

GEOTECHNICAL INVESTIGATION REPORT
Residential Development at High Peak Barkway, Hertfordshire. SG8 8EY

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CON71-BARK-001

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London Road
Barkway
Hertfordshire
SG8 8EY

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London Road
Barkway
Hertfordshire
SG8 8EY

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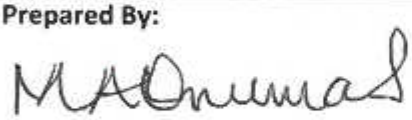

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EXECUTIVE SUMMARY

Stansted Environmental Services (SES) was commissioned by Laurel Developments through an Acceptance of Proposal document dated 4th December 2017 to undertaken a ground investigation at High Peak, London Road, Barkway, Royston, Hertfordshire, SG8 8EY to identify the geotechnical characteristics of the ground to provide the basis for the design of efficient, economic and safe foundations.

The site is bounded to the North and West by Nuthampstead Road and London Road, respectively. The Eastern boundary of the site is shared with an open expanse of land and a residential building is located on the Southern boundary.

It is understood that the residential development will comprise the extension of an existing single-storey building into a two storey building and the construction of an additional two dwellings of 1½-2 storeys in height. The development will also include driveways, landscaped and garden areas. The proposed site layout is shown in Appendix B.

The British Geological Survey, (BGS), website indicates that the Superficial geology of the site consists of The Lowestoft Formation formed of chalky till which comprise gravels, sands, silts and clays. The till content is characterized by chalk and flints. The bedrock geology below the superficial deposit is the Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated).

A site walkover was undertaken on the 6th December 2017. Field works were then carried out between 4th and 11th January 2018, which comprised five rotary drilled boreholes to depths of between 3.0m bgl (123.58m OD) and 5.0m bgl (121.55m OD). Representative sampling and in-situ testing was also performed, and chemical and geotechnical laboratory testing was carried on the retrieved samples to provide additional information.

The boreholes broadly encountered the anticipated geological sequence to the full depth of the investigation. Made Ground was proven to a depth of 0.4m bgl while the Chalky till was found to be between 0.2m bgl and 5.0m bgl.

Groundwater was not encountered during the fieldwork in any of the boreholes sunk but post-drilling monitoring visits recorded ground water at approximately 1.0m bgl in BH01 only.

The Made Ground has a poor load bearing capability; therefore, it is not considered a suitable stratum on which to set the foundation of the proposed dwellings. The Lowestoft deposit was found to be > 4.0m thick with geotechnical properties that could provide adequate bearing capacity for the proposed load. The clayey characteristic of this soil is considered to govern the engineering behaviour of the stratum.

Based on ground conditions, the use of strip foundations is considered safe and economical for the Upper and Lower Zones of the site as identified on the plan attached as Appendix B. For the Upper zone, a 600mm width strip foundation placed at 1.1m bgl provided an Allowable Net Bearing Pressure (ANBP) of 115 kN/m^2 while a 800mm wide strip foundation placed at 1.45m bgl gave an ANBP of 102 kN/m^2.

1. INTRODUCTION

This report was prepared by Stansted Environmental Services Limited (SES) upon the request of Laurel Developments through an Acceptance of Proposal document dated 4th December 2017. The content of this report comprises the final results of the Phase 2 Geotechnical Ground Investigation, the evaluation and conclusions of the laboratory tests conducted. Also, the recommendations on soil properties and relevant parameters required for the foundation design and construction of the proposed residential dwellings at High Peak, London Road, Barkway, Royston, Hertfordshire, SG8 8EY are presented.

This Geotechnical Investigation Report was prepared in accordance with AGS Guidelines and in conformance to BS 5930:2015. There was no construction activity on site at the time of the site investigation works, but an existing building was in use as a residential dwelling. It is understood from the project brief provided by the client that the development intends to include landscaped and garden areas.

The purpose of this site investigation was to establish the prevailing ground stratigraphy and conditions, determine the relevant ground characteristics and parameters to inform the design of a suitable and safe foundation whilst being mindful of the client's aspirations to construct asphalt drive ways.

In addition to the intrusive ground investigation, this study consulted and reviewed existing geotechnical, topographical, hydrological, hydrogeological, geological information relating to the site.

Attention is drawn to the fact that whilst every effort has been made to ensure the accuracy of the data supplied and any analysis derived from it, there is the potential for variations in ground conditions and contamination between and beyond the specific locations investigated. No liability can be accepted for any such variations. Furthermore, any recommendations are specific to the clients' requirements and no liability will be accepted should these be used by third parties without prior consultation with SES.

2. SITE SETTING

2.1. Site Location

The site is located at High Peak, London Road, Barkway, Royston, Hertfordshire, SG8 8EY and may be located by National Grid Reference (NGR) TL 384348. The site location is shown in Figure 1.

The site is located within a rural area. The immediate surrounding area comprises a mixture of residential buildings, commercial property and farmland set in close proximity to the village centre. Within the immediate surrounding is mixture of activities including trades services and residential properties.

A site reconnaissance was carried out on the 6th December 2017. As at the time of the walkover and field investigation, the site was occupied by a residential building that had been extended to the front from the original structure. There was no construction activity on site during the time of this investigation.

The area of the site was estimated to be 2450 m^2. The land is relatively flat and shaped like a stretched pentagon situated within a countryside setting. The tip of the land faces the west and the base towards the east.

Historical records showed that the existing building was the last development on this land.

The unoccupied ground surface is mainly grassed with some areas lightly vegetated, consisting of shrubs, conifer, hedge and some mature trees dotted along the western boundary. An asphalt driveway covers a portion of the ground area between the garage and the existing building.

The site elevation above sea level is approximately 126.6m AOD which is slightly lower than the adjacent roads.

Figure 1: Site Location



2.2. Site Description

The proposed building development will be constructed on a site area estimated to be 2450 m^2. The site is relatively level with a slight slope from west (Existing building) to east (Garage) and shaped like a stretched pentagon situated within a countryside setting.

A main drain line runs under Nuthampstead road which also serve as the main vehicular access into the site.

During the field investigation, the land was occupied by a two-storey Victorian building, a stand-alone garage, three wooden sheds and mature gardens. The planted area covered approximately 80% of the unoccupied land while about 20% is taken up by the asphalt drive way.

The planted ground included an area of grass and dense vegetation with a further area covered by mature trees, dense vegetation, shrubs, hedges, conifers and asphalt drive way. The species of trees included Sycamore, Willow and Walnut and Chestnut. The spatial arrangement of these plants is shown in Appendix B.

