Version E3 OCTOBER 2020

Report of a Basement Impact Assessment for a Proposed Basement Extension of

31 Willoughby Road London NW3 1RT

Ref. G1808-RP-01-E3

CONSULTING ENGINEERS
Geotechnical Geoenvironmental Structural & Civil
11AWoodside BR6 6JR
mail@eldreds-geo.co.uk

Author accreditation.

Report author	Michael Eldred MSc. C.Eng. F.I.Struct.E. M.I.C.E. Director Eldred Geotechnics Ltd.
Consultant to Eldred Geotechnics Ltd.	MH de Freitas PhD, DIC, C.Geol, C.WEM, Director First Steps Ltd, and Emeritus Reader in Engineering Geology Imperial College London. Ground Engineering Advisor, UK Register of Ground Engineering Professionals (RoGEP) (68302453)

Ownership and copyright

Editing history

Edition	Summary	Date
E1 draft	Issued for team comment	31/07/19
E1	Issued for submission	31/10/19
E2	Geotech report updated reissued for submission	07/02/20
E3	Amended and extended in response to 1st audit made on behalf of the LLP	6/10/20

Contents

1 Non-technical summary

1.1 Background and brief

1. Planning application 2016/7146/P for a basement extension of 31 Willoughby Road was withdrawn for review following consultation with Camden Local Planning Authority. The owner of the property, Manuela Eleuteri (the client), subsequently appointed Eldred Geotechnics Ltd to reassess the potential impact of the proposed basement and to provide a new basement impact assessment report to accompany a further planning application.

2. The purpose of the assessment is to determine:

   the subterranean conditions of land to be developed,

   the changed conditions that will result from that development,

   the potential vulnerability of neighbouring property to those changes,

   the changes that might constitute increased hazard for neighbouring property

   and to present methods of preventing occurrence of those hazards

3. To that end new work has been undertaken directed and reported by Michael Eldred with the benefit of advice and interpretive documentation from Michael de Freitas on matters relating to engineering geology.

1.2 Preliminary studies

4. Existing records in the client's possession have been examined and those parts judged to be factual rather than opinion have been adopted for reference during the current work. They have been complemented by additional study of the regional history, geology and hydrology, construction of the subject property and probable construction of neighbouring property.

5. Study and interpretation of the information gained, and formal screening identified the need of further work to clarify the extent to which the proposed basement might increase the risk of harm and what might be done to prevent that increase. Beyond 31 Willoughby Road, property potentially at risk included Nos.29 and 33 Willoughby Road, Willow Cottages and the retaining wall between Willow Cottages and the site. Matters in doubt were:

(a) Not enough was known about ground and groundwater conditions for the design of the basement, for site specific assessment of subsidence risk and for protection of neighbouring property and the boundary retaining wall.

(b) The potential for the risk of groundwater flood affecting other property to be increased by the basement construction.

6. It was considered that further ground investigation could provide the means of dealing with the hazards associated with these matters.

1.3 New ground investigation

7. New work has comprised,

(a) excavation of further boreholes using equipment more suited to certain types of sampling, testing and detailed examination of the ground encountered than that used for previous investigations.

(b) installation of six transducers (data logging water pressure sensors), at differing depths within the new and existing boreholes. Over the period August 2018 to March 2019, and at 10 minute intervals, each transducer collected raw data which, in combination with barometric and rainfall records, enabled calculation of groundwater pressures according to both depth and weather.

(c) laboratory tests made on a selection of the recovered samples followed by examination of samples at the laboratory, and preparation of a record of their characteristics to a geologist's degree of detail.

(d) geological hydrogeological and hydrological interpretation of the information acquired, and interpretation of that in terms of the structural and geotechnical engineering requirements

1.4 Outcomes

8. The group of buildings of concern to this assessment are situated on the floor of and close to the west end of a valley bounded to the west by the older higher part of Hampstead and respectively, to north and south, by the Heath and High Street. Willow Cottages and their retaining walls were built in an excavated cutting in about 1850, Gayton Road and Crescent followed in the 1870's, Nos 29 and 31 Willow Road at the end of the 19th Century and No 33, in later style, by 1903.

9. Ground in the site for a depth of 3m to 3.5m below the surface is variable made ground, which, according to the contractor responsible for the Gayton Road estate,

was largely in place before the estate was built. The three Willoughby Road Properties are founded upon it and show no obvious sign of undue historical settlement

10. Below the made ground is an approximately 2.5m to 3m thickness of ground disturbed by periglacial conditions, termed “Head” which is also of variable strength, The upper part of the material is a random mixture derived from higher ground which has flowed downhill during freeze/thaw cycles of the ice ages. With depth, the material becomes less disturbed and terminates upon undisturbed London Clay.

11. Groundwater flows from sides and head of the valley towards the buildings, the flows converging close to Willow Cottages, which may have been built on or close to the stream bed, before continuing along the valley floor towards the lowest of the Hampstead ponds. There is no recorded history of groundwater flood affecting the cottages.

12. The ground and groundwater regimes in the site are now sufficiently understood for the adequate design of the basement and avoidance of increased risk for other property.

13. Experience suggests that the damming effect of a normal basement construction below No.31 would probably cause only millimetres variation of groundwater height across the basement, and that has been confirmed by a series of numerical analyses based upon conservative assessment of both ground properties and groundwater flow. The estimated maximum realistic water level variation is less than 25mm.

14. The underside of the basement slab will be situated within the transported Head material. This has clearly provided adequate support for load spreading downward from the existing shallow foundations of Nos 29 – 33 Willoughby Road over the last 100 or so years, but the deposit continues for a depth below proposed basement slab level which varies considerably and does so over short distances, as shown by EGL BH1 and BH2 records. Some possibility of uneven settlement and/or uplift of ground supporting a conventional basement shell exists.

15. To avoid the uncertainties associated with the ground conditions immediately below the basement, and to facilitate groundwater flow, piles will support the construction proposed and reduce any ground heave caused by the excavation. They will also be arranged to support underpinning below perimeter walls in such a way as to increase wall resistance to inward movement during the construction period.

16. Within the basement and ground floor, the Architect's design calls for an open plan and, in the rear extension, significantly glazed external walls. The structure will be inserted as a steel frame.

17. The measures already described will avoid potentially harmful changes to the current state of the boundary retaining walls. Nevertheless, site clearance at the start of the works will allow excavations to be made to examine the concealed backs of the walls. At this stage, the scheme makes provisional allowance for insertion of piles designed to strengthen ground in the site close to the oldest wall, at 39 Willow Road.

1.5 Final impact assessment

18. The following table lists potentially damaging hazards for neighbouring property that might be associated with basement construction in the site and the probability that they will occur when the basement is constructed as proposed.

Hazard	Damage probability
27, 29 and 33 Willoughby Road Differential settlement due to excavation Differential settlement due to tree induced subsidence	Categories 0-1; the use and arrangement of piles restricts lateral and heave movement within the excavation and settlement beyond. The probability of subsidence movement is negligible.
Retaining walls bounding the site. Increase of destabilizing ground pressure on walls. Reduction of resistance to destabilizing forces	Negligible; the older wall of Nos 39 and 40 Willow Road will not be affected by the works. Construction of the basement will remove some of the ground that causes pressure upon other parts of the wall and reduce the destabilizing force Negligible: any change of the groundwater regime will be insignificant and resistance to destabilizing forces will not be affected.
Willow Cottages Differential settlement due to excavation Increased probability of groundwater flooding.	Negligible; analysis of damage risk shows that the level of risk for Willow Cottages falls within Category zero. Negligible; change to the current groundwater regime will be negligible.

1.6 Response to July 2010 Audit Query Tracker by Campbell Reith Hill LLP

19. The report has been amended in consideration of the Tracker. Main reference locations are cited in the following table. Other relevant amendments have been made to the text and locations of all alterations may be identified by vertical lines added to the right hand page margins.

Query No.	Subject	Comment	Reference
1	BIA	Screening questionnaire completed	5.1
2	BIA	Drg. 101 amended & dimension added following extended survey and adjustment of basement profile	App'x D
3	Subterranean flows/stability	Groundwater regime reassessed using new information. New analyses provide conservative estimates of groundwater flow and variation. Proposal amended.	3.6, 4.3, 4.7, 4.8, 8, App'x E
4	Subterranean flows/stability		
5	Subterranean flows	Search of basement permissions and possible c19 construction extended. None adversely affect or affected by current proposal.	3.2, 11.4
6	Stability	Method statement amended, underfloor drainage omitted and transfer of load to piles justified.	9.32, App'x E
7	Stability	Analyses extended. Contour plots for sections provided but not for plan views. Data extracts are tabled and provide numerical results related to accompanying drawings which allow all situations to be examined.	App'x E

2.Introduction

2.1 Instructions and purpose of report

20. Eldred Geotechnics Ltd (Eldred's) are appointed by Manuela Eleuteri (the client) to undertake and provide this basement impact assessment report to support a planning application to Camden Local Planning Authority for permission to construct a basement and alter the existing ground floor at 31 Willoughby Road NW3 1RT. This is termed the project. A planning proposal for the project has been prepared by Ungar Architects of 10 to 12 Perrins Ct, London NW3 1QS.

2.2 Information provided by the client

21. Planning application 2016/7146/P was supported by a basement impact assessment (BIA) prepared jointly by Geotechnical and Environmental Associates (GEA) together with their specialist consultants, and Richard Tant Associates who were then structural engineers for the development. The proposal met with considerable opposition from local residents and the provisions of the BIA failed to satisfy Campbell Reith Hill (CRH), consultants to the local planning authority. In 2018 the application was withdrawn and the involvement of GEA and Richard Tant Associates ceased.

22. Information acquired and reported by Ungar Architect, GEA and Richard Tant Associates for the client's beneficial use with respect to the development has been made available by the client for selective use by Eldreds under their appointment. Documents which have been adopted by Eldreds are listed below. Factual data within these documents that is relevant to this project have been accepted and used as appropriate but interpretive statements and opinions within the documents have been disregarded.

Document list

(a)	Blueprint Surveys Ltd	Land & measured building survey
(b)	Ungar Architects	Existing & proposed building plans & sections
(c)	UK Power Networks	Asset plans
(d)	National Grid	Asset plans
(e)	Thames Water	Asset location search & plans
(f)	Metro Rod	CCTV Drain survey & report
(g)	Landmark Information Group	Envirocheck report

Document list

(h)	Landmark Information Group	Historical large & small scale OS maps
(i)	Evans River & Coastal	Flood risk assessment for proposed basement
(j)	GEA	Basement impact assessment appendix part 1B – Records of ground investigation fieldwork and laboratory testing

2.3 Other sources of information

[1] Internet source: Baker T. Bolton D. Croot P, 'Hampstead: Public Services'. A History of the County of Middlesex: Volume 9, Hampstead, Paddington, ed. C R Elrington (London, 1989), pp. 138-145 http://www.british-history.ac.uk/vch/middx/vol9/pp138-145

[2] Internet source: Baker T. Bolton D. Croot P, 'Hampstead: Hampstead Town'. A History of the County of Middlesex: Volume 9, Hampstead, Paddington, ed. C R Elrington (London, 1989), pp. 138-145 http://www.british-history.ac.uk/vch/middx/vol9/pp138-145

[3] Objections to application 2016/7146/P lodged on the Camden Planning Portal

[4] Clayton C.R.I. (1995) The Standard Penetration Test (SPT): Methods and Use. CIRIA Report 143.

[5] Powrie W. Preene M. (1994) Time-drawdown behaviour of construction dewatering in fine soils. Geotechnique 44.(1).pp83-100.

[6] Terzaghi K. Peck R. B.(1967) Soil mechanics in Engineering Practice 2nd Ed. Ch.3

[7] Cording E.J. Long J.L. Son M. Laefer D. Ghareman B. (2010) Assessment of excavation induced building damage, Proceedings of Earth Retention Conference 3. ASCE 2010.

[8] Potter G.W. (1904) Hampstead Wells. Published by George Bell & Sons & reprinted by Carlile House Press 1978.

[9] Planning application 2019/5141/P for alterations to 33 Willow Road

3 Desk study 1. Current and historical surficial site environment.

3.1 Location and topography of site and region

23. No. 31 Willoughby Road (the site) is situated at a height of 85.50m above Ordnance Datum (AOD) on the west side of Willoughby Road and midway between its junctions with Willow Road and Denning Road. The property has a National Grid Reference 526730E,185854N and this study is limited to a region within 250m radius of the site centre; broadly between, respectively, Hampstead High Street and East Heath Road to south and north and Well Road and Downshire Hill to the west and east. This is the area covered by the smallest of the circles marked on the maps included in the Envirocheck report in Appendix A.

24. Figure 1 shows the site together with contours at 2m intervals of height which are derived from Environment Agency Lidar data and superimposed upon an O.S. plan of the immediate area. Contours define a valley which falls eastward approximately along a line slightly south of Willow Road to the lowest of the Hampstead ponds. The site is situated on the south slope close to the valley head. Ground slope and slope direction vary locally within the region. Averaged over the ground above the site, the approximate general ground slope is 1:10. Maximum slope direction follows the valley form, aligning with the southern part of Gayton Crescent before turning northward on the line of Willoughby Road.

25. Nos. 29 and 33 Willoughby Road are on the south and north sides respectively of No.31. Refer to drawing G1808-PA-001-E1 which shows the northern boundaries of Nos. 31 and 33 with 33 to 40 Willow Road, a terrace otherwise known as Willow Cottages. A retaining wall at the boundary line supports ground in the Willoughby Road properties between 2.0m and 2.5m above the passage giving rear access to the cottages. With a height of about 83.1m AOD, the passage floor is lower than Willow Road, which is between 85m and 88m AOD in front of the cottages and lower also than Willoughby Road, which has a height of about 84.5m AOD next to the passage entrance.

26. Ground to the north of the cottages falls towards the cottages with a general gradient of about 1:10 in a direction 20 degrees south of east with an incidence of 30 degrees to the cottages, which are oriented with the length of the terrace at 10 degrees north of east..

3.2 Current land use and history of development within the region

27. Current land use in the region is almost entirely residential with trade uses listed in the Envirocheck report being for commerce and confined to the High Street area. No. 37 Willow Road is listed as having commercial cleaning use, but the named Company is described elsewhere as art consultants, possibly no longer active.

28. Reference [1] shows that Willow Cottages were built at some time between 1850 and 1860. and that by 1871 housing development to form Gayton Road and Crescent had commenced in land then owned by a Norfolk lawyer. According to the title deed of 31 Willoughby Road, The British Land Company Ltd too seem to have acquired a large amount of land in the area, apparently including most of what maps then showed as the garden of 14 Gayton Crescent. In 1877 British Land sold part of this "garden land" as the plot of 31 Willoughby Road, and the remainder became Nos. 29 and 33. From the appearance and timing of their buildings, it seems likely that the three plots were bought by the same person but were developed at different times. Nos. 29 and 31 strongly favour 19th Century construction and No.33, in later style, was on the registry plan in 1903 when No.31 was registered immediately following the introduction of compulsory registration in London.

29. Early historical maps in the set obtained by GEA and provided by the client do not reflect the above dates. It is therefore relevant to what follows to point out that the earliest map, apparently published in 1879 is identical in all material respects to another acquired by Eldreds for this BIA which was published in 1870 and based upon an 1866 survey. The map has been added to Appendix A.

30. The survey depicted the Willow Road cottages with a small area of woodland and otherwise open ground to the south and streams flowing down to watercress beds on the valley floor. Land to the west, now developed with Gayton Road and Crescent, was also used then for watercress beds. An open stream flowed from the future line of Gayton Road curving to align with the west end of the cottages and then flowed down the valley to join the River Fleet at the lowest of the Hampstead ponds.

31. Potter [8] was the contractor for roads and buildings of Gayton Road and Crescent. Interpreting his account, ground above what became Gayton Road (up to about 1870 the rear of Gardnor House) must, at some much earlier time, have been filled across a quite deeply eroded valley. Before the valley below was filled for development, Potter estimated it to be about 30 feet deep. There was a brick conduit in the steeply banked face of the ground below Gardnor House. Excavation before development revealed two adjacent conduits with the original stream bed concealed below a further 4 feet of

fill in the valley floor. Water from the spring was finally conveyed by a pipe drain into the new adjacent deep sewer under Gayton Road.

32. The construction of piped sewers in Hampstead started in 1850 and was complete by 1872 [2]. Interest in developing the region of the site coincided with these works.

33. The aggregate night time bomb census 07/10/1940 to 06/06/1941 reported on the Bombsite web page records a high explosive bomb in Gayton Crescent but there is no indication of building damage on the post WW2 maps. Gayton Crescent gardens extending to Willoughby Road were divided and developed for housing in the 1950s.

34. In the 19th Century and until 1932, land next to the high street, between Gayton and Willoughby Roads was used for the Hampstead Brewery. Later, until being redeveloped for housing in about 1970, the land was used by the motor trade.

35. A scan of the Camden Council Planning Portal for the number of successful planning applications in recent years involving construction or extension of basements in local roads revealed the following information:

Willoughby Road	Nos 1, 2, 21, 27, 34, 44.
Willow Road	Nos 8, 57
Gayton Crescent	Nos 20-22, 4-5.,
Gayton Road	Nos 15, 21, 28, 33, 35
Rudall Crescent	Nos 37, 39

No 29 Willoughby Road has a shallow coal cellar and most of the older terraced houses in the area are likely to have been built with either similar coal cellars or lower ground floors. The lower ground floors of Willow Cottages, Nos. 33 to 41 Willow Road, constitute one large basement.

3.3 Existing structures - 31 Willoughby Road

36. Drawings in Appendix D have been prepared by reference to the measured site survey, Architect's design drawings and inspection of the premises. The original house was of Edwardian age, attached to No. 29 on its left side as seen from the front, and with its right side being an exposed flank wall. There was a rear extension which was narrower than the front part. A narrow coal cellar at the left side extended over the length of the front part of the building, which had 3 levels of above ground accommodation below the roof space. The rear extension had 2 floors of accommodation with a flat roof above and was surrounded by a ground floor conservatory.

37. All external and party walls are of solid brickwork. Internal walls are of solid brickwork in the ground floor and studwork above. Floors are of timber joist and board overlaid with hardwood timber strip finish; span indicators on the drawings have been assumed from experience.

38. In the 1990s the rear roof became a tiled terrace and a window in the main rear wall was enlarged to provide an access doorway.

39. Prior to the 1990s the building had been converted into apartments. A 1992 planning drawing in Appendix A shows a plan of the ground floor at the time and the scheme which altered the ground floor to its current arrangement. Notably, the opening between front and rear living rooms was widened and a large part of the weight of the rear extension first floor, walls and roof was transferred to the back corner which is the nearer No.33.

40. Perhaps due to redistribution of the building weight the rear extension has settled slightly causing slight cracking in the party wall with No.29 at the junction of the front and back parts of the building.

41. At some unknown time, possibly during conversion to apartments, the roof space above 2nd floor became habitable space now used as a study. In the process, much of the roof weight was transferred to the party and external flank walls.

42. With the exception of some small planted areas occupying about 2.5% of the plot area all external surfaces are covered by impermeable surfaces, which drain to the public sewer. At the west end of the paved area is an approximately 8m high Horse Chestnut tree which has been heavily pollarded. According to planning records pollarding to this state has been undertaken on a 3 to 5 year cycle since at least 1996.

3.4 Existing structures - 29 Willoughby Road

43. No inspection has been made of the property and very few planning records exist. Those that are available, however, indicate that this property too was once divided into apartments and for present purposes it has been assumed that the house is sufficiently close to a structural reflection of 31 Willoughby Road to be considered as such.

3.5 Existing structures - 33 Willoughby Road

44. The house was built after No.31 and enclosed upon the flank wall of the existing building. No internal inspection of the property has been made. For present purposes the internal arrangement of the house has been sketched provisionally following sight of drawings by Guard Tillman Pollock Ltd published on the Camden Planning Portal for

a withdrawn planning application. They suggest that the structure and its force paths to foundations are rather fragmented.

3.6 Existing structures - Willow Cottages

45. The 3 storey terrace was built about 170 years ago in watercress fields with the lower ground floor level of the houses about 2 to 2.5m below ground level in what became the plots of Nos.31 & 33 Willoughby Road, and about 3m below ground level on the front, Willow Road elevation. The lower ground floor of the terrace thus constitutes a one storey basement some 38m long x14m wide.

46. Reference [3] is helpful; it agrees with the Authors' prior opinion that the terrace was probably constructed by excavating a wide trench which allowed the houses to be built with a horizontal roof line in the rising ground. Allowing for construction thickness, the resulting excavation would have been slightly more than 1.5m deep at the eastern end increasing to more than 2.0m depth at the opposite end. The volume of soil removed would have been some 1600 cubic metres after bulking.

47. Investigations for reference [9] found the footings of the flank wall close to Willoughby Road at a depth of 3.78m below general garden ground level next to the building (about 1.5m below the passage which provides access to the basement at the rear of the houses). Founding depth elsewhere is unknown. That said, the residents' group statement refers to poor footings. It also points out that the lower ground floors of the houses are of timber with air space below and probably little to prevent any tendency for groundwater to rise and flood.

48. The front and rear walls of the houses are not overly perforate, and they are restrained by the party walls at regular intervals Some distortion has occurred, however, seemingly necessitating the installation of tie bolts, which are evident on the face of some units. One resident's objection also refers to a surveyor's opinion that expansion of front and rear walls has caused damage to one of the end houses.

49. Drainage for the building is shown on a plan obtained from the National Archives for reference [9]. Below the rear access, 9 inch and 12 inch diameter glazed pipes were to serve Nos. 33-35 and Nos 36-41 respectively. They are shown joined to a brick oval or egg sewer passing diagonally below Nos. 35 and 36 towards the sewer in Willow Road close to the junction with Willoughby Road. By reference to the Thames Water information in Appendix A and using minimum gradients, conservatively estimated maximum sewer trench depths are 1.6m at No. 36 reducing to 1.4m at No.39.

3.7 Retaining wall between Nos.31, 33 Willoughby Road and Willow Cottages

50. Reference [9] National Archives plan shows that the houses were to be built 7ft from an existing “old wall” rising from basement level. The construction of the retaining walls supporting ground opposite Nos. 33 to 38 Willow Road is completely different to that in Nos. 39 and 40. Plate 1 shows the 33 to 38 wall viewed from Willoughby Road and plate 2 is a photograph of the much older wall at No 39 taken in 2013 in consequence of an earlier instruction to Eldreds from the present client.

51. Plates 3 and 4 provide enlarged extracts from the 1:2500 scale O.S. maps published respectively in 1870 and 1954. The 1870 publication, based upon an 1866 survey, provides more detail than later editions; paths to the front entrances of the cottages and small outbuildings (probably sanitary installations) in the back yards are evident. It is also clear that all the party walls then extended to divide the plots and support the retaining wall. The party wall extensions are just visible on the 1949 aerial photograph in Appendix A but those separating Nos.33 to 39 Willow Road had been removed by the time of the survey for the 1954 publication. Drawing G1808-PA-001-E1, based upon the 2014 measured survey, shows a 102mm thick partial dividing wall has since been built between Nos 38 and 39 and that the more recent retaining wall to the east is set forward of the wall at No.39

Plate 1 Rear access 33 – 38 Willow Road

Plate 2 Retaining Wall at 39 Willow Road 2013

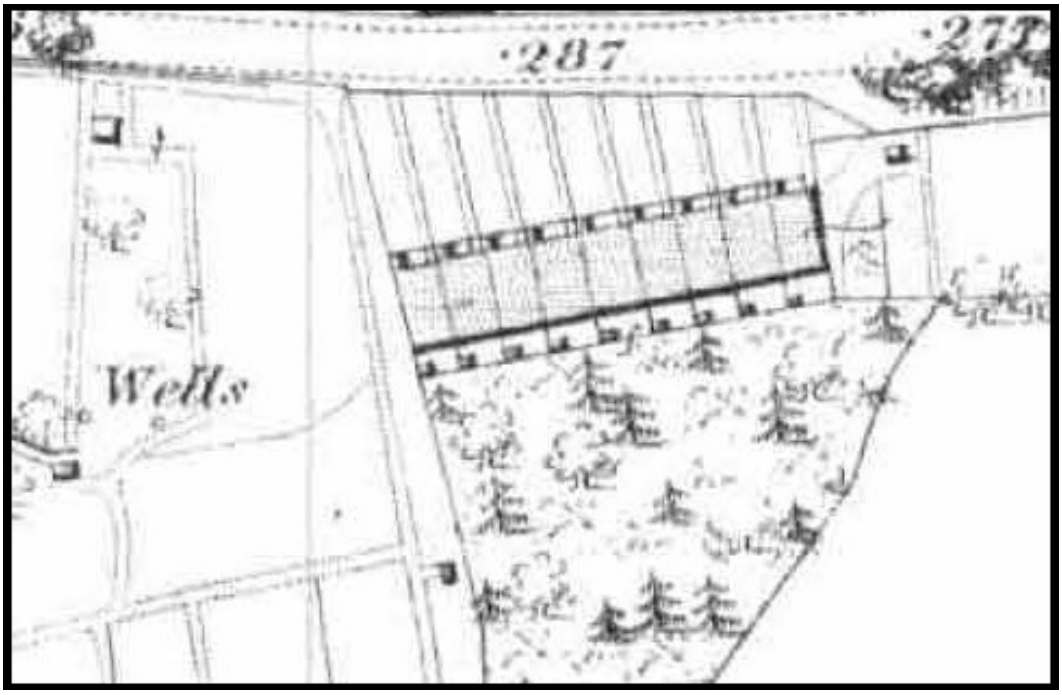


Plate 3 Willow Cottages 1866

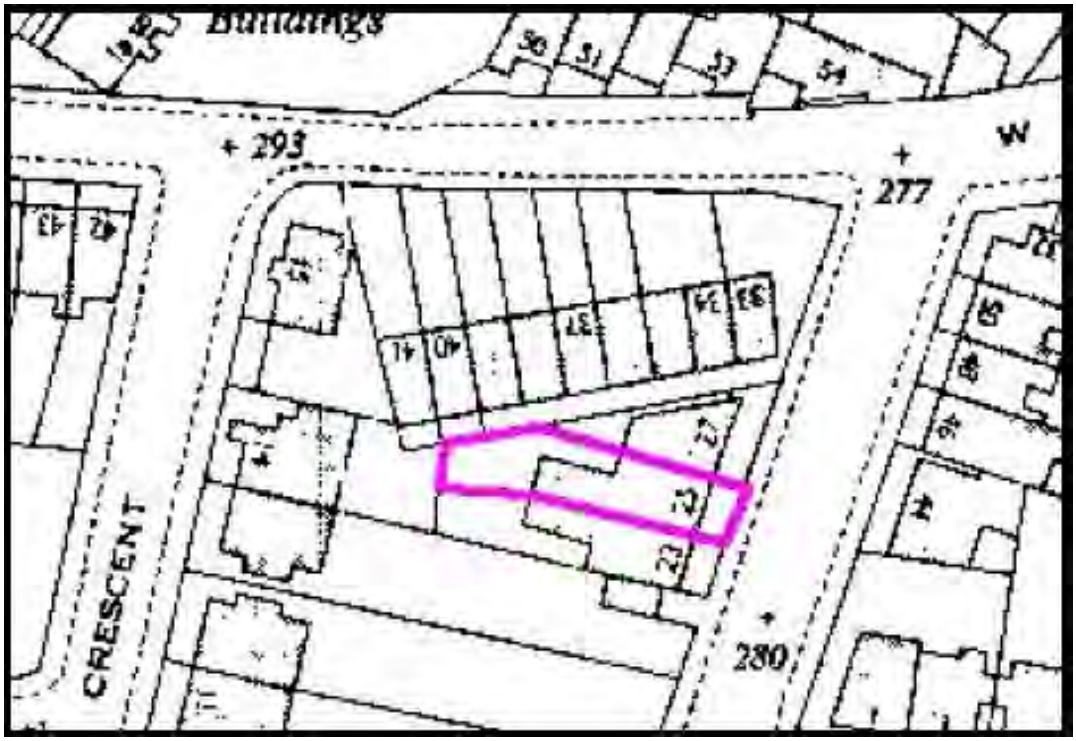


Plate 4Willow Cottages 1954

52. A logical explanation for the differing walls stems from the removal of the party wall extensions and need of a structurally different form of support for the ground and buildings of 31 and 33 Willoughby Road. The proximity of both the cottages and Willoughby Road buildings to the boundary, and the difficulty of removing and replacing the original wall would have prompted extreme caution. Demolition of the old retaining wall seems likely to have been avoided by building the new wall against it. Buttresses were added next to No.33 Willoughby Road.

