

Newark Road
Peterborough
PE1 5UA
Tel: 01733 566566
Fax: 01733 315280

GROUND INVESTIGATION REPORT

LAND AT LOW ROAD &

PLANK DROVE

CROWLAND

LINCOLNSHIRE

Report Reference No. C14335

On behalf of:-

Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner
5 Mace Road
Peterborough
PE2 8RQ

December 2017

MR. C. SHARPE, MRS. L. FOX & MRS. E. SKINNER

BARKER STOREY MATTHEWS

REPORT ON A GROUND INVESTIGATION

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INTRODUCTION

Mr. C. Sharpe, Mrs. L. Fox and Mrs. E. Skinner (the clients) intend to construct a new residential development within land at Low Road and Plank Drove, Crowland, Lincolnshire. The proposals include low rise housing, together with gardens and access driveways. Further details of the proposed development were not available at the time of report preparation.

Ground Engineering Limited were instructed by the clients to undertake a ground investigation. The purpose was to provide geotechnical information on the underlying ground conditions in relation to foundation/pile design and construction. In addition, a contamination assessment was to be included within this investigation.

LOCATION, TOPOGRAPHY AND GEOLOGY OF THE SITE

The site is located within land to the immediate south of Low Road and east of Plank Drove, on the south-west outskirts of Crowland, Lincolnshire. The site is centred at approximate National Grid Reference TF 2337 0989. A site location plan is presented in Appendix 1, together with a plan of the existing site.

The trapezoid-shaped site has an approximately 60m wide frontage onto the southern side of Low Road from which it extends south for up to 165m.

At the time of the investigation the majority of the site comprised a fallow field. A detached bungalow with front and rear gardens, No. 18, was located near centrally in the northern part of the site, facing north onto Low Road. Several outbuildings were in the south-west corner of the site and were in a poor state of repair. With the exception of garden hedgerows around No. 18, the northern and western boundaries were open onto Low Road and Plank Drove, respectively. The eastern and southern boundaries were defined by hedgerows, separating the site from properties, respectively facing Beechcroft Gardens and an arable field. A field boundary drain was also along the southern edge of the site.

Various trees were within the garden of No. 18 Low Road, and along the southern and eastern site boundaries. These trees included mature Cypress, Hawthorn, Horse Chestnut, Poplar, Pine and Willow.

The site is generally level at approximately 3mOD. The surroundings generally slope gently down to the south-west to Fenland beyond, whereas the town of Crowland is on an island to the east. The straightened north-east flowing River Wellend is approximately 700m north of the site. Several associated straightened tributaries are also to the north, including New River about 100m north of the site, beyond Corporation Bank. The latter is an approximately 3m high flood alleviation bund opposite the site to the north.

The 1984 geological map of Peterborough at 1:50,000 scale, Sheet 158, shows the site and areas of higher ground to the east to be covered by a superficial deposit of Abbey Gravels

(Marine/Estuarine Sand and Gravel) and underlain by the solid geology of the Oxford Clay Formation. The low-lying Fenland, beyond the site to the west and south is indicated to be covered by superficial Nordelph Peat. Areas to the north of the site, beyond Corporation Bank are indicated to be covered by a superficial deposit of Alluvium, associated with the River Welland floodplain.

The Crowland Bed is a widespread layer of sandy silty clay or clay that is present above the Abbey Gravels in this locality, and typically contains pebbles from underlying deposits by repeated cryoturbation. The Crowland Bed is typically less than 1m thick and therefore not indicated on the geological map for this locality, but is detailed in the accompanying 1989 BGS geological memoir for the Peterborough district.

SITE WORK

The site work was undertaken on 14th, 15th and 17th November 2017, and comprised three cable percussion boreholes and seven machine excavated trial pits. The exploratory holes were positioned as shown approximately on the site plan presented in Appendix 1.

Detailed records of the boreholes have been produced in accordance with British Standard BS5930:2015 'Code of Practice for Site Investigations'. The exploratory hole records are presented in Appendix 2 and give the descriptions and depths of the various strata encountered, details of all samples taken, results of the in-situ tests, installation details and the groundwater conditions observed during excavation/boring, on completion, and subsequently within standpipes during return monitoring visits.

Prior to commencement of intrusive works, all available statutory service plans were provided by the client and consulted, and a cable avoidance tool (CAT) was used to confirm the absence of buried services at each exploratory hole position.

Cable Percussion Borehole

The boreholes (BH1, BH2 and BH3) were undertaken using a standard cable percussion rig. Prior to boring, a starter pit was dug at each position to 1.20m below ground level using hand tools, in order to ensure the absence of buried services. The boreholes were then advanced using weighted claycutter and shell tools, initially working within 150mm diameter casing. The boreholes were completed at the intended depths of 15.00m (BH1) and 10.00m (BH2 and BH3) below ground level.

Standard penetration tests were undertaken in order to give an indication of the in-situ relative density of the soils encountered at regular intervals. The test was made by driving a 50mm diameter solid cone point (C) into the soil at the base of the borehole by means of an automatic trip hammer weighing 63.50kg falling freely through 760mm. The penetration resistance was determined as the number of blows (N) required to drive the tool the final 300mm

of a total penetration of 450mm into the soil ahead of the borehole. The SPT results are tabulated to the rear of the borehole records.

Representative small disturbed (D) and bulk (B) samples of soil were taken from the boring tools at regular intervals throughout the depth of the boreholes.

A water sample (W) was taken from BH3 following a groundwater strike and once a sufficient quantity had entered the hole.

On completion of each borehole, 50mm diameter groundwater monitoring standpipes were installed to 5.00m depth with a pea gravel surround to within 1.00m of ground level. Above this, a top seal of bentonite was placed around each pipe. A rubber bung was installed in the top of each standpipe and protective stopcock cover was concreted into the ground flush with the surface over each installation. The boreholes were backfilled with clean arisings beneath the installations.

Trial Pits

The trial pits (TP1 to TP7) were undertaken using a JCB 3CX-type excavator to depths between 2.00m and 3.00m. The exposed strata were logged and the soils sampled by the supervising Geo-environmental Engineer.

Small disturbed (D) samples of soil were taken at regular intervals throughout these pits and placed in small plastic bags. Near surface soil samples were also sealed in polycarbonate pots and glass jars pending selection for chemical testing. Bulk disturbed (B) samples were obtained in selected trial pits and sealed in large plastic bags.

A hand vane (V) was used to determine the in-situ apparent shear strength in clay soil, where possible. The results, the average of three, are presented on the respective exploratory hole records and are plotted against depth in Figure 2, Appendix 3, together with the results of laboratory triaxial testing to 5.50m depth.

A Mackintosh Probe (MP) was used to ascertain the in-situ relative density of granular soils. The 25mm diameter solid cone point of the probe was screwed onto the rods and

driven into the ground by repeated blows of a 4.5kg slide hammer with a fall of 0.3m. The blow counts for each 0.30m driven or, alternatively the depth driven for 100 blows were recorded.

Prior to backfilling TP1, TP2 and TP3, soakaway tests were undertaken in broad accordance with BRE Digest 365. Water was delivered to the site, added to the excavations and the fall in water level was measured relative to a datum over a period of up to 295 minutes. Due to the slow rate of dissipation, only one filling was undertaken during the single day allocated for these tests. The results follow the respective trial pit records.

On completion the trial pits were backfilled with the spoil that was placed in compacted layers.

Photographs of the trial pits were taken by the supervising Geo-environmental Engineer and are presented with the respective trial pit records in Appendix 2.

Gas and Groundwater Monitoring

Three return visits were made on 24th November, 1st and 8th December 2017 in order to monitor the water level within the three borehole standpipes. Concentrations of methane, carbon dioxide and oxygen gas, together with ambient pressures and flow rates were also recorded. The water levels have been added to the borehole records and the gas/groundwater results are presented to the rear of Appendix 2. Groundwater samples were obtained from each standpipe during the second visit and sealed in 1 litre glass bottles, a 1 litre plastic bottles and a 15ml glass vials.

LABORATORY TESTING

The samples were inspected in the laboratory and assessments of the soil characteristics have been taken into account during preparation of the exploratory hole records. The soil sample descriptions are in accordance with BS5930:2015.

Geotechnical tests were conducted to BS1377:1990 and the results are presented in Appendix 3, whilst the results of the chemical tests are presented in Appendix 4.

Geotechnical Testing

The moisture content and index properties of selected soil samples were determined as a guide to soil classification and behaviour. The liquid limit was determined by a cone penetrometer. The moisture contents are plotted against depth in Figure 1, Appendix 3.

The particle size distributions of selected samples were obtained by sieve analysis. Results of these tests are given as particle size distribution curves at the end of this report.

Immediate undrained triaxial compression tests were made on selected undisturbed samples under a single cell pressure equivalent to the overburden pressure at each sample's depth. The moisture content and bulk density of the specimens were also determined. The triaxial test results are plotted together with the hand vane results to 5.50m depth in Figure 2, and separately to 15.00m depth in Figure 3, Appendix 3.

California Bearing Ratio (CBR) tests were performed on selected samples of the near surface soils. The test consisted of jacking into the remoulded soil a cylindrical plunger with a cross sectional area of 1935mm². A force of 50N was applied initially to seat the plunger on the soil surface and then the plunger was made to penetrate the soil at a uniform rate of 1mm/min. Readings of force were taken at intervals of penetration of 0.25mm to a penetration not exceeding 7.50mm. The CBR value is the ratio of the force required to achieve 2.50mm or 5.00mm penetration to standard forces expressed as a percentage.

Selected samples of soil were analysed to determine the concentration of soluble sulphates. The pH values were also determined using an electrometric method.

Chemical Testing

Chemical analysis of selected soil samples recovered from the exploratory holes was undertaken, by an independent laboratory, primarily for characterisation purposes. The samples were tested for a suite encompassing a wide range of potential contaminants outlined by the Environment Agency (EA) and National House Building Council (NHBC) document R&D 66; 2008 'Guidance for the Safe Development of Housing on Land Affected by Contamination'

Ten soil samples and one water sample recovered from the exploratory holes were tested for total concentrations of arsenic, cadmium, chromium, lead, mercury, selenium, nickel and benzo[a]pyrene (the CLEA suite), together with speciated polycyclic aromatic hydrocarbons (PAH), boron, copper and zinc, phenols, total and free cyanide, hexavalent chromium, sulphate, sulphide, and pH. The soil samples were also tested for organic content.

Four soil samples were tested for total petroleum hydrocarbons (TPH) and five soil samples were screened for the presence/absence of asbestos containing material (ACM).

The water sample was also tested for speciated TPH Criteria Working Group (CWG).

A sample of near surface soil from TP2 was scheduled for a Waste Acceptance Criteria (WAC) CEN Leachate Suite at 10l/kg.

GROUND CONDITIONS

The ground conditions comprised a 0.30m to 1.15m thick surface layer of made ground/topsoil, mantling the anticipated Crowland Bed over the Abbey Gravels. The initially reworked solid geology of the Oxford Clay was met below the superficial deposits at depths between 2.30m and 3.00m, with the shallowest proved in the eastern part of the site (BH3). The deepest borehole was completed within the Oxford Clay at 15.00m depth.

Made Ground/Topsoil

A surface layer of made ground, 0.20m to 0.60m thick, was encountered across the majority of the site, generally comprising firm, locally stiff where desiccated (TP4), dark brown or brown, slightly gravelly, sandy clay. This topsoil fill locally varied to clayey, sandy gravel in the south-west corner of the site (BH2). The gravel fraction comprised brick, flint and ash. Topsoil was locally met beneath the made ground or from ground level in near central and southern parts of the site (BH1 and BH3). This topsoil or buried topsoil generally comprised firm, friable, dark brown, slightly gravelly, sandy, clayey, slightly organic silt. The gravel fraction, where encountered, comprised flint, quartz, quartzite and limestone. The base of this topsoil or buried topsoil was proved across the site at depths between 0.30m and 1.15m.

Crowland Bed

The anticipated Crowland Bed was met beneath the topsoil fill or topsoil at depths between 0.30m and 1.15m. This comprised a 0.35m to 1.50m thick layer of firm, locally becoming soft, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty clay. Occasional cobble size pockets of clayey sand and gravel were noted within it below 1.20m depth in TP6. The base of the Crowland Bed was proved across the site at depths between 0.70m and 2.00m. The deepest was noted in TP6, located near centrally within the site.

Abbey Gravels

Below the Crowland Bed at 0.70m to 2.00m across the site, a 0.90m to 1.80m thick layer of coarse-grained Abbey Gravels was met. The shallowest was encountered in TP2, located in the southern part of the site. This was initially medium dense, orange brown, clayey, very gravelly sand, and became slightly silty, very sandy gravel with depth. A 0.20m thick pocket or lense of firm, orange brown and light grey mottled, slightly gravelly, sandy clay was met in TP2 at 1.50m depth, within the Abbey Gravels. The gravel fraction comprised angular to rounded flint, quartz, quartzite, ironstone and limestone. The base of the Abbey Gravels was proved at depths between 2.30m and 3.00m, with the deepest encountered in BH3 in the southern part of the site.

Oxford Clay

The Oxford Clay was met below Abbey Gravels across the site at depths below 2.30m to 3.00m. The shallowest Oxford Clay was encountered in BH1, located near centrally in the northern half of the site. The Oxford Clay was generally initially reworked, comprising a 0.20m to 0.50m thick layer of firm or soft, grey and orange brown mottled, slightly gravelly clay. The gravel fraction comprised angular rounded flint, quartz, quartzite and limestone. Below this reworked layer or below the Abbey Gravels in TP6, the Oxford Clay was stiff, locally very stiff, fissured, grey clay with occasional fossil shell fragments. The latter were less fragmented and recognisably bivalves (including gryphaea) with depth. This solid geology clay became very stiff below 8.00m or 8.50m depth, and below 12.50m depth in BH1, was hard. The three boreholes were completed within the Oxford Clay at 15.00m (BH1) or 10.00m (BH2 and BH3) depth.

Groundwater and Stability

Groundwater strikes were noted within the Abbey Gravels in all of the exploratory holes at depths between 1.90m and 2.60m, rising to depths between 1.70m and 2.50m within fifteen minutes. The shallowest groundwater strikes were noted in southern and near central parts of the site. In the boreholes, casing was installed to depths of 3.00m (BH1 and BH2) or 3.70m (BH3)

that sealed out this groundwater above the practically impervious Oxford Clay. On completion, prior to the withdrawal of the casing, the boreholes were recorded as dry.

The groundwater levels in the BH1, BH2 and BH3 standpipes during the subsequent return monitoring visits, undertaken during November and December 2017, were recorded at depths between 1.49m and 1.64m. The shallowest was noted in BH2, located within the south-west corner of the site. This groundwater is considered to be 'perched' within the Abbey Gravels, above the practically impervious Oxford Clay.

Live Roots

Live roots were observed in all of the exploratory holes to depths between 0.20m and 1.80m. The deepest live roots were noted in BH3, located in the south-east corner of the site, close to several mature Willow and Poplar trees.

Evidence of Contamination

The made ground locally within the site was found to contain occasional fragments of brick and ash. No visual or olfactory evidence of hydrocarbon contamination was detected in the exploratory holes. No apparent asbestos containing materials were observed within the made ground across the site.

COMMENTS ON THE GROUND CONDITIONS

IN RELATION TO FOUNDATION DESIGN & CONSTRUCTION

The investigation found a 0.60m to 0.80m thick layer of made ground/topsoil over a 0.35m to 1.50m thick layer of Crowland Bed clay over Abbey Gravels. The underlying solid geology of the initially reworked Oxford Clay was met at depths between 2.30m and 3.00m, below the medium dense Abbey Gravels. The made ground and topsoil should be avoided as bearing stratum. Foundations will also locally require deepening within clay soils due to the presence of trees within the site and along the site boundaries. The Abbey Gravels and Oxford Clay are suitable bearing strata for the adoption of deepened traditional pad or strip foundations. A piled foundation scheme may also be considered, with piles extending into the very stiff Oxford Clay at depth.

Mass Concrete Foundations

The exploratory holes encountered made ground and topsoil to depths between 0.20m and 1.15m across the site. Large scale processes of natural sedimentation allow a certain degree of confidence to be placed in the absence of important variation of the engineering properties of natural soils across sites. By contrast, made ground, whose history is not completely known, must, despite any amount of investigation, inevitably present the possibility of conditions existing which could not be accepted when considering the material as a bearing stratum. As such all foundations should be extended through the made ground/topsoil and into the underlying naturally deposited soils.

The underlying Crowland Bed had a modified plasticity index of 16%, which therefore has a low volume change potential. On an open site, at least 30m distant from the influence of trees, a minimum foundation depth of 0.75m below current or proposed ground level, whichever is greater within low volume change potential clay, would be required in order to be below the zone of seasonal volume change in accordance with modern building standards. In close proximity to trees foundations would require deepening within the Crowland Bed or extending into

the underlying non-shrinkable Abbey Gravels. The Abbey Gravels, met below the Crowland Bed at 0.70m to 2.00m depth across the site, above the Oxford Clay, is non-shrinkable and a minimum foundation depth of 0.60m below finished ground level could be used within this deposit.

The underlying Oxford Clay had a plasticity index of 29% and is rated as having a medium volume change potential. Various trees were within the garden of No. 18 Low Road, and along the southern and eastern site boundaries. These trees included mature Cypress, Hawthorn, Horse Chestnut, Pine, Poplar and Willow. The presence of trees within and around the site will locally have increased the depth affected by seasonal changes in moisture content of clay soils and consequently require deepened foundations. Reference to the National House Building Council (NHBC) Standards Chapter 4.2 'Building near trees' (2017), indicates for example, a required foundation depth of greater than 2.50m depth when at a distances of less than 8m from a mature Willow tree and less than 9m from a mature Poplar tree, within medium volume change potential soil. Further guidance on the necessary foundation depths relating to tree species, distance to the foundation and soil plasticity can be determined from the above cited document.

