Lifecare Residencies Ltd

Gondar Gardens, West Hampstead, NW6 1QF

Geo-environmental/Geotechnical Site assessment.

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RSK GENERAL NOTES

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1 INTRODUCTION

RSK Environment Limited (RSK) was commissioned by Lifecare Residencies Ltd to carry out a Geo-Environmental/Geotechnical Site Assessment at the site of a disused Thames Water underground reservoir at Gondar Gardens, West Hampstead, NW6 1QH.

It is understood the site is being considered for redevelopment through the construction of 28 dwellings close to the Gondar Gardens frontage of the site. These will comprise blocks of 3-4 storeys above a basement level that will contain residential accommodation. The proposals will incorporate the existing buried reservoir structure as a basement in part at 72.50m AOD, and require additional excavations to form new sections of lower ground at 75.30m AOD and basement structure, mainly to the front elevation and adjacent to 1-6 Chase Mansions.

To the rear of the frontage scheme the proposal is to demolish the existing reservoir roof structure retaining the perimeter masonry arched walls and buttresses. Between the retained buttresses a crushed fill material will be placed to form sloped banks down to the enhanced landscaped habitat area of the former reservoir structure.

This report is subject to the RSK service constraints given in **Appendix A**.

1.1 Objective

The objective of the work reported herein is to provide information and an assessment on ground conditions with respect to the proposed development.

The aims are to:

- Obtain sufficient information regarding ground conditions from which risks to end-users, the environment and structures can be assessed;
- Confirm the engineering characteristics of the ground sufficiently to enable the detailed design of the proposed new buildings and associated infrastructure; and
- Enable a preliminary assessment of the potential waste classification implications of soil arisings.

1.2 Scope

The scope of the investigation and layout of this report has been designed with consideration of CLR11 (Environment Agency, 2004a) and BS 10175: 2011 (BSI, 2011).

The project was carried out to an agreed brief as set out in RSK's proposal (ref 371487-T03 (00), dated March 2017). The scope of works for the assessment included:

- A preliminary risk assessment (PRA) to include a review of existing reports, geological, hydrogeological and hydrological information, a commercially available environmental database, and historical plans; correspondence with regulatory authorities; and a site walkover – this information is used to develop an initial conceptual site model to consider any potentially complete pollutant linkages.
- an intrusive investigation consisting of 3 no. deep boreholes, 6 no. shallow boreholes, one hand excavated trial pit to expose foundation of adjacent building in northwest of the site and one machine excavated trial pit to investigate the presence of a secondary reservoir structure;
- Installation of groundwater monitoring standpipe piezometer in the borehole BH01 to a depth 29.0 mbgl, with a response zone from 28.50 mbgl to 30.50 mbgl;
- Installation of groundwater monitoring standpipes in borehole BH02 to a depth of 12.0 mbgl, with a response zone from 11.00 mbgl to 13.00 mbgl, and borehole BH03 to a depth of 10.00 mbgl, with a response zone from 1.00 mbgl to 11.00 mbgl.
- Subsequent laboratory analysis plus groundwater and gas monitoring;
- development of a refined conceptual site model followed by generic quantitative risk assessment (GQRA) to assess complete pollutant linkages that may require the implementation of mitigation measures to facilitate redevelopment
- identification of outline mitigation measures for complete pollutant linkages or recommendations for further work
- interpretation of ground conditions and geotechnical data to provide recommendations with respect to foundations and infrastructure design
- a factual and interpretative report
- an assessment of the potential waste classification implications of soil arisings and of the stockpiled material across the site.

Part of the scope of work also comprised a internal structural investigation which comprised the following scope:

- taking of 10No. brick and mortar samples for subsequent laboratory testing.
- Establish the thickness of the brick masonry roof arch by drilling through at one location.
- Excavation of two internal trial pits at two column locations to establish the makeup of existing foundations.

The findings of the above structural investigation are reported separately, report reference 288627-01 (00), dated April 2017, a copy of which is provided in **Appendix D** for reference.

1.3 Existing reports

The following reports detailing previous works at the site were made available for review:

- RSK Geo-Environmental Site Assessment: Gondar Gardens, West Hampstead, report reference 23283-1 (00)dated December 2009.
- RSK Summary of Hydrogeology Letter Report: Gondar Gardens, West Hampstead, report reference 25113-01L (01), dated April 2015.

These have been summarised in Section 2 and a copy included in **Appendix D** for reference.

1.4 Limitations

The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows may vary from those reported due to seasonal, or other, effects.

Whilst asbestos containing materials were not identified during the fieldworks or supporting laboratory analysis, the history of the site indicates asbestos may well be present. Asbestos is often present in discrete areas. Thus, although not encountered during the site investigation, may be found during more extensive ground works.

2 THE SITE

2.1 Site location and description

The site is located on Gondar Gardens, West Hampstead, London and is centred at Grid Reference 524838, 185309, as shown on **Figure 1**. The area around the site is primarily residential as detailed in

Table 1.

Table 1: Site setting

To the north:	Terraced houses and their associated rear gardens occupy the full extent of the northern boundary. The western end of the northern border is occupied by southern wall of a residential mansion block.
To the east:	The eastern boundary is marked by a slope leading down to rear gardens of terraced houses.
To the south:	The majority of the southern boundary comprises a slope leading down to the rear gardens of terraced houses. At the western end of the southern boundary is a residential mansion block
To the west:	Immediately to the west of the site is Gondar Gardens road, which slopes down to the south.

The site covers an area of approximately 1.2 hectares at an elevation of approximately 80 m above Ordnance Datum (AOD) and is rectangular. It comprises a former Thames Water buried reservoir of masonry construction, built in circa 1890, which occupies approximately two thirds of the site footprint. The surface of the site comprises an open grassed field, designated as a conservation area.

The eastern boundary of the sites is marked by an approximately 19° slope, which reduces the level from 79 m AOD to 75 m AOD, down to rear gardens of residential terraced houses.

The southern boundary is marked by an approximately 17° slope at the eastern end, which reduces level from approximately 78.5 m AOD to 72.5 m AOD, down to rear gardens of residential terraced houses. The slope reduces in height from east to west along the southern boundary, to adjacent to the mansion block at the western end of the southern boundary, where the slope is reduced in height to approximately 1 m, reducing levels from approximately 80.0 m AOD to 79.0 m AOD. Topographical information is not available for the private rear gardens to the north of the site, but from observations made during the site walkover, it is apparent the gardens are approximately 1-2 m lower than the surface elevation across the site.

Gondar Gardens to the west of the site, itself at an elevation of approximately between 78 m AOD and 78.6 m OAD, slopes down away from the south-western corner of the site towards Mill Lane.

It is apparent the ground levels have been raised slightly across much of the site, by the placing of a cover material over the roof of the brick reservoir.

The site comprises the following main attributes (some of which are shown on **Figure 2**):

- A series of vent pipes and box covers are present along the western and northern boundaries of the site, just outside the line of the reservoir walls.
- A small brick building and access hatch into the reservoir is located in the south-western corner of the site.
- A brick retaining wall of approximately 1.1 m in height is located in the south-west corner of the site. To the west and downside of the wall is a small area of concrete hardstanding, which extends to the only entrance to the site from Gondar Gardens.
- Various semi mature and mature trees run alongside the western, southern and eastern site boundaries, mostly within the sloping areas.
- Areas of thick brambles are present along the northern boundary and west/north-western boundary of the site. The possible Japanese knotweed noted during RSK's previous investigation in 2009 could not be located at the time of investigation . The presence may have been obscured by the thickness of bramble vegetation.

2.2 Proposed development

The proposal comprises the construction of 28 dwellings close to the Gondar Gardens frontage of the site. These will comprise blocks of 3-4 storeys above a basement level that will contain residential accommodation. The proposals will incorporate the existing buried reservoir structure as a basement in part at 72.50m AOD, and require additional excavations to form new sections of lower ground at 75.30m AOD and basement structure, mainly to the front elevation and adjacent to 1-6 Chase Mansions. Adjacent structures are very close to the proposed new retaining structures and particular attention needs to be paid to protection of the adjacent third party assets. Lateral support will need to be provided prior to commencement of excavation.

