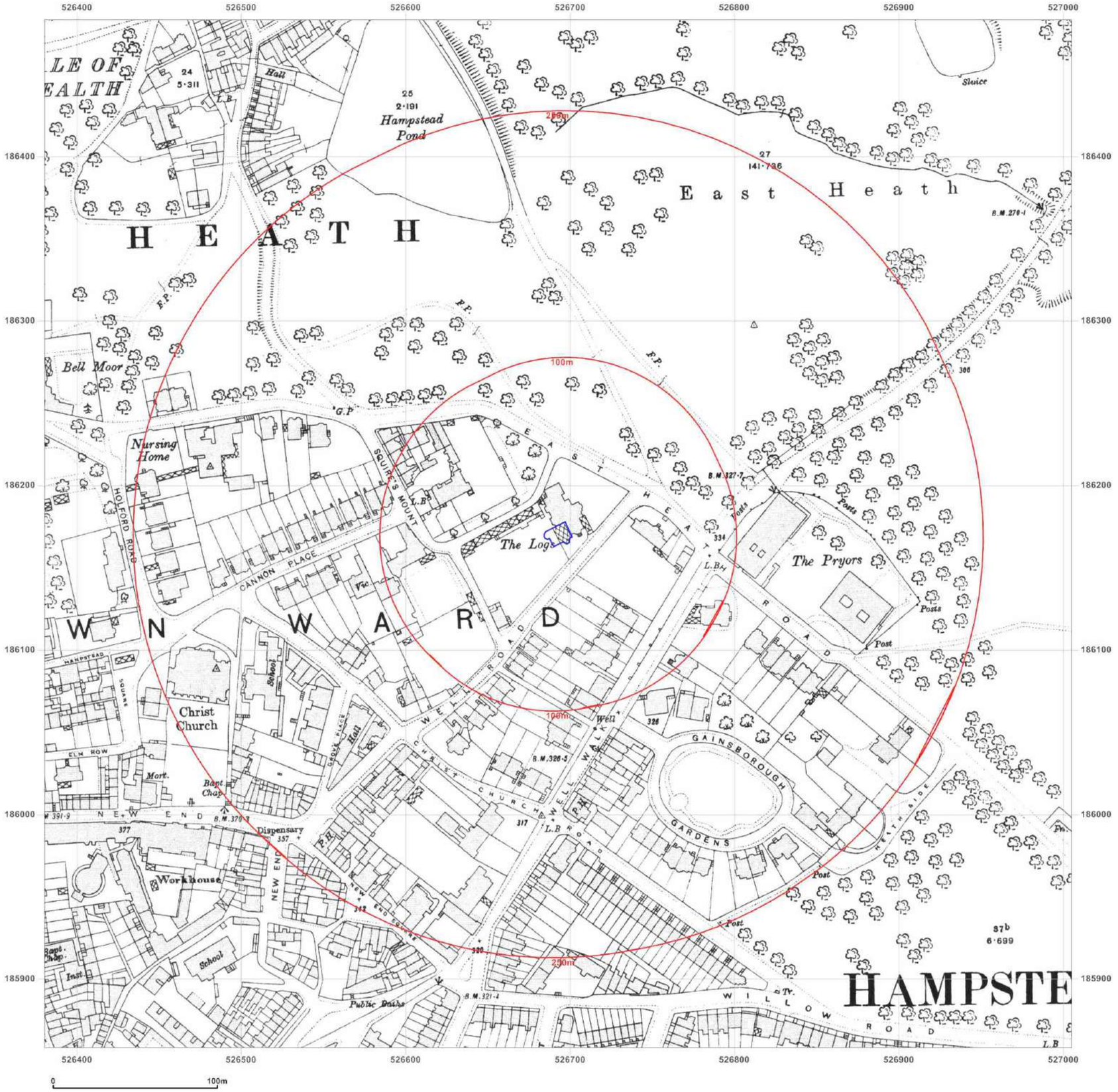

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Site Details:

20, WELL ROAD, LONDON, NW3 1LH

Client Ref: GWPR2241
Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: County Series

Map date: **1915**

Scale: 1:2,500

Printed at: 1:2,500

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Grid Ref: 526693, 186170

Map Name: National Grid

Map date: **1953**

Scale: 1:1,250

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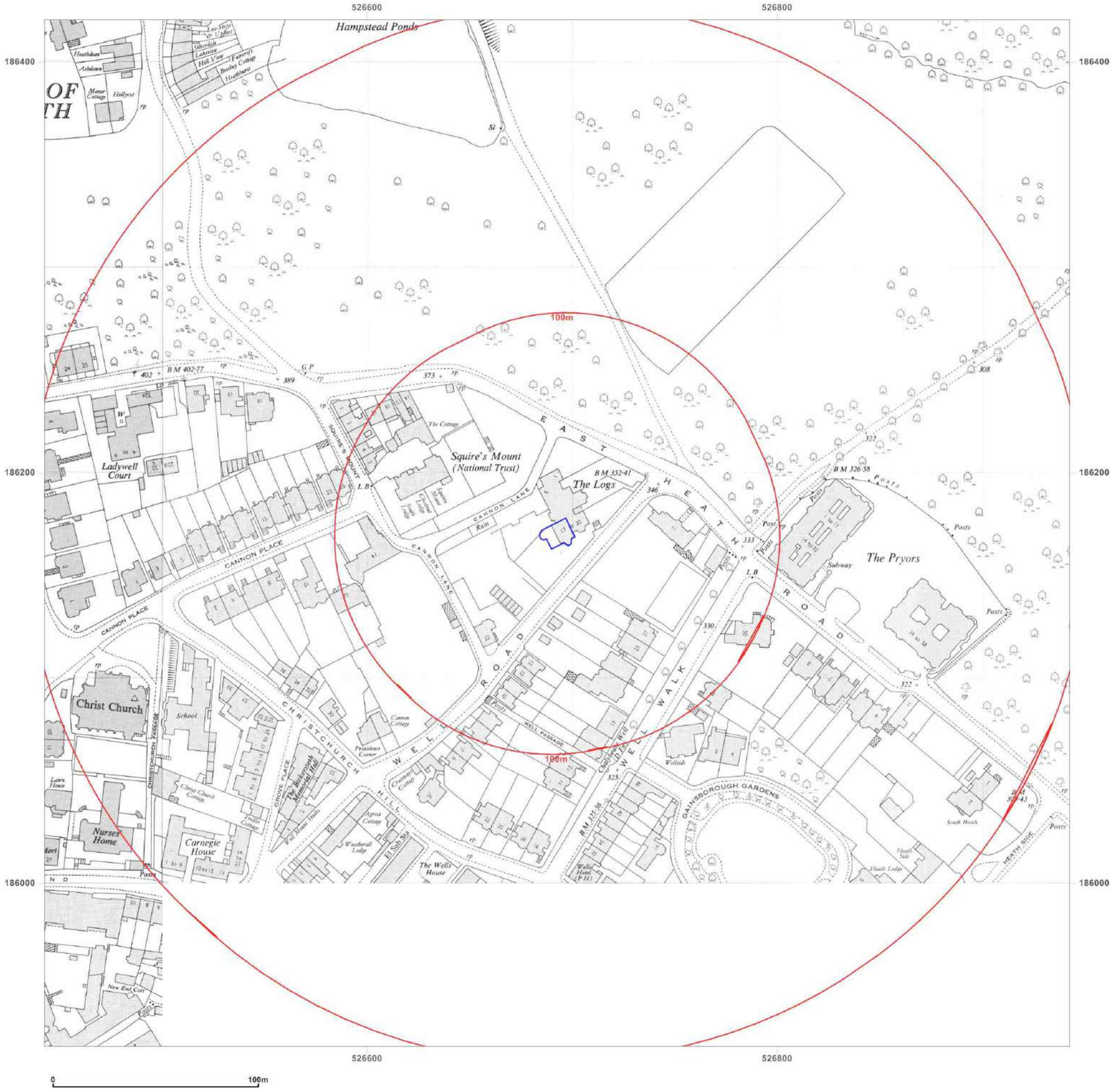

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Client Ref: GWPR2241
Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: National Grid

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Scale: 1:1,250

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Map Name: National Grid

Map date: **1952-1953**

Scale: 1:2,500

Printed at: 1:2,500

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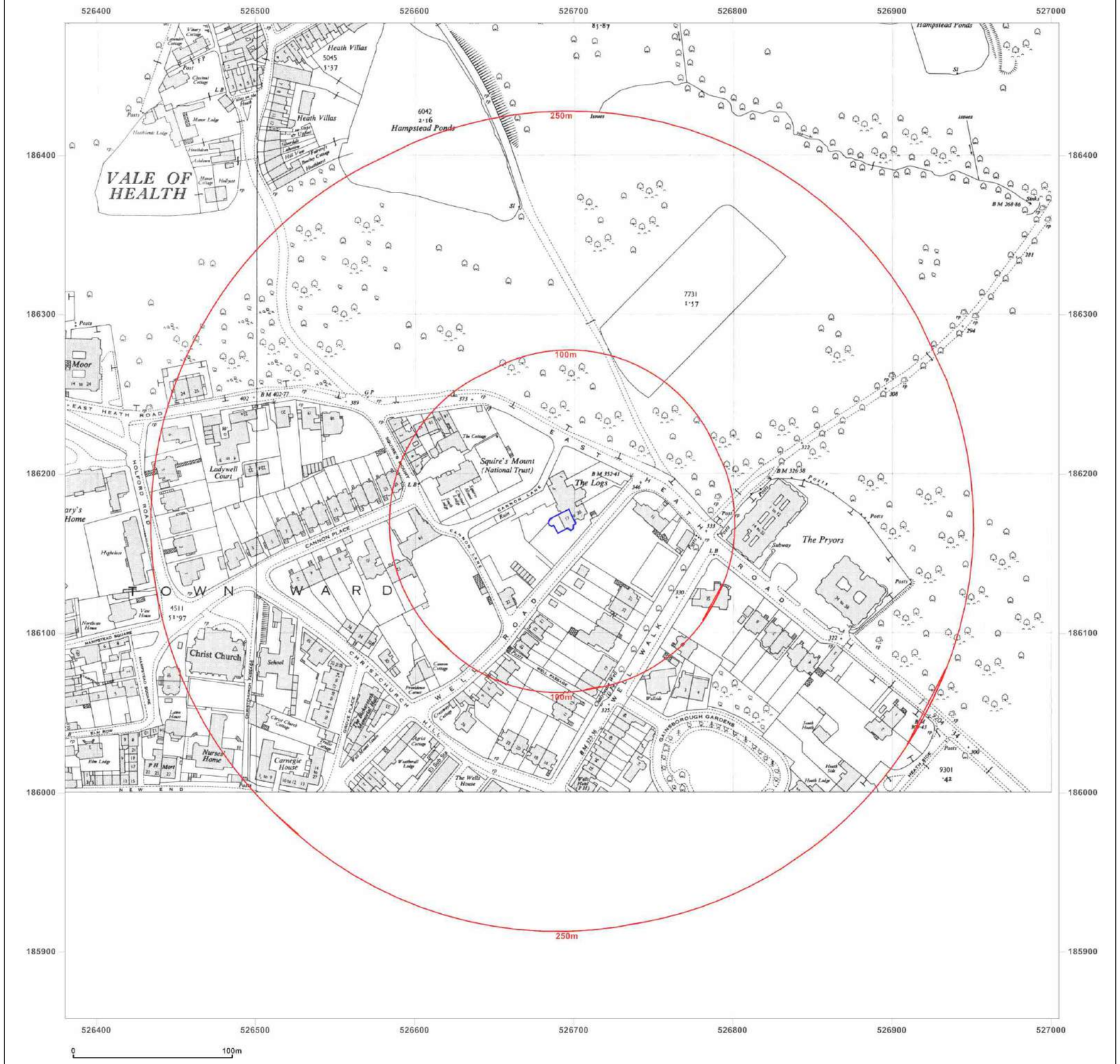

Groundsure INSIGHTS

Site Details:

20, WELL ROAD, LONDON,
NW3 1LH

Client Ref: GWPR2241
Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: National Grid

Map date: **1953**

Scale: 1:2,500

Printed at: 1:2,500

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Grid Ref: 526693, 186170

Map Name: National Grid

Map date: **1954**

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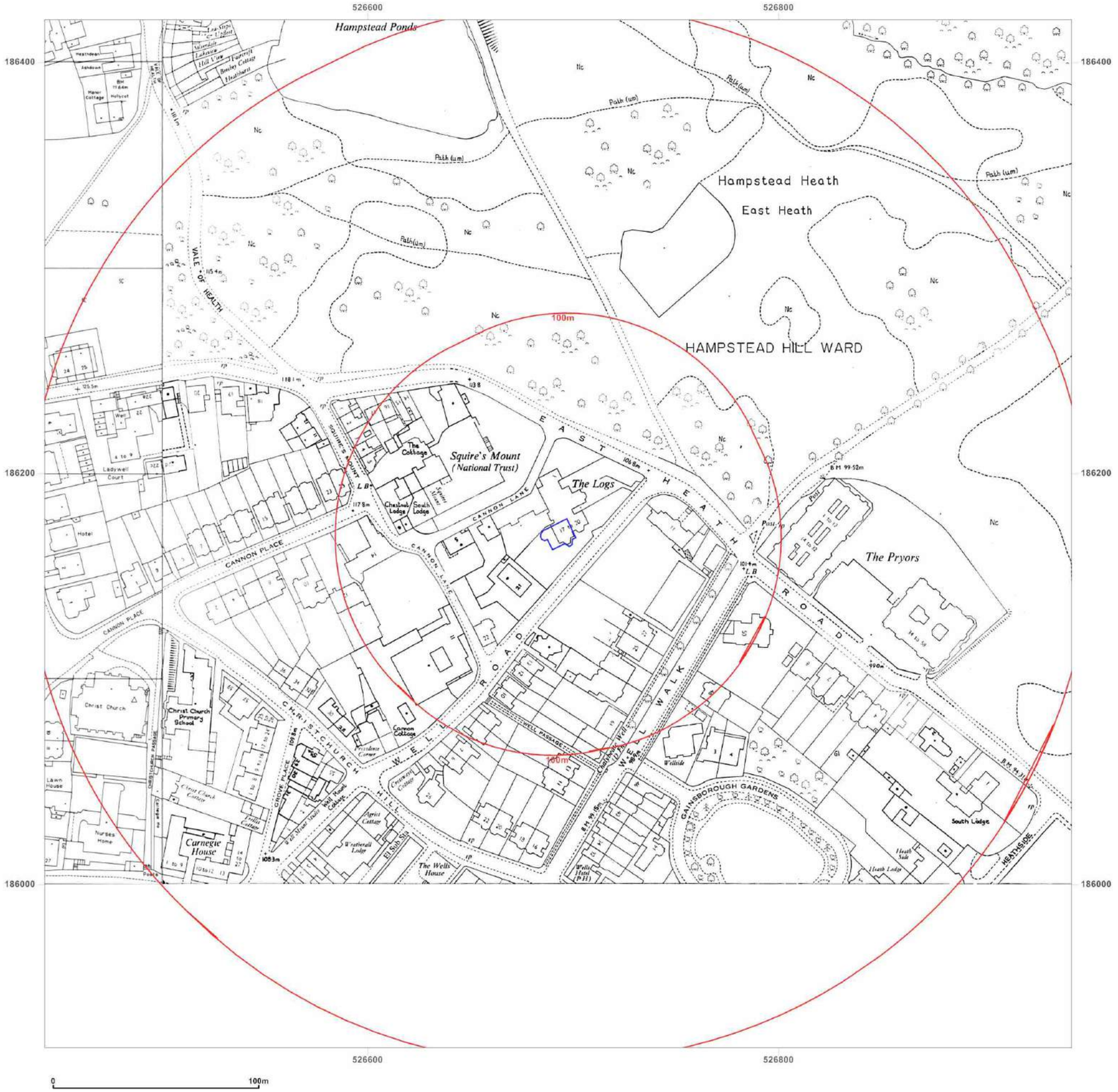