The site perimeter is defined by a 1.8m close boarded fence to all of the sites boundaries.

The existing building on site occupies the North-West area of the plot. Historical records show that the existing building may have been built during the Victorian period, and is the last development on the site. The original 2 storey building was extended to the front.

2.3. Historical Site Investigation

During the field investigation, a water well of 1.5m diameter in excess of 22m deep was identified at approximately 6.5m from the southern boundary (on approximately a central line). The details of the well and the type of construction materials used for the installation indicated that it was unlikely that the original purpose of the well is associated with a previous ground investigation.

2.4. Existing Building Foundations

Noticeable fine cracks on the external walls and lintels suggest some structural movement. This could be associated to several factors which may include structural defects of decay, ground movement from seasonal variations in ground moisture content and foundation failure.

Three (3) trenches were hand dug adjacent to the external walls of the existing building to expose and examine the foundation. The foundation is similar to a stepped brick concrete foundation estimated to be between 400 – 500 mm wide placed at a depth of approximately 0.4m bgl and 0.5m bgl in the Lowestoft soil. Photographs and a schematic diagram of the exposed foundation are depicted in Appendices E & F respectively.

2.5. Site Boundaries

The site is bordered to the west and north by London Road and Nuthampstead road, respectively. The site shares its eastern boundary with an empty plot, which was assumed to be farmland. The southern boundary is shared with a building occupied for residential dwelling.

2.6. Published Geological Setting

The superficial deposit of the site is published in the British Geological Survey (1995), Hitchin, England and Wales Map 1:50 000, Sheet 221, Solid and Drift Geology as consisting of the Lowestoft Formation formed of Chalky Till of the Anglian Glacial which comprise gravels, sands, silts and clays. The Till content is characterized by chalk and flints. The bedrock geology below the superficial deposit is the Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated).

The BGS record of a nearby borehole, located approximately 1.7Km south-east of the site, indicated that the superficial geology may likely consist of Boulder Clay overlying the Upper Chalk. A copy of this borehole log is included in Appendix A.

2.7. Hydrology and hydrogeological settings

According to Environment Agency map, the potential of flooding risk from surface water is very low.

The superficial Lowestoft deposit is designated as a Secondary Aquifer (undifferentiated) overlying the Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated) which has been classified by the Environment Agency as a Principal Aquifer.

The site is located within a Total Catchment (Zone 3) for groundwater source protection zone. At the time of this investigation, there was no record of licenced ground water abstraction points within 500m from the site. However, two licenced abstraction from surface water and groundwater points was noted within 1.5Km and 2.0Km, respectively, from the site.

3. PROPOSED DEVELOPMENT

The project brief proposes to redevelop the site with the extension of an existing single-storey building into a two storey building and the construction of an additional two dwellings of 1½-2 storeys in height. The development will also comprise driveways, landscaped and garden areas. The proposed site layout is shown in Appendix B.

The imposed foundation load from the proposed buildings is assumed to be of a Geotechnical Category 2 structure adopting domestic and residential activities.

4. FIELD WORK AND LABORATORY TESTING

The field works were undertaken between 4th and 11th January 2018 and comprised five rotary drilled boreholes to depths between 3.8m bgl to 5.0m bgl, the installation of monitoring stand pipes, and the retrieval of representative disturbed and undisturbed soil samples and in-situ testing.

All field work procedures conformed to BS 10175:2001, BS 5930:2015 and ISO 1997:2007. Also, the AGS guidelines for good practice in geotechnical ground investigation were incorporated in all field works. The structure of this report conforms to the AGS Guide to Ground Investigation Reports.

4.1. Exploratory Holes

Five vertical boreholes, BH01, BH02, BH03, BH04 and BH05, were drilled by rotary drilling techniques at positions determined by SES as shown on the exploratory hole location plan attached as Appendix B.

The borehole records and drilled depth for each borehole and encountered geology are presented in Appendix C.

The field works were supervised by a Geotechnical Engineer from SES.

4.2. Geotechnical Sampling and Laboratory Testing

Representative disturbed samples were taken at pre-determined depths from the encountered strata. The sampling frequency adopted is detailed in the borehole logs, attached as Appendix C.

All samples were visually classified and logged by a competent Geotechnical Engineer from SES.

Samples were conserved in the field following best practice and thereafter shipped to a UKAS accredited laboratory for testing.

In-situ and laboratory testing were undertaken on all the geological layers encountered during the drilling works.

The geotechnical laboratory testing was scheduled by SES to provide and determine soil properties and design parameters for the proposed project.

The laboratory tests included classification and chemical testing. The classification tests were conducted by Soil Properties Testing Limited while Concept Life Sciences carried out the chemical analysis.

Unless otherwise stated, all applied laboratory test procedures were in accordance to BS 1377 "Methods of Test for Soils for Civil Engineering Purposes."

The following accredited test procedures were carried out

- Atterberg Limits Determination
- Moisture Content Test
- BRE SD1 Tests
- Triaxial Compression Test Multi Stage

The summary of laboratory tests carried out on each soil stratum is shown in Table 1 and the details of the laboratory test report are presented in Appendix D.

Table 1: Summary of Laboratory Tests

Strata Description	Strata Group	BH01	BH02	BH03	BH04	BH05	Depth range (mbgl)	Geotechnical Test				Chemical Test	
								Water Content	Triaxial compression test	Particle size distribution	Atterberg limits	Sulphate Test (2:1 Water Soluble)	pH
Grass/Concrete paving over black gravelly SAND	Made Ground	0.2	0.1	0.1	0.1	0.1	0.1 - 0.2	0	0	0	0	0	0
Soft to firm slightly sandly gravely CLAY	Made Ground	0.4	0.4	0.3	0.4	0.4	0.3 - 0.4	0	0	0	0	0	0
Stiff brown slightly sandy slightly gravelly CLAY.	Lowestoft	3.0	5.0	5.0	3.8	3.8	3.0 - 5.0	5	1	1	5	3	3

5. ENCOUNTERED GROUND CONDITIONS

The ground stratigraphy revealed during the intrusive investigation is similar to the geological records for the study area published in the British Geological Survey (1995), Hitchin, England and Wales Map 1:50 000, Sheet 221, Solid and Drift Geology.

The superficial geology was expected to consist of the Lowestoft Formation formed of Chalky Till of the Anglian Glacial which comprised gravels, sands, silts and clays. The Till content is to be characterized by chalk and flints. The superficial layer encountered was described as stiff to very stiff brown slightly sandy slightly gravelly CLAY (Lowestoft formation). The grading of the sand particles ranged from fine to medium while the gravels were fine to medium angular to sub-angular fragments of Chalk and flint.

The Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated) was not encountered during the investigation works. However this is recorded as the anticipated bedrock below the superficial deposits noted in the BGS record sheets.

The summary description of the geological strata and the depth range at which they were encountered in each borehole during the intrusive investigation are given in Table 2. A detailed description of each stratum is presented in the borehole logs attached as Appendix C.

Table 2: Summary of geological strata across site

Geological strata	BH01 (mbgl)	BH02 (mbgl)	BH03 (mbgl)	BH04 (mbgl)	BH05 (mbgl)	Depth range (mbgl)	Summary of strata description
Made Ground	0.1	-				0.0 - 0.1	Concrete paving/Topsoil
Made Ground	0.2	0.1	0.1	0.1	0.1	0.0 - 0.2	Black gravelly SAND. Sand is fine to medium. Gravel is angular to sub-angular fine to medium granites.
Made Ground	0.4	0.4	0.3	0.4	0.4	0.1 - 0.4	Firm grey slightly sandy slightly gravelly CLAY. Sand is fine to medium. Gravel is angular to sub-rounded fine to coarse of various lithologies including fragments of granites, concretes, and red bricks.
Lowestoft formation	3.0	5.0	5.0	3.8	3.8	0.4 - 5.0	Stiff brown slightly sandy slightly gravelly CLAY. Sand is fine to medium. Gravel is angular to sub-angular fine to medium Chalk and flint fragments.

Three hand excavated trenches (0.6m wide by 1.0m length) were dug to expose the existing foundations which was encountered at a depth of approximately 0.4m below the existing ground level. The structure of the existing foundation is similar to that of a strip foundation and the schematic diagram of the exposed foundation is attached in Appendix F.

The ground stratigraphy observed in the boreholes and machine excavated pits are consistent with the anticipated succession of geological strata: Made Ground over Lowestoft formation (stiff sandy gravelly Clay).

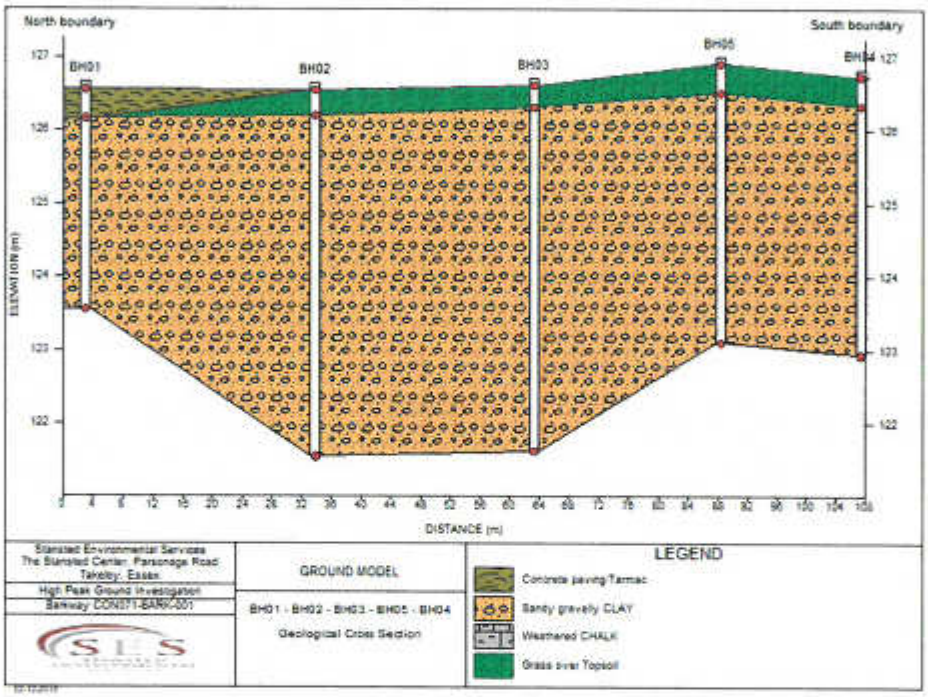
No obstructions were met during the advancement of drilling in all five boreholes. However, fragments of coarse gravels and cobbles of flint were recovered during drilling which were more frequent with depth.

During drilling groundwater was not encountered in any boreholes. Post drilling monitoring visits identified groundwater in BH01 at approximately 1.0m bgl. Details of the standpipes installed are included in Appendix C.

A geological section of the stretched-out path BH01-BH02-BH03-BH05-BH04 to cover the entire site is presented in Figure 2.

The succession of geological strata, based on the five boreholes sunk during the site investigation, appears to be consistent across the site. However, due to the variability of ground conditions, this does not indicate consistent geotechnical properties across the site and as such this information should be used with caution.

Figure 2: Geological cross-section



6. GEOTECHNICAL ASSESSMENT AND RECOMMENDATIONS IN RELATION TO THE PROPOSED DESIGN

6.1. Details of proposed development

It is understood that the redevelopment will comprise three number 1½ to 2 storey replacement dwellings. The redevelopment scheme will comprise driveways, landscaped and garden areas.

6.2. Assessment of ground conditions

The assessment of ground conditions of the site was based on information gathered from the soil samples retrieved and examined during the drilling of five boreholes, the examination of hand dug trenches, available published information and the prevailing environmental setting of the site as at the time of the investigation. The sequence of encountered geology, described previously in Table 2, is Made Ground over the Lowestoft formation underlain by the Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated).

Made Ground: Two layers of Made Ground were encountered, asphalt hardstanding and reworked clay soil. The hardstanding comprises asphalt and concrete paving over gravelly SAND encountered between ground level and 0.2m bgl. Underlying the hardstanding is a brownish clay fill that extended to about 0.4m bgl. The clay has a consistency ranging from soft to firm. The fill is slightly sandy with some fine to medium fragments of concrete, chalk, red brick and flint gravels.

The Made Ground is not recommended as a load bearing layer and the placement of foundations within this zone should be avoided.

Lowestoft Formation: Underlying the Made Ground, between 0.4m bgl and 5.0m bgl, is the Lowestoft deposit comprising a variety of soil particles including clay, sand and gravels. This Chalky Till is described as firm to stiff dark brown slightly sandy slightly gravelly CLAY. The size of the sand grains ranged from fine to coarse. The gravels are angular to sub-angular fine to medium of various lithologies including flints, white chalk, quartzite and sandstones. The recovered gravels from the Lowestoft formation are mainly flints but there may be the possibility of encountering flint cobbles or larger, hence difficult ground may be expected.

