



## **DESIGN & CONSTRUCTION DEVELOPMENT & CORPORATE SERVICES**

### **Cottam Parkway Access Bridge and Road Preliminary Sources Study Report**

Geotechnical Report No. CLM07

[www.lancashire.gov.uk](http://www.lancashire.gov.uk)

# Document Control Sheet

## Record of Issue

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# DISCLAIMER

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Notwithstanding anything to the contrary contained in the report, the LCC Geotechnical Team is obliged to exercise reasonable skill, care and diligence in the performance of the services required by LCC Bridges and the LCC Infrastructure Delivery Team and the LCC Geotechnical Team shall not be liable except to the extent that it has failed to exercise reasonable skill, care and diligence, and this report shall be read and construed accordingly.

This report has been prepared by the LCC Geotechnical Team. No individual is personally liable in connection with the preparation of this report. By receiving this report and acting on it, the client or any other person accepts that no individual is personally liable whether in contract, tort, for breach of statutory duty or otherwise.

The LCC Geotechnical Team has used reasonable skill, care and diligence in the design and interpretation of the ground investigation, however, the inherent variability of ground conditions allows only definition of the actual conditions at the location and depths of exploratory holes and samples/tests therefrom, while at intermediate locations conditions can only be inferred.

New information, changed practices, or new legislation may necessitate revised interpretation of the report after the date of its submission.

The layout of the scheme has been altered since the completion of this report however the information contained within the follow sections remains relevant and correct.

LANCASHIRE COUNTY COUNCIL

DESIGN AND CONSTRUCTION

GEOTECHNICAL REPORT NO: CLM07

Cottam Parkway Access Bridge and Road

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**Appendix List:**

- Appendix A – Site location;**
- Appendix B – Site photographs;**
- Appendix C – Previous investigation logs and testing;**
- Appendix D – Service information;**
- Appendix E - Preliminary site investigation model;**
- Appendix F – Additional topographical map**

***Hard copies of all desk study reference material can be provided upon request***

# **LANCASHIRE COUNTY COUNCIL**

## **DESIGN AND CONSTRUCTION**

### **GEOTECHNICAL REPORT NO: CLM07**

#### **Cottam Parkway Access Bridge and Road**

## **1.0 INTRODUCTION**

At the request of Lancashire County Council Design and Construction (Bridges Team and Infrastructure Delivery Team), a Preliminary Sources Study Report (PSSR) has been undertaken for a proposed bridge, embankments, access road, and car park related to the proposed Cottam Parkway rail interchange, (grid ref. E349043:N431609). This PSSR has been produced with reference to Design Manual for Roads and Bridges, CD 622 "Managing Geotechnical Risk".

## **1.2 Description of the project**

This project involves the proposed construction of a new road to connect the planned Cottam Railway Station with the Cottam Link Road that is currently under construction. The current proposal is for a two-way road, approximately 450m in length starting at E349107:N431357 and connecting to a roundabout on the Cottam Link Road at E349039:N431712. The new road will cross the Lancaster Canal at E349043:N431625 via a proposed three span bridge with embankments leading up to the bridge. Two non-vehicular access tracks have also been designed to travel underneath the bridge on either side of the canal. Additionally, to the bridge, a roughly 400m long car park is planned to be built for the railway station on its north side. An attenuation pond is also planned, located at E348993:N431694.

A general overview of the project can be seen in Figure 1 and detailed plans of the proposed route are available upon request. The location maps of the site can be viewed in Appendix A.

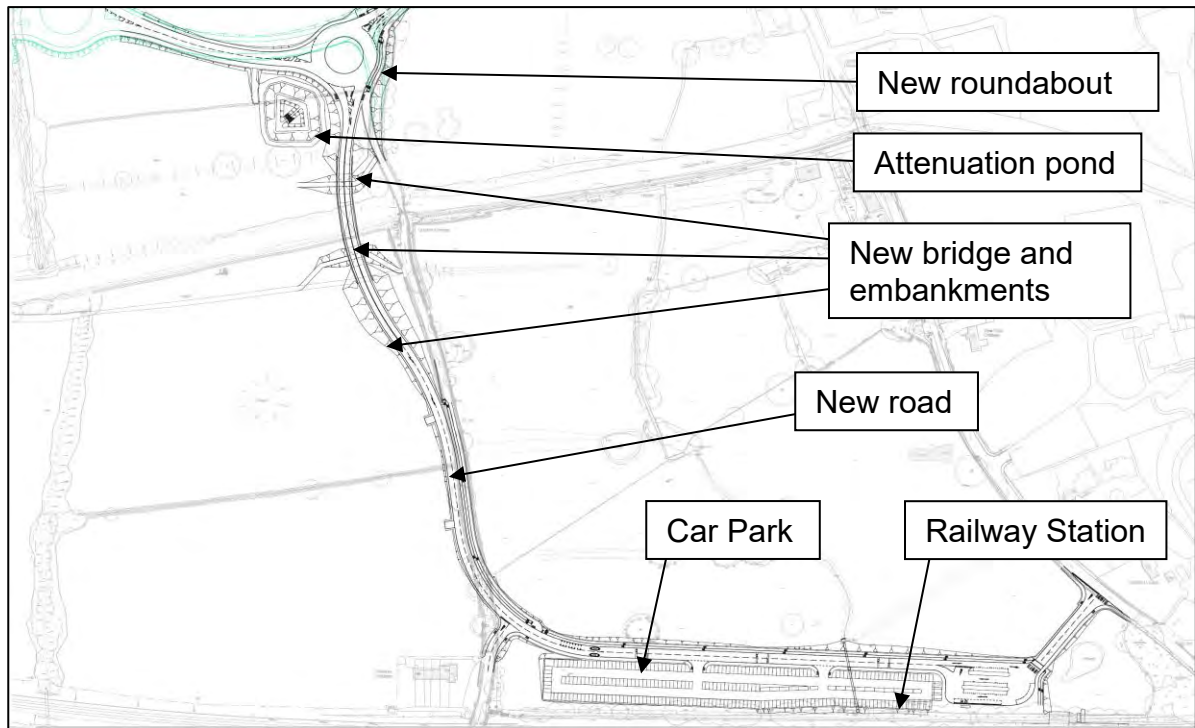


Figure 1, General overview of proposed project.

### 1.3 Scope of Report

This PSSR will review the existing information associated with the site to assess the geotechnical hazards and the risks associated with the proposed scheme. This report provides a summary of the anticipated ground conditions in the vicinity of the scheme based on available information.

## **2.0 DESK STUDY**

### **2.1 Site Description/Walkover**

The majority of the proposed scheme is adjacent to the existing Sidgreaves Lane, which is south west of Cottam. The proposed route travels across the Lancaster Canal via a new bridge. The surrounding land is mainly agricultural fields. There are four large ponds located within 150m of the proposed scheme, although none are located beneath the development area: Pond A (E348978:N431508), Pond B (E349096:N431541), Pond C (E349201:N431476) and Pond D (E349488:N431338). These ponds are labelled on the location plan in Appendix A.

A visual inspection of the site was undertaken on the 2<sup>nd</sup> of December 2020, followed by further inspections on the 1<sup>st</sup>, 5<sup>th</sup> and 19<sup>th</sup> of March 2021. Photographs from the site walkovers are available in Appendix B. The following was noted in the inspections:

- Access to the fields on either side of the canal is available through two farm gates located on Sidgreaves Lane, at E349045:N431667 and E349064:N431589. The gates are large enough to allow for drilling equipment to access the fields. Access to the south western field is available through another large gate located at E349113:N431370. Access to the south eastern field is available through either two medium sized gates at E349118:N431394 or one large gate located at E349457:N431415.
- The first site inspection was carried out during wet conditions, and it was noted that the fields were waterlogged. The second site and third inspection were undertaken in clear conditions, however the south eastern fields were noted to still have patches of surface water at E349217:N431363 and boggy ground at E349394:N431314.
- Located at E349032:N431665 is a mature oak tree which will need to be removed in order to construct the northern embankment. In addition, located at E349208:N431362 and E349108:N431387 are trees, which will need to be removed for the construction of the new road. The removal of these trees is likely to result in localised heaving of the ground. It is anticipated that further vegetation clearance on the banks of Lancaster Canal, along the sides of

Sidgreaves Lane and along the railway will be required in order to allow for the construction of the proposed structures. It is recommended that ecology surveys are undertaken in these areas, and that any trees, hedgerows and vegetation are removed outside of bird nesting season.

- There were no visual or olfactory signs of contamination at the site during the site walkover.
- Quakers Canal Bridge was noted to have a large crack on the underside of the bridge and masonry protruded from the main structure by 10-30mm, which may be indications of structural instability. In addition, Quakers Bridge is quite narrow and has notable scrapes along its parapets, presumably caused by traffic.
- Located in the south eastern field is a large plastic pipe that protrudes out from the railway embankment at E349346:N431304.
- An unnamed small watercourse in the eastern fields is culverted underground at E349338:N431351, directly beneath the proposed car park. Located at E349348:N431303 is a brick culvert that transports this watercourse underneath the railway. The culvert has one large crack that protrudes from the top of the archway, but otherwise looks to be in a good structural condition.

## **2.2 Topography**

Sidgreaves Lane is situated at approximately 21mAOD in the south, rising to 25mAOD at the junction with Lea Road. The surrounding fields are typically 20mAOD, with localised depressions. The centre of Quakers Canal Bridge is recorded at 24.7mAOD according to Mapzone. AutoCAD topographical maps can be supplied upon request.

Also noted during the site walkover, several drainage ditches are located across the south eastern field, with an average depth of 0.25m. These ditches do not appear on any of the topographical maps. however, there is some correlation between them and the surface water flood maps. An approximate location map of these ditches is available in Appendix F.

## 2.3 Site History

Historical maps and aerial photographs from Mapzone showing the site between 1845 and the present day have been reviewed as part of this report, which can be supplied upon request. Historical maps from the National Library of Scotland have also been reviewed and can be accessed via: <https://maps.nls.uk/>.

The historical information indicates there has been no significant change along or adjacent to the proposed route since 1845. The surrounding land has been used primarily for agriculture since 1845. The only property development has been the construction of the Railway Cottages and the houses on the west side of Lea Road, recorded on the 1895 map.

As mentioned previously, there are ponds A, B, C and D within 150m of the proposed scheme. However, the 1940's and 1960's aerial photograph indicate two additional ponds located at E349020:N431479 and E348990:N431370 that have likely been infilled. Neither the existing ponds nor the infilled ponds are within the location of the proposed scheme.

A Roman road (Danes Pad) is recorded on several historical maps, which has an east-west orientation and crosses Sidgreaves Lane at E349083:N431547. The proposed road will likely cross this historic site and, consequently, this may be an archaeological constraint to development. Historical maps are available upon request.

## 2.4 Geology

The maps from the BGS geology of Britain viewer and BSG solid and drift geology Sheet 75 (Preston) map indicate that the superficial geology beneath the site is glacial till deposits comprising predominantly clays with some sands, silts and gravels.

The BGS geology of Britain viewer and BSG Sheet 75 (Preston) map indicates the underlying solid geology is sandstone of the Sherwood Sandstone Group.

(<http://mapapps.bgs.ac.uk/geologyofbritain/home.html>)

(<http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=1004280>)

There are no BGS boreholes within the proposed route of the scheme.

## 2.5 Hydrology and Hydrogeology

Lancaster Canal is located within the position of the proposed route, orientated in an east to west direction. In addition, there is an un-named small watercourse located approximately 120m east of Sidgreaves Lane, in a parallel direction to the road. The small watercourse is culverted beneath the area of the proposed car park at E349338:N431351, re-emerging on the southern side of the railway. There are also the ponds A, B, C and D, which have been previously discussed.

Magic Maps (<https://magic.defra.gov.uk/MagicMap.aspx>) defines the superficial geology at the site as a secondary undifferentiated aquifer. The Environment Agency defines a secondary undifferentiated aquifer as:

- Secondary Undifferentiated Aquifer: *'has been assigned in cases where it has not been possible to attribute either category A or B to a soil type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the soil type'.*

The BGS Hydrogeology map linked below, describes the Triassic Sherwood Sandstone Group as being a highly productive principle aquafer. The Environment Agency defines a principal aquifer as:

- Principal Aquifer: *'These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale'.*

(<http://mapapps2.bgs.ac.uk/geindex/home.html?layer=BGSHydroMap>)

## 2.6 Flood Risk

The site, as identified in Mapzone, is not located within a fluvial flood watch area and is classed as Flood Zone 1. The Environment Agency (<https://flood-map-for-planning.service.gov.uk>) identifies Flood Zones 1 as:

- *Low probability - Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3).*

Mapzone identifies the whole site as having a low risk (less than a 25%) of groundwater flooding.

Surface water flooding maps from Mapzone show the canal path and localised areas of the proposed route along Sidgreaves Lane are moderately susceptible to surface water flooding. Additionally, there are localised areas of intermediate flood risk in the field where the proposed car park is located (at E349135:N431360, E349211:N431412, E349218:N431384 and E349216:N431364). The area around the eastern small watercourse is considered intermediate to high risk, including the culverted section below the railway.

## **2.7 Unexploded Ordnance Risk**

According to the Zetica risk maps (<https://zeticauxo.com/downloads-and-resources/risk-maps/>), the site has a low bomb risk, which is defined as an area having 15 bombs per 1000 acre or less.

## **2.8 Previous Site Investigations**

Preston Western Distributor, 2014-2015.

As part of a large scale ground investigation carried out in 2014 for the Preston Western Distributor scheme, Ian Farmer Associates was contracted by LCC to drill four cable precaution boreholes (BH221-224) to depths of between 20.30mbgl and 22.80mbgl, and one window sample borehole (WS227) to a depth of 5.45mbgl. The boreholes were drilled within the location of the proposed bridge, as shown below in Figure 2.