Live roots were noted to depths between 0.20m and 1.80m in the exploratory holes. The deepest live roots were noted in BH3, within the south-east corner of the site near several mature Willow and Poplar trees. The moisture contents, plotted to 5.50m depth in Figure 1, Appendix 3, and apparent cohesion results plotted to 5.50m depth in Figure 2, Appendix 3, indicate desiccation within the near surface buried topsoil and Crowland Bed clay to approximately 1.00m depth in BH3 and TP3, and locally to 1.80m depth in TP6. Indeed across the site, the Abbey Gravels was initially firm, becoming soft with depth, indicating near surface desiccation.

No evidence of significant desiccation is evident within the underlying Oxford Clay. An elevated triaxial shear strength result (254kPa) at 3.80m to 4.25m depth in BH3 is thought to be due to lithological variation, rather than desiccation, particularly as no live roots were encountered extending below the thick layer of water bearing Abbey Gravels. Indeed, the thickness of non-shrinkable sand and gravel above the Oxford Clay is sufficient to satisfy National House Building Council (NHBC) Standards Chapter 4.2 'Building near trees' (2017). Any

seasonal or root-induced volume change within the underlying Oxford Clay would not affect foundations based within the top of the overlying non-shrinkable Abbey Gravels.

For new foundations, excavations should be inspected for live roots, and where present in clay soils, deepened to at least 0.50m below the deepest visible root in the side of the footing trenches. It is considered that, due to the inferior bearing properties of the Crowland Bed, all foundation should be extended into the top of the underlying non-shrinkable Abbey Gravels which have far superior bearing properties. This would also reduce the potential for differential movements where foundations would otherwise span varying thicknesses and instances of soft clay over the medium dense sand and gravel.

In summary, foundations across the site should be extended through the made ground, topsoil and Crowland Bed, and deepened into the non-shrinkable Abbey Gravels met across the site at depths between 0.70m and 2.00m. The NHBC document should be referred to in any areas where trees are to remain, are removed or where any new planting or landscaped areas are proposed.

Bearing Capacity

A net allowable bearing pressure for the medium dense Abbey Gravels where present at its shallowest (0.70m depth in TP2) would be in the order of 150kN/m² for footings up to 1.20m wide for up to 25mm of immediate settlement. This should be sufficient for the proposed low rise buildings, and such foundation loads would not overstress the underlying Oxford Clay.

Piled Foundations

In the unlikely event that a piled foundation solution is required, the ground conditions are considered suitable for bored or CFA, but not driven piles as the vibrations during installation of driven piles could damage the neighbouring houses. The advice of specialist piling contractors should be sought as to their preferred method of pile installation in these conditions. Although not met in the exploratory holes attention should also be given to the potential

obstructions such as cobbles within the Abbey Gravels, or potential concretionary limestone nodules within the underlying Oxford Clay.

In order to avoid piles being subjected to the effect of future seasonal and tree root-induced moisture content and volume changes, predominantly heave, it will be necessary to either sleeve the piles to a minimum depth in excess of the maximum potential root depth, or ensure that the piles are reinforced sufficiently to withstand any uplift forces due to such changes. Similarly compressible material would need to be placed around pile caps and ground beams. These measures will be particularly relevant following the removal of trees from this site.

Preliminary working loads may be estimated for design and cost purposes using pile bearing coefficients, which are based on the following assumptions.

- 1) The ultimate load on a pile would be the sum of the side friction/adhesion acting on the pile shaft together with the end bearing load.

- 2) The pile bearing properties within potentially desiccated soils have been ignored.

- 3) In coarse-grained strata, the shaft friction would be a function of the in-situ standard penetration test results and effective overburden pressure. The groundwater level is assumed at approximately 1.50m depth, based on the conditions at the time of the return monitoring visit.

- 4) In clay, the shaft adhesion and end bearing would be a function of apparent cohesion values determined by the triaxial compression strength tests in the laboratory, plotted against depth in Figure 3, Appendix 3.

- 5) A factor of safety of at least 2.0 would be used to assess pile working loads. If test loading of selected piles were not practical the factor of safety would be increased to at least 2.5.

Item	Ultimate Pile Bearing Value kN/m ²
Shaft adhesion made ground/desiccated clays	Ignored
Average shaft friction in Abbey Gravels	5
Average shaft adhesion in stiff clay to 8.50m	50
Average shaft adhesion in very stiff clay, 8.50m to 12.50m	75
Average shaft adhesion in hard clay below 12.50m	100
End bearing in very stiff clay, 8.50m to 12.50m	1350
End bearing in hard clay below 12.50m	3700

Using these coefficients it is estimated that a single 450mm diameter bored pile installed to depths of 9.00m and 13.00m at BH1 would have anticipated working loads of 270kN and 340kN, respectively, each with a factor of safety of 2.5.

Different pile lengths, or diameters, from those detailed above would give different available working loads, which could be tailored to suit the working loads required. A piling specialist should undertake final design of piles.

Excavations

Excavations on this site are likely to be unstable and prone to collapse, particularly within the Abbey Gravels. Statutory safety precautions should not be neglected and excavations especially those where personnel are to enter, will need to be supported, or have battered sides where space permits. All excavations should be undertaken in accordance with CIRIA Report 97 *Trenching Practice*

Based on the conditions observed at the time of the investigation, groundwater was recorded within the Abbey Gravels standing at depths between 1.49m and 1.64m in the borehole standpipes, although shallower groundwater may be anticipated during wetter months. The

proposed foundation excavations, extending into the Abbey Gravels are likely to encounter groundwater, particularly when below about 1.50m depth. Inflows are likely to be accompanied by running sand conditions within the Abbey Gravels beneath this site, with ensuing side instability. Where inflows are encountered, dewatering by pumping from screened sumps should be sufficient to keep shallow excavations dry. Heavy pumping from screened sumps may be required for deeper excavations.

The base of foundation excavations should be inspected on completion to ensure that the condition of the soil complies with that assumed in design. Should pockets of inferior material, root infested clay, or made ground be present, they should be removed and replaced with well-graded, well compacted hardcore or lean mix concrete. The excavated surface should be protected from deterioration and a blinding layer of concrete used where foundations are not completed without delay.

Floor Slab

Away from trees, ground bearing floor slabs could be adopted for the proposed buildings, following removal of the surface layer of made ground, and provided that the sub-grade is inspected and any soft or root infested clay is removed and replaced with well graded, compacted coarse-grained fill material in accordance with the NHBC Standards Chapter 4.2. Incorporation of adequate reinforcement within the slab, removal of any root infested clay and compaction using a vibratory roller, should ensure that any such movements are minimised.

For areas of deeper made ground or root affected clay, suspended floor slabs would be more practical.

Pavement Design

The pavement formation across this site should either be within the near surface Crowland Bed or, at a reduced level, the Abbey Gravels. Laboratory CBR testing was undertaken

on four recompacted samples of near surface soils, three of which comprised Crowland Bed clay and one comprised Abbey Gravels.

The CBR results for the Crowland Bed clay were between 2.3% and 13%. The highest values were considered to be elevated due to some localised near surface desiccation of these clay soils, which were initially firm, becoming soft with depth. This clay had a plasticity index of 15%. IAN 73/06 (2009) Design Guidance for Road Pavements, recommends design CBR values of 3.0% and 4.0% for a thin pavement on clay with a plasticity index of 10% and 20%, respectively, a low water table and average construction conditions. A CBR design value of 3.0% is therefore considered to be appropriate for the near-surface clay soils.

The recompacted sample of Abbey Gravels tested in the laboratory had CBR results of 48% and 80%, which broadly agrees with IAN 73/06 (2009) Design Guidance for Road Pavements. The latter recommends a design CBR value of 60% for pavements on well graded sandy gravel, with a low water table and average construction conditions. However, the near surface Abbey Gravels was generally silty, with up to 20% passing the 75µm sieve, and should therefore be considered a frost susceptible soil, requiring a minimum construction thickness of 450mm.

A careful check should be made for soft and loose ground, and root-infested clay. If present, such poor ground should also be removed and replaced with well compacted coarse-grained fill. Similarly differential settlement could take place where former foundations and floors remain in the ground, as these would form 'hard spots'. These should also be removed and replaced with compacted coarse-grained fill material prior to pavement construction.

Soakaway Drainage

The soakaway testing performed within TP1, TP2 and TP3 yielded infiltration rates of 5.42×10^{-6} m/s, 3.28×10^{-6} m/s and 4.65×10^{-6} m/s, respectively, in the Abbey Gravels.

The results rate the Abbey Gravels as having a borderline good/poor drainage potential based on Figure 6 of BS 8004:1986. These results are considered to be representative of

the Abbey Gravels encountered, with slow infiltration due to the silt content. The presence of groundwater at shallow depths beneath the site (standing water levels of 1.49m to 1.64m depth during return monitoring visits) would also limit the size of soakaways.

For any proposed soakaway drainage, chambers should be designed with sufficient storage capacity and surface area to cope with storm events as well as the perched shallow groundwater table. Any proposed soakaway chambers should incorporate silt and leaf traps to ensure the infiltration rates do not deteriorate with time.

Sulphate Analysis

Sulphate analysis of the soil and water samples tested gave results within Design Sulphate Classes DS-1 and DS-2 of the BRE Special Digest 1, Table C1 (2005), presented in Appendix 5. The mean of the highest 20% of the sulphate results to the nearest 100mg/l (400mg/l) is taken as the characteristic value and gives a Design Sulphate Class of DS-1. The pH results were between 6.3 and 9.0 and so acidic to alkaline.

Oxford Clay is listed in this publication as being a stratum that may contain sulphides, such as pyrite, hence oxidation due to disturbance during the excavation of foundations may increase the total potential sulphate content. This clay should not be left exposed to the elements for any length of time, otherwise there would be a potential for oxidation of any pyrite within the Oxford Clay and, in the long term, possible thaumasite formation. It should be noted that the use of piled foundations would minimise disturbance of the ground and consequently reduce the potential for the oxidation of any pyritic clay, although arisings of Oxford Clay should not be re-used as infill adjacent foundations or beneath the floor slabs.

The DS-1 and pH results indicate an Aggressive Chemical Environment for Concrete (ACEC) Class of AC-1. This ACEC Class should be considered when specifying a Design Chemical Class (DC Class) for buried concrete on this site, as detailed in the above cited BRE document.

COMMENTS ON THE CHEMICAL TEST RESULTS

The results of the laboratory chemical testing on near surface soil samples have primarily been compared to soil screening values (SSVs) produced by Land Quality Management Limited (LQM) and the Chartered Institute for Environmental Health (CIEH) presented in their document 'The LQM/CIEH S4ULs for Human Health Risk Assessment: 2015 (Publication Number S4UL3608)'. The LQM/CIEH S4ULs are intended for use in assessing the potential risks posed to human health by contaminants in soil and are transparently-derived and cautious 'trigger values' above which further assessment of the risks or remedial action may be needed. The S4ULs (Suitable for Use Levels) have been derived, in accordance with UK legislation and Environment Agency policy, using a modified version of the Environment Agency CLEA 1.06 software.

Reference has also been given to ATRISKsoil soil screening values produced by Atkins Limited and provided under licence to Ground Engineering Limited. Atkins SSVs have been derived in line with the Environment Agency 2009 guidance using the CLEA 1.04 and 1.06 software. With the absence of a S4UL for cyanide the ATRISKsoil SSV has been used as the soil screening criteria within this report.

In 2014 the Department for Environment Food and Rural Affairs (DEFRA) published, in their document SP1010, Category 4 Screening Levels (C4SL) for several contaminants including lead. The C4SL represent screening levels below which the land could be considered suitable for a specified use and definitely not contaminated land in respect of those determinands. With the absence of S4UL for lead the C4SL has been used as the soil screening criteria within this report.

For each contaminant the adopted soil screening criteria have been calculated for the following land uses:

- Residential use with home grown produce
- Residential use without home grown produce
- Commercial and industrial usage

The intended purpose of the SSVs are as "intervention values" in the regulatory framework for assessment of human health risks in relation to land use. These values are not binding standards, but are intended to inform judgements about the need for action to ensure that a new use of land does not pose any unacceptable risks to the health of the intended users.

Table 1 compares the test results for the made ground with the SSVs in relation to the specified uses. The number of test results, which exceed these values, are also provided.

Table 1: Comparison of Chemical Test Results for Near Surface Soil with Soil Screening Values (SSVs)

Determinand	Number of Samples	Min Value (mg/kg)	Max Value (mg/kg)	Number of Samples Exceeding SSVs for:			Measured 95 th Percentile (mg/kg)	Soil Screening Values (SSVs) (1% SOM)			
				Residential with home grown produce	Residential without home grown produce	Commercial / Industrial		Assessment Method	Residential with home grown produce (mg/kg)	Residential without home grown produce (mg/kg)	Commercial/ Industrial (mg/kg)
Organic matter	10	<0.40%	10%	-	-	-	-	-	-	-	-
Arsenic	10	7.9	37	0	0	0	33.56	S4UL	37	40	640
Cadmium	10	<0.10	0.26	0	0	0	0.22	S4UL	11	85	190
Trivalent* Chromium	10	14	65	0	0	0	55.55	S4UL	910	910	8,600
Hexavalent Chromium	10	<0.50	<0.50	0	0	0	<0.50	S4UL	6	6	33
Lead	10	10	120	0	0	0	69.95	C4SL	200	310	2330
Mercury	10	<0.10	0.58	0	0	0	0.28	S4UL	11	15	320
Selenium	10	<0.20	0.91	0	0	0	0.73	S4UL	250	430	12,000
Nickel	10	8.4	47	0	0	0	40.63	S4UL	130	180	980
Phenols	10	<0.30	<0.30	0	0	0	<0.30	S4UL	120	440	440
Benzo[a]pyrene	10	<0.10	0.85	1	0	0	0.44	S4UL	0.79	1.2	15
Copper	10	4.0	36	0	0	0	32.51	S4UL	2400	7100	68,000
Zinc	10	27	220	0	0	0	135.98	S4UL	3,700	40,000	730,000
Free Cyanide	10	<0.50	<0.50	0	0	0	<0.50	ATRISK	34	34	34

Notes

*The concentration of Trivalent Chromium is assumed to be equivalent to the Total Chromium concentration. This is because most naturally occurring chromium is in the trivalent (chromic) state.

S4UL and C4SL for metals were derived using 6% SOM. These values are not sensitive to SOM and would also be applicable for 1% SOM and 2.5% SOM.

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ATRISKsoil SSVs produced by Atkins Limited and provided under licence to Ground Engineering Limited.

Discussion of Results

The results of the laboratory analysis (Table 1) indicate that one of the samples of near surface soils tested contained a concentration of benzo[a]pyrene that marginally exceeded the respective soil screening values for the most sensitive residential with home grown produce end use. None of the results exceeded the screening values for a residential without home grown produce end use or a commercial/industrial end use.

Statistical analysis, based on the mean value test, indicates that all of the US95 values, including that for benzo[a]pyrene, fall below the respective screening values for the specified end uses.

The maximum value test for the benzo[a]pyrene dataset indicates that the highest value obtained (0.85mg/kg) is not a statistical outlier and is representative of the respective dataset.

In summary, the results indicated that the made ground/topsoil across the site would be considered suitable for retention or re-use at the surface within the proposed residential development.

Visual and olfactory evidence of hydrocarbon impacted soils was not detected within the soils beneath this site during the investigation. The total petroleum hydrocarbon results for the five specimens tested, including the results determined during the two WAC test, were all <10mg/kg indicating the absence of TPH contamination in the samples tested.

Five samples of made ground were screened for asbestos containing material (ACM) by a qualified chemist using optical microscopy. No ACM was found in these samples and visual evidence of ACM was not recorded within the soils during the investigation.

Comparison of Water Analysis with Inorganic Drinking Water Standards

A single sample of groundwater recovered from the standpipe in BH1 was analysed in the laboratory for a suite of common inorganic and organic potential contaminants primarily for characterisation purposes.

The primary assessment tool employed for the generic screening of samples for the protection of 'Controlled Waters' consists of the Statutory Instrument 2000 No. 3184 'The Water Supply (Water Quality) Regulations 2000' that amends the 1991 version, which provided a standard threshold for TPH of 10µg/l. In the absence of an amended TPH threshold in the updated version, we defer to the 1991 standard, which is generally accepted within the industry.

The fraction of test results that exceed these levels are summarised in Table 2.

Table 2 Comparison of Chemical Test Results with Water Supply Regulations

Determinand	Value detected	The Water Supply (Water Quality) Regulations 1989-2000 Maximum Concentration/Value for Consumers Taps	Fraction of samples Exceeding Water Supply Regulation
	BH1 1.49m		
Arsenic (total) µg/l	<1.0	10 µg/l	0/1
Boron (Water Soluble) µg/l	140	1000 µg/l	0/1
Cadmium (total) µg/l	<0.080	5.0 µg/l	0/1
Chromium (total) µg/l	<1.0	50 µg/l	0/1
Copper (total) µg/l	<1.0	2000µg/l	0/1
Cyanide (total) mg/l	<0.050	0.05 mg/l	0/1
Lead (total) µg/l	<1.0	10 µg/l	0/1
Mercury (total) µg/l	<0.50	1.0 µg/l	0/1
Nickel (total) µg/l	1.7	20 µg/l	0/1
pH value	7.6	6.5 minimum 10.0 maximum	0/1
Phenols mg/l	<0.030	0.0005 mg/l	-/1
Selenium (total) µg/l	1.7	10 µg/l	0/1
Sulphate (soluble) mg/l	91	250mg/l	0/1
Sulphide mg/l	<0.050	No limit	0/1
Zinc (total) µg/l	2.0	5000 µg/l	0/1
Total of 16 PAH's µg/l	<0.20	0.10 µg/l	-/1
Total TPH µg/l	<10	10 µg/l	0/1

With regard to the groundwater quality recorded, none of the recorded concentrations of contaminants exceeded the respective standard thresholds.

Soil Gas Monitoring Results

Three return visits were made during November and December 2017 to record the concentrations of landfill type gases (methane, carbon dioxide, oxygen) in the BH1, BH2 and BH3 standpipes. The results are presented following the exploratory hole records.

