Report Title: # Hydrogeological Assessment

Project Name: # 13a Linksway, Northwood

Report Reference: **BRD2144-OR1-B**

Date: **April 2020**

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REPORT CONTROL SHEET

REPORT TITLE	**HYDRO-GEOLOGICAL ASSESSMENT**
PROJECT	**13A LINKSWAY, NORTHWOOD**
CLIENT	**MR P GOODMAN**

REPORT REFERENCE	ISSUE DETAIL	DATE	PREPARED BY	CHECKED BY
BRD2144-OR1-A	First Issue	07/05/2014	G Dowlen	B Devonshire
BRD2144-OR1-B	Second Issue – Update with additional monitoring visit	27/4/2020	B Devonshire	C Bishop

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REPORT LAYOUT

This report is divided into the following four sections: Summary Report, Technical Report, Supporting Information and Appendices.

SUMMARY REPORT

This expanded executive summary provides the main findings of the work undertaken in brief non-technical language. This section provides an overview of the key outcomes for the benefit of non-specialists and concludes with the main recommendations. This section should only be relied upon in the context of the whole report and the Technical Report should be referred to support any design decisions.

TECHNICAL REPORT

The main report section is intended to provide the technical detail of the investigation and is intended to provide the level of information required by current guidance documents and practice. The Technical Report is written in a language that, in part, assumes knowledge of subject matter so that it can be written in as concise a form as possible. Its intended audience is peers, regulators and other professionals in related disciplines.

SUPPORTING INFORMATION

This section of the report provides background details of a generic nature together with specific technical approaches adopted by BRD and details of the guidance documents that are commonly referenced in the report. The section also includes explanations of technical terms to assist non-specialist readers in understanding the Technical Report. It should be noted that not all the information within this section is necessarily applicable to this specific report.

APPENDICES

The final section of the report presents the factual data collected and employed as part of the investigation.

APPENDIX 1 SITE PLANS & PHOTOGRAPHS

Site Location Plan	Ref: BRD2144-OP1-A
Proposed Development Layout	'Proposed Site Plan' dwg no. PL 106 and 'Proposed Cross Section 3' dwg no. PL 114, Smerin Architects, both dated 16.01.17.
Exploratory Hole Location Plan	Ref: BRD2144-OP3-A

APPENDIX 2 EXPLORATORY HOLE & MONITORING RECORDS

Logs of boreholes.	Ref: WS01-WS03
BRE365 simplified soakage test records.	3 x A4 pages
Groundwater monitoring records.	2 x A4 pages

SUMMARY REPORT

SUBJECT	COMMENTS
CURRENT SITE USE	The site currently comprises a landscaped garden.
PROPOSED USE	It is proposed that the site will be developed with construction of a four storey house to include basement and roof space accommodation.
HISTORICAL SUMMARY	Originally part of a wood, the current house was constructed between the 1916 and 1932 dated plan editions. No significant changes occurred to the site on subsequent editions of the plans.
PUBLISHED GEOLOGY	The site is shown to be underlain by the bedrock deposits of the Lambeth Group Formation of clays, silts and sands.
ACTUAL GROUND CONDITIONS	The investigation has proved a thin cover of superficial Head Deposits of silty sandy gravelly clays to between 0.60m and 0.90m depth, underlain by Lambeth Group silty fine sands proved to a maximum depth of 6.45m. The boreholes were dry when drilled. The subsequent monitoring of the standpipes on two occasions indicated the boreholes to be dry to the base of the installations at 3.61mbgl in borehole WS01 and 1.93mbgl in borehole WS03.
HYDROGEOLOGY	The site is situated upon a Secondary A Aquifer. The site is located within a groundwater Source Protection Zone 1(Inner Protection Zone).
HYDROLOGY	The closest water feature to the site is an un-named stream and small pond within the adjacent golf course, located approximately 370m east of the rear garden fenceline to Plot 13a. The site is not in an area indicated to be at risk of flooding from water courses, the nearest such area being located approximately 800m south of the site, associated with the un-named water course which flows through the golf course.
SOAKAWAYS	Site may be suitable for surface water disposal to soakaways or other forms of infiltration device, however infiltration rates are low.
GROUNDWATER	The investigation undertaken has identified that the groundwater table lies at depth beneath the site and it is considered that basement construction will not impact the groundwater.
PREVIOUS GROUND REPORTS	BRD is unaware of any previous hydrogeological surveys undertaken for the site or properties in the vicinity of the site.

1. INTRODUCTION TO TECHNICAL REPORT

1.1. CONTRACT DETAILS

CLIENT	Mr P Goodman.
SITE	Land situated at 13a Linksway, Northwood, Middlesex.
CLIENT'S ADVISORS	BRD Environmental Limited (BRD) was originally commissioned by Andrews Eades Chartered Surveyors on behalf of Client for the works completed in 2014. BRD were subsequently commissioned to review and update the report in 2020 by Smerin Architects on behalf of the same Client.
REPORT CONTEXT	It is understood that the Client intends to split the current No.13 Linksway plot into two with the original house and part garden retained to No. 13, and the remaining part of the garden redeveloped with a new house (No.13a) incorporating a basement. It is understood that the local planning authority required the report to be updated in support of a re-submission for planning of the same scheme.
REPORT TYPE	The report provides a hydrogeological assessment to comply with groundwater aspects of Policy DMHD 3: Basement Development of London Borough of Hillingdon 'Local Plan Part 2 - Development Management Policies', Adopted Version, 16 January 2020.
REPORT OBJECTIVES	The purpose of the report is to provide an assessment of the current hydro-geotechnical and hydrological conditions at the site and potential impact on the current conditions as a result of basement construction.

1.2. SCOPE OF WORKS

The original 2014 scope of works was:

- Interpretation of the geological, hydrogeological and hydrology setting of the site from published sources.
- One day of windowless sampling using a percussive drilling rig that will yield 2-3No. boreholes to a nominal depth of up to 6m, ground conditions permitting.
- Undertake an infiltration test in one of the boreholes to establish the likely soil permeability.
- Installation of a 4m depth groundwater monitoring well (nominal 50mm diameter) into 2No. boreholes. Installations will be finished with a flush fitting metal stopcock cover.
- All exploratory points will be logged and sampled in general accordance with BS5930:1999+A2:2010 by a supervising Geo-Environmental Consultant.
- Determination of the location of exploratory points by hand held tape measurements.
- Environmental Technician to undertake a return groundwater monitoring visit to determine resting groundwater level.

- Provision of a combined factual and interpretative investigation report. Factual findings to include all exploratory point records and monitoring results. Interpretative reporting to include a preliminary groundwater assessment, including soakaway feasibility. Report to be supplied in an electronic Adobe pdf format and forwarded on CD-ROM.