To the rear of the frontage scheme the proposal is to demolish the existing reservoir roof structure retaining the perimeter masonry arched walls and buttresses. Between the retained buttresses a crushed fill material will be placed to form sloped banks down to the enhanced landscaped habitat area of the former reservoir structure.

Within the frontage scheme there are requirements to remove the current buttresses which brace the vertical perimeter masonry arches. It is intended to construct new reinforced vertically spanning RC walls in front of the arches sequentially.

These will span between the basement floor, lower ground and ground floors of the new reinforced concrete framed development with the RC floor plates acting as diaphragms transferring lateral loads across the floor plates which will either be resisted by forces in opposing directions or by the core walls to the development. During construction temporary works may be required utilising diagonal temporary propping to provide lateral support to the walls.

Once the walls are constructed, the void between the rear of the new RC wall and the existing masonry arch will be in filled with a foamed concrete. Once the arches are supported via the new RC lining walls the buttresses will be demolished and completed to form a continuous concrete box.

Where excavations are required to form lower ground and basement areas retaining structures will be required. These structures will be simple vertical retaining structures which provide lateral support.

The proposed building will be founded at depth on piles into the London Clay to minimise the risks of differential settlement due to the different founding levels.

It is currently assumed that for the areas of retaining structure that are non vertically load bearing these will be constructed using either Permanent Sheet Piles or Contiguous Piles which are then faced with a concrete lining wall.

2.3 Where the retaining walls need to support both vertical and horizontal loads then contiguous piles will be utilised.Review of Existing Reports

The following reports detailing previous works at the site were made available for review:

- RSK Geo-Environmental Site Assessment: Gondar Gardens, West Hampstead, report reference 23283-1 (00), dated December 2009.
- RSK Summary of Hydrogeology Letter Report: Gondar Gardens, West Hampstead, report reference 25113-01L (01), dated April 2015.

Geo-Environmental Site Assessment – 23283-1 (00), December 2009.

A Geo-environmental and geotechnical assessment was carried out by RSK for the former site owner, (ref 23283-1 (00), dated December 2009), to which the reader is referred. A copy is provided in **Appendix D** and a summary of the pertinent information is below.

The RSK investigation was conducted in December 2009 and consisted of the following aspects:

- A Preliminary Risk Assessment (PRA), comprising a desk study and site walkover survey
- A Generic Quantitative Risk Assessment (GQRA);

- Intrusive investigation and laboratory analysis to enable soil parameters for geotechnical purposes to be ascertained; and

- Interpretation of ground conditions and geotechnical data to provide recommendations with respect to foundations, floor slabs and infrastructure.

At the time of the investigation, the site was in the same condition as present. A summary of the PRA findings is presented below. For full information the reader should refer to the report;

The published records for the area indicate the geology of the area comprises the London Clay Formation. The report states that reworked materials (London Clay) are likely to be present, associated with the construction of the reservoir.

The report states National Radiological Protection Board indicates that the percentage of homes above the action level is less than 1%. This is confirmed by reference to the British Geological Survey information contained within the environmental database, stating that no radon protective measures are necessary for the site.

The London Clay is classed as a non-aquifer on the Groundwater Vulnerability Map.

The site is located with a Nitrate vulnerable zone. At the time of the investigation, the site was designated by the local council as 'private open space' and it is noted in the report that a ecological survey was being conducted at the time of investigation.

The review of historical maps indicates that the site was developed with the reservoir from 1972, with the first available map from 1896 showing the reservoir to be present. The surrounding area to the east and south are shown to be developed with the existing housing by this time. By the 1915 map the surrounding area is generally developed with the existing residential properties. The only other notable change to the site and/or surrounding area is the construction of the existing sub-station in the north-western corner shown on the 1962 map. It is understood the reservoir was decommissioned in circa 2000.

During the site walkover survey Japanese knotweed was identified at three locations along the northern boundary.

The scope of the intrusive investigation included:

- 7No. drive in sampler boreholes advanced to depths of 4.0 mbgl,

- 1No. Cable Percussion Borehole drilled to a depth of 20 mbgl,

- Installation of gas and groundwater monitoring standpipes in four of the window sample boreholes and were positioned to provide general coverage of the site, in absence of any identified areas of concern. No monitoring was conducted as part of the scope of works.

- Laboratory testing of recovered samples for contamination and geotechnical purposes.

The RSK investigation encountered a nominal thickness of topsoil to a maximum depth of 0.3 mbgl. This was underlain by made ground, comprising silty sandy clay with fragments of brick, stone, concrete, mudstone, tarmac and roots, extending to a depth of 4.0 mbgl. In several locations the material is described as reworked London Clay, likely associated with the construction of the reservoir. Beneath the made ground London Clay was encountered and proved to the full depth investigated of 20.0 mbgl. The London Clay was found to comprise firm becoming stiff and very stiff silty clay with occasional pockets of sand. In four of the window sample boreholes the clay was found to be desiccated to depths of up to 3.0 mbgl.

A single groundwater seepage was noted in the cable percussion borehole at a depth of 13.0 mbgl.

The RSK investigation was designed to investigate the site for the original scheme, which comprised the partial demolition of the reservoir and the construction of three storey terraced housing with partial double basements, with the former reservoir being considered for underground parking. As such a residential end use was assumed for assessing contamination in the GQRA. The results of contamination testing found a single elevated concentration of benzo(a)pyrene in window sample borehole PH1. This was in an area of a proposed house and as such was de-risked on the bases of pathway to end users being broken.

Comparison of the results against GAC values for water supply pipes found values of arsenic exceeding recommended GAC values in four locations.

With regard to geotechnical recommendations, the recommended foundation solution was piled foundations, with continuous flight auger (cfa) or continuous helical replacement piles considered appropriate for the ground conditions encountered.

Summary of Hydrogeology Letter – 25113-01L (01), Dated April 2015

RSK Environment Ltd were instructed by the previous owner to provide a summary of the hydrogeology beneath the site in order to inform the preparation of a basement impact assessment. The reader is referred to the letter for full information, however a brief summary is provided below.

The underlying London Clay Formation is classified as a non-aquifer, reflecting its inability to store or transmit large quantities of water. The clay has very low permeability values, ranging from 3×10^{-9} for clays with sand partings to 3×10^{-11} for intact clay.

At depth beneath the site, the Thanet Sand Formation and White Chalk Sub-group are designated as Secondary ‘A’ aquifers and Principal aquifers respectively. These form a regional resource for public supply. Given the thickness of overlying London Clay, the proposed development was not considered to represent a risk to the aquifers.

The aforementioned site investigation was reviewed to confirm the anticipated absence of any continuous body of shallow groundwater. There are no known ponds, streams or drainage ditches on or adjacent to the site.

The hydrogeological site conditions were considered for the purpose of screening in accordance with CPG4, **Figure 1** – Subterranean (ground water) flow screening chart. The answers presented in the report are considered to remain relevant and correct for the current proposed scheme.

2.4 Preliminary Risk Assessment

A preliminary risk assessment (PRA) was prepared for the site by RSK as part of the previous Geo-Environment Site Assessment (ref 23283-1 (00), dated December 2009). A summary of the PRA is provided above.

As part of the scope of this investigation, we have obtained updated environmental database searches. Reviewing the updated information against the current proposed development, which has changed from terraced residential houses to a scheme comprising the construction of 28 dwellings close to the Gondar Gardens frontage of the site. These will comprise blocks of 3-4 storeys above a basement level that will contain both residential accommodation and resident parking and areas of enhanced landscaped habitat will be formed in the area of the former reservoir structure. It is considered that the original outline conceptual model remains valid for the current proposed scheme. The findings of the PRA was used to inform the phase II geoenvironmental assessment reported herein.

The previous RSK report should be referenced for detailed information on the published geology and hydrogeology, site history and the initial conceptual model of contamination. A copy of the report is included in **Appendix D** for reference.

3 SITE INVESTIGATION METHODOLOGY

RSK carried out intrusive investigation work and subsequent groundwater monitoring during a period from 3rd March 2017 to 25th April 2017. The purpose of the intrusive investigation was to aid confirmation of the ground conditions at the site, obtain geotechnical information for design purposes, to allow for a preliminary assessment for waste disposal purposes and to investigate the potential pollutant linkages identified in the outline conceptual site model.

