comprised firm brown slightly sandy clay, which locally contained gravel sized siltstone and/or limestone lithorelicts down to a typical depth of 1.5m. Below this it became less weathered and was generally recovered as medium strong fractured grey limestone, which was interbedded with thin siltstone beds. However, at BH103 and BH104, the weathered strata were encountered deeper, down to 5.9m and 5.0m respectively.

The results of the field strength tests, and other relevant data, are summarised below:

Parameter	Range	Comments
SPT '*N*' values	2 to >50	Typically, 5 to 38 at 1.2m depth and >50 from 3.0m depth.

Laboratory testing on the shallower fine-grained samples revealed the following:

Parameter	Range	Comments
Water Content (%)	15 to 27	-
Liquid Limit (%)	24 to 47	Mainly Clay of low Plasticity (BS5930 Casagrande)
Plastic Limit (%)	18 to 25	
Plasticity Index (%)	6 to 22	
Modified Plasticity Index (%)	5 to 20	Mainly non-shrinkable or shrinkable soil of low Volume-Change Potential (NHBC Standards)
Retained on 425µm sieve (%)	4 to 54	BS1377 coarse soil fraction
Passing 63µm sieve (%)	29 to 77	Fines fraction

GROUNDWATER

No groundwater strikes were encountered at any of the boreholes during this latest phase of the investigations.

CONCRETE AGGRESSION TESTS

The results of laboratory aggression tests on selected samples of soil are summarised below:

Stratum	Water-soluble Sulphate SO_4 (mg/l)	pH (pH units)	Number tested
Black Rock Subgroup and Gully Oolite Formation	190 to 230	6.2 to 7.2	3

GEOTECHNICAL ENGINEERING CONCLUSIONS

It is proposed to redevelop the site to accommodate a residential development of two storey houses and apartments, with an access road, driveways and gardens.

REVISED GROUND MODEL

The site and laboratory works carried out as part of this and the previous investigations have shown the ground conditions to comprise Topsoil down to a typical depth of 0.3m over bedrock of the Black Rock Subgroup and Gully Oolite Formation.

The Black Rock Subgroup and Gully Oolite Formation strata was encountered beneath the Topsoil down to the base of the exploratory holes, at depths down to 12.0m. Generally, it comprised a more weathered layer that consisted of firm medium strength brown slightly sandy non-shrinkable or low volume change potential clay, which contained some gravel sized siltstone and limestone lithorelicts, down to 1.5m to 2.0m depth. However, locally this layer was encountered down to 5.0m depth. Beneath this layer the strata became less weathered and generally comprised medium strong fractured grey limestone.

To allow a conservative approach, we recommend the more weathered clay strata be classified as having low volume change potential.

No groundwater strikes or seepages were recorded during the fieldworks and the standpipe wells were recorded to be dry down to their bases at 3.0m depth at the monitoring visit carried out as part of the previous investigation. Based on this, it is considered the local groundwater level is likely to be below 3.0m depth.

INTERPRETATION OF THE ERT AND DISSOLUTIION FEATURES

As noted earlier in this report, no obvious evidence of dissolution features has been recorded as part of the geophysics or intrusive investigations formed as part of this or the previous investigation. Therefore, contact was made with Stantec to request further details of the known dissolution feature recorded in the desk study data. Following a check of their records Stantec informed ListersGeo that the identification of the dissolution feature is based on the presence of the surface depression and a water course, aligned roughly east to west across the site, intersecting the surface depressions under the site and to the east. A drawing showing the location of this water course, taken from the desk study data included in Appendix E from the previous report, is provided in Appendix A. However, they also stated no known intrusive works have been carried out to prove the existence of dissolution features under the depression. No evidence of this east to west water course was noted during either of the walkovers or fieldworks, however it is possible it was a historical watercourse.

The thickness of the more weathered upper layer of strata has been shown to be variable and the results of the ERT were also laterally and vertically variable. As noted in the previous report, the area is known to be affected by faulting, and the lateral variation in the ERT results is considered more likely to be as a result of faulting.

Drawing reference, ‘Structural Interpretation and Mitigation Measures,’ is provided in Appendix A, and gives our interpretation of the potential structures in the ground, based on the findings of this and the previous investigation. Based on this interpretation, two faults, one aligned roughly north to south and the other roughly west to east, intersect approximately at the location of the depression in the central western area of the site. In addition, another fault, aligned roughly west to east across the southern area of the site, is projected to cross under the depression just beyond the eastern boundary.

It is considered likely that preferential drainage routes associated with the faulting and juxtaposition of strata with differing drainage properties is the cause of the surface depressions and therefore the potential for dissolution features, such as sinkholes, remains. No other evidence of dissolution features has been encountered across the site.

Consequently, it is recommended mitigations measures, which are covered in the sections below, are included in the southern area of the site underneath and connecting between the two depressions. This area is highlighted on the drawing titled, ‘Structural Interpretations and Mitigation Measures,’ which, as noted above, is provided in Appendix A.

SITE EXCAVATION

Conventional hydraulic plant will be satisfactory for excavations in the more weathered Black Rock Subgroup and Gully Oolite Formation strata; however, specialist breaking plant will be required for excavations into and through the limestone.

Most of the excavations were noted to be stable in the short time they were open in this investigation, however some collapse of coarse-grained materials was noted in one of the trial pits formed in the eastern area during the previous investigation. In line with HSE guidelines, all excavations requiring personnel access should be adequately supported to avoid the risk of collapse. Consideration should also be given to the stability of open trenches where personnel are working in close proximity.

It is considered the local groundwater level is below 3.0m depth. Therefore, should any shallow minor seepages of groundwater be encountered then the use of conventional pumping from a sump should be sufficient to keep the excavation dry. It is our understanding some surface flooding has occurred in the eastern area of the site previously, in these circumstances a larger capacity pump will be required to keep excavations dry.

It would be prudent to carry out all ground works in the late summer or autumn when groundwater levels and flows are usually at their lowest.

There are numerous trees and hedgerows around the site’s boundaries and consideration should be given to the effects of trees and shrubs on service runs that cross the site. Soil movements brought on by the influence of vegetation can severely disrupt the drain runs and mains services, and measures should be incorporated into the excavations to allow for future ground movements.

FOUNDATION SOLUTIONS

Shallow Foundations

The investigations have shown the ground conditions at 1.0m depth generally comprise medium strength slightly sandy clay of the Black Rock Subgroup and Gully Oolite Formation. These soils are considered to be suitable for traditional spread foundations, with a minimum foundation depth of 1.0m below existing ground level is recommended, or 0.20m into the top of the formation, whichever is the deeper. Should variable ground conditions be encountered across foundations then we recommend appropriately designed reinforcement is introduced throughout the foundation concrete to accommodate the variable soils likely to be encountered at formation level.

For foundations that fall within the Mitigation Zone highlighted on the drawing provided in Appendix A, we recommend that spread foundations should be of the 'cruciform' type, extending beyond the corners and with full reinforcement to span a potential loss of support of suitable size.

The allowable bearing pressure recommended below is made on the assumption of an acceptable total settlement for the proposed structures of 25mm. Should the building design require a significantly different serviceability limit state (tolerance to settlement) then it is recommended that these recommendations be revised accordingly.

At the minimum founding depth provided above, an allowable bearing pressure (or net loading intensity increase) of 100kPa may be adopted for conventional foundations up to 1.0m in width. This allows for a suitable factor of safety against shear failure and should result in acceptable levels of differential and total vertical settlement some of which will take place in the short term, with the rest taking place over a number of years.

Some of the founding soils have low volume change potential; where foundations are to be constructed within the vicinity of trees or shrubs on this site then they will require deepening in accord with guidelines given in NHBC Building Standards Chapter 4.2. For trees that are not to be removed, mature tree heights should be assumed when determining the foundation depths.

As with all sites where dissolution may be present, site operatives should remain vigilant, report any loosening or weak zones of soil and seek advice from a specialist.

GROUND FLOOR SLABS

In the areas of the site outside of the Mitigation Zone, ground bearing floor slabs should be suitable. In these areas the Topsoil should be removed and the exposed surface proof-rolled to expose any excessively soft or compressible zones, which should also be removed. Coarse-grained backfill should then be placed in layers and subjected to controlled compaction.

In accord with NHBC guidelines: if it is required to deepen the main foundations below 1.50m depth, such as on account of trees or shrubs, then ground floor slab to that building should be suspended.

A void should be left below the floor slab to accommodate future moisture content-related soil movements. This may be achieved by use of a proprietary compressible material such as Clayboard or Cellcore.

For floor slabs within the mitigation zone, we recommend suspended floor slabs should be used.

SUBSURFACE CONCRETE

Using the results of the concrete aggression tests from this and the previous investigation, the concrete design mix recommendations for subsurface concrete have been assessed in terms of BRE Special Digest 1, as follows:

Type of Site	Groundwater	Characteristic Sulphate	Characteristic	
		Soil Soluble (mg/l)	Design Sulphate Class	pH (pH units)
Natural	Mobile	260	DS-1	6.0

The above assessment provides an Aggressive Chemical Environment for Concrete (ACEC) class of **AC-1.**

ACCESS ROADS AND PARKING

The structural design of a road or hardstanding is based on the strength of the subgrade, which is assessed on the California Bearing Ratio (CBR) scale. Based on laboratory classification testing, in-situ dynamic plate testing and site observations from this and the previous investigation, for formation at 0.5m depth in the Black Rock Subgroup and Gully Oolite Formation soils we recommend a value of 2% is adopted for preliminary design.