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Site Details:

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NW3 1LH

Client Ref: GWPR2241
Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: National Grid

Map date: **1987-1991**

Scale: 1:1,250

Printed at: 1:2,000

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Surveyed 1991	Surveyed 1975
Revised 1991	Revised 1987
Edition N/A	Edition N/A
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Report Ref: HMD-445-4363862
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Map Name: National Grid

Map date: **1986-1991**

Scale: 1:1,250

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Surveyed N/A Revised N/A Edition N/A Copyright 1991 Levelled N/A	Surveyed 1975 Revised 1986 Edition N/A Copyright 1986 Levelled 1975
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Client Ref: GWPR2241
Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: National Grid

Map date: **1991**

Scale: 1:1,250

Printed at: 1:2,000

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Surveyed 1991 Revised 1991 Edition N/A Copyright 1991 Levelled N/A	Surveyed 1991 Revised 1991 Edition N/A Copyright 1991 Levelled N/A

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Report Ref: HMD-445-4363862
Grid Ref: 526693, 186170

Map Name: National Grid

Map date: **1991**

Scale: 1:1,250

Printed at: 1:2,000

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Surveyed 1991
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Edition N/A
Copyright 1991
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Surveyed 1991
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APPENDIX C
Tree Survey Report

MARTIN DOBSON ASSOCIATES
ARBORICULTURAL CONSULTANCY

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TREE SURVEY, ARBORICULTURAL IMPACT ASSESSMENT AND TREE PROTECTION PLAN

A report to accompany a planning application for the construction of a basement extension beneath 20 Well Road, London, NW3 1LH and associated lightwells

Report by

Dr Martin Dobson
BSc (Hons) Biol, DPhil, FArborA, MEWI
Registered Consultant of the Arboricultural Association

On the instructions of Geoffrey Prentice, 5D Architects

16th September 2017

MDA reference H23

Contents

1. Introduction

1.1 Martin Dobson Associates Ltd were instructed by Geoffrey Prentice, 5D Architects in March 2017 to carry out a survey of trees on or immediately adjacent to land at 20 Well Road, London, NW3 1LH. The purpose of the survey was to provide information with which to discharge arboricultural conditions relating to planning consent 2014/2114/P dated 18th July 2014. I received further instructions on 6th September 2017 to provide a report in support of a planning application for the construction of a basement extension under the footprint of the building

1.2 The British Standard 5837: 2012 *Trees in relation to design, demolition and construction – Recommendations* provides a framework for considering trees in the planning process. It gives guidance on categorising the qualities of trees in order to enable decisions to be made as to which trees are appropriate for retention within a development. It then advises on options for protecting trees to be retained during the development (at all stages including demolition, construction and hard landscaping), and the means of incorporating trees into the developed landscape.

1.3 The property is within the Hampstead Conservation Area and this means that all trees with a trunk diameter of 75 mm or more benefit from statutory protection and no work can be carried out to them (including cutting roots or branches or felling) without statutory notification to the local planning authority. However, the granting of planning permission allows trees to be removed if they are shown as being removed on approved plans.

1.4 Seventeen trees were surveyed and all of them are unremarkable and have been classified as category C (low value and quality). In general category C trees should not be considered a material constraint to development.

1.5 The approved Condition 7 of planning consent 2014/2114/P allow for the removal of blackthorn T2 as it is too close to the approved ground floor extension. The current proposals do not require the removal of any other trees.

1.6 The retained trees will be protected during development. Details of tree protection are contained in this report.

2. Tree survey

2.1 The tree survey was carried out by Martin Dobson on 13th March 2017.

2.2 Appended at **MD1** is the tree survey schedule which provides details of the seventeen trees present within or immediately adjacent to the property.

2.3 The site survey drawing appended at **MD2** shows the positions of the surveyed trees and gives a reasonable indication of their comparative branch spreads. The drawing has been colour coded as follows:

A trees (high quality and value, minimum 40 years useful life)	LIGHT GREEN
B trees (moderate quality and value, minimum 20 years useful life)	MID BLUE
C trees (low quality and value, minimum 10 years useful life)	GREY
U trees (unsuitable or dead/dying/dangerous, less than10 years useful life)	RED

2.4 It should be understood that no individual safety inspection has been carried out on any tree. Similarly, any suggestions for tree work should not be taken as a specification for tree works.

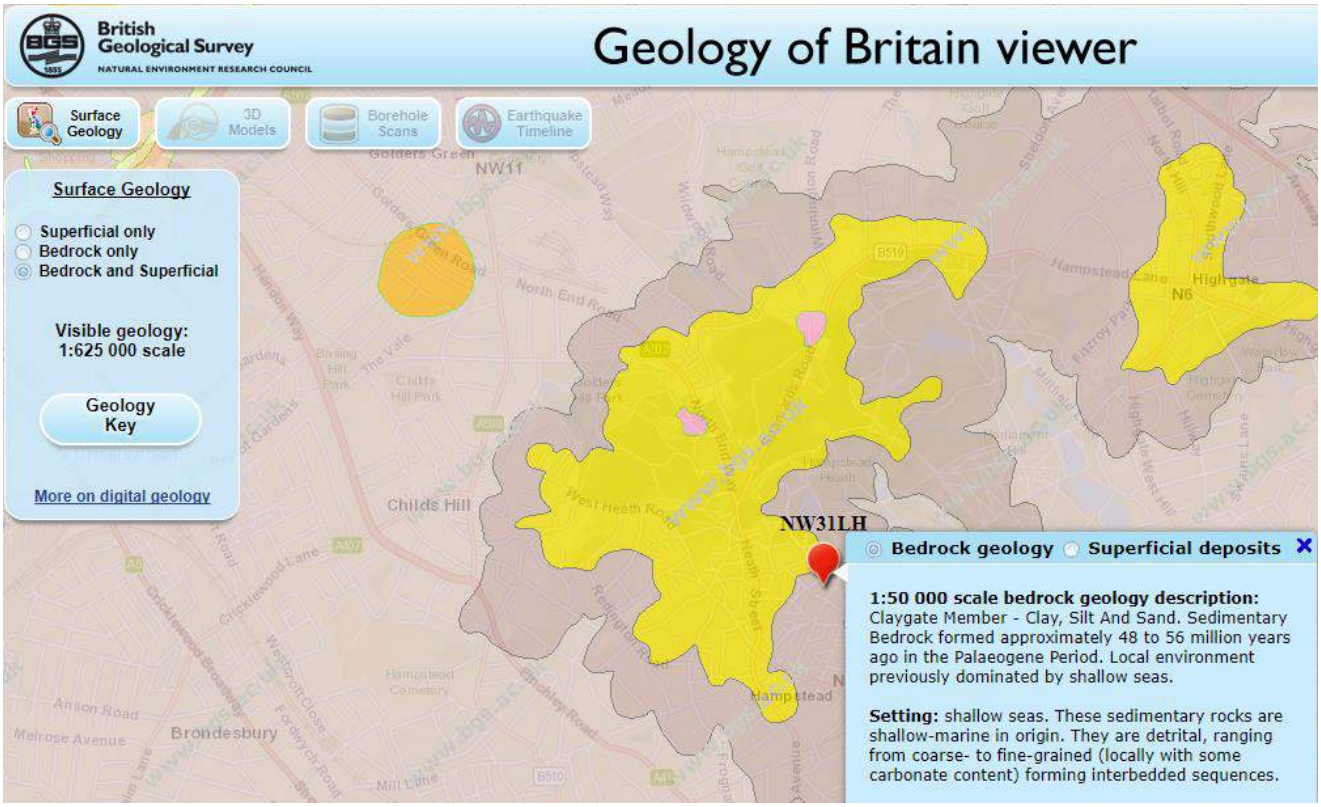
2.5 Adequate protection, both above and below ground, is essential for trees that are to be retained as part of a development. The British Standard BS5837: 2012 *Trees in relation to design, demolition and construction - Recommendations* advises that there should be a root protection area (RPA) around trees which is kept free of construction activities by means of an exclusion zone enforced by protective fencing and/or ground protection. The RPA is calculated as the area equivalent to a circle with a radius of 12 times the trunk diameter at a height of 1.5 m above ground level. Based on the tree survey data root protection areas (and radial distances from the trunk to be protected) have been calculated and these are shown as circles around the trees on the tree constraints plan at **MD2** and are tabulated at **MD3**.

3. Soil assessment

3.1 BS5837: 2012 advises that soil properties should be considered as part of a tree survey report. This is necessary because trees can cause damage to structures founded on soils that shrink and swell with changes in moisture content (principally clays). Such movement is exacerbated by the influence of trees and therefore if a shrinkable soil is suspected foundations should be deigned to extend below the likely zone of seasonal moisture change.

3.2 The British Geological Survey 1: 50,000 scale map indicates that the underlying geology of the site is shrinkable Claygate Member – Clay, Silt and Sand (Figure 1). Thus, foundations will need to be more than 1 m deep to take account of trees. Foundations must be designed with reference to the National House Building Council's Standards Chapter 4.2 *Building near trees*.

Figure 1. British Geological Survey 1: 50,000 scale plan showing that the site is underlain by the Claygate Member – Clay, Silt and Sand



4. Arboricultural impact assessment

4.1 The purpose of an arboricultural impact assessment (AIA) is to evaluate the direct and indirect effects of proposed development on trees and, where necessary, to consider appropriate mitigation. It should set out which, if any, trees are to be removed to facilitate the development and should consider the possible effects on retained trees of potentially damaging activities on the site (for example changes in ground level and installation of below ground services). Requirements for access around trees should be considered and potential conflicts identified, for example, where branches overhang the development area and may require pruning.

4.2 Mitigation for any issues identified should be proposed and addressed in the arboricultural method statement (AMS).

Tree removals

4.3 The proposed development includes the removal of one category C blackthorn (T2). Permission has already been obtained for the removal of this tree. No other trees need to be removed.

Tree pruning

4.4 Depending on the technique adopted for construction of the retaining walls of the lightwell adjacent to magnolia T16 it is possible that some branch reduction may be required. It is likely that this would involve removal of the two lowest branches growing towards the house – neither branch is particularly large and therefore the tree will be relatively unaffected (Figure 2).

Figure 2. Magnolia T16 which may need branches growing towards the proposed lightwell to be removed/shortened.

Tree protection

4.5 Trees to be retained and will be protected from mechanical damage to their trunk, branches and roots by the installation of 2 m high protective fencing to create a construction exclusion zone (CEZ) to exclude site workers, machinery and storage of materials. There is sufficient space outside the CEZ for all construction activities to take place without creating pressure on tree protection.

4.6 The existing path next to cypress T15 will be retained throughout the works provide access for pedestrian traffic. Fencing has been stepped back away from the footpath but will still protected the trunk and branches. The footpath will form ground protection to avoid root damage.

4.7 Trees T1 and T3 are in the rear garden of the neighbouring property, No. 18. It may be possible to demolish the existing structure and build the new one without encroaching on the neighbouring property, but this seems unlikely and therefore a Party Wall Award will most likely be necessary. On the assumption that some work will need to take place within the garden of No. 18 it is proposed that fencing will be erected and ground protection installed on the neighbouring land to protected T1 and T3.

4.8 It is considered that the foundations of the existing conservatory and boundary wall will be located at least 600 mm below ground level – the conservatory foundations are likely to be significantly deeper. Since most woody structural roots are located in the upper 600 mm of soil this means that the boundary walls and their foundations will act as a root barrier and there will be little or no root growth onto the land at 20 Well Road. Nonetheless, care will need to be taken when removing the existing foundations and installing new ones to avoid damaging roots that may be growing against them.

5. Arboricultural method statement and tree protection plan

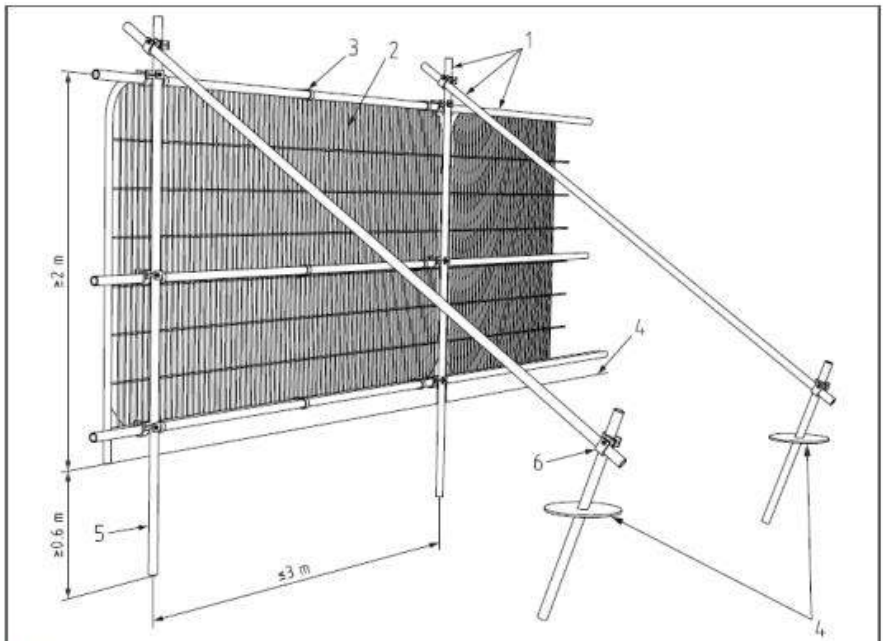
5.1 Trees can very easily be damaged during construction activities through their branches being broken by construction traffic passing close to the canopy or by root severance during the digging of foundation or service trenches. The majority of roots are to be found in the upper 600 mm of soil and so even relatively shallow trenches can sever a significant number of roots growing across the direction of the trench. Similarly, the diameter of tree roots tapers sharply within a few metres of the trunk of a tree, so that what might seem to an uninitiated site worker to be an insignificant root (perhaps only a few centimetres in diameter) may actually be highly important.