In 2020, the agreed scope of works was:

- Geo-Environmental Technician to undertake a site visit to confirm conditions had not changed and assess whether the monitoring wells were still operational. If the well are operational, determine resting groundwater level if any.

- Update original hydrogeological assessment report to reflect the findings of the monitoring visit and confirm that the original findings remain valid.

1.3. REPORT LIMITATIONS

Any site boundary lines depicted on plans included within this report are approximate only and do not imply legal ownership of land. Any observations of tree species, asbestos containing materials within structures or invasive weeds, such as Japanese Knotweed, does not constitute a formal survey of such features. The identification of such features is therefore tentative only. The report does not consider whether sensitive ecology or archaeology is present as these require consideration by professionals specialising in these matters.

The recommendations, interpretations and conclusions of this report are based solely on the ground conditions found at the exploratory holes. Due to the variability in the nature of ground, conditions between exploratory holes can only be interpreted and not defined. The description of the site and the ground conditions is accurate only for the dates of the field works. In particular, groundwater levels can vary due to seasonal and other effects.

This report is restricted to the provision of a hydro-geological, hydrological and geological assessment of the ground conditions at the site only and does not include any form of contamination or geotechnical assessments which were not required, as confirmed by the Chartered Surveyors.

2. SITE CHARACTERISTICS

2.1. SITE SETTING

SITE ADDRESS AND POST CODE	13a Linksway, Northwood, Middlesex, HA6 2XA
NATIONAL GRID REFERENCE	508514E, 190815N

2.2. SITE SUMMARY

SUBJECT	COMMENTS
CURRENT SITE CONDITION	The site currently comprises part of the large garden to No.13 Linksway, Northwood. At the time of the additional monitoring visit undertaken in 2020, the site appeared largely unchanged from 2014 with the exception of some new tree/shrub planting.
PROPOSED DEVELOPMENT	It is proposed that the site will be developed as a four storey residence incorporating a basement and roof space living area.
HISTORICAL SUMMARY	A brief review of on-line publically available historical Ordnance Survey maps was undertaken. The following comments are for information only as a detailed historical review was not undertaken. Pre 1916 Plot13/13a was formerly located within Copse Wood, adjacent to the eastern limit of the wood, with the plot being identified as being wooded; the open land of the adjacent golf course is identified immediately east of the rear garden fenceline to the plot. By the 1932 dated plan the current house is identified (No.13), with landscaped gardens in the area of the proposed No.13a house. No significant changes are identified to Plot 13a on the subsequent map editions.
PUBLISHED GEOLOGY	The site is shown to be devoid of superficial deposits and located directly on the Lambeth Group bedrock sequence of silts, sands and clays.
HYDROGEOLOGY	The site is situated upon a Secondary A Aquifer relating to the Lambeth Group bedrock deposits. The site is located within a Source Protection Zone 1(Inner Protection Zone). There is one groundwater abstraction licence for supply of potable water identified associated with the hospital located approximately 800m north/northwest of the site.

SUBJECT	COMMENTS
HYDROLOGY	The closest water feature to the site is an un-named stream and small pond within the adjacent golf course, located approximately 370m east of the rear garden fence-line to Plot 13a. From a review of the Environment Agency website in 2014, the site is not in an area indicated to be at risk of flooding from water courses, the nearest such area being located approximately 800m south of the site, associated with the un-named water course which flows through the golf course. A search of the government website in 2020 revealed that the flood map for planning had not changed. The risk of surface water flooding, sometimes known as flash flooding, was considered low. The risk of river flooding was considered very low.

2.3. PREVIOUS INVESTIGATIONS

BRD is unaware of any previous hydrogeological surveys undertaken for the site or properties in the vicinity of the site.

3. GROUND INVESTIGATION

3.1. INVESTIGATION DESIGN

METHODOLOGY	Due to access constraints and requirement to minimise damage within the existing garden, a tracked windowless sampler drilling rig was used to assess the deeper ground conditions at the site and allow installation of groundwater level monitoring standpipes.	
DATES OF INTRUSIVE GROUND INVESTIGATION	The main field works were undertaken on 23rd April 2014 The first groundwater level monitoring visit was undertaken on 29th April 2014. A second groundwater monitoring visit was undertaken on 15th April 2020.	
CONSTRAINTS TO EXPLORATORY HOLE LAYOUT	There were no constraints to the location of the boreholes, but they were positioned to minimise damage to the landscaping as much as possible.	
EXPLORATORY HOLE SPACING	Approximately 20m grid.	
LAYOUT RATIONALE	**SOURCE / FEATURE**	**EXPLORATORY HOLE**
GROUND FEATURES TARGETED	Groundwater level beneath the site	WS01 to WS03

3.2. BRD FIELDWORK

WINDOWLESS SAMPLING BOREHOLES	
REFERENCES	WS01 to WS03
DEPTH RANGE	WS01 drilled to 6.45m depth, WS02 and WS03 both terminated at 2.45m on cemented deposits through which no further penetration could be achieved.
RIG TYPE	Premier Drilling Rig.
INSTALLATION / BACKFILL	Borehole WS02 was backfilled with arisings only. Boreholes WS01 and WS03 had monitoring wells installed. These comprised 50mm nominal diameter standpipes fitted with a plain cap finished with a flush metal cover. The slotted response length of the well is shown on the individual logs. Bentonite seals are also indicated on the logs. The filter medium used was pea gravel.

MONITORING	
TYPE	Groundwater monitoring on 29th April 2014 and 15th April 2020.

4. GROUND CONDITIONS

4.1. OVERVIEW

Published geological records indicated the site to be devoid of superficial deposits and underlain by the Lambeth Group Formation bedrock deposits identified to comprise clays, silts and sands.

The ground conditions within the boreholes confirmed the presence of the Lambeth Group deposits, but these were overlain by a thin cover of variable silty sandy gravelly clays considered to be Head Deposits.

4.2. ARTIFICIAL GROUND

SURFACE HARDSTANDING	Not encountered in exploratory points.
BURIED STRUCTURES	Not encountered in exploratory points.
BURIED SERVICES	Not encountered in exploratory points.

Made Ground was not encountered in any of the exploratory holes.

4.3. SUPERFICIAL DEPOSITS

TOPSOIL	Topsoil of dark brown/black organic sandy, locally gravelly, clay with rootlets was encountered at all three boreholes from ground level to 0.10m depth.

HEAD DEPOSIT			
LOCATION	All three boreholes.		
DEPTH TO BASE	0.60m to 0.90m.	**THICKNESS**	0.50m to 0.80m.
DESCRIPTION			
Firm mottled grey brown silty sandy gravelly clay with roots and rootlets.			
OBSERVATIONS			
GROUNDWATER	Groundwater was not observed in this stratum.		