Site conditions should be reassessed at the time of construction and the CBR/pavement design updated accordingly if considered necessary. If pavement construction is undertaken during wetter parts of the year, then a greater pavement thickness or geogrid reinforcement may be required.

Classification testing indicates the soils under this site are likely to be frost susceptible, therefore a suitable minimum pavement thickness will need to be specified depending upon the proposed pavement usage.

For roads and driveways within the Mitigation Zone, we recommend that the proposed development includes for a degree of redundancy within the road pavement design. This should include for the provision of reinforcement within foundations to cater for a potential future localised loss of ground support and considerations of geogrids within road pavements to limit the risk of a sudden collapse should underlying dissolution occur.

INFILTRATION MEASURES

Appropriately designed sustainable drainage systems (SuDS) are more sustainable than using piped drainage to local sewer systems. However, infiltration measures close to buildings may result in undermining of foundations and softening of soils leading to instability. Attenuation measures should be located at suitable distances from foundations and infrastructure and consideration given to the effects on slopes, flooding and mobilisation of contaminants.

Test Results

As part of the previous investigation, infiltration testing was carried out at seven locations. Three locations tested the clay soils at shallow depth, with the other four locations testing the deeper strata. At one of the deeper locations the test was carried out entirely in clay soils, however at the other three the trial pits were taken down into the top of the underlying fractured limestone.

The results indicate the shallower clay soils have an infiltration rate in the region of 1.0×10^{-6}m/s and the deeper clay soils, down to approximately 2.2m depth, have an infiltration rate of less than 6.5×10^{-7}m/s.

The tests carried out into the top of the fractured limestone recorded results that varied from less than 1.1×10^{-6}m/s to 5.1×10^{-4}m/s. This range of results is considered to reflect the nature of the fracturing in the limestone, with thicker more fractured beds having a higher infiltration capacity.

Taking account of the risks of ground dissolution, soakaway drainage should be kept out of the Mitigation Zone and at least 20m from any structures across the whole site.

CONCLUSIONS AND LIMITATIONS

No direct evidence of dissolution features, beyond the surface depressions, have been revealed during the investigations. However, taking account of all the information gathered during these investigations, it is considered the potential for such features exists in the areas under and between the depressions. Therefore, we have recommended a Mitigation Zone where the design should include measures to protect the development against ground instability associated with dissolution features.

As with all sites where there is a risk from dissolution features, site operatives should remain vigilant, report any loosening or weak zones of soil and seek advice from a specialist.

REFERENCES

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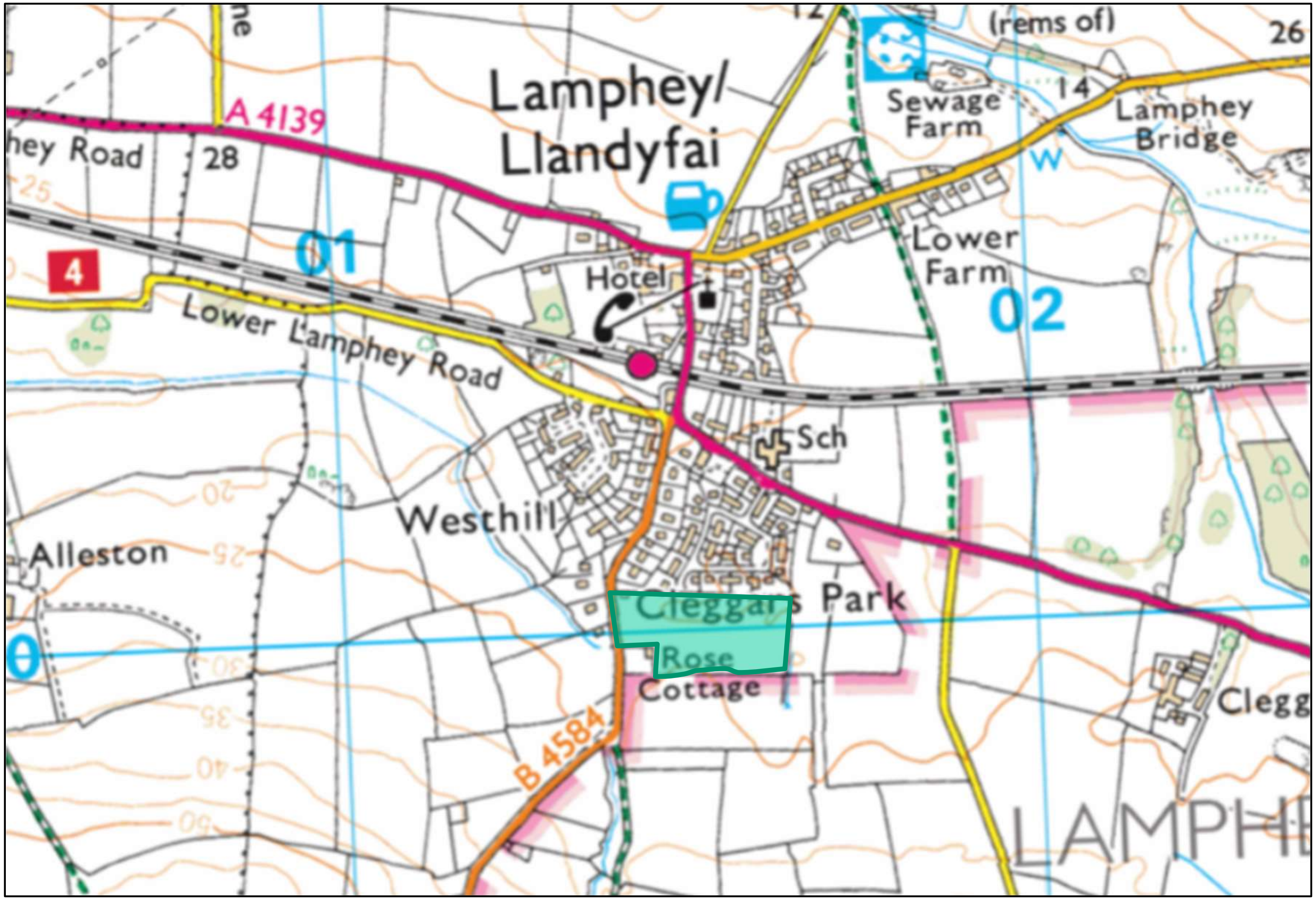
- J. Milsom Field Geophysics

APPENDIX A
PLANS & PHOTOGRAPHS



LISTERS GEO

Geotechnical and Geoenvironmental Consultants

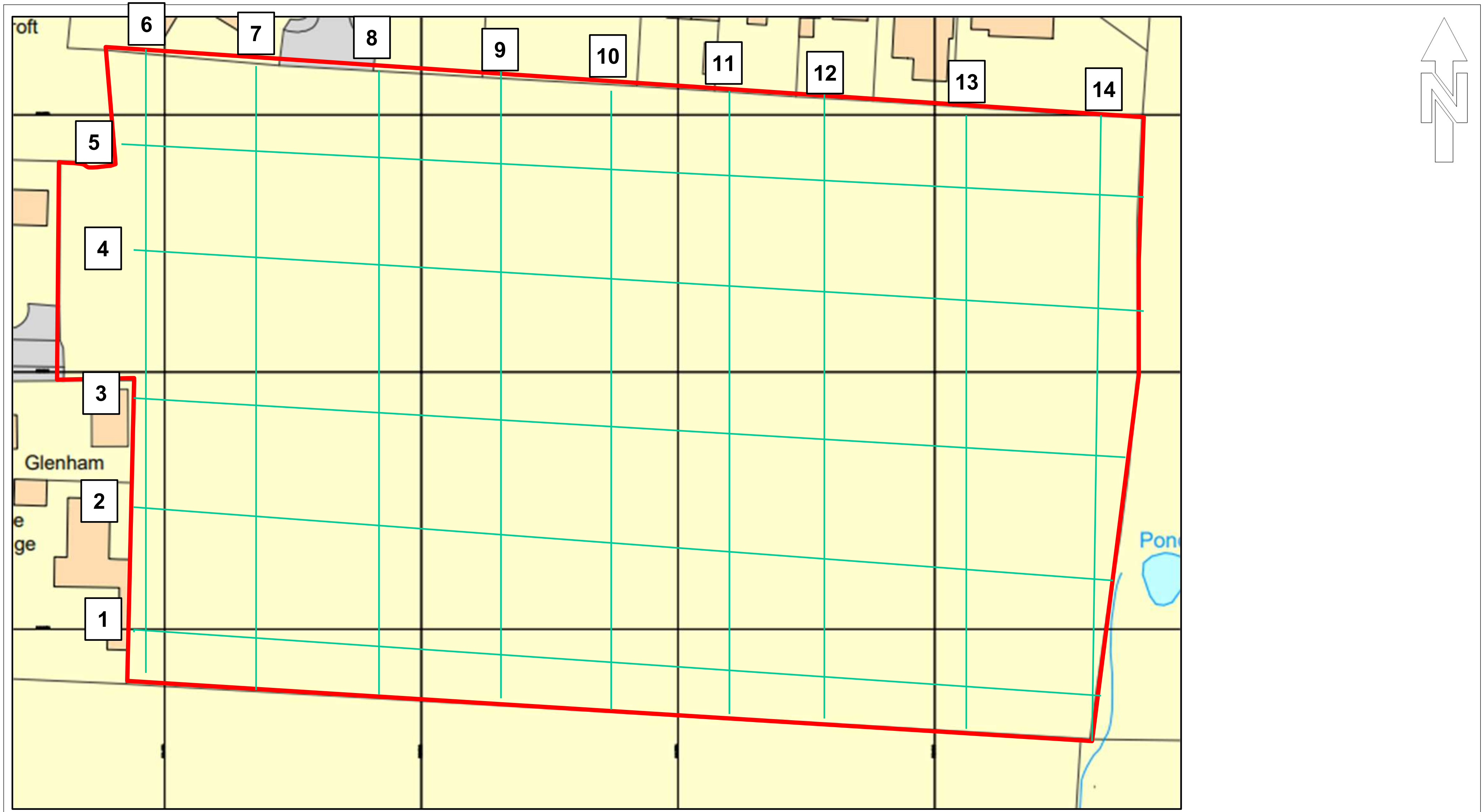
Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