The geological cross section (Figure 2) shows that this Lowestoft strata appeared in all of the boreholes sunk, suggesting that the layer may be present across the entire site. The geological cross sections indicated a relatively consistent average thickness of >3.0m for this stratum.

Bringing into context, the layout of the proposed buildings, the environmental settings, the observed ground conditions, results from in-situ and laboratory test results it was apparent that the Lowestoft formation may potentially exhibit two distinct geotechnical properties. This was evident from the difference in ground water content and volume change potential. On this basis, the site was zoned into two (Figure 3), the Upper zone and Lower zone.

The Upper zone comprises the portion of the land towards the London Road (western part of the site). The geotechnical assessment of the ground within this zone was based on data obtained from BH03, BH04 and BH05. The sequence of encountered soil strata in this zone is represented by the geological cross section of the path from BH04-BH05-BH03. The existing residential building, which the Client intends to extend, was within this zone as at the time of the investigation. The adjacent land to the south of this building is the proposed area for the construction of two detached 1-1/2 storey buildings. A pre-existing water well was observed within the footprint of the proposed detached dwellings. Attached in Appendix B is a plan showing the spatial distribution of plants and mature moderate to high water demand trees in close proximity to the proposed building. The ground surface around this zone was relatively dry during the field study and the laboratory test results showed lower ground water content. These ground conditions may be attributed to the

presence of the moderate-high water demand trees. The laboratory test results of the sub-soil samples collected from BH03, BH04 and BH05 indicate that the Lowestoft layer may exhibit a low volume change potential. For foundation design purposes, a low shrinkage soil and high-water demand tree is adopted for this area.

For the Upper zone, a conservative undrained shear strength (Stroud, 1974) of 70 kN/m^2 is recommended for this soil layer between 1.2m and 2.5m. Based on modified plasticity index, the expansion potential of this stratum within the Upper zone is classified as low. Groundwater was not encountered in the boreholes sunk within this zone. However, the groundwater depth at 6.9m bgl measured in the existing water well is taken as a representative groundwater level for the entire site.

The Lower zone cover the plot area in the east part of the site, where the garage is located. The ground condition of this zone was assessed based on data collected from BH01, BH02 and BH03 (Figure 3). Directly behind the garage, outside the site boundary, a dense vegetation with mature tree was observed during the site investigation. The water content of samples taken from this zone showed some relatively higher values which is consistent with the marshy-ground condition observed in the area during field investigation. The surface water infiltration rate within this zone was observed very slow suggesting a low soil permeability. The laboratory test results of the sub-soil samples collected from BH02, BH02 and BH03 showed a mixture of medium volume change potential and low volume change potential.

For the lower zone area, a value of 63 kN/m^2 (Stroud, 1974) is taken as a conservative undrained shear strength for this soil layer between 1.45m bgl and 3.0m bgl. A medium volume change potential and a moderate water demand tree is adopted for this area for design. During drilling, groundwater was not encountered in the boreholes sunk within this zone. However, post-drilling monitoring visit recorded water at about 1.0m bgl in BH01. Based on the prevailing site setting and ground characteristics, the water recorded in BH01 is considered to be a transient surface water due to poor drainage of this zone.

The results of the plasticity index laboratory test are shown in Appendix D while a summary of plasticity index and modified plasticity index are shown in Table 3.

Table 3: Plasticity Index Record

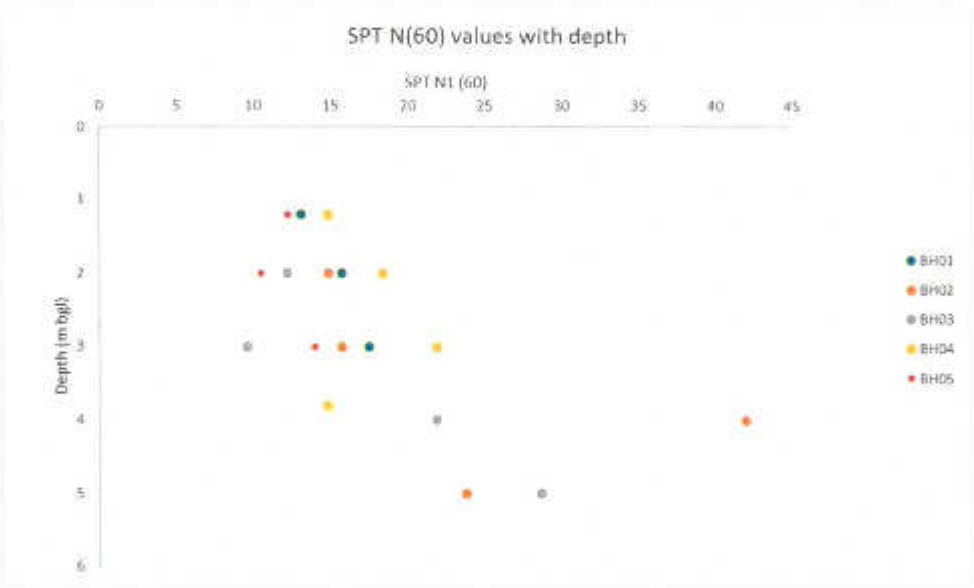
Borehole	Depth	Moisture content (%)	Plasticity Index (PI) %	% < 425um	Modified PI (%)	Volume change potential	Class	Geological Strata	Strata Description
BH01	1.20	20.3	29	91	26	Medium	CL	Lowestoft formation	Stiff to very stiff brown slightly sandy slightly gravelly CLAY.
BH02	2.00	18.8	25	66	17	Low	CL		
BH04	3.80	11.6	11	36	4	Low	CL		
BH05	4.00	15.7	8	41	3	Low	CL		
BH03	5.00	11.0	6	40	2	Low	CL/ML		

The anticipated Chalk bedrock was not encountered during this investigation. However, as part of the field study, there were no observable signs on the ground surface that are indicative of probable Chalk dissolution features. Chalk being a variety of Limestone could exhibit dissolution features influenced by local geological conditions, and the pattern and frequency of bedrock fractures/discontinuities. However, the risk of such features existing at this site is judged to be very low.

Generally, the sequence of stratigraphy observed from this site is analogous to the geology recorded for the existing borehole outside the site.