5.2 Tree roots can also be damaged indirectly, often inadvertently, through soil compaction, which disrupts soil structure and can lead to root death through the development of anaerobic soil conditions. Spillage of toxic materials (e.g. oil or diesel) can also result in root damage and ultimately the death of a tree. Protection of the soil around trees by means of a construction exclusion zone (CEZ) is therefore vitally important in order to preserve roots undamaged.

Fencing and ground protection

5.3 Tree protection will comprise of 2 m tall fencing installed in the positions shown at **MD4** before the building is stripped out or materials are delivered to site or construction commences. The fencing will consist of a scaffold framework, well braced to resist impacts, with vertical tubes spaced at a maximum interval of 3 m (Figure3). Onto this, weld mesh panels or 2 m high shuttering board will be securely fixed with wire or scaffold clamps. Un-braced weld mesh panels on unsecured rubber or concrete feet will not be used as these are not resistant to impact and are too easily removed by site operatives. An alternative system of bracing which does not require a scaffold framework is shown in Figure 4.

Figure 3. Diagram to illustrate design of protective fencing with scaffolding anchored into the ground



Key
1 Standard scaffold poles
2 Heavy gauge 2 m tall galvanized tube and welded mesh infill panels
3 Panels secured to uprights and cross-members with wire ties
4 Ground level
5 Uprights driven into the ground until secure (minimum depth 0.6 m)
6 Standard scaffold clamps

Figure 4. Diagram to illustrate alternative design of protective fencing

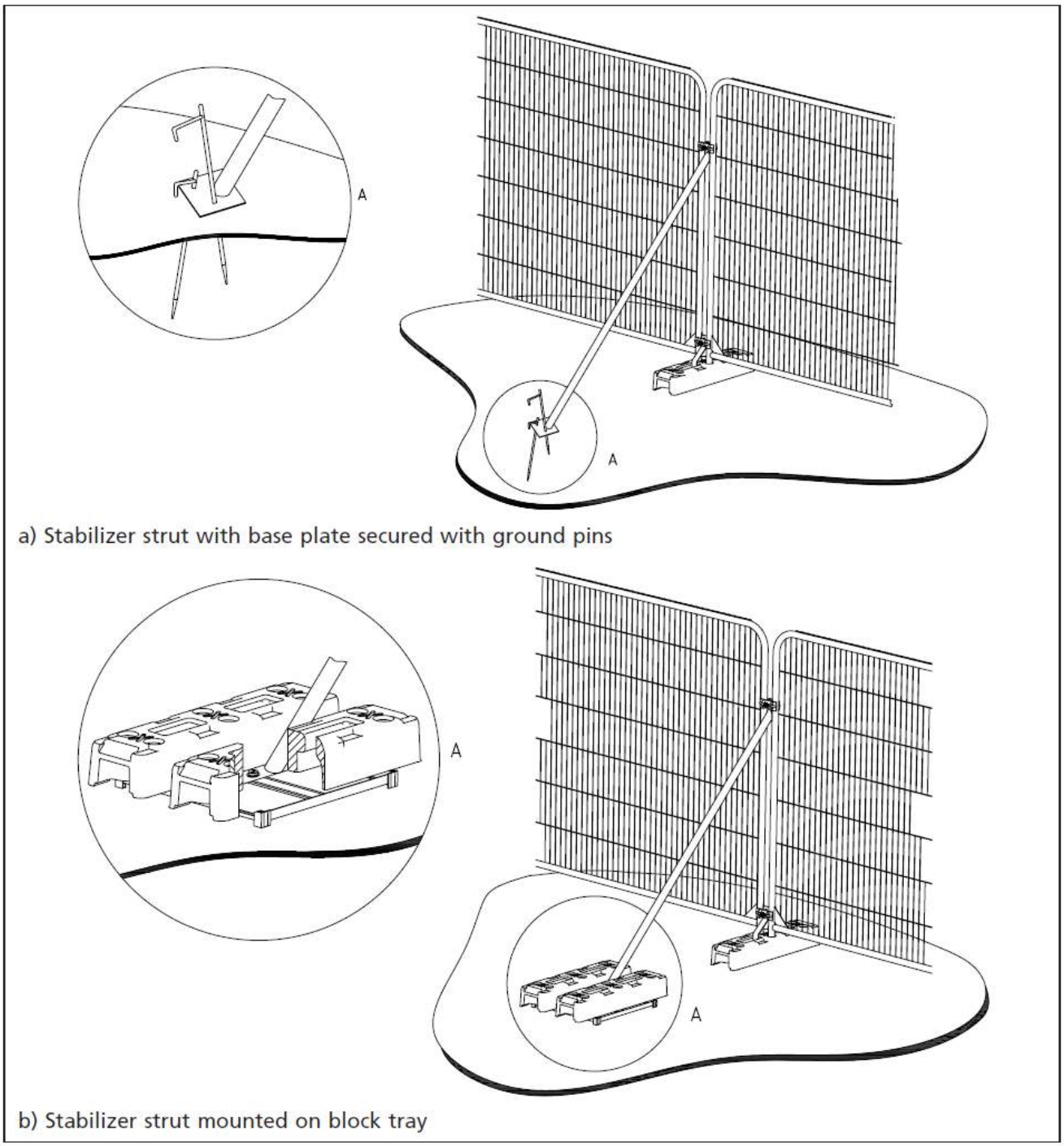


Figure 5. Photograph to illustrate installed protective fencing

5.4 High visibility all weather notices at a size no less than A3 will be securely attached to each panel of the barrier around the CEZ with wording as shown in Figure 6.

Figure 6. Wording to be included in high visibility all-weather sign attached to protective fencing

Arboricultural supervision

5.5 It is recommended that a project arboricultural consultant is appointed to oversee tree protection for the duration of the construction/landscaping contract(s). Alternatively, a designated person (site foreman or site owner) should take on the responsibility of overseeing tree protection. If appointed, the project arboriculturists will be consulted on any issues that may arise concerning trees and will visit the site as often as necessary to ensure that trees are protected and/or at the following key stages:

- Prior to contractors commencing works on site in order to meet with the supervising architect and/or the contractor's nominated site manager to ensure that the principles of tree protection are understood and the procedure, timescale and materials for installation of tree protection are agreed;

- Following installation of tree protection but prior to any works commencing on site to confirm that it is fit for purpose;

- At monthly intervals and at any time that there are potential conflicts with tree protection;

- At the completion of construction works to confirm that tree protection may be removed to enable final landscaping;

5.6 A pre-start meeting should be held on site with the project arboriculturist and the contractor's representative(s) so that the precise details of the schedule of works together with details of installation of tree protection can be agreed and personnel induction carried out. The site manager/foreman will be fully briefed on tree protection measures and procedures before any workers or sub-contractors are permitted onto the site. Following induction, a copy of the Induction Sheet (**MD5**) will be provided to and be signed by the site manager/foreman in recognition of acceptance of their role in enforcing day to day tree protection.

5.7 All contractors involved in the project have a duty to comply with all the specified tree protection measures and all workers will be provided with induction by the site manager/foreman and be required to sign an Induction Sheet confirming they have understood the protection measures. Signed sheets will be kept on site for inspection.

5.8 No enabling works will take place until after the meeting has been held and tree protection has been installed, inspected and approved as fit for purpose.

5.9 Fencing and ground protection will not be removed under any circumstances during construction unless with the express approval of the local authority. If in any doubt the site manager must contact the nominated arboricultural consultant.

Burning of waste

5.10 No fires will be lit on site within 3 m of root protection areas, including the area of the no-dig driveway, due to the danger of scorching of leaves and branches of overhanging trees.

Space for machinery, parking of vehicles, storage of materials and site huts

5.11 All machinery required on site will operate outside of root protection areas. Site accommodation, if required, will be located outside root protection areas.

5.12 Delivery vehicles will park in the road and storage of materials will be outside root protection areas.

Services

5.13 The proposed layout of incoming (water, gas and electricity) and outgoing (foul sewer) services is not yet established but they should be installed outside root protection areas. If it is necessary for a trench to be dug through an RPA a specific method statement will be required which will need to specify that the trench will be hand dug and that care will be taken to preserve all roots encountered which are larger than 25 mm diameter.

Tree works

5.14 Tree removals will be undertaken as preliminary works. This will be carried out by suitably qualified arboriculturists to the standards set out in BS3998: 2010 *Tree works – recommendations*.

Landscaping

5.15 Once construction has demonstrably finished (to the satisfaction of the project arboriculturist) fencing may be removed in order to allow final landscaping to be undertaken. Landscaping plans will be prepared by others and will not involve any changes in soil levels, digging of any trenches or construction of masonry or retaining walls within root protection areas.

6. Conclusions

6.1 A BS5837: 2012 survey of seventeen trees has been carried out at 20 Well Road, London, NW3 1LH. All of the surveyed trees are considered to be category C and are of low value.

6.2 The proposed development does not require the removal of any trees (T2 is permitted to be removed as a result of an earlier application).

6.3 The trees to be retained will be protected during development and methods for ensuring their protection have been described.

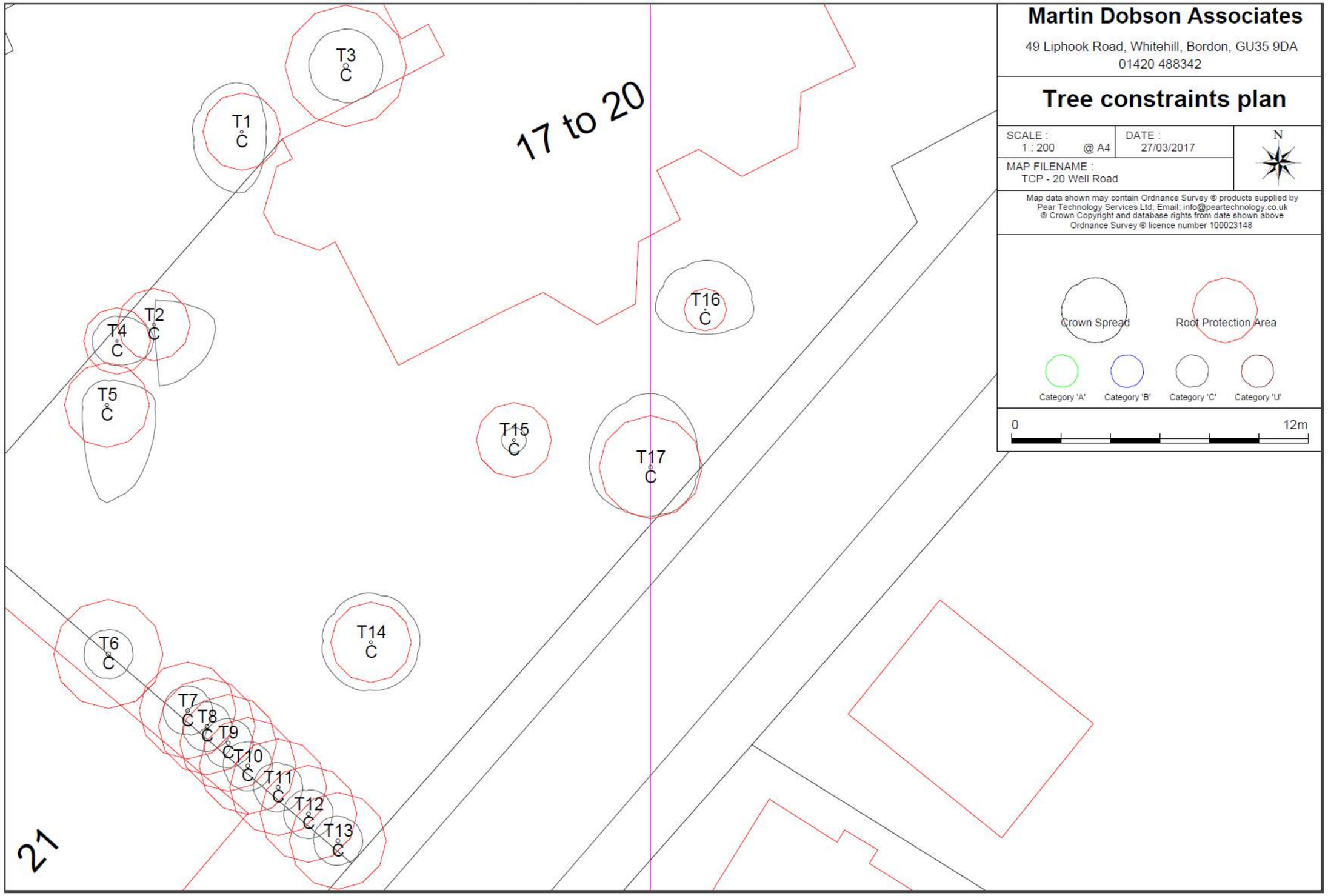
6.4 It is considered that the proposed development will pose no threat to trees to be retained and is sympathetic to the character of the Conservation Area.

APPENDIX MD1
Tree survey schedule (BS5837: 2012)

Tree No.	Species	Height (m)	Trunk diameter (mm)	N (m)	E (m)	S (m)	W (m)	Age class	Physiological condition	Structural condition	Useful Life (y)	BS5867 Category	Comments
T1	Maple	5	100	2	1	2.5	2	Young	Good	Good	10 – 20	C	
T2	Blackthorn	5	120	1	2.5	2.5	0	Semi-mature	Good	Good	10 – 20	C	Leaning to SE
T3	Magnolia	6	200	1.5	1.5	1.5	1.5	Young	Good	Good	10 – 20	C	
T4	Blackthorn	5	110	1	1.5	1	1	Semi-mature	Good	Good	10 – 20	C	
T5	Prunus	5	140	1	2	4	1	Semi-mature	Good	Fair	10 – 20	C	Leaning to south
T6	Leyland Cypress	6	180	1	1	1	1	Young	Good	Good	10 – 20	C	
T7-T13	Leyland Cypress	6	160	1	1	1	1	Young	Good	Fair	10 – 20	C	
T14	Prunus	5	80	2	2	2	2	Young	Good	Fair	10 – 20	C	
T15	Cypress	3	75	0.5	0.5	0.5	0.5	Young	Good	Good	10 – 20	C	
T16	Magnolia	4	70	2	2	1	2	Young	Good	Fair	10 – 20	C	
T17	Unknown large shrub	4	90	3	2	2	2.5	Mature	Good	Fair	10 – 20	C	

APPENDIX MD2

Tree constraints plan (TCP) showing existing plot layout with tree numbers, BS5837: 2012 colour codes (A – Green, B – Blue, C – Grey, U - Red) and root protection areas (dashed circles). The plan has been provided separately as a PDF at a scale of 1: 200 @ A4.