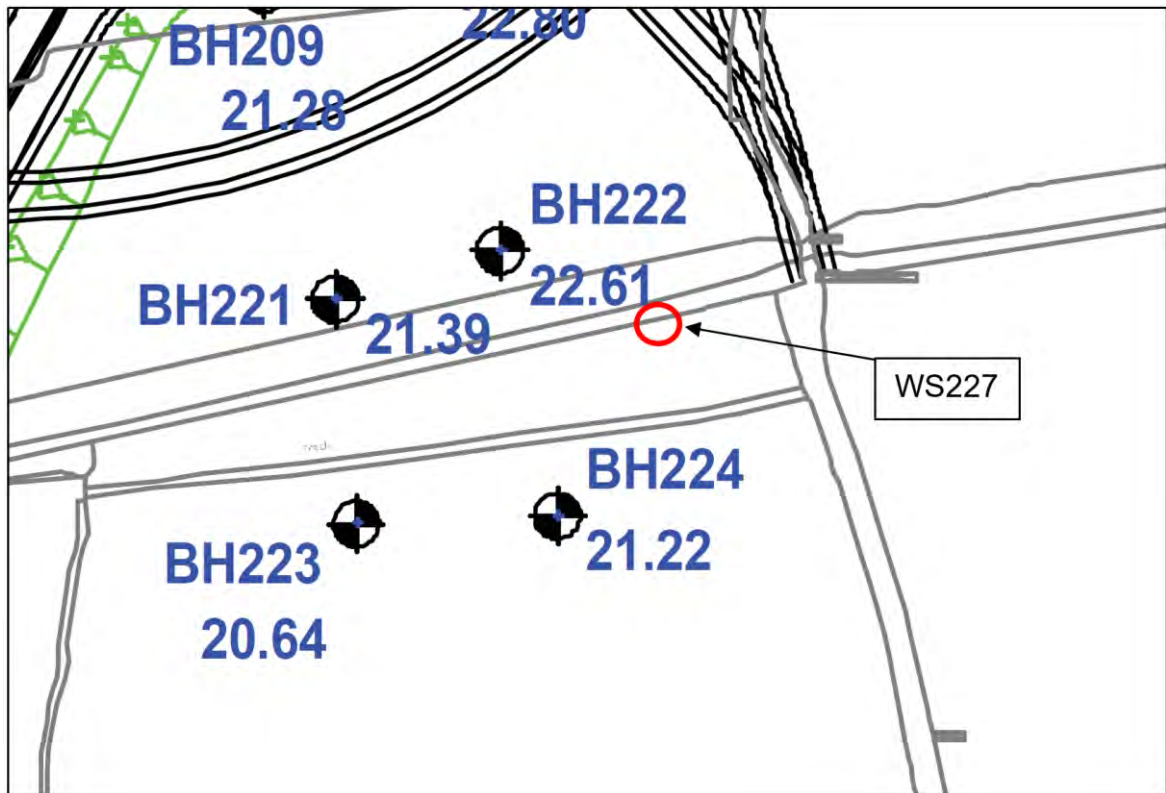


Figure 2, Location of 2014 site investigation boreholes

A summary of the ground conditions and recorded SPT N values is detailed in Table 1. No hand vane tests were recorded.

Horizon	Strata Description	Depth to top (mbgl)	Depth to base (mbgl)	SPT N-Values
Topsoil	Slightly clayey, fine and medium SAND with rootlets	0.00	0.40	-
Upper Cohesive Clay	Firm, slightly sandy, slightly gravelly, silty CLAY	0.30	13.00	2 - 25
Upper Granular Material	Medium dense to very dense, slightly clayey, fine to medium SAND	12.30 (10.00 in BH221)	15.50 (17.00 in BH221)	14 - 52
Lower Cohesive Clay	Firm to stiff, slightly sandy, silty CLAY	15.20	18.20	-

Horizon	Strata Description	Depth to top (mbgl)	Depth to base (mbgl)	SPT N-Values
Lower Granular Material	Dense, gravelly, clayey, fine to coarse SAND (recorded as a gravel in BH223)	17.80 (16.90 in BH224)	20.45	40 - 50
Bedrock	Weathered SANDSTONE	19.20 (only in BH223)	>20.80 (in BH223)	50+

Table 1: Summary of borehole logs from 2014 site investigation

Extensive geotechnical testing was conducted as part of the investigation. The testing was conducted in accordance with BS1377:1990 Methods of test for soils for civil engineering purposes and consisted of:

- 15 Atterberg tests,
- 7 particle size distribution tests (PSD),
- 33 unconfined compressive strength tests,
- 2 undrained triaxial tests,
- 4 one-dimensional consolidation tests.

Design parameters derived from these tests are listed in Table 2.

Strata (Depth, mbgl)	Moisture content (MC%)	N - Values	Bulk Density (Mg/m <sup>3</sup> )	Dry Density (Mg/m <sup>3</sup> )	Compressive Strength (q) (kPa)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Settlement Data		Class
									Pressure (kN/m <sup>2</sup> )	Mv (m <sup>2</sup> /MN)	
<b>Topsoil</b> 0.00 – 0.40	11.0 – 28.0	NR	NR	NR	NR	NR	NR	NR	NR		NR
<b>Upper Cohesive Material</b> 0.30 – 13.00	9.4 – 34.0	14 - 19	1.99 -2.23	1.49 – 2.05	56 - 330	27 - 75	14 - 20	13 - 55	25	0.55 – 0.60	CL/CH
									35	0.62	
									50	0.24 – 0.45	
									70	0.30	
									100	0.21 – 0.33	
									140	0.23	
									200	0.15 – 0.22	
									280	0.16	
									400	0.09 – 0.14	
									560	0.10	
									800	0.08	
<b>Upper Granular Material</b> 10.00 – 17.00	6.6 – 31.0	14 – 52	1.63 - 1.84(*)	NR	NR	NR	NR	NR	NR		NR
<b>Lower Cohesive Material</b> 15.20 – 18.20	10.0 – 19.0	NR	2.12 – 2.27	1.97 – 1.81	53 - 1055	27 - 35	15 - 17	11 - 20	NR		CL/CI
<b>Lower Granular Material</b> 16.90 – 20.45	7.0 – 14.0	40 - 52	1.73 – 2.04(*)	NR	NR	NR	NR	NR	NR		NR
<b>Bedrock</b> >20.45	15.0 – 28.0	50+	NR	NR	NR	NR	NR	NR	NR		NR

Table 2, Design parameters of deposits from previous investigation.

(\*) = Empirical values taken from BS 8004:2015 Code of practice for foundations.

Chemical testing was conducted on samples taken from BH221-224. The results of the tests showed no contaminants exceeded hazardous levels.

Water strikes were recorded between 11.60mbgl and 18.20mbgl, subsequently piezometers were installed in boreholes BH221 and BH224 down to 20.00m in order to monitor the groundwater of the site. Measurements were first taken on the 03/12/2014 with subsequent measurements taken approximately once every month until 18/10/2017, where after they were recorded yearly until the final measurement on 30/01/2019. BH221 recorded maximum and minimum groundwater levels of 4.18mbgl and 12.76mbgl respectively. BH224 recorded maximum and minimum groundwater levels of 0.00mbgl and 12.72mbgl respectively.

Logs, testing results and piezometer readings from these boreholes are available in Appendix C.

## **2.9 Services**

A summary of the services located in the vicinity of the site is detailed below. The service drawings are enclosed in Appendix D.

Electricity – Service drawings provided show there are low voltage cables that cross the railway tracks and connect the Railway Cottages. One of the low voltage cables runs down the centre of Sidgreaves Lane for approximately 30m before entering the field to the east and running in a north east direction. This cable then connects with a 6kV-6.6kV cable that runs along the west side of Lea Road. Off shoots of the 6kV-6.6kV cable supply the houses on the western side of the Lea Road.

Gas – Service drawings provided show there is no gas apparatus in the area.

United Utilities (UU) – The service drawings indicate that UU have two 90mm PE distribution mains, one located west of Lea Road and the other is at Sidgreaves Lane which continues north under the canal bridge. In addition to these there is a foul water pipe located in the western fields, it crosses the canal roughly 110m west of the canal bridge.

Virgin Media (VM) – Virgin Media service drawings confirm they do not have services within the area of the site.

BT Openreach – BT service drawings show there is a number of live cables to the south of the proposed works around the area of the Railway Cottages. These cables connect to the railway and do not run further north along Sidgreaves Lane. Overhead BT cables are present along Lea Road which also connect to the cables along the railway.

## 2.10 Contaminated Land – Initial Conceptual Site Model

An initial Conceptual Site Model (CSM) has been developed from the available information which has been used to identify potential sources, receptors and pathways present at the site.

### Potential Contamination Sources

Potential sources of contamination identified by the desk study process include:

- Previous site uses: herbicides and pesticides used on agricultural land
- Existing road material (risk of tar bound material)
- Contaminants associated with road use (vehicle fuel spillages);

The principal contaminants of concern associated with the aforementioned potential contamination sources are presented in Table 3 below.

Area of site	Metals							Others			Herbicides/Pesticides	Hydrocarbons	
	As	Cd	Cr	Cu	Pb	Ni	Zn	Sulphide	Asbestos	pH		Oil/fuel hydrocarbons	PAHs
<b>Farmland</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>Highway</b>	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓

Table 3, the principal contaminants of concern. Based on Waste Landfill DEFRA & EA (2002) CLR 8 Priority Contaminants for the Assessment of Land

### Potential Receptors

Potential receptors were identified as:

- Construction workers involved in the development of the scheme.
- Maintenance workers associated with the road.
- Current and future public users of the canal.
- Vegetation and Wildlife.

- Road structures associated with the existing and proposed highway scheme.

Potential controlled water receptors were identified as:

- The Sherwood Sandstone Group (Principle aquifer)
- Lancaster Canal
- Small watercourse culverted under proposed car park acting as tributary for Savick Brook

### Potential Pollutant Pathways

The following pathways were considered relevant for human receptors:

- Dermal absorption and/or ingestion
- Ingestion and/or inhalation of dust
- Inhalation of outdoor vapour

The following pathways were considered relevant for controlled water receptors:

- Unsaturated zone transport of pore-water to groundwater
- Saturated zone transport of soluble contaminants in groundwater
- Unsaturated zone transport of soluble contaminants to surface water (i.e. runoff and interflow).
- Preferential contaminant migration along drains, ducts, culverts.
- Unnamed watercourse in the eastern field which acts as a tributary for Savick Brook.

Based on the site's historical use as predominantly agricultural land, it is not considered likely to be affected by widespread or significant contamination. Nevertheless, as there are no records for the type of farming carried out it should be assumed that pesticides and herbicides have been used on the land in the past.

Based on an assessment of the risk posed by ground gas to nearby property receptors it is considered unlikely that significant risks will be present along the scheme route due to the following:

- There is expected to be minimal made ground on site which could represent a potential source of ground gases.
- Although the majority of underlying natural bedrock geology is unlikely to represent a source of ground gases, there is a low possibility that areas with deeper topsoil deposits could contain low levels of biogenic methane and carbon dioxide.

Furthermore, risks of aggressive ground conditions impacting existing and proposed concrete road infrastructure, including the proposed bridge, are considered to be very low due to the following:

- There is minimal made ground at the site, which could represent a potential source of aggressive chemicals.
- Reference to guidance on assessing aggressive ground risk to concrete (BRE 2005) indicates that the underlying natural geology is unlikely to contain pyrite or sulphate minerals which may lead to attack on buried concrete.

#### Potential Pollutant Linkages

The initial Conceptual Site Model (CSM) has identified that Potential Pollutant Linkages (PPLs) potentially exist at the site. Therefore, an appropriate site investigation is recommended to confirm whether these PPLs exist.

## **3.0 GROUND CONDITIONS**

### **3.1 Introduction**

An assessment of the ground conditions underlying the site has been made based on available information from the LCC archives and from BGS borehole information and geological maps. The conditions encountered in the 2014 ground investigation exploratory holes broadly confirm the information on the geological mapping. The location of these boreholes is close to the site of the proposed bridge, giving a good representation of the ground conditions in that area, but is quite distant from the proposed car park and other areas of the scheme. However, since there is no indication the geology changes significantly across the area, it is considered that the 2014 site investigation is likely representative of ground conditions across the route of the scheme.

### **3.2 Preliminary Ground Model**

#### Topsoil

The 2014 boreholes have indicated that topsoil extends from the surface to 0.40mbgl and was recorded as a grassed over brown, slightly clayey, fine to medium sand with rootlets.

#### Made Ground

The 2014 boreholes did not record any made ground and there is no indication that made ground is likely present across the route of the scheme, although it cannot be discounted.

#### Superficial Geology (Glacial Till)

The geological information indicates the superficial geology to consist of glacial till deposits. The 2014 boreholes recorded the glacial till deposits to comprise an upper layer of glacial till described as a firm, slightly sandy, slightly gravelly, silty clay present between 0.30mbgl to 13.00mbgl. The limited SPT information obtained for this layer recorded values ranging between 14 and 16, indicating a medium to high strength clay. Shear strength values for this layer ranged between 54kPa and 108kPa, indicating a medium to high strength.



Below this layer, between 10.00mbgl and 17.00mbgl, is a lense of medium dense to very dense, slightly clayey, fine to medium sand which, varies in thickness between 3.00m and 5.00m. SPT N values for this layer ranged between 14 and 52, indicating it is medium dense to very dense.

Below the sand layer, the superficial geology comprises a firm to stiff, slightly sandy, silty clay between 15.20mbgl and 18.20mbgl. Shear strength values for this layer were not recorded however SPT information indicate it to be of medium to high shear strength.

The deepest recorded superficial layer consists of either a dense to very dense, gravelly, clayey, fine to coarse sand or a dense very sandy gravel, recorded between 16.90mbgl and 20.45mbgl (SPT N values ranging between 40 and 52). Considering bedrock was recorded at 19.20mbgl in BH223, the gravelly sand and very sandy gravel layer is potentially highly weathered bedrock.