The scatter plot of corrected SPT N-values obtained from in-situ testing is shown in Figure 4. The measured SPT N-values were not used directly to derive soil properties and parameters, they were corrected to account for any variability in measurements, equipment and overburden stress. Following best engineering judgement, the lower bound of corrected SPT N-values were adopted and applied in empirical derivations of soil properties presented in this report. Corrected SPT N-values with depth are depicted in Figure 4.

Figure 4: Scatter plot of SPT N-values with depth



It is unlikely that a significant amount of water will be encountered during shallow excavation for foundation construction, however, it is recommended to consider adequate groundwater control measures during excavation.

All excavation should be provided with adequate ground support. Although deep excavations are not anticipated, deeper excavation may encounter some difficulties due to the presence of frequent flint cobbles.

Good practice for the management of excavations should be adopted to include proper planning and risk assessment with a competent person engaged to continually inspect the exposed excavation faces and supports.

6.3. Foundation design

The stratigraphy encountered from the intrusive investigation appears to be consistent across the site based on the geological cross-section of the Upper Zone and Lower Zone areas. The sequence of stratigraphy identified during investigation was Made Ground overlying the Lowestoft soil.

Based on our understanding of the project brief provided by the client, a wall-line load of 50kN/m run is adopted assuming that a 300mm thick cavity brick and wall construction will be used.

Following our review of the Project brief provided by the client, and taking into account the Geotechnical Category of the proposed buildings and encountered ground conditions, the Made Ground should not be used for load bearing.

Evaluation of ground volume change potential was based on modified Plasticity Index in line with NHBC recommendations. The Modified Plasticity Index results (Table 3) indicates that the Lowestoft

layer may be characterized with medium volume change potential within the Lower Zone and low volume change potential within the Upper Zone.

The undrained shear strength of the Lowestoft stratum, at the Upper and Lower zones, are indicative of a competent layer that could support the applied load from the proposed development. A shallow strip foundation set on this layer presents sufficient bearing capacity to support the load from the proposed dwelling development. Therefore, strip foundations are the simplest and most cost-effective shallow foundation options recommended for this development, both at the Upper Zone and Lower zone areas.

The existing buildings on the Upper Zone is supported by a shallow strip foundation set at about 0.5m bgl within the Lowestoft stratum. During the investigation, several cracks were observed on the walls of existing buildings, shown in Appendix E, this suggests some possible ground movement issue. We do not recommend the use of the Lowestoft stratum at this depth for continued load bearing as it poses some risks from the effects of low volume change potential and the proximity of moderate and high-water demand trees. Therefore, a shallow foundation placed at a deeper depth is recommended to conform to NHBC Standards (2010). To ensure that both the general ground failure and structural settlement requirements are satisfied, it is recommended to place the strip foundation further into the ground at a depth of 1.1m bgl. A conservative characteristic shear strength value, for the Lowestoft layer between 1.1m bgl and 2.5mbgl, estimated after Stroud and Butler (1974), is taken as 70 kN/m^2. For a strip foundation, 600mm width placed at a depth of 1.1m bgl, the Ultimate Bearing Capacity of the ground at this level based on shear strength was 484 kN/m^2 (Brinch Hansen, 1970). Applying a safety factor of 3.0, a Safe Net Bearing Pressure of 161 kN/m^2 was obtained. Taking into account the sensitivity of the existing building to ground movement as noted in the site photograph showing cracks, and the close proximity of moderate and high-water demand tress, a further material partial factor of 1.4 was applied to limit total and differential settlements by adopting an Allowable Net Bearing Pressure (ANBP) of 115 kN/m^2 for the Upper Zone area.

It is recommended to backfill the existing water well within this area.

For the Lower Zone area, a foundation depth of 1.45m bgl is recommended for a medium shrinkage and moderate water demand trees. Empirical calculations using a shear strength of 63 kN/m^2 gave an Ultimate Bearing Capacity of 429 kN/m^2 (Brinch Hansen, 1970) for a strip footing 800mm wide. A safety factor of 3.0 was applied to give a Safe Net Bearing Pressure of 143 kN/m^2. On the basis that the Lower Zone area is marshy, a further material partial factor of 1.4 was applied to limit general ground failure and excessive settlement. Therefore, an Allowable Net Bearing Pressure (ANBP) of 102 kN/m^2 is recommended for adoption for the Lower Zone area.

6.4. Slope Stability

Conventional excavation equipment can be used to excavate the encountered soil though some difficulties should be expected due to gravelly and likely cobble contents.

During the borehole drilling, repeated borehole collapse was recorded indicating natural ground instability at near surface layers. The prevailing ground stability requires consideration for a detailed engineering assessment of slope stability and the need for suitable shoring.

As at the time of the investigation the source and characteristics of earth works materials were unknown. There is no guarantee that soils from the site could meet the specification for soils used in earthwork, but treatment for reuse could be a possibility provided the fill meets the standards of earthworks specifications for retaining wall.

6.5. Pavement design

California Bearing Ratio (CBR) values were empirically derived from correlations to SPT N-value after Liveneh et. al. (1992). The derived values for the upper layer between 0.5m bgl and 1.0m bgl is about 6%.

A CBR value between 2.5% and 3.0% is recommended for pavement design, however, IAN73/06 has recommended a subgrade improvement where the CBR values fall below 2.5%. It is recommended to conduct a CBR test upon exposure of the ground to obtain an intrinsic CBR value for final pavement design.

6.6. Floor Slabs

The floor slab could be placed on the ground surface for the proposed buildings located in the Upper zone, provided the design conforms to NHBC specifications.

Due to the expansive nature of the ground encountered within the Lower zone, a suspended floor may be more appropriate for this development to accommodate heave movement. The final design of the suspended floor slabs should conform to the NHBC minimum void requirement.

It is recommended to replace weak soil with suitable fill material and the formation layer proof-rolled and compacted.

6.7. Chemical Attack on Buried concrete

Chemical testing was carried out on three (3) soil samples taken from the Lowestoft formation. Following the guidance of BRE Special Digest 1:2005 Third Edition "Concrete in Aggressive Ground", Table C1 for natural ground classification, the Design Sulphate Class and ACEC Class have been established based upon the available laboratory results.

The analysis results showed water soluble sulphates in the range of 0.02g/l to 0.06g/l with pH in the range of 8.4 to 8.7. Assuming a natural ground condition and mobile groundwater, a Design Sulphate Class of DS-1 and ACEC Class of AC-1 should be adopted.

6.8. Radon

In accordance with BRE 211:2007, the site does not lie within a zone known to exceed the Radon gas threshold hence basic radon protection measures may not be needed. A good practice is to measure the levels of radon gas during construction.