4.4. BEDROCK

LAMBETH GROUP FORMATION			
LOCATION	All three boreholes.		
DEPTH TO BASE	>6.45m	**THICKNESS**	>5.55m
DESCRIPTION			
Medium dense, becoming dense and very dense, variably brown, grey orange brown, locally light brown, silty fine sand.			
OBSERVATIONS			
GROUNDWATER	Groundwater was not observed in this stratum during drilling.		

4.5. GROUNDWATER MONITORING

VISIT DATE	RESTING GROUNDWATER RANGE	COMMENTS
29/04/2014	Greater than 3.61mbgl	Both borehole standpipes were dry to the base of the boreholes at 3.61mbgl in WS01 and 1.93mbgl in borehole WS03 (originally drilled to 2.45m but silted up during simplified soakaway testing).
15/04/2020	Greater than 3.61mbgl	The monitoring wells had been deliberately buried in 2014 so that the turf could be reinstated. With the aid of a metal detector, measurements and photographs the two wells were uncovered again in 2020. Borehole WS03 had silted up ever so slightly in the intervening six years, but borehole WS01's well was still present to the original depth. The boreholes were dry as expected from the previous assessment.

5. HYDROGEOLOGICAL ASSESSMENT

5.1. INTRODUCTION

The original ground investigation was carried out to establish the ground and groundwater conditions beneath the site to establish whether or not the proposed basement construction could impact the water table in terms of obstructing the flow path.

For the 2020 update of this report, the proposed scheme is essentially unchanged and therefore the conclusion of the original version of this report remains valid. This has been confirmed by the additional groundwater monitoring visit with the existing monitoring wells recorded as dry.

Policy DMHD 3: Basement Development of London Borough of Hillingdon 'Local Plan Part 2 - Development Management Policies', Adopted Version, 16 January 2020 requires comments on drainage, flooding, groundwater conditions and structural stability. As previously mentioned the site is not in an area at risk of flooding. BRD are unaware of the proposed drainage scheme for the development, but have previously observed that soakaways could be used although infiltration rates will be low. The assessment of groundwater conditions is unchanged in that the basement will have negligible impact.

Consideration of structural stability is beyond the remit of the original report. However, it is worth noting that the proposed basement is centred within the property and well away from boundaries. It is considered that there is sufficient room available from the site boundaries that with appropriate safety precautions (e.g. slope angle, protecting the cut slope from scour, etc.) the basement could be constructed within an open excavation and that such an approach would not impact the stability of any nearby third party structures.

5.2. GROUNDWATER ASSESSMENT

On the basis of the groundwater monitoring undertaken at the site the groundwater table is at a depth of in excess of 3.61mbgl. As the boreholes were dry when drilled this indicates that the groundwater table is in excess of 6.45m depth beneath the site.

The basement construction will extend to approximately 3.00m depth. Based on the monitoring of water levels within the standpipes and observation that ground water was not encountered during drilling it is considered that the proposed basement construction will be above the water table and consequently have minimal impact on the groundwater flow.

It is considered unlikely that seasonal groundwater level variation will change this conclusion. It is worth noting that the winter of 2020 was exceptionally wet with a succession of significant storm events that led to widespread flooding and a marked decrease in the depth to groundwater across the country. From experience of monitoring at other locations nationally, groundwater levels in early April 2020 were still elevated. In such circumstances, the fact that no groundwater was recorded in the second monitoring visit gives confidence that the original assessment was correct.

5.3. SOAKAWAYS

5.3.1. Soil Infiltration Rate

Infiltration tests were carried out within boreholes in general accordance with the methodology detailed in BRE Digest 365 adapted for a circular hole. The results should be used as a guide only due to the limited volume of water used during the tests.

The records of the soakage tests are presented in the Appendices that include the calculation of the soil infiltration rate. A summary of results are presented in the table below:

BOREHOLE	SOIL INFILTRATION RATE		STRATUM TESTED
WS01	Test 1	1.60×10^{-5} m/s	Lambeth Group silty fine sands.
	Test 2	4.94×10^{-6} m/s	
WS03	Test 1	1.18×10^{-5} m/s	Lambeth Group silty fine sands.

5.3.2. Soakaway Design Advice

As soil infiltration rates are relatively poor, it is recommended that consideration is given to incorporating some form of rainwater reuse system into the new house to reduce the volume of water to be discharged to soakaway.

Traditional soakaways should be located at least 5m away from any foundations. Infiltration devices that do not lead to concentrated water inflows, such as permeable pavements, can be located closer than this offset distance subject to careful design and construction.

Trench soakaways or ring soakaways linked by permeable pipes should be considered as this will increase the area through which infiltration can occur compared to conventional single point soakaways, which should increase the rate of discharge into the ground.

REPORT SPECIFIC REFERENCES

- British Geological Survey sheet 255 "Beaconsfield" Solid and Drift edition (1:50,000) published 1974.

- 'Local Plan Part 2 - Development Management Policies' London Borough of Hillingdon, Adopted Version, 16 January 2020.

SUPPORTING INFORMATION

SITE CHARACTERISTICS

The site characteristics are collated from various information sources, including but not limited to Ordnance Survey, British Geological Survey (BGS), Environment Agency (EA) and local authorities.

BRD generally commission the Landmark Information Group to produce an Envirocheck Report for study sites and where employed this is included in the Appendices. It should be noted that some of the data provided in the Envirocheck report is not considered within BRD's interpretation for the site characteristics as it is not relevant. Examples of this are:

- *Nitrate Sensitive Zones and Nitrate Vulnerable Zones are ignored as these are only applicable to agricultural activities relating to the application of manure and fertilisers to land.*
- *River Quality is ignored as at this preliminary stage of risk assessment as all surface water bodies are considered equally sensitive to contamination risks.*

In assessing site characteristics, BRD also consider the area within a surrounding 250m buffer zone extending from the site boundary.

HISTORY

Mapped History

The site history summarises the changes in use or layout of the site over time and is largely developed from a study of available Ordnance Survey maps. It should be noted that changes to the site may have occurred between the editions of the maps employed to assess the history of the site. Historical information of relevance within the 250m surrounding the site is also discussed in a separate section. The historical plans referred to in the text are generally included in an Appendix.

GEOLOGY

The geology of the site is assessed by reference to the relevant British Geological Survey (BGS) 1:50,000 scale sheet in Bedrock and Superficial (historically Solid and Drift) edition. Many of these geological maps are relatively old with superseded terminology and descriptions. BRD therefore employ the BGS Open Geoscience website to determine current nomenclature of strata and to assist in determining geological boundaries against current topographic features. BRD also employ BGS Regional Geology Guides to assist in understanding the geological context of the site.