### Bedrock Geology

Solid geology was encountered in the 2014 site investigation at 19.20mbgl within BH223. The bedrock consisted of a weathered red brown sandstone, recovered as a sandy, subangular, medium to coarse gravel with a low cobble content. This description matches the BGS websites designation of The Sherwood Sandstone. As discussed above, it is possible the gravelly sand and very sandy gravel layers recorded in BH221, BH222 and BH224 between 16.90mbgl and 20.45mbgl is potentially highly weathered bedrock.

### Ground Water Conditions

During the 2014 site investigation, BH221 to BH224 encountered water strikes. The Records of the groundwater strikes can be found below:

Borehole Number	Water Strike Depth (mbgl)	Depth after 20 minutes (mbgl)	Final water depth (mbgl)
BH221	18.20	18.20	18.20
BH222	17.30	17.30	17.30
BH223	13.00	11.30	15.20

Borehole Number	Water Strike Depth (mbgl)	Depth after 20 minutes (mbgl)	Final water depth (mbgl)
BH223	17.10	16.70	16.70
BH224	3.10	3.10	3.40
BH224	12.30	10.70	15.40
BH224	16.90	15.10	15.10

Table 4: Water Strike information from the 2014 Investigation.

### 3.3 Engineering Properties

As outlined above, ground conditions along the route of the scheme likely consist of glacial till deposits comprising clay with lenses of either sand or gravel sand, overlying bedrock at approximately 20.00mbgl.

The engineering properties are predominantly based on in-situ SPT data and lab tests from the 2014 investigation. Design parameters derived from this investigation are located in Table 2. However, it should be noted that the table is designed to provide an indication of the possible engineering properties of the ground conditions and should not be taken as representative of the ground conditions across the entire area of the proposed scheme. In order to obtain a comprehensive understanding of the engineering properties across the site, further site investigation and lab testing is required.

In general, the soils that are indicated along the proposed route are typical of the superficial deposits in this area, where the presence of glacial deposits predominates. Therefore, it is probable that further intrusive investigation works will confirm that the ground conditions and soil parameters are similar to those proved in the 2014 site investigation within the proposed bridge area.

## 4.0 PRELIMINARY ENGINEERING ASSESSMENT

### 4.1 General Geotechnical Issues

The 2014 site investigation and geological mapping indicates that ground conditions along the route of the scheme likely consist of glacial till deposits comprising clay with lenses of either sand or gravel sand, overlying bedrock at approximately 20.00mbgl. Given the extent of this site, it is possible that the thickness and strengths of these deposits may differ between different locations, resulting in differential settlement.

Shallow groundwater (less than 2 metres below the proposed road level) was not encountered in the 2014 site investigation (groundwater recorded between 11.60mbgl and 18.20mbgl in the boreholes). However, given the perched nature of groundwater within glacial till deposits, shallow groundwater entries during excavations cannot be discounted.

It is known from the historical information and maps that ponds are located in the fields near to the route of the proposed scheme. While none of these ponds directly intersect the route, any further site investigation must consider the possibility of unidentified historic ponds which result in patches of soft ground. Additionally regarding watercourses, the area around the unnamed stream that travels underground at the location of the car park must be investigated further as any soft ground will need to be considered in the final design.

The locations of known ponds, historic ponds and watercourses on the line of or close to the proposed Cottam Parkway design are outlined below:

Feature	Location
Lancaster Canal	Crossed by proposed bridge at (E349036:N431624)
Unnamed watercourse	South-eastern field, goes under proposed car park at (E349338:N431352)
Pond A	Western field (E348978:N431508)
Pond B	East of proposed road (E349096:N431541)
Pond C	East of proposed road (E349201:N431476)
Pond D	South-eastern field (E349488:N431338)
Historic Pond	Western field (E349020:N431479)
Historic Pond	South-western field (E348990:N431370)

Table 5, Features along the route that pose a potential geotechnical hazard.

## 4.2 Structure Foundations

The only above ground structure currently within the proposed route is Quakers Canal Bridge (Structure Reference: 837B), a single arch span Victorian bridge roughly 4.00m in height and with a span of 10.00m. No bearing capacity or technical drawings of the bridge are available. As noted in the site walkover section, the bridge shows signs of structural damage. It is therefore recommended that an assessment by a bridge engineer be undertaken as to instruct on its stability during and after the construction of the new bridge.

The structural condition of the existing culvert, diverting the unnamed watercourse under the existing railway and proposed car park area, is unknown. It is therefore recommended that an assessment and survey of the culvert be undertaken by a suitably qualified engineer to inform design of the proposed car park.

Structures that will require foundations to be designed include the proposed bridge over Lancaster Canal, road signs, the attenuation pond and possibly the car park, depending on the complexity of its final design. The calculations for these foundations will be determined from the results of site investigation.

It is proposed that further investigations should be undertaken, comprising of deep boreholes to obtain information for the foundation design of the bridge and shallow boreholes/trial pits to ascertain the ground conditions of the proposed road and car park. These boreholes should be accompanied by appropriate laboratory testing where possible.

## 4.3 Embankments

No cuttings are currently proposed for the scheme and it is likely that the proposed road will either be at grade or be on shallow embankment (less than 2m height). The new embankments planned for the proposed Cottam Parkway Bridge are expected to be greater than 2m height and at a grading of 1(v) in 3(h). However, subject to the results of the site investigation, the slopes gradients may change based on the nature of the ground conditions. The proposed fill for these embankments is yet to be determined, however given the likely low volume of any site won material generated during development, it is likely to comprise of imported granular fill.

The excavated material from any excavations are likely to generate cohesive glacial till, which should meet Class 2 fill requirements or granular materials, which should be acceptable for Class 1 fill. Both of these materials should be acceptable for use as embankment fill within the scheme but will require side slopes for cohesive material to be a maximum of 1 in 2½ and slopes for the granular material to be a maximum of 1 in 2, to ensure the long-term stability of the embankment construction. Assessment of suitability for reuse shall be undertaken in accordance with the Specification for Highways Work, Series 600 (SHW600).

It is anticipated that drainage will be installed at the crest and the toe of each slope to control surface and groundwater.

It is envisaged that the embankments will be founded on sufficiently dense cohesive deposits. Soft and compressible founding strata will be removed (where practicable) and be replaced with compacted granular fill. Where complete removal of the soft and compressible soil is not possible, consideration will be given to alternative ground improvement solutions.

#### **4.4 Subgrade**

It is anticipated that clay will be encountered at sub-formation level and that the CBR values associated with the clay will be less than 2%. Therefore, for any of the proposed road at grade, it is anticipated that a 600mm thick capping layer will be required for the pavement construction.

#### **4.5 Buried Concrete**

From analysis of the available information, buried concrete is suspected to not require sulphite resistance, however this is subject to further site investigation and chemical testing.

#### **4.6 Contaminated Land**

Based on the site's historical land use as predominantly agricultural land the proposed scheme is not considered likely to be significantly affected by contamination. Nevertheless, appropriate chemical analyses will be undertaken to allow assessment of the risk to human health and controlled waters, plus categorisation for off-site of

unsuitable materials. However, should more significant contamination be encountered during the site investigation, additional testing will be required.

#### **4.7 Site Investigation**

A comprehensive site investigation comprising of cable percussion boreholes, window sample boreholes and trial pits will be undertaken across the scheme, in order to determine ground conditions for the proposed new structures, embankments, roads and car parking areas. The investigation will include both geotechnical and geo-environmental testing. With the current information available, this report recommends that an appropriate site investigation should consist of:

- 4 cable percussion boreholes drilled to 30.00mbgl where the proposed bridge crosses the Lancaster Canal, two on each side, to determine whether the ground conditions are appropriate for either pad or piled foundations. It is suggested that 2 of these boreholes have piezometers installed to monitor groundwater.
- In addition to the boreholes above, 2 further cable percussion boreholes, drilled to 15.00mbgl, should be undertaken at the locations of the embankments leading up to the bridge on either side of the canal, in order to determine the ground conditions. It is recommended to install 2 piezometers in these boreholes to monitor groundwater.
- 14 window sampler boreholes, drilled to 3.00-4.00mbgl drilled within the proposed car park and along the route of the proposed road at 50m intervals to determine the ground conditions and identify any possibly unknown hazards. Piezometers should be installed in these boreholes at locations where groundwater is encountered.
- A further 4 window sampler boreholes, drilled to 6.00mbgl, should be located in the car park area, specifically targeting the area around the watercourse that runs underground through that area. A minimum of 1 piezometer should be installed in these boreholes.

- 6 trial pits excavated within the proposed car park to determined ground conditions and inform design.

Details of the proposed site investigation will be described either in a Site Investigation Scope Report, that shall be submitted subsequently, or in the forthcoming Site Investigation Report.

## **5.0 GEOTECHNICAL RISK REGISTER**

### **5.1 Introduction**

From a review of the available information, the key geotechnical risks have been identified as:

- Differential settlement causing damage to the proposed bridge and embankments;
- Stability of the proposed earthworks;
- Groundwater during construction;
- Potential for contaminated ground;
- Possible unidentified historical in-filled ponds, clay pits or areas of depressions ;
- Ecological sensitivity of ponds and watercourses within or near to the proposed route;
- Interference with underground service utilities associated with the proposed earthworks and structures;
- Unforeseen ground conditions.

### **5.2 Geotechnical Risk Register**

Risks discussed throughout this report are further categorised using a risk register in order to assess a risk factor based upon its effect on the project in terms of cost and programme delays. The risk register lists the type of hazard/risk and scores each risk based on probability/impact and risk rating. A summary of the risk register methodology is presented in Tables 6-8. The risk register also presents suggested methods of reducing these risks.



Likelihood		Severity				
		1	2	3	4	5
		Minor	Moderate	Serious	Major	Catastrophic
1	Extremely unlikely	1	2	3	4	5
2	Unlikely	2	4	6	8	10
3	Likely	3	6	9	12	15
4	Extremely likely	4	8	12	16	20
5	Almost certain	5	10	15	20	25

Table 6 – Risk Register Methodology – Likelihood vs Severity

Potential severity of harm occurring		
1	Minor	Minor damage or loss – (no human injury)
2	Moderate	Moderate damage or loss – (Slight injury or illness)
3	Serious	Substantial damage or loss – (Serious injury or illness)
4	Major	Major damage or loss – (Fatal injury)
5	Catastrophic	Catastrophic loss or damage – (Multiple fatalities)

Table 7 – Risk Register Methodology – Potential severity of harm occurring

Risk Classification	
Low (1-8)	Ensure assumed control measures are maintained and reviewed as necessary
Medium (9-19)	Additional control measures to reduce risk rating to a level that is equivalent to a test of "reasonably required" for
High (20-25)	Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable level.

Table 8 – Risk Register Methodology – Risk Classification

Risk/Hazard	Consequence	Likelihood	Severity	Risk	Mitigation	Likelihood	Severity	Residual Risk
1. Construction of embankment causing excessive settlement	<ul style="list-style-type: none"> <li>• Hazardous to users of the new road.</li> <li>• Damage to the new road seen as cracking in the surfacing, depressions.</li> <li>• Damage to the new bridge.</li> <li>• Potential cost and time implications of remedial works.</li> </ul>	3	4	12	<ul style="list-style-type: none"> <li>• Determine ground parameters based on the historic and proposed site investigation.</li> <li>• Carry out settlement analysis.</li> </ul>	2	4	8
2. Self-settlement of fill in new embankment	Differential settlement in the embankment, causing damage to the road and bridge.	3	4	12	<ul style="list-style-type: none"> <li>• Carry out settlement analysis.</li> <li>• Ensure long and short term design conditions have been properly assessed.</li> <li>• Suitable fill material and compaction to be specified to reduce the amount of self-settlement.</li> </ul>	1	4	4
3. Slope failure of new embankment	<ul style="list-style-type: none"> <li>• Hazardous to users of the new road.</li> <li>• Damage to the new road seen as cracking in the surfacing, depressions.</li> <li>• Damage to the new bridge.</li> <li>• Potential cost and time implications of remedial works.</li> <li>• Encroachment of slipped debris onto land at the toe.</li> </ul>	3	4	12	<ul style="list-style-type: none"> <li>• Determine slope stability parameters based on the historic and proposed site investigation.</li> <li>• Ensure long and short term design conditions have been properly assessed by conducting slope stability analysis.</li> <li>• Ensure appropriate construction materials are assessed for design.</li> </ul>	2	4	8
4. Rising groundwater during construction	• Dewatering required during construction causing delays in the programme.	4	2	8	• In depth review of piezometer readings to locate areas of risk of rising groundwater during construction.	2	2	4

Risk/Hazard	Consequence	Likelihood	Severity	Risk	Mitigation	Likelihood	Severity	Residual Risk
					<ul style="list-style-type: none"> <li>Examine the borehole information to understand any at risk areas i.e. thick layers of sand.</li> <li>Construction of drainage pond to mitigate flooding risk to the highway after construction.</li> </ul>			
5. Severing underground services	<ul style="list-style-type: none"> <li>Injury/Death of Operatives and Delay to Contract.</li> </ul>	2	5	10	<ul style="list-style-type: none"> <li>Ensure all services are located prior to excavating.</li> </ul>	1	5	5
6. Ground variability/unforeseen ground conditions	<ul style="list-style-type: none"> <li>Unacceptable ground movement/settlement.</li> <li>Safety of workers/disposal costs.</li> </ul>	3	3	9	<ul style="list-style-type: none"> <li>Ensure appropriate design parameters are determined to accommodate for potentially lower shear strength/ increased compressibility etc.</li> <li>Re-evaluate soil parameters.</li> </ul>	2	3	6
7. Location of in-filled ponds or depressions presenting areas of weak ground filled with unidentified material.	<ul style="list-style-type: none"> <li>Potential for areas of weak ground, which may give rise to high settlement over and above that anticipated.</li> <li>Potential for bearing capacity failures if not treated.</li> </ul>	3	2	6	<ul style="list-style-type: none"> <li>Undertake additional geotechnical survey/ investigation to locate potential areas of risk.</li> <li>If in-filled ponds are present beneath proposed structures/ earthworks some form of treatment may be required prior to construction i.e. geotextiles/ excavate and replace.</li> </ul>	2	2	4
8. Ecological sensitivity established with the nearby ponds and watercourses. In particular if species such as Great Crested Newts identified.	<ul style="list-style-type: none"> <li>Exclusion zones may need to be set up to prevent construction movement near habitats.</li> <li>Programme time and cost implications due to relocation of habitat and constraints being put in place.</li> </ul>	3	4	12	<ul style="list-style-type: none"> <li>Early co-ordination with an ecologist to determine the risk and potential mitigation measures.</li> </ul>	1	4	4