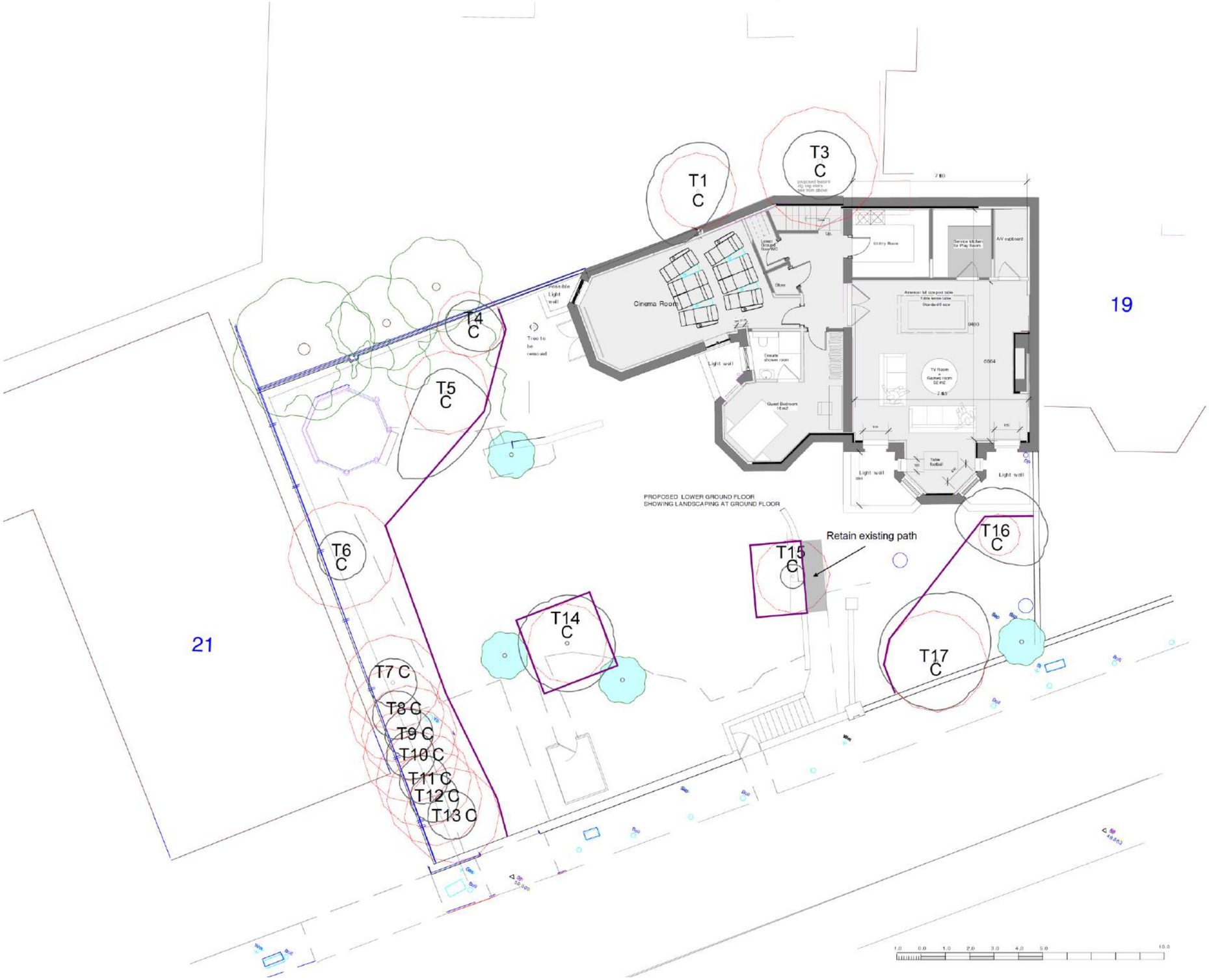


APPENDIX MD3
BS5837 schedule of protection areas

Tree No.	Species	Trunk diameter (mm)	BS5837: 2012 Root protection area, RPA, (m^2)	BS5837: 2012 Radial protection distance (m)
T1	Maple	206	19.2	2.5
T2	Blackthorn	120	6.5	1.4
T3	Magnolia	200	18.1	2.4
T4	Blackthorn	110	5.5	1.3
T5	Prunus	140	8.9	1.7
T6	Leyland Cypress	180	14.7	2.2
T7-T13	Leyland Cypress	160	11.6	1.9
T14	Prunus	133	8.0	1.6
T15	Cypress	124	7.0	1.5
T16	Magnolia	150	10.2	1.8
T17	Unknown large shrub	170	13.1	2.0

APPENDIX MD4

Tree protection plan (TPP) showing retained trees, tree numbers and root protection areas (dashed circles). The location of 2m tall protective fencing is shown as purple lines. The plan has been provided separately as a PDF at a scale of 1: 200 @ A2



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1). ALL DIMENSIONS TO BE CHECKED ON SITE BEFORE FABRICATION.
2). CONTRACTOR IS TO REFER TO THE ENGINEERS DRAWINGS BEFORE PROCEEDING WITH WORKS.
3). ALL DRAWINGS AND DESIGNS ARE COVERED BY DESIGN RIGHT (INTERLECTUAL PROPERTY) AND MAY NOT BE DISTRIBUTED, COPIED OR ISSUED WITHOUT WRITTEN PERMISSION OF THE ARCHITECT.
4). ALL DESIGN CONCEPTS CONTAINED ON THIS DRAWING ARE THE SOLE PROPERTY OF THE ARCHITECT AND NO ADAPTIONS, REPRODUCTIONS OR COPIES MAY BE MADE WITHOUT WRITTEN PERMISSION OF THE ARCHITECT.
5). THESE DRAWINGS MAY BE SUBJECT REVISION FOR THE PROPER CARRYING OUT OF THE WORKS.
6. LOCAL AUTHORITY AND STATUTORY REQUIREMENTS MAY OVERRIDE THESE DRAWINGS AND AMENDMENTS MAY BE REQUIRED.
7). SAMPLES OF MATERIALS WILL BE REQUIRED TO BE SUPPLIED BY THE CONTRACTOR. THE CONTRACTOR SHALL NOT RELY SOLELY OF THE WRITTEN DESCRIPTION CONTAINED WITHIN THE WORDING ON THESE DRAWINGS.
8). ALL FINISHES SHALL BE TO THE ARCHITECTS SATISFACTION.
9). ALL CRITICAL DIMENSIONS SHALL BE APPROVED BY THE ARCHITECT BEFORE CONSTRUCTION.
9) ANY DISCREANCY BETWEEN THIS DRAWING AND ON-SITE DIMENSION SHALL BE REFERRED TO THE ARCHITECT FOR CLARIFICATION AND INSTRUCTION BEFORE WORKS ON THAT PART SHALL COMMENCE.

REVISIONS

NO	DATE	DESCRIPTION	BY

5d L T D ARCHITECTS
764 FINCHLEY ROAD TEMPLE FORTUNE NW11 LONDON 7TH
TELEPHONE 020 8458 4283
FAX NUMBER 020 8458 4322
MOBILE NUMBER 07721 598207
E-mail geoff@5darchitects.org.uk

PROTECTIVE FENCING

PROJECT
20 WELL ROAD, HAMPSTEAD, LONDON, NW3

DRAWING TITLE
PROPOSED SITE AND TREE PROTECTION PLAN

SCALE 1:200 @ A2 DATE Sep 2017

DRAWING NUMBER
06.953.14

APPENDIX MD5

TREE AWARENESS – SITE INDUCTION SHEET

SITE NAME: 20 Well Road, London, NW3 1LH

Trees are an important part of this development and all trees noted on the Tree Protection Plan are protected by planning conditions and by virtue of being in a Conservation Area. Trees must not be damaged in any way, including indirectly through compaction/contamination of soil, so that they can fully integrate into the finished project and stay healthy well into the future. All persons working on this site have a responsibility to be aware of trees and to abide by tree protection procedures.

How can trees can be damaged?

Above the ground – contacts and impacts with branches and trunk (for example by machine operations: piling rigs, high-sided vehicles, crane use, fixings to trunk, unauthorised cutting back of branches). Make sure there is adequate clearance under the tree canopy and don't stray close to the trunk. Damage to bark allows infections to enter the tree.

Below the ground – roots spread out from the trunk horizontally at shallow depth and are therefore easily damaged. Vehicle and pedestrian movements and storage of materials on unprotected ground causes compaction, especially in wet weather, and must be avoided. Soil stripping during site clearance or landscaping is prohibited in root protection areas. The effects of root damage may take some time to become obvious, but can result in disfiguring dieback of leaves and branches, or even death.

Tree protection procedures

Provided that the simple steps below are followed most tree protection is straightforward:

- Stay out of tree Construction Exclusion Zones (CEZs). These are the areas of ground surrounding retained trees that are protected by barriers and/or ground protection. If you need to go into a CEZ, you must first gain authorisation from the Site Manager.
- No construction activity of any description within CEZs, e.g. soil stripping, cement mixing, services installation, storage of materials etc.
- No fires within 20m of trunk of any retained tree.
- If authorised to work within a CEZ, for example, for installation of an above-ground no-dig driveway you must follow the procedures set out in the **Arboricultural Method Statement.**
- If damage occurs, you must inform the Site Manager who must, in turn, inform the project arboriculturist.

Planning Authority enforcement action needs to be avoided:

- 'Breach of Conditions' notices can prevent a site from being signed-off.
- 'Temporary Stop Notices' halt site operations and result in associated high costs.
- Wilful damage/destruction of TPO/Conservation Area trees can result in company and/or individual prosecutions - fines can me anything up to £20,000 (County Court fines are unlimited). Remember that fines may apply to the person committing the offence as well as the site owner and main contractors!

I have received site induction in tree awareness and tree protection procedures

PRINT NAME

SIGN

DATE

APPENDIX MD6

Qualifications and Experience

Dr Martin Dobson has been engaged in research and advisory work on trees since graduating in 1986 with a BSc (Hons) Degree in Biology. Subsequent postgraduate research led to the award of a Doctor of Philosophy (DPhil) Degree in Tree Physiology in 1990.

Postgraduate studies began in 1986 at the University of Ulster and continued in 1987 at the Forestry Commission's Research Station in Hampshire and focussed on the influence of air pollution on trees. Upon completion of this research in 1989 Dr Dobson was employed by the Forestry Commission and worked in both the Tree Pathology and Environmental Research Branches. During the next six years he was responsible for Department of Environment research contracts focussing on air pollution, climate change, de-icing salt damage to trees, woodland establishment on landfills and tree root research. He has authored two books: *De-icing Salt Damage to Trees and Shrubs* and *The Potential for Woodland Establishment on Landfill Sites.* He concluded his time at the Forestry Commission as Project Manager for research into the interaction between trees, roots and clay soils which included laboratory investigations, testing of root barriers and a three-year field-scale monitoring programme investigating the influence of woodland and grassland on the moisture status of clay soils.

In 1995 Martin joined the Arboricultural Advisory and Information Service as a senior Arboricultural Advisor. The AAIS advised the (then) Department of the Environment on matters concerning amenity trees and was the principal source of technical advice and information to the arboricultural profession as well as landscape architects, engineers, the horticultural industry and private individuals. A large proportion of advisory work focussed on issues relating to tree diseases and interactions between trees and buildings.

In 1997 Martin started an arboricultural consultancy practice specialising in subsidence and tree root claims, planning and development, tree safety and disease diagnosis. He was a local authority retained consultant providing expertise on tree protection practice and legislation from 1999 - 2006 and has dealt with several thousand Tree Preservation Order and Conservation Area applications.

He has extensive experience as an Expert Witness in the High Court, County Court and Magistrates Court. Notable recent cases he has been involved in include Robbins v London Borough of Bexley and Khan v London Borough of Harrow and Kane.

From 1995 to 2011 he was an examiner for the Professional Diploma in Arboriculture for the Royal Forestry Society/ABC Awards and he is currently an assessor for the Arboricultural Association Registered Consultant scheme. He has been a guest lecturer for the Middlesex University Countryside Management MSc course and for Portsmouth University. Together with Dr Giles Biddle he has devised and teaches introductory and advanced courses on trees and subsidence and co-presents seminars on trees and climate change with Professor Andy Moffat for the Arboricultural Association.

In addition to over 30 publications in scientific and technical journals he is the author of Arboriculture Research and Information Note 130/95/ARB *Tree Root Systems*, and leading author of:

Driveways Close to Trees. Arboricultural Practice Note 1. AAIS, Farnham.
Trees in Dispute. Arboricultural Practice Note 3. AAIS, Farnham.
Root Barriers and Building Subsidence. Arboricultural Practice Note 4. AAIS, Farnham.

He is a Fellow and Registered Consultant of the Arboricultural Association and is a Member by examination of the Expert Witness Institute.

APPENDIX D
Fieldwork Logs

Ground and Water Ltd

Borehole No
BH1
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
20 Well Road	GWPR2241		WLS
Location: Hampstead, London, NW3 1LH		Level: -	Scale 1:50
Client: Vincent Rymill		Dates: 11/08/2017	Logged By JH

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.25	D		0.30			MADE GROUND: Dark brown, gravelly sand. Sand is fine to medium grained. Gravel is occasional, fine to medium, sub-angular to sub-rounded flint and brick.
		0.50	D		0.50			MADE GROUND: Light brown silty gravelly sand. Sand is fine to medium grained. Gravel is abundant, fine to coarse, sub-angular to sub-rounded flints and brick.
		0.80	D					
		1.00	SPT	N=6				MADE GROUND: Light brown silty gravelly sand. Sand is fine to medium grained. Gravel is abundant, fine to coarse, sub-angular to rounded flints.
		1.00	D	(1,1/				
		1.30	D	1,1,2,2)	1.30			MADE GROUND: Light brown silty gravelly sand. Sand is fine to medium grained. Gravel is rare, fine to coarse, sub-angular to sub-rounded flint. (small clay lense noted at 1.50m bgl).
		1.50	D					
		1.80	D		1.80			MADE GROUND: Dark brown silty gravelly sand. Sand is fine to medium grained . Gravel is abundant, fine to coarse, angular to sub-angular, brick, tile and flint.
		2.00	SPT	N=9	2.00			
		2.00	D	(2,2/ 2,2,2,3)	2.30			MADE GROUND: Brown silty gravelly sand . Sand is fine to medium grained. Gravel is occasional, fine to medium, sub-angular to sub-rounded, brick and flint.
		2.50	D		2.60			
					2.80			MADE GROUND: Dark brown gravelly clayey sand. Sand is fine to medium grained. Gravel is occasional to rare, fine to medium, sub-angular to sub-rounded brick and flint.
		3.00	SPT	N=14				
		3.00	D	(3,2/ 3,3,4,4)	3.40			HEAD DEPOSITS: Light brown gravelly silty SAND. Sand is fine to medium grained. Gravel is rare, fine to medium, sub-rounded flint.
		3.50	D					
					3.90			CLAYGATE MEMBER OF THE LONDON CLAY FORMATION: Brown grey sandy CLAY. Sand is fine grained.
		4.00	SPT	N=18				
		4.00	D	(4,3/ 3,4,5,6)				CLAYGATE MEMBER OF THE LONDON CLAY FORMATION: Light brown SAND. Sand is fine grained.
		4.50	D					
								CLAYGATE MEMBER OF THE LONDON CLAY FORMATION: Light brown grey very sandy silty CLAY. Sand is fine grained , pockets of fine sand.
		5.00	SPT	N=17	5.00			
		5.00	D	(4,3/ 4,4,4,5)				CLAYGATE MEMBER OF THE LONDON CLAY FORMATION: Brown grey very clayey silty SAND. Sand is fine to medium grained. Pockets of clay.
		5.50	D					
		6.00	SPT	N=20				
				(4,4/ 4,5,5,6)				
					6.45			End of Borehole at 6.45 m
			Type	Results				

Remarks: No groundwater encountered.
Roots noted to 0.30 m bgl.