Title: Site Location Plan

Key: Approximate site location

Site: : Cleggars Park, Lamphey, Pembrokeshire, SA71 5JY

Scale: NTS	Job Number: 22.09.023a	Drawn By: LC



LISTERS GEO

Geotechnical and Geoenvironmental Consultants

Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

Title: Electrical Resistivity Tomography (ERT) Lines

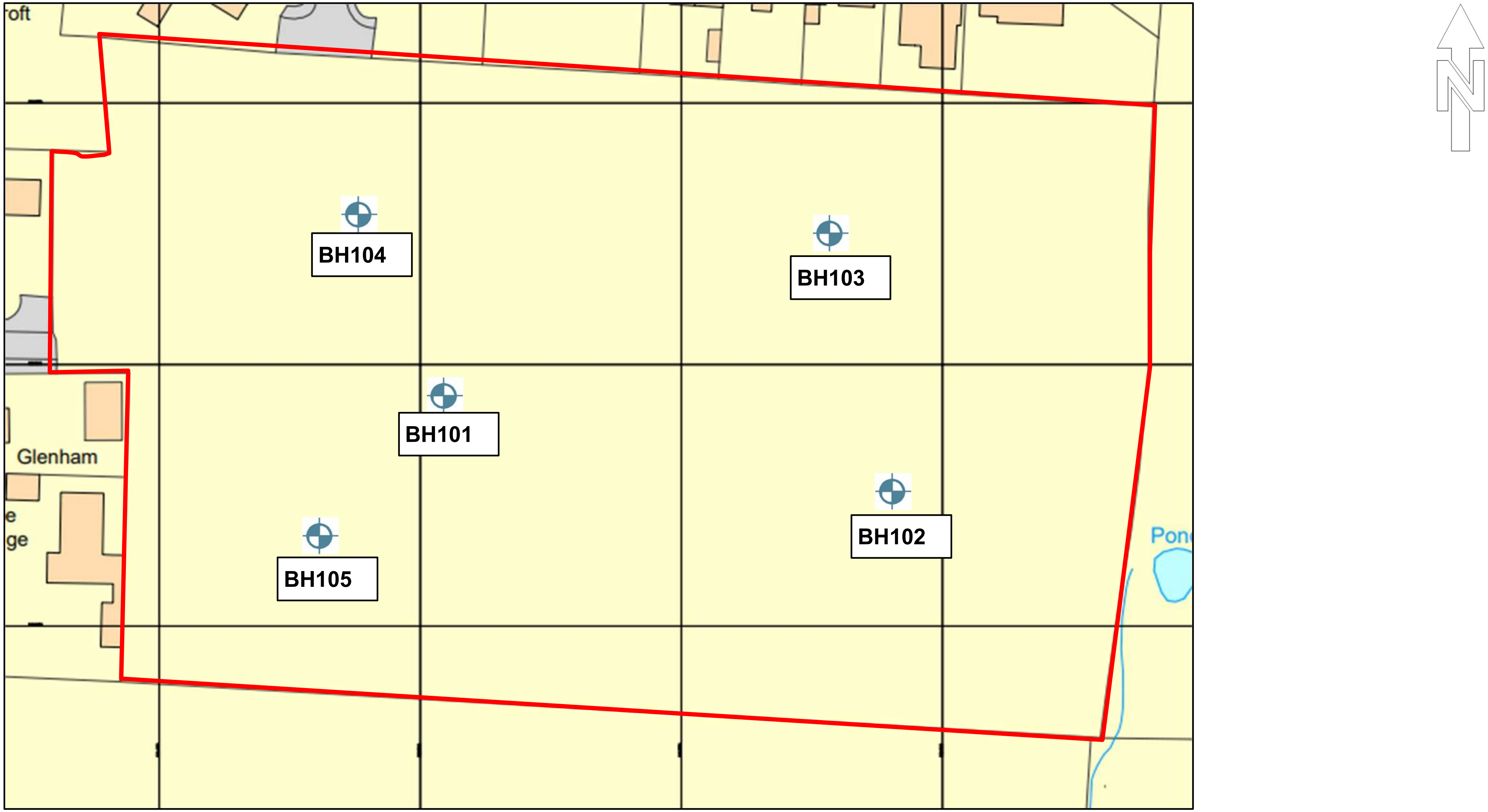
Site: Cleggars Park, Lamphey, Pembrokeshire, SA71 5JY

Scale: NTS	Job Number: 22.09.023a	Drawn By: LC

Key:

ERT Lines

Approximate Site Boundary



LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

Title: Exploratory Hole Location Plan

Site: Cleggars Park, Lamphey, Pembrokeshire, SA71 5JY

Scale: NTS	Job Number: 22.09.023a	Drawn By: LC

Key:

Sonic Rig Boreholes

Approximate Site Boundary

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

Title: Electrical Resistivity Tomograpjhy (ERT) Results at 3.0m Depth

Key:

Site: : Cleggars Park, Lamphey, Pembroke, SA71 5JY

Scale: NTS	Job Number: 22.09.023a	Drawn By: LC

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

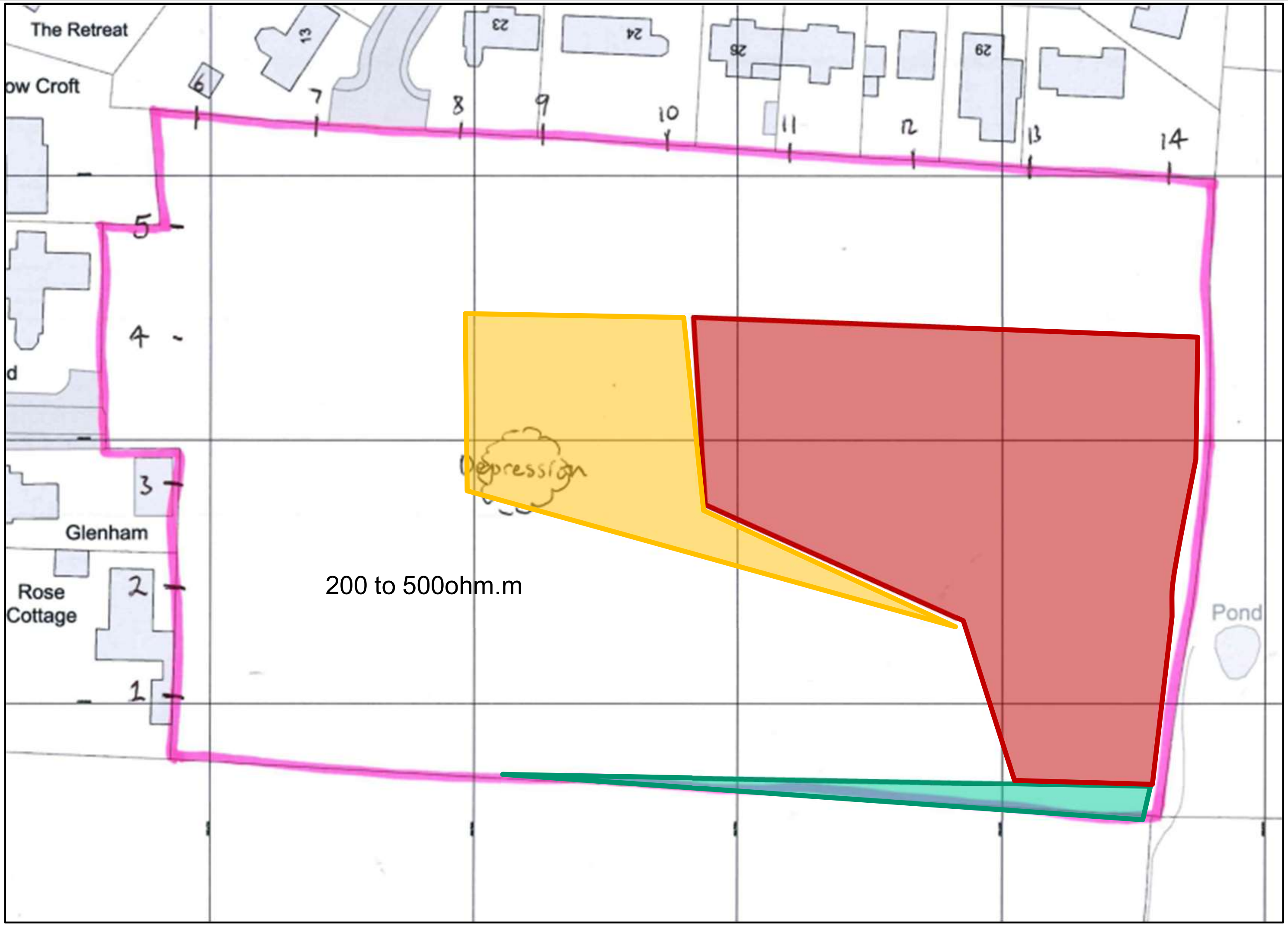
Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