The recorded concentrations of methane were all less than 0.1% whereas concentrations of carbon dioxide were between 2.1% and 4.7%. The recorded oxygen concentrations were depleted, between 13.3% and 18.1%. The in-situ measurements confirmed gas emissions with recorded flow rates of <0.1l/hr.

Assuming a positive flow rate of 0.1l/hr, the results give a Gas Screening Value (GSV) of 0.0047l/hr. This GSV falls within the modified Wilson and Card Characteristic Situation 1, or NHBC 'Green' classification, as defined by the Construction Industry Research and Information Association, CIRIA Report C665, 'Assessing risks posed by hazardous ground gasses to buildings'

COMMENTS ON GROUND CONTAMINATION RESULTS IN RELATION TO THE PROPOSED DEVELOPMENT

Anticipated exposure scenarios relating to the site and future use are discussed as follows.

The proposals include low rise housing, together with gardens and access driveways.

This investigation may not have revealed the full extent of contamination on the site and appropriate professional advice should be sought if subsequent site works reveal materials that may appear to be contaminated.

Contaminated Soil

A 0.20m to 1.10m thick surface layer of made ground/topsoil was encountered in the exploratory holes. Chemical test results for the samples of near surface soils recovered from across the site found the elements and compounds tested statistically fell below the respective SSVs for a residential with home grown produce end use, considered representative of the proposed end use.

Human Health - Construction Workers

No special precautions would be required during the development of the site by workers who may come into contact with the soil during groundworks, providing standard precautions are adopted which should generally include the procedures given by the Health and Safety Executive (The Blue Book).

For the protection of these workers during groundworks the following is recommended:

a) Limit repeated or prolonged skin contact with soils by wearing gloves with sleeves rolled down.

b) Washing facilities should be made available to groundworkers, so as to minimise the potential for inadvertent ingestion of soil.

c) If any soils are revealed which are different to those encountered by this ground investigation, the advice of a specialist should be sought in view of classifying the material and ascertaining its risk to groundworkers.

d) Consideration should be given to gas monitoring within deep or confined spaces to ensure safety of personnel entering them, in light of the potential for depleted oxygen within service chambers or sub-structures.

Human Health – End Users

Remediation of the soils beneath the site is not considered to be necessary in relation to the creation of any new soft landscaping/gardens, as the concentrations of contaminants tested statistically fell below the residential with home grown produce end use screening criteria, considered to be representative of the proposed end use.

Soil Gas

The gas monitoring has determined that a 'Green' classification of the NHBC traffic light system would apply and that no special precautions are required to protect the proposed development from ingress of soil gases.

Water Environment

The site is covered by Crowland Bed clay and Abbey Gravels, and underlain at depth by the solid geology Oxford Clay. The shallowest groundwater level was at 1.49m depth during the return monitoring visits and contained no concentrations of contaminants that exceeded drinking water standards. It is considered unlikely that the proposed development would impact the quality of the water environment.

Off-Site Disposal of Soil Arisings

The results of chemical analysis are provided in Appendix 4 and can be used for the basic characterisation of the soil destined for landfill. The Environment Agency publication Hazardous Waste, Technical Guidance WM2 outlines the methodology for classifying wastes and should be referenced for guidance. The test results (total metals, hydrocarbons and cyanide) should be compared to the relevant thresholds to determine whether they fall into the primary categories of non-hazardous waste or hazardous waste and will help indicate the likely European Waste Catalogue (EWC) code, which is determined by the waste type. The results of Waste Acceptance Criteria (WAC) leachate testing are presented to the rear of this report and should be used to check whether, if categorised as non-hazardous waste it could be disposed of at an inert waste landfill; or if categorised as hazardous waste whether it could qualify as stable non-reactive hazardous waste for disposal in non-hazardous landfill.

Excavated material and excess spoil should always be classified prior to removal from site as required by 'Duty of Care' (Environmental Protection Act, 1990) legislation. This means that material has to be given a proper description and waste classification prior to removal. Basic characterisation is the responsibility of the waste producer and compliance checking and on-site verification are generally the responsibility of the landfill operator. The landfill operator will need to liaise with the waste producer as the approach relies on the information from basic characterisation.

It is expected that clean arisings from the natural soils across this site would fall into the inert category under the European Waste Catalogue description 'Soil and Stones', EWC code 17 05 04 with restrictions excluding topsoil and peat.

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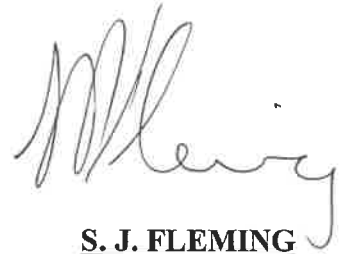


J. E. M. DAVIES

B.Sc. (Hons.), M.Sc.,

C.Geol., F.G.S.,

Senior Geotechnical Engineer



S. J. FLEMING

M.Sc., M.C.S.M.,

C.Geol., F.G.S.,

Director

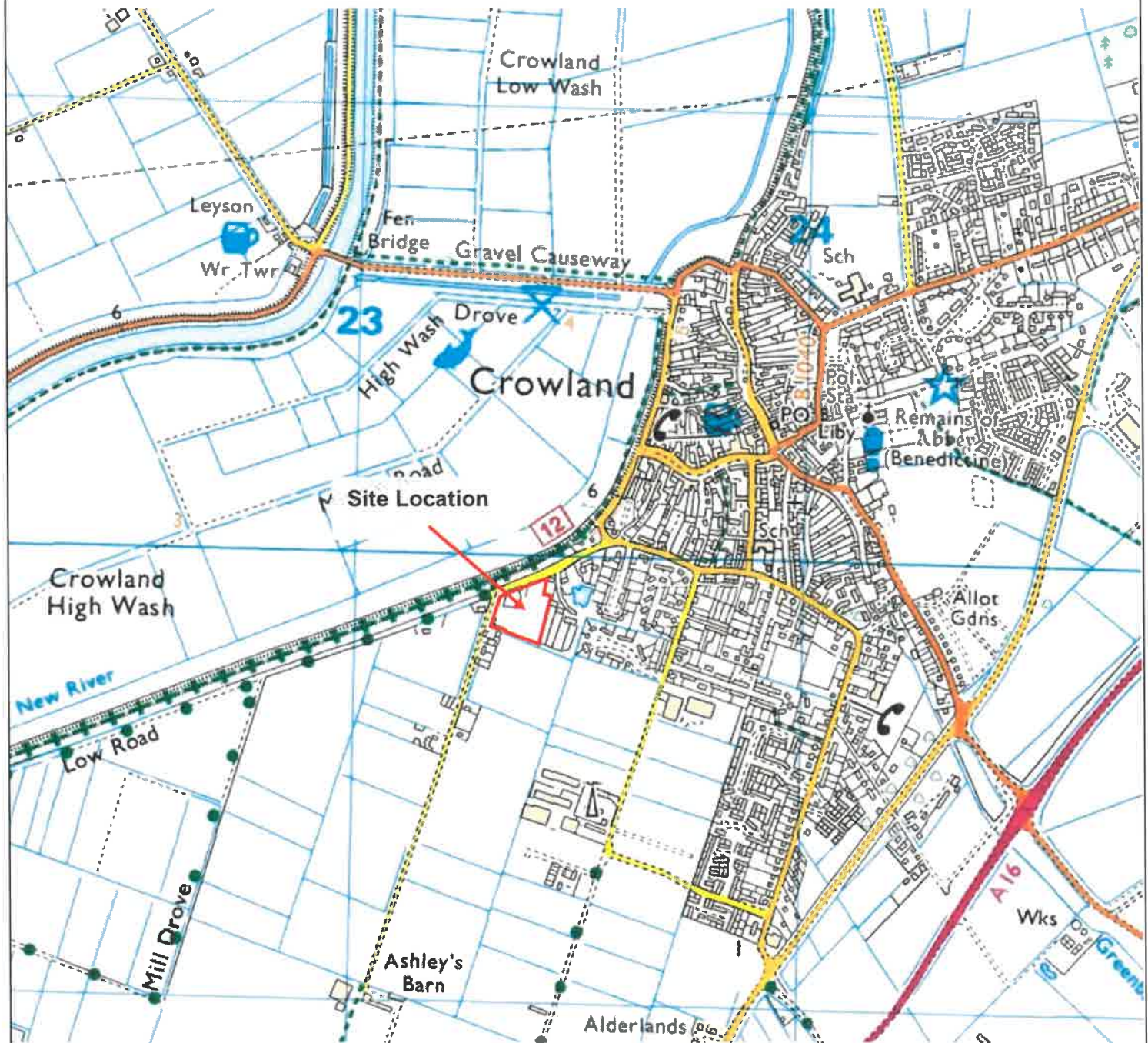
Appendix 1

Site Location Plan

Exploratory Hole Location Plan

Site Location Plan

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Scale = 1km Grid

Project: Land at Low Road/Plank Drive, Crowland

Client: Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

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Peterborough

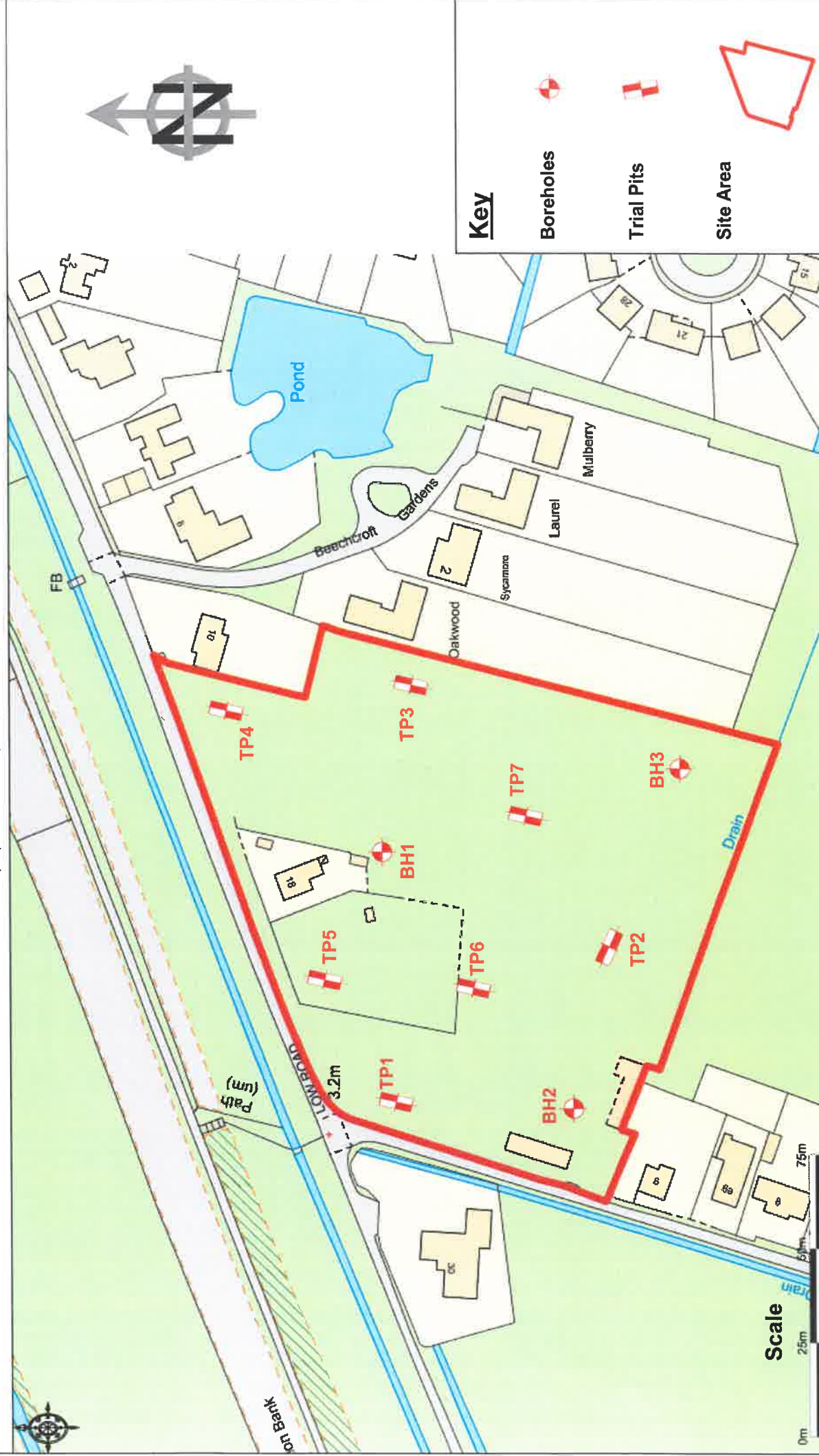
Tel : 01733 566566

Project No.

C14335

Exploratory Hole Location Plan

(Reproduced from plan provided by the Client)



Project: Land at Low Road/Plank Drive, Crowland	GROUND ENGINEERING LTD Peterborough Tel : 01733 566566	Project No. C14335
Client: Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner		

Appendix 2

Exploratory Hole Records

Tabulated SPT results

Soakaway Test Results

Trial Pit Photographs

Groundwater/Gas Monitoring Record

Site: **LAND AT LOW ROAD & PLANK DROVE, CROWLAND**

BOREHOLE
BH1

Date: 15/11/17

Hole Size: 150mm dia to 15.00m

Ground
Level:

Samples and in-situ Tests			(Date)	Inst.	Description of Strata	Legend	Depth m	O.D. Level m	
Depth m	Type	Blows	Casing						
0.00-0.30	B1	N21	1.50		TOPSOIL - Firm, friable, dark brown, slightly gravelly, sandy, clayey, slightly organic SILT. Gravel of angular to sub-rounded flint, quartzite and limestone.		0.30		
0.30-0.60	B2				Firm, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite and limestone. (CROWLAND BED)		1.10		
0.60-1.00	B3								
1.00-1.20	B4								
1.20-1.70	B5								
1.35-1.65	C	N8	1.50		Medium dense, orange brown, silty, very sandy GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone. (ABBEY GRAVELS)		2.30		
1.70-2.00	B6								
2.00-2.40	B7								
2.15-2.45	C								
2.40-2.70	B8								
2.70-3.15	U1	40	2.70		Firm, grey and orange brown mottled, slightly sandy, gravelly CLAY. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone. (REWORKED OXFORD CLAY)		2.70		
3.15	D1	50	3.00			Stiff, fissured, grey CLAY with occasional fossil shell fragments.			
4.00-4.45	U2								
4.45	D2								
5.00-5.45	U3								
5.45	D3								
6.00	D4	60	3.00		(OXFORD CLAY)				
6.50-6.95	U4								
6.95	D5								
7.50	D6								
8.00-8.45	U5				65	3.00		Very stiff, closely fissured to stiff, grey CLAY with occasional fossil bivalves.	
8.45	D7								
9.00	D8	75	3.00		(OXFORD CLAY)				
9.50-9.95	U6								
9.95	D9								

REMARKS 1. Excavating a pit from 0.00m to 1.20m for 1 hour
2. Live roots observed to 1.10m depth
3. Borehole cased to 3.00m depth
4. Gas monitoring standpipe installed to 5.00m depth

Project No
14335

Scale	Page
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KEY	N/* - SPT Blows for 0.3m or given penetration B - Bulk Sample ES - Environmental Sample U - Undisturbed Sample V - Vane Shear Test W - Water Sample Cohesion () kPa S/C - SPT Spoon/Cone Level on completion Water Strike c Level casing withdrawn Water Rise Standpipe Level	Groundwater Strikes						Groundwater Observations			
		Depth m						Date	Depth m		
		No Struck	Rose to	Rate	Cased	Sealed	Hole		Casing	Water	
		1	1.90	1.80	slow	1.50	2.50	15/11/17	15.00	3.00	dry
								15/11/17	15.00	0.00	dry
								24/11/17	5.00	1.00	1.60
								01/12/17	5.00	1.00	1.59
								08/12/17	5.00	1.00	1.58

GROUND ENGINEERING L I M I T E D Tel: 01733-566566 www.groundengineering.co.uk			Site: LAND AT LOW ROAD & PLANK DROVE, CROWLAND				BOREHOLE BH1				
			Date: 15/11/17		Hole Size: 150mm dia to 15.00m			Ground Level:			
Samples and in-situ Tests			(Date) Casing	Inst.	Description of Strata	Legend	Depth m	O.D. Level m			
Depth m	Type	Blows									
10.50	D10		3.00		Very stiff, closely fissured to stiff, grey CLAY with occasional fossil bivalves. (OXFORD CLAY)		10.00				
11.20-11.60	U7	80									
11.60	D11										
12.30	D12		3.00		Hard, fissured, grey CLAY with occasional fossil bivalves. (OXFORD CLAY)		12.50				
12.80-13.20	U8	80									
13.20	D13										
14.00	D14		3.00		(OXFORD CLAY)		15.00				
14.60-15.00	U9	85									
15.00	D15										
					Borehole completed at 15.00m depth						
REMARKS								Project No 14335			
								Scale 1:50	Page 2/2		
KEY D - Disturbed Sample B - Bulk Sample U - Undisturbed Sample W - Water Sample S/C - SPT Spoon/Cone W - Water Strike W - Water Rise			N/* - SPT Blows for 0.3m or given penetration ES - Environmental Sample V - Vane Shear Test Cohesion () kPa Level on completion Level casing withdrawn Standpipe Level			Groundwater Strikes Depth m No Struck Rose to Rate Cased Sealed			Groundwater Observations Date Hole Casing Water		