3.1 Sampling strategy and methodology

The techniques adopted for the investigation have been chosen considering the previously recorded ground conditions, existing land use and the proposed development. At the time of investigation, the site was vacant. The intrusive investigation comprised deep and shallow boreholes and trial pits. The reasoning behind the supplementary investigation is as follows:-

- Three deep boreholes were advanced to determine sufficient ground conditions below the significant thickness of made ground and existing reservoir depth to facilitate a robust pile design and to obtain parameters for the ground movement assessment. One of these boreholes was advanced to investigate the potential presence of a secondary reservoir chamber on the northern side of the known reservoir, to attempt to find the foundation depth and depth to natural ground.
- Undisturbed samples were taken to design an accurate strength profile for use in pile design and other geotechnical matters.
- A single machine excavated trial pit to expose the northern reservoir wall and investigate immediately north of this for the potential presence of a second reservoir structure.
- Additional shallow boreholes were drilled to obtain samples of made ground from across the site to assess the site for potential contamination and allow for preliminary classification of the soils Waste Acceptance Criteria (WAC).

3.1.1 Health and safety considerations

A statutory service search was consulted before positioning each exploratory location and subsequently a Ground Penetrating Radar (GPR) and Cable avoidance Tool clearance scan was completed by a qualified engineer.

3.1.2 Investigation locations

The following site work was carried out between the dates the 3rd March 2017 to 25th April 2017:

- 2 No. 50 m deep borehole drilled by cable percussion techniques
- 1 No. 15 m deep borehole drilled by cable percussion techniques
- 6 No. dynamic 'windowless' sampler boreholes to a maximum of 7.0 m depth
- 1 No. machine excavated trial pit to expose the northern wall of the reservoir and investigate for the presence of a second reservoir wall
- Internal structural investigations (reported separately).
- Monitoring of the installations in BH1, BH2 and BH3 on a single occasion.

The investigation and the soil descriptions were carried out in general accordance with 'BS 5930:2015. Code of Practice for Site Investigations' (BSI, 2015).The exploratory hole records are presented in **Appendix E**.

The locations of the intrusive investigations are shown in **Figure 2**. The rationale for these locations is given in **Table 2**. In terms of assessing ground contamination, the RSK PRA identify potential contaminative history of the site to include the possible made ground associated with the construction of the reservoir. The RSK investigation found a single isolated elevated benzo(a)pyrene concentration when assessed against human health GAC's based on a residential end use, and several slightly elevated concentrations of arsenic when compared to GAC's for water supply pipes. Given the limited extent of elevated contamination found during the previous RSK investigation and the potential widespread presence of made ground across the site the investigation was designed to provide further general coverage.

Table 2: Exploratory hole location rationale

Exploratory hole number	Location	Rationale
BH1	Adjacent to north-west extent of the existing reservoir	To retrieve undisturbed samples of the underlying ground in order to prove the geological succession beneath the site, obtain geotechnical data, to a sufficient depth to inform pile, retaining wall design and slope stability assessment. To install groundwater monitoring standpipe piezometers.

Exploratory hole number	Location	Rationale
BH2	Adjacent to south-eastern extent of the existing reservoir	To retrieve undisturbed samples of the underlying ground in order to prove the geological succession beneath the site, obtain geotechnical data, to a sufficient depth to inform pile, retaining wall design and slope stability assessment. To install gas and groundwater monitoring standpipe.
BH3	Approximately midway along the northern wall of the existing reservoir. Advanced through TP3.	To drill adjacent to the existing buttress to the reservoir and attempt to encounter the foundation, with a secondary objective, if the foundation is not encountered, to prove the depth to natural soil. To install gas and groundwater monitoring standpipe with a response zone within the made ground.
WS1	Central north-western part of the site	To prove depth of made ground fill material above the reservoir roof and to obtain samples for soil contamination and waste classification testing.
WS2	Central south-western part of the site	To prove depth of made ground fill material above the reservoir roof and to obtain samples for soil contamination and waste classification testing.
WS3	Central northern part of the site	To prove depth of made ground fill material above the reservoir roof and to obtain samples for soil contamination and waste classification testing.
WS4	Central southern part of the site	To prove depth of made ground fill material above the reservoir roof and to obtain samples for soil contamination and waste classification testing.
WS5	Central north-eastern part of the site, outside of the footprint of existing reservoir	To prove depth of made ground fill material above the reservoir roof and to obtain samples for soil contamination and waste classification testing.
WS6	Central south-eastern part of the site, outside of the footprint of existing reservoir	To prove depth of made ground fill material above the reservoir roof and to obtain samples for soil contamination and waste classification testing.
TP1	Approximately midway along northern wall, but outside of existing reservoir.	Expose the northern wall of the known reservoir and investigate the presence of a second reservoir to the north
Notes:		

The investigation points were located approximately by reference to physical features present on the site at the time of investigation. The ground levels and coordinates at the borehole and trial pit location were measured using Leica GPS equipment. .

3.1.3 Soil sampling, in-situ testing and laboratory analysis

3.1.3.1 Chemical testing

Soils were collected for laboratory analysis in a variety of containers appropriate to the anticipated testing suite required. Samples were stored in accordance with the RSK quality procedures to maintain sample integrity and preservation and to minimise the chance of cross contamination.

The samples taken are recorded together with their depths on the exploratory hole records in **Appendix F**. The samples were transported to the laboratory in chilled cool boxes. Laboratory chain of custody forms can be provided if required. The rationale for soil sample chemical analysis is presented in **Table 3**.

Table 3: Summary of chemical testing programme

Strata	Tests undertaken	No of Tests	Rationale
Made Ground (from Boreholes)	Metals suite (As, Cd, tCr, Pb, Hg, Se, Cu, Ni, Zn) and pH	10	Standard suite of testing undertaken on a selection of non-targeted samples obtained from the made ground deposits encountered in all locations.
	Asbestos screen	10	
	Total Petroleum Hydrocarbons of the Criteria Working Group (TPHCWG) plus BTEX and MTBE	5	
	Total TPH Banded (C6-C40)	5	
	Speciated Polycyclic Aromatic Hydrocarbons (PAHs)	10	
	Waste Acceptance Criteria (WAC) testing	2	Samples tested due to the proposal to excavate soils for the basement excavation.
Notes:			

3.1.3.2 *Geotechnical testing*

A program of geotechnical testing, scheduled by RSK, was carried out on selected soil samples, as detailed below. The laboratory results, as listed in the Contents, are presented in **Appendix H**.

A summary of the geotechnical testing carried out is given in **Table 4** below.

Table 4: Summary of geotechnical testing

Type of Test	Location	Purpose
Moisture Content	BH1 & BH2	Index testing for classification and selection of geotechnical parameters for the London Clay.
Liquid and Plastic Limit	BH1 & BH2	
Particle Size Distribution and Sedimentation	BH1 & BH2	Testing for earthworks classification of the London Clay
Undrained Triaxial Compression	BH1 & BH2	Confirm the undrained shear strength with depth profile of the London Clay.
Consolidated Undrained Triaxial Compression	BH1 and BH2	Confirm the effective stress strength parameters of the London Clay
Odometer Consolidation	BH1	Confirm the consolidation parameters of the London Clay
Compaction	BH1 & BH2	Confirm earthworks performance characteristics of the London Clay and made ground
Water soluble sulphate & pH	BH1 & BH2	To establish exposure conditions.
Notes: * Testing still underway at time of writing		

Standard penetration tests (SPTs) were carried out within the made ground and London Clay at regular intervals within all cable percussion boreholes, alternated with UT100 samples at a frequency of 1m for the first 5m below ground level, increasing the 1.5m thereafter. Test results are given on the borehole records presented in **Appendix F**. Disturbed samples were taken from each stratum encountered for subsequent geotechnical analysis.

3.1.4 Groundwater monitoring

Depths to groundwater have been recorded in standpipes using an electronic dip meter on two occasions to date and the results are presented in **Appendix G**. The monitoring results are summarised in Section 4.2.