Title: Electrical Resistivity Tomograpjhy (ERT) Results at 6.0m Depth

Key:

Site: : Cleggars Park, Lamphey, Pembroke, SA71 5JY

Scale: NTS	Job Number: 22.09.023a	Drawn By: LC



<200ohm.m

1,000 to 1,500ohm.m

>1,500ohm.m

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

Title: Electrical Resistivity Tomograpjhy (ERT) Results at 9.0m Depth

Key:

Site: : Cleggars Park, Lamphey, Pembroke, SA71 5JY

Scale: NTS	Job Number: 22.09.023a	Drawn By: LC

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

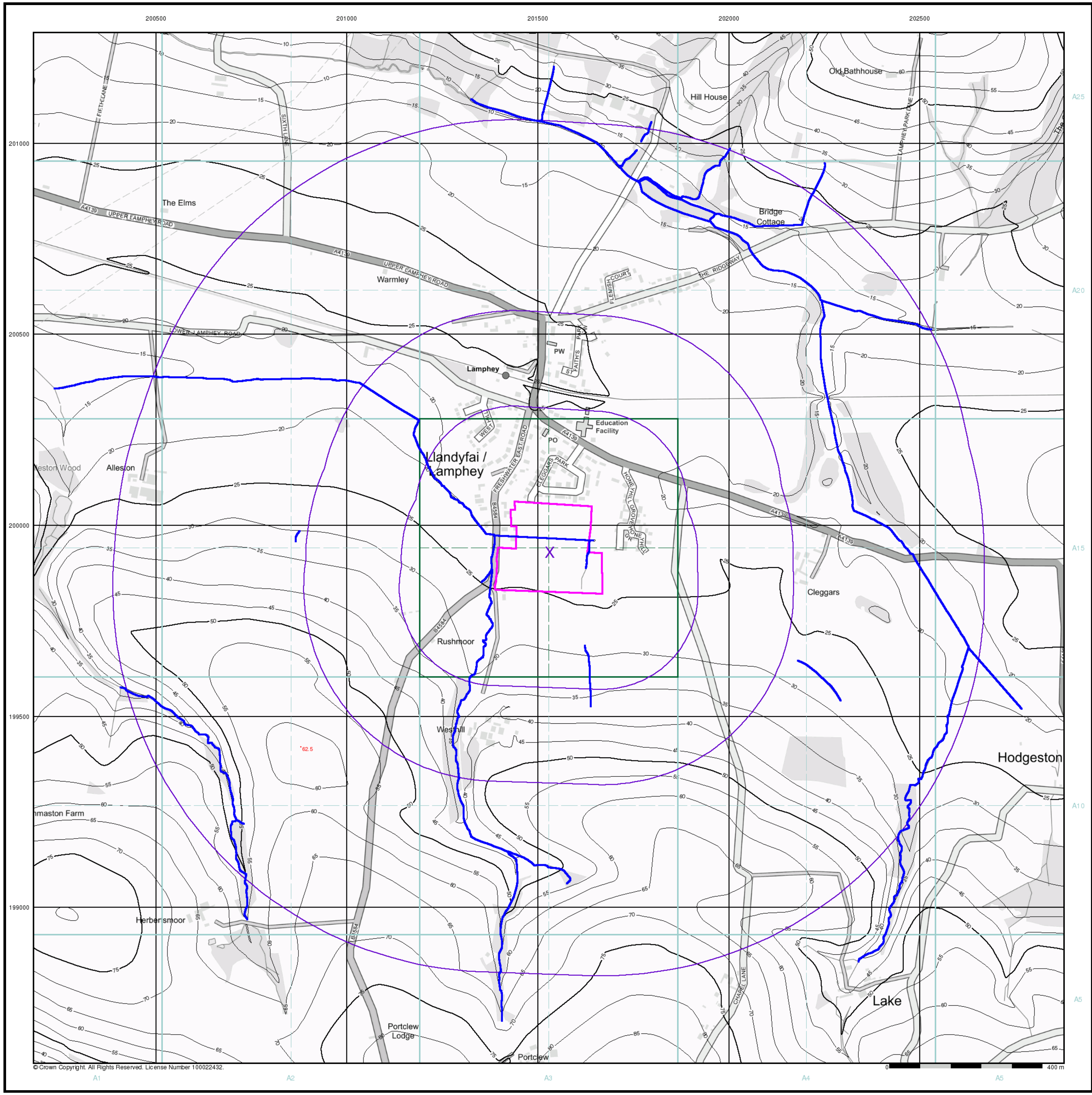
Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

Title: Electrical Resistivity Tomograpjhy (ERT) Results at 12.0m Depth

Key:

Site: : Cleggars Park, Lamphey, Pembroke, SA71 5JY

Scale: NTS	Job Number: 22.09.023a	Drawn By: LC



LISTERS GEO

Geotechnical and Geoenvironmental Consultants

General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

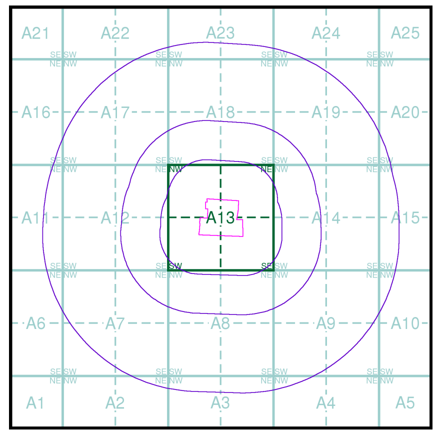
OS Water Network Data

- Canal
- Reservoir
- Foreshore
- Marsh
- Tidal River
- Inland River
- Drain
- Other
- Lake
- Transfer
- Lock Or Flight Of Locks
- Sea

Contours (height in meters)

- Standard Contour
- Master Contour
- Spot Height
- Mean Low Water
- Mean High Water

OS Water Network Map - Slice A



Order Details

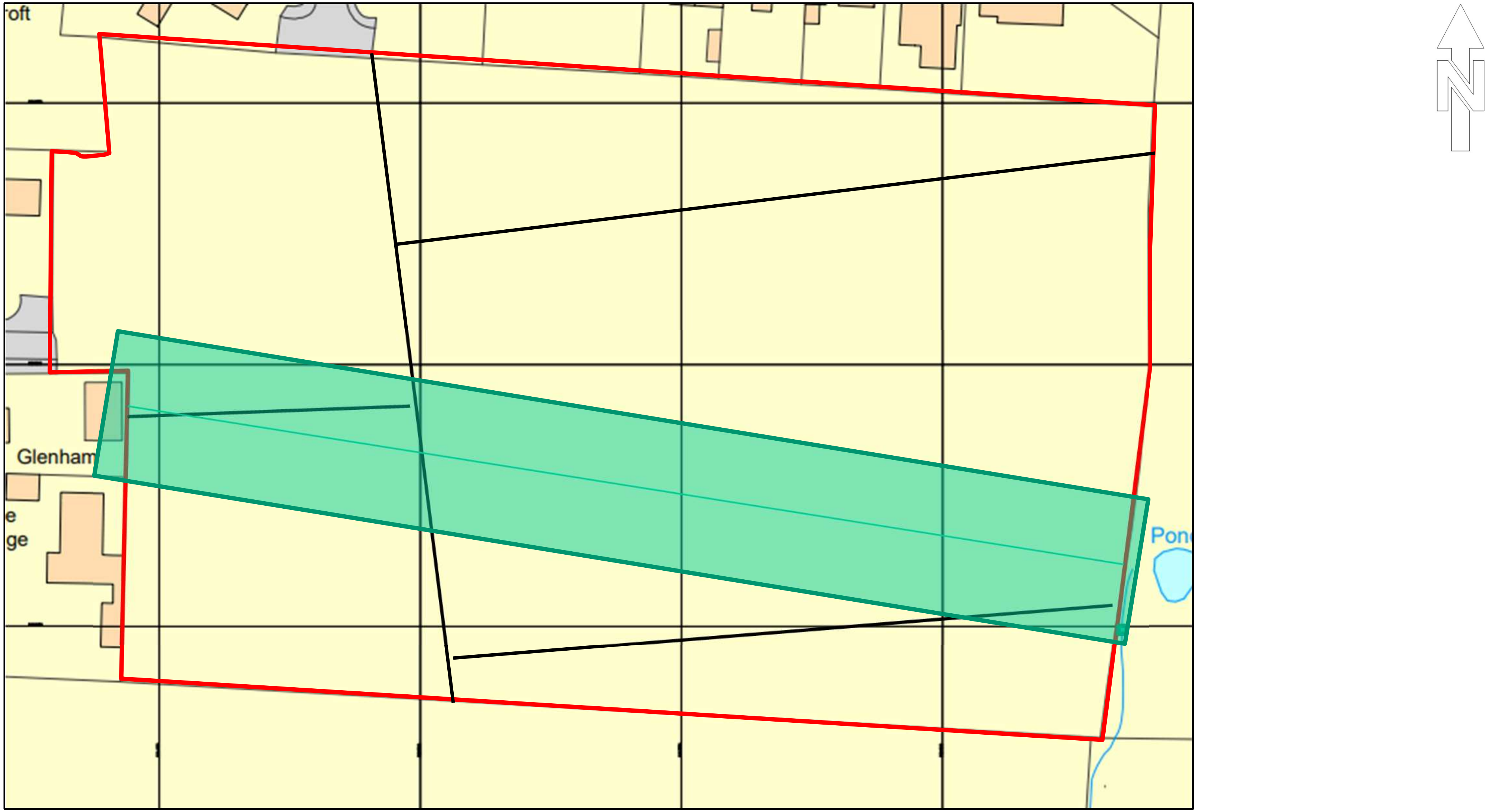
Order Number:	302445936_1_1
Customer Ref:	22.09.023
National Grid Reference:	201530, 199930
Slice:	A
Site Area (Ha):	5.43
Search Buffer (m):	1000