Risk/Hazard	Consequence	Likelihood	Severity	Risk	Mitigation	Likelihood	Severity	Residual Risk
<b>10.</b> Unforeseen contaminated ground due to the infilled ponds and buried material.	<ul style="list-style-type: none"> <li>• Hazardous to construction works.</li> <li>• Potential for additional disposal costs offsite and costs for remediation.</li> </ul>	3	3	9	<ul style="list-style-type: none"> <li>• Carryout additional contamination testing in the forthcoming site investigation.</li> <li>• Review desk study and previous site investigation information.</li> <li>• If necessary further consultation with the Environment Agency website and check the Envirocheck Report.</li> </ul>	2	3	6
<b>11.</b> Unexploded ordnance	<ul style="list-style-type: none"> <li>• Encountering/detonation of UXO during GI and construction.</li> </ul>	1	5	5	From the desk study undertaken by Zetica, it is inferred that the risk associated with UXO is low.	1	5	5

Table 9 – Geotechnical Risk Register

## REFERENCES

- BS 5930:2015 Code of practice for site investigations
- BS 1377:1990 Methods of test for soils for civil engineering purposes
- BS 8004:2015 Code of practice for foundations
- British Geological Survey Sheet 75 Drift & Solid – Preston 1:50,000  
(<https://www.bgs.ac.uk/data/maps/home.html>)
- British Geological Survey – Geology of Britain Viewer -  
<http://mapapps.bgs.ac.uk/geologyofbritain/home.html>
- Environment Agency - <https://flood-map-for-planning.service.gov.uk>
- Coal Authority - <https://www.gov.uk/check-if-property-is-affected-by-coal-mining>
- National Library of Scotland - <https://maps.nls.uk/>

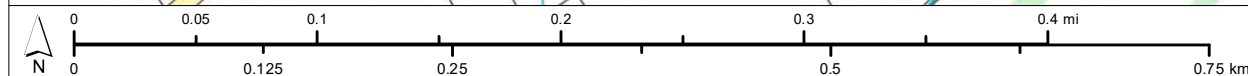
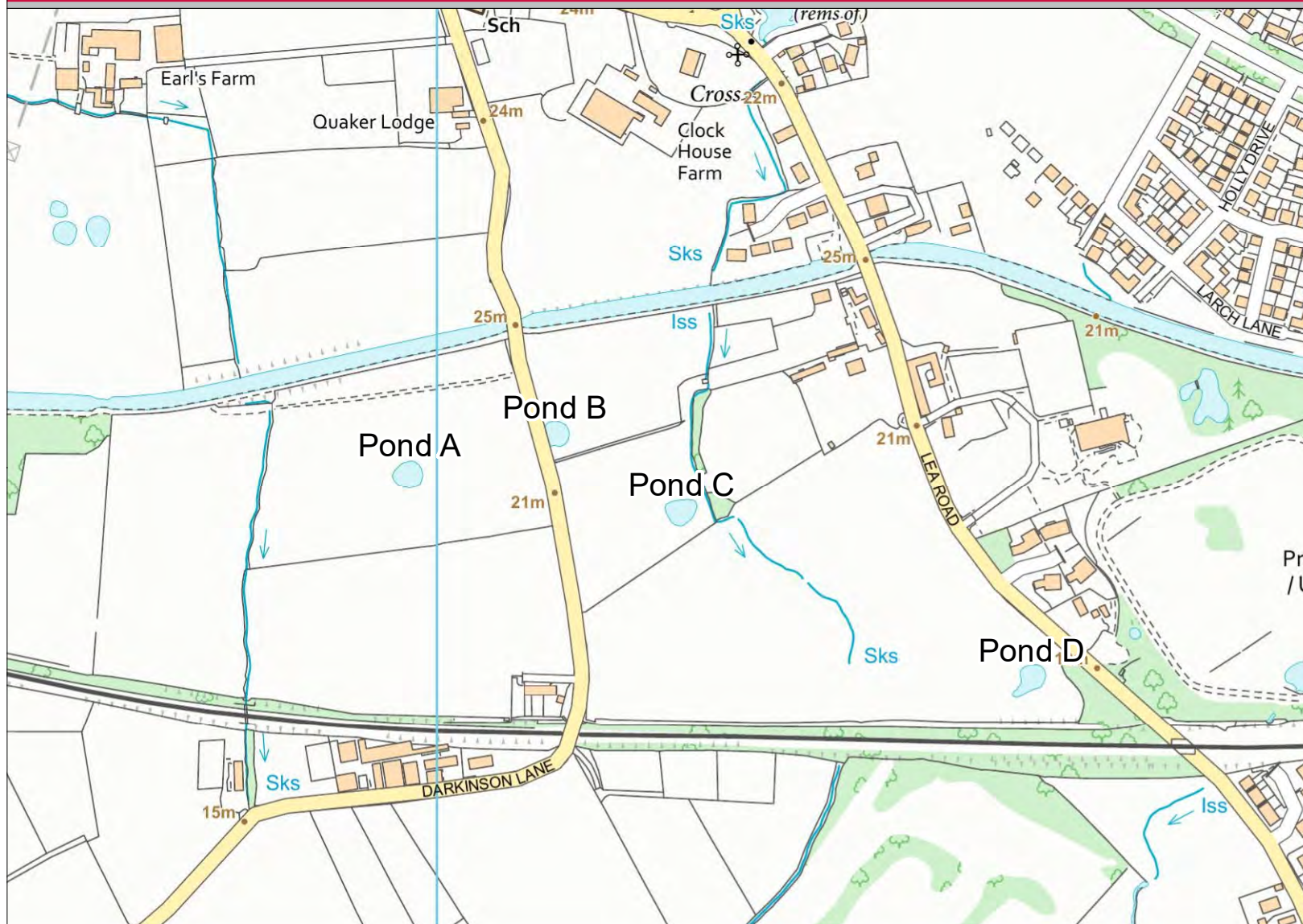
## **Appendix A**

### Site Location

# Location Map

Author:

Date Created: 25/02/2021



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Map Scale: 1:5,000  
Map Centre: 349,185 431,512

## **Appendix B**

Site photographs





North side of canal

348964:431634



Location where proposed bridge will cross canal

349036:431644



Tree that must be removed to build embankment

349031:431659



Access Gate 1

349067:431592





Access Gate 2

349046:431667



Site south of the canal

349050:431587



Current path in south of site

349050:431587



Fields to the south where new road is planed

349062:431584





Quaker's Bridge east side

E349047:N431614



Quaker's Bridge under side

E349066:N431625



Quaker's Bridge west side

E349072:N431627





Quaker's Bridge top

E349063:N431625



View from the road of the proposed carpark location.

E349121:N431338





Newly installed drain in Sidgreaves Lane

E349118:N431381



First access gate for window samples in eastern fields.

E349116:N431397



Second access gate for window samples in eastern fields.

E349116:N431397





View from the road of the proposed carpark location.

E349121:N431338



View from the road of the proposed carpark location.

E349121:N431338





View from the road of the proposed carpark location.

E349121:N431338



Access gate for window samples in western fields.

E349105:N431413



Secondary gate access to south eastern fields.

E349457:N431415





Pond D.

E349500:N431298



Boggy Ground in south eastern field

E349399:N431300





Trees in south eastern field.

E349259:N431300





Stream in south eastern field.

E349344:N431300



Abandoned fencing and unidentified pipe next to railway embankment.

E349344:N431300





Culvert where stream runs underneath railway. One large crack is noted from the crest of the arch to the top of the bridgework.

E349347:N431303





Shallow ditch orientated east-west.

Approximately E349267:N431318



Distant image of stream.

E349338:N431329





Shallow ditch initially orientated east-west however diverges south towards the railway.

Approximately E349360:N431340



Boggy ground.

E349392:N431315





Shallow ditch orientated north-south towards railway.

Approximately E349275:N431328





Image of stream at the location where it travels underground.

E349339:N431352





Localised depressions close to the location of an unidentified tree.

E349197:N431353





Medium depth ditch orientated northeast-southwest between stream and Lea Road.

E349398:N431385





Updated and clearer defined image of crack under bridge

E349068:N431626

## **Appendix C**

Previous investigation logs and testing





**IAN FARMER  
ASSOCIATES**

**Site**

Preston Western Distributor Road, Preston

**Borehole  
Number**

**BH221**

**Boring Method**

Cable Percussion

**Casing Diameter**

200mm cased to 9.00m  
150mm cased to 20.00m

**Ground Level (mOD)**

21.39

**Client**

Lancashire County Council

**Job  
Number**

41455

**Location**

348934.4 E 431615.3 N

**Dates**

10/07/2014-  
14/07/2014

**Engineer**

Lancashire County Council

**Sheet**

1/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.25 0.25 0.50 0.50	D1 J2 D3 J4				21.09	(0.30) 0.30	Brown, slightly clayey, fine and medium SAND with rootlets.			
1.20-1.65	U5 0.35		DRY	70 blows			Firm, in places stiff, brown mottled grey, slightly gravelly, silty CLAY of low plasticity with occasional brown, fine sand lenses. Gravel is subrounded, fine and medium including mudstone and quartz.			
1.70	D6									
2.00-2.45	U7 0.25	1.50	DRY	90 blows		(3.90)				
2.50	D8									
2.80	D9									
3.00-1.20 3.00-3.45	B10 U11 0.35	3.00	DRY	70 blows						
3.50	D12									
3.80	D13									
4.00-4.45 4.00-4.45 4.00-4.45	SPT N=14 B14 D15	4.00	DRY	1,2/3,4,4	17.19	4.20	Firm, brown, slightly gravelly, silty CLAY. Gravel is subrounded, fine and medium including mudstone.			
4.80	D16									
5.00-5.45	U17 0.45	4.50	DRY	60 blows		(1.80)	At 5.00m: very high plasticity.			
5.50	D18									
5.80	D19									
6.00-6.45	U20 0.35	6.00	MOIS	30 blows	15.39	6.00	Firm, brown, slightly sandy, silty CLAY.			
6.50	D21									
6.80	D22					(1.80)				
7.00-7.45	U23 0.45	7.00	DRY	35 blows						
7.50	D24									
7.80 8.00-8.45	D25 SPT N=16	7.50	DRY	1,2/3,4,4,5	13.59	7.80	Firm, in places stiff, brown, silty CLAY of low plasticity with occasional brown, fine sand lenses.			

**Remarks**

Samples marked as J comprise 1 x amber jar and 1 x vial.  
Borehole backfilled on completion - flagstone installed.  
Excavating from 0.00m to 1.20m for 1.00 hour.

**Scale  
(approx)**

1:40

**Logged  
By**

TO

**Figure No.**

41455.BH221



**IAN FARMER  
ASSOCIATES**

**Site**

Preston Western Distributor Road, Preston

**Borehole  
Number**

**BH221**

**Boring Method**

Cable Percussion

**Casing Diameter**

200mm cased to 9.00m  
150mm cased to 20.00m

**Ground Level (mOD)**

21.39

**Client**

Lancashire County Council

**Job  
Number**

41455

**Location**

348934.4 E 431615.3 N

**Dates**

10/07/2014-  
14/07/2014

**Engineer**

Lancashire County Council

**Sheet**

2/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
8.00-8.45 8.00-8.45	B26 D27									
8.80	D28					(2.20)				
9.00-9.45	U29 0.45	9.00	DRY	65 blows						
9.50	D30									
9.80	D31									
10.00-10.44 10.00 10.00-10.45 10.00-10.45	SPT 50/285 D33 B32 D34	10.00	DRY	5,9/11,13,15,11	11.39	10.00	Very dense, brown, slightly silty, fine and medium SAND with rare fine gravel.			
11.00	D35									
11.50-11.95 11.50-11.95 11.50-11.95	SPT N=52 B36 D37	11.50	11.00	4,7/10,12,14,16		(3.00)				
12.50	D38						Below 12.50m: fine to coarse.			
13.00-13.45 13.00-13.45 13.00-13.45	SPT N=22 B39 D40	13.00	12.10	2,3/4,5,6,7	8.39	13.00	Medium dense, brown, slightly silty, slightly gravelly, fine to coarse SAND. Gravel is angular to subrounded, fine to coarse including mudstone.			
14.00	D41									
14.50-14.95 14.50-14.95 14.50-14.95	SPT N=20 B42 D43	14.50	13.00	2,3/4,5,5,6		(4.00)				
15.50	D44									
16.00-16.45	SPT N=23	16.00	14.50	2,4/5,5,6,7						

**Remarks**

Water added from 10.50m to 13.00m. Water added from 13.00m to 17.00m.

**Scale  
(approx)**

1:40

**Logged  
By**

TO

**Figure No.**

41455.BH221



**IAN FARMER  
ASSOCIATES**

**Site**

Preston Western Distributor Road, Preston

**Borehole  
Number**

**BH221**

**Boring Method**

Cable Percussion

**Casing Diameter**

200mm cased to 9.00m  
150mm cased to 20.00m

**Ground Level (mOD)**

21.39

**Client**

Lancashire County Council

**Job  
Number**

41455

**Location**

348934.4 E 431615.3 N

**Dates**

10/07/2014-  
14/07/2014

**Engineer**

Lancashire County Council

**Sheet**

3/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
16.00-16.45 16.00-16.45	B45 D46									
17.00	D47				4.39	17.00	Stiff, brown, silty CLAY of low to intermediate plasticity.			
17.50-17.95	U48 0.45	17.50	WET	110 blows		(1.20)				
18.00	D49									
18.20 18.20	D50 W51			Water strike(1) at 18.20m, no rise after 20 mins.	3.19	18.20	Dense, brown, slightly gravelly, fine to coarse SAND. Gravel is angular to subrounded, fine to coarse including mudstone,			
18.50-18.95 18.50-18.95 18.50-18.95	SPT N=47 B52 D53	18.50	14.00	5,7/10,11,12,14		(2.25)				
19.50	D54									
20.00-20.45 20.00-20.45	SPT N=50 B55	20.00	17.00	5,9/11,12,13,14		0.94	20.45			
							Complete at 20.45m			

**Remarks**

Chiselling from 18.00m to 18.20m for 0.50 hours.