AGS

Ground and Water Ltd

Borehole No
BH2
Sheet 1 of 1

Project Name 20 Well Road	Project No. GWPR2241	Co-ords: -	Hole Type WLS
Location: Hampstead, London, NW3 1LH		Level: -	Scale 1:50
Client: Vincent Rymill		Dates: 11/08/2017	Logged By JH

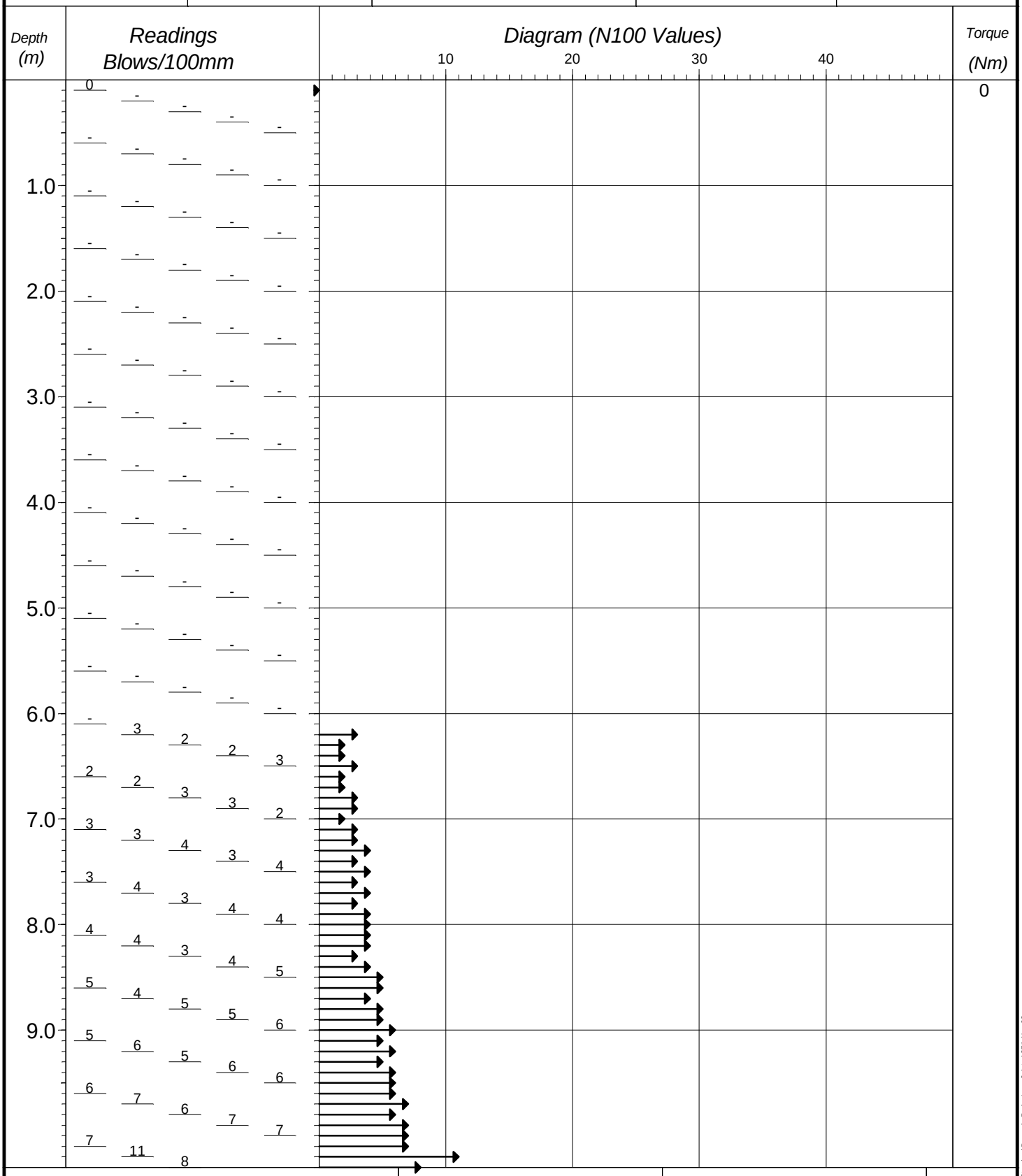
Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
		0.30	D					MADE GROUND: Dark brown gravelly sandy sitly clay. Sand is fine to medium grained. Gravel is occasional to rare, fine to coarse, sub-angular to sub-rounded flint and tile.
		0.50	D		0.50			MADE GROUND: Dark brown clayey gravelly silty sand. Sand is fine to medium grained. Gravel is occasional to rare, fine to medium, sub-angular to sub-rounded flints, brick and coal. Pockets of clay.
		0.80	D					
		1.00	D		1.10			MADE GROUND: Light brown silty gravelly sand. Sand is fine to medium grained. Gravel is occasional, fine to medium, sub-rounded to sub-angular flint and porcelain.
		1.30	D					
		1.50	D		1.50			MADE GROUND: Dark brown silty gravelly sand. Sand is occasional, fine to medium, sub-angular to sub-rounded flint, porcelain and coal.
		1.80	D		1.80			
		2.00	D		2.00			HEAD DEPOSITS: Brown gravelly sandy CLAY. Sand is fine to medium grained. Gravel is abundant to occasional, fine to coarse, angular to sub-rounded flints.
		2.30	D					
		2.50	D		2.50			HEAD DEPOSITS: Light brown gravelly silty SAND. Sand is fine to medium grained. Gravel is rare, fine to medium, sub-angular to sub-rounded flints.
		3.00	D					CLAYGATE MEMBER OF THE LONDON CLAY FORMATION: Sandy silty CLAY. Sand is very fine grained. Sand lenses noted, 2.70 - 2.80m bgl, 3.70 - 3.80m bgl and 4.80 - 4.90m bgl.
		3.50	D					
		4.00	D					
		4.50	D					
		5.00	D					
		5.50	D		5.60			CLAYGATE MEMBER OF THE LONDON CLAY FORMATION: Brown clayey SAND. Sand is fine to medium grained.
		5.75	D					
					6.00			End of Borehole at 6.00 m
			Type	Results				

Remarks: No groundwater encountered.
Roots noted to 1.60m bgl.

AGS

DYNAMIC PROBING

Probe No **DP1**	
Client **Vincent Rymill**	Sheet 1 of 2
Site **20 Well Road**	*Project No* **GWPR2241**
E **-** *N* **-** *Level* **-**	*Date* **11/08/2017** *Logged by* **Borehole**



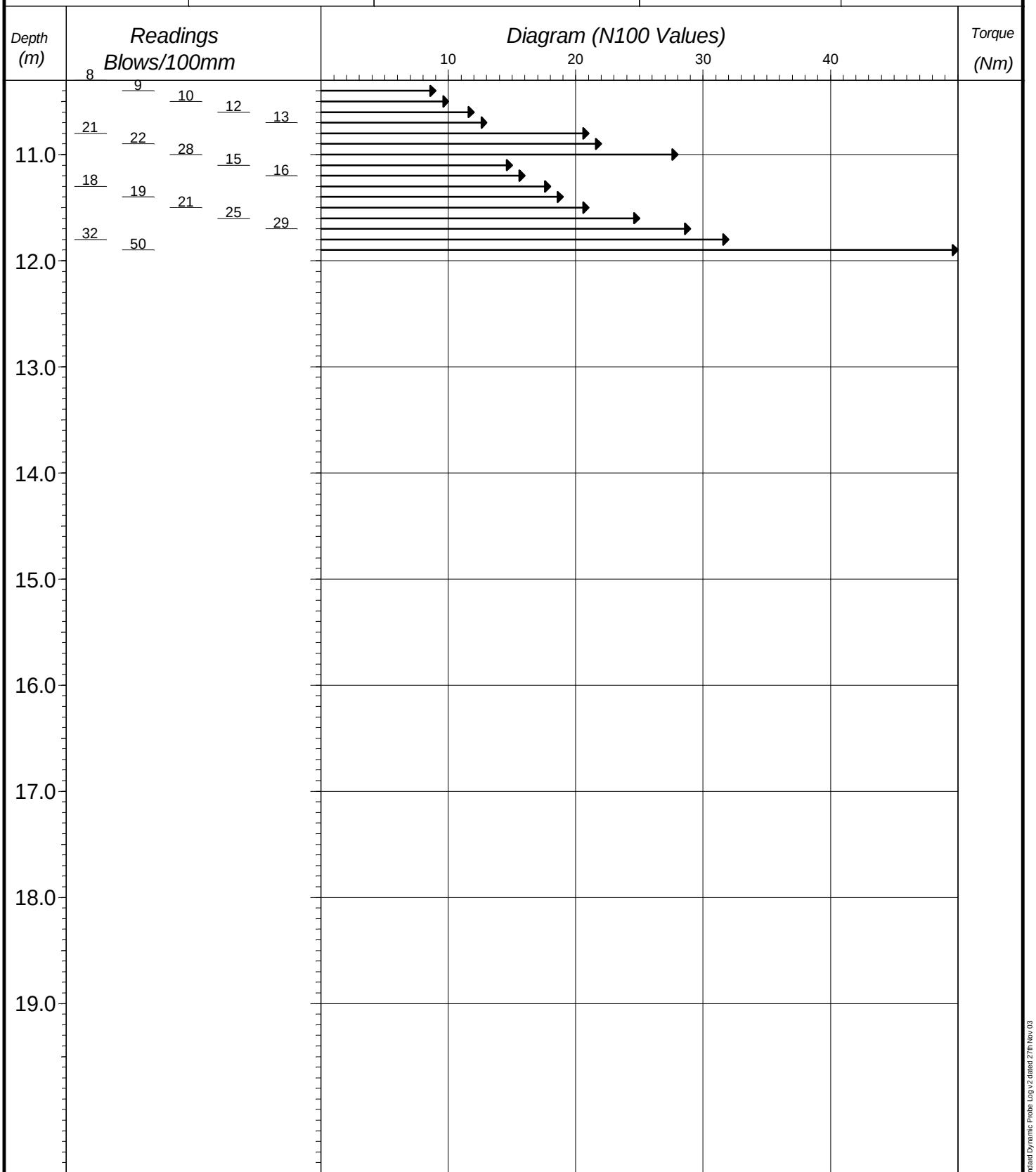
Ground and Water Ltd

Fall Height	**500**	*Cone Base Diameter*	**43**
Hammer Wt	**50.00**	*Final Depth*	**11.80**
Probe Type	**DPSH**	*Log Scale*	1:50

AGS

DYNAMIC PROBING

Probe No **DP1**	
Client **Vincent Rymill**	Sheet 2 of 2
Site **20 Well Road**	*Project No* **GWPR2241**
E - *N* - *Level* -	*Date* **11/08/2017** *Logged by* **Borehole**



Ground and Water Ltd

Fall Height	**500**	*Cone Base Diameter*	**43**
Hammer Wt	**50.00**	*Final Depth*	**11.80**
Probe Type	**DPSH**	*Log Scale*	1:50

AGS

APPPENDIX E
Geotechnical Laboratory Test Results

Summary of Natural Moisture Content, Liquid Limit and Plastic Limit Results

Job No.	Project Name	Programme	
23285	20 Well Road	Samples received	25/08/2017
		Schedule received	24/08/2017
Project No.	Client	Project started	29/08/2017
GWPR2241	Ground & Water Ltd	Testing Started	08/09/2017

Hole No.	Sample				Soil Description	NMC	Passing 425µm	LL	PL	PI	Remarks
	Ref	Top	Base	Type		%	%	%	%	%	
BH1	-	3.00	-	D	Orangish brown and greenish grey slightly sandy silty CLAY	21	100	47	18	29	
BH1	-	4.00	-	D	Brown, grey and orangish brown sandy silty CLAY	26	100	48	20	28	
BH2	-	1.80	-	D	Greyish brown and orangish brown slightly gravelly sandy silty CLAY (gravel is fmc and sub-rounded to rounded)	19	92	32	17	15	
BH2	-	2.00	-	D	Greyish brown and orangish brown slightly gravelly sandy silty CLAY (gravel is fmc and sub-rounded to rounded)	21					
BH2	-	2.50	-	D	Orangish brown and greenish grey slightly sandy silty CLAY with rare fmc sandstone fragments	22					
BH2	-	3.00	-	D	Orangish brown and greenish grey silty sandy CLAY	23	100	40	19	21	
BH2	-	3.50	-	D	Orangish brown and greenish grey silty sandy CLAY	22					
BH2	-	4.00	-	D	Orangish brown and greenish grey silty sandy CLAY	25					

Test Methods: BS1377: Part 2: 1990:
Natural Moisture Content : clause 3.2
Atterberg Limits: clause 4.3 and 5.0

Test Report by K4 SOILS LABORATORY
Unit 8 Olds Close Olds Approach
Watford Herts WD18 9RU

Tel: 01923 711 288
Email: James@k4soils.com

Checked and Approved

Initials **J.P**

Date: 11/09/2017

Sulphate Content (Gravimetric Method) for 2:1 Soil: Water Extract and pH Value - Summary of Results

Tested in accordance with BS1377 : Part 3 : 1990, clause 5.3 and clause 9

Job No.	Project Name	Programme	
23285	20 Well Road	Samples received	25/08/2017
		Schedule received	24/08/2017
Project No.	Client	Project started	29/08/2017
GWPR2241	Ground & Water Ltd	Testing Started	05/09/2017

Hole No.	Sample				Soil description	Dry Mass passing 2mm	SO3 Content	SO4 Content	pH	Remarks
	Ref	Top	Base	Type		%	g/l	g/l		
BH2	-	2.00	-	D	Greyish brown and orangish brown slightly gravelly sandy silty CLAY (gravel is fmc and sub-rounded to rounded)	96	0.18	0.22	7.25	

Test Report by K4 SOILS LABORATORY
Unit 8 Olds Close Olds Approach
Watford Herts WD18 9RU
Tel: 01923 711 288
Email: James@k4soils.com

Checked and Approved

Initials J.P

Date: 11/09/2017

Roger Foord
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GU34 3NB

QTS Environmental Ltd
Unit 1
Rose Lane Industrial Estate
Rose Lane
Lenham Heath
Kent
ME17 2JN
t: 01622 850410
russell.jarvis@qtsenvironmental.com

QTS Environmental Report No: 17-63532

Site Reference:	20 Well Road
Project / Job Ref:	GWPR2241
Order No:	None Supplied
Sample Receipt Date:	25/08/2017
Sample Scheduled Date:	25/08/2017
Report Issue Number:	1
Reporting Date:	01/09/2017

Authorised by:

Kevin Old
Associate Director of Laboratory

Authorised by:

Russell Jarvis
Associate Director of Client Services

QTSE is the trading name of DETS Ltd, company registration number 03705645

QTS Environmental Ltd
Unit 1, Rose Lane Industrial Estate
Rose Lane
Lenham Heath
Maidstone
Kent ME17 2JN
Tel : 01622 850410

4480

Soil Analysis Certificate							
QTS Environmental Report No: 17-63532	**Date Sampled**	11/08/17	11/08/17			
Ground & Water Ltd	**Time Sampled**	None Supplied	None Supplied			
Site Reference: 20 Well Road	**TP / BH No**	BH1	BH2			
Project / Job Ref: GWPR2241	**Additional Refs**	None Supplied	None Supplied			
Order No: None Supplied	**Depth (m)**	0.80	2.30			
Reporting Date: 01/09/2017	**QTSE Sample No**	287734	287735			

Determinand	Unit	RL	Accreditation					
pH	pH Units	N/a	MCERTS	7.7	6.9			
Total Sulphate as SO_4	mg/kg	< 200	NONE	< 200	217			
Total Sulphate as SO_4	%	< 0.02	NONE	< 0.02	0.02			
W/S Sulphate as SO_4 (2:1)	mg/l	< 10	MCERTS	105	13			
W/S Sulphate as SO_4 (2:1)	g/l	< 0.01	MCERTS	0.11	0.01			
Total Sulphur	%	< 0.02	NONE	< 0.02	< 0.02			
Ammonium as NH_4	mg/kg	< 0.5	NONE	< 0.5	< 0.5			
Ammonium as NH_4	mg/l	< 0.05	NONE	< 0.05	< 0.05			
W/S Chloride (2:1)	mg/kg	< 1	MCERTS	14	10			
W/S Chloride (2:1)	mg/l	< 0.5	MCERTS	7.2	5.2			
Water Soluble Nitrate (2:1) as NO_3	mg/kg	< 3	MCERTS	8	6			
Water Soluble Nitrate (2:1) as NO_3	mg/l	< 1.5	MCERTS	4.1	3.2			
W/S Magnesium	mg/l	< 0.1	NONE	2.5	0.3			

Analytical results are expressed on a dry weight basis where samples are assisted-dried at less than 30^{O}C
Subcontracted analysis (S)

QTS Environmental Ltd
Unit 1, Rose Lane Industrial Estate
Rose Lane
Lenham Heath
Maidstone
Kent ME17 2JN
Tel : 01622 850410

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME
UKAS TESTING 4480

Soil Analysis Certificate - Sample Descriptions	
QTS Environmental Report No: 17-63532	
Ground & Water Ltd	
Site Reference: 20 Well Road	
Project / Job Ref: GWPR2241	
Order No: None Supplied	
Reporting Date: 01/09/2017	

QTSE Sample No	TP / BH No	Additional Refs	Depth (m)	Moisture Content (%)	Sample Matrix Description
$ 287734	BH1	None Supplied	0.80	11.6	Brown clayey sand
$ 287735	BH2	None Supplied	2.30	15.2	Brown clayey sand

Moisture content is part of procedure E003 & is not an accredited test

Insufficient Sample I/S

Unsuitable Sample U/S

$ samples exceeded recommended holding times

QTS Environmental Ltd
Unit 1, Rose Lane Industrial Estate
Rose Lane
Lenham Heath
Maidstone
Kent ME17 2JN
Tel : 01622 850410

4480

Soil Analysis Certificate - Methodology & Miscellaneous Information
QTS Environmental Report No: 17-63532
Ground & Water Ltd
Site Reference: 20 Well Road
Project / Job Ref: GWPR2241
Order No: None Supplied
Reporting Date: 01/09/2017

Matrix	Analysed On	Determinand	Brief Method Description	Method No
Soil	D	Boron - Water Soluble	Determination of water soluble boron in soil by 2:1 hot water extract followed by ICP-OES	E012
Soil	AR	BTEX	Determination of BTEX by headspace GC-MS	E001
Soil	D	Cations	Determination of cations in soil by aqua-regia digestion followed by ICP-OES	E002
Soil	D	Chloride - Water Soluble (2:1)	Determination of chloride by extraction with water & analysed by ion chromatography	E009
Soil	AR	Chromium - Hexavalent	Determination of hexavalent chromium in soil by extraction in water then by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry	E016
Soil	AR	Cyanide - Complex	Determination of complex cyanide by distillation followed by colorimetry	E015
Soil	AR	Cyanide - Free	Determination of free cyanide by distillation followed by colorimetry	E015
Soil	AR	Cyanide - Total	Determination of total cyanide by distillation followed by colorimetry	E015
Soil	D	Cyclohexane Extractable Matter (CEM)	Gravimetrically determined through extraction with cyclohexane	E011
Soil	AR	Diesel Range Organics (C10 - C24)	Determination of hexane/acetone extractable hydrocarbons by GC-FID	E004
Soil	AR	Electrical Conductivity	Determination of electrical conductivity by addition of saturated calcium sulphate followed by electrometric measurement	E022
Soil	AR	Electrical Conductivity	Determination of electrical conductivity by addition of water followed by electrometric measurement	E023
Soil	D	Elemental Sulphur	Determination of elemental sulphur by solvent extraction followed by GC-MS	E020
Soil	AR	EPH (C10 – C40)	Determination of acetone/hexane extractable hydrocarbons by GC-FID	E004
Soil	AR	EPH Product ID	Determination of acetone/hexane extractable hydrocarbons by GC-FID	E004
Soil	AR	EPH TEXAS (C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C40)	Determination of acetone/hexane extractable hydrocarbons by GC-FID for C8 to C40. C6 to C8 by headspace GC-MS	E004
Soil	D	Fluoride - Water Soluble	Determination of Fluoride by extraction with water & analysed by ion chromatography	E009
Soil	D	FOC (Fraction Organic Carbon)	Determination of fraction of organic carbon by oxidising with potassium dichromate followed by titration with iron (II) sulphate	E010
Soil	D	Loss on Ignition @ 450oC	Determination of loss on ignition in soil by gravimetrically with the sample being ignited in a muffle furnace	E019
Soil	D	Magnesium - Water Soluble	Determination of water soluble magnesium by extraction with water followed by ICP-OES	E025
Soil	D	Metals	Determination of metals by aqua-regia digestion followed by ICP-OES	E002
Soil	AR	Mineral Oil (C10 - C40)	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge	E004
Soil	AR	Moisture Content	Moisture content; determined gravimetrically	E003
Soil	D	Nitrate - Water Soluble (2:1)	Determination of nitrate by extraction with water & analysed by ion chromatography	E009
Soil	D	Organic Matter	Determination of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphate	E010
Soil	AR	PAH - Speciated (EPA 16)	Determination of PAH compounds by extraction in acetone and hexane followed by GC-MS with the use of surrogate and internal standards	E005
Soil	AR	PCB - 7 Congeners	Determination of PCB by extraction with acetone and hexane followed by GC-MS	E008
Soil	D	Petroleum Ether Extract (PEE)	Gravimetrically determined through extraction with petroleum ether	E011
Soil	AR	pH	Determination of pH by addition of water followed by electrometric measurement	E007
Soil	AR	Phenols - Total (monohydric)	Determination of phenols by distillation followed by colorimetry	E021
Soil	D	Phosphate - Water Soluble (2:1)	Determination of phosphate by extraction with water & analysed by ion chromatography	E009
Soil	D	Sulphate (as SO4) - Total	Determination of total sulphate by extraction with 10% HCl followed by ICP-OES	E013
Soil	D	Sulphate (as SO4) - Water Soluble (2:1)	Determination of sulphate by extraction with water & analysed by ion chromatography	E009
Soil	D	Sulphate (as SO4) - Water Soluble (2:1)	Determination of water soluble sulphate by extraction with water followed by ICP-OES	E014
Soil	AR	Sulphide	Determination of sulphide by distillation followed by colorimetry	E018
Soil	D	Sulphur - Total	Determination of total sulphur by extraction with aqua-regia followed by ICP-OES	E024
Soil	AR	SVOC	Determination of semi-volatile organic compounds by extraction in acetone and hexane followed by GC-MS	E006
Soil	AR	Thiocyanate (as SCN)	Determination of thiocyanate by extraction in caustic soda followed by acidification followed by addition of ferric nitrate followed by colorimetry	E017
Soil	D	Toluene Extractable Matter (TEM)	Gravimetrically determined through extraction with toluene	E011
Soil	D	Total Organic Carbon (TOC)	Determination of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphate	E010
Soil	AR	TPH CWG (ali: C5- C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C34, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35)	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge for C8 to C35. C5 to C8 by headspace GC-MS	E004
Soil	AR	TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10 C12, C12-C16, C16-C35, C35-C44, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35, C35-C44)	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge for C8 to C44. C5 to C8 by headspace GC-MS	E004
Soil	AR	VOCs	Determination of volatile organic compounds by headspace GC-MS	E001
Soil	AR	VPH (C6-C8 & C8-C10)	Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID	E001

D Dried
AR As Received

APPENDIX F
Ground Movement Assessment Calculations

Ground Movement Analysis - CIRIA C580 Embedded Retaning Walls (For EXCAVATION ONLY)

CONSERVATIVE

Project Ref: GWPR2241
Site: 20 Well Road

Excavation Depth: 3.6

Neighbouring Property 1

House No.	18
Closest Wall (m)	0.00
Length (m)	10.00
Furthest Wall (m)	10.00
Height	15.00

Ground Movement Due to Excavtion - Assuming High Stiffness Clays

(Table 2.4 CIRIA C580)

Surface Movement at Wall	(m)	(mm)
Horizontal:	0.0054	5.4
Verticle:	0.0036	3.6

Distance to Negligible Movement	(m)
Horizontal:	14.4
Verticle:	12.6

Fig 2.11

Neighbouring Property 1 No. 18 Interval 2.50

Contour Plot Point	Distance (m)	Distance/Max Excavtion Depth
A	0.00	0.00
B	2.50	0.69
C	5.00	1.39
D	7.50	2.08
E	10.00	2.78

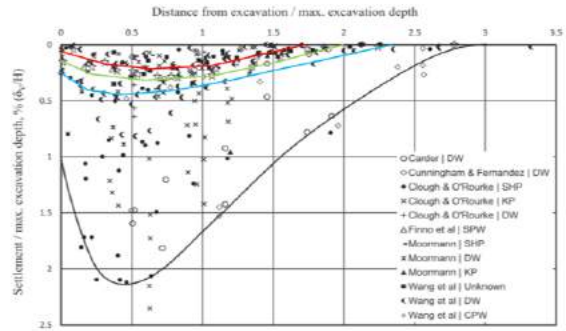
Horizontal Movement

Distance (m)	%	(m)	(mm)	
0.00	0.15	0.00540	**5.40**	Movement at closest wall
2.50	0.12	0.00446	4.46	
5.00	0.10	0.00353	3.53	
7.50	0.07	0.00259	2.59	
10.00	0.05	0.00165	**1.65**	Movement at furthest wall

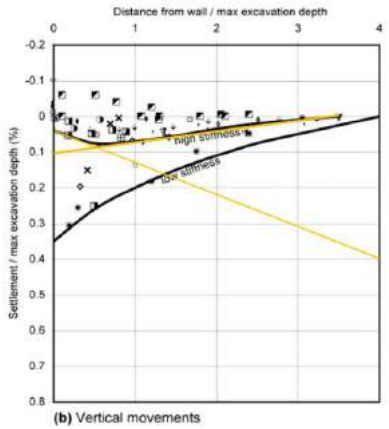
Verticle Movement

Distance (m)	%	(m)	(mm)	
0.00	0.04	0.00144	**7.20**	Movement at closest wall
2.50	0.08	0.00289	12.90	
5.00	0.06	0.00217	7.50	
7.50	0.04	0.00146	0.90	
10.00	0.02	0.00074	**0.03**	Movement at furthest wall

NOTE: If there are any are minus numbers change to 0 (Distance is more than distance to negligible movement from Table 2.4)

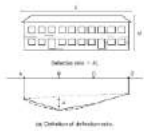


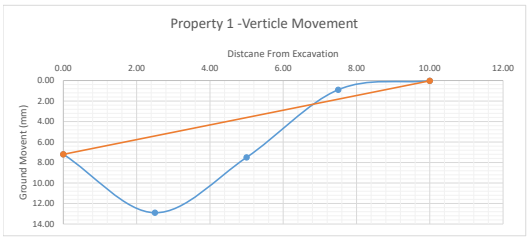
a Normalised settlements due to excavation in soft to firm clay

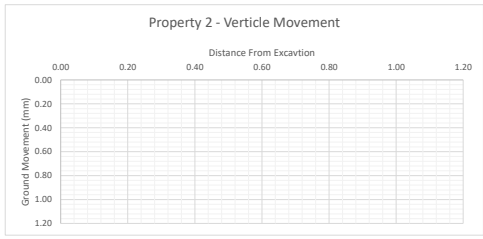


(b) Vertical movements

Potential Damage to Building







Neighbouring Property 1 No. 18

	m	mm
L	10.00	10000
H	15.00	15000
L/H	0.67	

Verticle Deflection (Δ)	7.6	mm	from graph (max difference between blue and orange line)
Defelction Ratio (Δ/L)	0.076000	%	
Horizontal Movement (δh)	3.75	mm	difference between horizontal movement at nearest and farthest walls
Horzontal Strain (Ɛh) = δh/L	0.03750	%	

Neighbouring Property 2 No. 0

	m	mm
L	0.00	0
H	0.00	0
L/H	#DIV/0!	

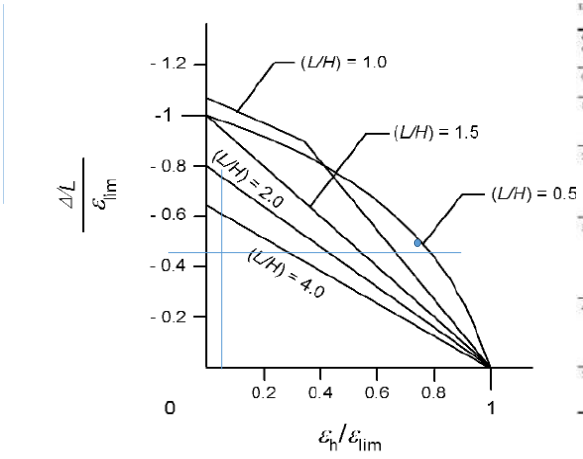
Verticle Deflection (Δ)	3.4	mm	from graph (max difference between blue and orange line)
Defelction Ratio (Δ/L)	#DIV/0!	%	
Horizontal Movement (δh)	0.00		difference between horizontal movement at nearest and farthest walls
Horzontal Strain (Ɛh) = δh/L	#DIV/0!	%	

CATEGORY OF DAMAGE Damage category limits are given in Table 2.5 (below) you will also need Fig 2.18 (also shown below).