53. Eldreds involvement with the 39 Willow Road retaining wall in 2013 resulted from the client's concern for the stability of ground in 31 Willoughby Road consequent upon the removal of the small outbuildings in 39 Willow Road that had abutted and supported the wall. on the 31 Willoughby Road boundary. At the time it was assumed that the developer of No.31 had built the thinner upper part of the wall behind the original wall and on a separate shallow footing to permit filling to achieve a level site. Eldreds approximate stability estimates made on this assumption and without good ground information suggested that the wall did not have an acceptable stability reserve. It has since been reinforced.

4 Desk study 2. Subterranean environment and surface hydrology

4.1 Regional geology

54. The 1:50,000 scale map for the area from the British Geological Survey, Sheet 256 North London (Bedrock & Superficial deposits. NERC 2006) shows the site to be located on the feather edge of the mapped outcrop for the Claygate Member of the London Clay Formation, which used to be called the Claygate Beds, and just above the London Clay itself. The map describes ground at and in the general vicinity of the site as having a propensity for “Head”; a deposit formed by the downslope movement of ground usually as mudflows and landslips. The mapped extent of the Claygate Member is shown by the Envirocheck report.

55. There are no mapped landslides in the region; the British Geological Survey database referenced by the Envirocheck report indicates a very low risk of such movement at the site and it is only at the northwest and southeast extremities of the region that the hazard propensity rises to low.

56. The database refers to the risk of ground subsidence or swelling movement at the site as moderate only; although part of the London Clay Formation, the Claygate Member has a much lower propensity for such movement than the London Clay below.

57. There are no known occurrences of anthropologically worked ground in the region but from the account given in reference [8] and previous investigation by GEA there is filled made ground in and around the site. This is supported by reference [9] which reports made ground extending to a depth approaching 4m below garden level in Willow Cottages.

58. Records of the British Geological Survey on open access record a deep borehole located approximately 60m south east of the site and stated to be in land of the former Hampstead Brewery. The record cited is badly located; as noted in section 3.2, the brewery was situated in the High Street and a duplicate record is located to the correct position. The well record is nevertheless helpful in that it confirms the general geology to expect for the area and that the London Clay extends to 5m below sea level and is underlain by the sediments of the Lambeth Group, the Thanet Sand and Upper Chalk.

4.2 Hydrogeology

59. The site is located on a Secondary ‘A’ Aquifer as designated by the EA; the Claygate Member of the London Clay. It has the characteristics of Non-Productive Strata, as far as supply is concerned but carries ground water of significance to ground engineering.

Permeability of the deposit is variable and vulnerability of the groundwater within to mobile contaminants draining through the soil is high.

60. Below the Claygate Member, the London Clay has very low permeability and whilst storing water, effectively diverts most water draining from above along its surface gradient. The edge of the Claygate member is just below the site location and has potential to be a spring line.

61. The nearest groundwater source protection zone is more that 1000m to the south of the site.

4.3 Ground and groundwater information available for the study

62. Unusually, the study has the benefit of a prior ground investigation for the site. Records of the investigation, designed and conducted by GEA in January 2016 and supplemented by further work in July 2017 (the GEA Aug 2017 Report) are copied in Appendix B. Records of investigations at two other sites, 37/39 Rudall Crescent and 9 Downshire Hill, which were acquired by the authors while acting on behalf of residents have also been consulted in part for comparison with the GEA records. More recently, ground investigations at 33 Willow Road were reported in reference [9].

4.4 Ground and groundwater information – 37-39 Rudall Crescent

63. This site is located at National Grid reference 526688E,185783N. Two cable percussion boreholes, 10m (BH1) and 20m (BH2) deep were excavated in 2012 from ground levels of 93m and 92m respectively. BH2 and BH1 were respectively close to and remote from a 15m high mature sycamore tree. Measured groundwater level in 2012 was approximately 90.5m OD. A small superficial thickness of made ground covered the Claygate Formation which extended to an average depth of 5m (87.5mOD) and rested upon London Clay.

4.5 Ground and groundwater information – 9 Downshire Hill

64. This site is located at National Grid Reference 526894E, 185678N and is situated a short distance away from the Claygate Formation, where the immediate subsoil is mapped as London Clay. Shallow geomechanical conditions there are thus not relevant to this study. Groundwater level in 2010 was 73mOD.

4.6 GEA August 2017 Report

4.6.1 Information provided

65. The fieldwork conducted included:

(a) Two windowless sampler holes to 4.0m (81.55m OD) and 5.0m (80.5m OD) in the back garden of the property, and one in the front garden to 4.5m (80.9m OD). The plant used and borehole diameter(s) are not described but the depths achieved and absence of SPT tests suggest the use of hand held equipment with borehole diameters diminishing with depth.

(b) Two open drive boreholes were excavated in July 2017, one to 10m (75.4m OD) in the front garden and the other to 5.45m (80.05m OD) in the back garden with Standard Penetration test equivalents (SPT's) conducted at regular intervals of depth within each. Again, the plant is not described but hole depths, reference to 110mm diameter boreholes and the inclusion of SPT tests for each sampler length make the use of a Dando Terrier or similar rig fairly certain.

(c) Two dynamic probes in July 2017 to 6.0m in the front and back gardens respectively. Although the plant used is not described, these would have been made using the same equipment as for the open drive work but without excavation.

(d) The installation of standpipes in BH's 1, 2, 3, & 4 to provide access for the assessment of in-situ permeability from rising head tests and to observe and monitor ground water in each with time. Occasional measurements from February 2016 to July 2017 showed levels varying over the site area and monitoring period by slightly about a metre between 82.3m and 83.2m OD without obvious reason.

(e) The hand excavation of 6 shallow trial pits around the property to confirm the nature and depth of the foundations and their immediate substrate. Two of these, close to the boundary retaining wall, were extended by probing. They did not clarify the hidden construction of the walls.

66. Laboratory tests were made on selected samples recovered from the boreholes. Tests comprised 7 Atterberg Limit tests on samples from boreholes 1, 2 & 4 and a loss on ignition organic matter test on a dark grey sample from borehole 4. Limit tests classified the samples generally as having high plasticity; the sample of carbonaceous material from borehole 4 exhibited 6.2% by weight of organic material. The Environmental Laboratory Ltd analysed a specimen of the same sample using titration and determined an organic content of 3.3% by weight

67. Insitu penetration tests (SPT) were undertaken during excavation of boreholes 4 and 5 and dynamic penetrometer tests DP1 and DP2 were made on the same day. excavations revealed an unusual failure of the ground to rise above low strength classification until tests were made of soil at 5m and 4m below ground level in GEA

boreholes 4 & 5 respectively. From 6m below ground level, however, penetration resistance declined again to a very low value.

68. In their report, GEA added their own experience from a drill hole located opposite the site at 44 Willoughby Rd where they had encountered a “significant” thickness of Made Ground overlying orange-brown mottled grey clay with occasional brick fragments to 2.9m, covering “soft dark greyish brown silty clay with roots and wood fragments” to depths of 3.3m and 4.5m, above “firm becoming stiff clay (London Clay) to the maximum depth of investigation, of 8.0m”.

4.6.2 Comment

69. The relevance of the regional topography is that it provides a slope down which strata can move under the force of gravity. There is no suggestion that this currently constitutes a hazard but such movement must be expected to have occurred at this site in the recent (c20,000 years) geological past.

70. Investigations for the GEA Aug 2017 Report confirm the possibility of this basic geology, with GEABH4 providing the best profile of that investigation.

71. Data for BH4 collated from its log and other sections of the GEA report are shown in Appendix B Figure 2. The figure confirms the geology expected from the BGS map, it also shows that the ground is not as simple and straight forward as the GEA report suggests. The profile of SPT results with depth shows that initially low penetration resistance continued without improvement to 4m depth, increased between 4m and 6m, but then declined to an unusually low value at a depth of 10m.

72. Figure 3 of Appendix B compares the GEA and Rudall Crescent SPT results. There is some similarity between results for the two sites in the shallow material but divergence below 6m bGL is pronounced.

73. GEA dynamic penetrometer tests DP1 and DP2 encountered very low penetration resistance above depths of 3m below ground level but resistance then increased, slightly erratically, to the 6m depth at which they terminated.

74. Length to diameter ratios, and area ratios of the borehole samplers used by GEA with the types of equipment described cause very severe disturbance of samples recovered, which precludes meaningful laboratory tests of their shear strength. Dynamic penetrometer tests add helpful information about local variation but even when torque resistance of the ground to shaft rotation is measured as required by the British Standard (it is rarely done) there is no reliable relationship between blow counts and soil strength.

75. Consequently, the SPT results, correlated to undrained shear strength values [4] provided the only indication of ground strength in the site. At face value, they suggest that the undrained shear strength does not rise above 35KPa for the first 4m to 5m of site depth.

76. The weight of the two buildings carried by the party wall between Nos 29 and 31 Willoughby Road amounts to about 126KN/m length, which according to GEA TP1, is likely to have imposed a pressure of some 140KPa on the made ground below. Conventional bearing capacity assessment based upon the GEA report and ground strength noted above suggests that whilst such an applied foundation pressure ought not to cause ground failure, it should have caused the two buildings to settle and distort quite excessively after they were built.

77. That has not happened, but since the basement will cause the three buildings of Nos.29 to 33 to be supported at differing levels, determining the reason for the apparent lack of excessive historical settlement becomes important. The profile of mechanical properties with depth needs to be studied further.

78. Structural slab level of the proposed basement is to be at 81.95m OD, which suggests an excavation extending to 81,5m OD or lower. It is evident that excavation will go below the levels at which water was struck. The ground that will be affected by the excavation will have layers that are capable of carrying pulses of recharge following heavy rain discharged to soakaways and leaky drains through their more permeable horizons. These events are short lived and the occasional monitoring of water level, as has been done by GEA, does not reflect their hydrological potential. Further investigation is required.

4.7 Ground and groundwater information – 33 Willow Road [9]

79. The BIA for this property contains the substance, without detail, of a preliminary investigation by the RSK Group in 2019. Two boreholes excavated in the garden area next to the flank wall and approximately 9m apart. Both encountered made ground to a depth of approximately 4.4m resting upon clay. Groundwater, monitored for a 7 week period stood at 81.61mOD in both boreholes.

4.8 Hydrology drainage and flood

80. Groundwater levels measured on the same days at irregularly spaced intervals by GEA in 4 boreholes varied between 82.5m and 83.4m O.D. Variation over time within the set for a single borehole varied from 0.51m to 0.14m. Three rising head

permeability tests in standpipes in BH1 (3.28m deep) BH2 (3.82m deep) and BH4 (4.8m deep) gave k(m/s) values of 1.8E-8, 1.1E-7 and 1.5E-7 respectively.

81. In the 19th Century several streams flowed on the south face of the regional valley and towards the lowest of the Hampstead ponds, facilitating use of the land for watercress beds (see 3.2 above). Several wells existed to east and west of the site close to the route of the drainage path.

82. Although it was previously acknowledged that subterranean variations causing obstructions and conduits would affect the groundwater gradient, groundwater information then available did not permit a rational examination of this. Using information since published [9], gradients calculated from water levels in EGL BH1 & 2, GEA BH4 and Willow Rd (4.94%, bearing 37 degrees) show good agreement with those calculated from water level at 33 Willow Rd, together with sewer invert levels at the angle of Gayton Crescent and sewer inverts at junctions of Willoughby Road with both Rudall Crescent and Willow Road (gradient 5%, bearing 38 degrees). A 4.94% gradient, bearing 37 degrees has been adopted. The water level found in GEA BH2 is not conformable with this assessment and has been discounted. The reason for such a large difference in groundwater level between GEA BH2 and both EGLBH1 and BH2 is not currently known but it is possible that a locally steep gradient is associated with the proximity of the drain serving the Willow Road buildings; extended, the gradient between the EGL boreholes and GEA BH2 passes close to what is thought to be the base of the drain trench.

83. Measurements at 33 Willow Road showed no change of groundwater level over the approximately 9m distance between boreholes. This together with the rise in ground level from the front side of the terrace of the cottages suggests that the line of groundwater flow convergence passes below the cottages. Figure 15 shows the contours and adopted flow lines. The line of convergence has been defined to represent both the local fall line of the valley and to provide a line of symmetry for analysis which permits a conservative assessment of relative ground movement and damage risk assessment for Willow Cottages.

84. At present 97.5% of the site is covered by buildings and impervious surface and pipe drainage discharges all surface water to the public sewer. The proposed development will retain that arrangement.

85. The GEA Aug 2017 Report includes a flood risk assessment conducted by *Evans Rivers & Costal Ltd*. (Report 1543/RE/12-15/01 Rev a. January 2016). A copy is provided in Appendix B.

86. The assessment contains an important caveat to the effect that instructions for the assessment precluded consideration of risk both to property beyond the site and to any part of the site but the proposed basement.

87. Consultation of statutory requirements and industry standard guidance based upon historical records and climate change prediction is reported, and the outcomes are presented as report conclusions. The conclusions that the site is situated within rivers and sea Flood Zone 1, making all land uses appropriate that the site is not at risk of reservoir flooding and that risk of flood from Regents canal is low are adopted here as fact.

88. The following conclusions are adopted as fact solely in the context of the limitations placed upon the scope of the assessment by the caveat referred to above.

    (a) The risk of flood from surface water is low.

    (b) The risk of flood from sewers is low to moderate and the risk may be mitigated by introducing a non-return valve to the pumped system.

89. Comments concerning the risk of groundwater flood have not been adopted. They cite the BGS Groundwater Susceptibility Map and the Camden Strategic Flood Risk Assessment (SFRA), both of which are based upon historical events and current development, and upon the GEA report, which does not provide sufficient information for consideration of risk consequent upon the proposed basement construction.

90. The potential impact of the basement scheme upon flood risk to other property was not considered. Policy CC3(c) requires developers to consider the impact of development upon other property in areas at risk of flooding. The Camden SFRA considers that the passage at the rear of Willow Cottages currently has a low (0.1%) probability of surface water flooding risk but that the consequent flood hazard is significant, causing danger for most.

4.9 Geoenvironmental and ground chemistry information available

91. Appendix B includes a copy of report J15315 by Chemtest concerning the analysis of 4 soil samples for concentrations of a suite of determinands associated with ground contamination. Lead and arsenic were found to be resident in the site in concentrations above screening values in some samples. Subjecting the results to the mean value test predicted a 95% probability that the general site concentration would not exceed 42ppm for arsenic and 346ppm for lead.

92. One sample, from next to the front bay, was from ground containing charcoal and ash and exhibited higher than screening values of two PAH compounds, which are the

products of incomplete combustion. Statistically, these are outliers, spot occurrences atypical of the site as a whole and the different nature of the sample tested tends to support this conclusion. The same sample exhibited slight Total Petroleum Hydrocarbon (TPH) contamination; which again constitutes an outlier.

93. The required protocol for considering the risk of harm due to contaminants resident in the site, or either entering or leaving the site is to assess the combination of probabilities that there exists a source of contamination, a vulnerable receptor and a viable contaminant pathway between them. If any one of these is absent the risk becomes zero.

94. Information provided shows the following with respect to these 3 components of risk.

(1) Potential sources of contamination are ground in the site and contaminating land use in the region. The region is identified at section 3.2 above and displays no current or historical landfills that could be sources of soil gas and no current uses that are potential sources of contamination. Historically, land adjacent to Hampstead High Street had use first for a brewery and then for the motor trade. DEFRA R&D Publication CLR8 “Priority contaminants for the assessment of land” does not list breweries as a potentially significantly contaminating land use. The subsequent historical use of the brewery site for the motor trade might however have led to accidental spills of hydrocarbons into the ground. The predominantly eastward direction of groundwater flow, the usually volatile nature of lighter more mobile compounds associated with motor trade use and the fairly low mobility of heavier oils make the probability of the site having been significantly affected by this use very low.

(2) Potential site receptors are humans using the site and buildings. The principal off site receptor would be the Hampstead ponds, the lowest of which is about 500m from the site.

(3) Any linkage between contaminated ground in the site and humans using the land would be initially via skin contact. At present 97.5% of the site is covered by buildings and impervious surface and working arrangements for construction of the proposed development would necessitate replacement of planter soil in the remainder, removing the probability of a pathway to humans.

(4) Water draining downslope at shallow depth through the site and thence to the ponds provides a transporting pathway to the ponds for water soluble pollutants. Arsenic and lead, TPH and the PAH compounds benzo(a)pyrene and benzo(a)anthracene that were found at higher than normal concentration in one

sample are only sparingly soluble in water. The inefficiency of the linkage resulting from dilution and diffusion over a 500m flow path would make the soluble concentrations reaching the ponds negligible. In effect, the probability of a viable pathway is negligible.

95. Methods of pre-treatment, disposal and the need or not of acceptance criteria testing for waste arising are not considered for current purposes. They are matters for consideration by principal contractor and subcontractors for the proposed works and by waste facilities in the context of their individual permits.

96. A total of 8 samples were tested for pH and concentrations of chemicals which are potentially aggressive to concrete. Four samples were from shallow ground and four were from ground between 3.5 and 6.5m deep. pH values were all close to 8. Concentration in the shallow samples were negligible. Based upon the results for samples that were deeper but still within the zone where basement concrete will be placed, characteristic site values were: Sulphate 1040ppm, Sulphide 870ppm. Referring to BRE Special Digest 1:2005, in the presence of mobile groundwater, the Design sulphate class is DS-2 and ACEC class is AC-2.

97. No further investigation is required in respect of geoenvironmental and ground chemistry information.

5 Screening

5.1 Camden questionnaire

98. The Camden LPA requires planning applications for basements to answer a standard questionnaire. The following responses given to the questions within the three parts of the Camden document are drawn from the desk study reported in section 3 above.

Table 5.1.1. Surface Screening – Surface flow and Flooding	
Question	Response for 31 Willoughby Rd
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No. Figure 14 (Arup report) shows the site is not in this catchment area.
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	No. The surrounding hard standing areas remain unchanged.

Table 5.1.1. Surface Screening – Surface flow and Flooding	
Question	Response for 31 Willoughby Rd
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. There will be no change
5. Will the proposed basement result in changes to the quantity of surface water being received by adjacent properties or downstream watercourses?	No. The surrounding hard standing areas remain unchanged.
6. Is the site in an area known to be at risk from surface water flooding such as South Hampstead, West Hampstead, Gospel Oak and Kings Cross, or is it at risk of flooding because the proposed basement is below the static water level of a nearby surface water feature?	1st Question: Yes. Although surface water flood risk for the site is very low, the passage behind Willow Cottages has a low (0.1% probability) of flood risk which generates a significant (danger for most) hazard. 2nd Question: No. There are no nearby surface water features.
Aspects requiring Scoping	Potential impact of proposed basement on flood risk for Willow Cottages.

Table 5.1.2 Subterranean Screening - Ground water	
Question	Response for 31 Willoughby Rd
1a. Is the site located directly above an aquifer?	Yes. The site is located on a Secondary 'A' Aquifer as designated by the EA; the Claygate Member of the London Clay. It has the characteristics of Non-Productive Strata, as far as supply is concerned but carries ground water of significance to ground engineering.

Table 5.1.2 Subterranean Screening - Ground water	
Question	Response for 31 Willoughby Rd
1b. Will the proposed basement extend beneath the water table surface?	Yes.
2. Is the site within 100 m of a watercourse, well (used/disused) or potential spring line?	Yes. Several historical wells were located to the east and west of the site but were "lost" between 1879 and 1896 when these areas were developed with the existing residential properties. The site is located close to the mapped boundary between the Claygate Member and underlying London Clay.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. The surrounding hard standing areas remain unchanged.
5. As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	No. The majority of run-off from hardstanding will drain to the sewer system, as it does currently.
6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to or lower than, the mean water level in any local pond or spring line?	Yes. The formation level for the basement is probably at or just below the elevation of the spring line between the Claygate Member of the London Clay and the London Clay itself.
Aspects requiring Scoping	The current and predicted post development ground water regimes in the site including variation with depth and

Table 5.1.2 Subterranean Screening - Ground water	
Question	Response for 31 Willoughby Rd
	time and potential impacts upon groundwater flood risk.

Table 5.1.3 Subterranean Screening - Land stability	
Question	Response for 31 Willoughby Rd
1. Does the existing site include slopes, natural or manmade, greater than 7°?	Yes. There is a retaining wall adjacent to the property across which a difference of approximately 2m occurs
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No. The elevation of the sites on either side of the retaining wall will remain unchanged
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	Yes. As answered to Q1. There is a retaining wall adjacent to the property across which a difference of approximately 2m occurs
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No.
5. Is the London Clay the shallowest strata at the site?	No. On the BGS map the site is underlain by the Claygate Member of the London Clay but at the feather edge of its outcrop.
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained	No. The existing tree on the rear part of the site is subject to a tree protection order (TPO).

Table 5.1.3 Subterranean Screening - Land stability	
Question	Response for 31 Willoughby Rd
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	There is no factual history of subsidence damage in the surrounding area or at site. No.31 is cracked; cause unknown. Other buildings too have cracked with cause anecdotally attributed to subsidence but not demonstrated.
8. Is the site within 100 m of a water course or potential spring line?	Yes. The BGS map shows the site located just above the mapped boundary between the Claygate Member and underlying London Clay.
9. Is the site within an area of previously worked ground?	According to the BGS lexicon and map there is no worked ground but made ground, which has been raised by filling does exist in both the site and surrounding land.
10a. Is the site within an aquifer?	Yes. The site is located above a Secondary 'A' Aquifer as designated by the EA. Although no longer used as a source for supply it carries water of significance to ground engineering
10b. Will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Possibly, depending on the water level at the time but dewatering as such is unlikely although the need to manage groundwater should be expected.
11. Is the site within 50 m of Hampstead Heath ponds?	No
12. Is the site within 5 m of a highway or pedestrian right of way?	Yes. The site fronts onto a public road, with pedestrian right of way.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No

Table 5.1.3 Subterranean Screening - Land stability	
Question	Response for 31 Willoughby Rd
Aspects requiring Scoping	Verification of the ground across the site and confirmation of its mechanical properties in relation to the proposed basement and retaining wall. Further assessment of the cause of existing crack damage in the property.

5.2 Scope of further investigation required

99. Not enough was known about ground and groundwater conditions for the design of the basement, for site specific assessment of subsidence risk and for protection of neighbouring property and the boundary retaining wall.

100. The declared scope of Evans Rivers and Coastal 2016 flood risk assessment did not satisfy the current requirement of Camden 2017 Local Plan Policy CC3(c), and assessment of groundwater flood risk did not and could not account for the potential effect of change resulting from basement construction.

101. It was considered that further ground investigation could provide the means of dealing with the hazards potentially associated with these matters.

102. Matters relating to Utilities and ground contamination require no further Scoping.

6 Factual report of further ground investigation undertaken

6.1 Design

103. The aim of the work was to:

(a) Provide ground samples which were sufficiently indicative of insitu conditions to permit reasonable assessment of insitu fabric, consistency and structure, including features linked to the site's recent geological history.

(b) Enable reliable results of classification and undrained shear strength tests performed according to British Standard methods to be obtained.

(c) Sample particularly within the depth affected by the proposed excavation and at the depths where changes in strength had been detected by the GEA Report August 2017.

(d) Enable Standard Penetration Test profiles obtained by the British Standard method to be compared to the pseudo SPT profiles obtained by the equipment employed for the GEA Report.

(e) Measure and enable the long term characteristics of the groundwater regime and its response to rainfall to be understood.

Although an eventual requirement, excavation of further trial pits close to the boundary wall and deep enough to determine wall constructions was considered impracticable whilst the garden is in use.

6.2 Execution

6.2.1 Fieldwork

104. Two boreholes referenced EGL BH1 & BH2, which were 15m and 5m deep respectively were excavated in the rear garden of the property. Contactors for the works were PJ Drilling Ltd, excavations were made using a Dando 100 modular cable percussion drilling rig carried through the property and assembled at the points of investigation. These were dictated by the restricted area available for the purpose.

105. Locations of the EGL boreholes and previous excavations by GEA are shown by the site plan, Figure 4 in the report appendix.

106. To allow for multiple borehole standpipes, diameters of the EGL boreholes were 200mm from ground level to depths of 5m and 150mm thereafter

107. Continuous alternate U100 samples and SPT samples were taken from each borehole; failed U100 samples were recovered in disturbed bulk form. A schedule giving detailed descriptions of both bulk and disturbed samples seen and logged at site and of tube samples examined subsequently at the testing laboratory has been prepared by Dr. de Freitas and is included in Appendix C. Also in the appendix, Eldreds borehole logs in record the general nature of conditions encountered, the sampling and insitu testing carried out and water observations during drilling. In general, material descriptions in the borehole records are abbreviated from the de Freitas schedule.

108. During drilling, EGL BH1 encountered seeps of groundwater at depths of 2.8m and 13m; EGL BH2 did not encounter water.

109. Two standpipe piezometers with bottom caps and with geo-socks protecting the slotted lengths of their response zones were installed in each of the EGL boreholes. Within response zones the standpipes were surrounded by fine gravel and all other sections of borehole lengths to ground level were packed with bentonite pellets. Pressure

transducers, factory calibrated for immersed depths up to 10m and set to collect data at 10minute intervals, were suspended in each of the response zones. A barometric transducer, factory set for hourly data intervals, was suspended above ground in a sheltered location near the boreholes. Data gathering commenced on 24th August 2018. Similar transducers had been suspended during June in GEA BH2 & BH4 after their standpipes had been checked for silting. Data gathering had commenced on 18th June.

110. Data was periodically downloaded to check transducer performance.

6.2.2 Laboratory tests

111. Samples were collected from the site by K4 Soil Testing Laboratory on 17th August and stored pending instruction. Eldreds issued one schedule of tests required on 22nd October and a further schedule on 9th November following receipt of first results.

112. Tests undertaken were moisture content and Atterberg Limits, particle size distribution and unconsolidated undrained triaxial tests. Records are provided in Appendix C.

7 Interpretation of findings in context of scoping requirements.

7.1 Geology and constitutive characteristics

7.1.1 Eldreds boreholes BH1 and BH2

113. In Eldreds BH1, samples from Ground Level to 2.8m are typically Made Ground; between 2.8m and 3.5m this classification, based upon a highly disturbed bulk sample, is less certain but has been retained. Below 3.5m, the basic geology to be expected from an interpretation of the geological map of the British Geological Survey is present; viz. that a layer of transported strata, derived in part from the Claygate Member of the London Clay at its base and contributions from the Bagshot Formation, overlies in-situ London Clay.

114. The differences between these layers are easily appreciated from the PSD plots (Figure 6). Starting from the oldest, the in-situ London Clay:-

(a) BH1 Sample 16 from 7m has a particle size that is an almost 50 – 50 mix of silt and clay and typical of the London Clay in this part of London.

(b) BH1 Samples 14, 12 and 10, from 6m, 5m and 4m exhibited small quantities of sand in a silty clay as expected in material derived from the Claygate Formation

(c) BH1 Samples 5 and 4 from 2m and 1.5m show unnatural compositions ranging from coarse gravel to clay that are typical of man-made ground; fragments of brick were described from this section of the borehole.

115. This layering also is reflected in Eldreds BH2 where the PSD results confirm the stratigraphy; starting from the oldest:-

(a) BH2 Samples 14 from 4.5m and 11 from 3.5m have a PSD similar to BH1 samples 14, 12 and 10 which detected small quantities of sand as expected in material derived from the Claygate Formation in a silty clay.

(b) BH2 samples 8 and 2 from 2.5m and 1.0m show unnatural compositions ranging from coarse gravel to clay that are typical of man-made ground; fragments of brick were described from this section of the BH.

116. The plasticity of samples tested over this range (Figure 7, BH1 samples 4, 5 and 8) are similar and markedly different from those below indicating this ground is essentially an inhomogeneous mix of clay, silt and sand with its moisture content close to its Plastic Limit.