HYDROGEOLOGY

Aquifer Designations

The Environment Agency's Groundwater Protection Policy uses designations that reflect the importance of aquifers in terms of groundwater as a drinking water resource, but also their role in supporting surface water flows and wetland ecosystems.

In defining groundwater vulnerability, both the superficial (drift) deposits and bedrock (solid) geology are considered separately with the following aquifer designations:

- *Principal Aquifers: 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.*

- *Secondary Aquifers: These include a wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into two types:*

    - *Secondary A - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.*

    - *Secondary B - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering.*

- *Secondary Undifferentiated - has been assigned in cases where it has not been possible to attribute either category A or B to a rock type.*

- *Unproductive Strata: These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.*

Source Protection Zones

The Environment Agency (EA) has defined Source Protection Zones for groundwater sources, such as boreholes and springs, that are used for public water supply. The EA uses the zones to target pollution prevention measures and monitor the activities of potential polluters within the affected area. There are three types Source Protection Zone:

- *Zone 1(Inner Protection Zone) is the most sensitive area within which pollution could reach the borehole within 50 days. Alternatively it is defined by a minimum 50m radius around the borehole.*

- *Zone 2 (Outer Protection Zone) are defined by the area within which pollution could reach the borehole within 400 days or 25% of the total catchment area.*

- *Zone 3 (Total Catchment) are defined by the total area required to support the removal of water from the borehole.*

HYDROLOGY

Flooding

The Environment Agency has zoned England and Wales in respect of the risk from flooding from 'highly unlikely' in Zone 1 to 'likely' in Zone 3. The zones ignore the presence of flood defences or certain other manmade structures and channel improvements.

National Planning Policy Framework, Department for Communities and Local Government, dated March 2012 states "A site-specific flood risk assessment is required for proposals of 1 hectare or greater in Flood Zone 1; all proposals for new development (including minor development and change of use) in Flood Zones 2 and 3, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency); and where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding".

GROUND INVESTIGATION

Exploratory holes are logged by an experienced Geo-Environmental Consultant in general accordance with 'Code of practice for site investigations' BS5930:1999 +A2:2010, BSi, August 2010. Soil samples for chemical and geotechnical analysis are taken from the exploratory holes at intervals dictated by the nature of the soils and the objectives of the investigation.

Where stated on the logs of inspection pits, trial pits or boreholes (where insitu testing has not been undertaken), the relative density of coarse (sand and gravel) soils is tentative only. Such assessments of density are on the basis of visual inspection only taking into consideration such factors as drilling rates, stability of pit side walls, appearance and behaviour under excavation.

Windowless Sampling Boreholes

This type of borehole is formed by a small tracked dynamic percussion drilling rig with samples retrieved in thin plastic liners within the narrow diameter steel sampling tubes. Borehole depths of up to 6m are typically, but in exceptional circumstances up to 15m depth can be achieved. This is the smallest type of rig that is capable of undertaking Standard Penetration Tests (SPTs).

Groundwater Level Monitoring

Groundwater levels are recorded with an electronic dip meter that has a detector end that is lowered into the borehole well. An audible signal is made when water is reached and the depth recorded from the graduated tape used to lower the detector. Where there is potential for a separate Light Non Aqueous Phase Liquid (LNAPL) to be present floating on the groundwater an oil/water interface meter is used in preference to a conventional dip meter so that any such floating product can be detected.

Geotechnical Sampling

BRD schedule a range of geotechnical testing as appropriate to the identified ground conditions, available budget and the proposed development. Different types of soil samples are obtained as appropriate to the ground conditions and planned testing.

SAMPLE TYPE	***SYMBOL USED ON LOGS***	***DESCRIPTION***
Disturbed	*D*	*Small disturbed soil samples of about 1 to 2 kg are collected in plastic bags.*
Bulk	*B*	*Large disturbed bulk samples up to about 30 kg are collected in plastic bags*
Undisturbed	*U*	*'Undisturbed' samples generally collected in plastic or metal tubes within cable percussive boreholes of 100mm diameter for samples of fine soils of firm to stiff consistency. Can also be representative of samples taken by cutting plastic sample liners from windowless sampling drilling methods. It is recognised that such samples do not generally meet Eurocode sample quality requirements for the tests commonly employed. However, given the wealth of experience with these sampling methods this continues to be common in United Kingdom practice particularly for*

		less sensitive developments where more expensive sampling techniques are not economically justifiable.
Undisturbed	*UT*	*A thin walled steel sampler developed by Archway Engineering called a UT100 in an attempt to gain better quality samples of soft to firm fine soils when using cable percussive drilling methods.*

GEOTECHNICAL PARAMETERS

Soakage Tests

Soakage tests comprise the filling of a test pit with water and recording the time taken for the water to drain away. The test are undertaken in general accordance with 'BRE Digest 365: Soakaway design', Building Research Establishment, 1991. Water is generally supplied by a tanker to allow fast filling of the pits with water. Repeat tests are undertaken where possible within the time available on site with the investigation budget.

Standard Penetration Tests

The standard penetration test (SPT) determines the resistance of soils at the base of a borehole to the dynamic penetration of a split barrel sampler and the recovering of disturbed samples for identification purposes. In gravelly soils and some soft rocks a solid cone is used in preference to the sampler.

The basis of the test consists in driving a sampler by dropping a hammer of 63.5 kg mass on from a height of 760 mm. The number of blows (N value) necessary to achieve a penetration of the sampler of 300 mm is recorded. The test is described in 'Geotechnical investigation and testing — Field testing — Part 3: Standard penetration test - BS EN ISO 22476-3:2005 Incorporating corrigendum no. 1', BSi, 2007.

The uncorrected N values of the SPT tests are recorded upon the borehole logs together with a record of blows for each 75mm test portion including the seating blows. Where the full test depth cannot be achieved due to refusal on hard stratum, the number of blows and the distance achieved is recorded and the N value given as >50. The abbreviation SPT(c) is used upon the logs indicates that the test was performed with a solid cone rather than a split spoon sampler.

It is necessary to apply a correction to the N values to account for the effects of energy delivery using the equation: $N_{60} = \frac{E_r}{60} N$ *where* E_r *is the energy ratio of the specific test equipment.*

In the case of tests in sand, for the effects of overburden and rod length the equation is modified to $N_{60} = \frac{E_r}{60} \; x \; \lambda \; x \; C_N \; x \; N$ *where* λ *is the correction factor for energy losses due to the rod length and* C_N *is the correction factor for vertical stress due to overburden of the soil.*

APPENDIX 1

Site Location Plan

Not to scale.