Site Details

Fernbrook, Freshwater East Road, Lamphey, PEMBROKE, SA71 5JY

Landmark INFORMATION GROUP

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060

Title: Structural Interpretation & Mitigation Measures

Site: Cleggars Park, Lamphey, Pembrokeshire, SA71 5JY

Scale: NTS	Job Number: 22.09.023a	Drawn By: LC

Key:

Faults

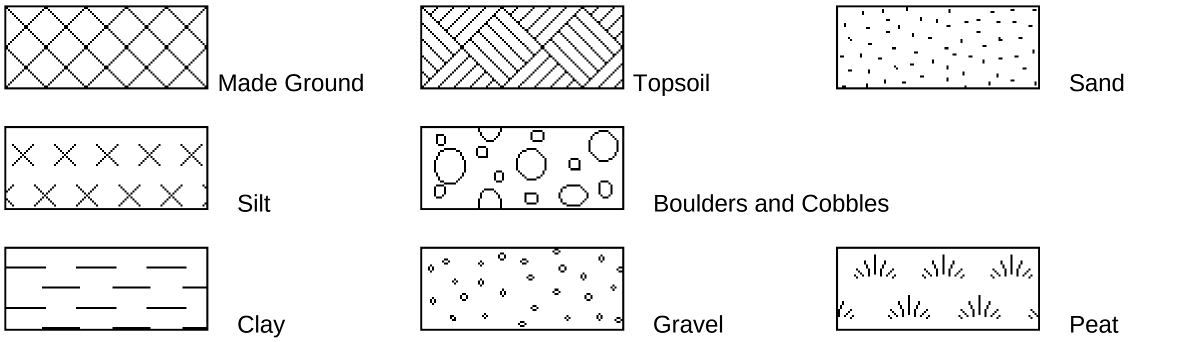
Approximate route of water course

Approximate Site Boundary

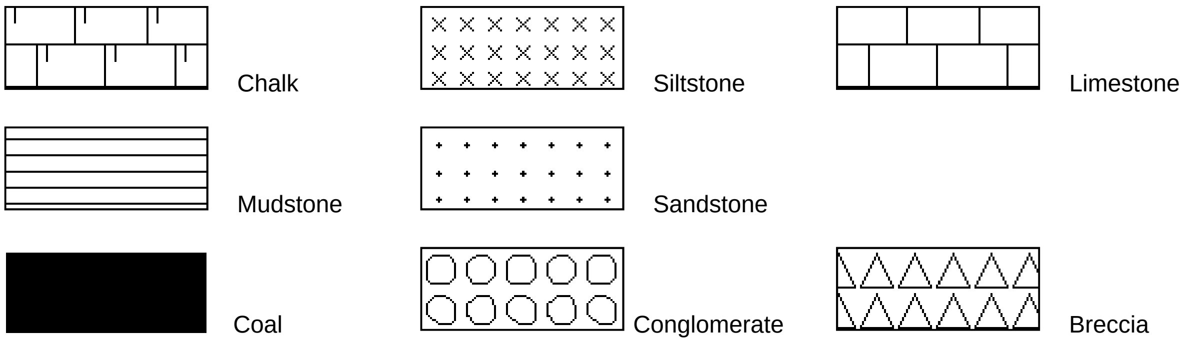
Area of dissolution features mitigation measures

APPENDIX B
FIELDWORK AND TESTING

LEGEND - Soils



LEGEND - Rocks (Sedimentary)



LOG ABREVIATIONS

W	Water Sample	▽	Water Strike
B	Bulk Sample	▼	Water (Standing Level)
D	Disturbed Sample	PP	Pocket Penetrometer
J	Jar Sample	HV	Hand Vane
U	Undisturbed Sample	SPT	Standard Penetration Test
(No. of blows shown in brackets for U100 samples)		CPT	Cone Penetration Test
WAC	Waste Acceptance Criteria Sample	CBR	California Bearing Ratio
		*	Extrapolated Value

Pocket penetrometer testing provides values of unconfined compressive strength. The results have been converted to an approximate equivalent shear strength which should be used with due circumspection. As the pocket penetrometer tends to overestimate shear strength, we have used an appropriate reduction factor.

LOG KEY

Rotary Borehole Log

LISTERS GEO — Geotechnical and Geoenvironmental Consultants

Borehole No. BH 101

Project Location: Cleggars Park, Lamphey, Pembroke, SA71 5JY

Co-ords: 201499E - 199994N

Level:

Dates: 01/03/2023 to 01/03/2023

Project Number: 22.09.023a

Logged By: Lee Chippington to BS 5930:2015

Well	Water Strikes	Depth (m)	Samples and Testing: Type	Samples and Testing: Result	Coring (%): TCR	Coring (%): SCR	Coring (%): RQD	Depth (m)	Level (m)	Legend	Stratum Description
								0.30			TOPSOIL Brown slightly sandy slightly organic CLAY
								1.50			BLACK ROCK SUB-GROUP & GULLY OOLITE FORMATION Firm brown slightly sandy CLAY. Contains some gravel sized lithorelicts
		1.20 - 1.47	C								
		1.20 - 3.00	D								
		1.20	SPT (S)	50 for 120mm (22/15,35 for 45mm)	83	83					
		3.00 - 4.50	C								
		3.00	SPT (C)	50 for 76mm (25 for 50mm/45,5 for 1mm)	100	100					
		4.50 - 6.00	C								
		4.50	SPT (C)	50 for 70mm (25 for 50mm/50 for 70mm)	100	100					
		6.00 - 7.50	C								
		6.00	SPT (C)	50 for 50mm (25 for 78mm/50 for 50mm)	100	100					
		7.50	SPT (C)	50 for 50mm (25 for 40mm/50 for 50mm)				9.00			BLACK ROCK SUB-GROUP & GULLY OOLITE FORMATION Medium strong fractured grey LIMESTONE. Contains some thin beds of siltstone down to 7.50m depth

End of Borehole at 9.00m

Rig Type: Sonic Rig

Borehole Diameter: 100mm

Instrumentation:

Groundwater: Not encountered

Flushing Medium:

Casing Depth: None

Remarks: Los of flush below 7.50m depth

QMS ISO 9001 REGISTERED FIRM

AGS Association of Geotechnical & Geoenvironmental Specialists

Rotary Borehole Log

LISTERS GEO — Geotechnical and Geoenvironmental Consultants

Borehole No. BH 102

Project Location: Cleggars Park, Lamphey, Pembroke, SA71 5JY	**Co-ords:** 201585E - 199979N		**Project Number:** 22.09.023a
	Level:		**Logged By:** Lee Chippington to BS 5930:2015
	Dates: 02/03/2023 to 02/03/2023		

Well	Water Strikes	Depth (m)	Samples and Testing: Type	Samples and Testing: Result	Coring (%): TCR	Coring (%): SCR	Coring (%): RQD	Depth (m)	Level (m)	Legend	Stratum Description
								0.30			TOPSOIL Brown slightly sandy slightly organic CLAY
		1.20 - 3.00	C					1.50			BLACK ROCK SUB-GROUP & GULLY OOLITE FORMATION Firm brown slightly sandy CAY
		1.20	SPT (S)	N=28 (7/5,6,7,10)	83	83					BLACK ROCK SUB-GROUP & GULLY OOLITE FORMATION Medium strong fractured grey LIMESTONE interbedded with weak grey siltstone down to 4.50m depth
		3.00 - 4.50	C								
		3.00	SPT (S)	N=44 (12/9,10,12,13)	100	100					
		4.50 - 6.00	C								
		4.50	SPT (S)	50 for 130mm (15/25,25 for 55mm)	100	100					
		6.00 - 7.50	C								
		6.00	SPT (C)	50 for 78mm (25 for 30mm/45,5 for 3mm)	100	100					
		7.50	SPT (C)	50 for 40mm (25 for 30mm/50 for 40mm)				9.00			End of Borehole at 9.00m