117. The plot of SPT vs depth for BH1 (Figure 12) implies that ground from 3m to 6m has a geological history that has been dominated by one process and the samples recovered from coring suggest that process was transport as part of mass movements down-hill during periglacial periods with associated disturbance from freezing and thawing. The same trend is seen in BH2 which extends only to 5m.

118. The SPT profile changes between 5m and 6m and the sample from that interval contains many structures (see the detailed sample descriptions in the factual report appendix); as follows:-

119. 5.0m – 5.45m. Firm grey very closely fissured clay going brown on the fissures. Fissures producing blocks 5cm -6cm across; clay in blocks @ PL. Between these blocks is soft grey clay on wet side of PL consisting of 1cm angular fragments forming a clay clast supported fabric in a soft clay matrix. Some of the boundaries between this soft clay and the blocks bounded by fissures are striated surfaces that are sub-horizontal and at 45°. Fine lace-like network of black fibrous rootlets on some planar surfaces. (Disturbed with what appear to be zones of concentrated mobilization; slope instability, valley bulge?).

120. Between 6m and 9m the gradient of the SPT shows no increase with depth and careful examination of samples from this interval revealed no obvious visible explanation for

this. Smooth horizontal surfaces were present which may be reflecting some period of transient unloading associated with the development of the post glacial topography.

121. Below 9m the Figure 12 plot of SPT vs depth for BH1 indicates a continuous sequence such as can result from a geological history of sedimentation, loading and unloading; typical of essentially undisturbed London Clay.

122. Laboratory testing of samples between 4m and 6m depth produced a linear increase in quick undrained strength with depth. There is then a hiatus until approximately 8m when the same trend appears to be re-established until approximately 11m. Deeper than that there is no trend to be detected. These samples were inspected, and no discernible reason could be attributed to the lack of trend other than their being close the Plastic Limit (Figure 7), possibly reflecting they had been affected by expansion on stress relief at extrusion.

7.1.2 GEA BH 4 reconsidered

123. GEA BH 4 (see Appendix B) is the deepest of the holes drilled by that investigation and extends to 10m below ground level; it is considered the best of the BH's from that investigation for illustrating the character of the ground.

124. Made Ground is recorded to 2.5m and overlies material described as containing gravel, silt and clay mixed with carbonaceous layers which could be palaeo soils. This is typical of material transported downhill from the Claygate by the processes of mass movement operating during periglacial conditions.

125. Below that, the ground has an SPT profile with depth which is very similar to that measured from Eldred BH1, even to the point of ceasing to increase with depth at around 5m depth, as seen in Eldred BH1 (Figure 12). Referring to Figure 3 in Appendix B, Rudall BH1 profile has the same trend, and there are feint signs of it in the Rudall BH2 profile also

126. Plasticity Limits and natural moisture contents measured in samples from BH4 were very similar to those measured from samples in Eldred BH1.

7.2 Interpretation of water levels with depth and time

127. Free groundwater was only encountered as a slow seepage at 2.8m and 13m in EG BH1, 3m in GEA BH1& 2 and 3.3m in GEABH4.

128. Four piezometers were installed on site, two in each of the Eldred boreholes and one in each of GEA BH2 and BH4. The water levels in each of these was monitored every 10 minutes and these observations are shown as a plot of water level with reference to

Ordnance Datum against time on Figure 8. Daily rainfall, measured at the time at *"NW3 Weather"* (nw3weather.co.uk) has also been plotted. The plot, aided by statistical analysis, provides the conservative assessment of water level shown by the drawings.

129. Objectors to the planning application have since questioned the suitability and accuracy of these rainfall records by comparing them with monthly totals measured by the meteorological office at Heathrow: Camden LPA advisers have requested a response.

130. The purpose of adding rainfall records to the groundwater information was to examine the possibility that short term variation producing peaks in the plots of groundwater levels might be associated with the varied population and severity of local rainfall events. Daily records were essential and, since rainfall varies over small areas, they had to be reasonably local. The "NW3 Weather" station is at the south-east edge of Hampstead Heath, slightly more than 1 km from the site. It is inevitable that the pattern of rainfall at Heathrow, 24Km west and with significantly different elevation and terrain, will differ from that at Hampstead. A high level of measurement accuracy was not necessary for the purpose of this exercise and, in any event, methods of rainfall measurement give at best, approximate values. That being so it is of interest to note that in the period 2010-2016 when both the Met Office weather station on Hampstead Heath and NW3 Weather stations, both automatic, were in operation, the two sets of records showed good agreement. Doubt concerning the suitability of NW3 Weather records for the purpose is not justified.

131. Also shown on the figure 8 plot are the existing site ground level, together with the approximate basement formation level and the Willow Cottages rear access. Figures 9, 10 & 11 provide existing and proposed cross sections through the site and nearby property and show a drain trench below the access way. Contrary to previous expectations, reference [9] indicates that the drain discharges, not to the Willoughby Road sewer but to the Willow road sewer. It is probable that the drain trench assists flow in that direction..

132. The 4 piezometers in Eldred boreholes took time to settle down, which is normal, and the shallow piezometers in BH1 and BH2 did so first. They reflected rainfall but being at 2.66m and 3.95m below ground level are less sensitive to rainfall than the GEA standpipes which extend from 1.0m to 4.0m. The GEA standpipes can readily pick up water that has not infiltrated to 1.0m but been discharged to the ground upstream from

leaky drains and soakaways, and thus their response to infiltration is more sensitive than that of the lower instruments.

133. Water levels in the lower piezometer in Eldred BH1 eventually followed those of the upper piezometer in that hole, suggesting the seal between them leaks.

134. Water levels measured at 2m below ground level by the latest investigation agree with the dampness and wetness of the samples recovered and the moisture content of the sample just below 3m. Although the water levels measured in the GEA holes reflect rainfall in a similar way to those measured in the Eldred holes, they are approximately 0.5m lower. This may be due to the length of the standpipes used (from 1.0m to 4.0m in BH2 and 1.0m to 5.0m in BH4) which permits any more permeable layers at depth to drain water from the pipes.

135. Water levels measured in the shallow piezometers in Eldred BH's 1 and 2 show the head at BH1W2, 3.95m bGL, is slightly higher than that at BH2W2, 2.66m bGL, indicating an upward component to ground water flow as would be expected from ground water flowing towards a valley floor that is above it. Pore water pressure at BH1W2 is about 19kN/m^2

136. The record of these shallow water levels also demonstrates that they shadow rainfall. This occurs most sensitively in the GEA standpipes in GEA BH2 and 3. The tops of their response lengths are within 1.0 m of ground level and extend to depths of 4m. Since the area is paved, it is possible they are detecting the effect of rainfall from soakaways and leaky drains trenched into the Made Ground above the site rather than that of rainfall upon the site itself.

137. The response in Eldred BH2W2 at 2.66m is slightly subdued compared with that for the same rainfall event measured in Eldred BH1 at 3.95m and suggests the piezometer in Eldred BH1 could be responding to changes in the saturated weight of the soil column above it; this could be a second indication that discharge from leaky services and soakaways is active in the Made Ground as such recharge would facilitate this sensitivity of saturated weight to rainfall.

138. Relative depths of the proposed basement and groundwater indicate that a basement would normally impede groundwater flowing in the general direction towards Willow Rd. Most of the water is travelling through the Made Ground as this is more permeable than the clay rich layers beneath; the bagged sample to this level (Table 4), which was something of a mixture from the upper levels, was wet.

139. Figs.10 & 11 also show the water levels with respect to the retaining wall. Considering groundwater flow as seen in plan (Section 3 & drawing G1808-PA-001) it is likely that a basement construction sealed to the clay below would act as a small dam and impound water slightly on its boundary with No.29. This would tend to lower the levels between No.31 and 33 and the retaining walls, however such changes would not be expected to be more than a few millimetres and possibly undetectable within the daily variation of water levels in response to rainfall.

8 Conceptual ground model

140. Nos. 29 to 33 Willoughby Road and 33 to 40 Willow Road are situated respectively on the south slope and floor of an east facing valley into which ground to the north, west and south slopes down at a maximum general gradient of approximately 1:10, which reduces in the vicinity of both the site and Willow Cottages.

141. Horizon of the undisturbed insitu London Clay is about 6m to 8m below ground level in No.31 and it extends for a further depth of about 100m to approximately 15m below sea level. Above the undisturbed clay are, from ground level, about 3m of made ground, 1.5m of periglacial head, which rests in turn upon at least 2m of disturbed London Clay. Disturbance of this layer too was caused by periglacial conditions.

142. The situation shows the periglacial effect on ground stability during the ice ages diminishing from flow at the surface to disruption of the deposited clay structure for a few metres below. Initially the ground reached a state of stability commensurate with the effects of gravity and climate. It then consolidated over time to develop its current strength and evidently adequate margin of safety. The trend of the ground strength profile shown by Figure 13 illustrates both the geological history and a possibly weaker zone between 6m and 8m depth.

143. Preliminary tests made by GEA in 2 of their boreholes suggested ground permeability values of E-8 and E-7m/s; an equally preliminary assessment based upon the latest monitoring suggests a lateral value of E-6m/s. The three estimates are all tentative but fall within the range expected for Claygate and Head materials in the area.

144. The direction and gradient of groundwater flow over an area of 54m x58m has been assessed by the 3 point planar method both in relation to groundwater monitoring records and on the assumption that flow is controlled by drainage to deep sewer trenches. The two separate assessments give identical results. For purposes of two dimensional numerical analysis the flow has been divided into components acting

normal to each of the flank and rear faces of 31 Willoughby Road. Figures 15 & 16 provide details.

145. A line of convergence of flow from north and south sides of the valley has been assessed by reference to ground contours, an area of the valley floor where groundwater gradient becomes zero and the need for analysis to maximise risk of damage. The convergence line represents a line of symmetry for the analysis.

146. Parametric values for properties of the materials described above are considered in Section 10.

9. Engineering – overview and structure

9.1 Risk

147. The overriding general concern is to demonstrate a practicable scheme which allows the proposed basement to be constructed without significantly increasing the risk of damage or other harm to neighbouring property. That is the requirement of the client, the local planning authority and, by inference, members of the public who registered objections to the previous planning application.

148. Considering these last, reference [3] contains some 31 objections to application 2016/7146/P by residents. Their concerns were: groundwater diversion (26), foundation movement (5), Damage generally (4) and vibration (1). The figures are not exact. Several residents objected more than once and some objected under more than one of the headings, but the strength of concern was evident.

149. That being so, and with intent to assist would be objectors to better understand the situation, a brief statement of assessment rationale, the situation revealed by investigation and the risk it presents precedes description of the proposed engineering method of minimising that risk.

150. Assessment of risk utilises the same tripartite source/pathway/receptor methodology outlined in section 4.8. The potential source is construction of the proposed basement. Receptors are Nos. 29 and 33 Willoughby Road, the boundary retaining walls and Nos.33 to 41 Willow Road (Willow Cottages). Ground and water conditions in the region have the potential to pathways or linkages by which the source might affect the receptors.

151. The existing condition and vulnerability of receptors and regional ground and water conditions are beyond the client's control. They have to be accepted for what they are and the basement source has to be designed and constructed accordingly. Before

conditions can be accepted for what they are, what they are must be determined to the extent necessary for the purpose.

152. Section 3 deals with the built environment and more particularly with 31 Willoughby Road and the identified receptors. All are of substantial age and were built as speculative developments. All are either known to have been altered or have features indicative of alteration. As far as can be judged, transmission of structural load to the foundations of Nos. 29 and 31 Willoughby Road and Willow Cottages is direct via continuous load bearing walls, but the path shown by drawings of No.33 Willoughby Road is indirect. Slight damage is visible in the party structure of Nos 29 and 31 Willoughby Road and Willow Cottages have suffered enough movement to justify tie bolts and surveyors' advice. The old retaining wall bounding 39 Willow Road had to be resupported in recent years.

153. There is nothing exceptional about these conditions in mature urban conurbations, but Willow Cottages were built in a large basement constructed over the route of a stream which drained the surrounding slopes and fed the River Fleet. Although the stream was culverted before the cottages were built, indications are that its route continues to influence natural drainage.

154. Assessment of relevant ground and water conditions, including flood occupy Sections 4 to 7 and are summarised by Section 8.

155. Hazards identified as potential sources of risk for receptors and that are material considerations for engineering design and construction are described in the following table:

Hazards	
1	**Nos 29 &33 Willoughby Road**
a)	Tree induced subsidence effect exacerbated by differing foundation depths.
b)	Subsidence due to groundwater draw down below adjoining property during construction. *Groundwater level will be approximately 1.5m above the depth of basement excavation and some dewatering will be required.*
c)	Excessive settlement of party wall foundations lowered by underpinning to basement depth.

Hazards	
	The deeper underpinned foundations for a conventional basement would impose more load upon the apparently weaker stratum between 6m and 8m depth than presently caused by the existing shallow footings
d)	Settlement of ground below adjoining property due to basement excavation
e)	Ground movement below adjoining property caused by diversion of groundwater flow.
2	**Willow Cottages retaining walls**
a)	Increase of pressure upon back of wall during construction or due to groundwater diversion.
b)	Weakening of earth support to wall foundation. *The depth of the wall construction is not known but it is estimated that the basement excavation will be about 1m deeper than the wall construction.*
3	**Willow Cottages**
a)	Ground movement below the cottages due to diversion of groundwater flow.
b)	Increase of groundwater flood risk in the low level access between the dwellings and the boundary retaining walls.

9.2 Design concept

156. The proposed scheme has been designed to reduce the potential hazards listed above to insignificance.

157. In Section 7 Dr. de Freitas makes the preliminary observation that the damming effect of a normal basement construction below No.31 would probably cause only millimetres variation of groundwater height to affect Nos. 29 and 31. The analyses reported in Section 10 and Appendix E confirm this prediction. Consequently, the below structure drainage system previously proposed has been omitted from the scheme. The negligible effect of the proposed structure upon groundwater flow also avoids any practical need of provision for lateral drainage around the exterior of the basement.

158. To avoid the uncertainties associated with the ground conditions immediately below the basement, piles will support the construction proposed and reduce ground heave caused by the excavation. They will also be arranged to support underpinning below perimeter walls in such a way as to increase wall resistance to inward movement during the construction process.

159. Within the basement and ground floor, the Architect's design calls for an open plan and, in the rear extension, significantly glazed external walls. The structure will be

inserted as a steel frame. Preliminary scheme drawings and structural design report are provided in Appendix C.

160. Drawings and preliminary outline calculations supporting the design concept are provided in Appendix D.

9.3 Construction method statement for permanent and temporary structural works

9.3.1 Preliminary

161. The statement refers only to the proposed structural alterations and describes one possible sequence of work. An internal waterproofing system complying with BS8102 2009 Type C Grade 3 will be provided.

162. The Klemm 702 piling rig with remote power plant will be suitable equipment for this site. Operating height can vary from 2.5 to 3.3m. Existing ground floor ceiling height is 3.37m from oversite level in the front section and 2.6m from existing slab level in the rear extension Allowing for a 300mm thick piling mat, a preparatory excavation of 0.5m below existing oversite and floor levels respectively will suffice.

163. In the construction phase, the principal contractor for the project will be responsible for the planning and adequate execution of all engineered works and for the design of associated temporary works. In that capacity, the contractor will be required to consult with the engineer to be appointed for the works by the client to ensure that such plans and designs are compatible with the engineer's design intentions.

9.3.2 Statement

Item	Description
1.	Survey verticality of Willow Cottages retaining walls and sewer below rear access; establish monitoring targets; measure normal preconstruction movement and vibration in Nos. 29 & 33 Willoughby Rd, Willow Cottages and retaining wall.
2.	Client to vacate premises removing items of value and any particularly heavy items in the upper floors as agreed with the engineer.
3.	Soft strip ground floor; excavate trial pits (a) to determine currently unknown foundation depths and constructions (b) to allow investigation of boundary retaining walls (c) to assess groundwater inflows and plan management technique.
4.	Reduce levels by approximately 0.5m as necessary to provide working height clearances above piling mat in the front part of the building and rear extension respectively. Leave safe berms against No.33 garden boundary and at the rear, beyond the line of the lightwell retaining wall.

Item	Description
5.	Beam B1. Needle below 1st floor crosswall, support 1st floor joists , remove ground floor wall insert padstone in party walls, install beam.
6.	Beam B2. Cut out pockets in rear main wall transfer the wall load to stools remove intervening brickwork on line of beam and insert beam working from front & back faces of wall.
7.	Beam B3 Support wall above at ground floor ceiling with Strongboys or similar remove ground floor wall and install beam. Connect to B1 & B2
8.	Remove part of rear main wall as show by Engineer's drawings.
9.	Beam B4. Insert Strongboys or similar above existing beam and anchored to trestle braced both ways. Support 1st floor joists. Remove ground floor wall and beam and install new beam in 2 lengths with splice. Connect to B2. Pin up to wall above and adjust trestle in stages to transfer support to beam leaving clearance at plunge column positions for piling.
10.	Beam B5. Provide temporary support as beam 4. Remove ground floor wall install padstone in party wall an install beam anchored to party wall. Connect to B4 clear of corner column position. Pin up to wall above and adjust trestle in stages to transfer support to beam leaving clearance at plunge column position for piling.
11.	Beams B6 & B7. Install padstones in party wall and install beam anchored to wall and connected to B4.
12.	Break out existing cellar floor, carefully excavate and remove existing walls and footings at plunge pile location probe for obstructions. Bridge cellar for piling rig. Backfill excavated pits at plunge pile positions, install piling mat at ground floor level and ramp as required for piling rig access.
13.	Install piles with cut off approximately 0.5m above formation level; install 1st lift of plunge columns with splice lengths above mat level. Test integrity of all columns and backfill empty bores with granular material.
14.	Install ground floor beams except B8, B9, B14 and columns except C4, C6, C11, C12. (install beam B10 using method described for B2).
15.	Chase out front face of chimney breast on party wall with No.29, install beam B8, connect to B6 & B7& pin up. Remove ground floor chimney breast.
16.	Chase out front face of chimney breast on party wall with No.31; install temporary gallows bracket and beam support at ground floor level.
17.	Reduce ground level in preparation for underpinning to safe extent having regard for determined footing depths and adjoining ground levels. Leave safe berms against the No.33 boundary and to the rear

Item	Description
	beyond the line of the garden retaining wall. Bolt walings to walls and install temporary props between party/external walls at reduced levels as work proceeds.
18.	Excavate and construct Type 1 RC underpins in sequence to be agreed (see suggested on drawing G1808-GA-03) supporting excavation faces as necessary with 20mm Portland cement cemboard or equal strutted against dumpling and cutting down piles using non-vibratory method. No excavation to be open withing 3m of another and 7 days minimum to elapse between completion of one pin and excavation for neighbouring pin type 1.
19.	Excavate for Type 2 underpins as Type 1, release proprietary edge shutter and bend out continuity rebars, prepare joint faces apply hydrophilic water seal and construct pins as Type 1.
20.	Excavate in short lengths and construct retaining wall adjacent to No..33 garden as underpinning method, taking support from piles cut down as work proceeds and strutting against dumpling.
21.	Hand excavate ground locally behind Willow Cottages retaining wall near lightwell, support ground below the wall with sacrificial trench sheets and extend No. 33 garden wall to form new freestanding lightwell wall without taking falsework support from or otherwise imposing load upon existing cottage retaining wall.
22.	Excavate in short lengths and construct lightwell retaining wall adjacent to No..29 garden as underpinning, taking support from piles cut down using non vibratory methods as work proceeds and strutting against dumpling.
23.	Modify the system of temporary support to provide best access for basement excavation and allow removal of trench props as work proceeds. The feasibility of partial ground floor construction to allow moling excavation to be considered.
24.	Excavate to formation level in sections spanning the width of the basement while maintaining temporary support as required to perimeter walls and ground, cut down remaining piles install pump chambers and drainage. Lay concrete blinding, prepare and construct basement floor slab. Floor strips to be limited to areas filled by one concrete delivery.
25.	Install remaining columns and ground floor beams B9 & B14.
26.	Construct reinforced concrete ground floor slab.
27.	Remove temporarily retained section of rear main wall.

9.3.3Groundwater control

164. Management of groundwater will be an intrinsic part of the construction sequence. It is anticipated that the overall rate of groundwater flow into both underpinning and subsequent general excavations will not be great but achieving the groundworks sequence will require forethought and management. Based upon the investigations made but subject also to item 3 of the schedule, flow is likely to occur primarily through vertical sides of excavations from lateral fissures and sandy lenses and laminations. In some areas the local use of non-woven geotextiles may be required to prevent excessive wash out and loss of fine material.

165. Sub-formation collector drains and filtered sump pumps will be required to manage ground water and prevent instability of formation.

166. Disposal of groundwater to the public sewer will require the agreement of Thames Water and compliance with their conditions.

10 Engineering – Geotechnical

10.1 Ground strength

167. Undrained shear strength values plotted on Figure 14 have been derived in two ways:

    a) Undrained unconsolidated triaxial compression tests (UUTxl) of nominally 100mm diameter specimens extruded from driven U100 lined tube samples.

    b) Correlation of SPT N values with shear strength, excluding tests made using a solid cone rather than a split spoon sampler.

168. Triaxial tests made at depths of 1.5m and 2m bGL gave high results which are atypical of the ground conditions and have been rejected.

169. The empirical relationship between SPT field test results and undrained shear strength has been assessed conservatively having regard for the comprehensive review of the test method and its uses provided by Clayton [4]. N60 values were calculated using a rod energy ratio of 70% and borehole diameter corrections of 1.15 and 1.05 respectively for the 200mm and 150mm boreholes. No correction was made for rod lengths less than 10m. A correlation factor of 4.5 was applied to N60 values.

170. Regression lines for the UUTXL and correlated SPT Cu values plotted upon Figure 14 show reasonable agreement. The regression line for all accepted tests has a gradient from 1m bGL of 25+13.1Z and is taken as the mean profile for Cu with depth.

171. Lateral ground permeability values adopted are:

Clay Made Ground, Head & Disturbed London Clay	1e-8 m/sec
Insitu London Clay	1e-9 m/sec

10.2 Numerical analysis

172. Four analyses have been made for the sections F1 - F4 shown by figure 16 using the FLAC version 8 2D software.

173. The principal purposes of the analyses were:

(a) to examine the effect of the proposed basement structure upon a sloping ground water level, and

(b) to allow the risk of damage to nearby property consequent upon construction of the basement to be estimated.

174. Derivation of the groundwater levels and gradient are described in section 4.8 of the report and the graphics for the three-point method used are shown by figure 15.

175. Geometry for each of the four sections analysed is shown by figures 17 to 23, which also identify the monitoring points recording analytical history for each of the analyses. In summary, the staged procedure used throughout was as follows.

1. The sloping phreatic surface was generated from fixed pore water pressure distributions acting upon each of the vertical boundaries and groundwater levels were derived from pore pressure recorded at monitor points situated along the fixed boundary at the base of the model. The drained analysis used throughout is a simplified uncoupled method provided by the program, which provides close approximation to fully coupled analysis.

2. Existing structures and ground surface profiles were added to the “greenfield” state for a further stage of analysis to simulate present conditions.

3. Piles, perimeter walls and bases and basement excavation were added, and pore water pressure approximately 1 m below formation level was fixed at zero on two lines to simulate following review of the data drainage. A drained analysis was run to model equilibrium to simulate full dewatering. Time stepping for this operation was subsequently found to be equivalent to approximately 2000 years.

4. The basement floor was added, fixed pore water pressures below the construction were removed and a further run simulated rehydration of the model.

5. Following data evaluation, the “dewatering” stage for a sample of the models was run for time steps equivalent to a one-year operation before allowing rehydration.

176. Staged variation of groundwater levels and ground displacements recorded at the monitoring points are reported for each of the sections models in tables which follow their respective model geometry figures. Figures 24 to 26 provide pore water pressure and saturation contours which illustrate conditions for model F3 following stages 2, 3 and 5.

10.2.1 Output interpretation and conclusion

177. The general forms of groundwater profiles generated by the analyses are as expected, as is the predominantly positive (upward) vertical ground movement extending from the excavations. Where it was possible to estimate existing building loads with reasonable confidence, principally below the party walls of No.31, the estimated foundation settlements were reasonably in accord with expectations.

178. The program does not model partially saturated ground, which results in some lack of smoothness in portrayal of the sharp divide between fully saturated and dry soil. This is accentuated by local variation of zone size. Nonetheless, the arrangement fulfilled the purpose of measuring pressure variation at a point.

179. Undrained analysis was not undertaken in the interests of examining drained end states. Consequently, groundwater lowering was introduced at the same time as basement excavation to prevent failure of the basement formation which would, in reality, be resisted by capillary tension. The basement excavation was modelled in a series of steps designed to limit exaggeration of impact by inertial forces.

180. Recovery following a simulated 12month period of dewatering (more realistically groundwater control) resulted in final groundwater levels which were closer to those of existing conditions than those calculated after equilibrium dewatering of the entire model. Values reported are for the greater of the two sets of variations and are conservative.

181. End values derived by numerical modelling are always approximations but it is concluded that those reported provide a reasonable basis for meaningful risk assessment.

11 Assessment of risk of damage to neighbouring property.

11.1 The effect of trees and of differential settlement

11.1.1 Trees

182. An 8m high Horse Chestnut grows in the rear garden of the site and although the species has only moderate water demand, in the right circumstances it could be a source of subsidence damage to buildings. The rear extensions of Nos 29 and 31 are

8m from the tree and, according to GEA trial pit TP5, footings there are slightly more than 1m below ground level. NHBC, an insurer, considers that buildings with foundations at that depth and at that distance from a tree having moderate water demand are not vulnerable to subsidence damage, no matter how prone the ground might be to shrink/swell movement.

183. GEA trial pit TP5 was continued as the 4m deep GEA borehole BH1, and no roots were observed. Soil samples taken in August 2018 within the 4m depth above the disturbed London Clay, exhibit plasticity indexes in the low to mid 20s, which is typical of a soil with only medium tending towards low shrink/swell potential.

184. Comparison of SPT values measured in GEA BH4 and EGL BH1 & BH2 with those of GEA BH5, excavated close to the tree, revealed none of the increase of penetration resistance near the tree that is usually observed in soils affected by the water demand of tree roots in summer months. The constancy of groundwater level through the year corroborates this observation.

185. Two of the three elements necessary for risk to be evident are absent, and the risk of subsidence damage is currently negligible. The proposed development has been designed to avoid change of the subterranean regime affecting or affected by the tree. Consequently, construction of the basement will not increase the current risk of subsidence damage to No.29.

11.1.2 Differential settlement

186. Analyses undertaken and reported in Appendix E indicate that change of the existing groundwater regime during and following basement construction will be negligible, There is no reason beyond the effects of excavation to suppose that the basement will cause differential settlement between No.31 and adjoining property. The effect of excavation is considered in Appendix E and is shown to be negligible.

11.2 Risk of damage to the boundary retaining walls and Willow Cottages

11.2.1 Retaining walls

187. Changes of the groundwater regime by the proposed basement will be insignificant, which means that water pressure upon the retaining walls will not be increased.

188. Ground pressure against the older wall at 39 and 40 Willow Cottages will be not be affected by the basement development.

189. Ground pressure against the short length of the newer wall which bounds the site will be reduced by the presence of the basement. It is ground within 1.5m to 2m from the back of the wall that causes pressure on the wall. Much of that ground will be replaced

by the basement and the effect of that will be to reduce pressure on the wall. The construction method statement provides for isolating the wall from construction effects.

190. Construction of the remaining rear part of the basement will not affect the existing retaining wall bounding No.33. Willoughby Road.

191. Execution of the scheme will not decrease the current resistance of any of the walls to destabilising forces exerted by the retained soil.

192. Consequently, the risk of damage to walls bounding the site will be reduced by the basement, while the risk of damage to the remainder of the wall will be unaffected by the development proposed.

11.2.2 Willow Cottages.

193. Excavation for the proposed basement will take place at a minimum distance of about 3.5m from the rear face of Willow Cottages and will extend about 1m below the supposed depth of their footings. The analyses reported in Appendix E conclude that the risk of these properties suffering damage which is the consequence of the basement development fall within Category zero - negligible. This agrees with experience. The Category zero risk applies also to the rear face of the building, which displays substantial signs of damage caused by old movement and is perforated by doors and windows.