Samples and in-situ Tests			(Date)	Inst.	Description of Strata	Legend	Depth m	O.D. Level m
Depth m	Type	Blows	Casing					
0.00-0.20	B1	N11	2.10		MADE GROUND - Dark brown, clayey, sandy GRAVEL with occasional cobbles of brick. Gravel of angular flint, brick and ash.		0.20	
0.20-0.50	B2				BURIED TOPSOIL - Firm, friable, dark brown, slightly gravelly, sandy, clayey, slightly organic SILT. Gravel of angular to sub-rounded flint, quartzite and limestone.		0.50	
0.50-1.10	B3				Firm, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite and limestone.		1.40	
1.10-1.20	B4	N14	2.10		(CROWLAND BED)		1.80	
1.20-1.40	B5				Medium dense, orange brown, silty, very gravelly SAND. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		2.50	
1.35-1.65	C				(ABBEY GRAVELS)		2.80	
1.40-1.50	B6	40	2.80		Medium dense, orange brown, silty, very sandy GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		2.80	
1.80-2.10	B7				(ABBEY GRAVELS)		2.80	
2.10-2.50	B8				Firm, grey and orange brown mottled, slightly gravelly, sandy CLAY. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		2.80	
2.25-2.55	C	50	3.00		(REWORKED OXFORD CLAY)		2.80	
2.50-2.80	B9				Stiff, fissured, grey CLAY with occasional fossil shell fragments.		2.80	
2.80-3.25	U1						2.80	
3.25	D1	50	3.00				2.80	
4.00-4.45	U2						2.80	
4.45	D2						2.80	
5.00-5.45	U3	60	3.00				2.80	
5.45	D3						2.80	
6.00	D4						2.80	
6.50-6.95	U4	90	3.00				2.80	
6.95	D5						2.80	
7.50	D6						2.80	
8.00-8.30	U5	85	3.00				2.80	
8.30	D7						2.80	
9.00	D8						2.80	
9.60-10.00	U6	85	3.00		Very stiff, fissured, grey CLAY with occasional fossil bivalves.		2.80	
10.00	D9						2.80	

REMARKS

Borehole completed at 10.00m depth

1. Excavating a pit from 0.00m to 1.20m for 1 hour
2. Live roots observed to 0.50m depth
3. Borehole cased to 3.00m depth
4. Gas monitoring standpipe installed to 5.00m depth

Project No
14335

Scale	Page
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KEY	N/* - SPT Blows for 0.3m or given penetration B - Bulk Sample ES - Environmental Sample U - Undisturbed Sample V - Vane Shear Test W - Water Sample Cohesion () kPa S/C - SPT Spoon/Cone Level on completion Water Strike c/w Level casing withdrawn Water Rise w/s Standpipe Level	Groundwater Strikes						Groundwater Observations			
		Depth m						Depth m			
		No	Struck	Rose to	Rate	Cased	Sealed	Date	Hole	Casing	Water
		1	2.00	1.70	s low		2.50	14/11/17	10.00	3.00	dry
								14/11/17	10.00	0.00	dry
								24/11/17	5.00	1.00	1.49
								01/12/17	5.00	1.00	1.49
								08/12/17	5.00	1.00	1.49

GROUND ENGINEERING L I M I T E D Tel: 01733-566566 www.groundengineering.co.uk			Site: LAND AT LOW ROAD & PLANK DROVE, CROWLAND				BOREHOLE BH3				
Date: 14/11/17			Hole Size: 150mm dia to 10.00m				Ground Level:				
Samples and in-situ Tests			(Date)	Inst.	Description of Strata		Legend	Depth m	O.D. Level m		
Depth m	Type	Blows	Casing								
0.00-0.40	B1	N25		2.00	TOPSOIL - Firm, friable, dark brown, slightly gravelly, sandy, clayey, slightly organic SILT. Gravel of angular to sub-rounded flint, quartzite and limestone.			0.40			
0.40-1.10	B2				Firm, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite and limestone. (CROWLAND BED)			1.10			
1.20-1.50	B3				Medium dense, orange brown, clayey, gravelly SAND. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone. (ABBEY GRAVELS)			1.50			
1.50-1.80	B4				Medium dense, orange brown, slightly silty, sandy GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.						
2.00-2.50	B5				(ABBEY GRAVELS)						
2.15-2.45	C	N26									
2.50	W1										
3.00-3.50	B6	N13		3.00	Firm, grey and orange brown mottled, slightly gravelly CLAY. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone. (REWORKED OXFORD CLAY)			3.00			
3.15-3.45	C							3.50			
3.80-4.25	U1				57	3.50	Stiff, locally very stiff, fissured, grey CLAY with occasional fossil shell fragments.				
4.25	D2										
5.00-5.45	U2				65	3.70					
5.45	D3										
6.00	D4										
6.50-6.95	U3	70	3.70	(OXFORD CLAY)							
6.95	D5										
7.50	D6										
8.00-8.45	U4	75	3.70								
8.45	D7										
9.00	D8				Very stiff, fissured, grey CLAY with occasional fossil bivalves.			8.50			
9.50-9.95	U5	85	3.70	(OXFORD CLAY)							
10.00	D9							10.00			
REMARKS							Project No				
Borehole completed at 10.00m depth							14335				
1. Excavating a pit from 0.00m to 1.20m for 1 hour							Scale				
2. Live roots observed to 1.80m depth							1:50				
3. Water added from 1.50m to 3.00m							Page				
4. Borehole cased to 3.70m depth							1/1				
5. Gas monitoring standpipe installed to 5.00m depth											
KEY		N/* - SPT Blows for 0.3m or given penetration		Groundwater Strikes			Groundwater Observations				
D - Disturbed Sample		ES - Environmental Sample		Depth m			Depth m				
B - Bulk Sample		V - Vane Shear Test		No	Struck	Rose to	Date	Hole	Casing	Water	
U - Undisturbed Sample		Cohesion () kPa		1	2.50	2.00	fast				
W - Water Sample		Level on completion					14/11/17	10.00	3.70	dry	
S/C - SPT Spoon/Cone		Level casing withdrawn					14/11/17	10.00	0.00	dry	
Water Strike		Standpipe Level					24/11/17	5.00	1.00	1.64	
Water Rise							01/12/17	5.00	1.00	1.63	
							08/12/17	5.00	1.00	1.63	

GROUND ENGINEERING L I M I T E D Tel: 01733-666566 www.groundengineering.co.uk			Site: LAND AT LOW ROAD & PLANK DROVE, CROWLAND		TRIAL PIT TP1	
Date: 17/11/17			Pit Size: 2.00m L x 0.65m W x 2.00m D.		Ground Level:	
Samples and in-situ Tests			(Date)	Description of Strata	Legend	Depth m
Depth m	Type	Result	Water			
0.30 0.30	D1 V1	(75)		MADE GROUND - Firm, friable, dark brown, slightly gravelly, sandy, silty CLAY. Gravel of angular brick, flint and ash.		0.35
0.60 0.60 0.70	D2 V2 D3	(62)		Buried TOPSOIL - Firm, friable, dark brown, slightly gravelly, sandy, clayey, slightly organic SILT. Gravel of angular to rounded flint, quartz, quartzite and limestone.		0.65
0.90 1.00	V3 D4	(39)		Firm, becoming soft, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone. (CROWLAND BED)		1.10
1.20-1.70 1.20-1.42	B1 MP1	100		Medium dense, orange brown, silty SAND AND GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		
1.40 1.50-1.74	D5 MP2	100				
1.70	D6		1 ▼	(ABBEY GRAVELS)		
2.00	D7		1 ▼			2.00
				Pit completed at 2.00m depth		

KEY D - Disturbed Sample B - Bulk Sample U - Undisturbed Sample R - Root Sample W - Water Sample ES - Environmental Sample ▼ - Water Strike ▼ - Water Rise ▼c - Level on completion MP - Mackintosh Probe P () - Hand Penetrometer Cohesion () kPa V - Vane Shear Test Cohesion () kPa	REMARKS 1. Live roots observed to 0.30m depth 2. Pit sides unstable below 1.70m depth 3. Water met at 2.00m, rising to 1.80m depth 4. Soakaway test undertaken at 2.00m depth	Project No 14335	
		Scale 1:25	Page 1/1

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: Land at Low Road and Plank Drove, Crowland

Project No: C14335

Client: Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

Sheet No: 1/1

Trial Pit: TP1

Depth: 2.00

Length: 2.00

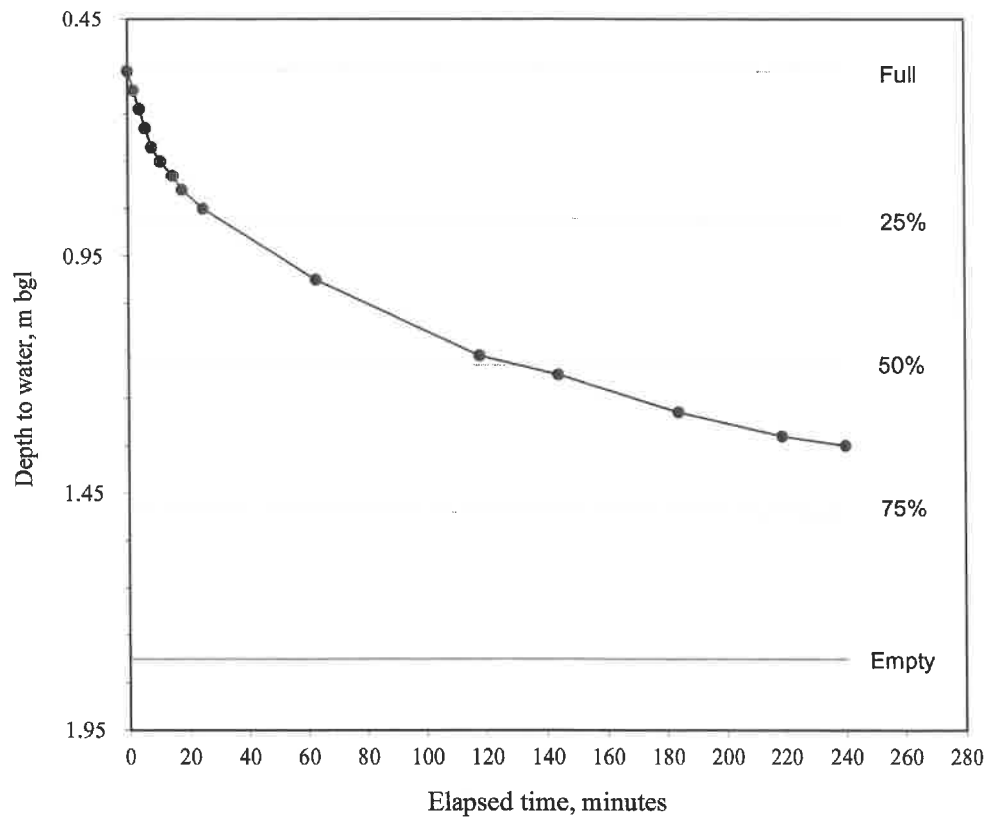
Width: 0.65

Description of Stratum under test: Medium Dense, orange brown, silty SAND AND GRAVEL

Depth to water prior to test: 1.80
(below ground level)

DEPTH TO WATER vs ELAPSED TIME

Elapsed Time min	Depth to Water m
0	0.56
2	0.60
4	0.64
6	0.68
8	0.72
11	0.75
15	0.78
18	0.81
25	0.85
63	1.00
118	1.16
144	1.20
184	1.28
219	1.33
240	1.35



All dimensions given in metres

$$f = (V75 - V25) / A50(T75 - T25)$$

$$V75 - V25 = 0.81$$

$$A50 = 4.59$$

$$T75 - T25 = 540 \quad (\text{extrapolated})$$

Soil Infiltration Rate

$$f = \underline{5.42E-06} \text{ m/s}$$

Trial Pit Photograph - TP1



Project : Land at Low Road & Plank Drove, Crowland

Client : Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

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Peterborough

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**Project No.
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GROUND ENGINEERING L I M I T E D Tel: 01733-566566 www.groundengineering.co.uk			Site: LAND AT LOW ROAD & PLANK DROVE, CROWLAND		TRIAL PIT TP2	
Date: 17/11/17			Pit Size: 2.00m L x 0.65m W x 2.00m D.		Ground Level:	
Samples and in-situ Tests			(Date) Water	Description of Strata	Legend	Depth m
Depth m	Type	Result				O.D. Level m
0.20	D1	(71)		MADE GROUND - Firm, friable, dark brown, slightly gravelly, sandy, silty CLAY. Gravel of angular flint, brick and ash.		
0.30	V1					0.35
0.50	D2			Firm, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite and limestone. (CROWLAND BED)		
0.80-1.30	B1					0.70
0.80	D3			Medium dense, orange brown and light brown, silty SAND AND GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		
1.10	D4			(ABBEY GRAVELS)		
1.40	D5			...Pocket of firm, orange brown and light grey mottled, slightly gravelly, sandy clay at 1.50m to 1.70m depth.		
1.60	D6	(48)				
1.60	V2					
1.70-2.00	B2					
1.70-1.42	MP1	100	1 ▽			
2.00	D7		1 ▽			2.00
			Pit completed at 2.00m depth			
KEY D - Disturbed Sample B - Bulk Sample U - Undisturbed Sample R - Root Sample W - Water Sample ES - Environmental Sample ▽ - Water Strike ▽ - Water Rise ▽c - Level on completion MP - Mackintosh Probe P () - Hand Penetrometer Cohesion () kPa V - Vane Shear Test Cohesion () kPa			REMARKS 1. Live roots observed to 0.20m depth 2. Pit sides unstable below 1.30m depth 3. Water met at 2.00m, rising to 1.80m depth 4. Soakaway test undertaken at 2.00m depth			
			Project No 14335		Scale 1:25	
			Page 1/1			

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: Land at Low Road and Plank Drove, Crowland
 Client: Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

Project No: C14335
 Sheet No: 1/1

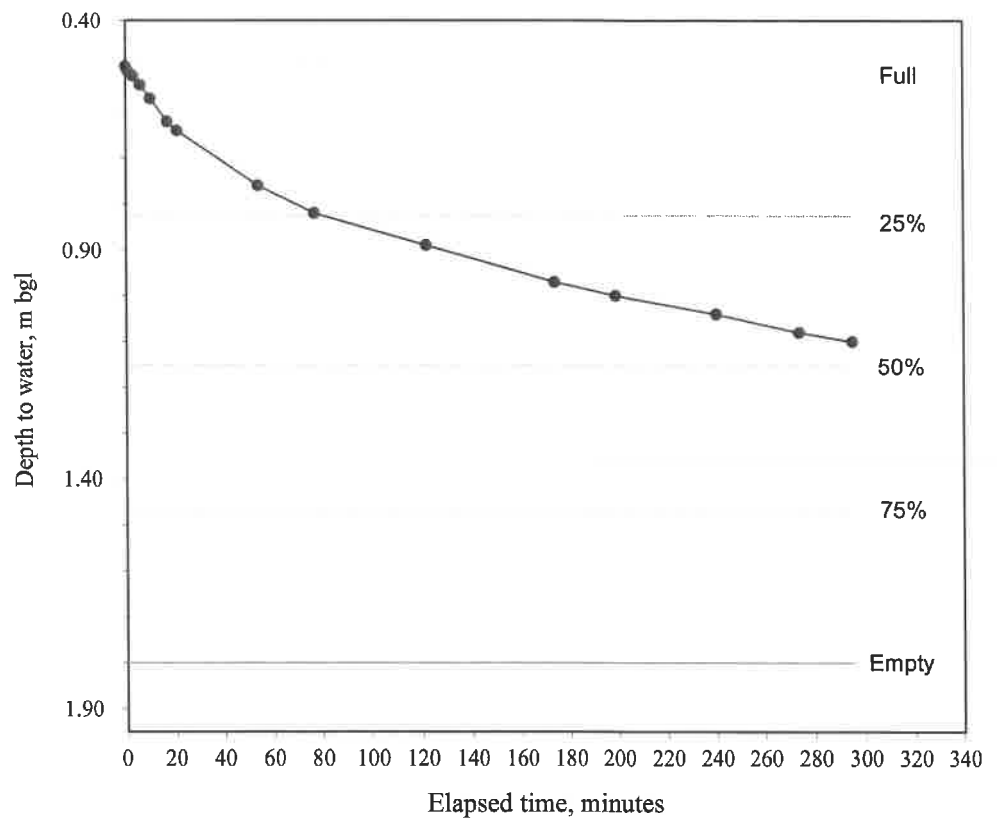
Trial Pit: TP2
 Depth: 2.00
 Length: 2.00
 Width: 0.65

Description of Stratum under test: Medium Dense, orange brown and light brown, silty SAND AND GRAVEL

Depth to water prior to test: 1.80
 (below ground level)

DEPTH TO WATER vs ELAPSED TIME

Elapsed Time min	Depth to Water m
0	0.50
1	0.51
3	0.52
6	0.54
10	0.57
17	0.62
21	0.64
54	0.76
77	0.82
122	0.89
174	0.97
199	1.00
240	1.04
274	1.08
295	1.10



All dimensions given in metres

$$f = \frac{(V_{75} - V_{25})}{A_{50}(T_{75} - T_{25})}$$

$V_{75} - V_{25} = 0.85$
 $A_{50} = 4.75$
 $T_{75} - T_{25} = 905$ (extrapolated)

Soil Infiltration Rate $f = \underline{\underline{3.28E-06}} \text{ m/s}$

Trial Pit Photograph – TP2



Project : Land at Low Road & Plank Drove, Crowland

Client : Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

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**Project No.
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GROUND ENGINEERING L I M I T E D Tel: 01733-566566 www.groundengineering.co.uk			Site: LAND AT LOW ROAD & PLANK DROVE, CROWLAND		TRIAL PIT TP3	
Date: 17/11/17			Pit Size: 2.10m L x 0.65m W x 2.00m D.		Ground Level:	
Samples and in-situ Tests			(Date) Water	Description of Strata	Legend	Depth m
Depth m	Type	Result				O.D. Level m
0.30 0.30 0.50	D1 V1 V2	(65) (55)		MADE GROUND - Firm, friable, brown, slightly gravelly, sandy, silty CLAY. Gravel of angular, brick, flint and ash.		0.60
0.75 0.80	D2 V3	(55)		Buried TOPSOIL - Firm, friable, brown, grey, sandy, slightly organic SILT.		1.15
1.10 1.20	D3 V4	(20)		Firm, becoming soft, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		1.70
1.40-1.74 1.50	MP1 V5	100 (30)		(CROWLAND BED)		2.00
1.60	D4		1 	Medium dense, orange brown, silty, very sandy GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone. (ABBEEY GRAVELS)		
2.00 2.00-2.30	D5 MP2	100	1 	Pit completed at 2.15m depth		
KEY D - Disturbed Sample B - Bulk Sample U - Undisturbed Sample R - Root Sample W - Water Sample ES - Environmental Sample  Water Strike  Water Rise  Level on completion MP - Mackintosh Probe P () - Hand Penetrometer Cohesion () kPa V - Vane Shear Test Cohesion () kPa			REMARKS 1. Live roots observed to 0.30m depth 2. Pit sides unstable below 1.50m depth 3. Water met at 2.00m, rising to 1.70m depth 4. Soakaway test undertaken at 2.00m depth			
			Project No 14335			
			Scale 1:25			
			Page 1/1			