3.1.5 Ground gas monitoring

In line with RSK's original conceptual model, three rounds of monitoring have been undertaken.

An infrared gas meter was used to measure gas flow, concentrations of carbon dioxide (CO_2), methane (CH_4) and oxygen (O_2) in percentage by volume, while hydrogen sulphide (H_2S) and carbon monoxide (CO) were recorded in parts per million. Initial and steady state concentrations were recorded.

The atmospheric pressure before and during monitoring, together with the weather conditions, was recorded.

All monitoring results are contained within **Appendix G** and discussed in Section 4.4.

4 GROUND CONDITIONS

The results of the intrusive investigation and subsequent laboratory analysis undertaken are detailed below. The descriptions of the strata encountered, notes regarding visual or olfactory evidence of contamination, list of samples taken, field observations of soil and groundwater, in-situ testing and details of monitoring well installations are included on the exploratory hole records presented in **Appendix F**.

4.1 Soil

The exploratory holes confirmed that the site is underlain by significant thickness of made ground over the London Clay Formation. This confirms the stratigraphical succession described within RSK's previous report, while determining the ground conditions at greater depths than previously investigated. For the purpose of discussion, the ground conditions are summarised in **Table 5** and the strata discussed in subsequent subsections.

Table 5: General succession of strata encountered

Strata	Exploratory holes encountered	Depth to top of stratum mbgl (mAOD)	Thickness (m)
Topsoil	All locations	0.00 (79.84 to 80.23)	0.10 to 0.30
Made Ground	All Locations	0.10 to 0.30 (79.64 to 80.03)	2.90 to 5.80
London Clay	BH1, BH2, BH3, WS5 & WS6	3.20 to 10.50 (76.70 to 69.54)	Not proven (>50m?)

4.1.1 Topsoil

Topsoil was encountered in all exploratory hole locations, extending to depths of between 0.10 mbgl and 0.30 mbgl (79.64 mAOD to 80.03 m AOD). It was found to generally comprise dark brown clayey sandy gravelly silt.

4.1.2 Made ground

Made ground was encountered in all exploratory hole locations, directly below the topsoil, and extended to significant depths of between 3.20 mbgl and 10.50 mbgl (76.70 m AOD to 69.54 m AOD).

Within window sample boreholes WS1, WS2, WS3 and WS4 the made ground extended to full depth of the borehole, which all terminated at shallow depth upon encountering the roof structure of the buried reservoir.

The made ground above the roof structure generally initially comprised initial thin layer of 'pea' gravel of between 100 mm and 150 mm thickness. Underlying the granular layer, the made ground generally comprised reworked clay, which consisted of brown and pale clay with minimal anthropogenic material consisting of red brick and occasional ash fragments. Root fibres and pockets of silt were occasionally present. Within WS1, WS2, WS3 and WS4 thin layers of granular fill were present, predominantly comprising brick rubble.

Within BH1, BH2, WS5 and WS6, the made ground extended to depths ranging between 3.20 and 6.00 m (76.70 m AOD to 73.84 m AOD and generally comprised reworked clay as described above.

Within borehole BH3, the made ground extended to a depth of 10.50 mbgl (69.54 m AOD). It was found to predominantly comprise brick rubble with occasional layers of very soft clay sandy gravelly silt and sandy clay.

A summary of the in-situ and laboratory test results in this stratum is presented in **Table 6**.

Table 6: Summary of in-situ and laboratory test results for made ground

Soil parameters	Range	Reference
Liquid limit (%)	68 to 84	Appendix H
Plasticity limit (%)	22 to 27	
Plasticity index (%)	45 to 57	
Plasticity term	High to Very High	
Moisture content (%)	23 to 36	
SPT 'N' values	8 to 21 (Generally Less than 10)	Appendix F
SPT 'N_{60}' values	8 to 21 (Generally Less than 10)	Appendix F
Undrained shear strength inferred from SPT 'N_{60}' values (kN/m^2) (based on Stroud Factor=4.5)	36 to 94.5**	Figure 7 & 8
Undrained shear strength measured by hand shear vane testing (kN/m^2)**	43 – 140 (Generally less than 63)	Figure 7 & 8
Optimum Moisture Content measured by Compaction Test (%)	TBC once Testing Completed	Appendix H
Maximum Dry Density measured by Compaction Test (Mg/m^3)	TBC once Testing Completed	Appendix H
Effective Cohesion (kN/m^2)	TBC once Testing Completed	Appendix H
Effective Angle of Shear Resistance (degs)	TBC once Testing Completed	Appendix H

4.1.3 London Clay

London Clay was encountered in BH1, BH2, BH3, WS5 and WS6 beneath the made ground and was proved to the terminal depth in each location of between 7.00 mbgl (72.80 m AOD) and 50.00 mbgl (29.84 m AOD).

Based on the site descriptions and in-situ and laboratory testing carried out this stratum can be described as initially comprising a firm, becoming stiff, medium strength, brown and slightly mottled pale brown silty clay, with frequent medium gravel sized selenite crystals and pockets of orange brown silt, typical of the weathered portion of the London Clay Formation, extending to the base of WS5 and WS6 and to depths of 5.00 mbgl (74.90 m AOD) in BH1 and 8.00 mbgl (71.84 m AOD) in BH2.

Underlying the weathered clay was stiff, becoming very stiff, high to very high strength, dark brownish grey and greyish brown silty clay with traces of pyrite, mica and occasional pockets/partings of grey silt and sand extending to the full depth investigated in BH1, BH2 and BH3 of up to 50.00 mbgl (29.84 m AOD).

Fine to medium gravel sized selenite crystals were noted to depths of between 13.00 mbgl (66.84 m AOD) and 19.50 mbgl (60.40 m AOD). Traces of pyrite and bioturbation markings, were common through the un-weathered portion of the London Clay and occasional pyritised fossil fragments and phospatic nodules were present at various depths throughout. The clay became fissured from a depth of 5.00 mbgl (74.90 m AOD) in BH1 and 7.00 mbgl (72.84 m AOD) in BH2. A summary of the in-situ and laboratory tests in this stratum is presented in **Table 8**.

Table 7: Summary of the in-situ and laboratory test results for London Clay

Soil parameters	Range	Reference
Moisture content (%)	22 to 33	Appendix H
Liquid limit (%)	55 to 82	Appendix H
Plasticity limit (%)	23 to 30	Appendix H
Plasticity index (%)	32 to 56	Appendix H
Modified Plasticity Index (%)	31 to 56	
Plasticity term	High to Very High	-
Consistency Index	0.90 to 1.02	-
Consistency Term (based on laboratory results)	Stiff to Very Stiff	-
SPT ‘N’ values	16 to 81*	Figure 5 & 6
SPT ‘N_{60}’ values	16 to 80*	Figure 5 & 6
Undrained shear strength inferred from SPT ’N_{60}’ values (kN/m^2) (based on Stroud Factor=4.5)	72 to360**	Figure 7 & 8

Soil parameters	Range	Reference
Undrained shear strength measured by triaxial testing (kN/m^2)	63 to 451	Appendix H & Figure 7 & 8
Undrained shear strength measured by hand shear vane testing (kN/m^2)**	61 to 283	Figure 7 & 8
Strength term	Medium to Very High	-
Coefficient of volume compressibility (m_v) (m^2/MN)	0.008 to 0.049	Appendix H
Coefficient of consolidation (c_v) (m^2/yr)	0.52 to 5.16	Appendix H
Optimum Moisture Content measured by Compaction Test (%)	TBC once Testing Completed	Appendix H
Maximum Dry Density measured by Compaction Test (Mg/m^3)	TBC once Testing Completed	Appendix H
Effective Cohesion (kN/m^2)	TBC once Testing Completed	Appendix H
Effective Angle of Shear Resistance (degs)	TBC once Testing Completed	Appendix H
*Extrapolated SPT 'N60' value **Based on Extrapolated SPT 'N60' value.		

4.2 Groundwater

Groundwater was encountered in BH1 at 29.50 mbgl (50.40 m AOD), as a seepage, associated with the presence of a claystone at that depth. Groundwater was not encountered during drilling of BH2, although slurry was noted in the base of the borehole on the morning of the third day of drilling. The borehole was dry on completion. Within BH3 groundwater was encountered within the made ground at a depth of 4.30 mbgl (75.84 m AOD).