**Scale  
(approx)**






















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**Logged  
By**

TO

**Figure No.**

41455.BH221

 <b>IAN FARMER ASSOCIATES</b>							<b>Site</b> Preston Western Distributor Road, Preston		<b>Borehole Number</b> <b>BH222</b>
<b>Boring Method</b> Cable Percussion		<b>Casing Diameter</b> 200mm cased to 10.00m 150mm cased to 19.50m		<b>Ground Level (mOD)</b> 22.61		<b>Client</b> Lancashire County Council		<b>Job Number</b> 41455	
		<b>Location</b> 348980 E 431628.8 N		<b>Dates</b> 14/07/2014- 15/07/2014		<b>Engineer</b> Lancashire County Council		<b>Sheet</b> 1/3	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.25 0.25 0.40-1.20 0.50 0.50	D1 J2 B3 D4 J5				22.21	(0.40) 0.40	Brown, slightly clayey, fine and medium SAND with rootlets. (Topsoil).		
1.20-1.65	U6 0.35		DRY	60 blows		(1.30)	Firm, brown mottled dark grey, slightly sandy, silty CLAY of low plasticity.		
1.70	D7				20.91	1.70	Firm, in places stiff, brown, slightly gravelly, silty CLAY of low plasticity. Gravel is angular to subrounded, fine and medium including mudstone.		
2.00-2.45	U8 0.40	1.50	DRY	67 blows					
2.50	D9								
2.80	D10								
3.00-3.45	U11 0.40	3.00	DRY	70 blows					
3.50	D12								
3.80	D13								
4.00-4.45 4.00-4.45 4.00-4.45	SPT N=19 B14 D15	4.00	DRY	2,3/4,4,5,6					
4.80	D16								
5.00-5.45	U17 0.45	4.50	DRY	65 blows					
5.50	D18								
5.80	D19								
6.00-6.45	U20 0.45	6.00	DRY	60 blows					
6.50	D21								
6.80	D22								
7.00-7.45	U23 0.45	7.00	DRY	65 blows		(11.00)			
7.50	D24								
7.80 8.00-8.45	D25 SPT N=23	7.50	DRY	2,3/5,5,6,7					
<b>Remarks</b> Borehole backfilled on completion - flagstone installed. Samples marked as J comprise 1 x amber jar and 1 x vial. Excavating from 0.00m to 1.20m for 1.00 hour.								<b>Scale (approx)</b> 1:40	<b>Logged By</b> DO
								<b>Figure No.</b> 41455.BH222	



**IAN FARMER  
ASSOCIATES**

**Site**

Preston Western Distributor Road, Preston

**Borehole  
Number**

**BH222**

**Boring Method**

Cable Percussion

**Casing Diameter**

200mm cased to 10.00m  
150mm cased to 19.50m

**Ground Level (mOD)**

22.61

**Client**

Lancashire County Council

**Job  
Number**

41455

**Location**

348980 E 431628.8 N

**Dates**

14/07/2014-  
15/07/2014

**Engineer**

Lancashire County Council

**Sheet**

2/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
8.00-8.45 8.00-8.45	B26 D27						At 8.00m: intermediate plasticity.		
8.80	D28								
9.00-9.45	U29 0.45	9.00	DRY	70 blows					
9.50	D30								
9.80	D31								
10.00-10.45	U32 0.45	9.00	7.50	70 blows					
10.50	D33								
11.00	D34								
11.50-11.95 11.50-11.95 11.50-11.95	SPT N=22 B35 D36	11.50	DRY	2,4/4,5,6,7					
12.70	D37				9.91	12.70	Medium dense, brown, fine to coarse SAND with occasional clayey silt lenses.		
13.00-13.45 13.00-13.45 13.00-13.45	SPT N=18 B38 D39	13.00	DRY	1,2/3,4,5,6					
14.00	D40					(2.80)			
14.50-14.95 14.50-14.95 14.50-14.95	SPT N=15 B41 D42	14.50	14.00	1,2/3,3,4,5					
15.50	D43				7.11	15.50	Firm, in places stiff, brown, silty CLAY of low plasticity with occasional brown, fine sand lenses.		

**Remarks**

Water added from 13.00m to 15.50m.

**Scale  
(approx)**

1:40


**Logged  
By**























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


















**Figure No.**


41455.BH222



 <b>IAN FARMER ASSOCIATES</b>							<b>Site</b> Preston Western Distributor Road, Preston		<b>Borehole Number</b> <b>BH222</b>
<b>Boring Method</b> Cable Percussion		<b>Casing Diameter</b> 200mm cased to 10.00m 150mm cased to 19.50m		<b>Ground Level (mOD)</b> 22.61		<b>Client</b> Lancashire County Council		<b>Job Number</b> 41455	
		<b>Location</b> 348980 E 431628.8 N		<b>Dates</b> 14/07/2014- 15/07/2014		<b>Engineer</b> Lancashire County Council		<b>Sheet</b> 3/3	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
16.00-16.45	U44 0.40	16.00	WET	70 blows					
16.50	D45					(2.50)			
17.00	D46								
17.50-17.95	U47 0.35	17.50	WET	Slight Seepage(1) at 17.30m. 120 blows					
18.00	D48				4.61	18.00	Medium dense, brown, clayey, fine to coarse SAND with firm clay pockets.		
18.70	D49								
19.00-19.45 19.00-19.50	U51 NR B50	19.00	WET	120 blows		(2.30)			
19.70	D52								
20.00-20.29 20.00-20.30 20.00-20.30	SPT 50/140 B53 D54	19.50	DRY	9,16/25,25	2.31	20.30	Below 20.29m: very dense. Complete at 20.30m		
<b>Remarks</b> Chiselling from 17.10m to 17.30m for 0.50 hours.								<b>Scale (approx)</b> 1:40	<b>Logged By</b> DO
								<b>Figure No.</b> 41455.BH222	

 <b>IAN FARMER ASSOCIATES</b>							<b>Site</b> Preston Western Distributor Road, Preston		<b>Borehole Number</b> <b>BH223</b>
<b>Boring Method</b> Cable Percussion		<b>Casing Diameter</b> 150mm cased to 20.80m		<b>Ground Level (mOD)</b> 20.65		<b>Client</b> Lancashire County Council		<b>Job Number</b> 41455	
		<b>Location</b> 348940.1 E 431553.2 N		<b>Dates</b> 15/07/2014		<b>Engineer</b> Lancashire County Council		<b>Sheet</b> 1/3	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.25 0.25 0.50 0.50 0.50-1.00	D1 J2 D4 J5 B3				20.35	(0.30) 0.30	Grass over TOPSOIL: Brown, slightly clayey, fine and medium SAND with rootlets.		
1.20-1.65	U6 0.45	1.20	DRY	64 blows		(1.70)	Firm locally stiff, brown mottled grey, slightly sandy, slightly gravelly, silty CLAY. Gravel is angular to subrounded, fine to coarse of mudstone.		
1.70 1.80	D7 D8				18.65	2.00	Firm locally stiff, brown, slightly sandy, slightly gravelly, silty CLAY of low plasticity. Gravel is angular to subrounded, fine and medium of mudstone.		
2.00-2.45	U9 0.45	2.00	DRY	61 blows					
2.50	D10								
2.80	D11								
3.00-3.45	U12 0.45	3.00	DRY	42 blows					
3.50	D13								
3.80	D14								
4.00-4.45	U15 0.45	4.00	DRY	40 blows					
4.50	D16								
4.80	D17								
5.00-5.45	U18 0.45	5.00	DRY	49 blows					
5.50	D19								
5.80	D20								
6.00-6.45	U21 0.45	6.00	DRY	53 blows					
6.50	D22								
6.80	D23								
7.00-7.45	U24 0.45	7.00	DRY	43 blows					
7.50	D25					(11.00)			
7.80	D26								
<b>Remarks</b> Samples marked as J comprise 1 x amber jar and 1 x vial. Borehole backfilled on completion - flagstone installed. Please note the CPT at 20.80m has been exemplified from 25 blows over 27mm Excavating from 0.00m to 1.20m for 1.00 hour.								<b>Scale (approx)</b> 1:40	<b>Logged By</b> TO
								<b>Figure No.</b> 41455.BH223	

<div> IAN FARMER ASSOCIATES</div>							Site Preston Western Distributor Road, Preston		Borehole Number BH223	
Boring Method Cable Percussion		Casing Diameter 150mm cased to 20.80m			Ground Level (mOD) 20.65		Client Lancashire County Council		Job Number 41455	
		Location 348940.1 E 431553.2 N			Dates 15/07/2014		Engineer Lancashire County Council		Sheet 2/3	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	
8.00-8.45	U27 0.45	8.00	DRY	47 blows						
8.50	D28									
8.80	D29									
9.00-9.45	U30 0.45	9.00	DRY	46 blows						
9.50	D31									
9.80	D32									
10.00-10.45	U33 0.45	10.00	DRY	56 blows						
10.50	D34									
11.00	D35									
11.50-11.95	U36 0.45	11.50	DRY	58 blows						
12.00	D37									
										
13.00-13.45	B38			Water strike(1) at 13.00m, rose to 11.30m in 20 mins, sealed at 15.20m. 3,4/3,5,5,7	7.65	13.00	Medium dense, brown, slightly clayey, fine and medium SAND.			
13.00-13.45	D39									
13.00-13.45	SPT N=20	13.00	13.00							
14.00	D40					(2.20)				
14.50-14.95	SPT N=14	14.50	13.10	2,3/3,4,3,4						
14.50-14.95	B41									
14.50-14.95	D42									
15.20	D43				5.45	15.20	Firm locally stiff, brown, slightly sandy, silty CLAY of low plasticity.			
15.50-14.95	U44 0.45	15.00	DRY	54 blows						
										
										
Remarks								Scale (approx) 1:40	Logged By TO	
								Figure No. 41455.BH223		

 <b>IAN FARMER ASSOCIATES</b>							<b>Site</b> Preston Western Distributor Road, Preston		<b>Borehole Number</b> <b>BH223</b>
<b>Boring Method</b> Cable Percussion		<b>Casing Diameter</b> 150mm cased to 20.80m		<b>Ground Level (mOD)</b> 20.65		<b>Client</b> Lancashire County Council		<b>Job Number</b> 41455	
		<b>Location</b> 348940.1 E 431553.2 N		<b>Dates</b> 15/07/2014		<b>Engineer</b> Lancashire County Council		<b>Sheet</b> 3/3	
Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
16.00	D45					(2.60)			
17.00 17.00-17.45	D46 U47 0.45	17.00	DRY	62 blows Water strike(2) at 17.10m, rose to 16.70m in 20 mins.					
17.50	D48								
17.80	D49				2.85	17.80	Dense, brown, very, sandy, angular to subrounded, fine and medium GRAVEL of sandstone and mudstone.		
18.00-18.45 18.00-18.45	SPT(C) N=40 B50	18.00	17.20	5,8/9,10,10,11		(1.40)			
19.00	D51				1.45	19.20	Weathered red brown SANDSTONE recovered as sandy, subangular, medium and coarse gravel with low cobble content. Between 19.50m and 19.95m: recovered as brown, gravelly sand. Gravel is angular to subrounded of sandstone and mudstone.		
19.50-19.72 19.50-19.73 19.70-20.00	SPT 15/72 D52 B53	19.50	17.60	15,20/15		(1.60)			
20.50-20.80	D54								
20.80-20.87	SPT(C) 25*/38 25/27	20.80	13.10	25/25	-0.15	20.80	Complete at 20.80m		
<b>Remarks</b> Chiselling from 20.00m to 20.80m for 1.00 hour.								<b>Scale (approx)</b> 1:40	<b>Logged By</b> TO
								<b>Figure No.</b> 41455.BH223	



**IAN FARMER  
ASSOCIATES**

**Site**

Preston Western Distributor Road, Preston

**Borehole  
Number**

**BH224**

**Boring Method**

Cable Percussion

**Casing Diameter**

150mm cased to 20.00m

**Ground Level (mOD)**

21.22

**Client**

Lancashire County Council

**Job  
Number**

41455

**Location**

348995.8 E 431555.4 N

**Dates**

14/07/2014-  
15/07/2014

**Engineer**

Lancashire County Council

**Sheet**

1/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
0.25 0.25 0.50 0.50 0.50-1.00	D1 J2 D4 J5 B3				20.92	(0.30) 0.30	TOPSOIL.  Firm, brown mottled grey, slightly sandy, slightly gravelly CLAY of low plasticity with occasional grey, fine sand lenses. Gravel is angular to subrounded, fine and medium including mudstone and sandstone.			
1.20-1.65	U6 0.45	1.20	DRY	68 blows		(2.20)				
1.70 1.80	D7 D8									
2.00-2.45	U9 0.45	2.00	DRY	38 blows						
2.50	D10				18.72	2.50	Firm, brown, slightly sandy, slightly gravelly CLAY of low plasticity. Gravel is angular to subrounded, fine and medium including mudstone and sandstone.			
2.80	D11									
3.00-3.45 3.00-3.45 3.00-3.45	SPT N=14 B12 D13	3.00	DRY	2,3/3,4,3,4 Seepage(1) at 3.10m, sealed at 3.40m.						
3.80	D14									
4.00-4.45	U15 0.45	4.00	DRY	48 blows						
4.50	D16					(4.00)				
4.80	D17									
5.00-5.45	U18 0.45	5.00	DRY	49 blows						
5.50	D19									
5.80	D20									
6.00-6.45	U21 0.45	6.00	DRY	52 blows						
6.50	D22				14.72	6.50	Firm, in places stiff, brown slightly gravelly CLAY. Gravel is angular to subrounded, fine and medium including mudstone.			
6.80	D23									
7.00-7.45	U24 0.45	7.00	DRY	54 blows						
7.50	D25									
7.80	D26					(2.30)				

**Remarks**

Samples marked as J comprise 1 x amber jar and 1 x vial.  
Excavating from 0.00m to 1.20m for 1.00 hour.