Rig Type: Sonic Rig
Flushing Medium:
Borehole Diameter: 100mm
Casing Depth: 1.50m
Instrumentation:
Groundwater: Not encountered

Remarks: Loss of flush below 7.50m depth

ISO 9001 REGISTERED FIRM

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LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Rotary Borehole Log

Borehole No. BH 103

Project Location:	Cleggars Park, Lamphey, Pembroke, SA71 5JY	**Co-ords:** 201578E - 200031N	**Project Number:** 22.09.023a
		Level:	**Logged By:** Lee Chippington to BS 5930:2015
		Dates: 02/03/2023 to 03/03/2023	

Well	Water Strikes	Depth (m)	Samples and Testing: Type	Samples and Testing: Result	Coring (%): TCR	Coring (%): SCR	Coring (%): RQD	Depth (m)	Level (m)	Legend	Stratum Description
								0.30			TOPSOIL Brown slightly sandy slightly organic CLAY
		1.20 - 3.00 1.20	C SPT (S)	N=15 (6/3,3,4,5)	83	83					BLACK ROCK SUB-GROUP & GULLY OOLITE FORMATION Firm brown slightly sandy CLAY
								1.80			BLACK ROCK SUB-GROUP & GULLY OOLITE FORMATION Dense grey clayey fine to coarse SAND. Contains abundant gravel sized limestone lithorelicts
		3.00 - 4.50 3.00	C SPT (C)	50 for 152mm (25/20,25,5 for 2mm)	100	100					
		4.50	SPT (C)	N=9 (3/2,2,2,3)	100	100					
								5.90			BLACK ROCK SUB-GROUP & GULLY OOLITE FORMATION Medium strong fractured grey LIMESTONE
		6.00 - 7.50 6.00	C SPT (S)	N=39 (11/8,9,10,12)	100	100					
		7.50 - 9.00 7.50	C SPT (C)	50 for 20mm (25 for 20mm/50 for 20mm)	100	100					
		9.00 - 10.50 9.00	C SPT (C)	50 for 30mm (25 for 30mm/50 for 30mm)	100	100					

Rig Type: Sonic Rig
Borehole Diameter: 100mm
Instrumentation:
Groundwater: Not encountered
Flushing Medium:
Casing Depth: 6.00m

Remarks:

QMS ISO 9001 REGISTERED FIRM
AGS Association of Geotechnical & Geoenvironmental Specialists

Rotary Borehole Log

LISTERS GEO — Geotechnical and Geoenvironmental Consultants

Borehole No.	**BH 103**
Project Location:	Cleggars Park, Lamphey, Pembroke, SA71 5JY
Co-ords:	201578E - 200031N
Level:	
Dates:	02/03/2023 to 03/03/2023
Project Number:	22.09.023a
Logged By:	Lee Chippington to BS 5930:2015

Well	Water Strikes	Depth (m)	Samples and Testing: Type	Samples and Testing: Result	Coring (%): TCR	Coring (%): SCR	Coring (%): RQD	Depth (m)	Level (m)	Legend	Stratum Description
											BLACK ROCK SUB-GROUP & GULLY OOLITE FORMATION Medium strong fractured grey LIMESTONE
		10.50 - 12.00	C								
		10.50	SPT (C)	50 for 60mm (25 for 50mm/50 for 60mm)	100	100					
		12.00	SPT (C)	50 for 10mm (25 for 10mm/50 for 10mm)				12.00			End of Borehole at 12.00m

Rig Type: Sonic Rig
Borehole Diameter: 100mm
Instrumentation:
Groundwater: Not encountered
Flushing Medium:
Casing Depth: 6.00m

Remarks:

ISO 9001 REGISTERED FIRM

AGS Association of Geotechnical & Geoenvironmental Specialists

Rotary Borehole Log

LISTERS GEO — Geotechnical and Geoenvironmental Consultants

Borehole No. BH 104

Project Location: Cleggars Park, Lamphey, Pembroke, SA71 5JY

Co-ords: 201484E - 200039N

Level:

Dates: 03/03/2023 to 04/03/2023

Project Number: 22.09.023a

Logged By: Lee Chippington to BS 5930:2015

Well	Water Strikes	Depth (m)	Samples and Testing: Type	Samples and Testing: Result	Coring (%): TCR	Coring (%): SCR	Coring (%): RQD	Depth (m)	Level (m)	Legend	Stratum Description
								0.30			TOPSOIL Brown slightly sandy slightly organic CLAY
		1.20 - 3.00	C								BLACK ROCK SUB GROUP & GULLY OOLITE FORMATION Firm brown sandy CLAY. Contains some gravel sized siltstone and limestone lithorelicts
		1.20	SPT (S)	N=5 (2/1,1,1,2)	83	83					
		3.00 - 4.50	C								
		3.00	SPT (S)	N=6 (3/2,1,1,2)	100	100					
		4.50 - 6.00	C								
		4.50	SPT (S)	2 for 320mm (1/1,0,1,0 for 95mm)	100	100		5.00			BLACK ROCK SUB GROUP & GULLY OOLITE FORMATION Medium strong fractured grey LIMESTONE
		6.00 - 7.50	C								
		6.00	SPT (C)	50 for 30mm (25 for 10mm/50 for 30mm)	100	100					
		7.50 - 9.00	C		100	100					
		9.00	SPT (C)	50 for 20mm (25 for 10mm/50 for 20mm)				9.00			End of Borehole at 9.00m

Rig Type: Sonic R

Borehole Diameter: 100mm

Instrumentation:

Groundwater: Not encountered

Flushing Medium:

Casing Depth: None

Remarks:

ISO 9001 REGISTERED FIRM

AGS Association of Geotechnical & Geoenvironmental Specialists

Rotary Borehole Log

LISTERS GEO
Geotechnical and Geoenvironmental Consultants

Borehole No. BH 105

Project Location: Cleggars Park, Lamphey, Pembroke, SA71 5JY

Co-ords: 201475E - 199974N

Level:

Dates: 04/03/2023 to 04/03/2023

Project Number: 22.09.023a

Logged By: Lee Chippington to BS 5930:2015

Well	Water Strikes	Depth (m)	Samples and Testing: Type	Samples and Testing: Result	Coring (%): TCR	Coring (%): SCR	Coring (%): RQD	Depth (m)	Level (m)	Legend	Stratum Description
								0.30			TOPSOIL Brown slightly sandy slightly organic CLAY
								1.50			BLACK ROCK SUB-GROUP AND GULLY OOLITE FORMATION Firm brown slightly sandy CLAY. Contains occasional gravel sized siltstone lithorelicts
		1.20 - 3.00	C		94	94					
		1.20	SPT (S)	N=38 (3/5,5,10,18)							
		3.00 - 4.50	C		100	100					
		3.00	SPT (C)	50 for 10mm (25 for 10mm/50 for 10mm)							
		4.50 - 6.00	C		100	100					
		4.50	SPT (C)	50 for 20mm (25 for 5mm/50 for 20mm)							
		6.00 - 7.50	C		100	100					
		6.00	SPT (C)	50 for 15mm (25 for 10mm/50 for 15mm)							
		7.50	SPT (C)	50 for 30mm (25 for 10mm/50 for 30mm)				7.50			BLACK ROCK SUB-GROUP AND GULLY OOLITE FORMATION Medium strong fractured grey LIMESTONE
											End of Borehole at 7.50m

Rig Type: Sonic Rig

Borehole Diameter: 100mm

Instrumentation:

Groundwater: Not encountered

Flushing Medium:

Casing Depth: 1.50m

Remarks: Loss of flush below 1.35m depth

QMS ISO 9001 REGISTERED FIRM

AGS Association of Geotechnical & Geoenvironmental Specialists

APPENDIX C
LABORATORY TEST REPORTS

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD

Telephone:- 01327 860947/860060 Email: lab@listersgeotechnics.co.uk

PROJECT INFORMATION		SAMPLE INFORMATION		
Site Location:-	Cleggars Park Lamphey Pembrooke SA71 5JY	**Laboratory Tests Undertaken:-**		
		TEST TYPE	**TEST METHOD**	**TESTED**
		Natural Moisture Contents (MC%)	(BS 1377:Part 2:1990 Clause 3.2)	✓
		Liquid Limits (%)	(BS 1377:Part 2:1990 Clause 4.3)	✓
		Plastic Limits (%)	(BS 1377:Part 2:1990 Clause 5.3)	✓
		Plasticity Index (%)	(BS 1377:Part 2:1990 Clause 5.4)	✓
		Linear Shrinkage (%)	(BS 1377:Part 2:1990 Clause 6.5)	
		PSD - Wet Sieving	(BS 1377:Part 2:1990 Clause 9.2)	✓
Client Reference:-		Engineering Sample Descriptions	(BS 5930 : Section 6)	✓
		Passing 425/63 (µm)	-	✓
		Hydrometer	(BS 1377:Part 2:1990 Clause 9.5)	
Date Samples Received:-	12th March 2023	Loss on Ignition (%)	-	
Date Testing Completed:-	27th March 2023	Soil Suctions (kPa)	BRE Digest IP 4/93, 1993	
		Bulk Density (Mg/m^3)	(BS 1377:Part 2:1990 Clause 7.2)	
		Strength Tests	(BS 1377:Part 7:1990 Clause 8 & 9)	
		Soluble Sulphate Content (SO_4g/l)	(BS 1377:Part 3:1990 Clause 5.3)	✓
		pH value	(BS 1377:Part 3:1990 Clause 9.4)	✓
		California Bearing Ratios (CBR)	(BS 1377:Part 4:1990 Clause 7)	
		Compaction Tests	(BS 1377:Part 4:1990 Clauses 3.0-3.6)	
The results relate only to the samples tested				