Within WS5 and WS6 groundwater seepages were recorded at 3.25 mbgl (76.75 m AOD) and 3.80 mbgl (76.00 m AOD), which on completion of drilling were at 2.60 mbgl (77.30 m AOD) and 6.02 m (73.78 m AOD) respectively.

Three monitoring visits have been completed, the results of which are summarised in **Table 10**.

Table 8: Groundwater monitoring data

Monitoring well	TOC elevation (m AOD)	Depth to water (mb TOC)			Groundwater elevation (m AOD)		
		Visit 1	Visit 2	Visit 3	Visit 1	Visit 2	Visit 3
BH1	79.90	7.55	7.37	7.10	72.35	72.53	72.80
BH2	79.84	6.65	6.62	6.55	73.19	73.22	73.29
BH3	80.04	4.23	4.28	4.23	75.81	75.76	75.81
Notes: mb TOC = metres below top of casing, m AOD = metres above Ordnance datum							

It should be noted that groundwater levels might fluctuate for a number of reasons including seasonal variations. Ongoing monitoring would be required to establish both the full range of conditions and any trends in groundwater levels.

4.3 Existing foundations & Structures

A single machine dug trial pit was excavated along the northern wall of the buried reservoir to expose the wall and attempt to locate a potential second reservoir wall. The location of the trial pit is shown on **Figure 2** and fieldwork records are presented in **Appendix F**. Two hand excavated trial pits were excavated internally, as part of the structural investigation scope of work, to expose the foundations of two internal columns. The fields records are included in the aforementioned structural investigation report, a copy of which is included in **Appendix D**.

Trial Pit No. 1

Trial Pit 1 was machine excavated using a 1.5 tonne tracked excavated. The pit was positioned midway between the fourth and fifth vent cover (from west to east) along the northern boundary of the site. Within the southernmost extent of the trial pit the northern wall of the reservoir structure was encountered at a depth of 1.1 mbgl (79.00 m AOD). The pit was extended north a total of 3.2 m. At a distance of 1.90 m to the north of the exposed northern wall was a second brick wall, orientated approximately east-west, although the eastern extent of the wall turned slightly toward the northeast. The second wall was found to step down from west to east, from a shallowest depth of 0.5 mbgl to 1.4 mbgl at the eastern end. Between the two brick walls were two approximately east-west aligned concrete masses.

Internal Trial Pits: TP No 1 and 2

The foundation to both columns was found to be two layers of brick corbels on to a thin 280 mm thick weak concrete base bearing on firm clay at a depth of 1.22 m below slab level. Hand shear vane readings were taken in the clay at the base of both trial pits to provide an indication of the strength of the founding stratum. The results indicate the clay to be medium strength at a depth of 0.5 m below the base of the pit, quickly increasing to high strength at a depth of 1.0 m below the base of the pit.

The full details of the each of the foundation trial pit excavations are included within **Appendix D**.

4.4 Visual/olfactory evidence of soil and groundwater contamination

No visual or olfactory evidence was noted within the soil or groundwater.

4.5 Ground gas regime

The results of the ground gas monitoring and testing carried out are given in **Appendix G** and are summarised in **Table 9**.

Table 9: Summary of ground gas monitoring results

Borehole	Response zone/strata	Probable source(s) of ground gas	Number of monitoring visits	Methane (%)	Carbon dioxide (%)	Oxygen (%)	Flow rate (l/hr)	Water level (m b TOC)	Atmospheric pressure (mbar)
BH2	11.00 – 13.00	--	2	<0.1	3.6 – 4.4	14.6 – 15.6	0.0 - 0.2	6.55 - 6.65	1005 - 1012
BH3	1.00 – 11.00	MG	2	<0.1	1.0 - 1.2	16.3 – 18.5	-0.1 – 0.1	4.23 – 4.28	1004 - 1012
PH3 (Old Installation from previous investigation	1.00 – 4.00	MG	2	<0.1	1.5 – 1.9	18.6 - 19.6	0.1	DRY	1005 - 1012

Note: *All – Alluvium, MG – Made Ground*

* Standpipe obscured by building rubble following demolition of house

4.6 Refinement of RSK previous conceptual site model

The ground conditions encountered during the intrusive investigation confirm those predicted within the RSK initial conceptual model.

Slightly elevated concentrations of carbon dioxide and slightly depleted oxygen levels have been recorded in the initial rounds of gas monitoring completed to date.

5 QUANTITATIVE RISK ASSESSMENT

In line with CLR11 (EA, 2004a), there are two stages of quantitative risk assessment, generic and detailed. The GQRA comprises the comparison of soil, groundwater, soil gas and ground gas results with generic assessment criteria (GAC) that are appropriate to the linkage being assessed. This comparison can be undertaken directly against the laboratory results or following statistical analysis depending upon the sampling procedure that was adopted.

5.1 Linkages for assessment

Section 4.6 presents the refined conceptual model which identified the linkages that required assessment after the findings of both the previous and current RSK site investigations had been considered. These linkages together with the method of assessment are presented in **Table 12**.

Table 10: Linkages for generic quantitative risk assessment

Potentially relevant pollutant linkage	Assessment method
1. Direct contact with impacted soil by future occupants	The assessment has predominantly been undertaken by means of a direct comparison of the laboratory results against Generic Assessment Criteria (GAC) derived for a residential without plant uptake end land use scenario as contained in Appendix J.
2. Contaminants permeating potable water supply pipes	Comparison of soil data to GAC in Appendix K for plastic water supply pipes using UKWIR (2010) guidance.
4. Concentrations of carbon dioxide in ground gas entering and accumulating in: depressions and excavations that could affect workers enclosed spaces or small rooms in new buildings, which could affect future residents.	Gas screening values (GSV) have been calculated using maximum methane and carbon dioxide concentrations with maximum flow rates recorded at the site. The GSV have been compared with the revised Wilson and Card classification presented within CIRIA report C665 (Wilson et al., 2007) owing to the development comprising buildings with a ground floor slab. In addition, the gas regime is considered within the context of a conceptual model as required by both aforementioned guidance documents and BS8576.

5.2 Methodology and results

The methodology and results of the GQRA are presented for each relevant pollutant linkage in turn.

The findings of the exploratory site investigation have been assessed in relation to the future development. Chemical analysis has been performed on ten selected soil samples comprising made ground deposits to a maximum depth of 6.00 mbgl. All soil samples scheduled for laboratory testing were also inspected visually on receipt at the laboratory for the presence of materials potential containing asbestos, e.g. fragments of asbestos-cement products.

For this assessment, the results of testing on all samples of made ground have been included, to allow for an assessment of the potential for reuse of cover materials and excavated material. In addition, results from the previous RSK report have been included on the same basis. A total of sixteen samples from both of the RSK investigations are included in the assessment.

The full chemical results from the RSK testing are presented within **Appendix I** and from the previous RSK testing are presented in **Appendix D**, as part of the previous report. The results have been assessed with respect to human health and the performance of construction materials and controlled waters (aquifer beneath the site) in the following sections.

The methodology and results of the GQRA are presented for each relevant pollutant linkage in turn.

5.2.1 Direct contact with impacted soil by future occupants

End users of the site are defined as those who are exposed to sources of contamination on a regular and predictable basis.

It should be noted that, in calculating the GAC, the model has assumed residential with home grown produce scenario. This is considered to be an appropriate mode of assessment based on the proposed development plans outlined in **Figure 3**, showing that communal soft landscaping will present.

The results of the laboratory analysis undertaken have been compared directly to the appropriate GAC for each contaminant, based upon a Soil Organic Matter (SOM) of 1%.

The results from the laboratory testing indicate that the maximum concentrations of all determinants tested are below the threshold limits for a residential with home grown produce end-use scenario.

On the basis of the above assessment, no potentially significant risks associated with the soil contamination have been identified with respect to the proposed end use. On this basis, risks to the end users of the site is considered to be low.