Project Title:	13a Linksway, Northwood
Client:	Mr P Goodman
BRD Reference:	BRD2144-OP4-A
Date Issued:	April 2014

BRD
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Beech Hedge

13 Linksway

Relocated Gateway/Driveway

+ 64.000

Relocated Garage

+ 63.800

New Brick Wall

New Brick Wall

New Timber Fence

New Semi-mature Oak

New Hornbeam Screen

+ 64.000

+ 63.800

Garage

New Semi-mature Beech

+ 64.450

Disposable/Recyclable Waste Store

Beech Hedge

+ 63.800

+ 64.100

Entry

+ 62.900

Rear Garden

+ 64.300

New Sewage/Utilities Connections

New Gateway/Driveway

+ 64.100

Courtyard

New Lawn To Replace Existing Tennis Court

Front Garden

Beech Hedge

+ 63.600

+ 63.100

New Hornbeam Screen

Chainlink Fence

15 Linksway

0 2 4 8 12 24 m

project	13A Linksway Northwood Middlesex HA6		
title	Proposed Site Plan		
scale	1:200 at A3	project number	A102
date	16.01.17	drawn by	PS
drawing status	Planning	checked by	PS
drawing number	PL 106	revision	-

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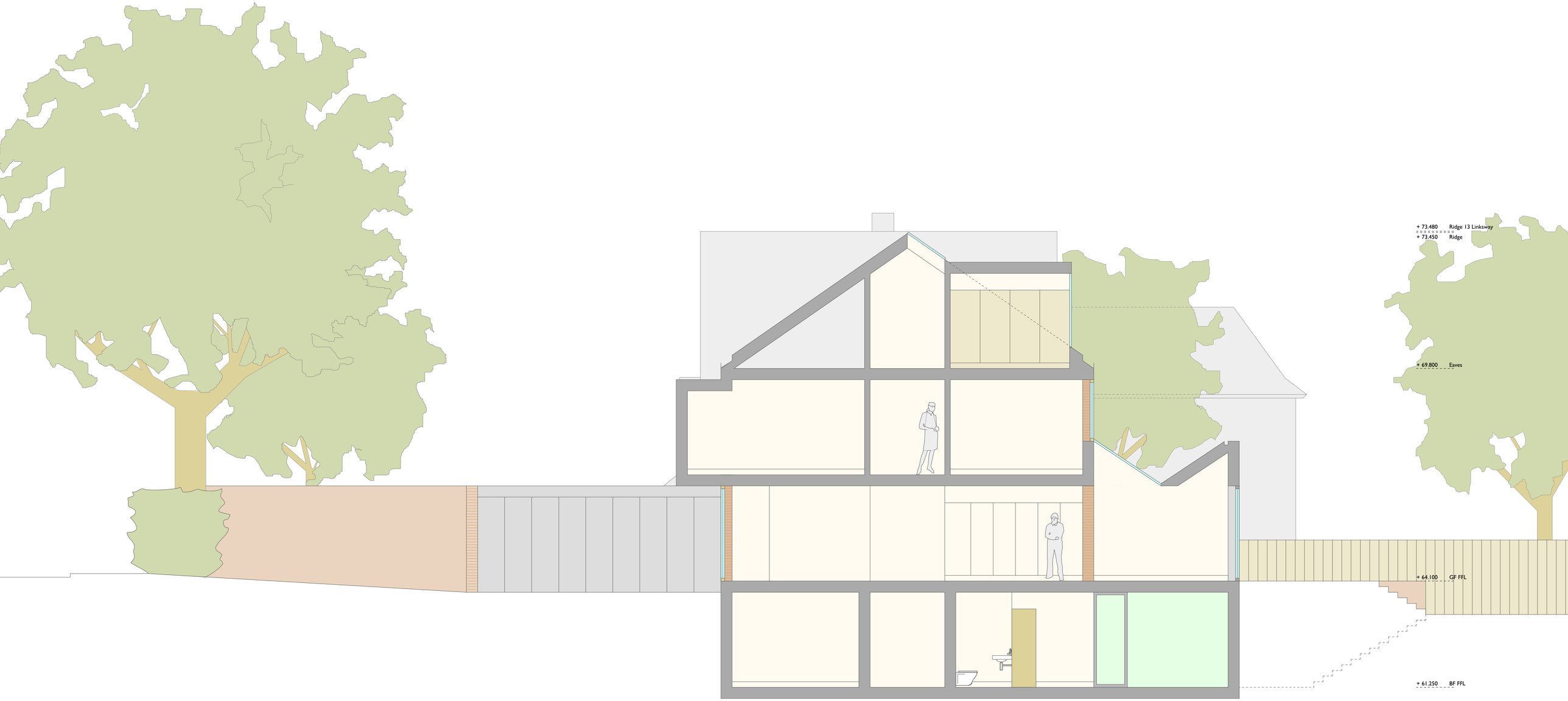

0 1000 2000 4000 6000 12000 mm

project	13A Linksway Northwood Middlesex HA6		
title	Proposed Cross Section 3		
scale	1:100 at A3	project number	A102
date	16.01.17	drawn by	PS
drawing status	Planning	checked by	PS
drawing number	PL 114	revision	-