Laboratory testing in accord with BS EN ISO/IEC 17025-2000 and Quality Management in accord with ISO 9001

Signed on behalf of GroundTech Laboratories:-____________________________________ Technical Signatory

Quality Assured to ISO 9001

GEOTECHNICAL LABORATORY TEST RESULTS

Report No: 22.09.023a

GroundTech Laboratories

Geotechnical Testing Facility

Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD
Telephone: 01327 860947/860060 Fax: 01327 860430 Email: groundtech@listersgeotechnics.co.uk

Quality Assured to ISO 9001

SAMPLES				CLASSIFICATION TESTS							CLASSIFICATION TESTS							STRENGTH TESTS					CHEMICAL TESTS	
Test Location	Sample Type	Sample Depth -m	Test Type	WC %	LL %	PL %	PI %	Passing 425 µm %	Modified PI %	Class	Passing 63 µm %	WC/ LL	PL+ 2%	Liquidity Index	Loss on Ignition %	Soil Suction kPa	Bulk Density Mg/m³	Test Type	Cell Pressure kN/m²	Deviator Stress kN/m²	Apparent Cohesion kN/m²	ϕ	pH Value	Soluble Sulphate Content SO4 g/l
BH 101	D	1.00	PI/63	21	33	21	12	76	9	CL	59	0.64	23	0.00									6.2	0.23
BH 102	D	1.00	PI/63	18	32	19	13	90	12	CL	69	0.56	21	-0.08										
	D	4.00	PSD	11																				
BH 103	D	1.00	PI/63	27	47	25	22	89	20	CI	77	0.57	27	0.09									7.0	0.19
	D	2.50	PSD	19																				
BH 104	D	0.50		16																				
	D	1.50	PI/63	15	24	18	6	78	5	ML	41	0.63	20	-0.50										
	D	3.00	PI/63	23	33	22	11	46	5	CL	29	0.70	24	0.09									7.2	0.19
BH 105	D	1.00	PI/63	18	33	19	14	96	13	CL	78	0.55	21	-0.07										

Symbols:

U	Undisturbed Sample	R	Remoulded	PI	Plasticity Index	T	Triaxial Undrained	L	100mm specimen
D	Disturbed Sample	63	Passing 63µm	F	Filter Paper Suction Tests	M	Multistage Triaxial	S	38mm specimen
B	Bulk Sample	H	Hydrometer	CC	Continuous Core	HP	Hand Penetrometer		
W	Water Sample	PSD	Wet Sieving			V	Vane Test		

LABORATORY TEST RESULTS

Project Reference
22.09.023a

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Quality Assured ISO 9001

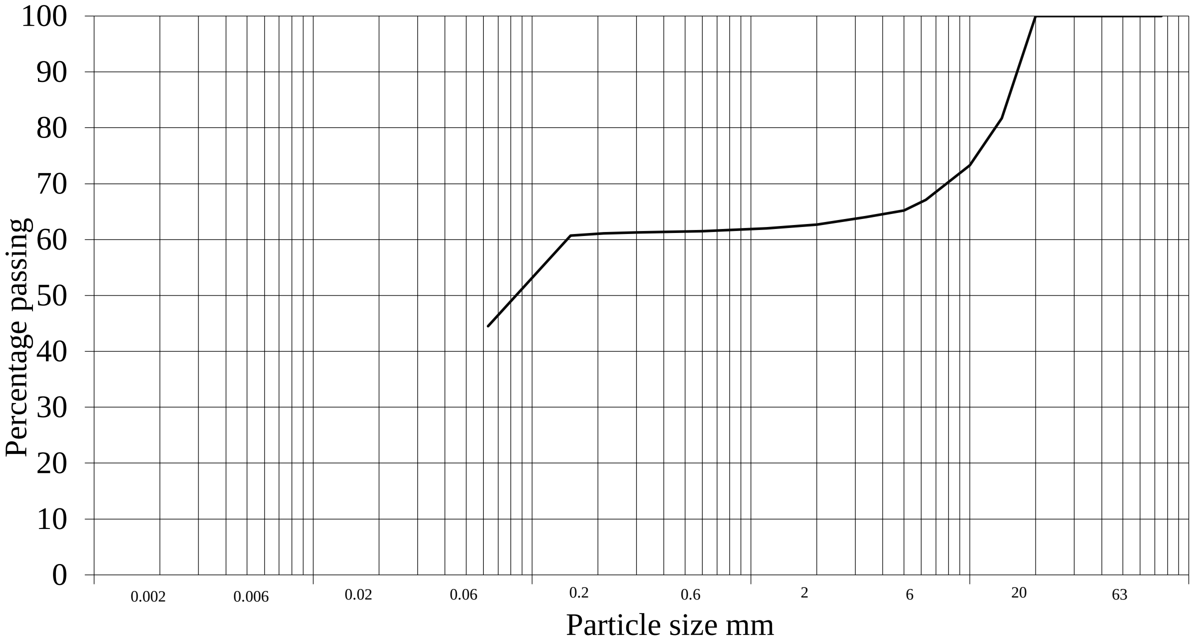
Site: Cleggars Park, Lamphey, Pembroke,SA71 5JY

Test Location: BH 102
Sample Depth: 4.00m
Sample Description:

Hydrometer No.:
SG Gs:
Water Visc. (N):
Dry Mass of Soil after pretreatment (g):

Test Method: BS 1377 : Part 2 : 1990 : 9.2

BS test sieve	Cumulative Passing - %	Hydrometer Particle Diameter	Cumulative Passing - %
75mm	100.00		
63mm	100.00		
50mm	100.00		
37.5mm	100.00		
26.5mm	100.00		
20mm	100.00		
14mm	81.70		
10mm	73.30		
6.3mm	67.10		
5mm	65.20		
3.5mm	64.00		
2mm	62.70		
1.18mm	62.00		
600µm	61.50		
425µm	61.40		
300µm	61.30		
212µm	61.10		
150µm	60.70		
63µm	44.50		



CLAY	SILT			SAND			GRAVEL			COBBLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
45%				18%			37%			0%

PARTICLE SIZE DISTRIBUTION

Project Reference
22.09.023a

GroundTech Laboratories

Geotechnical Testing Facility
Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northants. NN12 8QD
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Quality Assured ISO 9001

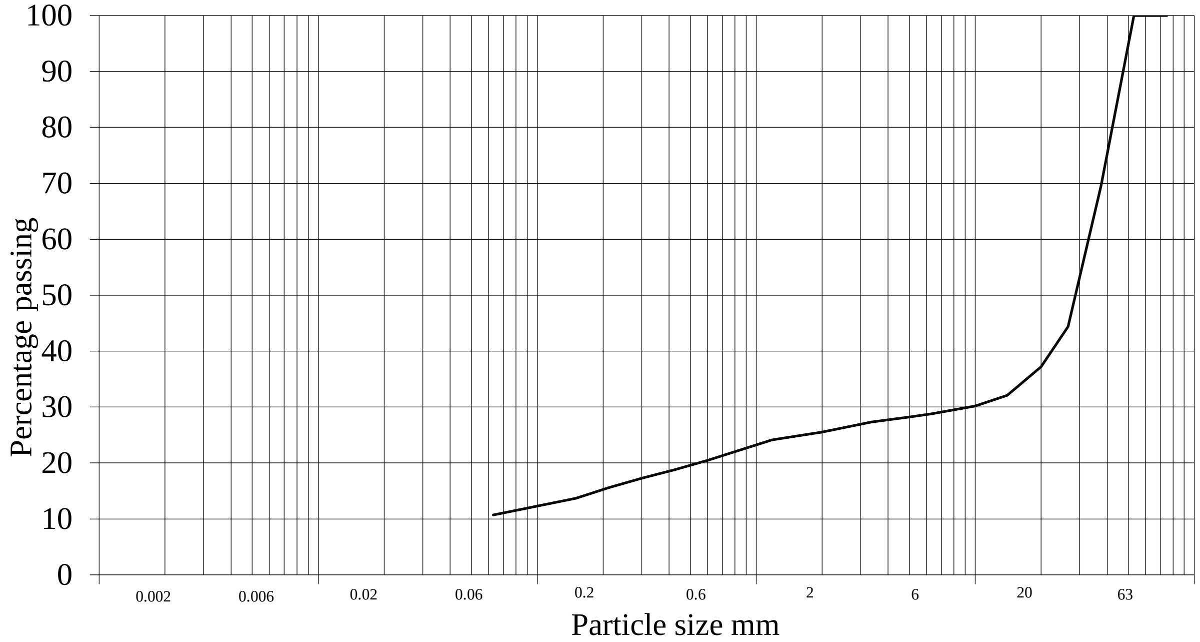
Test Method: BS 1377 : Part 2 : 1990 : 9.2