5.2.2 Inhalation exposure of future residents to asbestos fibres

The results of the screening on the samples of made ground completed by RSK on recovered samples of made ground found no presence of asbestos.

Notwithstanding this, the possible presence of asbestos in the made ground across other areas of the site cannot be completely ruled out at this stage due to the limited coverage of the investigation and this assessment should be reviewed should any suspected asbestos containing material be encountered during the works.

5.2.3 Impact of organic contaminants on potable water supply pipes

The results have been compared with the assessment criteria presented in **Appendix K**, which are reproduced from *UKWIR Report 10/WM/03/21 Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites* (UKWIR, 2010). For the purpose of this assessment, the results of the investigation have been compared against the threshold concentrations specified in Table 3.1 of Report 10/WM/03/21.

The results indicate that no relevant linkages exists. It should therefore be possible to use either pollutant polyethylene (PE) or polyvinyl chloride (PVC) water supply pipes.

It should be noted that at the time of this investigation the future routes of water supply pipes had not been established, and hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling/analytical strategy may be required at a later date once the route(s) of the supply pipe(s) are known. It is recommended that the relevant water supply company be contacted at an early stage to confirm its requirements for assessment.

5.2.4 Ground gas

The results have been assessed in accordance with the guidance provided in BS8576 and *CIRIA Report C665*. In the assessment of risks and selection of appropriate mitigation measures, both reports highlight the importance of the conceptual model.

CIRIA C665 identifies two types of development, termed Situation A (modified Wilson and Card method), appropriate to all development excluding traditional low-rise construction, and Situation B (National House-Building Council, NHBC) only appropriate to traditional low-rise construction with ventilated sub-floor voids.

Both methods are based on calculations of the limiting borehole gas volume flow for methane and carbon dioxide, renamed as the gas screening value (GSV). The GSV (litres of gas per hour) is calculated by multiplying borehole flow rate (litres per hour) and gas concentration (percent by volume).

In both situations, it is important to note that the GSV thresholds are guideline values and not absolute. The GSV thresholds may be exceeded in certain circumstances, if the site conceptual model indicates it is safe to do so. Similarly, consideration of additional factors such as very high concentrations of methane, should lead to consideration of the need to adopt a higher risk classification than the GSV threshold indicates.

The site is to be redeveloped for a residential end use and therefore falls under Situation A. This relates to all development types except low-rise housing and, by combining the qualitative assessment of risk (see refined conceptual model in Section 5.4) with the gas monitoring results, provides a semi-quantitative estimate of risk for a site. The method uses both gas concentrations and borehole flow rates to define a characteristic situation for a site based on the limiting borehole gas volume flows for methane and carbon dioxide. Having calculated the worst case GSVs for methane and carbon dioxide, the Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

Based on the monitoring visits completed on site to date, the maximum concentration and flows recorded within the installation to date are shown below:

- Methane - maximum concentration of <0.1%v/v;
- Carbon dioxide - maximum concentration of 4.4%v/v; and
- Flow - maximum flow rate of 0.1%v/v.

Based on the concentrations, Gas Screen Values (GSV's) may be calculated as follows:

- $CSV_{METHANE}$ = (0.0/100)*0.1 = 0.000 l/hr; and
- $CSV_{CARBON\ DIOXIDE}$ = (4./100)*0.1 = 0.0044 l/hr.

Based on the GSVs, and the maximum records carbon dioxide concentration, the site has been characterised Characteristic Situation 1 (CS1) for which no special protection measures are required. This will be reviewed once the full programme of gas monitoring has been completed.

5.3 Environmental assessment conclusions

The results of the investigation have confirmed that no relevant pollutant linkages are present with respect to human health on the basis of no contamination being found.

The visual inspection at the laboratory identified no materials suspected of potentially containing asbestos and the scheduled laboratory screening for asbestos found no detectable asbestos fibres within the samples of made ground. It should be noted that the potential presence of asbestos containing materials in the made ground on site cannot be ruled out at this stage and further investigation will be required to confirm this. It is essential that groundworkers are made aware of the potential risk of asbestos fibres within the made ground and suitable working practices are in place during groundworks stage to minimise the risks.

The results indicate that there are no relevant linkages in respect to water supply pipes. It should be noted that at the time of this investigation, the future routes of water supply pipes had not been established, and hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling/analytical strategy may be required at a later date once the route(s) of the supply pipe(s) are known.

No plausible pollutant linkages have been identified in respect to controlled waters beneath the site.

The conceptual model and results of the ground gas monitoring conducted on site indicate that the site falls into a Characteristic Situation 1, for which no gas protection measures will be required.

6 GEOTECHNICAL SITE ASSESSMENT

6.1 Engineering considerations

The proposal comprises the construction of 28 dwellings close to the Gondar Gardens frontage of the site. These will comprise blocks of 3-4 storeys above a basement level that will contain residential accommodation. The proposals will incorporate the existing buried reservoir structure as a basement in part at 72.50m AOD, and require additional excavations to form new sections of lower ground at 75.30m AOD and basement structure, mainly to the front elevation and adjacent to 1-6 Chase Mansions. Adjacent structures are very close to the proposed new retaining structures and particular attention needs to be paid to protection of the adjacent third party assets. Lateral support will need to be provided prior to commencement of excavation.

To the rear of the frontage scheme the proposal is to demolish the existing reservoir roof structure retaining the perimeter masonry arched walls and buttresses. Between the retained buttresses a crushed fill material will be placed to form sloped banks down to the enhanced landscaped habitat area of the former reservoir structure.

Within the frontage scheme there are requirements to remove the current buttresses which brace the vertical perimeter masonry arches. It is intended to construct new reinforced vertically spanning RC walls in front of the arches sequentially.

These will span between the basement floor, lower ground and ground floors of the new reinforced concrete framed development with the RC floor plates acting as diaphragms transferring lateral loads across the floor plates which will either be resisted by forces in opposing directions or by the core walls to the development. During construction temporary works may be required utilising diagonal temporary propping to provide lateral support to the walls.

Once the walls are constructed, the void between the rear of the new RC wall and the existing masonry arch will be in filled with a foamed concrete. Once the arches are supported via the new RC lining walls the buttresses will be demolished and completed to form a continuous concrete box.

Where excavations are required to form lower ground and basement areas retaining structures will be required. These structures will be simple vertical retaining structures which provide lateral support.

The proposed building will be founded at depth on piles into the London Clay to minimise the risks of differential settlement due to the different founding levels.

It is currently assumed that for the areas of retaining structure that are non vertically load bearing these will be constructed using either Permanent Sheet Piles or Contiguous Piles which are then faced with a concrete lining wall.

Load information has not been provided to date for the proposed buildings, but loads are anticipated to be moderate and this typical of this type of development.

6.2 Geotechnical hazards

A summary of commonly occurring geotechnical hazards is given in **Table 11** together with an assessment of whether the site may be affected by each of the stated hazards.

Table 11: Summary of main potential geotechnical hazards that may affect site

Hazard category (excluding contamination issues)	Hazard status based on investigation findings and proposed development			Engineering considerations if hazard affects site
	Found to be present on site	Could be present but not found	Unlikely to be present and/or affect site	
Sudden lateral changes in ground conditions	✓	Presence of localised varying depths of made ground		Likely to affect ground engineering and foundation design and construction
Shrinkable clay soils	✓	London Clay Formation – medium to high volume change potential soils		Design to NHBC Standards Chapter 4 or similar
Highly compressible and low bearing capacity soils, (including peat and soft clay)			✓	Likely to affect ground engineering and foundation design and construction
Silt-rich soils susceptible to loss of strength in wet conditions	✓	London Clay		Likely to affect ground engineering and foundation design and construction
Running sand at and below water table			✓	Likely to affect ground engineering and foundation design and construction
Karstic dissolution features (including ‘swallow holes’ in Chalk terrain)			✓	May affect ground engineering and foundation design and construction – refer to Section 4.1.2
Evaporite dissolution features and/or subsidence			✓	May affect ground engineering and foundation design and construction
Ground subject to or at risk from landslides			✓	Likely to require special stabilisation measures
Ground subject to peri-glacial valley cambering with gulls possibly present			✓	Likely to affect ground engineering and foundation design and construction