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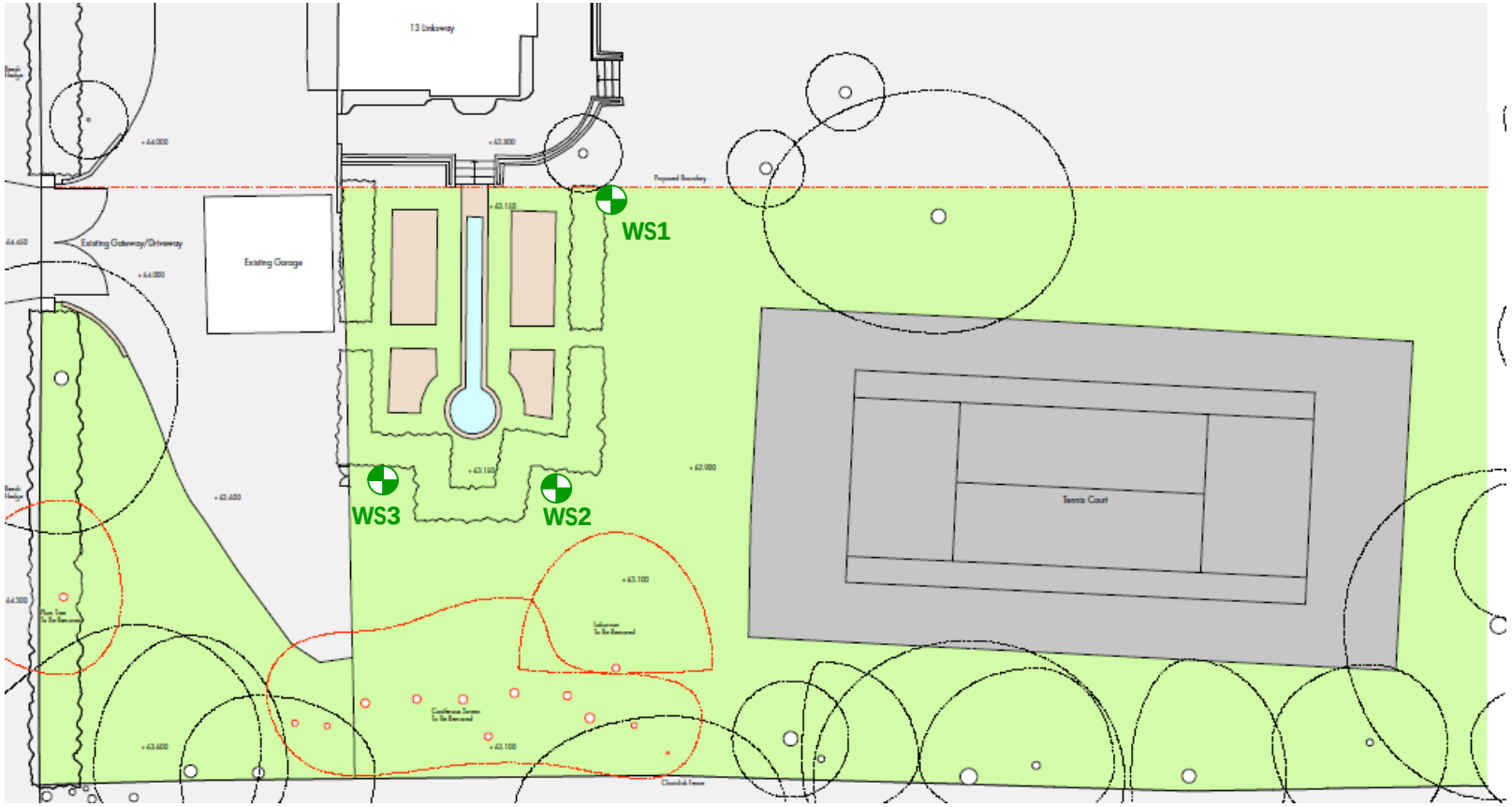
Exploratory Point Plan



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Not to scale.

All positions illustrative only.

Key: WS Window Sample Borehole

Project Title:	13a Linksway, Northwood
Client:	Mr P Goodman
BRD Reference:	BRD2144-OP3-A
Date Issued:	April 2014

BRD
01295 272244
info@brduk.com

APPENDIX 2

PROBEHOLE RECORD

Client: Philip Goodman
Project Title: 13a Linksway, Northwood
Project No: BRD2144
Logged By: E Liddle
Date Commenced: 23/04/2014
Date Completed: 23/04/2014
Method Used: Windowless Percussive Sampling Rig

Borehole No.

WS01

Sheet 1 of 2

Samples & Tests			Water	Description of Strata	Depth / (Level)	Legend	Geology	Installation /Backfill
Depth	Type & No	Value						
				TOPSOIL of dark brown / black, sandy, clay with rootlets and organic matter.	0.10		TS	
				Firm, mottled grey/ brown, sandy, gravelly, silty, CLAY with many roots and rootlets.			HEAD	
0.50	D1				0.90			
1.00	SPT	15 N		Medium dense, light brown/brown, silty, fine SAND. 1.00 : SPT 3,3/3,4,4,4	1.0			
1.50	D2							
2.00	SPT	27 N		2.00 : SPT 4,4/4,6,7,10	2.0			
				2.60 becoming red/brown from 2.6m bgl.			LAMBETH GROUP	
3.00	SPT	24 N		3.00 : SPT 4,4/5,5,7,7	3.0			
3.10	D3				3.40			
				Medium dense becoming dense, grey, silty, fine SAND.				
4.00	SPT	24 N		4.00 : SPT 5,5/6,6,6,6	4.0			
4.20	D4							

General Remarks:
WS01 was noted as dry during drilling. A soakage test was undertaken within WS01 following installation and is reported separately.

Surface Elevation Level:

All dimensions in metres
Log Scale 1:25

BRD
Telephone: 01295 272244
Fax: 01295 270098

PROBEHOLE RECORD

Client: Philip Goodman
Project Title: 13a Linksway, Northwood
Project No: BRD2144
Logged By: E Liddle
Date Commenced: 23/04/2014
Date Completed: 23/04/2014
Method Used: Windowless Percussive Sampling Rig

Borehole No.

WS01

Sheet 2 of 2

Samples & Tests			Water	Description of Strata	Depth / (Level)	Legend	Geology	Installation /Backfill
Depth	Type & No	Value						
5.00	SPT	49 N		5.00 : SPT 6,7/10,11,14,14	5.0		LAMBETH GROUP	
5.50	D5							
6.00	SPT	49 N		6.00 : SPT 9,9/10,12,13,14	6.0			
					6.45			
					7.0			
					8.0			
					9.0			

General Remarks:
WS01 was noted as dry during drilling. A soakage test was undertaken within WS01 following installation and is reported separately.

Surface Elevation Level:

All dimensions in metres
Log Scale 1:25

BRD
Telephone: 01295 272244
Fax: 01295 270098

PROBEHOLE RECORD

Client: Philip Goodman
Project Title: 13a Linksway, Northwood
Project No: BRD2144
Logged By: E Liddle
Date Commenced: 23/04/2014
Date Completed: 23/04/2014
Method Used: Windowless Percussive Sampling Rig

Borehole No.

WS02

Sheet 1 of 1

Samples & Tests			Water	Description of Strata	Depth / (Level)	Legend	Geology	Installation /Backfill
Depth	Type & No	Value						
				TOPSOIL of grey brown, sandy, gravelly, clay with rootlets and organic matter.	0.10		TS	
				Firm, mottled grey brown, sandy, silty, gravelly, CLAY with occasional rootlets.			HEAD	
				Medium dense becoming very dense, orange brown, silty, fine SAND.	0.60		LAMBETH GROUP	
1.00	SPT	22 N		1.00 : SPT 2,2/3,5,6,8	1.0			
1.50	D1							
2.00	SPT	88 N		2.00 : SPT 7,12/19,21,22,26	2.0			
				WS02 was terminated at 2.45m bgl due to the soil density reducing progress.	2.45			
					3.0			
					4.0			

General Remarks:
WS02 was terminated at 2.45m bgl due to the density of the soils limiting progress. WS02 was noted as dry during drilling.

Surface Elevation Level:

All dimensions in metres
Log Scale 1:25

BRD
Telephone: 01295 272244
Fax: 01295 270098

PROBEHOLE RECORD

Client: Philip Goodman
Project Title: 13a Linksway, Northwood
Project No: BRD2144
Logged By: E Liddle
Date Commenced: 23/04/2014
Date Completed: 23/04/2014
Method Used: Windowless Percussive Sampling Rig

Borehole No.