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: Land at Low Road and Plank Drove, Crowland
 Client: Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

Project No: C14335
 Sheet No: 1/1

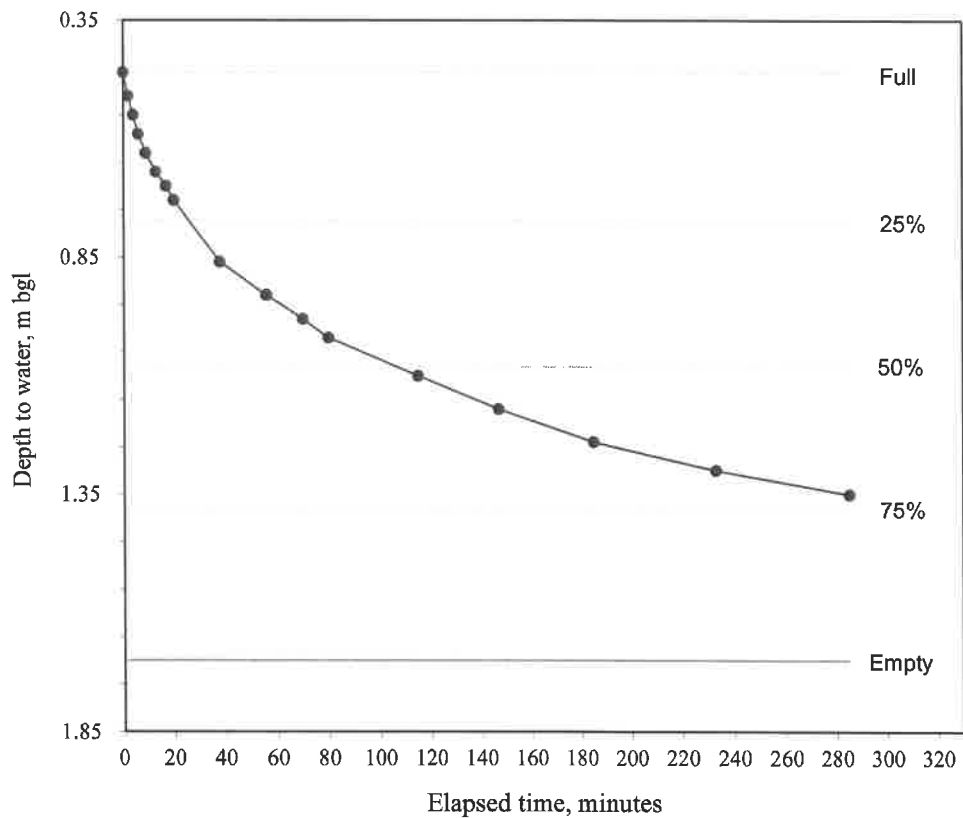
Trial Pit: TP3
 Depth: 2.00
 Length: 2.00
 Width: 0.65

Description of Stratum under test: Medium Dense, orange brown silty, very sandy GRAVEL

Depth to water prior to test: 1.70
 (below ground level)

DEPTH TO WATER vs ELAPSED TIME

Elapsed Time min	Depth to Water m
0	0.46
2	0.51
4	0.55
6	0.59
9	0.63
13	0.67
17	0.70
20	0.73
38	0.86
56	0.93
70	0.98
80	1.02
115	1.10
147	1.17
185	1.24
233	1.30
285	1.35



All dimensions given in metres

$$f = (V75 - V25) / A50(T75 - T25)$$

$V75 - V25 = 0.81$
 $A50 = 4.59$
 $T75 - T25 = 630$ (extrapolated)

Soil Infiltration Rate $f = \underline{4.65E-06} \text{ m/s}$

Trial Pit Photograph – TP3



Project : Land at Low Road & Plank Drove, Crowland

Client : Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

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GROUND ENGINEERING L I M I T E D Tel: 01733-566566 www.groundengineering.co.uk			Site: LAND AT LOW ROAD & PLANK DROVE, CROWLAND		TRIAL PIT TP4	
Date: 17/11/17			Pit Size: 2.20m L x 0.65m W x 3.00m D.		Ground Level:	
Samples and in-situ Tests			(Date)	Description of Strata	Legend	Depth m
Depth m	Type	Result	Water			
0.30	D1			MADE GROUND - Stiff, friable, dark brown, slightly gravelly, sandy CLAY. Gravel of angular brick and ash.		0.40
0.30	V1	(94)				
0.50	D2			Buried TOPSOIL - Firm, friable, brown, sandy, clayey, organic SILT.		0.85
0.60	V2	(68)				
0.80	D3			Soft, light brown, orange brown and light grey, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		1.50
0.90	V3	(35)				
1.00	D4			(CROWLAND BED)		2.00
1.30	V4	(35)				
1.40	D5			Medium dense, orange brown, clayey, very gravelly SAND. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		2.75
1.60-1.89	MP1	100				
1.70-2.20	B1		(ABBAY GRAVELS)		2.95	
1.70	D6					
2.00-2.21	MP2	100	1	Medium dense, orange brown, slightly silty, very sandy GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		3.00
2.20	D7					
2.40-2.70	B2		1	(ABBAY GRAVELS)		2.95
2.40	D8					
2.50-2.70	MP3	100	1	Firm, grey and orange brown mottled, slightly sandy, gravelly CLAY. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone. (REWORKED OXFORD CLAY)		3.00
2.70	D9					
2.90	D10		1	Stiff, fissured, grey CLAY with occasional fossil shell fragments. (OXFORD CLAY)		3.00
3.00	D11					
3.00	V5	(95)	Pit completed at 3.00m depth			

KEY	REMARKS
D - Disturbed Sample	1. Live roots observed to 0.60m depth 2. Pit sides unstable below 2.00m depth 3. Water met at 2.70m, rising to 2.50m depth
B - Bulk Sample	
U - Undisturbed Sample	
R - Root Sample	
W - Water Sample	
ES - Environmental Sample	
⚡ - Water Strike	
⬆ - Water Rise	
⬆c - Level on completion	
MP - Mackintosh Probe	
P () - Hand Penetrometer	
Cohesion () kPa	
V - Vane Shear Test	
Cohesion () kPa	

Project No 14335	
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Trial Pit Photograph – TP4



Project : Land at Low Road & Plank Drove, Crowland

Client : Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

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**Project No.
C14335**

GROUND ENGINEERING L I M I T E D Tel: 01733-566566 www.groundengineering.co.uk			Site: LAND AT LOW ROAD & PLANK DROVE, CROWLAND		TRIAL PIT TP5	
Date: 17/11/17			Pit Size: 2.00m L x 0.65m W x 3.00m D.		Ground Level:	
Samples and in-situ Tests			(Date)	Description of Strata	Legend	O.D. Level m
Depth m	Type	Result	Water			Depth m
0.30 0.30	D1 V1	(68)		MADE GROUND - Firm, friable, brown, slightly gravelly, sandy CLAY. Gravel of angular brick and ash.		0.50
0.60 0.70	V2 D2	(52)		Firm, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite and limestone. (CROWLAND BED)		0.90
1.00	D3			Medium dense, orange brown, silty, very sandy GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		1.80
1.20-1.48 1.30	MP1 D4	100		(ABBAY GRAVELS)		
1.50	D5					
1.70-1.97 1.80	MP2 D6	100		Medium dense, brown and grey, silty SAND AND GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.		
2.00	D7					
2.20-2.51	MP3	100	1 ↓	(ABBAY GRAVELS)		2.70
2.50	D8		1 ↓			
2.80 2.80	D9 V3	(35)		Soft, grey and brown mottled, slightly gravelly CLAY. Gravel of angular flint. (REWORKED OXFORD CLAY)		2.90
3.00 3.00	D10 V4	(102)		Stiff, fissured, grey CLAY with occasional fossil shell fragments. (OXFORD CLAY)		3.00
				Pit completed at 3.00m depth		

KEY	REMARKS
D - Disturbed Sample B - Bulk Sample U - Undisturbed Sample R - Root Sample W - Water Sample ES - Environmental Sample ▽ - Water Strike ▽ - Water Rise ▽c - Level on completion MP - Mackintosh Probe P () - Hand Penetrometer Cohesion () kPa V - Vane Shear Test Cohesion () kPa	1. Live roots observed to 0.70m depth 2. Pit sides unstable below 2.10m depth 3. Water met at 2.50m, rising to 2.30m depth

Project No 14335	
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Trial Pit Photograph – TP5



Project : Land at Low Road & Plank Drove, Crowland

Client : Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

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**Project No.
C14335**

GROUND ENGINEERING L I M I T E D Tel: 01733-566566 www.groundengineering.co.uk			Site: LAND AT LOW ROAD & PLANK DROVE, CROWLAND		TRIAL PIT TP6			
Date: 17/11/17			Pit Size: 2.20m L x 0.65m W x 3.00m D.		Ground Level:			
Samples and in-situ Tests			(Date) Water	Description of Strata	Legend	Depth m		
Depth m	Type	Result						
0.30 0.30	D1 V1	(62)		MADE GROUND - Firm, friable, brown, slightly gravelly, sandy CLAY. Gravel of angular brick and ash.		0.50		
0.60 0.60	D2 V2	(70)		Firm, becoming locally soft, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.				
0.90 0.90	D3 V3	(74)		(CROWLAND BED)				
1.20 1.20	D4 V4	(25)		...Occasional cobble size pockets of clayey sand and gravel below 1.20m depth.				
1.50 1.50	D5 V5	(68)						
1.80 1.80	D6 V6	(38)						
2.20 2.20-2.46	D7 MP1	100		Medium dense, orange brown, slightly silty, very sandy GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.				2.00
2.60-2.82	MP2	100		(ABBEY GRAVELS)				
2.70	D8							
3.00 3.00	D9 V7	(85)					Stiff, fissured, grey CLAY with occasional fossil shell fragments. (OXFORD CLAY)	
			Pit completed at 3.00m depth					
KEY D - Disturbed Sample B - Bulk Sample U - Undisturbed Sample R - Root Sample W - Water Sample ES - Environmental Sample Water Strike Water Rise Level on completion MP - Mackintosh Probe P () - Hand Penetrometer Cohesion () kPa V - Vane Shear Test Cohesion () kPa			REMARKS 1. Live roots observed to 0.80m depth 2. Pit sides unstable below 2.30m depth 3. Water met at 2.60m, rising to 2.50m depth					
			Project No 14335		Scale 1:25			
					Page 1/1			

Trial Pit Photograph – TP6



Project : Land at Low Road & Plank Drove, Crowland

Client : Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

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GROUND ENGINEERING L I M I T E D Tel: 01733-566566 www.groundengineering.co.uk			Site: LAND AT LOW ROAD & PLANK DROVE, CROWLAND		TRIAL PIT TP7		
Date: 17/11/17			Pit Size: 2.20m L x 0.65m W x 2.90m D.		Ground Level:		
Samples and in-situ Tests			(Date)	Description of Strata	Legend	Depth m	O.D. Level m
Depth m	Type	Result	Water				
0.30 0.30	D1 V1	(65)		MADE GROUND - Firm, friable, brown, slightly gravelly, sandy CLAY. Grave of angular brick and ash.		0.50	
0.60 0.70 0.80	D2 V2 D3	(57)		Firm, light brown, orange brown and light grey mottled, slightly gravelly, sandy, silty CLAY. Gravel of angular to rounded flint, quartz, quartzite and limestone. (CROWLAND BED)		0.90	
1.10	D4			Medium dense, orange brown, silty, very sandy GRAVEL. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone.			
1.50	D5			(ABBEY GRAVELS)			
2.00	D6		1 ↓				
2.40 2.55 2.60	D7 D8 V3	(53)	1 ↓	Firm, grey and orange brown mottled, slightly gravelly CLAY. Gravel of angular to rounded flint, quartz, quartzite, limestone and ironstone. (REWORKED OXFORD CLAY)		2.50	
2.70 2.70	D9 V4	(97)		Stiff, fissured, grey CLAY with occasional fossil shell fragments. (OXFORD CLAY)		2.70	
				Pit completed at 2.90m depth		2.90	
KEY D - Disturbed Sample B - Bulk Sample U - Undisturbed Sample R - Root Sample W - Water Sample ES - Environmental Sample ∇ - Water Strike ∇ - Water Rise ∇c - Level on completion MP - Mackintosh Probe P () - Hand Penetrometer Cohesion () kPa V - Vane Shear Test Cohesion () kPa			REMARKS 1. Live roots observed to 0.20m depth 2. Pit sides unstable below 2.30m depth 3. Water met 2.30m, rising to 1.80m depth				
						Project No 14335	
						Scale 1:25	Page 1/1

Trial Pit Photograph – TP7



Project : Land at Low Road & Plank Drove, Crowland

Client : Mr. C. Sharpe, Mrs. L. Fox & Mrs. E. Skinner

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**Project No.
C14335**

Groundwater/Gas Monitoring Record

Site: **Land at Low Road/Plank Drive, Crowland**

Report Ref: **C14335**

Date	Borehole No.	Methane (% v/v)		Carbon Dioxide (% v/v)		Oxygen (% v/v)		Flow Rate (l/hr)	Atmosph. Pressure (mb)	Dp (mb)	Depth of Well (mbgl)	Depth to Ground Water (mbgl)	Comments
		Peak	Steady	Peak	Steady	Min.	Max.						
24/11/2017	BH1	<0.1	<0.1	2.1	2.1	18.2	18.2	<0.1	1011	<1	5.00	1.60	Water Sample Obtained
24/11/2017	BH2	<0.1	<0.1	2.9	2.9	15.1	15.1	<0.1	1011	<1	5.00	1.49	Water Sample Obtained
24/11/2017	BH3	<0.1	<0.1	4.6	4.6	13.9	13.9	<0.1	1011	<1	5.00	1.64	Water Sample Obtained
01/12/2017	BH1	<0.1	<0.1	2.2	2.2	18.1	18.1	<0.1	1018	<1	5.00	1.59	
01/12/2017	BH2	<0.1	<0.1	3.4	3.4	14.8	14.8	<0.1	1018	<1	5.00	1.49	
01/12/2017	BH3	<0.1	<0.1	4.7	4.7	13.3	13.3	<0.1	1018	<1	5.00	1.63	
08/12/2017	BH1	<0.1	<0.1	2.4	2.4	17.8	17.8	<0.1	1009	<1	5.00	1.58	
08/12/2017	BH2	<0.1	<0.1	3.6	3.6	14.7	14.7	<0.1	1009	<1	5.00	1.49	
08/12/2017	BH3	<0.1	<0.1	4.6	4.6	14.0	14.0	<0.1	1009	<1	5.00	1.63	

Appendix 3

Geotechnical Test Results

Figure 1 - Moisture Content vs. Depth Plot

**Figure 2 - Apparent Cohesion vs. Depth Plot of
(Hand Vanes and Triaxial Test Results to 5.50m Depth)**

**Figure 3 - Apparent Cohesion vs. Depth Plot of
(Triaxial Test Results to 12.00m depth)**

LABORATORY TEST RESULTS

CONTRACT LAND AT LOW ROAD & PLANK DROVE, CROWLAND

Bore-hole	Sample	Depth m	Classification				Density		Triaxial Compression					Sulphates (SO ₄)				C.B.R.		Remarks
			Liquid Limit %	Plastic Limit %	Plasticity Index %	Moisture Content %	Bulk Mg/m ³	Dry Mg/m ³	Type	Principal Stress Difference kPa	Cell Pressure kPa	Shear Strength kPa	Angle of Shear Resistance degrees	Total % Dry Wt.	Soil Aqueous Extract mg/l	Water mg/l	pH	Top % 	Base % 	
BH1	B3	0.60 - 1.00				21	2.03	1.67										2.3	2.6	2% retained on 20mm sieve
	B5	1.20 - 1.70																		
	U1	2.70 - 3.15	46	17	29	18	2.12	1.81	Q	186	60	93	0		132		8.3			SOIL CLASSIFICATION = CI 0% retained on 425µm sieve
	U2	4.00 - 4.45				20	2.13	1.77	Q	285	90	143	0		350		8.2			
	U3	5.00 - 5.45				21	2.10	1.74	Q	258	110	129	0							
	U4	6.50 - 6.95				21	2.09	1.74	Q	298	140	149	0							
	U5	8.00 - 8.45				21	2.09	1.73	Q	192	170	96	0							
	U6	9.50 - 9.95				17	9.50	9.95	Q	201	200	101	0							
U7	11.20 - 11.60				18	2.14	1.81	Q	264	230	132	0								
U8	12.80 - 13.20				16	2.13	1.84	Q	835	260	418	0								

LABORATORY TEST RESULTS

CONTRACT LAND AT LOW ROAD & PLANK DROVE, CROWLAND

Bore-hole	Sample	Depth m	Classification				Density		Triaxial Compression						Sulphates (SO ₄)				C.B.R.		Remarks
			Liquid Limit %	Plastic Limit %	Plasticity Index %	Moisture Content %	Bulk Mg/m ³	Dry Mg/m ³	Type	Principal Stress Difference kPa	Cell Pressure kPa	Shear Strength kPa	Angle of Shear Resistance degrees	Total % Dry Wt.	Aqueous Extract mg/l	Water mg/l	pH	Top %	Base %		
BH1	U9	14.60 - 15.00				17	2.18	1.87	Q	894	300	447	0		449		9.0			0% retained on 20mm sieve	
BH2	B3	0.50 - 1.10				33	1.83	1.40										4.2	4.1		
	B8	2.10 - 2.50													123		8.4				
	U1	2.80 - 3.25				21	2.12	1.75	Q	193	65	97	0								
	U2	4.00 - 4.45				24	2.07	1.67	Q	165	90	82	0								
	U3	5.00 - 5.45				22	2.10	1.72	Q	203	110	102	0								
	U4	6.50 - 6.95				23	2.08	1.69	Q	178	140	89	0								
	U5	8.00 - 8.30				20	2.12	1.77	Q	436	165	218	0		230		8.7				
	U6	9.60 - 10.00				18	2.12	1.80	Q	598	200	299	0								
BH3	B2	0.40 - 1.10				12	1.98	1.68										11	13		0% retained on 20mm sieve