Hazard category (excluding contamination issues)	Hazard status based on investigation findings and proposed development			Engineering considerations if hazard affects site
	Found to be present on site	Could be present but not found	Unlikely to be present and/or affect site	
Ground subject to or at risk from coastal or river erosion			✓	Likely to require special protection/stabilisation measures
High groundwater table (including waterlogged ground)	✓	Perched groundwater within the made ground will affect the basement excavation & design		May affect temporary and permanent works
Rising groundwater table due to diminishing abstraction in urban area			✓	May affect deep foundations, basements and tunnels
Underground mining			✓	Likely to require special stabilisation measures
Existing sub-structures (e.g. tunnels, foundations, basements, and adjacent sub-structures)	✓	Former Thames Water buried Reservoir at the site and adjacent buildings fronting Gondar Gardens		Likely to affect ground engineering and foundation design and construction
Filled and made ground (including embankments, infilled ponds and quarries)	✓	Significant thickness of made ground encountered to the east and north of the reservoir.		Likely to affect ground engineering and foundation design and construction
Adverse ground chemistry (including expansive slags and weathering of sulphides to sulphates)	✓	Elevated concentrations of SO4 encountered		May affect ground engineering and foundation design and construction
Note: Seismicity is not included in the above table as this is not normally a design consideration in the UK.				

6.3 Foundations

6.3.1 General suitability

The borehole investigation has proven the presence of made ground to depths of between 3.20 mbgl and 10.50 mbgl (76.70 m AOD to 69.54 m AOD), which is underlain by firm, becoming stiff, medium to high strength clay of the London Clay Formation, which extends to the full depth investigated of 50.00 mbgl (29.84 m AOD). Groundwater has been recorded during the post-fieldwork monitoring at depths of between 4.23 mbgl (75.81 m AOD) and 7.55 mbgl (72.35 m AOD), which is believed to represent perched ground water within the made ground in BH3, and the general groundwater table in BH2 and BH3.

Given the anticipated moderate columns loads and proposal for a split level basement, it is considered that the use of shallow spread or rafted foundations will be precluded. Piled foundations end bearing in the London Clay at depth are considered the most suitable solution to support the proposed development.

The proposals will incorporate the existing buried reservoir structure as a basement in part at 72.50m AOD, and require additional excavations to form new sections of lower ground at 75.30m AOD and basement structure, mainly to the front elevation and adjacent to 1-6 Chase Mansions. Adjacent structures are very close to the proposed new retaining structures and particular attention needs to be paid to protection of the adjacent third party assets. Lateral support will need to be provided prior to commencement of excavation.

To the rear of the frontage scheme the proposal is to demolish the existing reservoir roof structure retaining the perimeter masonry arched walls and buttresses. Between the retained buttresses a crushed fill material will be placed to form sloped banks down to the enhanced landscaped habitat area of the former reservoir structure.

Within the frontage scheme there are requirements to remove the current buttresses which brace the vertical perimeter masonry arches. It is intended to construct new reinforced vertically spanning RC walls in front of the arches sequentially.

These will span between the basement floor, lower ground and ground floors of the new reinforced concrete framed development with the RC floor plates acting as diaphragms transferring lateral loads across the floor plates which will either be resisted by forces in opposing directions or by the core walls to the development. During construction temporary works may be required utilising diagonal temporary propping to provide lateral support to the walls.

Once the walls are constructed, the void between the rear of the new RC wall and the existing masonry arch will be in filled with a foamed concrete. Once the arches are supported via the new RC lining walls the buttresses will be demolished and completed to form a continuous concrete box.

Where excavations are required to form lower ground and basement areas retaining structures will be required. These structures will be simple vertical retaining structures which provide lateral support.

Given the presence of groundwater above the basement and the limited space available in the western portion of the site, it is unlikely to be possible to construct retaining walls in an open cut and it is considered likely that some form of embedded wall will be required.

Recommendations for pile foundations are provided in the following section.

6.3.2 Piled foundations

Recommendations for the design and construction of pile foundations in relation to the ground conditions are set out in **Table 12**.

Table 12: Design and construction of piled foundations

Preliminary design/construction considerations	Preliminary design/construction recommendations	
Pile type	The construction of both conventional rotary bored and CFA piles is considered technically feasible at this site.	
Constraints on choice of pile type	Given the close proximity of the site to a residential area it is considered that the vibration/noise associated with pile driving will not be acceptable Therefore bored or CFA piles are considered the most viable option.	
Temporary casing	It is understood the piling platform will be from existing reservoir slab level at 72.40m AOD and it is anticipated that London Clay will be present from this level. Given the presence of groundwater strikes and made ground to a depth of 10.50mbgl to the north of the reservoir and deeper water strikes within the London Clay, bored piles will require temporary casing or support fluid. Alternatively, the use of continuous-flight-auger (CFA) injected bored piles usually overcomes this issue.	
Hard strata	An allowance should be made for the presence of thin 'rock' bands (claystone) within the London Clay.	
Made ground / sleeving	For the purpose of assessing preliminary pile capacities, the made ground has been presumed not to contribute to the load-carrying capacity for the piles.	
Adopted pile parameters for cohesive deposits (London Clay Formation)	Adhesion factor α	0.5
	Bearing capacity factor N_c	9
	Undrained shear strength c_u (kN/m^2)	60 + 6.6z kN/m^2 where z = depth into clay
	Global margin of safety	2.6 – No load tests required 2.2 – Working tests only 2.0 – Preliminary pile test(s) and working tests
	Limiting concrete stress (kN/m^2)	7.5N/mm^2
	Limiting shaft friction	110kN/m^2
Special precautions relating to bored pile shafts and bases	Bored pile concrete should be cast as soon after completion of boring as possible and in any event the same day as boring Prior to casting the base of the pile bore should be clean; otherwise a reduced safe working load will be required. Similarly, if the pile bore is left open the shaft walls may relax/soften, leading to a reduced safe working load	
Notes:		

The design procedure for piles varies considerably, depending on the proposed type of pile. However, for illustrative purposes **Table 13** gives likely working pile loads for traditional bored, cast-in-situ concrete piles of various diameters and lengths, based on the design parameters given in **Table 12**. For this purpose the soil profile in BH1 has been considered.

Table 13: Illustration of typical pile working loads for bored cast-in-situ piles

Typical pile working loads (kN)			
Depth of pile below 71.4m AOD	Pile diameter		
	350mm	450mm	600mm
Global FoS 2.6 (based on testing requirements of Table 14)			
14	397	531	748
16	473	630	883
18	554	736	1028
20	641	849	1182
22	721	970	1346
24	-[1]	1096	1518
26	-[1]	1192	1690
28	-[1]	-[1]	1863
30	-[1]	-[1]	2035
Notes: [1]Limited by maximum concrete stress			
Global FoS 2.2 (based on testing requirements of Table 14)			
14	470	627	884
16	559	744	1044
18	655	870	1215
20	721	1004	1397
22	[1]	1146	1591
24	[1]	1192	1794
26	[1]	[1]	1998
28	[1]	[1]	2120
30	[1]	[1]	[1]
Notes: [1]Limited by maximum concrete stress			
Global FoS 2.0 (based on testing requirements of Table 14)			
14	517	690	972
16	615	819	1148
18	721	957	1336
20	[1]	1104	1537

22	[1]	1192	1750
24	[1]	[1]	1973
26	[1]	[1]	2120
28	[1]	[1]	[1]
30	[1]	[1]	[1]
Notes: [1]Limited by maximum concrete stress			

It should be stressed that the above capacities do not take into consideration pile group effects which is more pronounced for a large number of closely spaced piles.

Notwithstanding the above, it is recommended that the detailed advice of a specialist-piling contractor be sought as to the most suitable type of pile for the prevailing ground conditions and as to their lengths and diameters to support the required design loads.

6.3.3 Foundation works risk assessment

It is not anticipated that a foundation works risk assessment report will be required for the development because no concentrations of chemicals of potential concern (COPC) was identified at the site and, natural soils and piles will extend below the unproductive strata of the London Clay.