7. SUMMARY AND CONCLUSIONS

Stansted Environmental Services Limited was commissioned by Laurel Developments to undertake a Geotechnical Investigation to determine the ground conditions at High Peak, London Road, Barkway, Royston, Hertfordshire SG8 8EY to aid foundation design and construction.

The geotechnical characteristics of the ground makes the site suitable for the proposed redevelopment.

The intrusive investigation was carried out between the 4th and 11th January 2018 covering five rotary boreholes, the installation of monitoring stand pipes, retrieval of representative disturbed soil samples, in-situ testing, geotechnical laboratory testing and reporting.

The site is located within a dispersed rural area. The immediate surrounding area comprises a mixture of residential buildings, commercial property and farmland set in close proximity to the town centre.

Within the immediate surrounding is a mixture of activities including trade services and residential properties. The site is bordered to the west and north by London Road and Nuthampstead Road, respectively. The site shares the eastern boundary with an empty plot, which was assumed to be a farmland. The southern boundary is shared with a building occupied for residential dwelling.

The geology encountered during this investigation is consistent with our anticipation and similar to the geological records of the existing nearby boreholes off-site. The site geology revealed during this investigation comprises Made Ground over Lowestoft soil. However, during the SES field investigation, observable ground surface conditions that may be indicative of the presence of Chalk dissolution features were not found. This is not guaranteed as Chalk being a variety of Limestone is generally cavernous naturally and could exhibit dissolution features influenced by local geological conditions, the pattern and frequency of bedrock fissures and anthropogenic causes etc. While the potential inherent risk of Chalk dissolution features may not be very obvious on this site, we recommend extra caution and specialist advice when dealing with foundations in Chalk.

Representative groundwater level may be within the depth of 6.9m bgl, which is below the recommended strip foundation depths of 1.1m bgl and 1.45m bgl proposed for this development.

The computed Allowable Net Bearing Pressure for a 600mm width strip foundation placed at 1.1m bgl, within the Upper zone, is at least 115 kN/m^2 while a 800mm wide strip foundation placed at 1.45m bgl within the Lower Zone gave an ANBP of 102 kN/m^2

Since it is likely that the subgrade may be variable, it is recommended that the ground formation should be treated as being frost susceptible for pavement design purposes, and therefore a minimum pavement thickness of 450mm should be considered. Also, the formation level should be carefully proof rolled and any soft or loose materials replaced with well compacted granular fill.

The ground characteristics and properties identified from this investigation suggest that the Lowestoft soil zone should be capable of providing adequate support for the predicted light loads of the proposed building through a shallow wide strip foundation.

APPENDICES

Appendix A –Existing Borehole Records Off-site
Appendix B – Plans & Figures
Appendix C – Borehole Records
Appendix D – Laboratory Test Reports
Appendix E – General Photos
Appendix F – Sketch of Existing Building Foundation
Appendix G – Summary of SPT Results

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A. RECORD OF NEAREST EXISTING OFF-SITE BOREHOLE

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British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 541547 : BGS Reference: TL43SW5
British National Grid (27700) : 540160,234950
Report an issue with this borehole

TL 43 SW/5
4016.3495
1": 222

For Survey use only Licence No. N.....

222 / 329

RECORD OF WELL

At Nuthampstead Bury

Town or Village Nuthampstead

County Herts

EXACT SITE OF WELL

Six-inch sheet 9NW-E Six-inch National Grid sheet TL 43 SW [401 349]

For ..... State whether owner, tenant, builder, contractor, consultant, etc.:—

Address (if different from above).....

Level of ~~ground surface~~ top of tubes above sea level (O.D.) 1387.43 ft. levelled

If well top is not at ground level, state how far ..... above:* below: ..... ft.

SHAFT ..... ft.; diameter ..... ft.; HEADINGS (please attach details—dimensions and directions)

BORE ? ft.; diameter of bore: at top 4 in.; at bottom ..... in.

Full details of permanent lining tubes (position, length, diameter, plain, slotted etc.).....

Water struck at depths of ..... ft. below well top.

TEST CONDITIONS

Rest level of water ..... ft. above* below well top. Suction at ..... ft. Yield on ..... hours'* days' test pumping at ..... galls. per ..... with depression to ..... ft. below well top.

Recovery to rest level in ..... mins.* hours Capacity of pump ..... g.p.h. Date of measurements .....

NORMAL CONDITIONS

DESCRIPTION OF PERMANENT PUMPING EQUIPMENT:

Make and/or type ..... Motive power .....

Capacity ..... galls. per hour. Suction at ..... ft. below well top.

Amount pumped ..... galls. per day. Estimated consumption ..... galls. per week.

Well made by ..... Date of sinking .....

Information from Forbes' report appendix WE 204 Melbourn

ADDITIONAL NOTES ANALYSIS (please attach copy if available)

? Boulder clay UCK

RWL 81'6" 29/4/66

Disused. Headgear rising main and pump had to be lifted 1'6" to gain temporary access

MJC 7/7

DATA Bank

For Survey use only

Date Received 4/8/69

Section 6 .....

Pumping test .....

Observ. well .....

Recorder .....

R.R. log .....

Site marked on

1" map ⊙

6" map △ (use symbol)

Record forwarded

to .....

date .....

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

BGS ID: 541547 : BGS Reference: TL43SW5
British National Grid (27700) : 540160,234950
Report an issue with this borehole

For Survey use only Licence No. N.....

222 TL 43/15 / 329

RECORD OF WELL

At Nuthampstead Bury

Town or Village Nuthampstead

County Herts

EXACT SITE OF WELL

Six-inch sheet 9NW-E Six-inch National Grid sheet TL 43SW [401 349]

For ..... State whether owner, tenant, builder, contractor, consultant, etc.:— .....

Address (if different from above).....

* DELETE WHICHEVER IS INAPPLICABLE

Level of ~~ground-surface~~ top of tubes above sea level (O.D.) +387.43 ft. levelled

If well top is not at ground level, state how far ..... above:* below;.....ft.

SHAFT.....ft.; diameter.....ft.; HEADINGS (please attach details—dimensions and directions)

BORE ? ft.; diameter of bore: at top 4 in.; at bottom.....in.

Full details of permanent lining tubes (position, length, diameter, plain, slotted etc.).....

Water struck at depths of.....ft. below well top.

TEST CONDITIONS

Rest level of water.....ft. above* below well top. Suction at.....ft. Yield on..... hours'* days' test pumping at.....galls. per.....with depression to.....ft. below well top.