U - UNDISTURBED SAMPLE
D - DISTURBED SAMPLE
B - BULK SAMPLE
W - WATER SAMPLE

C.U. - CONSOLIDATED UNDRAINED
C.D. - CONSOLIDATED DRAINED
Q. - IMMEDIATE UNDRAINED
Q.M. - IMMEDIATE UNDRAINED MULTISTAGE

Aqueous Extract 2:1 Water:Soil
C.B.R. - CALIFORNIA BEARING RATIO

LABORATORY TEST RESULTS

CONTRACT LAND AT LOW ROAD & PLANK DROVE, CROWLAND

Bore-hole	Sample	Depth m	Classification				Density		Triaxial Compression					Sulphates (SO ₄)				C.B.R.		Remarks
			Liquid Limit %	Plastic Limit %	Plasticity Index %	Moisture Content %	Bulk Mg/m ³	Dry Mg/m ³	Type	Principal Stress Difference kPa	Cell Pressure kPa	Shear Strength kPa	Angle of Shear Resistance degrees	Total Dry Wt. %	Aqueous Extract mg/l	Water mg/l	pH	Top %	Base %	
BH3	B3	1.20 - 1.50													16		8.2			
	U1	3.80 - 4.25				18	2.17	1.85	Q	508	85	254	0		580		7.9			
	U2	5.00 - 5.45				20	2.10	1.75	Q	278	110	139	0							
	U3	6.50 - 6.95				21	2.09	1.73	Q	240	140	120	0							
	U4	8.00 - 8.45				29	2.11	1.64	Q	285	170	142	0							
	U5	9.50 - 9.95				19	2.09	1.76	Q	308	200	154	0							
Aqueous Extract 2:1 Water:Soil																				

U - UNDISTURBED SAMPLE
D - DISTURBED SAMPLE
B - BULK SAMPLE
W - WATER SAMPLE

C.U. - CONSOLIDATED UNDRAINED
C.D. - CONSOLIDATED DRAINED
Q. - IMMEDIATE UNDRAINED
Q.M. - IMMEDIATE UNDRAINED MULTISTAGE

C.B.R. - CALIFORNIA BEARING RATIO

LABORATORY TEST RESULTS

CONTRACT LAND AT LOW ROAD & PLANK DRIVE, CROWLAND

Trial-pit	Sample	Depth m	Classification				Density		Triaxial Compression					Sulphates (SO ₄)				C.B.R.		Remarks
			Liquid Limit %	Plastic Limit %	Plasticity Index %	Moisture Content %	Bulk Mg/m ³	Dry Mg/m ³	Type	Principal Stress Difference kPa	Cell Pressure kPa	Shear Strength kPa	Angle of Shear Resistance degrees	Total % Dry Wt.	Aqueous Extract mg/l	Water mg/l	pH	Top %	Base %	
TP2	B1	0.80 - 1.30				9.4	2.20	2.01										48	80	2% retained on 20mm sieve
TP3	D2	0.75				6.3													SOIL CLASSIFICATION = ML 3% retained on 425µm sieve	
TP4	D3	1.10	22	17	5	15														
TP6	D3	1.60				15														
TP6	D4	0.80				46														
TP6	D4	1.00				17														
TP6	D5	1.40				14														
TP6	D3	0.90				16														
TP6	D4	1.20				12														
TP6	D5	1.50	34	15	19	19														
TP6	D6	1.80				14														
SOIL CLASSIFICATION = CL 17% retained on 425µm sieve																				



8180

TEST CERTIFICATE**GROUND ENGINEERING**

Newark Road Peterborough
t: 01733 566566 f: 01733 315280
e: admin@groundengineering.co.uk

Determination of Particle Size Distribution

Tested in Accordance with BS 1377-2: 1990: Clause 9.2
Sieved Grading

Client: Ground Engineering Ltd
Client Address: Newark Road
Peterborough
PE1 5UA

Contact: James Davies

Site Name: Land at Low Road & Plank Drive
Site Address: Crowland

Certificate Number: PL6066-1/3/710-2
Client Reference: C14335
Lab Job Number: PL6066-1
Date Sampled: Unknown
Date Received: 22.11.2017
Date Tested: 29.11.2017
Certificate of Sampling: N/A
Sampling Certificate No.: N/A
Sampled By: Client

TEST RESULTS

Laboratory Reference: PL6066-1/3

Pre-treatment for organic material:

N/A

Client Reference: B6

Sample Description: Orange-brown very clayey SAND and GRAVEL. Gravel consists of angular to rounded flint

Material Specification: Not Required

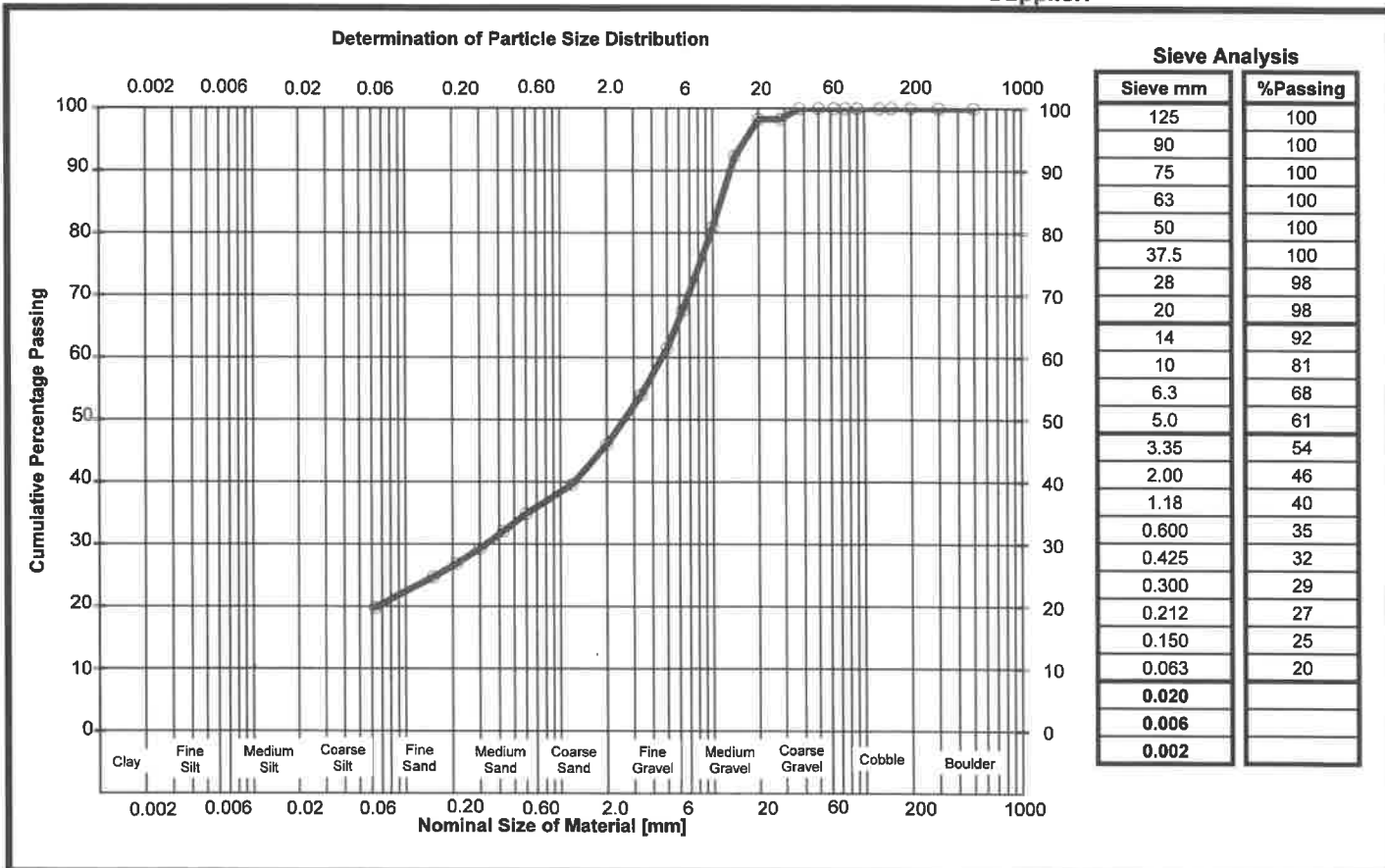
Depth Top: 1.70m

Location: BH1

Depth Base: 2.00m

Source:

Supplier:



Comments:

Approved Signatory: M. Hartnup - Laboratory Manager

Signed:

for and on behalf of Ground Engineering Ltd

Date Reported: 05.12.2017 Page 1 of 1
Form Number: GELab/C/709-2 Version 47

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Registered in England & Wales
Registration Number: 6929574
Reg Office: Ground Engineering Ltd
Newark Rd, Peterborough PE1 5UA



8180

TEST CERTIFICATE**GROUND ENGINEERING**

Newark Road Peterborough
t: 01733 566566 f: 01733 315280
e: admin@groundengineering.co.uk

Determination of Particle Size Distribution

Tested in Accordance with BS 1377-2: 1990: Clause 9.2
Sieved Grading

Client: Ground Engineering Ltd
Client Address: Newark Road
Peterborough
PE1 5UA

Certificate Number: PL6066-1/14/710-2
Client Reference: C14335
Lab Job Number: PL6066-1
Date Sampled: Unknown
Date Received: 22.11.2017
Date Tested: 29.11.2017
Certificate of Sampling: N/A
Sampling Certificate No.: N/A
Sampled By: Client

Contact: James Davies

Site Name: Land at Low Road & Plank Drove
Site Address: Crowland

TEST RESULTS

Laboratory Reference: PL6066-1/14

Pre-treatment for organic material: N/A

Client Reference: B6

Sample Description: Orange-brown clayey gravelly SAND. Gravel consists of angular flint

Material Specification: Not Required

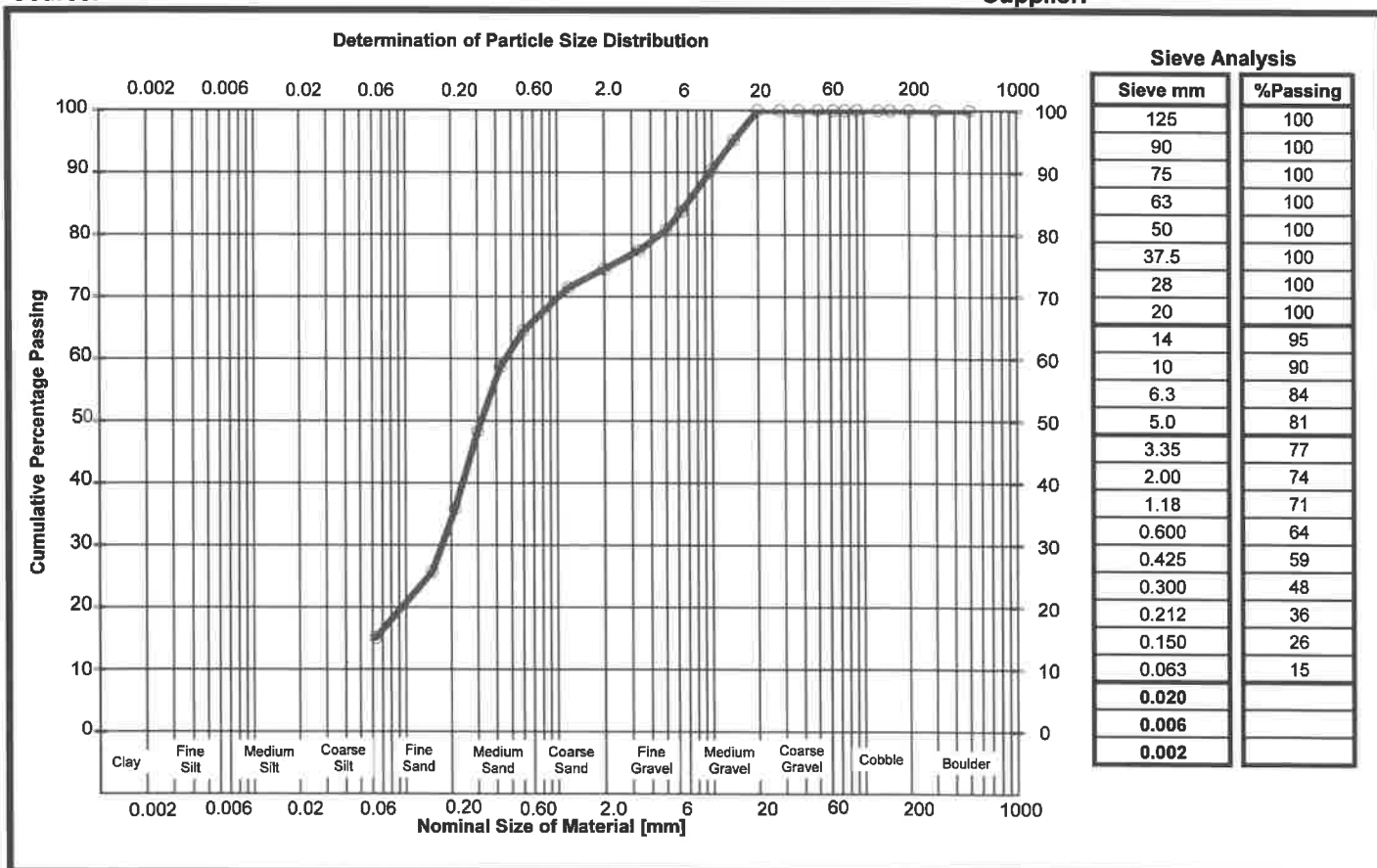
Location: BH2

Source:

Depth Top: 1.40m

Depth Base: 1.50m

Supplier:



Comments:

Approved Signatory: M. Hartnup - Laboratory Manager

Signed:

for and on behalf of Ground Engineering Ltd

Date Reported: 05.12.2017 Page 1 of 1
Form Number: GELab/C/709-2 Version 47

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8180

Newark Road Peterborough
t: 01733 566566 f: 01733 315280
e: admin@groundengineering.co.uk

TEST CERTIFICATE**Determination of Particle Size Distribution**

Tested in Accordance with BS 1377-2: 1990: Clause 9.2
Sieved Grading

Client: Ground Engineering Ltd
Client Address: Newark Road
Peterborough
PE1 5UA

Contact: James Davies

Site Name: Land at Low Road & Plank Drove
Site Address: Crowland

Certificate Number: PL6066-1/24/710-2
Client Reference: C14335
Lab Job Number: PL6066-1
Date Sampled: Unknown
Date Received: 22.11.2017
Date Tested: 29.11.2017
Certificate of Sampling: N/A
Sampling Certificate No.: N/A
Sampled By: Client

TEST RESULTS

Laboratory Reference: PL6066-1/24

Pre-treatment for
organic material: N/A

Client Reference: B4

Sample Description: Brown slightly sandy GRAVEL. Gravel consists of angular to rounded flint and quartzite

Material Specification: Not Required

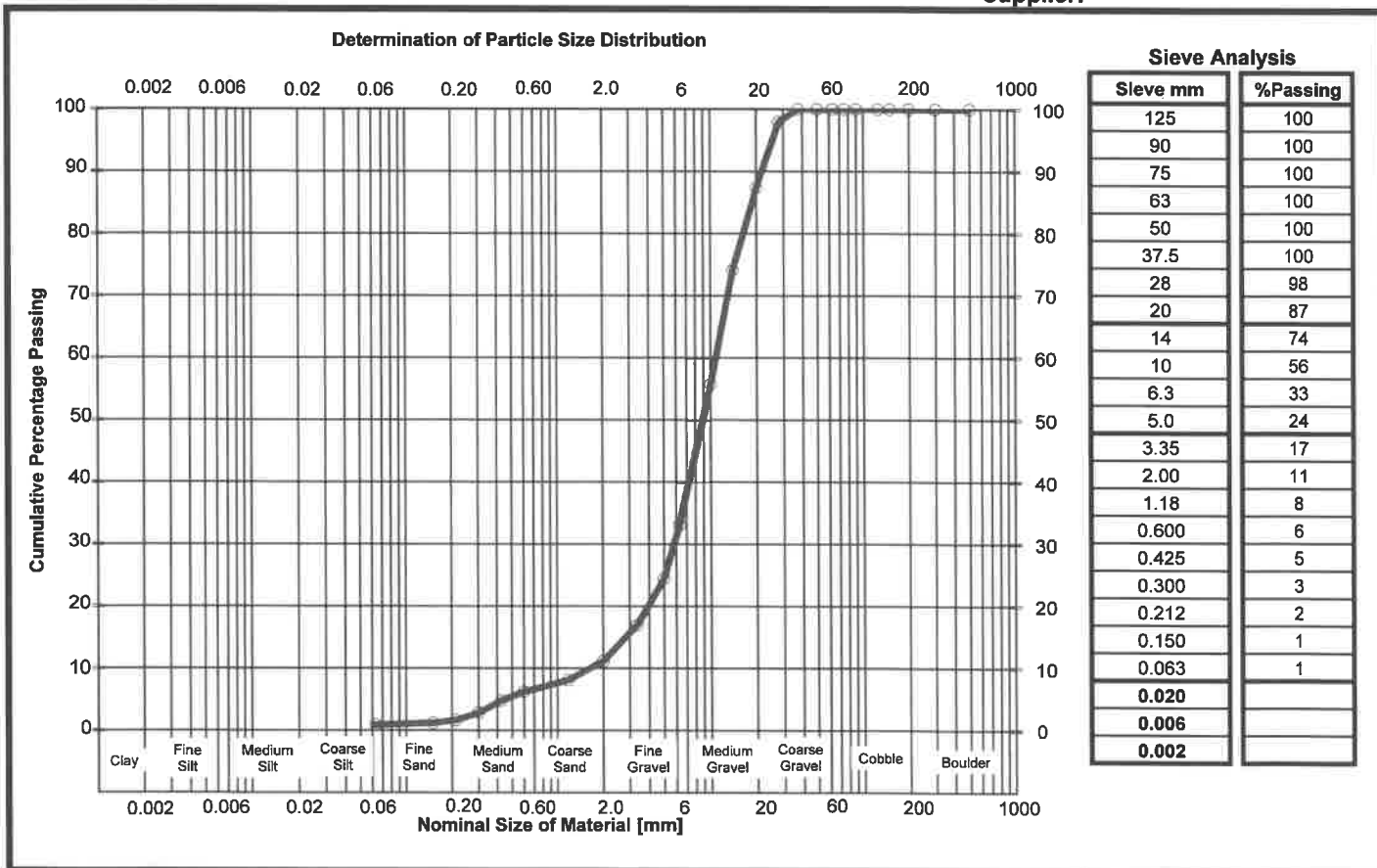
Depth Top: 1.50m

Location: BH3

Depth Base: 1.80m

Source:

Supplier:



Comments:

Approved Signatory: M. Hartnup - Laboratory Manager

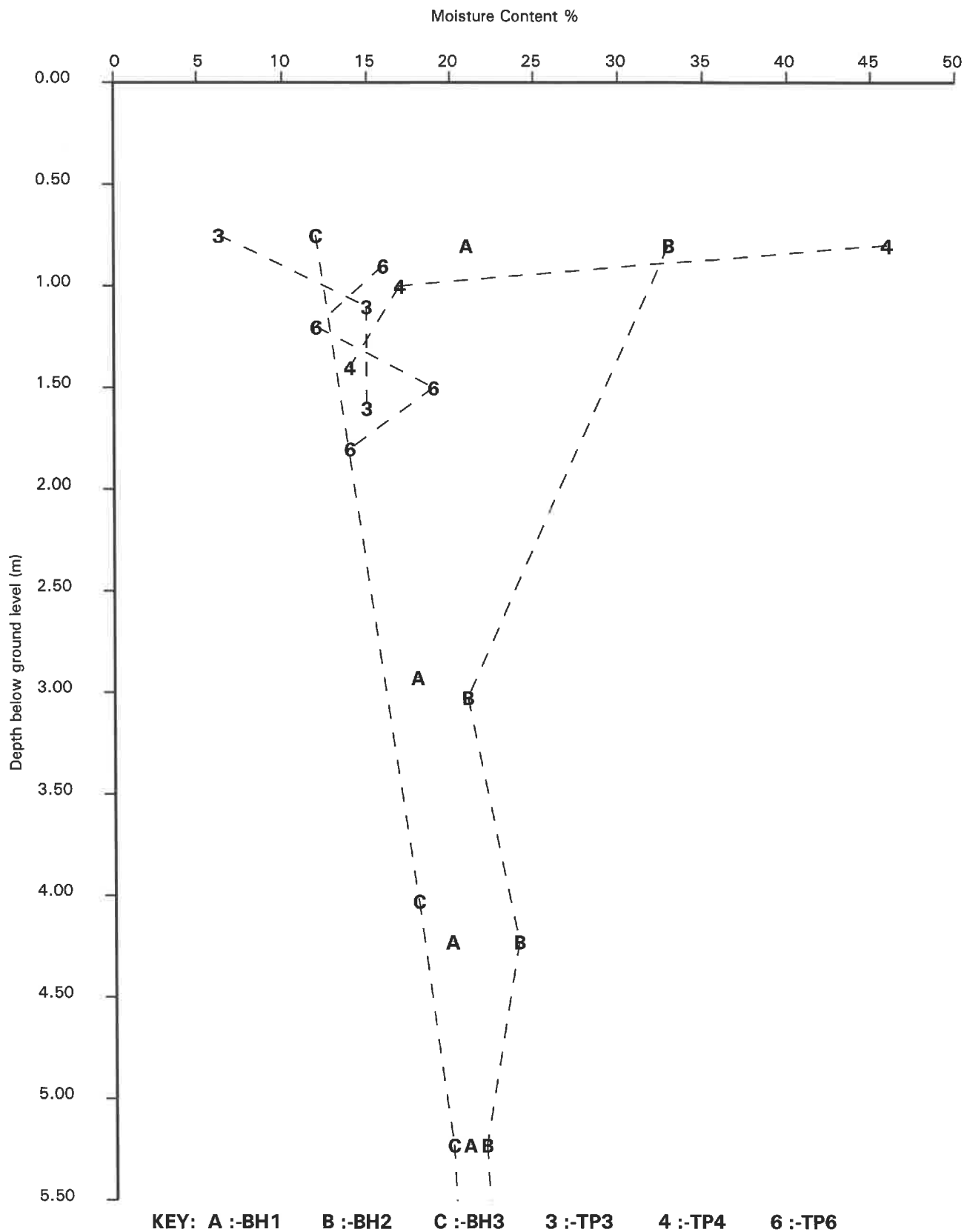
Signed:

Date Reported: 05.12.2017 Page 1 of 1
Form Number: GELab/C/709-2 Version 47

for and on behalf of Ground Engineering Ltd

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Registration Number: 6929574
Reg Office: Ground Engineering Ltd
Newark Rd, Peterborough PE1 5UA



Moisture Content % vs Depth below ground level (m).

SITE

LAND AT LOW ROAD & PLANK DROVE, CROWLAND

CLIENT

MR C. SHARPE, MRS L. FOX & MRS E. SKINNER

Contract

Number 14335

GROUND ENGINEERING

Tel: 01733-566566

Date

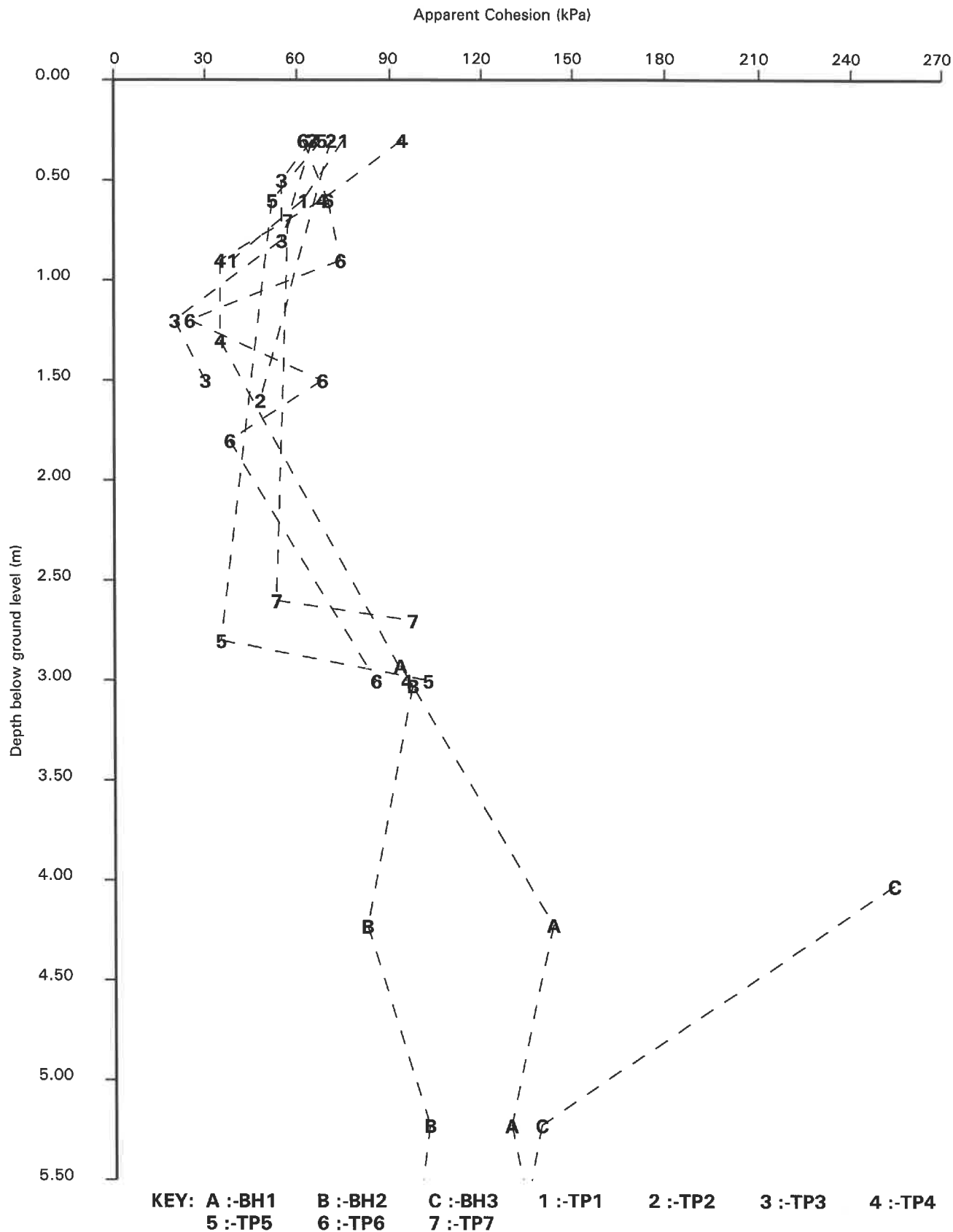
08/12/17

Figure

1

L I M I T E D

www.groundengineering.co.uk



Apparent Cohesion (kPa) vs Depth below ground level (m).

SITE

LAND AT LOW ROAD & PLANK DROVE, CROWLAND

CLIENT

MR C. SHARPE, MRS L. FOX & MRS E. SKINNER

Contract
Number 14335

GROUND ENGINEERING

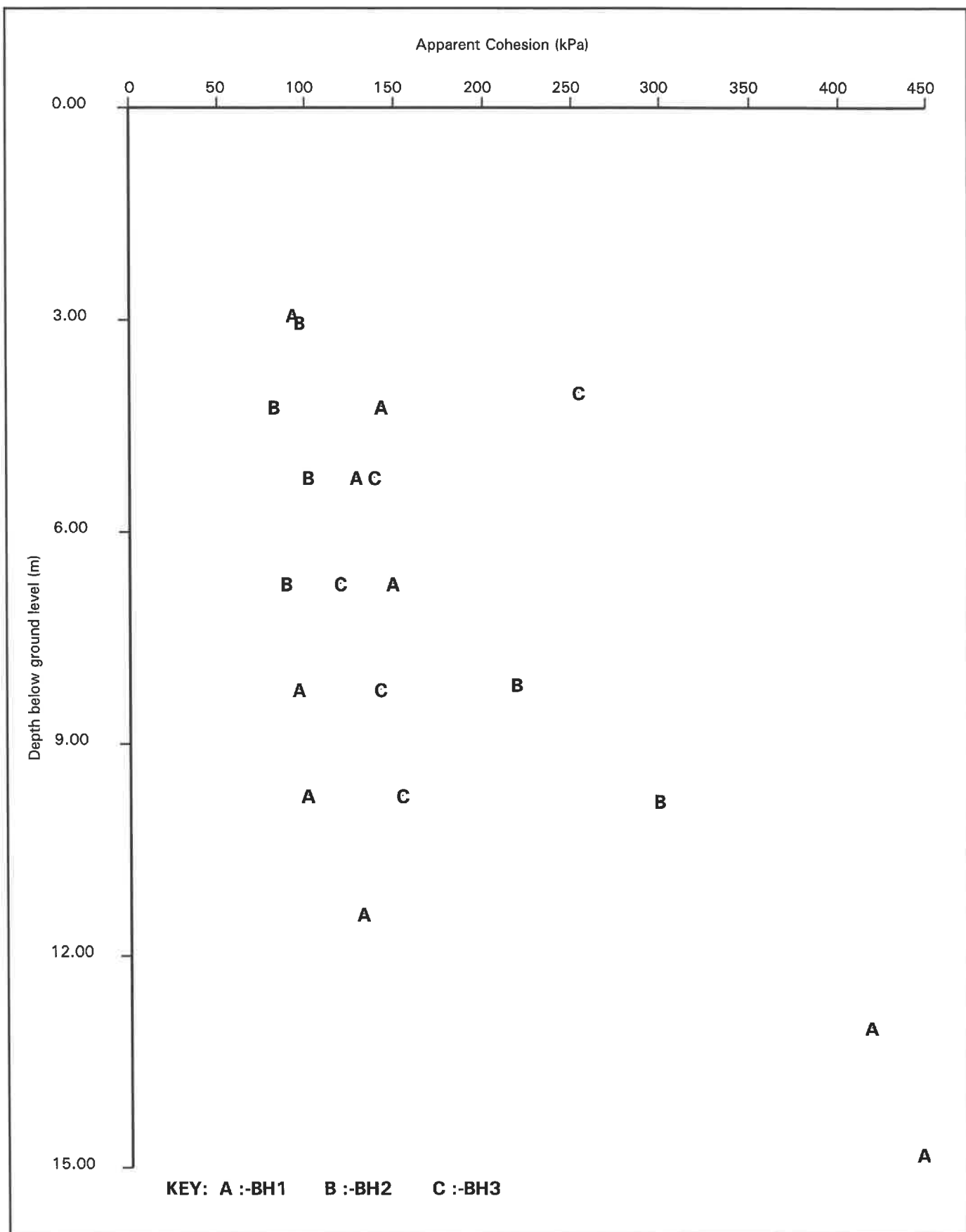
L I M I T E D

Tel: 01733-566566

www.groundengineering.co.uk

Date
08/12/17

Figure
2



Apparent Cohesion (kPa) vs Depth below ground level (m).

SITE

LAND AT LOW ROAD & PLANK DROVE, CROWLAND

CLIENT

MR C. SHARPE, MRS L. FOX & MRS E. SKINNER

Contract
Number

14335

GROUND ENGINEERING

L I M I T E D

Tel: 01733-566566

www.groundengineering.co.uk

Date

07/12/17

Figure

3

Appendix 4

Chemical Test Results



Final Report

Report No.: 17-31784-1
Initial Date of Issue: 05-Dec-2017
Client Ground Engineering Limited
Client Address: Newark Road
Peterborough
Cambridgeshire
PE1 5UA
Contact(s): James Davies
Project C14335 Land at Low Road & Plank
Drove, Crowland

Quotation No.:		Date Received:	29-Nov-2017
Order No.:	C14335	Date Instructed:	29-Nov-2017
No. of Samples:	1		
Turnaround (Wkdays):	5	Results Due:	05-Dec-2017
Date Approved:	05-Dec-2017		

Approved By:

Details: Glynn Harvey, Laboratory Manager

Project: C14335 Land at Low Road & Plank Drive, Crowland

Client: Ground Engineering Limited		Chemtest Job No.:			17-31784
Quotation No.:		Chemtest Sample ID.:			546583
Order No.: C14335		Client Sample Ref.:			BH1
		Client Sample ID.:			W1
		Sample Type:			WATER
		Top Depth (m):			0.00
		Bottom Depth (m):			0.30
		Date Sampled:			24-Nov-2017
Determinand	Accred.	SOP	Units	LOD	
pH	U	1010		N/A	7.6
Boron (Dissolved)	U	1450	µg/l	20	140
Sulphate	U	1220	mg/l	1.0	91
Cyanide (Free)	U	1300	mg/l	0.050	< 0.050
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050
Sulphide	U	1325	mg/l	0.050	< 0.050
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	1.7
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	1.7
Zinc (Dissolved)	U	1450	µg/l	1.0	2.0
Acenaphthene	N	1700	µg/l	0.010	< 0.010
Acenaphthylene	N	1700	µg/l	0.010	< 0.010
Anthracene	N	1700	µg/l	0.010	< 0.010
Benzo[a]anthracene	N	1700	µg/l	0.010	< 0.010
Benzo[a]pyrene	N	1700	µg/l	0.010	< 0.010
Benzo[b]fluoranthene	N	1700	µg/l	0.010	< 0.010
Benzo[g,h,i]perylene	N	1700	µg/l	0.010	< 0.010
Benzo[k]fluoranthene	N	1700	µg/l	0.010	< 0.010
Chrysene	N	1700	µg/l	0.010	< 0.010
Dibenz[a,h]Anthracene	N	1700	µg/l	0.010	< 0.010
Fluoranthene	N	1700	µg/l	0.010	< 0.010
Fluorene	N	1700	µg/l	0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1700	µg/l	0.010	< 0.010
Naphthalene	N	1700	µg/l	0.010	< 0.010
Phenanthrene	N	1700	µg/l	0.010	< 0.010
Pyrene	N	1700	µg/l	0.010	< 0.010
Total Of 16 PAH's	N	1700	µg/l	0.20	< 0.20
Total Phenols	U	1920	mg/l	0.030	< 0.030
Total Hardness as CaCO3	U	1270	mg/l	15	510
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10	< 0.10
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10	< 0.10
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10

1.49

Project: C14335 Land at Low Road & Plank Drive, Crowland

Client: Ground Engineering Limited		Chemtest Job No.:		17-31784
Quotation No.:		Chemtest Sample ID.:		546583
Order No.: C14335		Client Sample Ref.:		BH1
		Client Sample ID.:		W1
		Sample Type:		WATER
		Top Depth (m):		0.00
		Bottom Depth (m):		0.30
		Date Sampled:		24-Nov-2017
Determinand	Accred.	SOP	Units	LOD
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0
Aromatic TPH >C5-C7	N	1675	µg/l	0.10
Aromatic TPH >C7-C8	N	1675	µg/l	0.10
Aromatic TPH >C8-C10	N	1675	µg/l	0.10
Aromatic TPH >C10-C12	N	1675	µg/l	0.10
Aromatic TPH >C12-C16	N	1675	µg/l	0.10
Aromatic TPH >C16-C21	N	1675	µg/l	0.10
Aromatic TPH >C21-C35	N	1675	µg/l	0.10
Aromatic TPH >C35-C44	N	1675	µg/l	0.10
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0
Total Petroleum Hydrocarbons	N	1675	µg/l	10
				< 10