WS03

Sheet 1 of 1

Samples & Tests			Water	Description of Strata	Depth / (Level)	Legend	Geology	Installation /Backfill
Depth	Type & No	Value						
				TOPSOIL of dark brown, sandy, slightly gravelly, clay with rootlets.	0.10		TS	
0.50	D1			Firm, mottled, grey brown, sandy, silty, CLAY with occasional rootlets.			HEAD	
					0.70			
1.00	SPT	46 N		Dense becoming very dense, light brown cream, silty, fine SAND. 1.00 : SPT 4,7/10,12,11,13	1.0		LAMBETH GROUP	
1.50	D2							
2.00	SPT	79 N		2.00 : SPT 8,10/14,17,20,28	2.0			
					2.45			
				WS03 was terminated at 2.45m bgl due to the density of soils limiting progress.	3.0			
					4.0			

General Remarks:
WS03 was terminated at 2.45m bgl due to the density of soils limiting progress. WS03 was noted as dry during drilling. A soakage test was carried out within WS03 following installation and is detailed separately.

Surface Elevation Level:

All dimensions in metres
Log Scale 1:25

BRD
Telephone: 01295 272244
Fax: 01295 270098

SOAKAGE TEST RECORD

SOIL INFILTRATION RATE

(BRE Digest 365 : Soakaway Test - within borehole)

Client:	Mr P Goodman
Project Title	13a Linksway, Northwood
Project No.	BRD2144

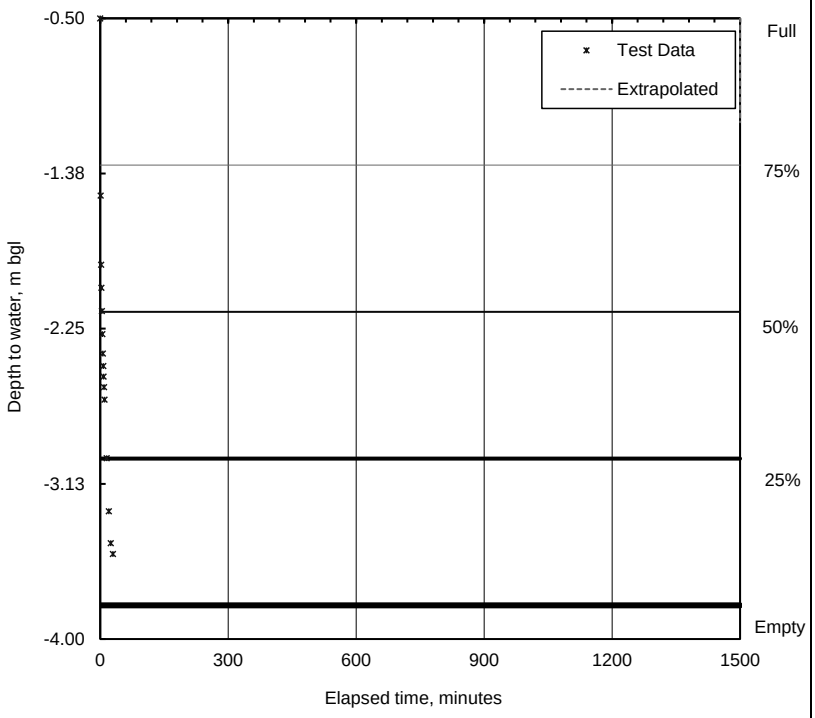
Test Details

Borehole Number	WS01	
Test Number	1	
Borehole Test Depth	3.81	**m**
Borehole diameter	0.06	**m**
Borehole area	0.0024	**m^2**
Depth to groundwater prior to test	below base of pit	**m**
Date of Test	23/04/2014	
Logged by	EL	
Description of Soil under Test	Medium dense to dense, silty, fine SAND.	

Test Record

Elapsed Time min	Depth to Water m
0	0.50
1	1.50
2	1.89
3	2.02
4	2.15
5	2.28
6	2.39
7	2.46
8	2.52
9	2.58
10	2.65
15	2.98
20	3.28
25	3.46
30	3.52

Plot of water level against elapsed time



Summary of Calculations and Result

Soil infiltration rate, *f*, is calculated from the time taken for the water to fall from 75% to 25% effective storage depth in the pit.

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

where, T75 (0.8 mins) is the time for the water level to fall to 75% effective depth (1.33m bgl)

and T25 (15 mins) is the time for the water level to fall to 25% effective depth (2.98m bgl)

thus, T75-T25 is the time for the water level to fall from 75% to 25% effective depth:

T75-T25 = 14 mins

V75-V25 is the effective storage volume in the trial pit between 75% and 25% effective depth:

V75-V25 = 0.0039 m^3

and A50 is the internal surface area of the trial pit up to 50% effective depth and including the base area:

A50 = 0.2883 m^2

Soil Infiltration Rate *f* = 1.60×10^{-5} m/s

Comments

SOAKAGE TEST RECORD

SOIL INFILTRATION RATE

(BRE Digest 365 : Soakaway Test - within borehole)

Client:	Mr P Goodman
Project Title	13a Linksway, Northwood
Project No.	BRD2144

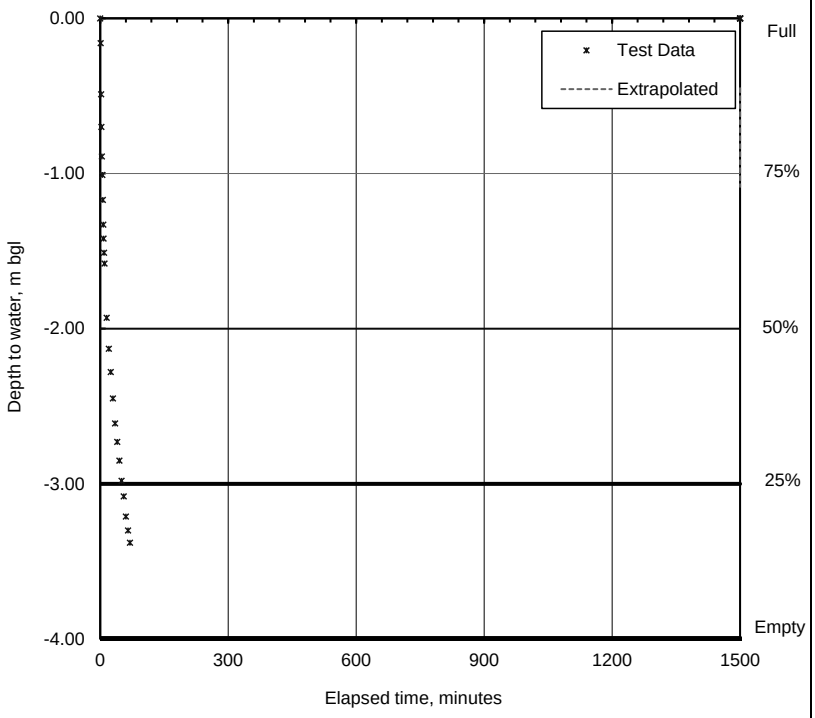
Test Details

Borehole Number	WS01	
Test Number	2	
Borehole Test Depth	4.00	**m**
Borehole diameter	0.06	**m**
Borehole area	0.0024	**m^2**
Depth to groundwater prior to test	below base of pit	**m**
Date of Test	23.4.14	
Logged by	EL	
Description of Soil under Test	Medium dense to dense, silty, fine SAND.	