**Scale  
(approx)**

1:40

**Logged  
By**

JC

**Figure No.**

41455.BH224





**IAN FARMER  
ASSOCIATES**

**Site**

Preston Western Distributor Road, Preston

**Borehole  
Number**

**BH224**

**Boring Method**

Cable Percussion

**Casing Diameter**

150mm cased to 20.00m

**Ground Level (mOD)**

21.22

**Client**

Lancashire County Council

**Job  
Number**

41455

**Location**

348995.8 E 431555.4 N

**Dates**

14/07/2014-  
15/07/2014

**Engineer**

Lancashire County Council

**Sheet**

2/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
8.00-8.45	U27 0.45	8.00	DRY	51 blows						
8.50	D28									
8.80	D29				12.42	8.80				
9.00-9.45	U30 0.45	9.00	DRY	57 blows			Firm, brown, slightly sandy, slightly gravelly CLAY of low plasticity. Gravel is angular to subrounded, fine and medium including sandstone and mudstone.			
9.50	D31									
9.80	D32									
10.00-10.45	U33 0.45	10.00	DRY	61 blows						
10.50	D34					(3.50)				
10.80	D35									
11.00-11.45	U36 0.45	11.00	DRY	58 blows						
11.50	D37									
12.00	D38									
12.50-12.95	B39				8.92	12.30				
12.50-12.95	D40						Dense, brown, slightly silty, fine and medium SAND.			
12.50-12.95	SPT N=49	12.50	12.30	Water strike(2) at 12.30m, rose to 10.70m in 20 mins, sealed at 15.40m. 3,5/6,14,14,15						
13.80	D41					(3.10)				
14.00-14.45	SPT N=52	14.00	12.70	6,8/9,13,15,15			Below 14.00m: very dense.			
14.00-14.50	B42									
14.00-14.50	D43									
15.40	D44				5.82	15.40				
15.50-15.95	U45 0.45	15.50	DRY	98 blows			Stiff, in places very stiff, brown, slightly sandy, silty CLAY of low plasticity.			

**Remarks**

Water added from 12.50m.

**Scale  
(approx)**

1:40

**Logged  
By**

JC

**Figure No.**

41455.BH224



**IAN FARMER  
ASSOCIATES**

**Site**

Preston Western Distributor Road, Preston

**Borehole  
Number**

**BH224**

**Boring Method**

Cable Percussion

**Casing Diameter**

150mm cased to 20.00m

**Ground Level (mOD)**

21.22

**Client**

Lancashire County Council

**Job  
Number**

41455

**Location**

348995.8 E 431555.4 N

**Dates**

14/07/2014-  
15/07/2014

**Engineer**

Lancashire County Council

**Sheet**

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Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
16.00	D46					(1.50)				
16.90 17.00-17.45 17.00-17.45 17.00-17.45	D47 B48 D49 SPT N=32	17.00	16.20	Water strike(3) at 16.90m, rose to 15.10m in 20 mins. 4,3/7,8,8,9	4.32	16.90	Dense, brown, slightly silty, gravelly, fine and medium SAND with low cobble content. Gravel is angular to subrounded, fine to coarse including mudstone.		▽3	
18.00	D50									
18.50-18.95 18.50-18.95 18.50-18.95	SPT N=38 B51 D52	18.50	16.70	5,9/8,11,9,10		(3.55)	At 18.50m: locally very gravelly.			
19.50	D53									
20.00-20.45 20.00-20.45 20.00-20.45	SPT N=49 B54 D55	20.00	16.80	6,11/10,13,12,14	0.77	20.45	Complete at 20.45m			

**Remarks**

Water added from 17.00m.

**Scale  
(approx)**

1:40

**Logged  
By**

JC

**Figure No.**

41455.BH224



**IAN FARMER  
ASSOCIATES**

<b>Site</b> Preston Western Distributor Road, Preston		<b>Number</b> <b>WS227</b>
<b>Excavation Method</b> Drive-in Window Sampler		<b>Client</b> Lancashire County Council
<b>Dimensions</b>		<b>Job Number</b> 41455
<b>Location</b> 349024.5 E 431611.4 N		<b>Engineer</b> Lancashire County Council
<b>Ground Level (mOD)</b> 21.51		<b>Sheet</b> 1/1
<b>Dates</b> 10/09/2014		

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00-1.20	D1					Grass over TOPSOIL with roots and rootlets.		
0.20	D2			21.11	(0.40)			
0.30	D3							
0.30	J4			20.91	0.40 (0.20)	Brown, angular to subrounded, fine to coarse GRAVEL including sandstone.		
0.50	D5				0.60			
0.50	J6					Stiff, brown, slightly sandy, slightly gravelly CLAY. Gravel is angular to subrounded, fine to coarse including sandstone.		
0.70	D7							
1.00	D8							
1.00	J9							
1.20-1.65	SPT N=2		1,0/0,0,1,1					
1.20-1.65	D10							
1.30	D11							
2.00-2.45	SPT N=7							
2.00-2.45	D12		1,2/1,2,1,3					
2.30	D13							
						Below 2.40m: silty.		
2.70	D14							
3.00-3.45	SPT N=13				(4.85)			
3.00-3.45	D15		1,2/2,3,4,4			Below 3.00m: firm.		
3.30	D16							
3.50-5.00	B17							
3.70	D18							
4.00-4.45	SPT N=9							
4.00-4.45	D19		1,1/1,2,3,3					
4.30	D20							
4.70	D21							
5.00-5.45	SPT N=25							
5.00-5.45	D22		4,4/5,6,7,7					
				16.06	5.45	Complete at 5.45m		

#### Remarks

Window sample hole backfilled on completion.  
Samples marked as J comprise 1 x amber jar and 1 x vial.  
Excavating from 0.00m to 1.20m for 1.00 hour.

**Scale (approx)**  
1:40

**Logged By**  
JC

**Figure No.**  
41455.WS227

**Site** : Preston Western Distributor Road, Preston

**Job Number**  
41455D

**Client** : Lancashire County Council

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**DETERMINATION OF MOISTURE CONTENT, LIQUID LIMIT AND PLASTIC LIMIT  
AND DERIVATION OF PLASTICITY AND LIQUIDITY INDEX**

Borehole/ Trial Pit	Depth (m)	Sample	Natural / Sieved	Natural Moisture Content %	Sample Passing 425µm Sieve		Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Class	Description / Remarks
					Percentage %	Moisture Content %						
BH205	1.00	D5	Natural	18								Brown silty sandy CLAY
BH205	1.20	U7	Natural	18								Brown silty sandy gravelly CLAY
BH205	1.70	D8	Natural	18								Brown silty sandy gravelly CLAY
BH205	2.00	D10	Natural	18								Brown silty sandy gravelly CLAY
BH205	3.00	U11	Natural	15	95	15	33	14	19	0.05	CL	Brown silty CLAY
BH205	3.50	D12	Natural	13								Brown silty gravelly CLAY
BH207	0.10	B1	Natural	20								Brown sandy CLAY
BH207	0.50	D2	Natural	20								Brown sandy gravelly CLAY
BH207	0.70	B4	Natural	21								Brown sandy gravelly CLAY
BH207	1.00	D5	Natural	19								Brown sandy CLAY
BH207	1.20	U7	Natural	15	99	15	33	14	19	0.05	CL	Brown silty gravelly CLAY
BH207	1.70	D8	Natural	11								Brown silty gravelly CLAY
BH207	2.00	U9	Natural	14								Brown silty gravelly CLAY
BH207	2.50	D10	Natural	13								Brown silty CLAY
BH207	3.00	D12	Natural	14								Brown silty gravelly CLAY
BH208	0.10	B1	Natural	34								Brown sandy CLAY
BH208	0.30	D2	Natural	27								Brown silty gravelly CLAY
BH208	0.80	D5	Natural	18								Brown silty gravelly CLAY
BH208	1.20	U7	Natural	14								Brown silty gravelly CLAY
BH208	1.70	D8	Natural	12								Brown silty gravelly CLAY
BH208	2.00	U9	Natural	22								Brown silty CLAY
BH208	2.50	D10	Natural	20								Brown silty gravelly CLAY
BH208	3.00	B11	Natural	21	100	21	34	20	14	0.07	CL	Brown silty CLAY
BH208	3.00	D12	Natural	23								Brown silty gravelly CLAY
BH209	0.50	D2	Natural	25								Brown sandy gravelly CLAY
BH209	0.70	B4	Natural	17								Brown sandy gravelly CLAY
BH209	1.00	D5	Natural	12								Brown sandy gravelly CLAY
BH209	1.20	D8	Natural	16								Brown sandy CLAY
BH209	2.00	U9	Natural	16	96	16	32	15	17	0.06	CL	Brown sandy gravelly CLAY
BH209	3.50	U13	Natural	14								Brown slightly sandy slightly gravelly CLAY
BH209	4.00	D14	Natural	20								Brown sandy gravelly CLAY
BH221	0.25	D1	Natural	16								Brown sandy gravelly CLAY
BH221	0.50	D3	Natural	17								Brown silty gravelly CLAY
BH221	1.20	U5	Natural	17								Brown silty gravelly CLAY
BH221	1.70	D6	Natural	14								Brown silty gravelly CLAY
BH221	2.00	U7	Natural	12	98	12	31	16	15	-0.27	CL	Brown silty gravelly CLAY

**Method of Preparation** : BS 1377:PART 1:1990:7.4 Preparation of samples for classification tests BS 1377:PART 2:1990:4.2 & 5.2 Sample preparations

**Method of Test** : BS 1377:PART 2:1990:3.2 Determination of moisture content 4.3 Determination of the liquid limit 5.3 Determination of the plastic limit and plasticity index

**Site** : Preston Western Distributor Road, Preston

**Job Number**  
41455D

**Client** : Lancashire County Council

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**DETERMINATION OF MOISTURE CONTENT, LIQUID LIMIT AND PLASTIC LIMIT  
AND DERIVATION OF PLASTICITY AND LIQUIDITY INDEX**

Borehole/ Trial Pit	Depth (m)	Sample	Natural Sieved	Natural Moisture Content %	Sample Passing 425µm Sieve		Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Class	Description / Remarks
					Percentage %	Moisture Content %						
BH221	2.50	D8	Natural	12								Brown silty CLAY
BH221	2.80	D9	Natural	16								Brown silty gravelly CLAY
BH221	3.00	U11	Natural	14								Brown silty gravelly CLAY
BH221	3.50	D12	Natural	14								Brown silty CLAY
BH221	3.80	D13	Natural	17								Brown silty CLAY
BH221	4.00	D15	Natural	14								Brown sandy CLAY
BH221	4.80	D16	Natural	16								Brown silty slightly gravelly CLAY
BH221	5.00	U17	Natural	20	99	20	75	20	55	0.00	CH	Brown silty slightly gravelly CLAY
BH221	5.50	D18	Natural	20								Brown silty slightly gravelly CLAY
BH221	5.80	D19	Natural	23								Brown silty slightly gravelly CLAY
BH221	6.00	U20	Natural	23								Brown silty sandy CLAY
BH221	6.50	D21	Natural	24								Brown silty sandy CLAY
BH221	6.80	D22	Natural	25								Brown silty sandy CLAY
BH221	7.00	U23	Natural	25								Brown silty sandy CLAY
BH221	7.50	D24	Natural	28								Brown silty sandy CLAY
BH221	7.80	D25	Natural	17								Brown silty CLAY
BH221	8.00	D27	Natural	14								Brown silty CLAY
BH221	8.80	D28	Natural	15								Brown silty CLAY
BH221	9.00	U29	Natural	15	97	16	29	15	14	0.07	CL	Brown silty CLAY
BH221	9.50	D30	Natural	16								Brown silty CLAY
BH221	9.80	D31	Natural	16								Brown silty CLAY
BH221	11.50	B36	Natural	6.6								Brown silty SAND
BH221	11.50	D37	Natural	17								Brown silty SAND
BH221	14.50	B42	Natural	21								Brown silty slightly gravelly SAND
BH221	17.00	D47	Natural	16								Brown sandy CLAY
BH221	17.50	U48	Natural	15	100	15	35	15	20	0.00	CL/CI	Brown sandy CLAY
BH225	0.10	B1	Natural	18								Brown sandy CLAY
BH225	0.30	D2	Natural	13								Brown sandy gravelly CLAY
BH225	1.00	D5	Natural	15								Brown silty CLAY
BH225	1.20	U7	Natural	13	94	14	31	14	17	0.00	CL	Brown silty gravelly CLAY
BH225	1.70	D8	Natural	16								Brown sandy gravelly CLAY
BH225	2.00	U9	Natural	15								Brown sandy CLAY
BH225	2.50	D10	Natural	14								Brown sandy CLAY
BH225	3.00	U11	Natural	16								Brown silty sandy CLAY
BH225	3.50	D12	Natural	14								Brown silty sandy CLAY
BH225	4.00	U13	Natural	14								Brown sandy gravelly CLAY

**Method of Preparation** : BS 1377:PART 1:1990:7.4 Preparation of samples for classification tests BS 1377:PART 2:1990:4.2 & 5.2 Sample preparations

**Method of Test** : BS 1377:PART 2:1990:3.2 Determination of moisture content 4.3 Determination of the liquid limit 5.3 Determination of the plastic limit and plasticity index