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO ₃ equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1325	Sulphide in Waters	Sulphides	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using N,N-dimethyl-p-phenylenediamine.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1675	TPH Aliphatic/Aromatic split in Waters by GC-FID(cf. Texas Method 1006 / TPH CWG)	Aliphatics: >C ₅ -C ₆ , >C ₆ -C ₈ , >C ₈ -C ₁₀ , >C ₁₀ -C ₁₂ , >C ₁₂ -C ₁₆ , >C ₁₆ -C ₂₁ , >C ₂₁ -C ₃₅ , >C ₃₅ -C ₄₄ Aromatics: >C ₅ -C ₇ , >C ₇ -C ₈ , >C ₈ -C ₁₀ , >C ₁₀ -C ₁₂ , >C ₁₂ -C ₁₆ , >C ₁₆ -C ₂₁ , >C ₂₁ -C ₃₅ , >C ₃₅ -C ₄₄	Pentane extraction / GCxGC FID detection
1700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenzo[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GC FID detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

Report Information

Key

- U UKAS accredited
- M MCERTS and UKAS accredited
- N Unaccredited
- S This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
- SN This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
- T This analysis has been subcontracted to an unaccredited laboratory
- I/S Insufficient Sample
- U/S Unsuitable Sample
- N/E not evaluated
- < "less than"
- > "greater than"

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

- A - Date of sampling not supplied
- B - Sample age exceeds stability time (sampling to extraction)
- C - Sample not received in appropriate containers
- D - Broken Container
- E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.co.uk



Final Report

Report No.: 17-31240-1
Initial Date of Issue: 29-Nov-2017
Client Ground Engineering Limited
Client Address: Newark Road
Peterborough
Cambridgeshire
PE1 5UA
Contact(s): James Davies
Project C14335 Land at Low Road & Plank
Drove, Crowland

Quotation No.:		Date Received:	23-Nov-2017
Order No.:	C14335	Date Instructed:	23-Nov-2017
No. of Samples:	12		
Turnaround (Wkdays):	5	Results Due:	29-Nov-2017
Date Approved:	29-Nov-2017		

Approved By:

Details: Martin Dyer, Laboratory Manager

Results - Soil

Project: C14335 Land at Low Road & Plank Drive, Crowland

Client: Ground Engineering Limited				Chemtest Job No.:		17-31240	17-31240	17-31240	17-31240	17-31240	17-31240	17-31240	17-31240	17-31240	17-31240	17-31240
Quotation No.:				Chemtest Sample ID.:		544060	544061	544062	544063	544064	544066	544067	544068			
Order No.: C14335				Client Sample Ref.:		BH1	BH2	BH3	TP1	TP1	TP3	TP3	TP4			
				Client Sample ID.:		B1	B1	B1	D1	D2	D1	D2	D1			
				Sample Type:		SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL			
				Top Depth (m):		0.00	0.00	0.00	0.30	0.60	0.30	0.50	0.30			
				Bottom Depth (m):		0.30	0.20	0.40								
				Date Sampled:		17-Nov-2017	17-Nov-2017	17-Nov-2017	17-Nov-2017	17-Nov-2017	17-Nov-2017	17-Nov-2017	17-Nov-2017			
				Asbestos Lab:		COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY			
Determinand	Accred.	SOP	Units	LOD	7.5	8.0	6.4	7.9	7.9	7.9						
pH	U	2010		N/A	31	32	26	22	27	12	28	8.2	7.8			
Moisture	N	2030	%	0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020			
Stones and Removed Materials	N	2030	%	0.020	1.3	2.1	1.4	1.6	1.9	0.45	1.6	0.45	1.6			
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	0.024	0.060	< 0.010	0.010	0.034	< 0.010	< 0.010	< 0.010	< 0.010			
Sulphate (2:1 Water Soluble) as SO4	U	2120	g/l	0.010	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50			
Cyanide (Free)	U	2300	mg/kg	0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50			
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50			
Sulphide (Easily Liberatable)	U	2325	mg/kg	0.50	79	41	9.9	12	3.3	4.0	2.7	4.0	2.7			
Arsenic	U	2450	mg/kg	1.0	30	37	31	30	34	7.9	33	7.9	33			
Cadmium	U	2450	mg/kg	0.10	0.22	0.26	0.15	0.19	< 0.10	< 0.10	0.23	< 0.10	0.23			
Chromium	U	2450	mg/kg	1.0	49	37	60	48	30	14	56	14	56			
Copper	U	2450	mg/kg	0.50	31	26	32	26	20	4.0	36	4.0	36			
Mercury	U	2450	mg/kg	0.10	0.17	0.58	0.21	0.14	< 0.10	< 0.10	0.19	< 0.10	0.19			
Nickel	U	2450	mg/kg	0.50	35	31	41	39	27	8.4	40	8.4	40			
Lead	U	2450	mg/kg	0.50	59	120	72	47	17	10	68	10	68			
Selenium	U	2450	mg/kg	0.20	0.74	< 0.20	0.50	0.49	0.86	< 0.20	0.67	< 0.20	0.67			
Zinc	U	2450	mg/kg	0.50	110	220	110	100	56	27	120	27	120			
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50			
Organic Matter	U	2625	%	0.40	8.5	10	8.1	6.7	5.6	< 0.40	7.2	< 0.40	7.2			
Acenaphthene	U	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10			
Acenaphthylene	U	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10			
Anthracene	U	2700	mg/kg	0.10	< 0.10	0.19	< 0.10	0.17	< 0.10	< 0.10	0.10	< 0.10	0.10			
Benzo[a]anthracene	U	2700	mg/kg	0.10	0.16	0.73	< 0.10	0.64	< 0.10	< 0.10	0.41	< 0.10	0.41			
Benzo[a]pyrene	U	2700	mg/kg	0.10	< 0.10	0.85	< 0.10	0.71	< 0.10	< 0.10	0.47	< 0.10	0.47			
Benzo[b]fluoranthene	U	2700	mg/kg	0.10	< 0.10	0.85	< 0.10	0.94	< 0.10	< 0.10	0.42	< 0.10	0.42			
Benzo[g,h,i]perylene	U	2700	mg/kg	0.10	< 0.10	0.93	< 0.10	0.94	< 0.10	< 0.10	0.31	< 0.10	0.31			
Benzo[k]fluoranthene	U	2700	mg/kg	0.10	< 0.10	0.28	< 0.10	0.27	< 0.10	< 0.10	0.11	< 0.10	0.11			
Chrysene	U	2700	mg/kg	0.10	0.24	0.54	< 0.10	1.1	< 0.10	< 0.10	0.57	< 0.10	0.57			
Dibenz(a,h)Anthracene	U	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10			
Fluoranthene	U	2700	mg/kg	0.10	0.43	1.9	0.36	1.9	< 0.10	< 0.10	0.88	< 0.10	0.88			
Fluorene	U	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10			
Indeno(1,2,3-c,d)Pyrene	U	2700	mg/kg	0.10	< 0.10	0.58	< 0.10	0.43	< 0.10	< 0.10	0.26	< 0.10	0.26			
Naphthalene	U	2700	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10			
Phenanthrene	U	2700	mg/kg	0.10	0.33	0.88	0.25	0.85	< 0.10	< 0.10	0.41	< 0.10	0.41			
Pyrene	U	2700	mg/kg	0.10	0.44	1.7	0.41	1.7	< 0.10	< 0.10	1.1	< 0.10	1.1			
Total Of 16 PAH's	U	2700	mg/kg	2.0	< 2.0	9.4	< 2.0	9.7	< 2.0	< 2.0	5.0	< 2.0	5.0			

Results - Soil

Project: C14335 Land at Low Road & Plank Drive, Crowland

Client: Ground Engineering Limited		Chemtest Job No.:										
Quotation No.:		Chemtest Sample ID.:										
Order No.: C14335		Client Sample Ref.:										
		Client Sample ID.:										
		Sample Type:										
		Top Depth (m):										
		Bottom Depth (m):										
		Date Sampled:										
		Asbestos Lab:										
Determinand		Accred.	SOP	Units	LOD							
Total Phenols		U	2920	mg/kg	0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
ACM Type		U	2192	N/A				-	-	-	-	-
Asbestos Identification		U	2192	%	0.001	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected
Total TPH >C6-C40		U	2670	mg/kg	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Project: C14335 Land at Low Road & Plank Drive, Crowland

Client: Ground Engineering Limited		Chemtest Job No.:		17-31240	17-31240	17-31240
Quotation No.:		Chemtest Sample ID.:		544069	544070	544071
Order No.: C14335		Client Sample Ref.:		TP5	TP6	TP7
		Client Sample ID.:		D1	D1	D1
		Sample Type:		SOIL	SOIL	SOIL
		Top Depth (m):		0.30	0.30	0.30
		Bottom Depth (m):				
		Date Sampled:		17-Nov-2017	17-Nov-2017	17-Nov-2017
		Asbestos Lab:				
Determinand	Accred.	SOP	Units	LOD		
pH	U	2010		N/A	7.1	6.4
Moisture	N	2030	%	0.020	28	26
Stones and Removed Materials	N	2030	%	0.020	< 0.020	< 0.020
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	2.3	2.0
Sulphate (2:1 Water Soluble) as SO4	U	2120	g/l	0.010	0.013	< 0.010
Cyanide (Free)	U	2300	mg/kg	0.50	< 0.50	< 0.50
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50
Sulphide (Easily Liberatable)	U	2325	mg/kg	0.50	2.4	1.9
Arsenic	U	2450	mg/kg	1.0	28	29
Cadmium	U	2450	mg/kg	0.10	0.12	0.25
Chromium	U	2450	mg/kg	1.0	65	52
Copper	U	2450	mg/kg	0.50	30	33
Mercury	U	2450	mg/kg	0.10	< 0.10	0.18
Nickel	U	2450	mg/kg	0.50	47	37
Lead	U	2450	mg/kg	0.50	35	63
Selenium	U	2450	mg/kg	0.20	0.91	0.62
Zinc	U	2450	mg/kg	0.50	110	110
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50	< 0.50
Organic Matter	U	2625	%	0.40	4.8	7.9
Acenaphthene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Acenaphthylene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Anthracene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Chrysene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Fluoranthene	U	2700	mg/kg	0.10	< 0.10	0.30
Fluorene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Naphthalene	U	2700	mg/kg	0.10	< 0.10	< 0.10
Phenanthrene	U	2700	mg/kg	0.10	< 0.10	0.17
Pyrene	U	2700	mg/kg	0.10	< 0.10	0.32
Total Of 16 PAH's	U	2700	mg/kg	2.0	< 2.0	< 2.0

Project: C14335 Land at Low Road & Plank Drive, Crowland

Client: Ground Engineering Limited		Chemtest Job No.:	17-31240	17-31240	17-31240
Quotation No.:		Chemtest Sample ID.:	544069	544070	544071
Order No.: C14335		Client Sample Ref.:	TP5	TP6	TP7
		Client Sample ID.:	D1	D1	D1
		Sample Type:	SOIL	SOIL	SOIL
		Top Depth (m):	0.30	0.30	0.30
		Bottom Depth (m):			
		Date Sampled:	17-Nov-2017	17-Nov-2017	17-Nov-2017
		Asbestos Lab:			
Determinand	Accred.	SOP	Units	LOD	
Total Phenols	U	2920	mg/kg	0.30	< 0.30
ACM Type	U	2192		N/A	
Asbestos Identification	U	2192	%	0.001	
Total TPH >C6-C40	U	2670	mg/kg	10	

Results - Single Stage WAC

Project: C14335 Land at Low Road & Plank Drive, Crowland

Chemtest Job No: 17-31240									Landfill Waste Acceptance Criteria			
Chemtest Sample ID: 544065									Limits			
Sample Ref: TP2									Inert Waste Landfill			
Sample ID: D1												
Top Depth(m): 0.20									Stable, Non-reactive hazardous waste in non-hazardous Landfill			
Bottom Depth(m):									Hazardous Waste Landfill			
Sampling Date: 17-Nov-2017												
Determinand	SOP	Accred.	Units									
Total Organic Carbon	2625	U	%	4.7			3			5		
Loss On Ignition	2610	U	%	15			--			--		
Total BTEX	2760	U	mg/kg	< 0.010			6			--		
Total PCBs (7 Congeners)	2815	U	mg/kg	< 0.10			1			--		
TPH Total WAC (Mineral Oil)	2670	U	mg/kg	< 10			500			--		
Total (Of 17) PAH's	2700	N	mg/kg	< 2.0			100			--		
pH	2010	U		6.3			--			>6		
Acid Neutralisation Capacity	2015	N	mol/kg	0.026			--			To evaluate		
Eluate Analysis				10:1 Eluate mg/l			10:1 Eluate mg/kg			Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg		
Arsenic	1450	U	0.0035	< 0.050			0.5			2		
Barium	1450	U	0.027	< 0.50			20			100		
Cadmium	1450	U	< 0.00010	< 0.010			0.04			1		
Chromium	1450	U	0.0053	0.053			0.5			10		
Copper	1450	U	0.0076	0.076			2			50		
Mercury	1450	U	< 0.00050	< 0.0050			0.01			0.2		
Molybdenum	1450	U	0.0032	< 0.050			0.5			10		
Nickel	1450	U	0.0058	0.058			0.4			10		
Lead	1450	U	0.0061	0.061			0.5			10		
Antimony	1450	U	0.022	0.22			0.06			0.7		
Selenium	1450	U	< 0.0010	< 0.010			0.1			0.5		
Zinc	1450	U	0.020	< 0.50			4			50		
Chloride	1220	U	5.5	55			800			15000		
Fluoride	1220	U	1.1	11			10			150		
Sulphate	1220	U	57	570			1000			20000		
Total Dissolved Solids	1020	N	65	640			4000			60000		
Phenol Index	1920	U	< 0.030	< 0.30			1			-		
Dissolved Organic Carbon	1610	U	24	240			500			800		
										1000		

Solid Information	
Dry mass of test portion/kg	0.090
Moisture (%)	30

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

SOP	Title	Parameters included	Method summary
1020	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Conductivity Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.
2010	pH Value of Soils	pH	pH Meter
2015	Acid Neutralisation Capacity	Acid Reserve	Titration
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2192	Asbestos	Asbestos	Polarised light microscopy / Gravimetry
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Alkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2325	Sulphide in Soils	Sulphide	Steam distillation with sulphuric acid / analysis by 'Aquakem 600' Discrete Analyser, using N,N-dimethyl-p-phenylenediamine.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2610	Loss on Ignition	loss on ignition (LOI)	Determination of the proportion by mass that is lost from a soil by ignition at 550°C.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.

SOP	Title	Parameters included	Method summary
2815	Polychlorinated Biphenyls (PCB) ICES7 Congeners in Soils by GC-MS	ICES7 PCB congeners	Acetone/Hexane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and Trimethylphenols Note: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

- U UKAS accredited
- M MCERTS and UKAS accredited
- N Unaccredited
- S This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
- SN This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
- T This analysis has been subcontracted to an unaccredited laboratory
- I/S Insufficient Sample
- U/S Unsuitable Sample
- N/E not evaluated
- < "less than"
- > "greater than"

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

- A - Date of sampling not supplied
- B - Sample age exceeds stability time (sampling to extraction)
- C - Sample not received in appropriate containers
- D - Broken Container
- E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.co.uk

Appendix 5

Classification of Aggressive Chemical Environment for Buried Concrete

TABLE C1 – AGGRESSIVE CHEMICAL ENVIRONMENT FOR CONCRETE

(ACEC) CLASSIFICATION FOR NATURAL GROUND LOCATIONS^a

Table C1 Aggressive Chemical Environment for Concrete (ACEC) classification for natural ground locations ^a						
Sulfate				Groundwater		ACEC Class for location
Design Sulfate Class for location	2:1 water/soil extract ^b	Groundwater	Total potential sulfate ^c	Static water	Mobile water	
1	2 (SO ₄ mg/l)	3 (SO ₄ mg/l)	4 (SO ₄ %)	5 (pH)	6 (pH)	7
DS-1	< 500	< 400	< 0.24	≥ 2.5		AC-1s
					> 5.5 ^d	AC-1 ^d
					2.5–5.5	AC-2z
DS-2	500–1500	400–1400	0.24–0.6	> 3.5		AC-1s
					> 5.5	AC-2
					2.5–3.5	AC-2s
DS-3	1600–3000	1500–3000	0.7–1.2	> 3.5		AC-3z
					> 5.5	AC-2s
					2.5–3.5	AC-3
DS-4	3100–6000	3100–6000	1.3–2.4	> 3.5		AC-3s
					> 5.5	AC-4
					2.5–3.5	AC-4s
DS-5	> 6000	> 6000	> 2.4	> 3.5		AC-5
					> 5.5	AC-4s
					2.5–3.5	AC-4s
DS-5	> 6000	> 6000	> 2.4	> 3.5		AC-5
					> 5.5	AC-4s
					2.5–3.5	AC-4s

Notes

- a** Applies to locations on sites that comprise either undisturbed ground that is in its natural state (ie is not brownfield – Table C2) or clean fill derived from such ground.
- b** The limits of Design Sulfate Classes based on 2:1 water/soil extracts have been lowered relative to previous Digests (Box C7).
- c** Applies only to locations where concrete will be exposed to sulfate ions (SO₄) which may result from the oxidation of sulfides (eg pyrite) following ground disturbance (Appendix A1 and Box C8).
- d** For flowing water that is potentially aggressive to concrete owing to high purity or an aggressive carbon dioxide level greater than 15 mg/l (Section C2.2.3), increase the ACEC Class to AC-2z.

Explanation of suffix symbols to ACEC Class

- Suffix 's' indicates that the water has been classified as static.
- Concrete placed in ACEC Classes that include the suffix 'z' primarily have to resist acid conditions and may be made with any of the cements or combinations listed in Table D2 on page 42.

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