Test Record

Elapsed Time min	Depth to Water m
0	0.00
1	0.16
2	0.49
3	0.70
4	0.89
5	1.01
6	1.17
7	1.33
8	1.42
9	1.51
10	1.58
15	1.93
20	2.13
25	2.28
30	2.45
35	2.61
40	2.73
45	2.85
50	2.98
55	3.08
60	3.21
65	3.30
70	3.38

Plot of water level against elapsed time



Summary of Calculations and Result

Soil infiltration rate, *f*, is calculated from the time taken for the water to fall from 75% to 25% effective storage depth in the pit.

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

where, T75 (4.9 mins) is the time for the water level to fall to 75% effective depth (1.00m bgl)

and T25 (51 mins) is the time for the water level to fall to 25% effective depth (3.00m bgl)

thus, T75-T25 is the time for the water level to fall from 75% to 25% effective depth:

T75-T25 = 46 mins

V75-V25 is the effective storage volume in the trial pit between 75% and 25% effective depth:

V75-V25 = 0.0048 m^3

and A50 is the internal surface area of the trial pit up to 50% effective depth and including the base area:

A50 = 0.3480 m^2

Soil Infiltration Rate *f* = 4.94×10^{-6} m/s

Comments

SOAKAGE TEST RECORD

SOIL INFILTRATION RATE

(BRE Digest 365 : Soakaway Test - within borehole)

Client:	Mr P Goodman
Project Title	13a Linksway, Northwood
Project No.	BRD2144

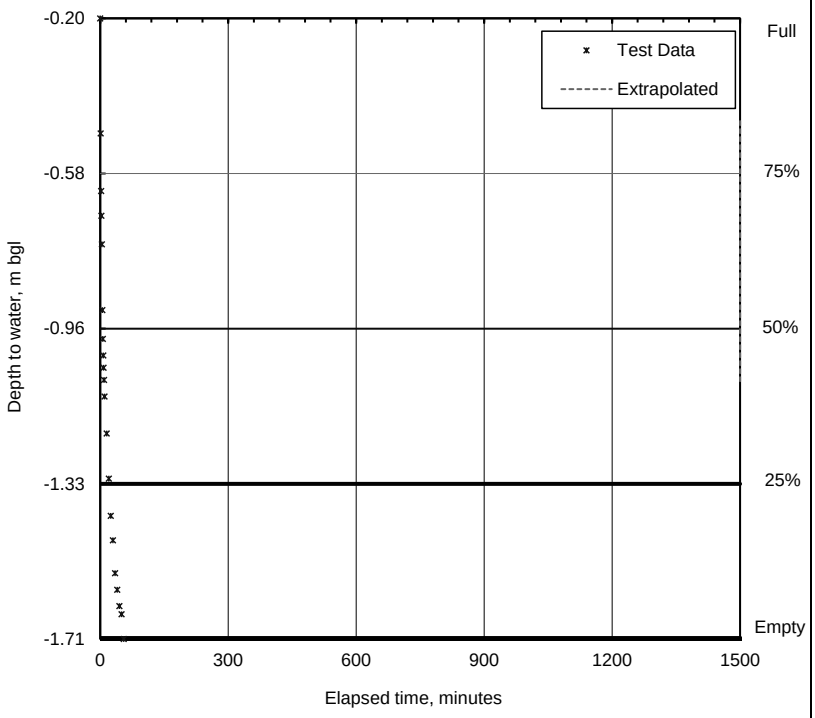
Test Details

Borehole Number	WS03	
Test Number	1	
Borehole Test Depth	1.71	**m**
Borehole diameter	0.06	**m**
Borehole area	0.0024	**m^2**
Depth to groundwater prior to test	below base of pit	**m**
Date of Test	23/04/2014	
Logged by	EL	
Description of Soil under Test	Dense, light brown cream, silty, fine SAND.	

Test Record

Elapsed Time min	Depth to Water m
0	0.20
1	0.48
2	0.62
3	0.68
4	0.75
5	0.91
6	0.98
7	1.02
8	1.05
9	1.08
10	1.12
15	1.21
20	1.32
25	1.41
30	1.47
35	1.55
40	1.59
45	1.63
50	1.65
55	1.71

Plot of water level against elapsed time



Summary of Calculations and Result

Soil infiltration rate, *f*, is calculated from the time taken for the water to fall from 75% to 25% effective storage depth in the pit.

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

where, T75 (1.7 mins) is the time for the water level to fall to 75% effective depth (0.58m bgl)

and T25 (21 mins) is the time for the water level to fall to 25% effective depth (1.33m bgl)

thus, T75-T25 is the time for the water level to fall from 75% to 25% effective depth:

T75-T25 = 19 mins

V75-V25 is the effective storage volume in the trial pit between 75% and 25% effective depth:

V75-V25 = 0.0018 m^3

and A50 is the internal surface area of the trial pit up to 50% effective depth and including the base area:

A50 = 0.1328 m^2

Soil Infiltration Rate *f* = 1.18×10^{-5} m/s

Comments

Groundwater Monitoring Record

Project: Linksway, Northwood
Client: Mr P Goodman
Project No: BRD2144

Borehole name	Date	Monitored by (initials)	Borehole depth (m)	Qty free product detected (mm)	Groundwater level below ground surface (m)	Groundwater level below top of standpipe (m)	Amount purged (l)	Post purge groundwater level below top of standpipe (m)	Comments
WS01	29/04/2014	EL	3.61	-	DRY	DRY	-	-	
WS03	29/04/2014	EL	1.93	-	DRY	DRY	-	-	

Groundwater Monitoring Record

Project: Linksway, Northwood
Client: Mr P Goodman
Project No: BRD2144

Borehole name	Date	Monitored by (initials)	Borehole depth (m)	Qty free product detected (mm)	Groundwater level below ground surface (m)	Groundwater level below top of standpipe (m)	Amount purged (l)	Post purge groundwater level below top of standpipe (m)	Comments
WS01	15/04/2020	CB	3.61	-	DRY	DRY	-	-	
WS03	15/04/2020	CB	1.85	-	DRY	DRY	-	-	