L/H	0.67	
Negligible damage limit (Ɛlim)	**0.05**	
(Δ/L)/(Ɛlim)	1.52	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below
(Ɛh)/(Ɛlim)	0.75	
Very Slight damage limit (Ɛlim)	**0.075**	
(Δ/L)/(Ɛlim)	1.013333333	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below
(Ɛh)/(Ɛlim)	0.5	
Slight damage limit (Ɛlim)	**0.15**	
(Δ/L)/(Ɛlim)	0.506666667	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below
(Ɛh)/(Ɛlim)	0.25	
Moderate damage limit (Ɛlim)	**0.3**	
(Δ/L)/(Ɛlim)	0.253333333	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'
(Ɛh)/(Ɛlim)	0.125	
Calculated Category of Damage	Slight	

L/H	#DIV/0!	
Negligible damage limit (Ɛlim)	**0.05**	
(Δ/L)/(Ɛlim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below
(Ɛh)/(Ɛlim)	#DIV/0!	
Very Slight damage limit (Ɛlim)	**0.075**	
(Δ/L)/(Ɛlim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below
(Ɛh)/(Ɛlim)	#DIV/0!	
Slight damage limit (Ɛlim)	**0.15**	
(Δ/L)/(Ɛlim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below
(Ɛh)/(Ɛlim)	#DIV/0!	
Moderate damage limit (Ɛlim)	**0.3**	
(Δ/L)/(Ɛlim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'
(Ɛh)/(Ɛlim)	#DIV/0!	
Calculated Category of Damage	Slight	

Fig 2.18 (b)



(b) Influence of horizontal strain on Δ/L / ε_{lim} (after Burland, 2001)

Table 2.5

Table 2.5 *Classification of visible damage to walls (after Burland et al., 1977, Boscardin and Cording, 1989, and Burland, 2001)*

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (per cent)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible.	< 0.1	0.0–0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly.	< 5	0.075–0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5–15 or a number of cracks > 3	0.15–0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted. Floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks	

Ground Movement Analysis - CIRIA C580 Embedded Retaning Walls (For EXCAVATION ONLY)

MODERATELY CONSERVATIVE

Project Ref: GWPR2241
Site: 20 Well Road

Excavation Depth: 3.6

Neighbouring Property 1

House No.	18
Closest Wall (m)	0.00
Length (m)	10.00
Furthest Wall (m)	10.00
Height	15.00

Ground Movement Due to Excavtion - Assuming High Stiffness Clays

(Table 2.4 CIRIA C580)

Surface Movement at Wall	(m)	(mm)
Horizontal:	0.0054	5.4
Verticle:	0.0036	3.6

Distance to Negligible Movement	(m)
Horizontal:	14.4
Verticle:	12.6

Fig 2.11

Neighbouring Property 1 No. 18 Interval 2.50

Contour Plot Point	Distance (m)	Distance/Max Excavtion Depth
A	0.00	0.00
B	2.50	0.69
C	5.00	1.39
D	7.50	2.08
E	10.00	2.78

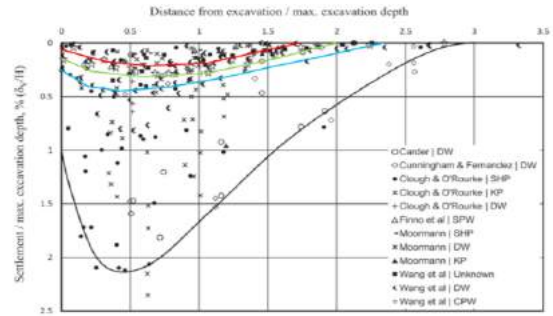
Horizontal Movement

Distance (m)	%	(m)	(mm)	
0.00	0.15	0.00540	**5.40**	Movement at closest wall
2.50	0.12	0.00446	4.46	
5.00	0.10	0.00353	3.53	
7.50	0.07	0.00259	2.59	
10.00	0.05	0.00165	**1.65**	Movement at furthest wall

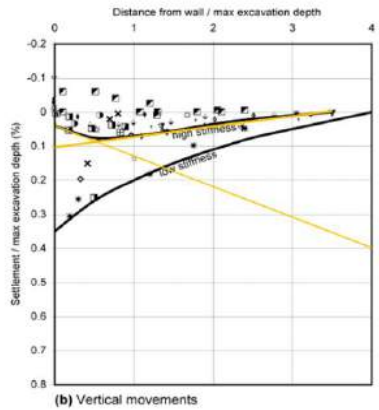
Verticle Movement

Distance (m)	%	(m)	(mm)	
0.00	0.04	0.00144	**5.40**	Movement at closest wall
2.50	0.08	0.00289	8.10	
5.00	0.06	0.00217	5.40	
7.50	0.04	0.00146	0.60	
10.00	0.02	0.00074	**0.03**	Movement at furthest wall

NOTE: If there are any are minus numbers change to 0 (Distance is more than distance to negligible movement from Table 2.4)

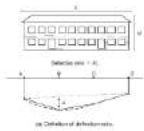


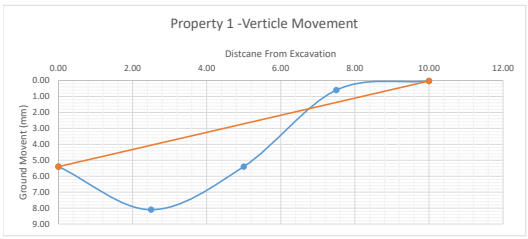
a Normalised settlements due to excavation in soft to firm clay

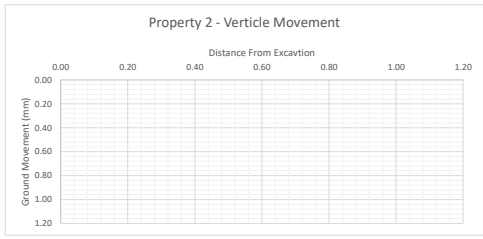


(b) Vertical movements

Potential Damage to Building







Neighbouring Property 1 No. 18

	m	mm
L	10.00	10000
H	15.00	15000
L/H	0.67	

Verticle Deflection (Δ)	4	mm	from graph (max difference between blue and orange line)
Defelction Ratio (Δ/L)	0.040000	%	
Horizontal Movement (δh)	3.75	mm	difference between horizontal movement at nearest and farthest walls
Horzontal Strain (Ɛh) = δh/L	0.03750	%	

Neighbouring Property 2 No. 0

	m	mm
L	0.00	0
H	0.00	0
L/H	#DIV/0!	

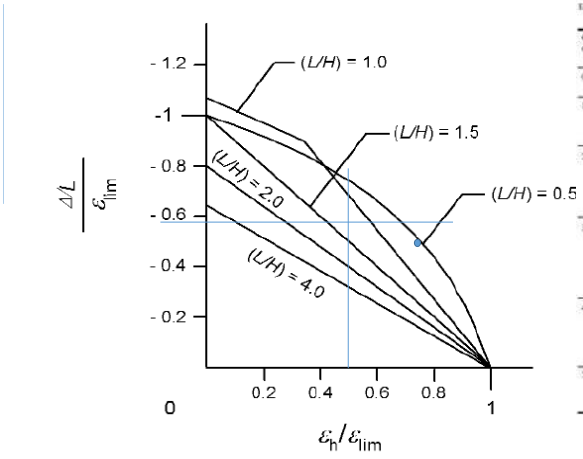
Verticle Deflection (Δ)	3.4	mm	from graph (max difference between blue and orange line)
Defelction Ratio (Δ/L)	#DIV/0!	%	
Horizontal Movement (δh)	0.00		difference between horizontal movement at nearest and farthest walls
Horzontal Strain (Ɛh) = δh/L	#DIV/0!	%	

CATEGORY OF DAMAGE Damage category limits are given in Table 2.5 (below) you will also need Fig 2.18 (also shown below).

L/H	0.67	
Negligible damage limit (Elim)	**0.05**	
(Δ/L)/(Elim)	0.8	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below
(Ɛh)/(Elim)	0.75	
Very Slight damage limit (Elim)	**0.075**	
(Δ/L)/(Elim)	0.533333333	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below
(Ɛh)/(Elim)	0.5	
Slight damage limit (Elim)	**0.15**	
(Δ/L)/(Elim)	0.266666667	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below
(Ɛh)/(Elim)	0.25	
Moderate damage limit (Elim)	**0.3**	
(Δ/L)/(Elim)	0.133333333	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'
(Ɛh)/(Elim)	0.125	
Calculated Category of Damage	Slight	

L/H	#DIV/0!	
Negligible damage limit (Elim)	**0.05**	
(Δ/L)/(Elim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below
(Ɛh)/(Elim)	#DIV/0!	
Very Slight damage limit (Elim)	**0.075**	
(Δ/L)/(Elim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below
(Ɛh)/(Elim)	#DIV/0!	
Slight damage limit (Elim)	**0.15**	
(Δ/L)/(Elim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below
(Ɛh)/(Elim)	#DIV/0!	
Moderate damage limit (Elim)	**0.3**	
(Δ/L)/(Elim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'
(Ɛh)/(Elim)	#DIV/0!	
Calculated Category of Damage	Slight	

Fig 2.18 (b)



(b) Influence of horizontal strain on Δ/L / ε_{lim} (after Burland, 2001)

Table 2.5

Table 2.5 *Classification of visible damage to walls (after Burland et al., 1977, Boscardin and Cording, 1989, and Burland, 2001)*

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (per cent)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible.	< 0.1	0.0–0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly.	< 5	0.075–0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5–15 or a number of cracks > 3	0.15–0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted. Floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks	

Ground Movement Analysis - CIRIA C580 Embedded Retaning Walls (For EXCAVATION ONLY)

HIGHLY CONSERVATIVE

Project Ref: GWPR2241
Site: 20 Well Road

Excavation Depth: 3.6

Neighbouring Property 1

House No.	18
Closest Wall (m)	0.00
Length (m)	10.00
Furthest Wall (m)	10.00
Height	15.00

Ground Movement Due to Excavtion - Assuming High Stiffness Clays

(Table 2.4 CIRIA C580)

Surface Movement at Wall	(m)	(mm)
Horizontal:	0.0054	5.4
Verticle:	0.0036	3.6

Distance to Negligible Movement	(m)
Horizontal:	14.4
Verticle:	12.6

Fig 2.11

Neighbouring Property 1 No. 18 Interval 2.50

Contour Plot Point	Distance (m)	Distance/Max Excavtion Depth
A	0.00	0.00
B	2.50	0.69
C	5.00	1.39
D	7.50	2.08
E	10.00	2.78

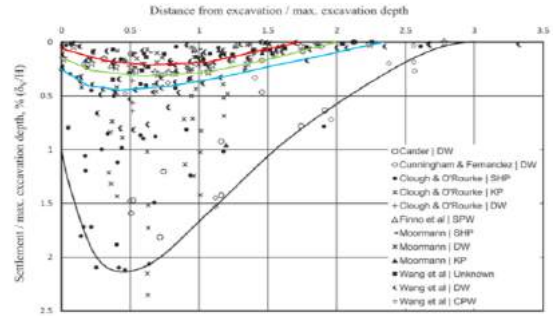
Horizontal Movement

Distance (m)	%	(m)	(mm)	
0.00	0.15	0.00540	**5.40**	Movement at closest wall
2.50	0.12	0.00446	4.46	
5.00	0.10	0.00353	3.53	
7.50	0.07	0.00259	2.59	
10.00	0.05	0.00165	**1.65**	Movement at furthest wall

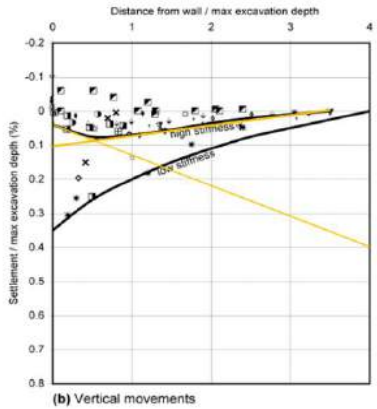
Verticle Movement

Distance (m)	%	(m)	(mm)	
0.00	0.04	0.00144	**7.20**	Movement at closest wall
2.50	0.08	0.00289	12.90	
5.00	0.06	0.00217	7.50	
7.50	0.04	0.00146	0.90	
10.00	0.02	0.00074	**0.03**	Movement at furthest wall

NOTE: If there are any are minus numbers change to 0 (Distance is more than distance to negligible movement from Table 2.4)

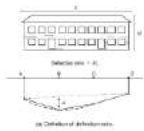


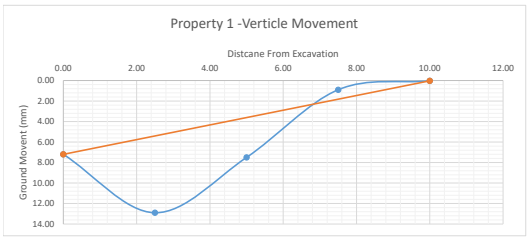
a Normalised settlements due to excavation in soft to firm clay

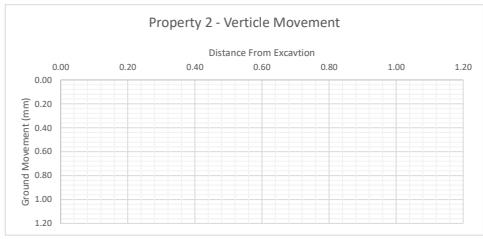


(b) Vertical movements

Potential Damage to Building







Neighbouring Property 1 No. 18

	m	mm
L	10.00	10000
H	15.00	15000
L/H	0.67	

Verticle Deflection (Δ)	7.6	mm	from graph (max difference between blue and orange line)
Defelction Ratio (Δ/L)	0.076000	%	
Horizontal Movement (δh)	3.75	mm	difference between horizontal movement at nearest and farthest walls
Horzontal Strain (Ɛh) = δh/L	0.03750	%	

Neighbouring Property 2 No. 0

	m	mm
L	0.00	0
H	0.00	0
L/H	#DIV/0!	

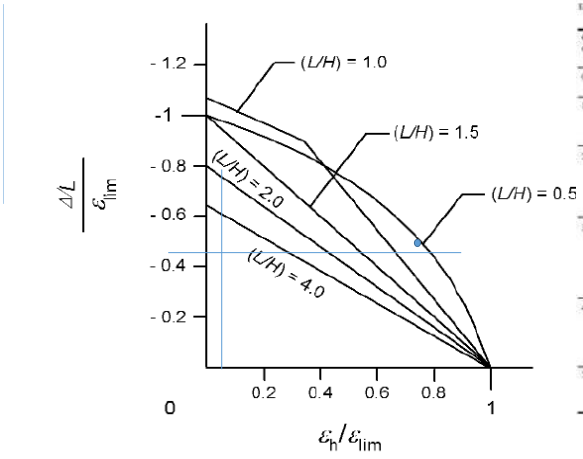
Verticle Deflection (Δ)	3.4	mm	from graph (max difference between blue and orange line)
Defelction Ratio (Δ/L)	#DIV/0!	%	
Horizontal Movement (δh)	0.00		difference between horizontal movement at nearest and farthest walls
Horzontal Strain (Ɛh) = δh/L	#DIV/0!	%	

CATEGORY OF DAMAGE Damage category limits are given in Table 2.5 (below) you will also need Fig 2.18 (also shown below).