194. Appendix E also demonstrates that any change of groundwater regime caused by the development will be negligible. Groundwater flood risk will not increase and as shown by Section 5, neither will the existing surface water flood risk.

11.3 Risk of damage to Nos 27, 29 & 33 Willoughby Road

195. Analyses reported in Appendix E show that the proposed structural configuration reduces differential ground and structural movement to very small amounts. Structural damage risk assessment provides risk categories bordering zero and 1 for Nos.27 & 29 and 1 for No.33.

11.4 Existing Basements

196. Basements listed in section 3.2 which are believed to exist in the in the region within approximately 100m of the site have been marked on Figure 1. The variation of groundwater level which is predicted to occur in consequence of the proposed development is very small. Conservatively, it will not exceed 25mm for conditions likely to occur in practice.

197. The analyses show that there will be negligible impact on the basement constituted by the Willow Road cottages. At 29 Willoughby Road, which mirrors No. 31, the cellar is currently above groundwater level and will remain so. Considering the level fluctuation noted above, the probability of other basements in the area affecting or being affected by the proposed development is negligible.

12 Monitoring of construction – engineering and surveying

12.1 Engineer

198. It is proposed that the client will appoint a suitably experienced Charted Civil and/or Structural Engineer to monitor the engineered works and their general compliance with the intentions of the engineering design, the service to include site visits at intervals and times determined by the engineer.

12.2 Surveyor

199. It is proposed that the client will appoint a suitably experienced surveying organisation to undertake and report pre-development and construction period measurement of movements occurring in the buildings of Nos. 29 and 33 Willoughby Road and both Willow Cottages and the retaining walls bounding Nos 31 and 33 Willoughby Road. Monitoring arrangements and frequency will be agreed with the client's monitoring engineer and neighbouring residents.

200. A "traffic light" system of dealing with measured results according to a site specific schedule of actions will be agreed. The range of measurements applicable to each class will be determined according to the pre-development measurements.

Appendix A Contents

Figure 1 Contoured plan of site and region

Architects' existing and proposed drawings

Historical maps

Envirocheck report

Utilities data asset location report – UK Power Network

Utilities data asset location report – National Grid

Utilities data asset location report – Thames Water

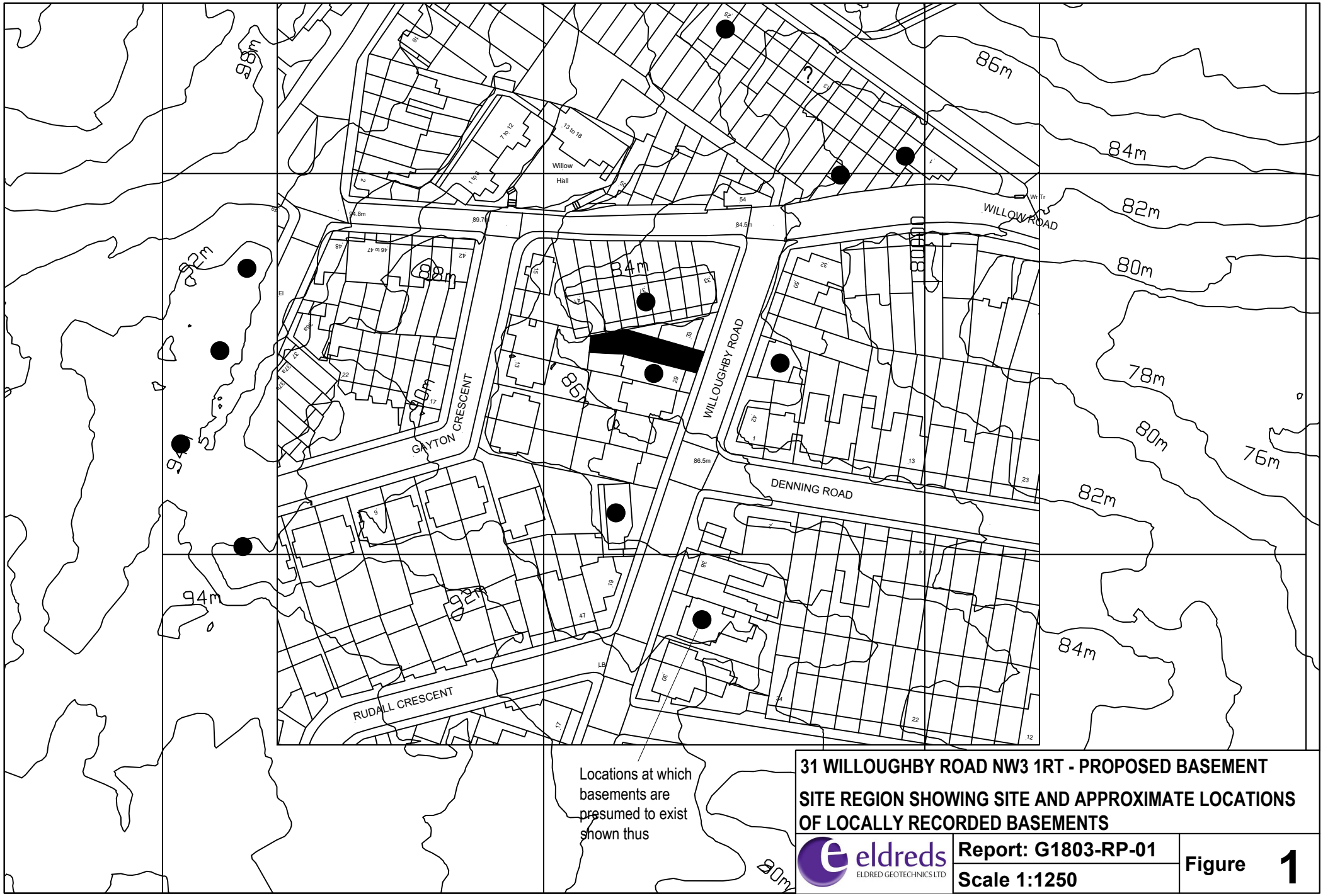
Site drain survey report – Metrorod

Appendix B Contents

Appendix C Contents

Appendix D Contents

Appendix E Contents



31 WILLOUGHBY ROAD NW3 1RT - PROPOSED BASEMENT

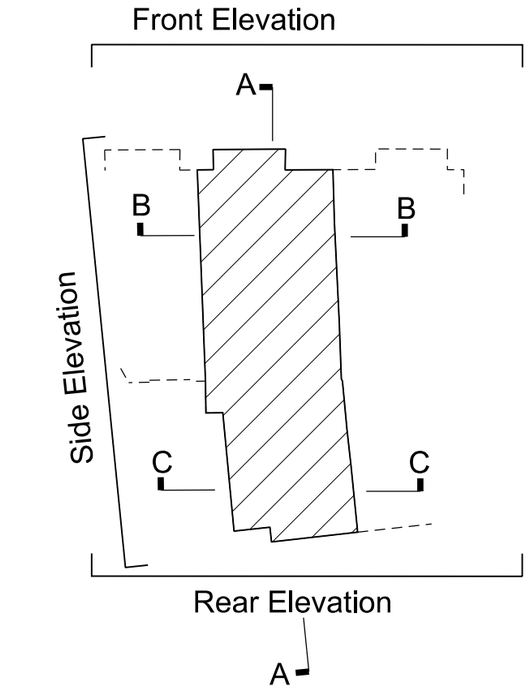
SITE REGION SHOWING SITE AND APPROXIMATE LOCATIONS OF LOCALLY RECORDED BASEMENTS

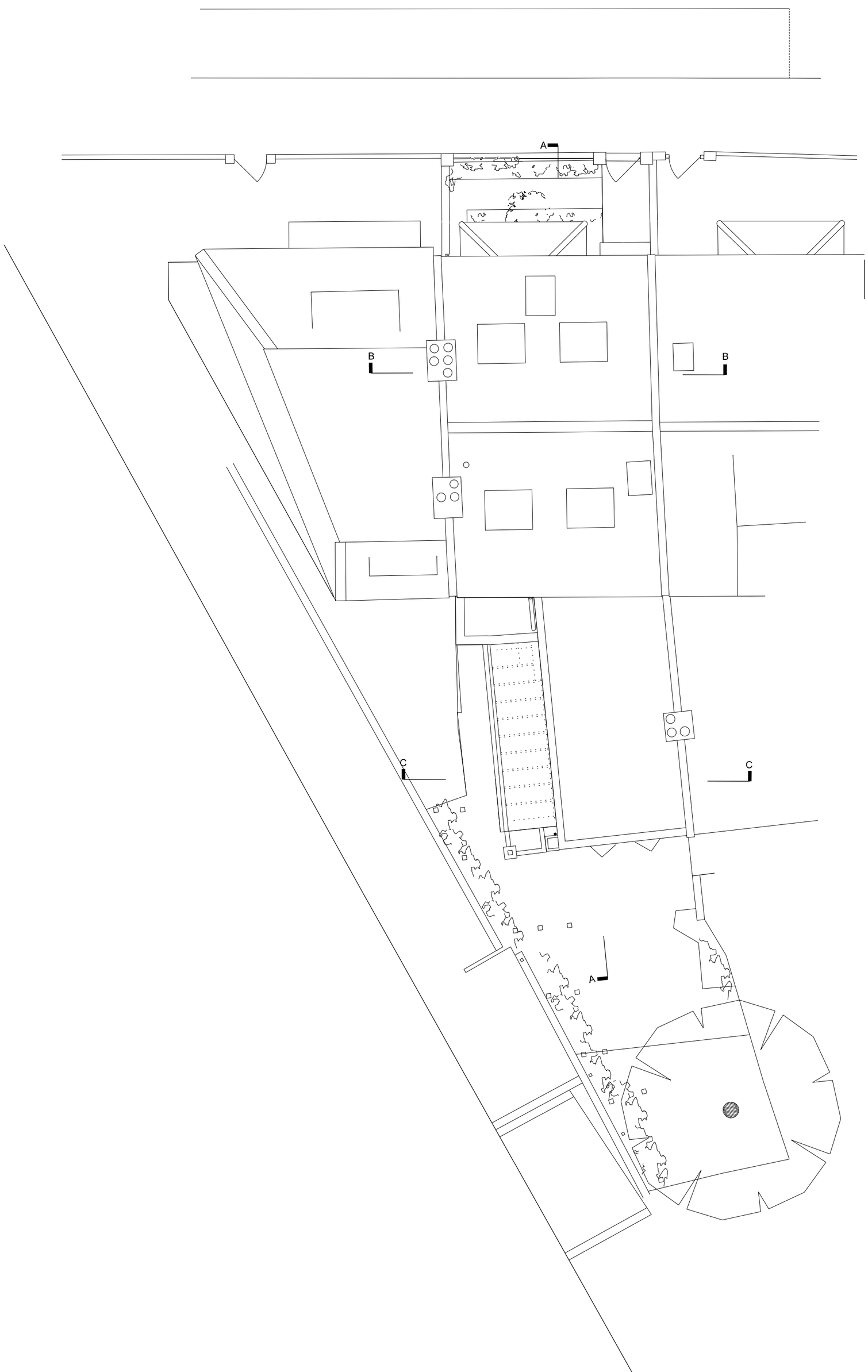
eldreds
ELDRED GEOTECHNICS LTD

Report: G1803-RP-01

Scale 1:1250

Figure 1





Existing Site Plan

m 1 2 3

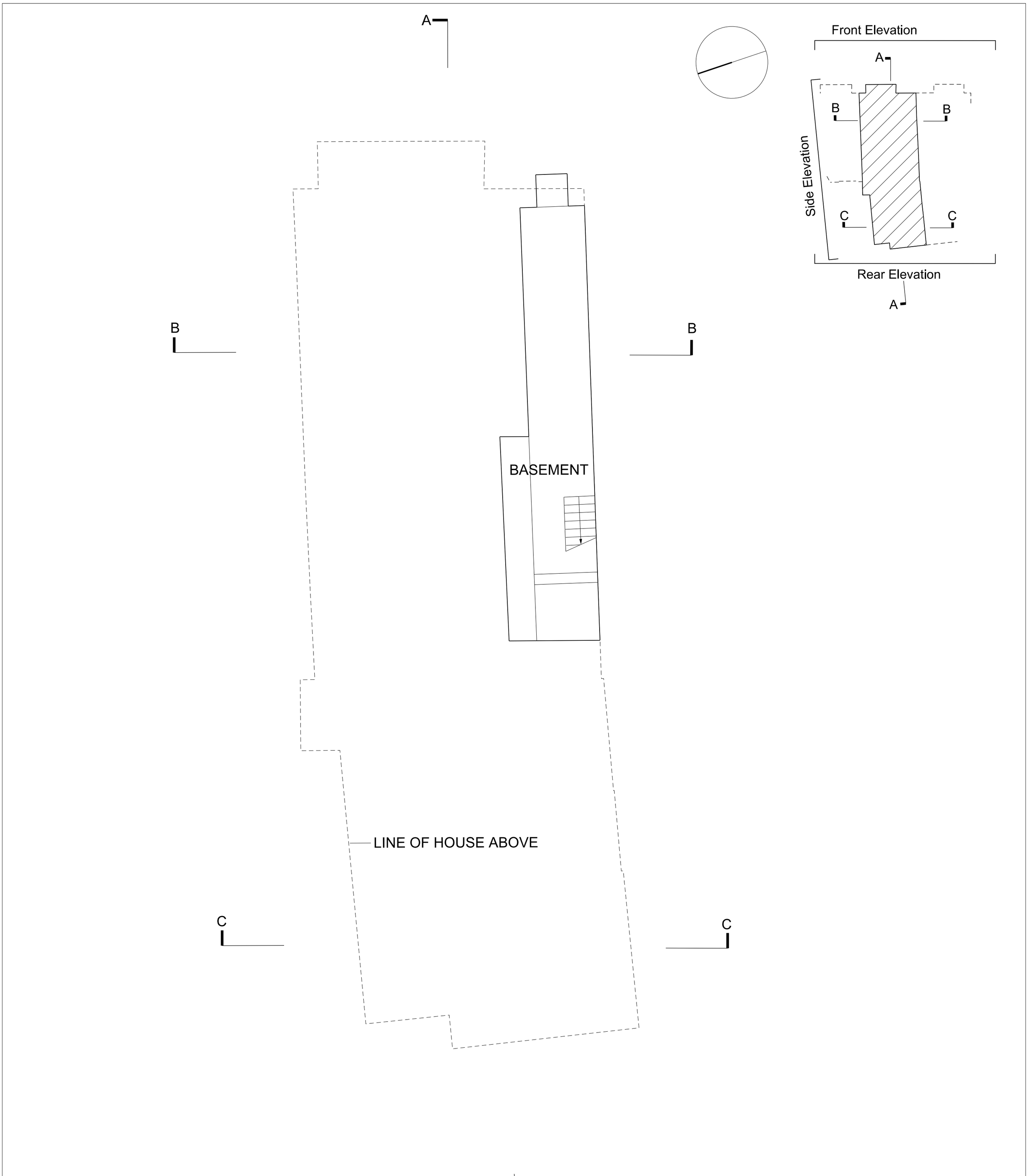
This drawing is for Planning Application only

ungar architects	Project	31 Willoughby Road
10 - 12 Perrins Court London, NW3 1QS UK Tel: +44 (0)20 7431 7547	Subject	Existing Site Plan
	Scale	1:100 Date 02/12/2014
	Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre Planning Application	02.04.15	A
Planning Application	16.12.16	B

Drawing No. 109_PLA_EX_SP



Existing Basement Plan

m 1 2 3

This drawing is for Planning Application only

ungar architects

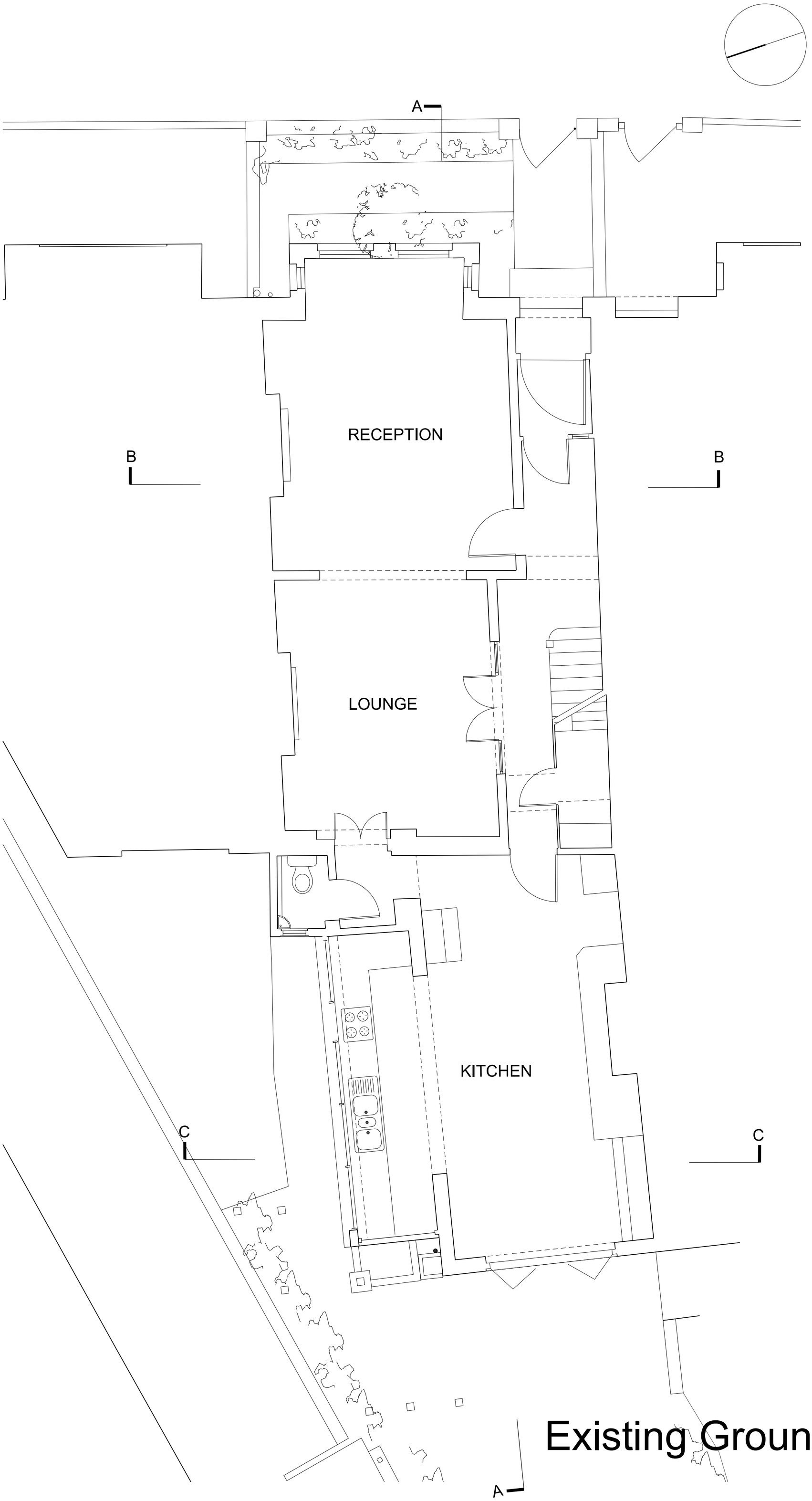
10 - 12 Perrins Court
London, NW3 1QS
UK

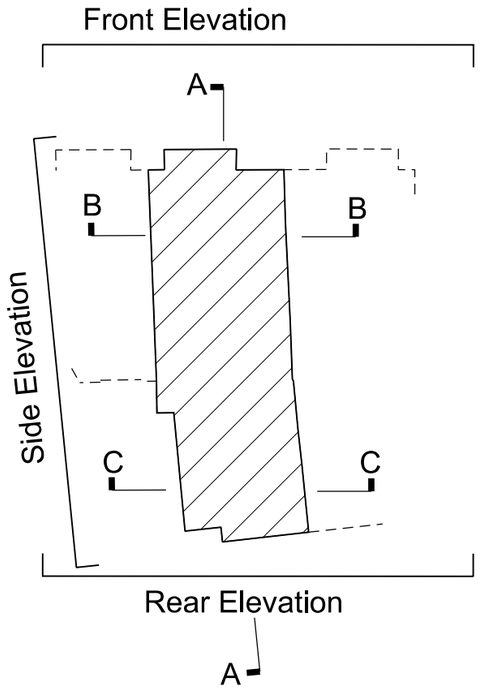
Tel: +44 (0)20 7431 7547

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre Application	02.04.15	A
Planning	16.12.16	B

Project	31 Willoughby Road
Subject	Existing Basement Plan
Scale	1:50
Date	02/12/2014
Original Size	A2
Drawing No.	109_PLA_EX_BP





Existing Ground Plan

m 1 2 3

This drawing is for Planning Application only

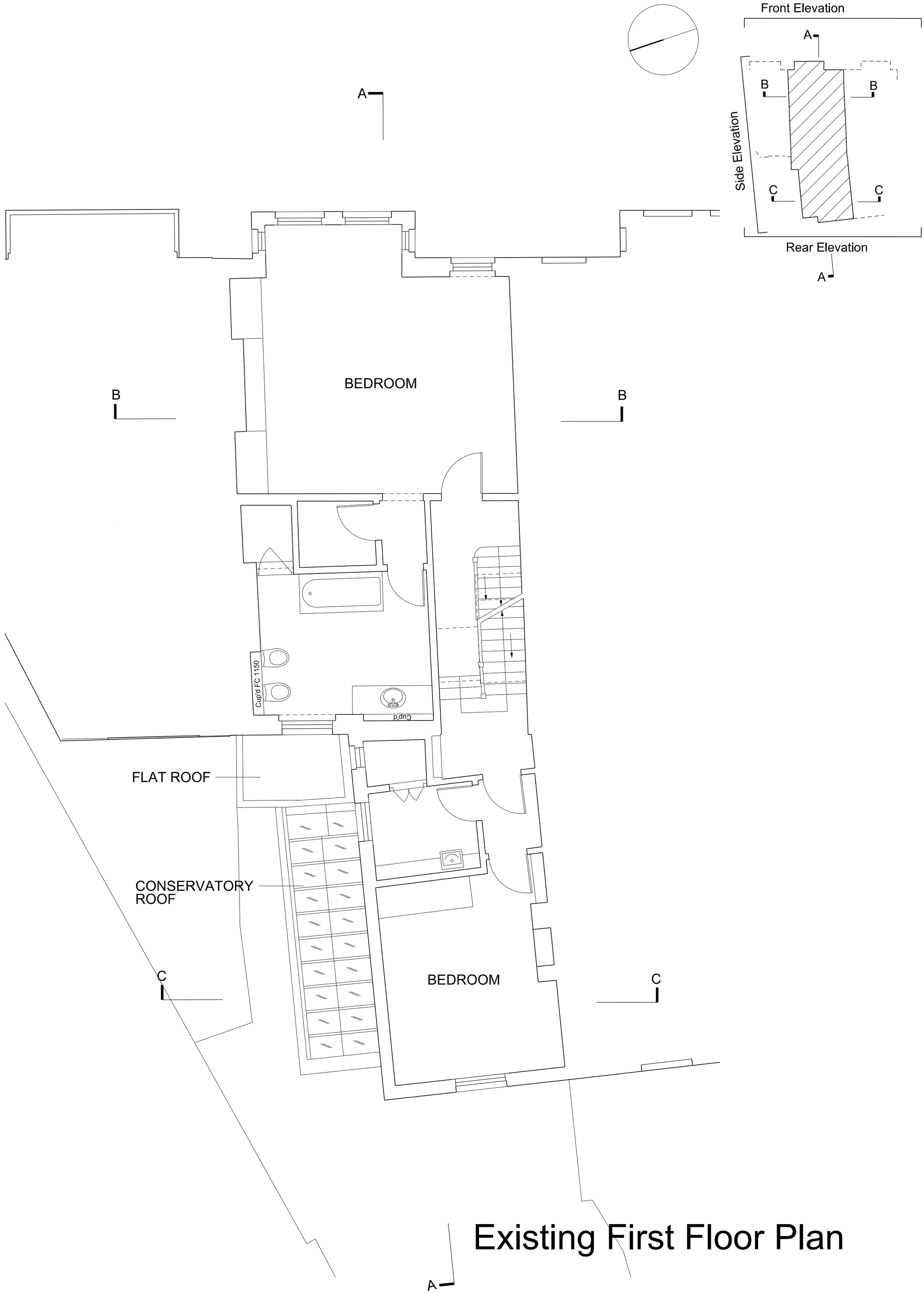
ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Existing Ground Floor Plan
Scale	1:50
Date	02/12/2014
Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre Application	02.04.15	A
Planning	16.12.16	B

Drawing No. 109_PLA_EX_GFP



Existing First Floor Plan

m 1 2 3

This drawing is for Planning Application only

ungar architects

10 - 12 Perrins Court
London, NW3 1QS
UK

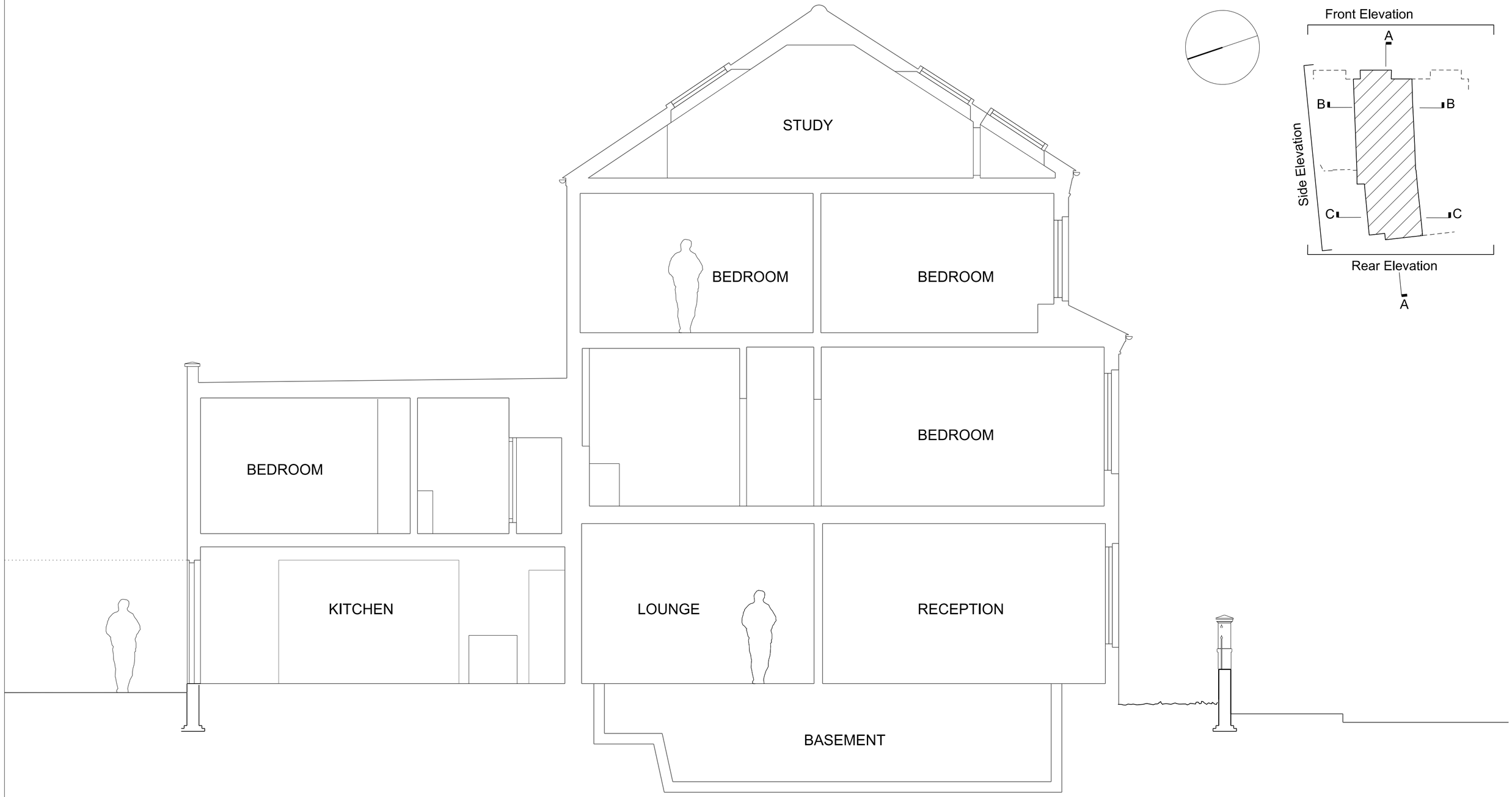
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Existing First Floor Plan
Scale	1:50
Date	02/12/2014
Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Planning Application	16.12.16	B