**Site** : Preston Western Distributor Road, Preston

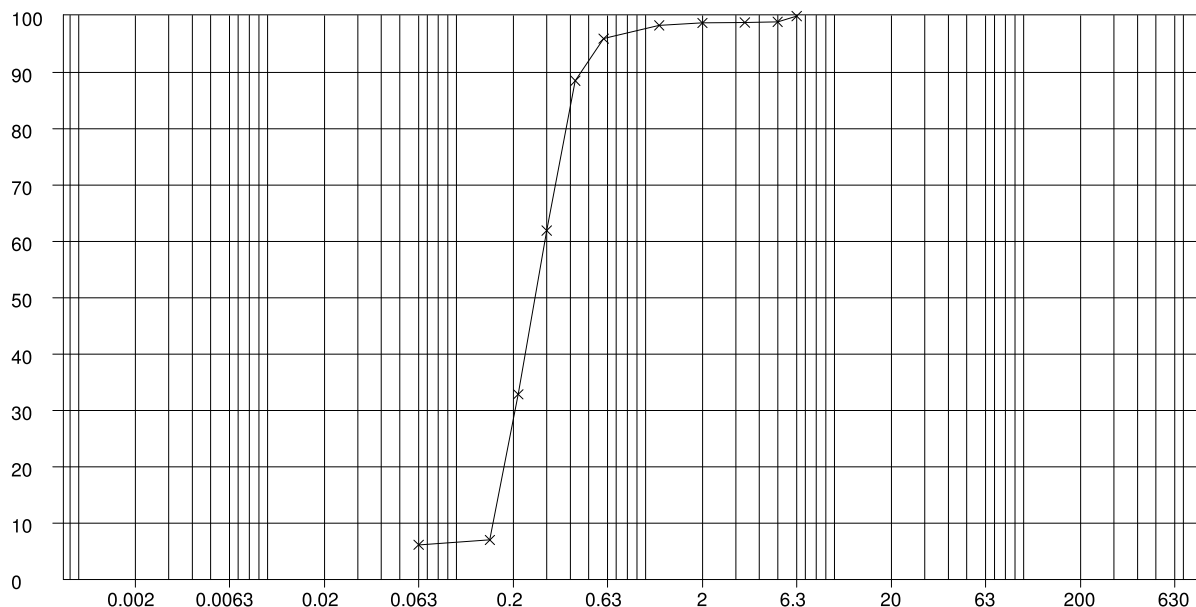
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41455D

**Client** : Lancashire County Council

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**DETERMINATION OF PARTICLE SIZE DISTRIBUTION**

Borehole / Trial Pit	Depth (m)	Sample	Pipette/ Hydrometer	Description
BH221	11.50	B36	N/A	Brown silty SAND



Sieve / Particle Size	% Passing
200 mm	100
150 mm	100
125 mm	100
90 mm	100
75 mm	100
63 mm	100
50 mm	100
37.5 mm	100
28 mm	100
20 mm	100
14 mm	100
10 mm	100
6.3 mm	100
5 mm	99
3.35 mm	99
2 mm	99
1.18 mm	98
600 µm	96
425 µm	89
300 µm	62
212 µm	33
150 µm	7
63 µm	6

CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES	BOULDERS
	SILT			SAND			GRAVEL				

Grading Analysis	
<b>D60</b>	294.1 µm
<b>D10</b>	157.0 µm
<b>Uniformity Coefficient</b>	1.9

Particle Proportions	
<b>Cobbles + Boulders</b>	0%
<b>Gravel</b>	1%
<b>Sand</b>	93%
<b>Silt/Clay</b>	6%

**Method of Preparation** : BS 1377:PART 1:1990:7.3 Initial preparation 7.4.5 Particle size tests

**Preparation Details** : Sample washed with no dispersant used, Oven Dried at 105 - 110 °C

**Method of Test** : BS 1377:PART 2:1990:9 Determination of particle size distribution

**Remarks** :

**Site** : Preston Western Distributor Road, Preston

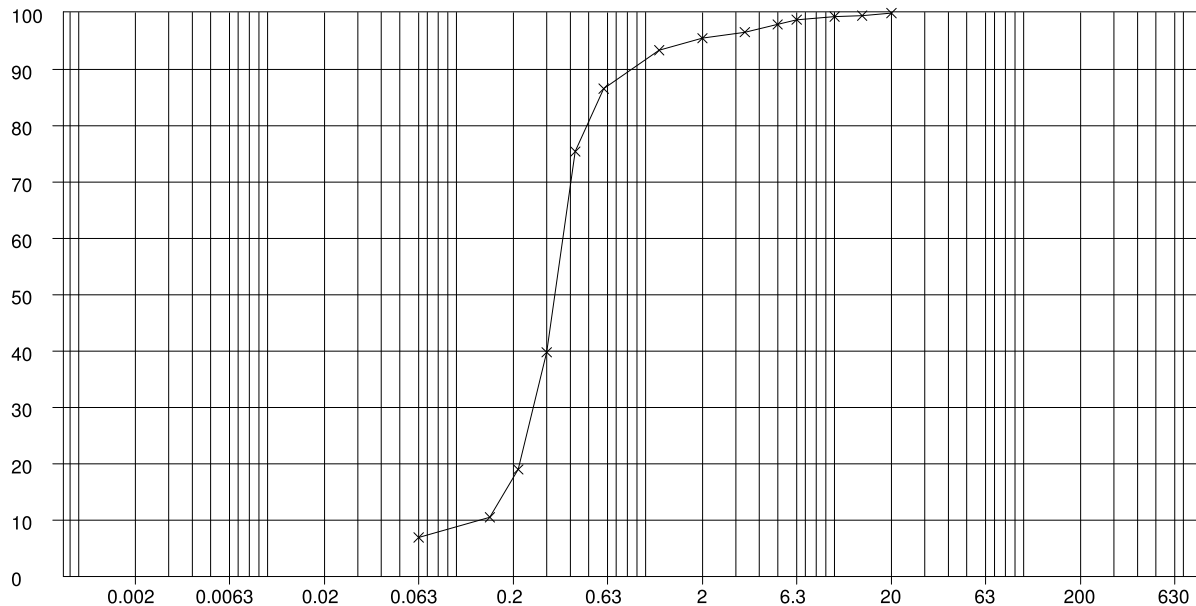
**Job Number**  
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**Client** : Lancashire County Council

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**DETERMINATION OF PARTICLE SIZE DISTRIBUTION**

Borehole / Trial Pit	Depth (m)	Sample	Pipette/ Hydrometer	Description
BH221	14.50	B42	N/A	Brown silty slightly gravelly SAND



Sieve / Particle Size	% Passing
200 mm	100
150 mm	100
125 mm	100
90 mm	100
75 mm	100
63 mm	100
50 mm	100
37.5 mm	100
28 mm	100
20 mm	100
14 mm	100
10 mm	99
6.3 mm	99
5 mm	98
3.35 mm	97
2 mm	96
1.18 mm	93
600 µm	87
425 µm	75
300 µm	40
212 µm	19
150 µm	11
63 µm	7

CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES	BOULDERS
	SILT			SAND			GRAVEL				

Grading Analysis	
<b>D60</b>	370.8 µm
<b>D10</b>	137.0 µm
<b>Uniformity Coefficient</b>	2.7

Particle Proportions	
<b>Cobbles + Boulders</b>	0%
<b>Gravel</b>	4%
<b>Sand</b>	89%
<b>Silt/Clay</b>	7%

**Method of Preparation** : BS 1377:PART 1:1990:7.3 Initial preparation 7.4.5 Particle size tests

**Preparation Details** : Sample washed with no dispersant used, Oven Dried at 105 - 110 °C

**Method of Test** : BS 1377:PART 2:1990:9 Determination of particle size distribution

**Remarks** :

**Site** : Preston Western Distributor Road, Preston


**Job Number**  
41455D

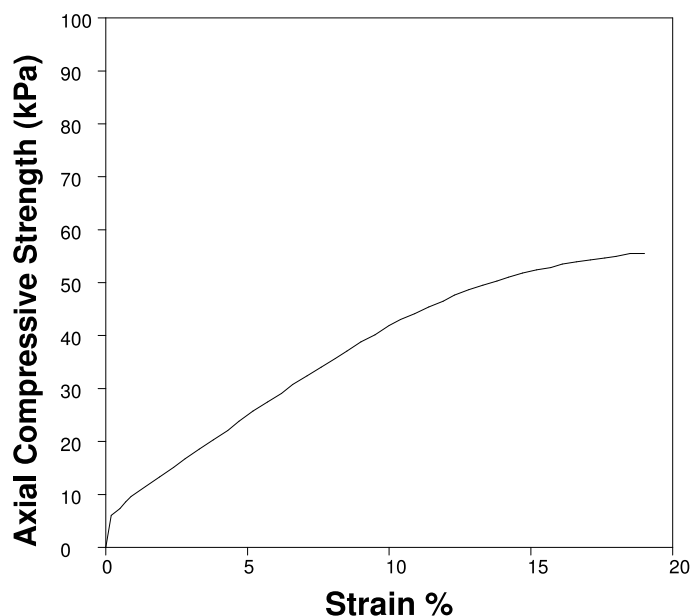
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**DETERMINATION OF MOISTURE CONTENT, DENSITY AND UNCONFINED COMPRESSIVE STRENGTH  
(LOAD FRAME METHOD)**

Borehole / Trial Pit	Depth (m)	Sample	Description
BH221	6.00	U20	Brown silty sandy CLAY

Initial Specimen		Length of Sample (mm)	450
		Depth from top of sample (mm)	50
		Condition of Sample:	Undisturbed
		Orientation:	Vertical
Length of Specimen (mm)			210.6
Diameter of Specimen (mm)			100.7
Moisture Content (%)			23
Bulk Density (Mg/m³)			2.06
Dry Density (Mg/m³)			1.68
Rate of Strain (%/min)			1.90
Test Results	Strain at Failure (%)		19
	Unconfined Compressive Strength (kPa)		56
	Mode of Failure (B/P/C)		Plastic


**Method of Preparation** : BS 1377:PT1:1990:7.4.2 Moisture Content, BS 1377:PT1:1990:8.3 Preparation of undisturbed samples for testing or BS 1377:PT1:1990:7.7.5.2 Preparation of disturbed samples for testing.

**Method of Test** : BS 1377:PT2:1990:3.2 Determination of moisture content, BS 1377:PT2:1990:7.2 Determination of density by linear measurement BS 1377:PT7:1990:7.2 Determination of unconfined compressive Strength using the Load Frame Method

**Remarks** :

**Site** : Preston Western Distributor Road, Preston


**Job Number**  
41455D

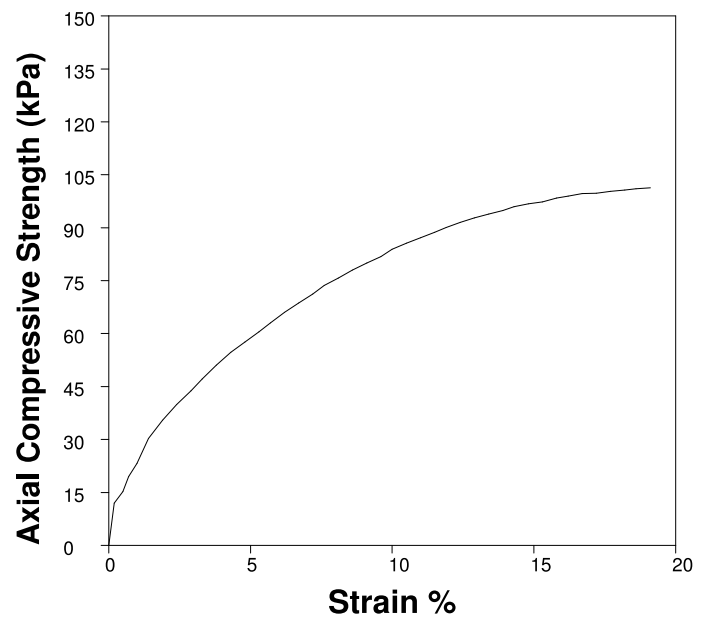
**Client** : Lancashire County Council

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### DETERMINATION OF MOISTURE CONTENT, DENSITY AND UNCONFINED COMPRESSIVE STRENGTH (LOAD FRAME METHOD)

Borehole / Trial Pit	Depth (m)	Sample	Description
BH221	7.00	U23	Brown silty sandy CLAY

Initial Specimen		Length of Sample (mm)	434
		Depth from top of sample (mm)	85
		Condition of Sample:	Undisturbed
		Orientation:	Vertical
Length of Specimen (mm)			209.3
Diameter of Specimen (mm)			101.3
Moisture Content (%)			0.00
Bulk Density (Mg/m³)			2.05
Dry Density (Mg/m³)			2.05
Rate of Strain (%/min)			1.91
Test Results	Strain at Failure (%)		19.1
	Unconfined Compressive Strength (kPa)		101
	Mode of Failure (B/P/C)		Compound


**Method of Preparation** : BS 1377:PT1:1990:7.4.2 Moisture Content, BS 1377:PT1:1990:8.3 Preparation of undisturbed samples for testing or BS 1377:PT1:1990:7.7.5.2 Preparation of disturbed samples for testing.