Recovery to rest level in..... mins.* hours Capacity of pump.....g.p.h. Date of measurements.....

NORMAL CONDITIONS

DESCRIPTION OF PERMANENT PUMPING EQUIPMENT:

Make and/or type.....Motive power.....

Capacity.....galls. per hour. Suction at.....ft. below well top.

Amount pumped.....galls. per day. Estimated consumption.....galls. per week.

Well made by.....Date of sinking.....

Information from Forbes' report appendix WE 204 Melbourn

ADDITIONAL NOTES ANALYSIS (please attach copy if available)

? Boulder clay UCK MJC 7/71

RWL 81'6" 29/4/66
Disused. Headgear rising main and pump had to be lifted 1'6" to gain temporary access

DATA Bank

For Survey use only

Date Received 4/8/69

Section 6 .....

Pumping test .....

Observ. well .....

Recorder .....

E.R. log .....

Site marked on

1" map ⊖

6" map △ (use symbol)

1094 1169 M.P.Ltd. G.722

33/11/59 (3697) W1.54188—P.S.47

LOG OF STRATA OVERLEAF.

Record forwarded

to .....

date .....

GEOLOGICAL SURVEY,
WATER DIVISION,
SOUTH KENSINGTON,
LONDON, S.W.7.

B. PLANS & FIGURES

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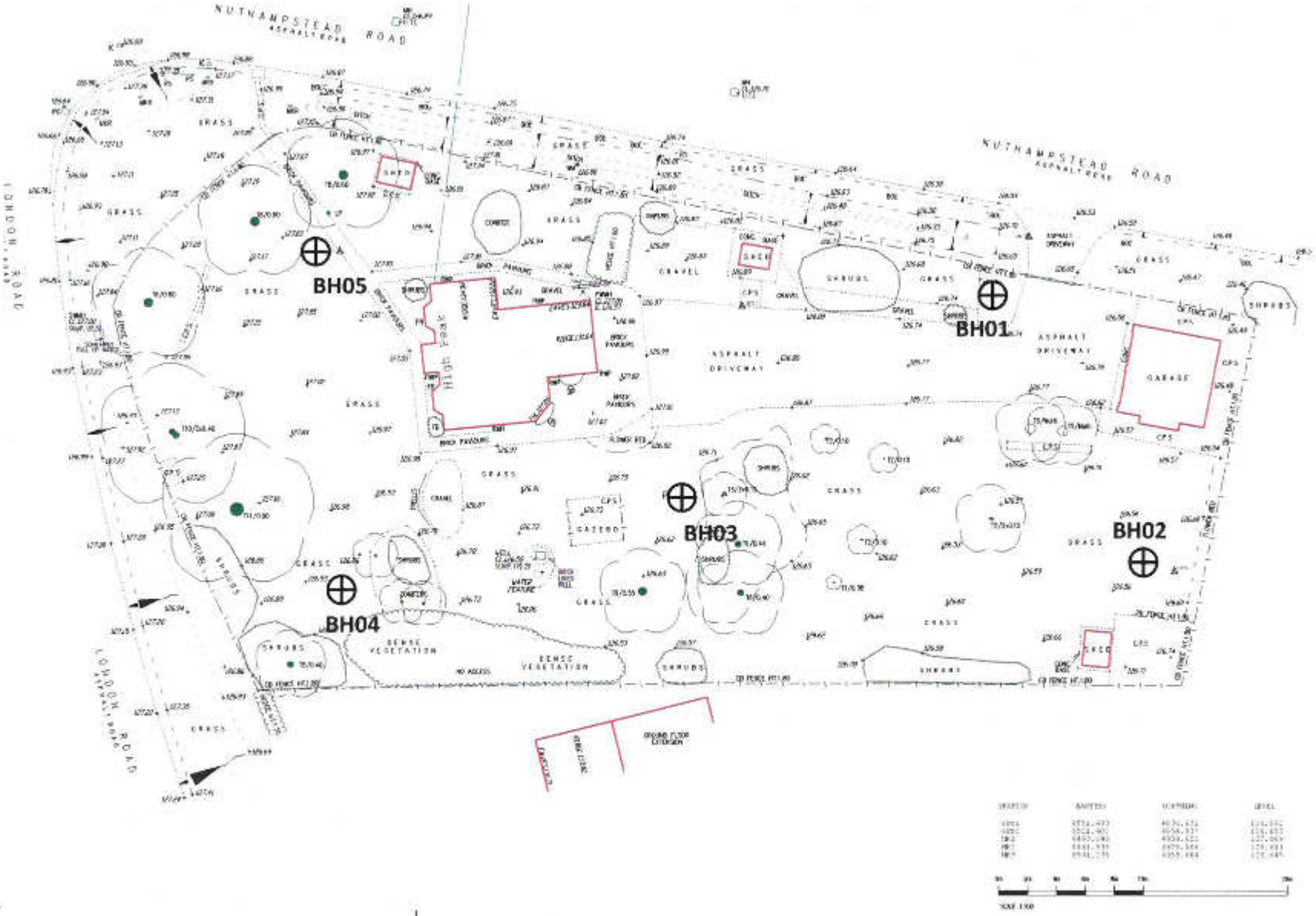