Drawing No. 109_PLA_EX_FFP



Existing Section AA

ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Existing Section AA
Scale	1:50
Date	02/12/2014
Original Size	A2

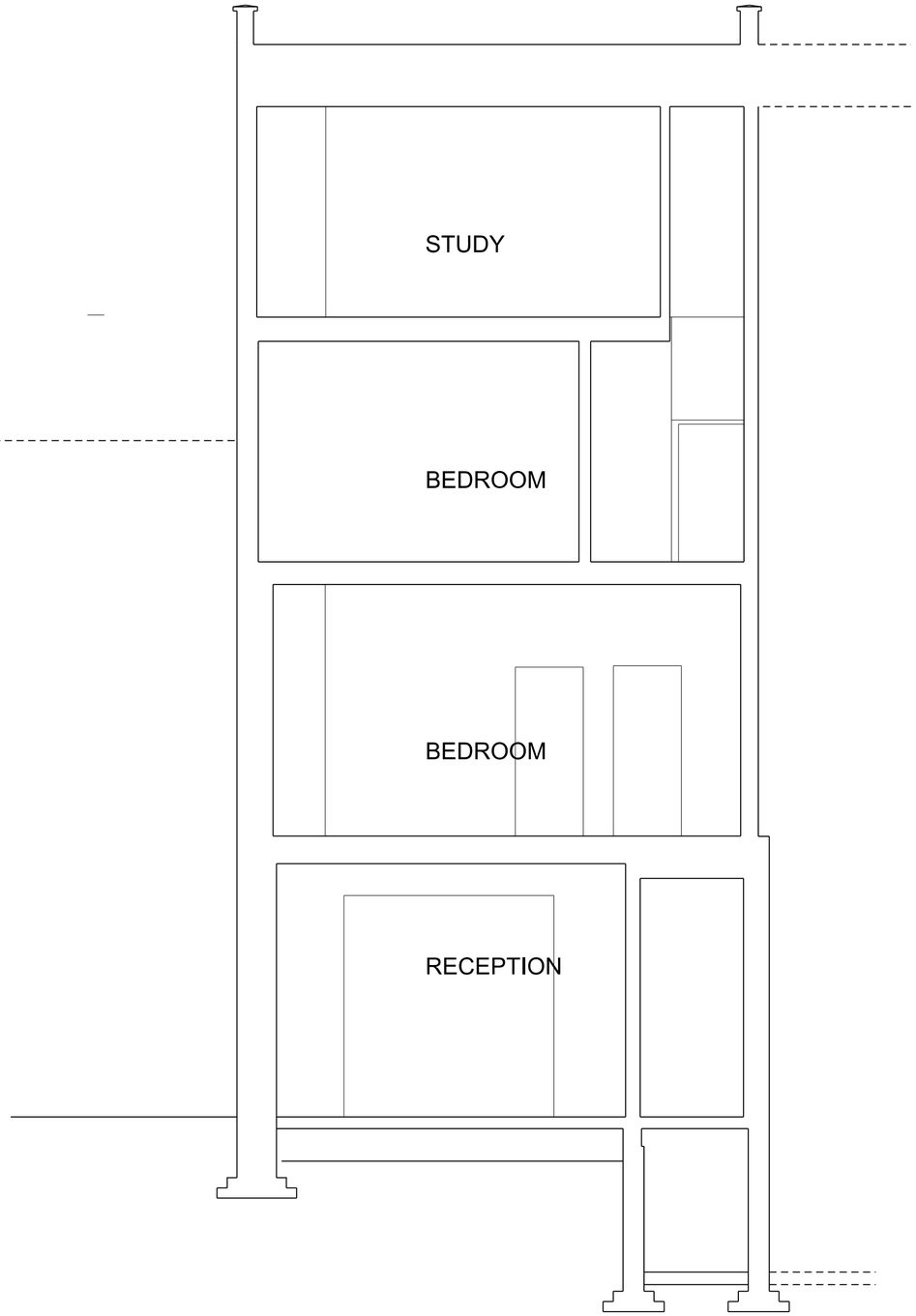
Unless indicated below, this drawing is for information only.

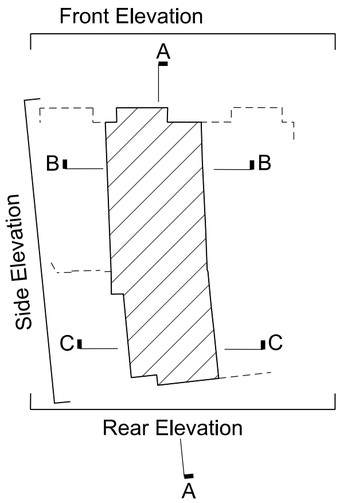
Issue / Revision	Date	Rev.
Pre-Planning Advice	02.04.16	A
Planning	19.12.16	B

Drawing No. 109_PLA_EX_SEC_AA

m 1 2 3

This drawing is for Planning Application only





Existing Section BB

m 1 2 3

This drawing is for Planning Application only

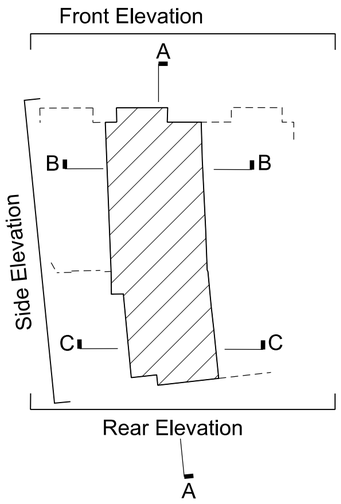
ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre-Planning Advice	02.04.16	A
Planning	16.12.16	B

Project	31 Willoughby Road
Subject	Existing Section BB
Scale	1:50
Date	02/12/2014
Original Size	A2

Drawing No. 109_PLA_EX_SEC_BB



Existing Section CC

m 1 2 3

This drawing is for Planning Application only

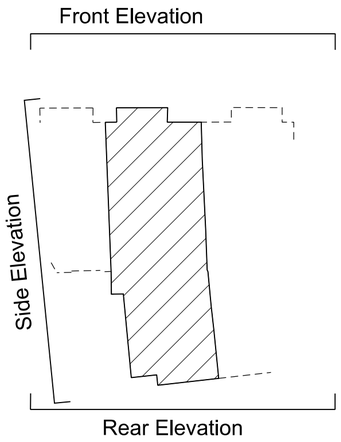
ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Proposed Section CC
Scale	1:50
Date	02/12/2014
Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Planning	16.12.16	B

Drawing No. 109_PLA_EX_SEC_CC



Existing Rear Elevation

m 1 2 3

This drawing is for Planning Application only

ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre Application	02.04.16	A
Planning	16.12.16	B

Project	31 Willoughby Road
Subject	Existing Rear Elevation
Scale	1:50
Date	02/12/2014
Original Size	A2
Drawing No.	109_PLA_EX_ELE_R

31 Willoughby Road

Existing Front Elevation

ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road		
Subject	Existing Front Elevation		
Scale	1:50	Date	02/12/2014
Original Size	A2		

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre Planning Application	02.04.15	A
Planning Application	16.12.16	B

Drawing No. 109_PLA_EX_ELE_F

m 1 2 3

This drawing is for Planning Application only

Existing Side Elevation

ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Existing Side Elevation
Scale	1:50
Date	02/12/2014
Original Size	A2

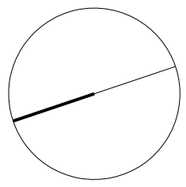
Unless indicated below, this drawing is for information only.

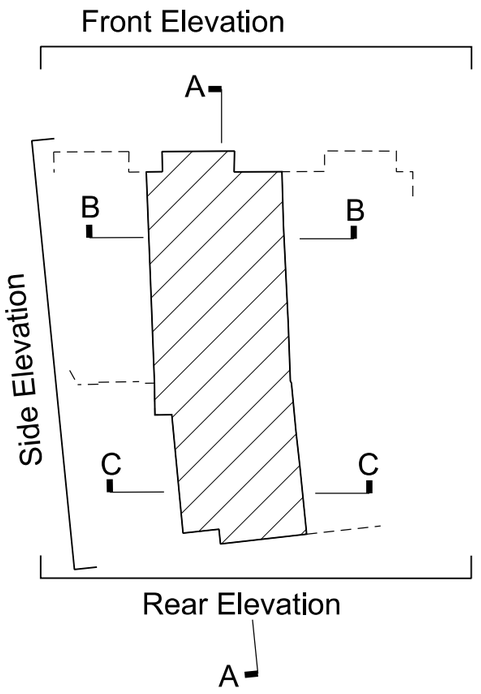
Issue / Revision	Date	Rev.
Pre - Planning Application Advice	02.04.15	A
Planning Application	16.12.16	B

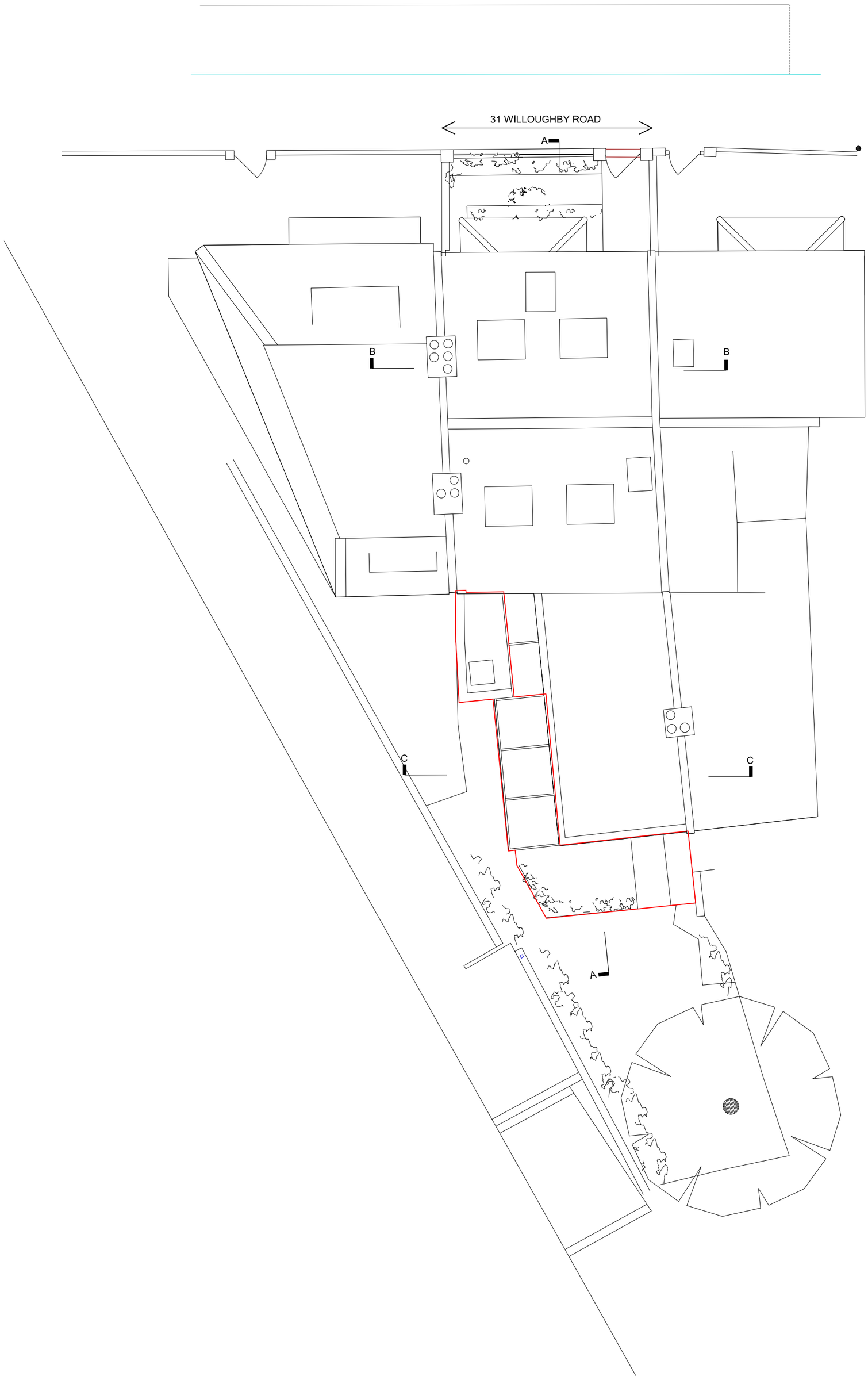
Drawing No. 109_PLA_EX_ELE_S

m 1 2 3

This drawing is for Planning Application only







Proposed Site Plan

m 1 2 3

This drawing is for Planning Application only

ungar architects

10 - 12 Perrins Court
London, NW3 1QS
UK

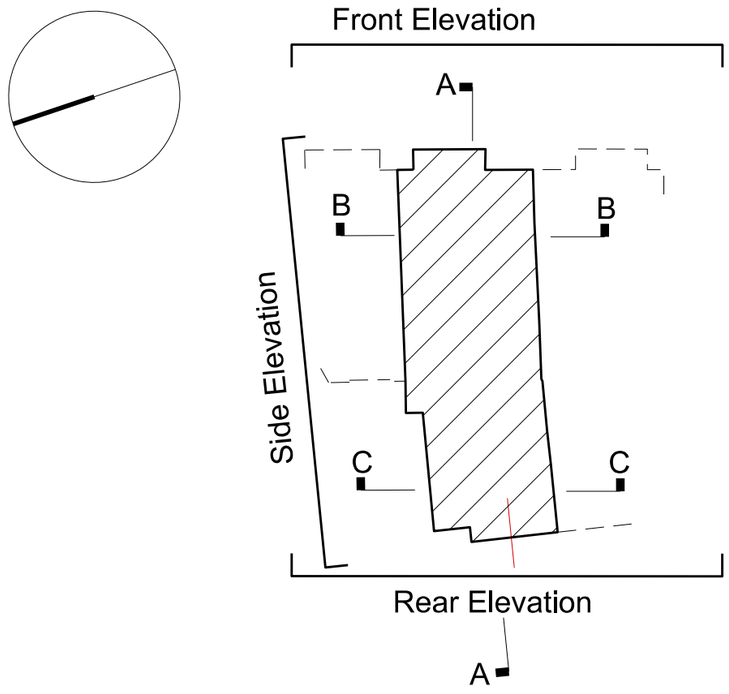
Tel: +44 (0)20 7431 7547

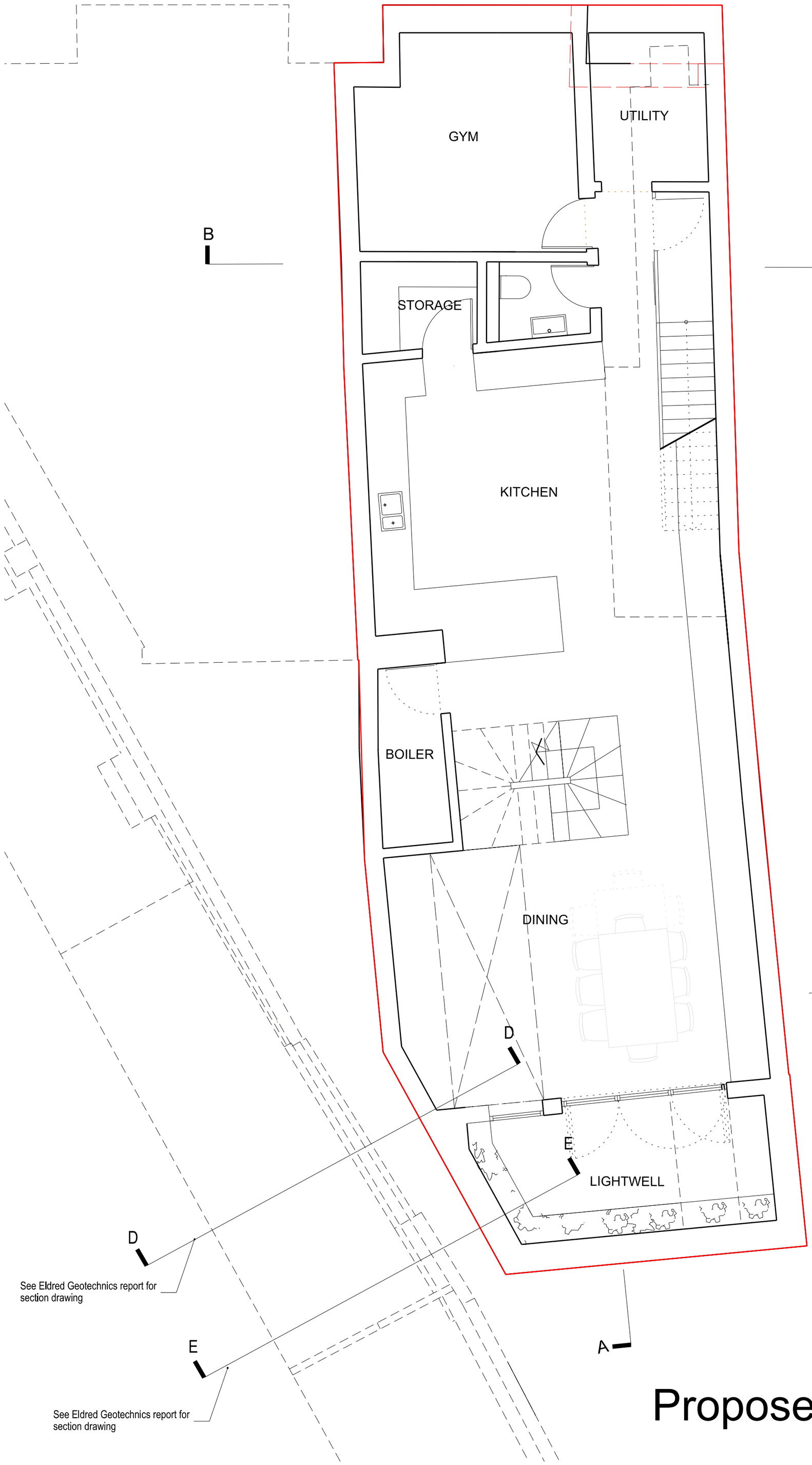
Project	31 Willoughby Road
Subject	Proposed Site Plan
Scale	1:100
Date	02/12/2014
Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre Application	02.04.15	A
Planning	16.12.16	B

Drawing No. 109_PLA_SP





Proposed Basement Plan

m 1 2 3

This drawing is for Planning Application only

ungar architects

10 - 12 Perrins Court
London, NW3 1QS
UK

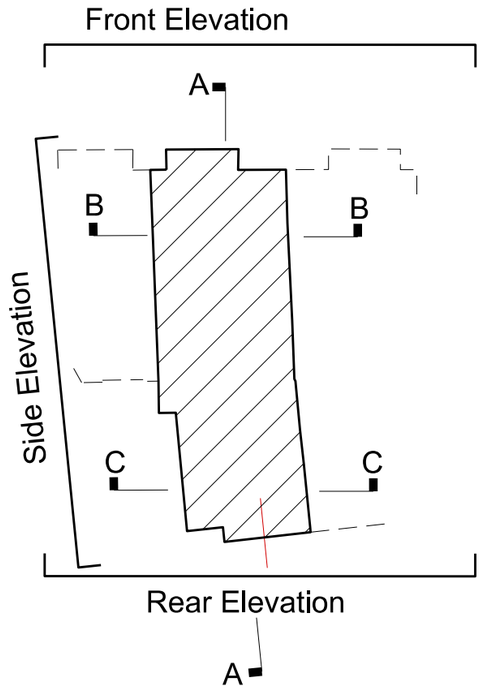
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Proposed Basement Floor Plan
Scale	1:50
Date	02/12/2014
Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre-Planning Advice	02.04.15	A
Planning	16.12.16	B
Planning	30.07.20	C

Drawing No. 109_PLA_BFP



Proposed Ground Floor Plan

m 1 2 3

This drawing is for Planning Application only

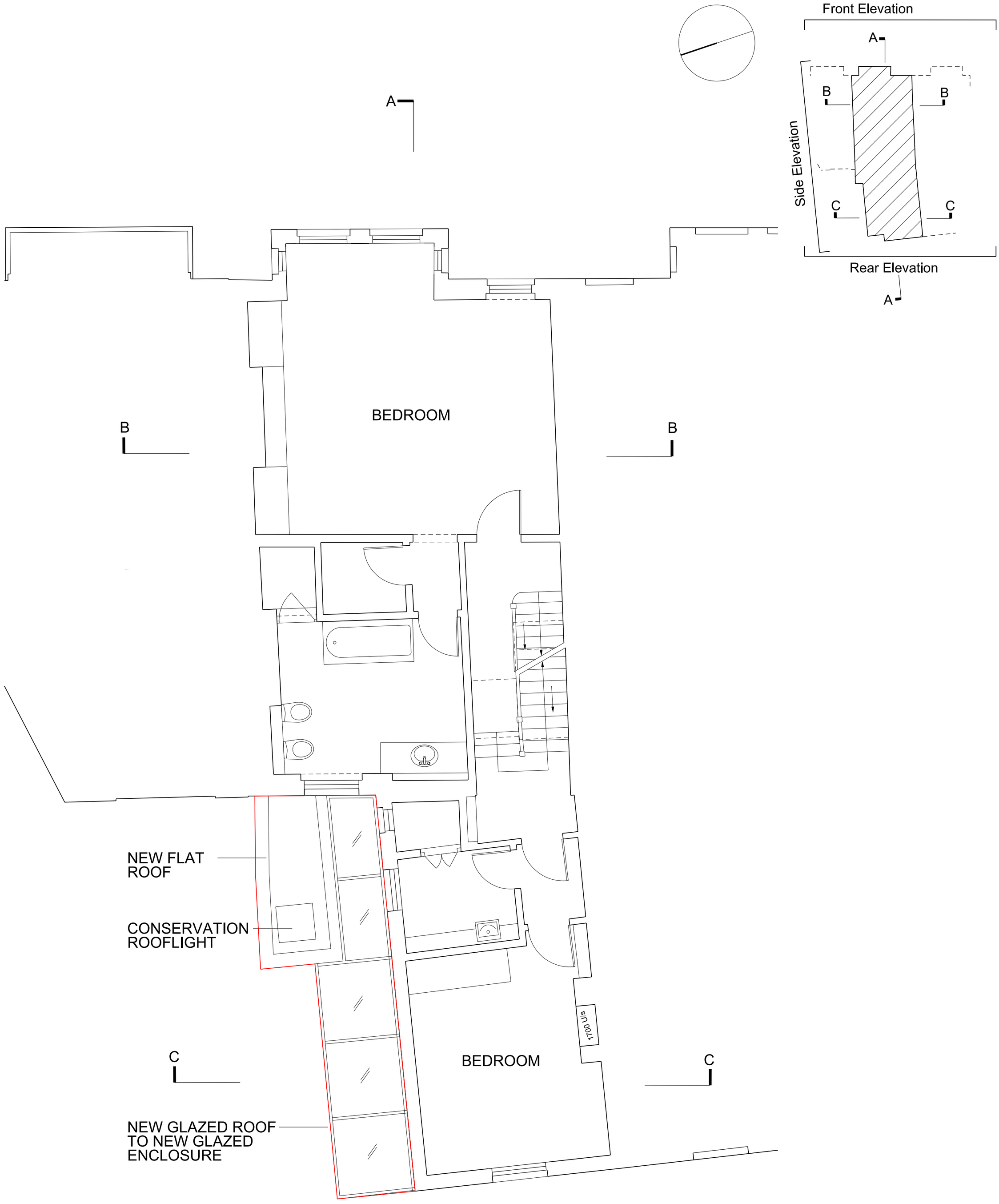
ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Proposed Ground Plan
Scale	1:50
Date	02/12/2014
Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre-Planning Advice	02.04.15	A
Planning	16.12.16	B
Planning	30.07.20	C

Drawing No. 109_PLA_GFP



Proposed First Floor Plan

This drawing is for Planning Application only

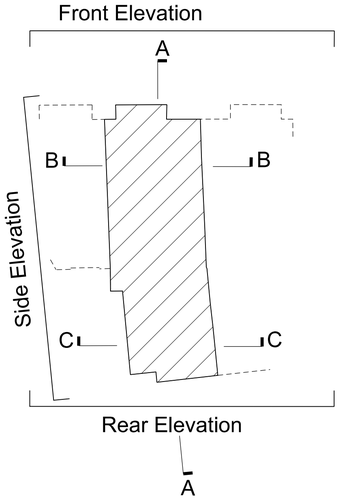
ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Proposed First Floor Plan
Scale	1:50
Date	02/12/2014
Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Planning Application	16.12.16	B

Drawing No. 109_PLA_FFP



STUDY

BEDROOM

BEDROOM

BEDROOM

BEDROOM

BEDROOM

RECEPTION

LOUNGE

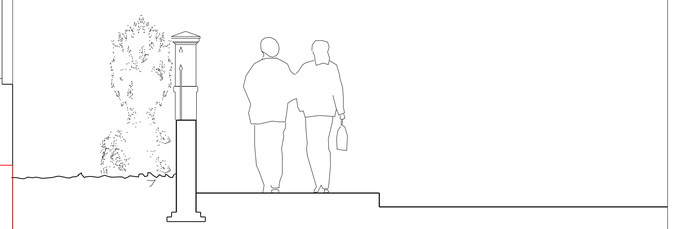
RECEPTION

LIGHT WELL

RECEPTION

KITCHEN

GYM



Proposed Section AA

m 1 2 3

This drawing is for Planning Application only

ungar architects

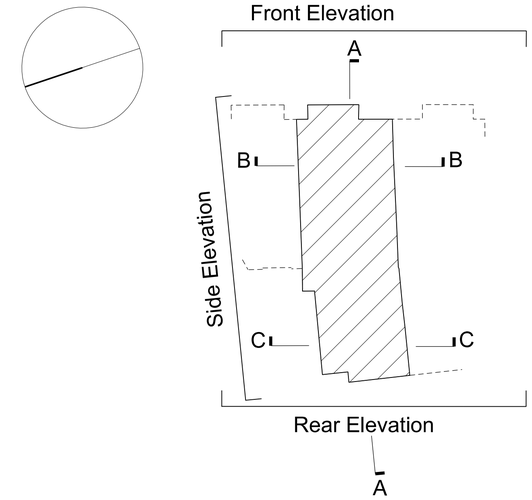
10 - 12 Perrins Court
London, NW3 1QS
UK

Tel: +44 (0)20 7431 7547

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre-Planning Advice	02.04.15	A
Planning	16.12.16	B