**Method of Test** : BS 1377:PT2:1990:3.2 Determination of moisture content, BS 1377:PT2:1990:7.2 Determination of density by linear measurement BS 1377:PT7:1990:7.2 Determination of unconfined compressive Strength using the Load Frame Method

**Remarks** :

**Site** : Preston Western Distributor Road, Preston


**Job Number**  
41455D

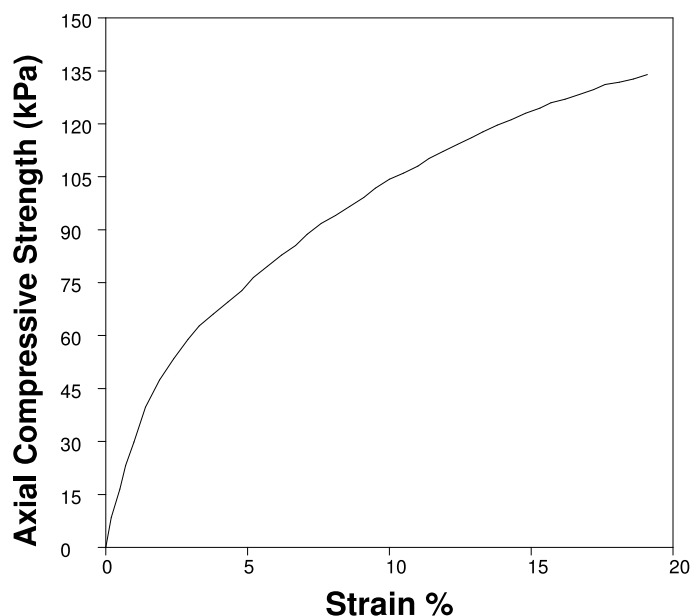
**Client** : Lancashire County Council

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**DETERMINATION OF MOISTURE CONTENT, DENSITY AND UNCONFINED COMPRESSIVE STRENGTH  
(LOAD FRAME METHOD)**

Borehole / Trial Pit	Depth (m)	Sample	Description
BH221	9.00	U29	Brown silty CLAY

Initial Specimen		Length of Sample (mm)	480
		Depth from top of sample (mm)	50
		Condition of Sample:	Undisturbed
		Orientation:	Vertical
Length of Specimen (mm)			209.8
Diameter of Specimen (mm)			102.6
Moisture Content (%)			15
Bulk Density (Mg/m³)			2.20
Dry Density (Mg/m³)			1.91
Rate of Strain (%/min)			1.91
Test Results	Strain at Failure (%)		19.1
	Unconfined Compressive Strength (kPa)		134
	Mode of Failure (B/P/C)		Plastic


**Method of Preparation** : BS 1377:PT1:1990:7.4.2 Moisture Content, BS 1377:PT1:1990:8.3 Preparation of undisturbed samples for testing or BS 1377:PT1:1990:7.7.5.2 Preparation of disturbed samples for testing.

**Method of Test** : BS 1377:PT2:1990:3.2 Determination of moisture content, BS 1377:PT2:1990:7.2 Determination of density by linear measurement BS 1377:PT7:1990:7.2 Determination of unconfined compressive Strength using the Load Frame Method

**Remarks** :



**Site** : Preston Western Distributor Road, Preston


**Job Number**  
41455D

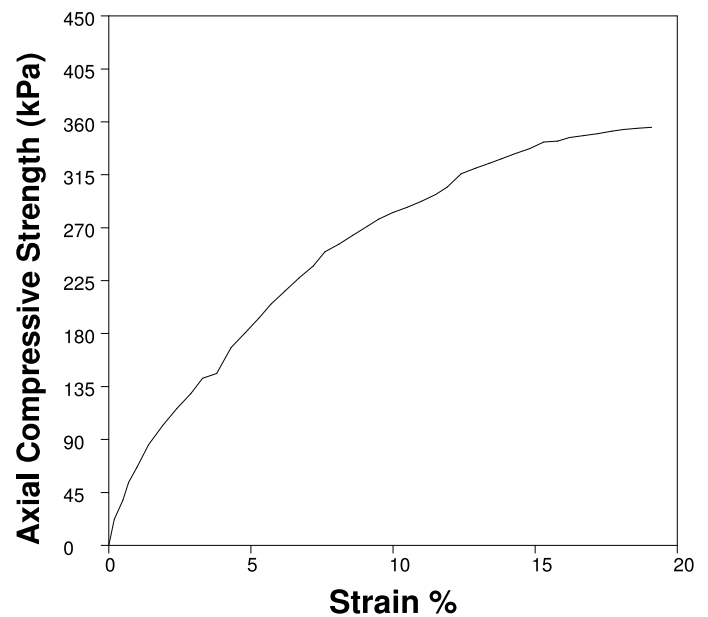
**Client** : Lancashire County Council

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### DETERMINATION OF MOISTURE CONTENT, DENSITY AND UNCONFINED COMPRESSIVE STRENGTH (LOAD FRAME METHOD)

Borehole / Trial Pit	Depth (m)	Sample	Description
BH221	17.50	U48	Brown sandy CLAY

Initial Specimen		Length of Sample (mm)	450
		Depth from top of sample (mm)	150
		Condition of Sample:	Undisturbed
		Orientation:	Vertical
Length of Specimen (mm)			209.5
Diameter of Specimen (mm)			100.7
Moisture Content (%)			15
Bulk Density (Mg/m³)			2.27
Dry Density (Mg/m³)			1.97
Rate of Strain (%/min)			1.91
Test Results	Strain at Failure (%)		19.1
	Unconfined Compressive Strength (kPa)		355
	Mode of Failure (B/P/C)		Compound


**Method of Preparation** : BS 1377:PT1:1990:7.4.2 Moisture Content, BS 1377:PT1:1990:8.3 Preparation of undisturbed samples for testing or BS 1377:PT1:1990:7.7.5.2 Preparation of disturbed samples for testing.

**Method of Test** : BS 1377:PT2:1990:3.2 Determination of moisture content, BS 1377:PT2:1990:7.2 Determination of density by linear measurement BS 1377:PT7:1990:7.2 Determination of unconfined compressive Strength using the Load Frame Method

**Remarks** :

**Site** : Preston Western Distributor Road, Preston


**Job Number**  
41455D

**Client** : Lancashire County Council

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### ONE-DIMENSIONAL CONSOLIDATION TEST

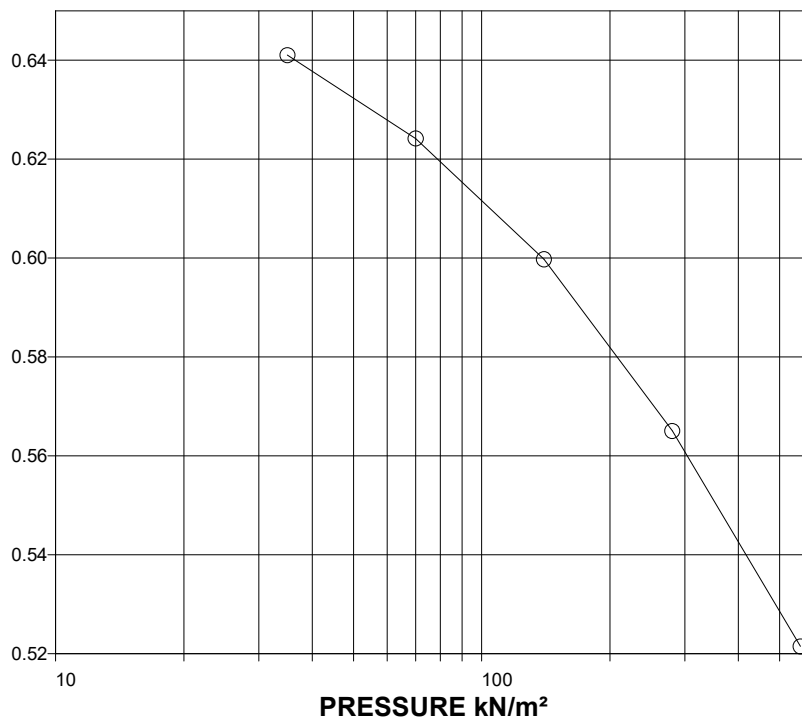
Borehole / Trial Pit	Depth (m)	Sample	Description
BH221	7.00	U23	Brown sandy CLAY

Initial Specimen		Length of Sample (mm)	450
		Depth from top of sample (mm)	50
		Condition of Sample:	Undisturbed
		Orientation:	Vertical

Diameter (mm)	74.95
Particle Density (Mg/m <sup>3</sup> )	2.65 (Assumed)
Swelling Pressure (kN/m <sup>2</sup> )	
Lab Temp (°C)	21

	Initial	Final
Height (mm)	19.08	17.23
Wet Weight (g)	171.01	166.39
Moisture Content (%)	28	23
Bulk Density (Mg/m <sup>3</sup> )	2.03	2.19
Dry Density (Mg/m <sup>3</sup> )	1.58	1.78
Void Ratio	0.677	0.489
Degree of Saturation (%)	110.38	126.00

VOID RATIO



Pressure kN/m <sup>2</sup>	Mv m <sup>2</sup> /MN	Cv m <sup>2</sup> /year	Void Ratio
35	0.62	7.0	0.641
70	0.30	1.2	0.624
140	0.23	1.4	0.600
280	0.16	2.0	0.565
560	0.10	2.9	0.521

Pressure kN/m <sup>2</sup>	Mv m <sup>2</sup> /MN	Cv m <sup>2</sup> /year	Void Ratio

**Method of Preparation** : BS 1377:PART 5:1990:3.3, 3.4

**Method of Test** : BS 1377:PART 5:1990:3.5

**Remarks** :

**Site** : Preston Western Distributor Road, Preston

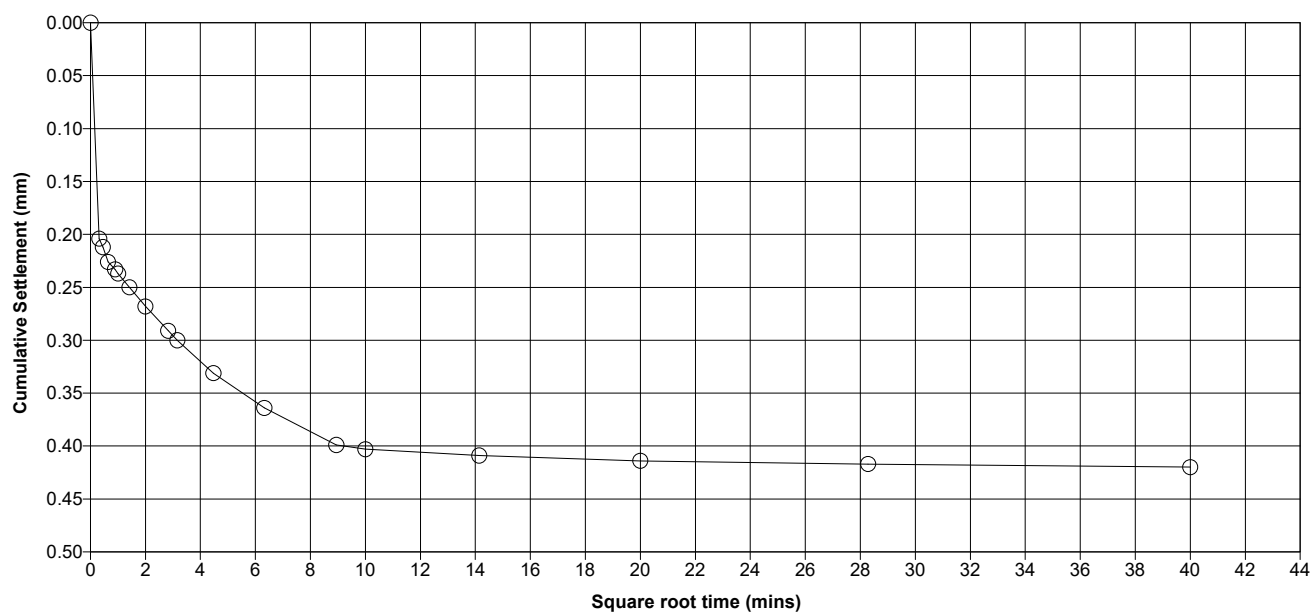
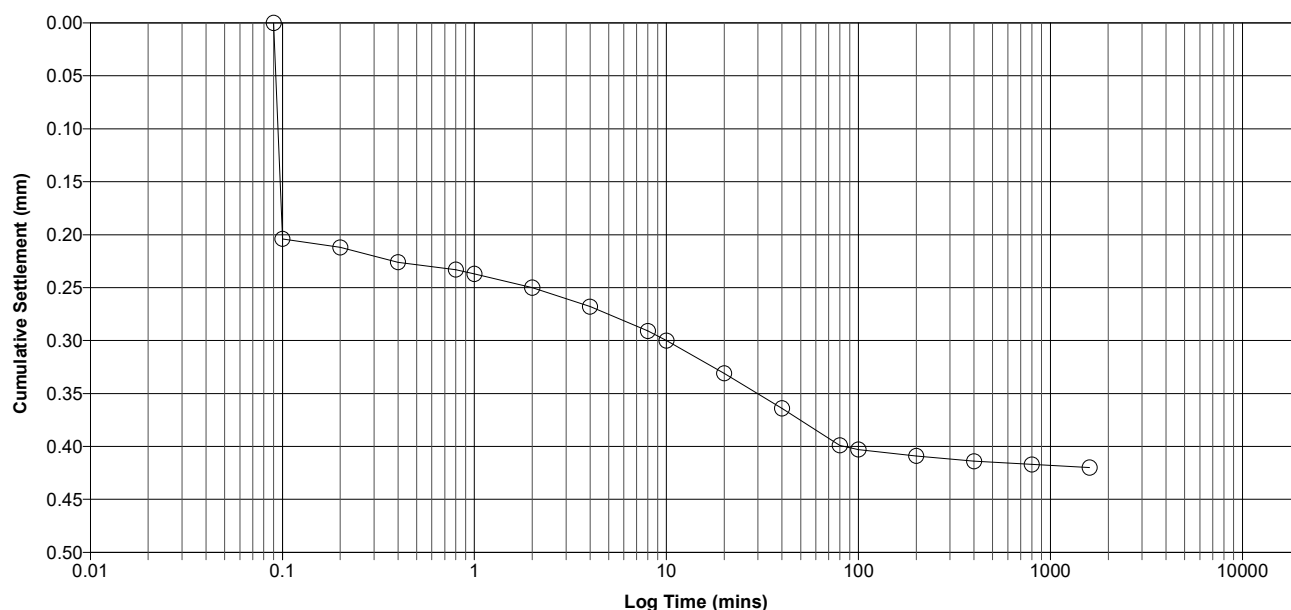
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**Client** : Lancashire County Council

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### ONE-DIMENSIONAL CONSOLIDATION TEST

Borehole / Trial Pit	Depth (m)	Sample	Stage	Description
BH221	7.00	U23	1	Brown sandy CLAY


**Method of Preparation** : BS 1377:PART 5:1990:3.3, 3.4

**Method of Test** : BS 1377:PART 5:1990:3.5

**Remarks** :