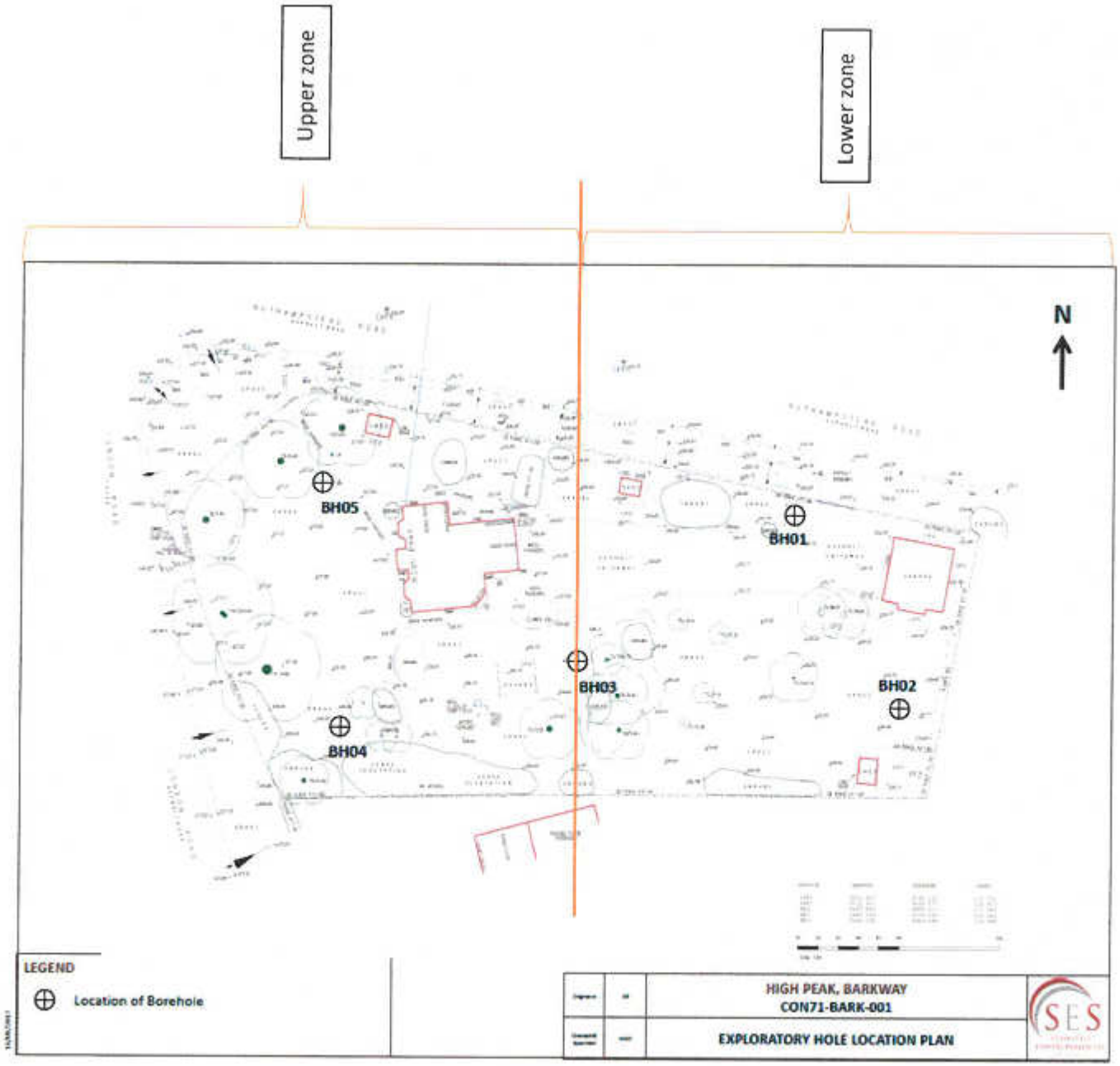
LEGEND

⊕ Location of Borehole

Originator:	GR	HIGH PEAK, BARKWAY CON71-BARK-001
Checked & Approved:	WH	EXPLORATORY HOLE LOCATION PLAN

SES STANSTED ENVIRONMENTAL SERVICES

16/08/2017


Upper zone
Lower zone
N
BH05
BH01
BH03
BH02
BH04
LEGEND
Location of Borehole
HIGH PEAK, BARKWAY
CON71-BARK-001
EXPLORATORY HOLE LOCATION PLAN
SES

C. BOREHOLE RECORDS

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Stansted Environmental Services Limited The Stansted Centre, Parsonage Road Takeley,Essex,CM22 5PU	Site High Peak, Barkway		Borehole Number **BH01**
Machine : Massenza MI3 **Flush :** Water **Core Dia:** 101 mm **Method :** Rotary	**Casing Diameter** 101mm cased to 3.00m	**Ground Level (mOD)** 126.60	**Client** Laurel Developments	**Job Number** CON71-EARK-001
	Location See site plan	**Dates** 08/01/2018	**Project Contractor** -	**Sheet** 1/1

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						126.50	0.10	CONCRETE PAVING (MADEGROUND)		
						126.40	0.20 (0.20)	Black gravelly SAND. Sand id fine to coarse. Gravel is fine to medium of granites. (MADEGROUND)		
						126.20	0.40	Soft grey slightly sandy slightly gravelly CLAY. Sand is fine to medium. Gravel is angular to sub-rounded fine to coarse of various lithologies including fragments of granites, concrete and brick. (MADEGROUND)		
1.20-1.65					1,2/2,4,4,5 SPT N=15			Firm to stiff brown slightly sandy slightly gravelly CLAY. Sand is fine to medium. Gravel is angular to sub-angular fine to medium fragments of Chalk and flints		
							(2.60)			
2.00-2.45					1,2/4,4,4,6 SPT N=18					
3.00-3.45					1,3/3,5,5,7 SPT N=20	123.60	3.00	Complete at 3.00m		

Remarks
Inspection pit hand dug to 1.2mbgl before the use of Rotary rig
Area CAT scanned before any excavation to check for underground services

Scale (approx)	Logged By
1:50	MAO

Figure No. B2

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Stansted Environmental Services Limited The Stansted Centre, Parsonage Road Takeley,Essex.CM22 5PU	Site High Peak, Barkway		Borehole Number **BH02**
Machine : Massenza MI3 **Flush :** Water **Core Dia:** 101 mm **Method :** Rotary	**Casing Diameter** 101mm cased to 5.00m	**Ground Level (mOD)** 126.60	**Client** Laurel Developments	**Job Number** GDN71-BARK-001
	Location See sit eplan	**Dates** 04/01/2018- 05/01/2018	**Project Contractor** -	**Sheet** 1/1

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						126.50	0.10 (0.25)	Black slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is sub-rounded fine of sandstones. Frequent rootlets (<2mm) (TOPSOIL)		
						126.25	0.35	Soft black slightly sandy slightly gravelly CLAY. Sand is fine to medium. Gravel is angular to sub-rounded fine to coarse of various lithologies including fragments of granites, concrete and brick. (MADEGROUND)		
1.20-1.65					2,2/2,4,4,4 SPT N=14			Firm to stiff brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular to sub-angular fine to coarse of flints, granite and white Chalk fragments.		
2.00-2.45					1,2/4,4,4,5 SPT N=17					
							(4.65)			
3.00-3.45					2,2/4,4,5,5 SPT N=18					
4.00-4.45					1,14/14,11,11,12 SPT N=48					
5.00-5.45					2,6/6,6,6,6 SPT N=24	121.60	5.00	Complete at 5.00m		

Remarks
Inspection pit hand dug to 1.2mbgl before the use of Rotary rig
Area CAT scanned before any excavation to check for underground services

Scale (approx)	Logged By
1:50	MAO

Figure No.
B3

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