L/H	0.67	
Negligible damage limit (Ɛlim)	**0.05**	
(Δ/L)/(Ɛlim)	1.52	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below
(Ɛh)/(Ɛlim)	0.75	
Very Slight damage limit (Ɛlim)	**0.075**	
(Δ/L)/(Ɛlim)	1.013333333	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below
(Ɛh)/(Ɛlim)	0.5	
Slight damage limit (Ɛlim)	**0.15**	
(Δ/L)/(Ɛlim)	0.506666667	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below
(Ɛh)/(Ɛlim)	0.25	
Moderate damage limit (Ɛlim)	**0.3**	
(Δ/L)/(Ɛlim)	0.253333333	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'
(Ɛh)/(Ɛlim)	0.125	
Calculated Category of Damage	Slight	

L/H	#DIV/0!	
Negligible damage limit (Ɛlim)	**0.05**	
(Δ/L)/(Ɛlim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below
(Ɛh)/(Ɛlim)	#DIV/0!	
Very Slight damage limit (Ɛlim)	**0.075**	
(Δ/L)/(Ɛlim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below
(Ɛh)/(Ɛlim)	#DIV/0!	
Slight damage limit (Ɛlim)	**0.15**	
(Δ/L)/(Ɛlim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below
(Ɛh)/(Ɛlim)	#DIV/0!	
Moderate damage limit (Ɛlim)	**0.3**	
(Δ/L)/(Ɛlim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'
(Ɛh)/(Ɛlim)	#DIV/0!	
Calculated Category of Damage	Slight	

Fig 2.18 (b)



(b) Influence of horizontal strain on Δ/L / ε_{lim} (after Burland, 2001)

Table 2.5

Table 2.5 *Classification of visible damage to walls (after Burland et al., 1977, Boscardin and Cording, 1989, and Burland, 2001)*

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (per cent)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible.	< 0.1	0.0–0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly.	< 5	0.075–0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5–15 or a number of cracks > 3	0.15–0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted. Floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks	

Ground Movement Analysis - CIRIA C580 Embedded Retaning Walls (For EXCAVATION ONLY)

Project Ref: GWPR2241
Site: 20 Well Road

Excavation Depth: 3.6

Neighbouring Property 1

House No.	20
Closest Wall (m)	0.00
Length (m)	10.00
Furthest Wall (m)	10.00
Height	15.00

Ground Movement Due to Excavtion - Assuming High Stiffness Clays

(Table 2.4 CIRIA C580)

Distance to Negligible Movement	(m)
Horizontal:	14.4
Vertical:	12.6

Fig 2.11

Neighbouring Property 1 No. 20 Interval 2.50

Contour Plot Point		Distance (m)	Distance/Max Excavtion Depth
	A	0.00	0.00
	B	2.50	0.69
	C	5.00	1.39
	D	7.50	2.08
	E	10.00	2.78

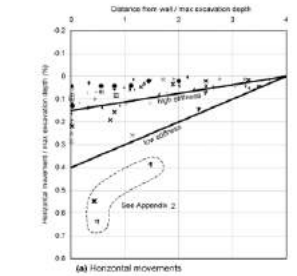
Horizontal Movement

Distance (m)	%	(m)	(mm)	
0.00	0.15	0.00540	**5.40**	Movement at closest wall
2.50	0.12	0.00446	4.46	
5.00	0.10	0.00353	3.53	
7.50	0.07	0.00259	2.59	
10.00	0.05	0.00165	**1.65**	Movement at furthest wall

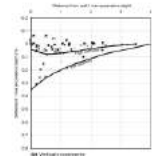
Vertical Movement

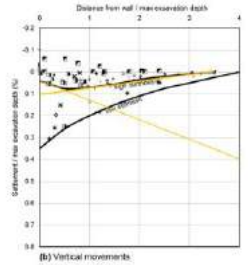
Distance (m)	%	(m)	(mm)	
0.00	0.04	0.00144	**1.44**	Movement at closest wall
2.50	0.08	0.00289	2.89	
5.00	0.06	0.00217	2.17	
7.50	0.04	0.00146	1.46	
10.00	0.02	0.00074	**0.74**	Movement at furthest wall

NOTE: If there are any are minus numbers change to 0 (Distance is more than distance to negligible movement from Table 2.4)



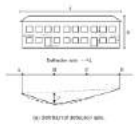
(a) Horizontal movements

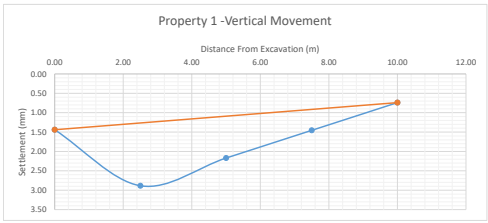


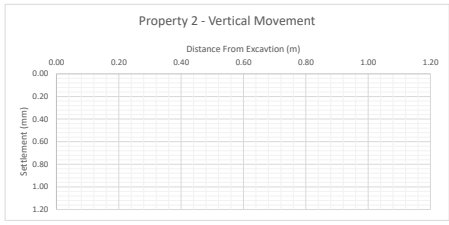


(b) Vertical movements

Potential Damage to Building







Neighbouring Property 1 No. 20

	m	mm
L	10.00	10000
H	15.00	15000
L/H	0.67	

Vertical Deflection (Δ)	1.3	mm	from graph (max difference between blue and orange line)
Defelction Ratio (Δ/L)	0.013000	%	
Horizontal Movement (δh)	3.75	mm	difference between horizontal movement at nearest and farthest walls
Horzontal Strain (Eh) = δh/L	0.03750	%	

Neighbouring Property 2 No. 0

	m	mm
L	0.00	0
H	0.00	0
L/H	#DIV/0!	

Vertical Deflection (Δ)		mm	from graph (max difference between blue and orange line)
Defelction Ratio (Δ/L)	#DIV/0!	%	
Horizontal Movement (δh)	0.00		difference between horizontal movement at nearest and farthest walls
Horzontal Strain (Eh) = δh/L	#DIV/0!	%	

CATEGORY OF DAMAGE Damage category limits are given in Table 2.5 (below).

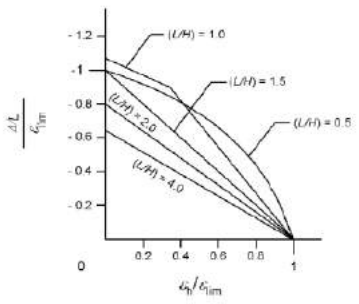
Method 1 - Prefferred method
- Open up 'Damage Category Relationship Plots GMA' spreadsheet
- Find relevant L/H graph (different graph on each each tab along the bottom of the spreadsheet)
- Input calculated values for deflection ratio and horizontal strain
- Point will plot on graph and show category of dameg

Method 2 - can be used to confirm category or is useful if L/H for property is between the given L/H graphs
- Plot points calculated below on figure 2.18 for each damage category
- Appropriate damage category will plot below L/H for property

L/H	0.67	
Negligible damage limit (Elim)	**0.05**	
(Δ/L)/(Elim)	0.26	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below
(Eh)/(Elim)	0.75	
Very Slight damage limit (Elim)	**0.075**	
(Δ/L)/(Elim)	0.173333333	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below
(Eh)/(Elim)	0.5	
Slight damage limit (Elim)	**0.15**	
(Δ/L)/(Elim)	0.086666667	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below
(Eh)/(Elim)	0.25	
Moderate damage limit (Elim)	**0.3**	
(Δ/L)/(Elim)	0.043333333	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'
(Eh)/(Elim)	0.125	
Calculated Category of Damage		

L/H	#DIV/0!	
Negligible damage limit (Elim)	**0.05**	
(Δ/L)/(Elim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below
(Eh)/(Elim)	#DIV/0!	
Very Slight damage limit (Elim)	**0.075**	
(Δ/L)/(Elim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below
(Eh)/(Elim)	#DIV/0!	
Slight damage limit (Elim)	**0.15**	
(Δ/L)/(Elim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below
(Eh)/(Elim)	#DIV/0!	
Moderate damage limit (Elim)	**0.3**	
(Δ/L)/(Elim)	#DIV/0!	Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'
(Eh)/(Elim)	#DIV/0!	
Calculated Category of Damage		

Fig 2.18 (b)



(b) Influence of horizontal strain on Δ/L / ε_{lim} (after Burland, 2001)

Table 2.5

Table 2.5 Classification of visible damage to walls (after Burland et al., 1977, Boscardin and Cording, 1989, and Burland, 2001)

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (per cent)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible	< 0.1	0.0–0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weather-tightness. Doors and windows may stick slightly.	< 5	0.075–0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possible a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5–15 or a number of cracks > 3	0.15–0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks	

Ground Movement Analysis - CIRIA C580 Embedded Retaning Walls (For EXCAVATION ONLY)

Project Ref: GWPR2241
Site: 20 Well Road

Excavation Depth: 3.6

Neighbouring Property 1		**Neighbouring Property 2**	
House No.	18	House No.	
Closest Wall (m)	0	Closest Wall (m)	
Length (m)	10	Length (m)	
Furthest Wall (m)	10	Furthest Wall (m)	0.00
Height	15	Height	

Ground Movement Due to Excavtion - Sand

Distance to Negligible Movement (m)

Vertical: 7.2

Fig 2.12

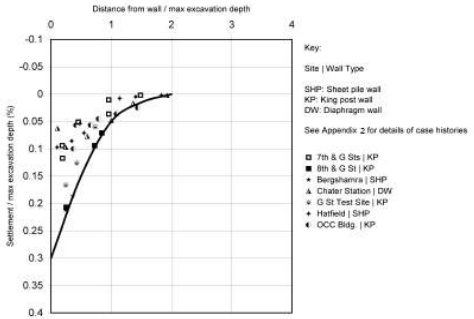


Figure 2.12 *Ground surface settlement due to excavation in front of wall in sand*

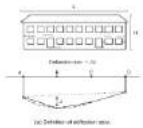
Neighbouring Property 1 No. 18 Interval 2.50

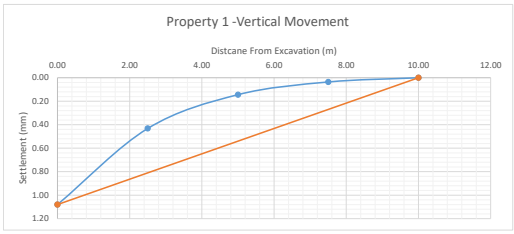
Contour Plot Point	Distance (m)	Distance/Max Excavtion Depth
A	0.00	0.00
B	2.50	0.69
C	5.00	1.39
D	7.50	2.08
E	10.00	2.78

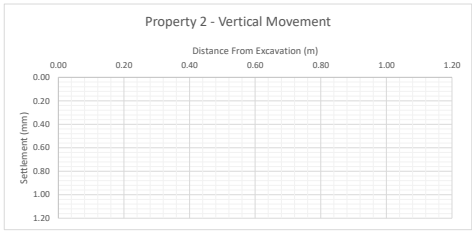
Distance (m)	Distance/Max Excavtion Depth	%	(m)	**Vertical Movement** (mm)	
0.00	0.00	0.30	0.01080	**1.08**	Movement at closest wall
2.50	0.69	0.12	0.00432	**0.43**	
5.00	1.39	0.04	0.00144	**0.14**	
7.50	2.08	0.01	0.00036	**0.04**	
10.00	2.78	0.00	0.00000	**0.00**	Movement at furthest wall

Manually input from Fig 2.12

Potential Damage to Building







Neighbouring Property 1 No. 18

	m	mm
L	10.00	10000
H	15.00	15000
L/H	0.67	

Vertical Deflection (Δ) 4 mm from graph (max difference between blue and orange line)

Defelction Ratio (Δ/L) 0.040000 %

Neighbouring Property 2 No. 0

	m	mm
L	0.00	0
H	0.00	0
L/H	#DIV/0!	

Vertical Deflection (Δ) 4.2 mm from graph (max difference between blue and orange line)

Defelction Ratio (Δ/L) #DIV/0! %

CATEGORY OF DAMAGE Damage category limits are given in Table 2.5 (below).

Method 1 - Prefferred method
- Open up 'Damage Category Relationship Plots GMA' spreadsheet
- Find relevant L/H graph (different graph on each each tab along the bottom of the spreadsheet)
- Input calculated values for deflection ratio and horizontal strain
- Point will plot on graph and show category of dameg

Method 2 - can be used to confirm category or is useful if L/H for property is between the given L/H graphs
- Plot points calculated below on figure 2.18 for each damage category
- Appropriate damage category will plot below L/H for property

L/H 0.67

Negligible damage limit (Elim) **0.05**

(Δ/L)/(Elim) 0.8
(Eh)/(Elim) #REF!
Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below

Very Slight damage limit (Elim) **0.075**

(Δ/L)/(Elim) 0.533333333
(Eh)/(Elim) #REF!
Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below

Slight damage limit (Elim) **0.15**

(Δ/L)/(Elim) 0.266666667
(Eh)/(Elim) #REF!
Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below

Moderate damage limit (Elim) **0.3**

(Δ/L)/(Elim) 0.133333333
(Eh)/(Elim) #REF!
Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'

Calculated Category of Damage

L/H #DIV/0!

Negligible damage limit (Elim) **0.05**

(Δ/L)/(Elim) #DIV/0!
(Eh)/(Elim) #REF!
Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'negligible' category - no need to plot points below

Very Slight damage limit (Elim) **0.075**

(Δ/L)/(Elim) #DIV/0!
(Eh)/(Elim) #REF!
Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'very slight' category - no need to plot points below

Slight damage limit (Elim) **0.15**

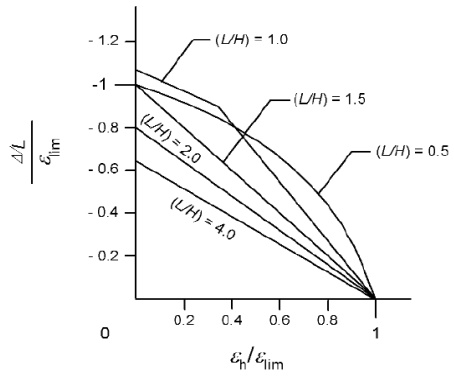
(Δ/L)/(Elim) #DIV/0!
(Eh)/(Elim) #REF!
Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'slight' category - no need to plot points below

Moderate damage limit (Elim) **0.3**

(Δ/L)/(Elim) #DIV/0!
(Eh)/(Elim) #REF!
Plot this point on fig2.18 (b) if the plotted point is below the appropriate L/H line then damage falls into 'moderate' category - if the point is not below, damage is 'severe'

Calculated Category of Damage

Fig 2.18 (b)



(b) Influence of horizontal strain on Δ/L / ε_{lim}
(after Burland, 2001)

Table 2.5

Table 2.5 Classification of visible damage to walls (after Burland et al. 1977, Boscardin and Cording, 1989 and Burland, 2001)

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (per cent)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible	< 0.1	0.0–0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly.	< 5	0.075–0.15
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4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted, floor slopes noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks.	