Site: Cleggars Park, Lamphey, Pembroke,SA71 5JY

Test Location: BH 103
Sample Depth: 2.50m
Sample Description:

Hydrometer No.:
SG Gs:
Water Visc. (N):
Dry Mass of Soil after pretreatment (g):

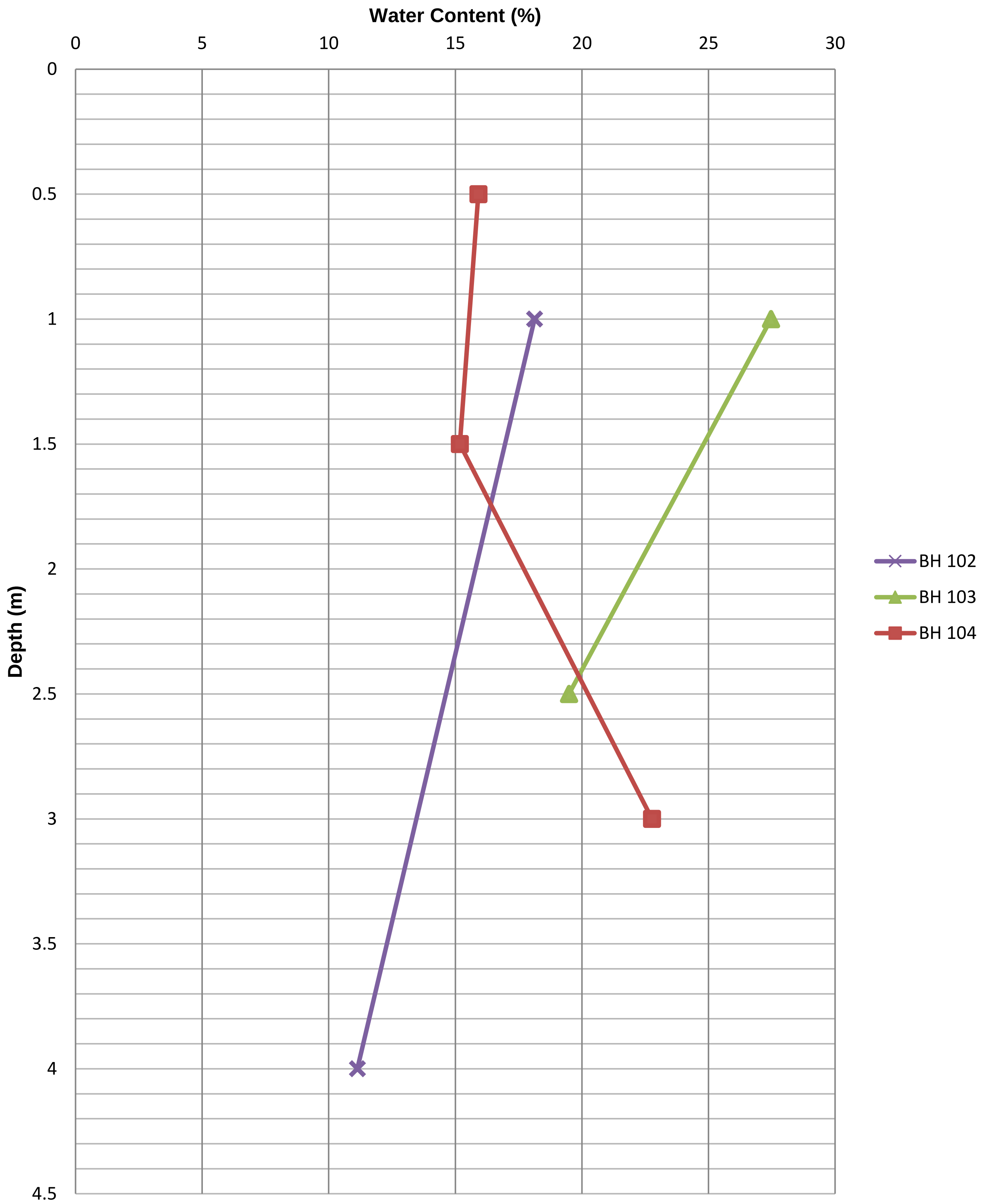
BS test sieve	Cumulative Passing - %	Hydrometer Particle Diameter	Cumulative Passing - %
75mm	100.00		
63mm	100.00		
50mm	100.00		
37.5mm	69.50		
26.5mm	44.40		
20mm	37.20		
14mm	32.10		
10mm	30.20		
6.3mm	28.80		
5mm	28.20		
3.5mm	27.30		
2mm	25.50		
1.18mm	24.10		
600µm	20.50		
425µm	18.80		
300µm	17.30		
212µm	15.60		
150µm	13.70		
63µm	10.70		



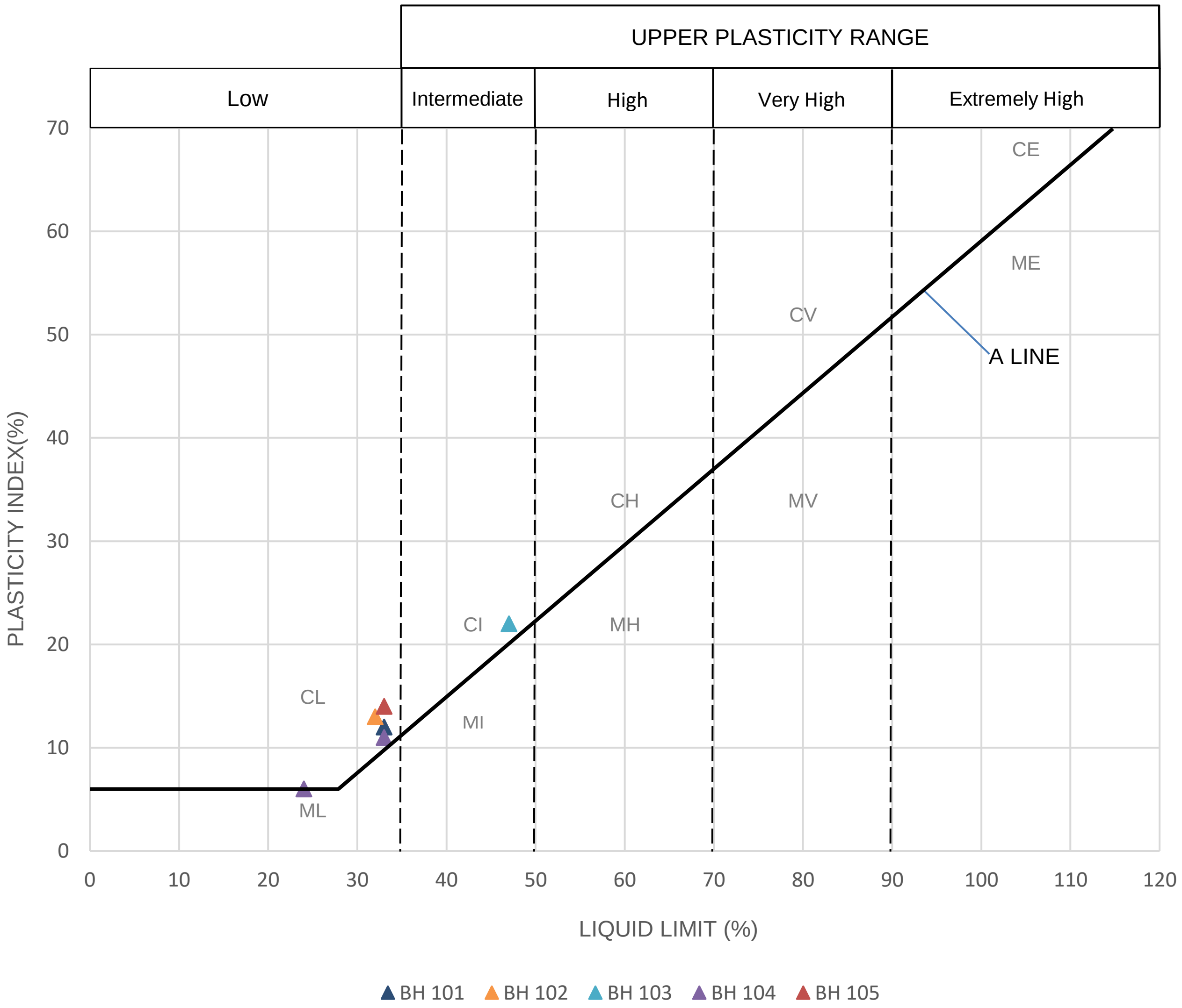
CLAY	SILT			SAND			GRAVEL			COBBLES
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
11%				15%			75%			0%

PARTICLE SIZE DISTRIBUTION

Project Reference
22.09.023a



WATER CONTENT v DEPTH	Report: 22.09.023a



PLASTICITY CHART	Report: 22.09.023a