Project	31 Willoughby Road
Subject	Proposed Section AA
Scale	1:50
Date	02/12/2014
Original Size	A2
Drawing No.	109_PLA_SEC_AA



m 1 2 3

This drawing is for Planning Application only

Proposed Section BB

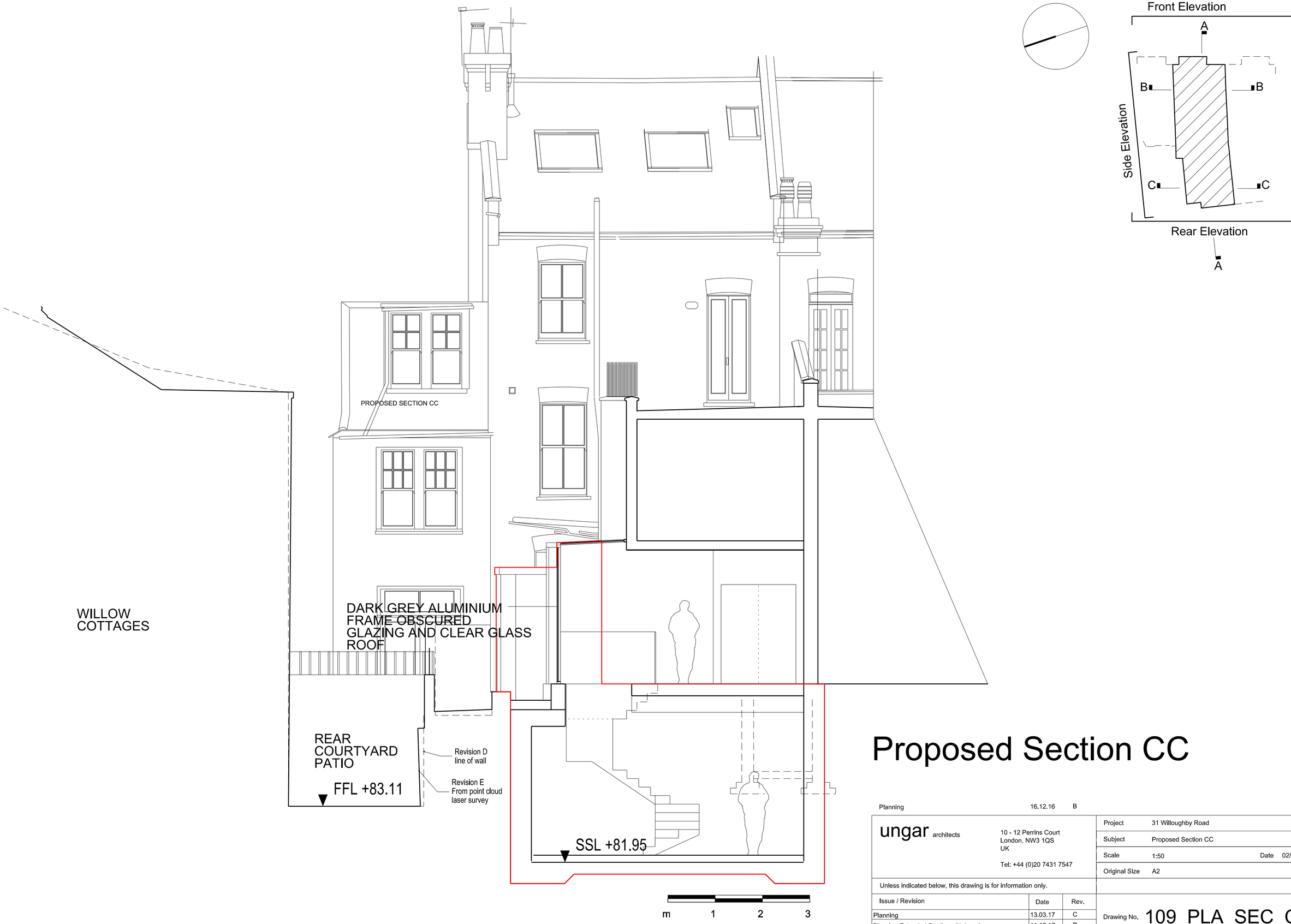
ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Proposed Section BB
Scale	1:50
Date	02/12/2014
Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre-Planning Advice	02.04.15	A
Planning	16.12.16	B

Drawing No. 109_PLA_SEC_BB



Proposed Section CC

Planning 16.12.16 B

ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

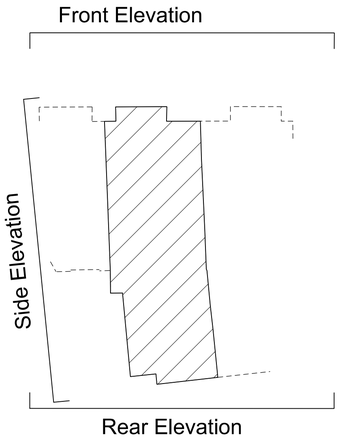
Project	31 Willoughby Road
Subject	Proposed Section CC
Scale	1:50
Date	02/12/2014
Original Size	A2

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Planning	13.03.17	C
Planning Extended Section with Levels	11.12.17	D
Planning Revision to wall from Point cloud laser survey	02.07.20	E

Drawing No. 109_PLA_SEC_CC

This drawing is for Planning Application only



GLASS BALUSTRADE
AND STAINLESS STEEL
GRILLE OVER LIGHTWELL

DARK GREY ALUMINIUM
FRAME FIXED GLAZED PANELS
AND DOORS

LIGHTWELL

m 1 2 3

This drawing is for Planning Application only

Proposed Rear Elevation

ungar architects

10 - 12 Perrins Court
London, NW3 1QS
UK

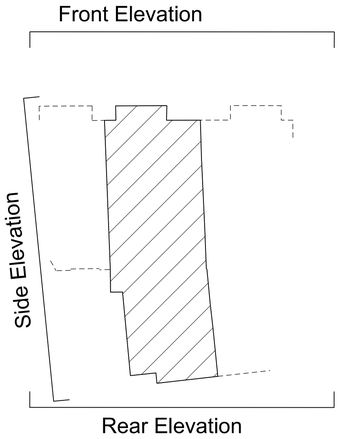
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road		
Subject	Proposed Rear Elevation		
Scale	1:50	Date	02/12/2014
Original Size	A2		

Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre Planning Application	02.04.16	A
Planning	16.12.16	B

Drawing No. 109_PLA_ELE_R



31 Willoughby Road

No Change

Proposed Front Elevation

ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Proposed Front Elevation
Scale	1:50
Date	02/12/2014
Original Size	A2

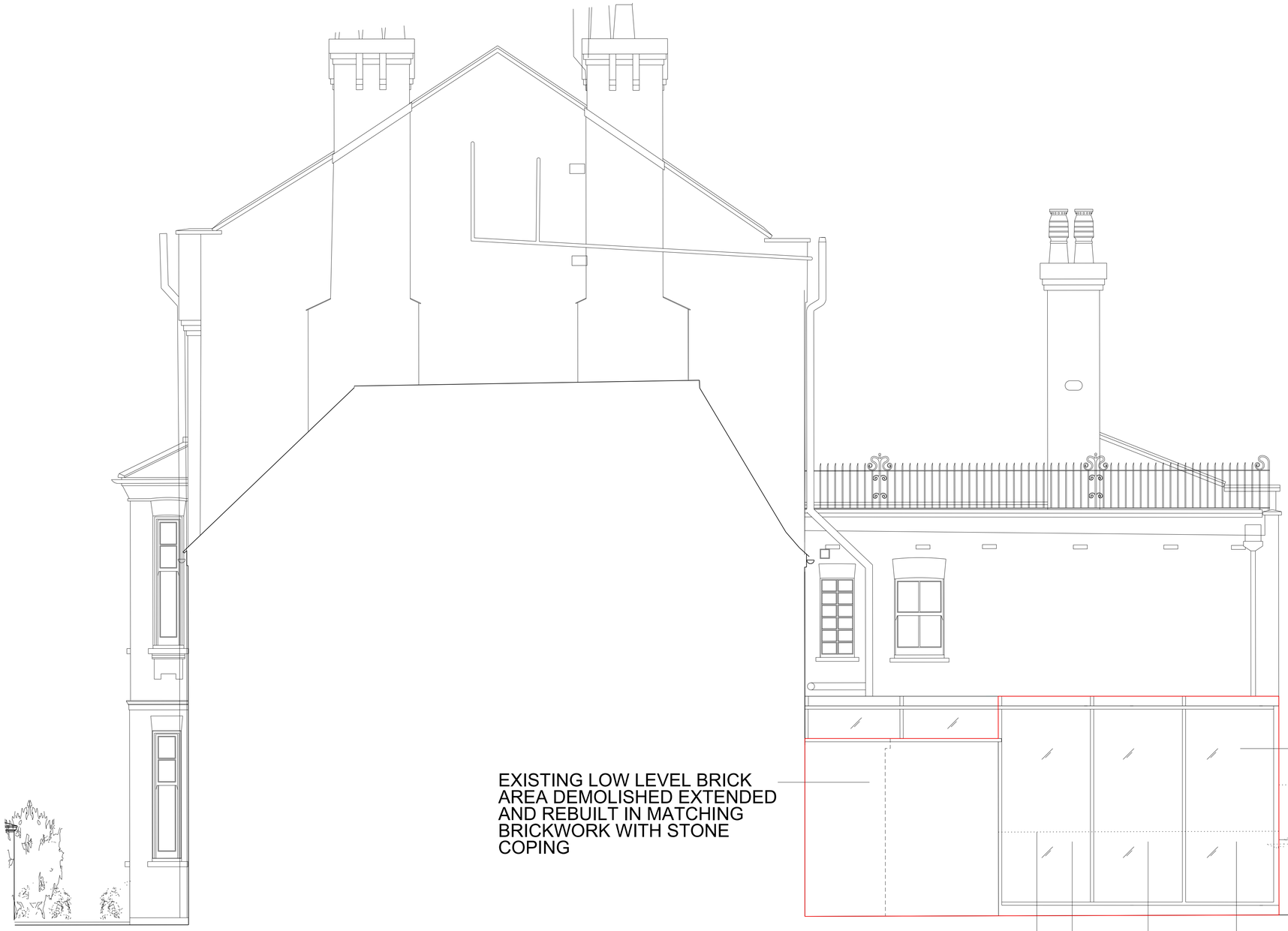
Unless indicated below, this drawing is for information only.

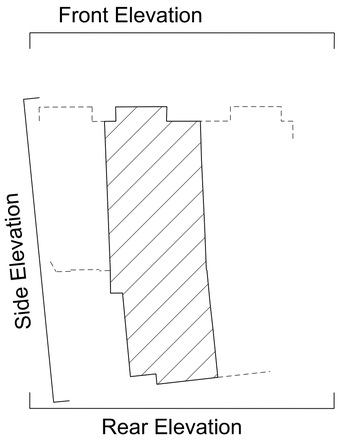
Issue / Revision	Date	Rev.
Pre Planning Application	02.04.15	A
Planning Application	16.12.16	B

Drawing No. 109_PLA_ELE_F

m 1 2 3

This drawing is for Planning Application only





Proposed Side Elevation

ungar architects
10 - 12 Perrins Court
London, NW3 1QS
UK
Tel: +44 (0)20 7431 7547

Project	31 Willoughby Road
Subject	Proposed Side Elevation
Scale	1:50
Date	02/12/2014
Original Size	A2

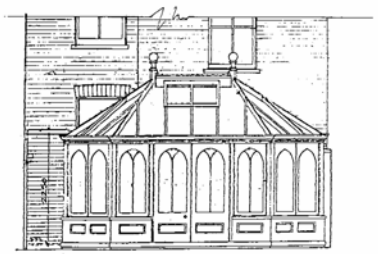
Unless indicated below, this drawing is for information only.

Issue / Revision	Date	Rev.
Pre Planning Application	02.04.15	A
Planning	16.12.16	B

Drawing No. 109_PLA_ELE_S

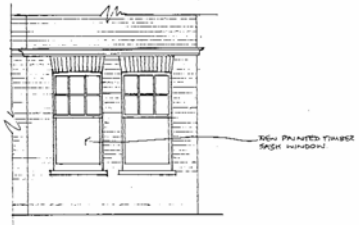
m 1 2 3

This drawing is for Planning Application only

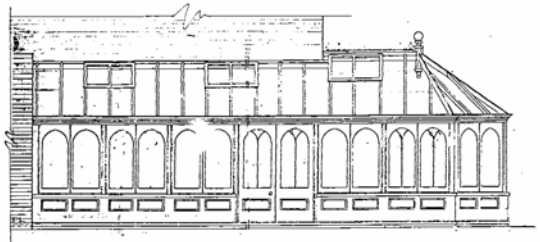


EXISTING REAR ELEVATION AA

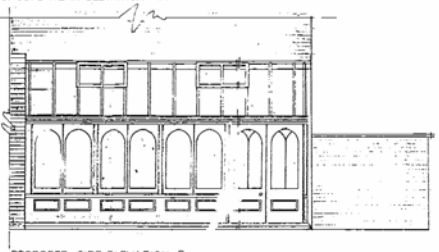
PROPOSED REAR ELEVATION AA



PROPOSED FRONT ELEVATION CC

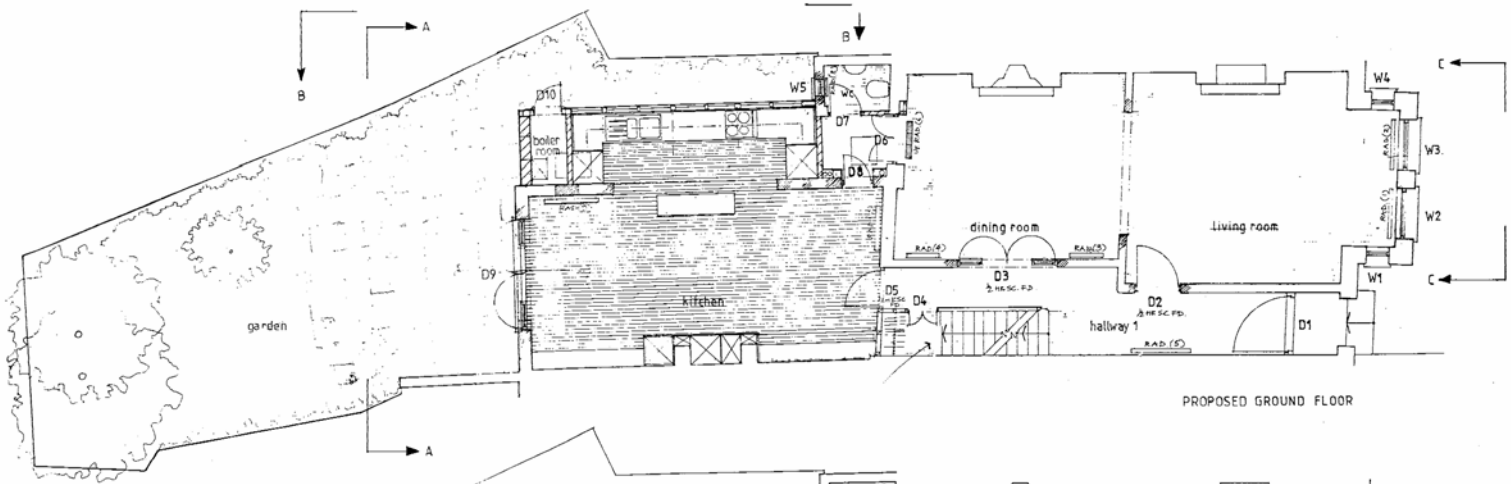


EXISTING SIDE ELEVATION

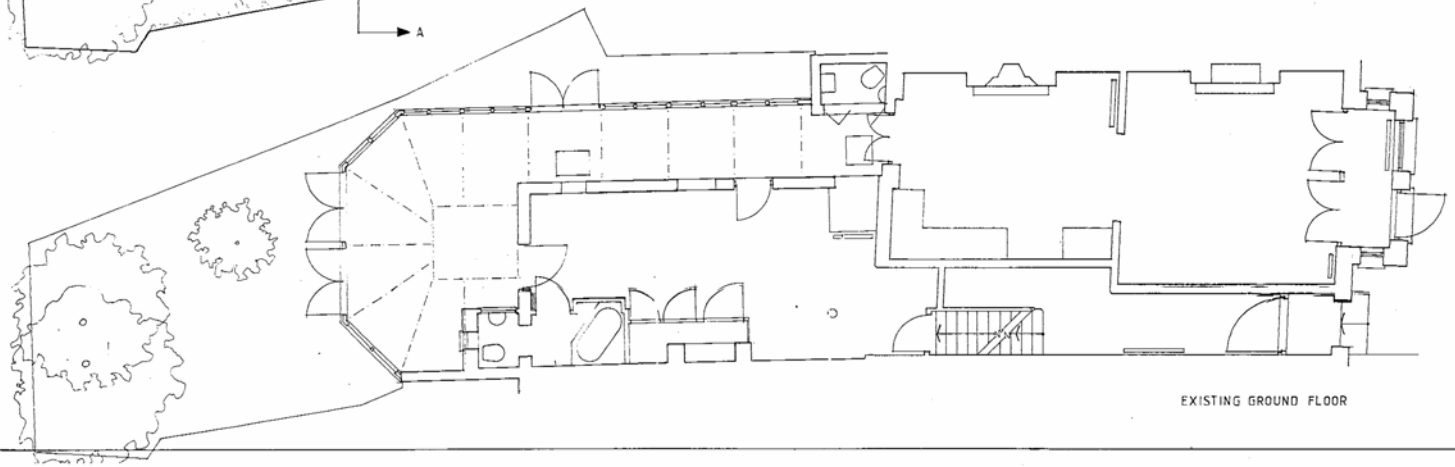


PROPOSED SIDE ELEVATION B

EXISTING FRONT ELEVATION CC



PROPOSED GROUND FLOOR



EXISTING GROUND FLOOR

LONDON BOROUGH OF CAMDEN
TOWN AND COUNTRY PLANNING ACTS
16 JUL 1992
APPROVED
PLANS NOT APPROVED
ON BEHALF OF THE COUNCIL

CA9260057

PROJECT

31 WILLOUGHBY ROAD
LONDON NW3

DRAWING

EXISTING AND PROPOSED
CHANGES TO FRONT AND REAR ELVTS.

SCALE

1:50

DRAWING No.

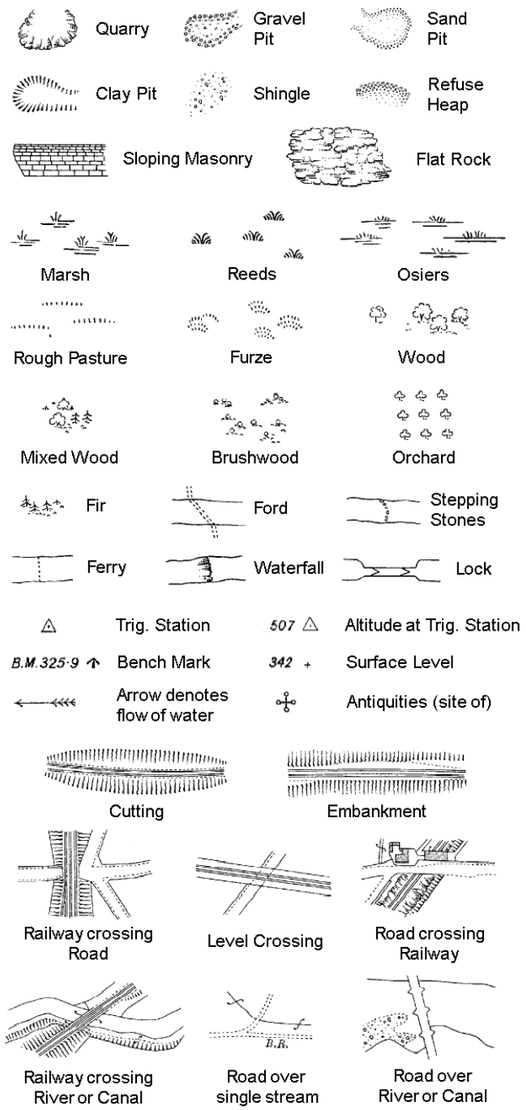
1216/10

BOTSFORD associates

ARCHITECTURAL AND INTERIOR DESIGN CONSULTANTS
8A PEMBRIDGE VILLAS, LONDON W11 2SU, ENGLAND
TELEPHONE 071-792 1726 FAX 071-794 4091

Historical Mapping Legends

Ordnance Survey County Series and Ordnance Survey Plan 1:2,500



County Boundary (Geographical)

County & Civil Parish Boundary

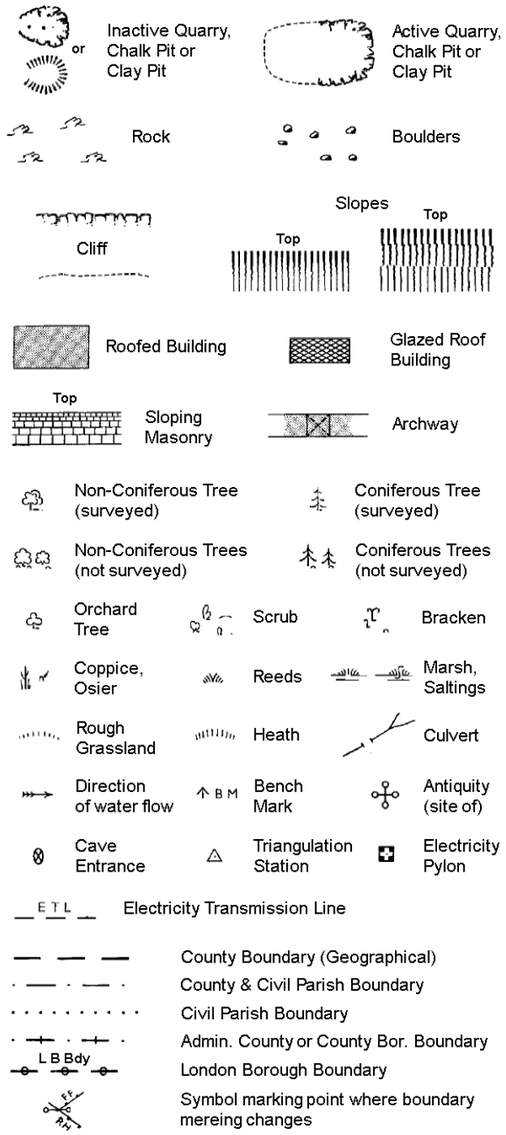
Administrative County & Civil Parish Boundary

Co. Boro. Bdy. County Borough Boundary (England)

Co. Burgh Bdy. County Burgh Boundary (Scotland)

B P B S	Boundary Post or Stone	P.C.B	Police Call Box
B.R.	Bridle Road	P	Pump
E.P	Electricity Pylon	S.P	Signal Post
F.B.	Foot Bridge	St.	Sluice
F.P.	Foot Path	Sp.	Spring
G.P	Guide Post or Board	T.C.B	Telephone Call Box
M.S	Mile Stone	Tr.	Trough
M.P M.R	Mooring Post or Ring	W	Well

Ordnance Survey Plan, Additional SIMs and Supply of Unpublished Survey Information 1:2,500 and 1:1,250



County Boundary (Geographical)

County & Civil Parish Boundary

Civil Parish Boundary

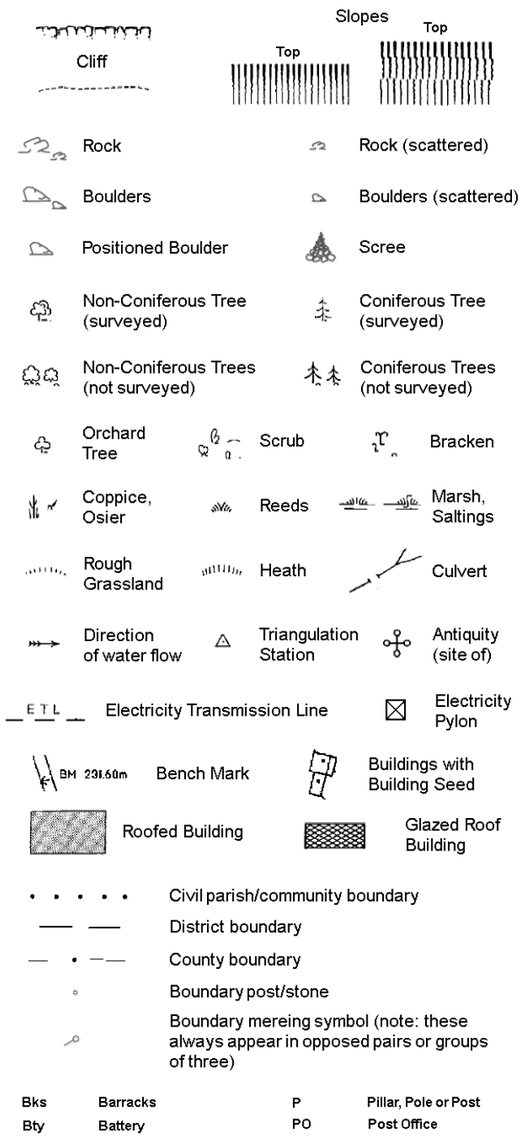
Admin. County or County Bor. Boundary

L B Bdy London Borough Boundary

Symbol marking point where boundary mereing changes

BH	Beer House	P	Pillar, Pole or Post
BP, BS	Boundary Post or Stone	PO	Post Office
Cn, C	Capstan, Crane	PC	Public Convenience
Chy	Chimney	PH	Public House
D Fn	Drinking Fountain	Pp	Pump
El P	Electricity Pillar or Post	SB, S Br	Signal Box or Bridge
FAP	Fire Alarm Pillar	SP, SL	Signal Post or Light
FB	Foot Bridge	Spr	Spring
GP	Guide Post	Tk	Tank or Track
H	Hydrant or Hydraulic	TCB	Telephone Call Box
LC	Level Crossing	TCP	Telephone Call Post
MH	Manhole	Tr	Trough
MP	Mile Post or Mooring Post	Wr Pt, Wr T	Water Point, Water Tap
MS	Mile Stone	W	Well
NTL	Normal Tidal Limit	Wd Pp	Wind Pump

Large-Scale National Grid Data 1:2,500 and 1:1,250



Civil parish/community boundary

District boundary

County boundary

Boundary post/stone

Boundary mereing symbol (note: these always appear in opposed pairs or groups of three)

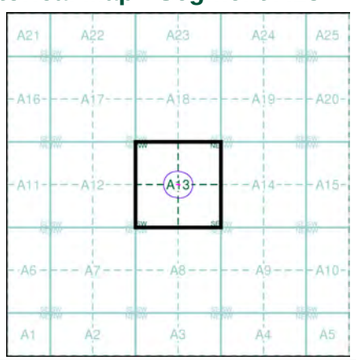
Bks	Barracks	P	Pillar, Pole or Post
Bty	Battery	PO	Post Office
Cemy	Cemetery	PC	Public Convenience
Chy	Chimney	Pp	Pump
Cis	Cistern	Ppg Sta	Pumping Station
Dismtd Rly	Dismantled Railway	PW	Place of Worship
El Gen Sta	Electricity Generating Station	Sewage Ppg Sta	Sewage Pumping Station
El P	Electricity Pole, Pillar	SB, S Br	Signal Box or Bridge
El Sub Sta	Electricity Sub Station	SP, SL	Signal Post or Light
FB	Filter Bed	Spr	Spring
Fn / D Fn	Fountain / Drinking Ftn.	Tk	Tank or Track
Gas Gov	Gas Valve Compound	Tr	Trough
GVC	Gas Governer	Wd Pp	Wind Pump
GP	Guide Post	Wr Pt, Wr T	Water Point, Water Tap
MH	Manhole	Wks	Works (building or area)
MP, MS	Mile Post or Mile Stone	W	Well

GEA Geotechnical & Environmental Associates

Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Middlesex	1:2,500	1864	2
London	1:2,500	1879	3
London	1:2,500	1896	4
London	1:2,500	1915	5
London	1:2,500	1934	6
Historical Aerial Photography	1:1,250	1946 - 1949	7
Ordnance Survey Plan	1:1,250	1952 - 1954	8
Additional SIMs	1:1,250	1952 - 1987	9
Ordnance Survey Plan	1:2,500	1953 - 1955	10
Additional SIMs	1:2,500	1954	11
Ordnance Survey Plan	1:1,250	1966 - 1981	12
Ordnance Survey Plan	1:2,500	1970	13
Ordnance Survey Plan	1:1,250	1973 - 1974	14
Additional SIMs	1:1,250	1985 - 1987	15
Large-Scale National Grid Data	1:1,250	1991	16
Large-Scale National Grid Data	1:1,250	1991	17
Large-Scale National Grid Data	1:1,250	1996	18

Historical Map - Segment A13



Order Details

Order Number: 74921429_1_1
Customer Ref: J15315
National Grid Reference: 526730, 185850
Slice: A
Site Area (Ha): 0.02
Search Buffer (m): 100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

CENTRE MAPS LIVE.
FOR A BETTER POINT OF VIEW

Site Details:

1870-A3PDF-2500

Client Ref: 4453
Report Ref: CMAPS-CM-809617-4453-250619
Grid Ref: 526730, 185854

Map Name: County Series

Map date: **1870**

Scale: 1:2,500

Printed at: 1:2,500

N
W E
S

Surveyed 1866
Revised N/A
Edition 1870
Copyright N/A
Levelled N/A

Groundsure INSIGHTS

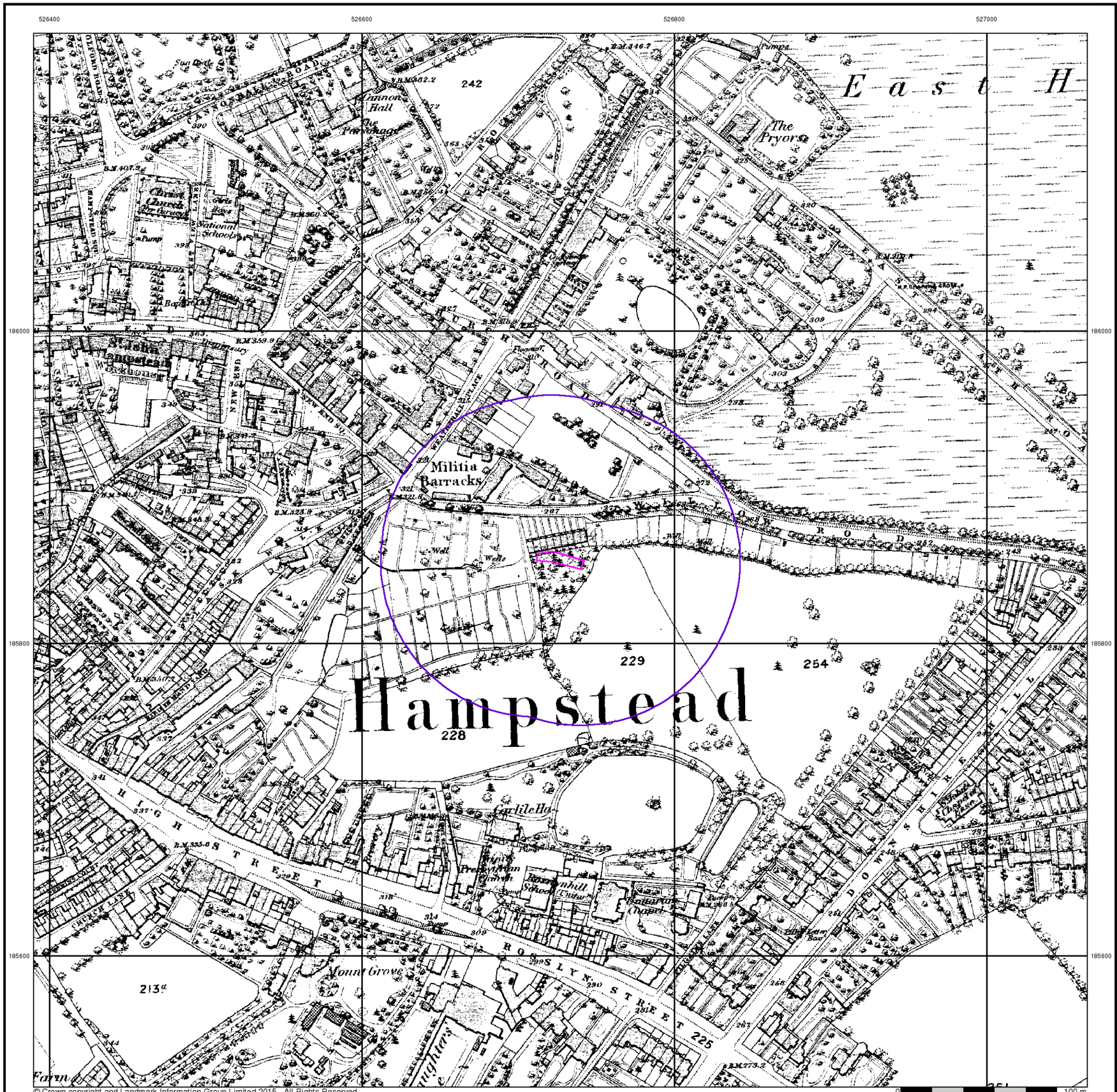
Produced by
Groundsure Insights
www.groundsure.com

Powered by

Supplied by:
www.centremapslive.com
groundsure@centremaps.com

Production date: 26 June 2019

Map legend available at:
www.groundsure.com/sites/default/files/groundsure_legend.pdf



GEA Geotechnical & Environmental Associates

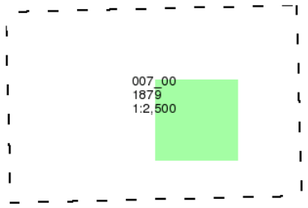
London

Published 1879

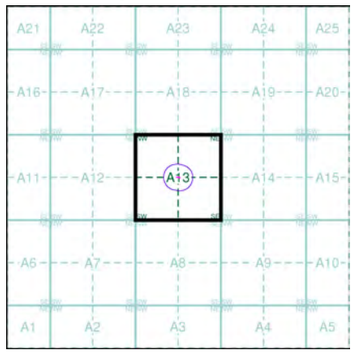
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



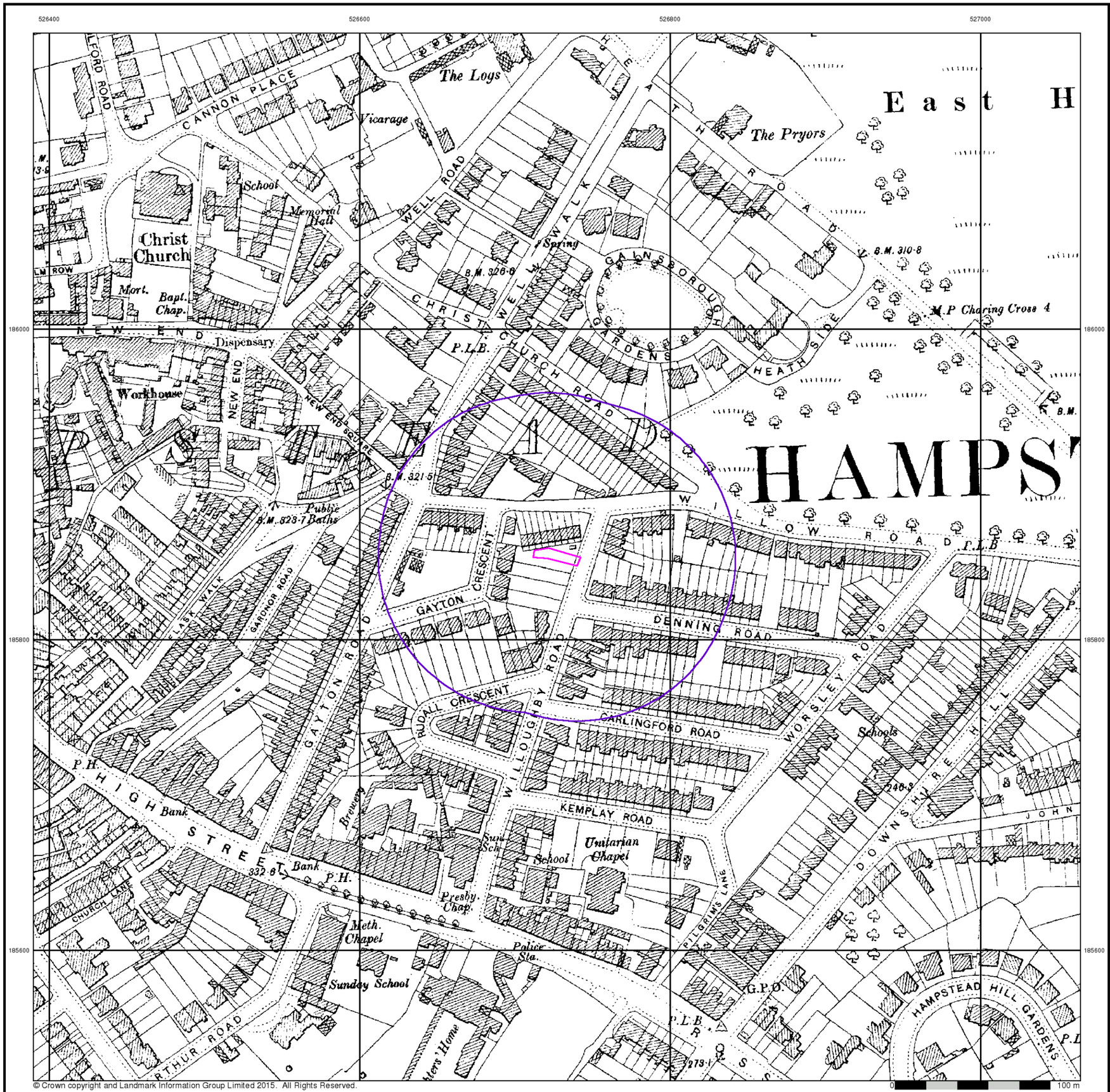
Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



GEA Geotechnical & Environmental Associates

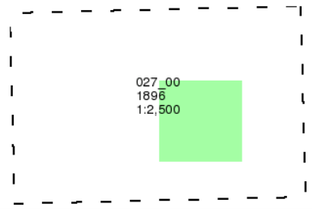
London

Published 1896

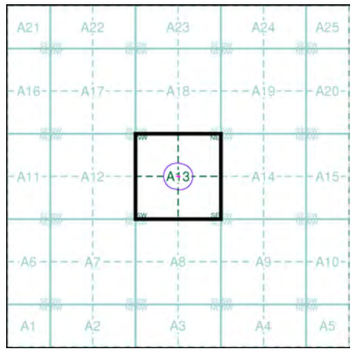
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13

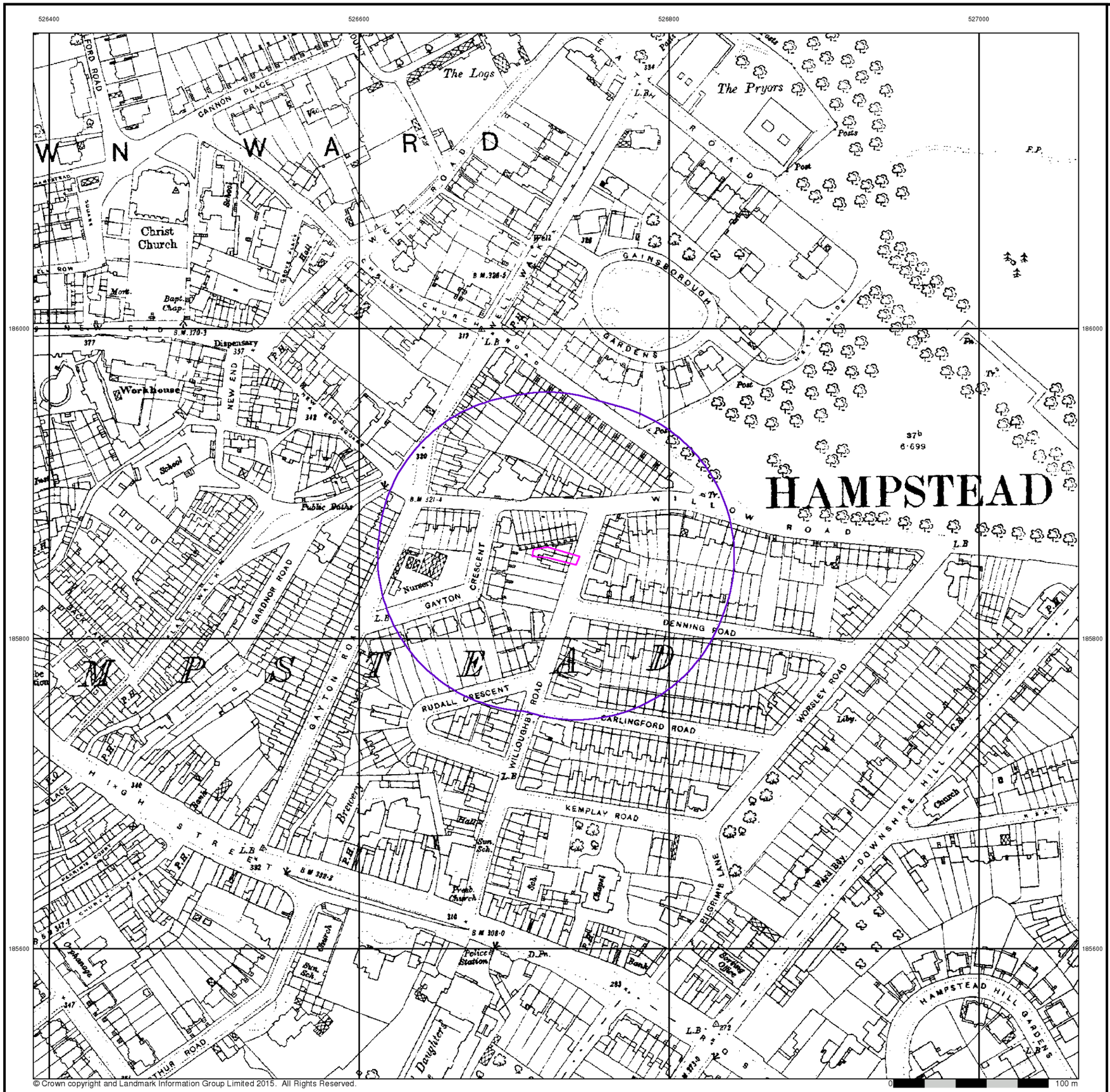


Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT



GEA Geotechnical & Environmental Associates

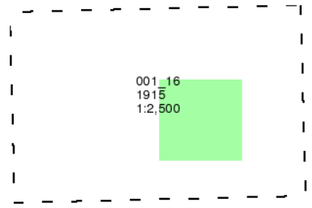
London

Published 1915

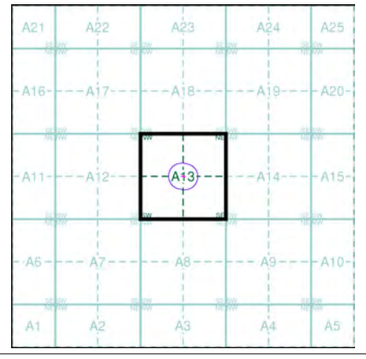
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



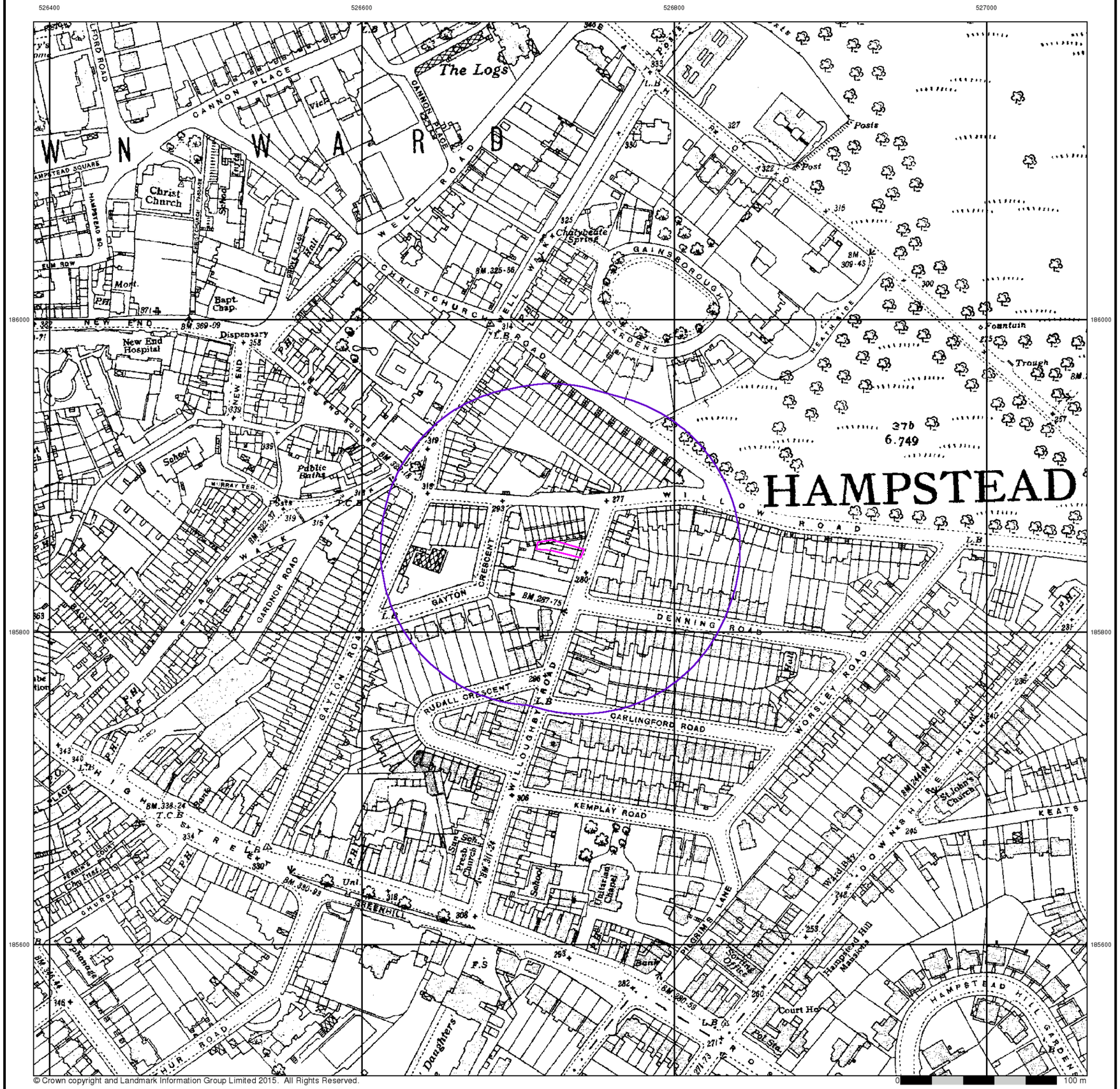
Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



GEA Geotechnical & Environmental Associates

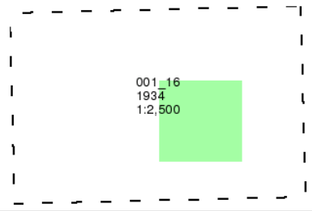
London

Published 1934

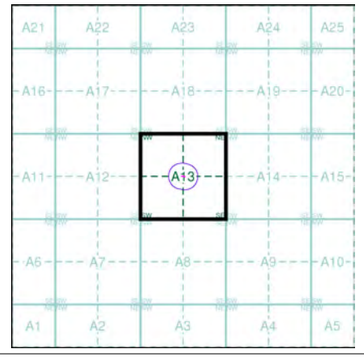
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



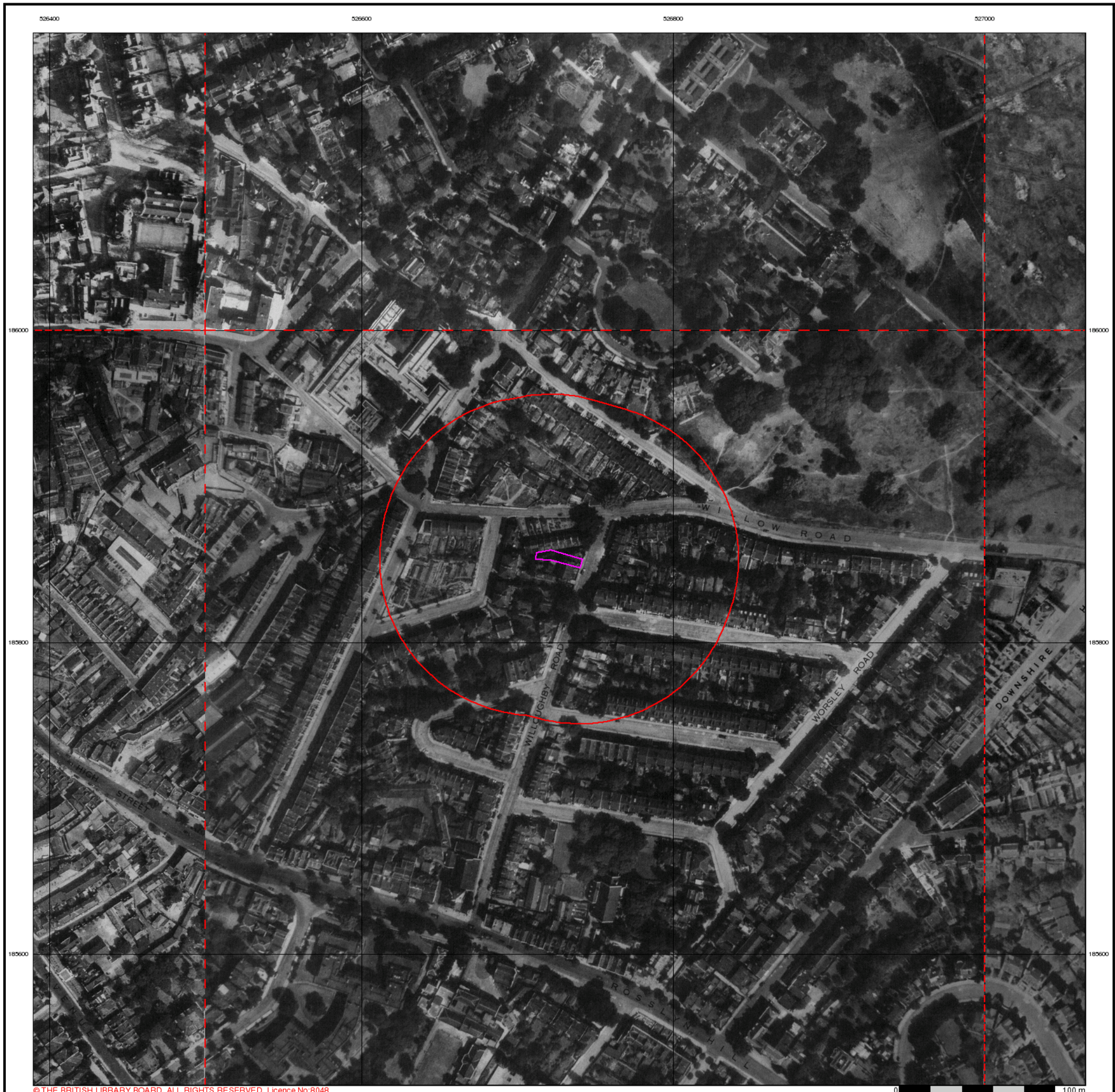
Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



GEA Geotechnical & Environmental Associates

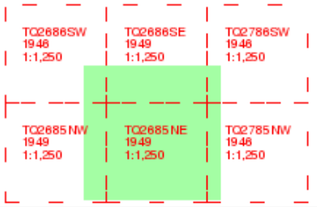
Historical Aerial Photography

Published 1946 - 1949

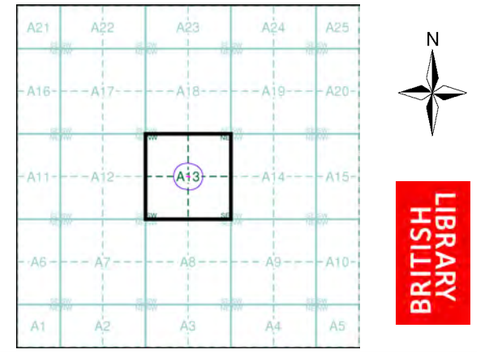
Source map scale - 1:1,250

The Historical Aerial Photos were produced by the Ordnance Survey at a scale of 1:1,250 and 1:10,560 from Air Force photography. They were produced between 1944 and 1951 as an interim measure, pending preparation of conventional mapping, due to post war resource shortages. New security measures in the 1950's meant that every photograph was re-checked for potentially unsafe information with security sites replaced by fake fields or clouds. The original editions were withdrawn and only later made available after a period of fifty years although due to the accuracy of the editing, without viewing both revisions it is not easy to spot the edits. Where available Landmark have included both revisions.

Map Name(s) and Date(s)



Historical Aerial Photography - Segment A13



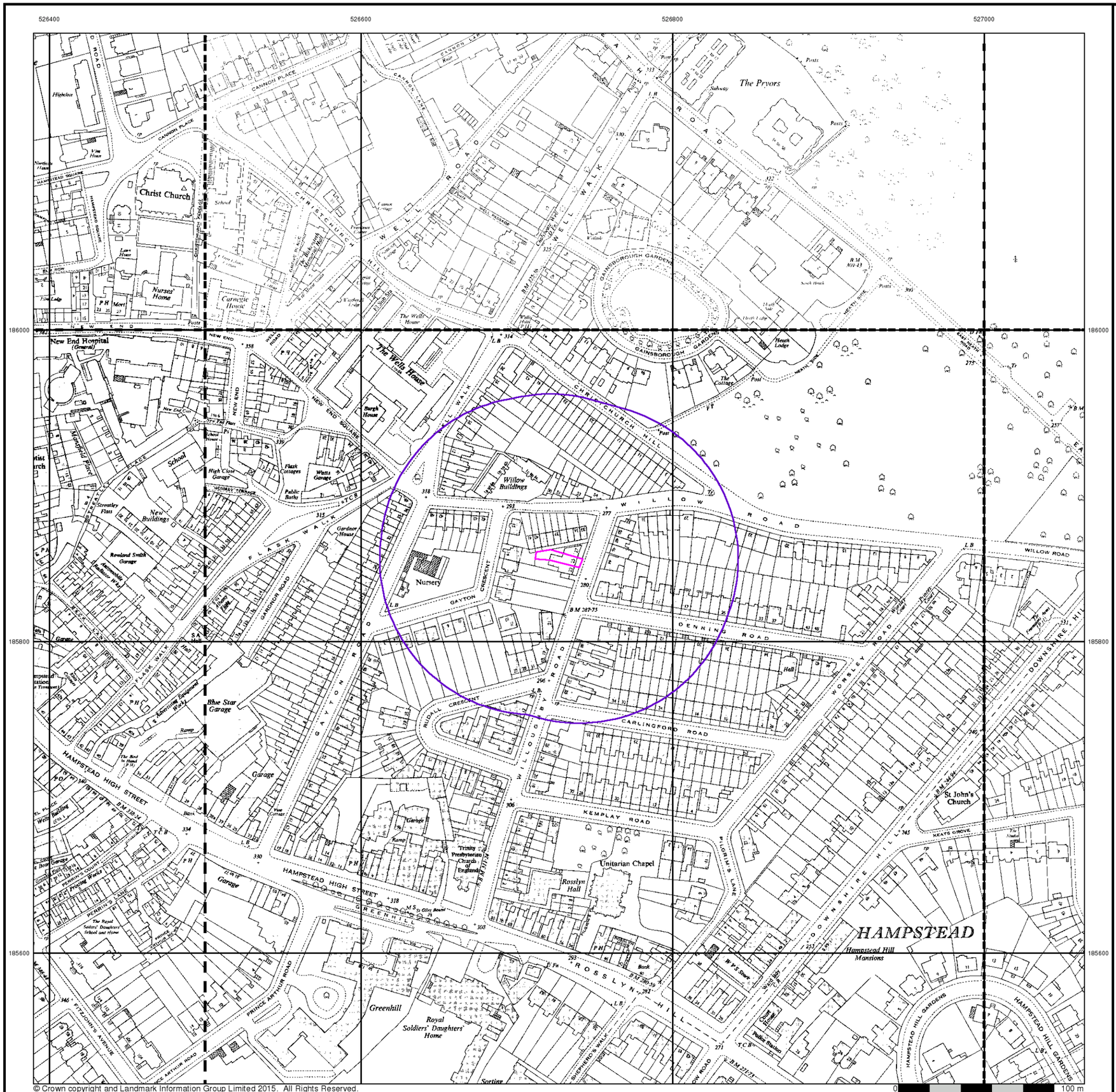
Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



GEA Geotechnical & Environmental Associates

Ordnance Survey Plan

Published 1952 - 1954

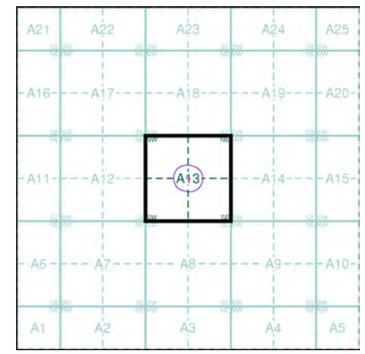
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)

TQ2686SW 1954 1:1,250	TQ2686SE 1954 1:1,250	TQ2786SW 1952 1:1,250
TQ2685NW 1954 1:1,250	TQ2685NE 1954 1:1,250	TQ2785NW 1954 1:1,250

Historical Map - Segment A13



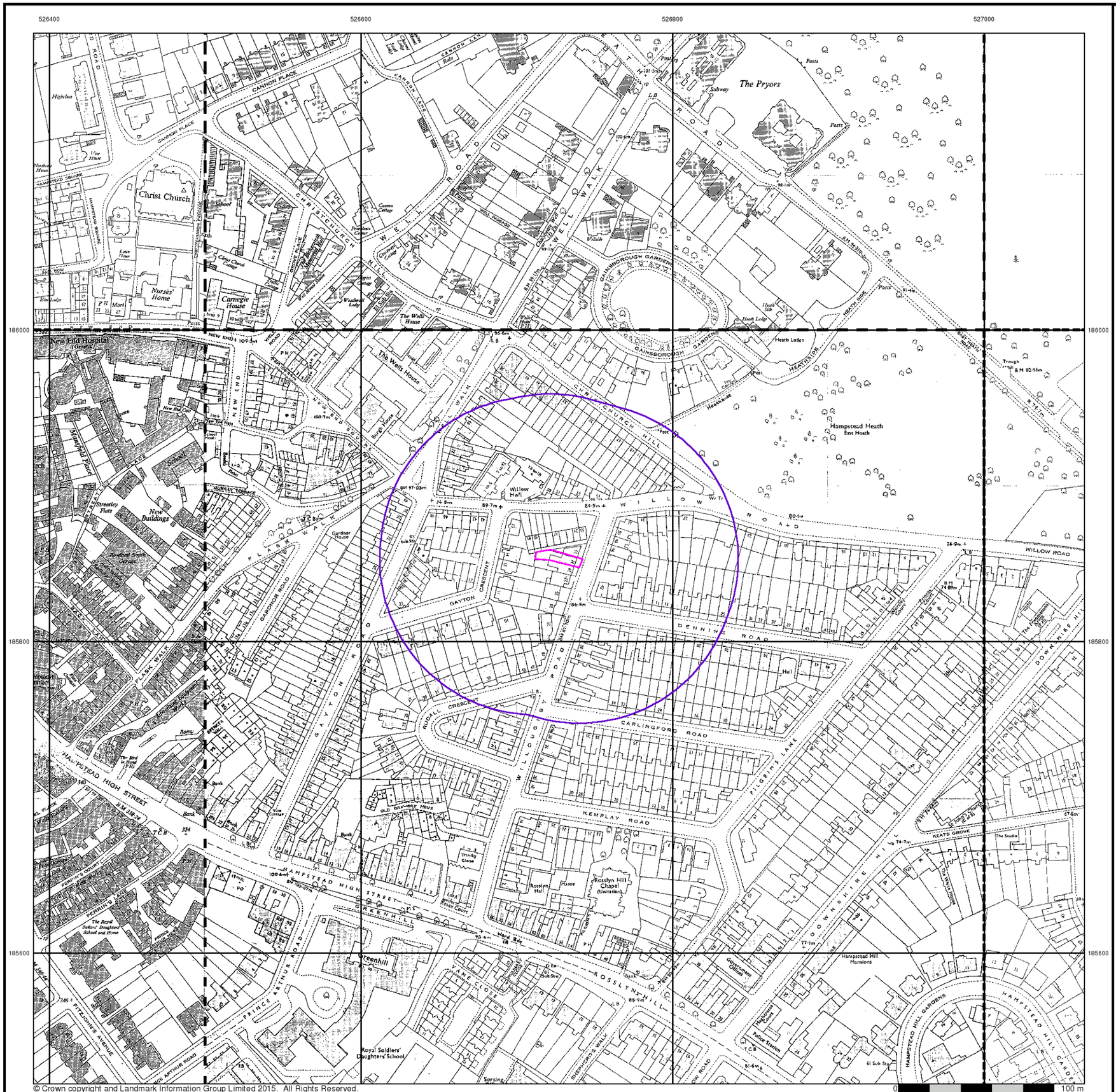
Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



GEA Geotechnical & Environmental Associates

Additional SIMs

Published 1952 - 1987

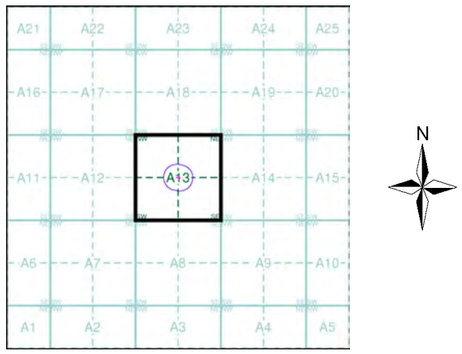
Source map scale - 1:1,250

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

TQ2686SW 1954 1:1,250	TQ2686SE 1954 1:1,250	TQ2786SW 1952 1:1,250
TQ2685NW 1954 1:1,250	TQ2685NE 1987 1:1,250	TQ2785NW 1954 1:1,250

Historical Map - Segment A13



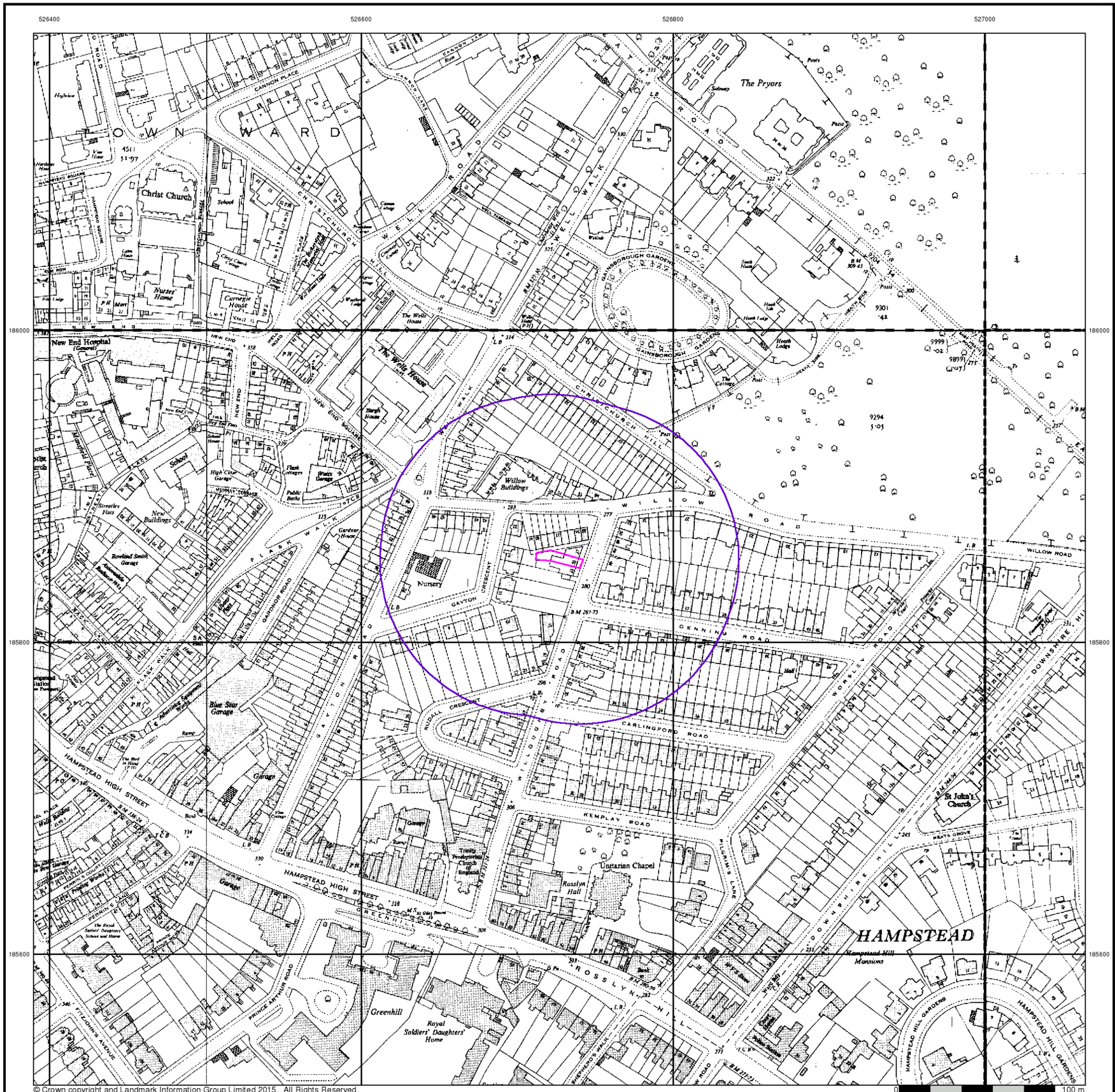
Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



GEA Geotechnical & Environmental Associates

Ordnance Survey Plan

Published 1953 - 1955

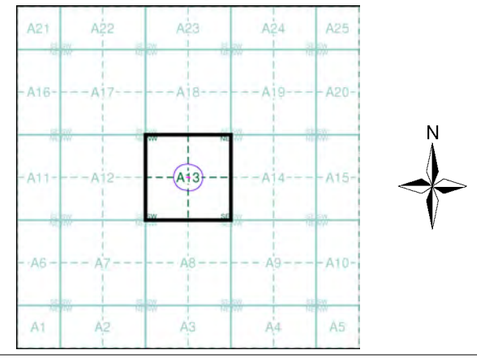
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)

TQ2686 1954 1:2,500	TQ2786 1953 1:2,500
TQ2685 1955 1:2,500	TQ2785 1954 1:2,500

Historical Map - Segment A13



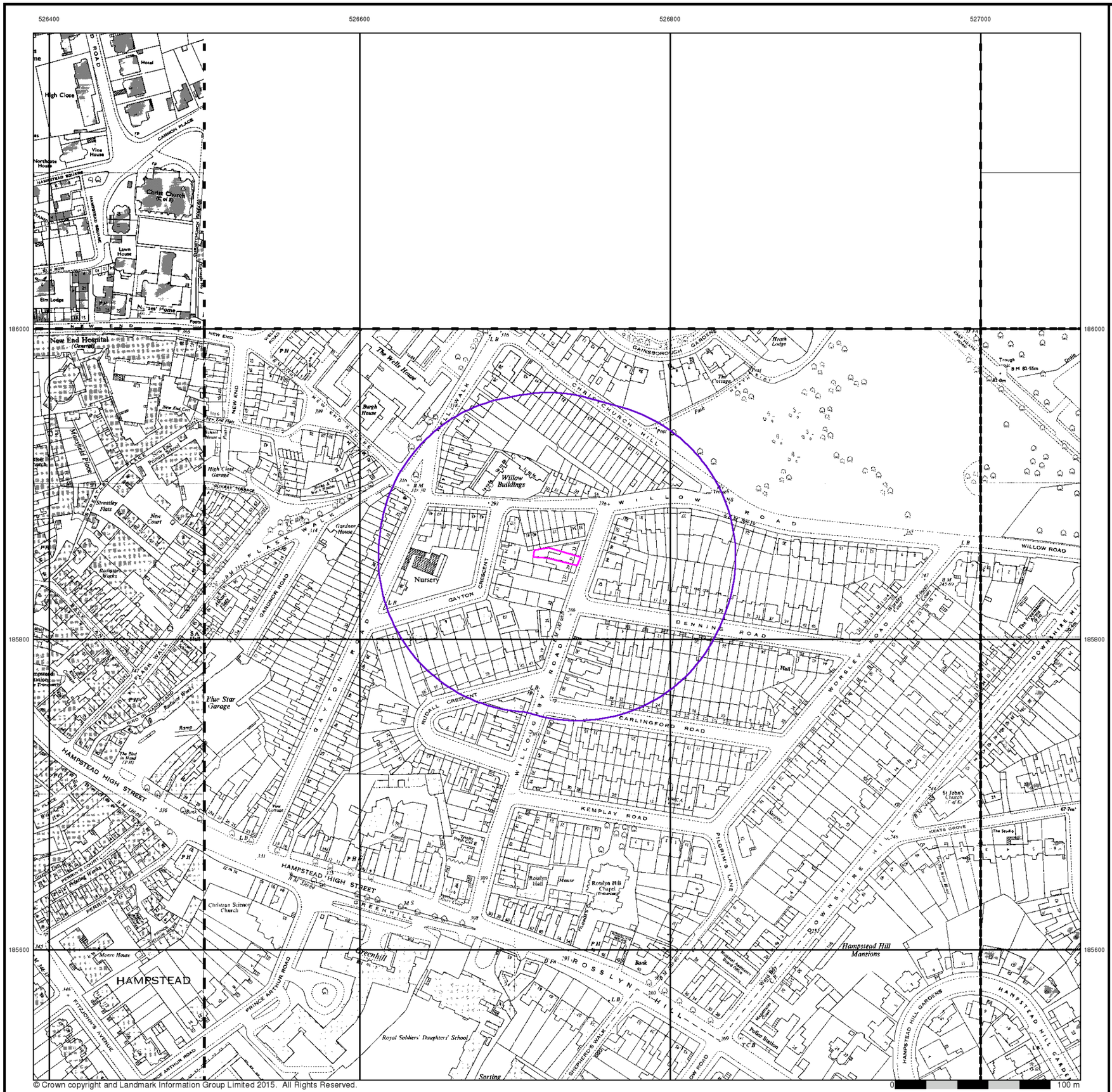
Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



GEA Geotechnical & Environmental Associates

Ordnance Survey Plan

Published 1966 - 1981

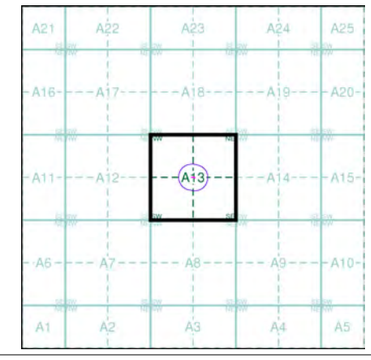
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)

TQ2686SW 1973 1:1,250		TQ2786SW 1981 1:1,250
TQ2685NW 1966 1:1,250	TQ2685NE 1966 1:1,250	TQ2785NW 1972 1:1,250

Historical Map - Segment A13



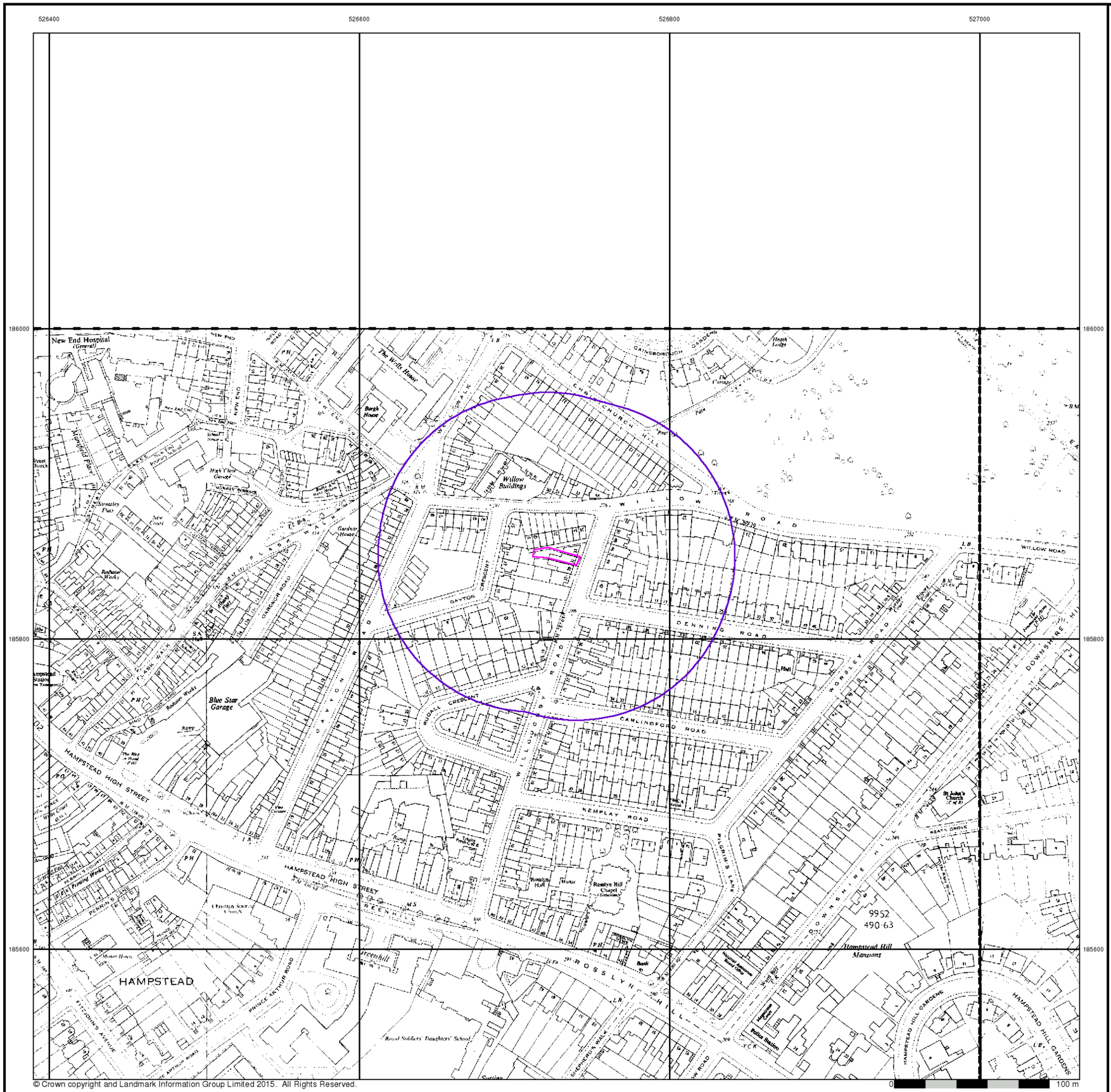
Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



GEA Geotechnical & Environmental Associates

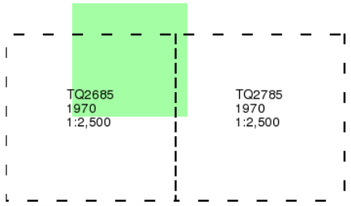
Ordnance Survey Plan

Published 1970

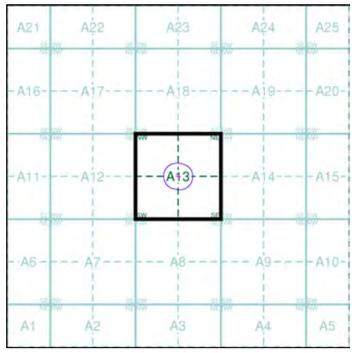
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13

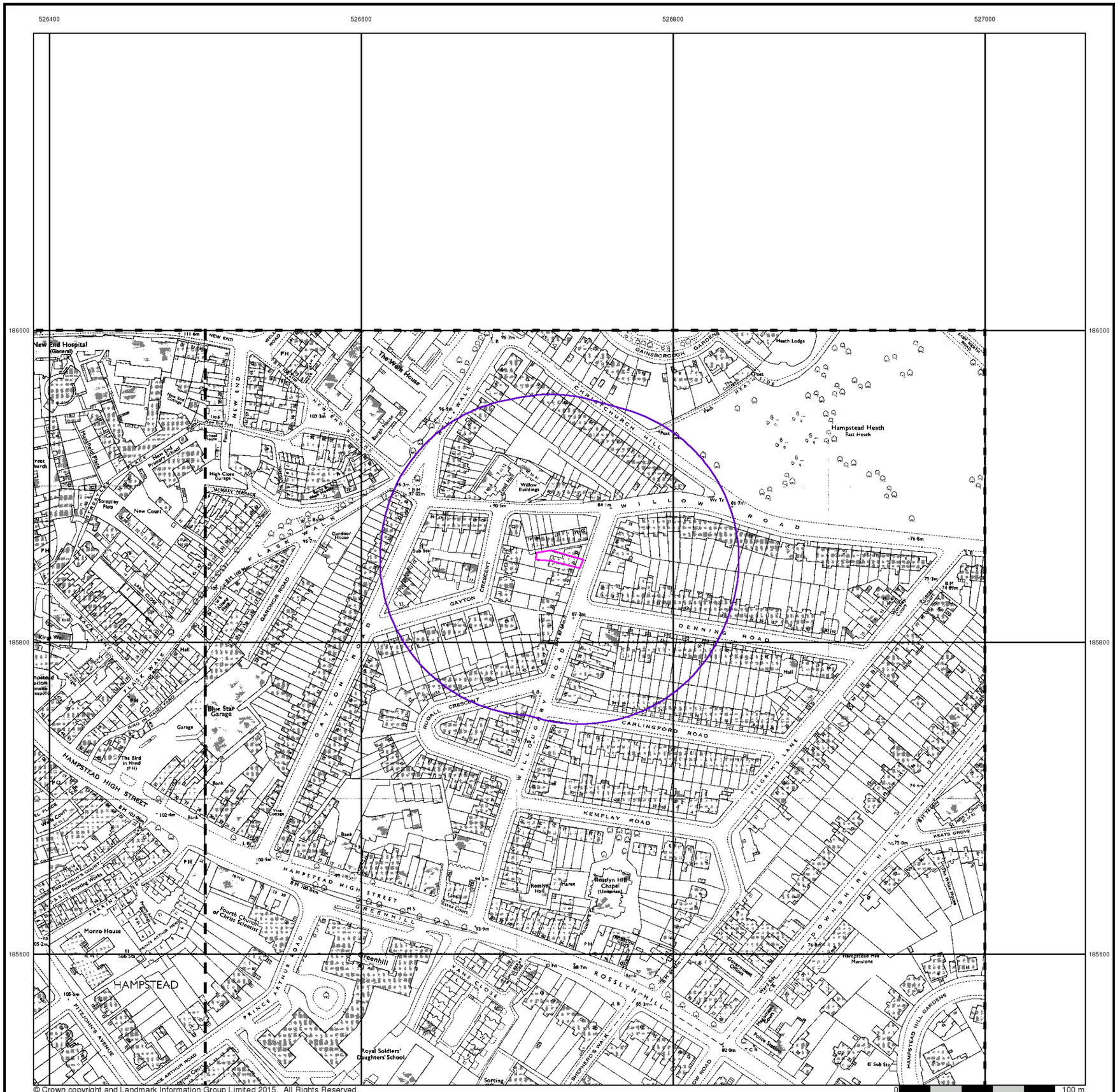


Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT



GEA Geotechnical & Environmental Associates

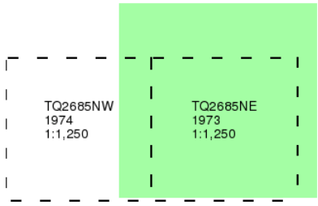
Ordnance Survey Plan

Published 1973 - 1974

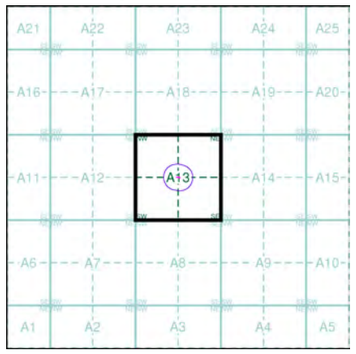
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



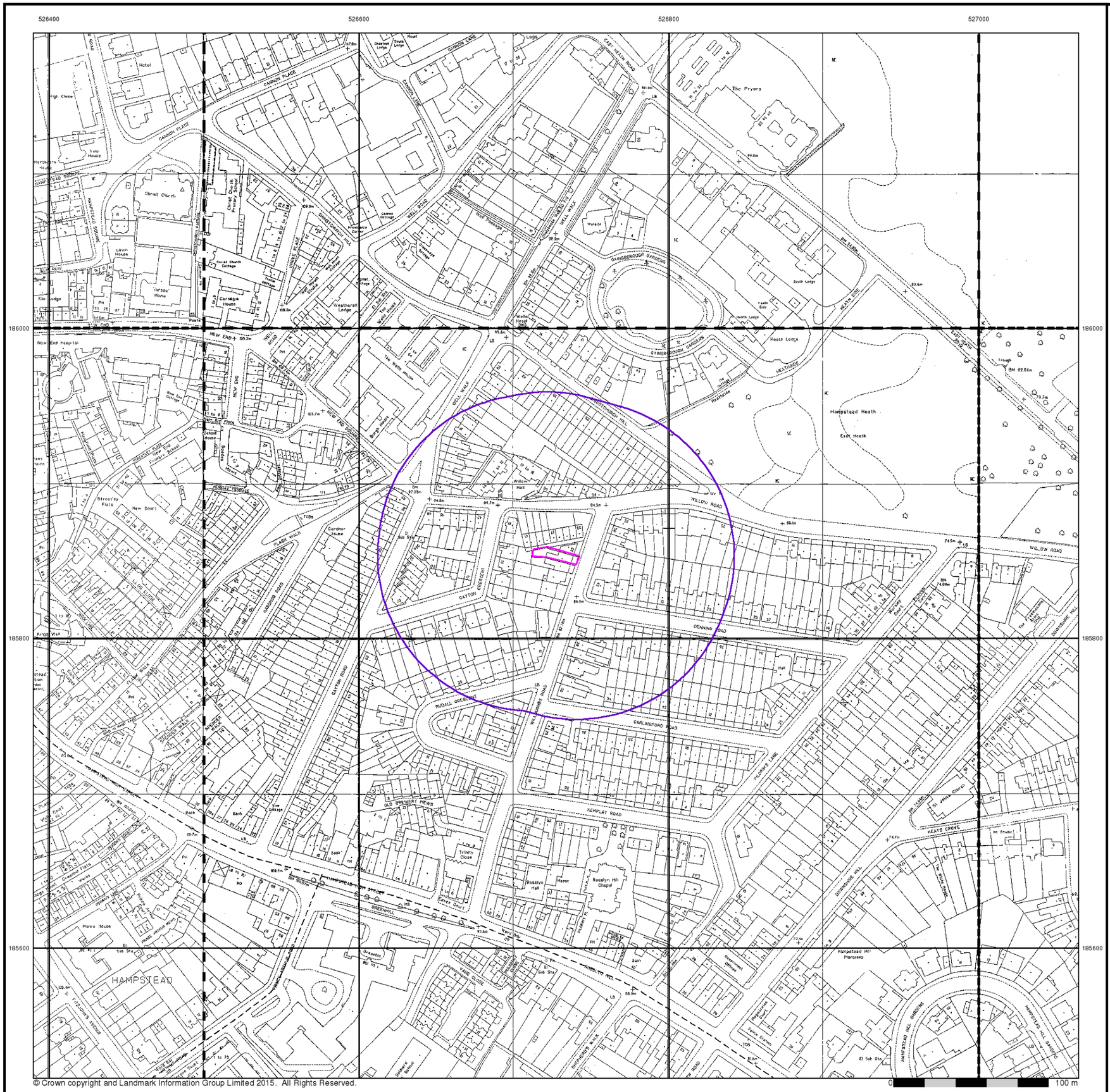
Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



GEA Geotechnical & Environmental Associates

Large-Scale National Grid Data

Published 1991

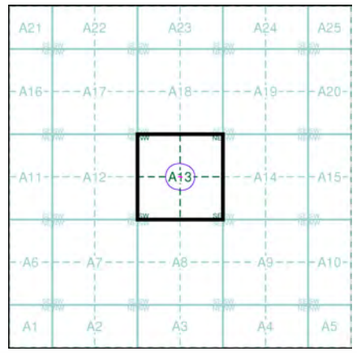
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

TQ2686SW 1991 1:1,250	TQ2686SE 1991 1:1,250	TQ2786SW 1991 1:1,250
TQ2685NW 1991 1:1,250	TQ2685NE 1991 1:1,250	TQ2785NW 1991 1:1,250

Historical Map - Segment A13



Order Details

Order Number:	74921429_1_1
Customer Ref:	J15315
National Grid Reference:	526730, 185850
Slice:	A
Site Area (Ha):	0.02
Search Buffer (m):	100

Site Details

31 Willoughby Road, LONDON, NW3 1RT