6.4 Floor slabs

Across the westtern part of the new building, in the area of the lower ground and where excavations for basement level are required, the basement slab will have to be designed to withstand potential heave of the underlying clay soils resulting from unloading due to excavation. Alternatively, suspending the slab with a void former beneath will overcome this issue. Further, allowance should be made for hydrostatic pressures acting on the base of the slab as a result of the groundwater table being recorded above the proposed slab levels.

Across the eastern part of the proposed basement level, which is to be constructed at the exsting reservoir level , iit may be possible to adopt a ground bearing slab , assuming that there is no net unloading in this area and that the slab is designed to withstand the hydrostatic pressures acting on the base of the slab as a result of the groundwater table being recorded above the proposed slab levels. Alternatively for continuity a suspended slab may be adopted for B1 also.

6.5 Retaining Wall Design Parameters

In order to facilitate basement and lower ground construction on the western part of the building it is considered likely that some form of embedded wall will be required due to the limited space for retaining walls to be constructed in an open cut and due to the presence of groundwater. It may therefore be necessary to construct a contiguous/secant bored pile wall or use temporary steel sheet piles along the northern and southern sides. The advice of a specialist contractor should be sought on the design of proposed contiguous/secant piled walls where incorporated into the development.

Groundwater was encountered during the subsequent monitoring visit at approximately 6.65 mbgl (73.19 m AOD) in the London Clay and 4.23 mbgl (75.81 m AOD) within the made ground to the north. Further, groundwater monitoring visits are scheduled to be carried out to confirm groundwater conditions and any impact this may have on design.

On the basis of the ground investigation information the following soil parameters in **Table 16** should be adopted for retaining wall design purposes.

Table 14: Retaining wall design parameters

Soil type	C_U (kN/m^3)	SPT 'N' value	Unit weight (kN/m^3)	Long Term Characteristics	
				c' (kN/m^3)	ϕ' (°)
Made Ground	-	-	18	0	25*
London Clay Formation	60 + 6.6z kN/m^2 where z = depth into clay	16 to 81**	19.5	2*	22***

Notes:
*Based on published information in the absence of site-specific data.
** Extrapolated value
***Results of CU TXL testing will be reported as an addendum.

In order to prevent damage to adjacent structures, the design of the retaining wall and basement excavation must address the risk of excessive deformation of the wall and bracing, both in the temporary and permanent condition, to ensure that the horizontal and vertical soil movement around and below the excavation remain within acceptable levels.

The investigation has indicated that ground water is likely to be present above the proposed lower basement level. The design will therefore need to consider hydrostatic pressures on the wall in both the temporary and permanent conditions. Further, reference should be made to BS BS8102:2009 "Protection of Structures Against Water from the Ground".

6.6 Chemical attack on buried concrete

The results of chemical tests carried out on soil samples of made ground indicate 2:1 water soil extract sulphate contents of up to 30 mg/l with near neutral pH values and for samples of natural soils indicate 2:1 water soil extract sulphate contents of up to 2730 mg/l with near neutral pH values.

These results indicate that, in accordance with BRE Special Digest 1: 2005 Concrete in aggressive ground (BRE, 2005), the Aggressive Chemical Environment for Concrete (ACEC) Classification is generally DS3 with a Design Sulphate Class for the site of AC-3 for natural soils.

6.7 Infiltration features

The ground conditions do not appear suitable for the use of pit soakaways or permeable paving due to the presence of essentially impermeable London Clay strata beneath the site and groundwater table above the proposed reduced level of the external amenity space. Additionally, some form of land drainage is likely to be required or waterproof structure to prevent groundwater ponding in this area.

7 REUSE OF MATERIALS AND WASTE

7.1 Reuse of suitable materials

Under the Waste Framework Directive naturally occurring soils are not considered waste if re-used on the site of origin for the purposes of development.

In accordance with the definition provided in the Waste Framework Directive, materials are only considered waste if 'they are discarded, intended to be discarded or required to be discarded, by the holder'. Thus, soils that are not of clean and natural origin, i.e. made ground (whether contaminated or not) and other materials such as recycled aggregate, do not become waste until the aforementioned criteria are met.

The Definition of Waste: Development Industry Code of Practice (CL:AIRE, 2011) (CoP) was developed in consultation with the Environment Agency and development industry to enable the re-use of materials under certain scenarios and subject to demonstrating that specific criteria are met. The current re-use scenarios covered by the CoP comprise:

- Re-use on the site of origin (with or without treatment)
- Direct transfer of clean and natural soils between sites
- Use in the development of land other than the site of origin following treatment at an authorised Hub site (including a fixed Soil Treatment Facility).

The importation of made ground soils (irrespective of contamination status) or crushed demolition materials is not currently permitted under the CoP and requires either a standard rules environmental permit or a U1 waste exemption (see below).

In the context of excavated materials used on sites undergoing development, four factors are considered to be of particular relevance in determining if the material is a waste or when it ceases to be waste:

- the aim of the Waste Framework Directive is not undermined, i.e. if the use of the material will create an unacceptable risk of pollution of the environment or harm to human health it is likely to be waste
- the material is certain to be used
- the material is suitable for use both chemically and geotechnically
- only the required quantity of material will be used.

The CoP requires the preparation of a materials management plan (MMP) that confirms the above factors will be met. This plan needs to be reviewed by a 'Qualified Person' (QP) who will then issue a declaration form to the EA. As the project progresses, data must be collated and on completion a verification report produced that shows the MMP was followed and describes any changes.

The MMP establishes whether specific materials are classified as waste and how excavated materials will be treated and/or re-used in line with the CoP. The MMP is likely to form part of the site waste management plan.

The site has been developed previously and the investigation has confirmed the presence of made ground. Therefore, before any excavation works begin on-site, an MMP will need to be prepared, reviewed by a QP; and a Declaration lodged with the EA.

As noted above, under the Waste Framework Directive naturally occurring soils are not considered waste and therefore arisings of clean natural soils, e.g. from foundation and drainage excavations, may be re-used on the site. However, it is important that these soils should be stockpiled separately and not become cross-contaminated with made ground / contaminated soils or construction wastes.

If it is proposed to import clean and naturally occurring soils direct from another site, the receiving site's MMP would need to be updated in advance of importation.

7.2 Treatment to meet suitable-for-use criteria

Where materials do not meet the suitable for use criteria it may be possible to treat them under an environmental permit (mobile treatment licence) to enable them to be reused onsite.

To enable the treatment options to be determined, an options appraisal and a remediation strategy document will be necessary to support discussion of the issues with regulators and third parties.

7.3 Reuse of waste materials

If material is discarded as waste then its reuse on site may still be possible. Waste soils and recycled aggregate can be reused on site under a standard rules environmental permit or a U1 waste exemption from the Environmental Permitting (England and Wales) Regulations 2010 provided that they are suitable for the proposed use, i.e. not cause harm to human health or the environment. However, it should be noted that these have strict limits on the quantity of material that can be reused.

7.4 Wastes for landfill disposal

Wastes require pre-treatment prior to disposal at landfill. Pre-treatment must be a physical, thermal, chemical or biological process (including sorting) that changes the characteristics of the waste to reduce its volume, reduce its hazardous nature, facilitate its handling and enhance its recovery.

The latest, edition of the EA's 'Technical Guidance WM3' (2015) Interpretation of the definition and classification of hazardous waste, requires that within a mixed waste* the separately identifiable wastes are assessed separately. Mixing of different types of hazardous waste and hazardous waste with other waste substances is prohibited under the Waste Framework Directive. Wastes that have been mixed must be separated whenever possible.

It is best practice to provide your waste carrier (or the disposal site) with details of how the waste has been treated. Your waste carrier may provide a pre-treatment confirmation form or space on the waste transfer note to detail the pre-treatment.

The classification of waste soil is a two-stage process, the first being an assessment of whether the soil is considered hazardous or not following the guidance within Technical Guidance WM3. For off-site disposal to landfill the results of Waste Acceptance Criteria (WAC) testing must then be reviewed to establish if the soil is acceptable at the relevant class of landfill or requires pre-treatment to reduce specific hazardous properties.

7.4.1 Waste acceptance criteria

All inert, stable non-reactive hazardous and hazardous wastes have limit values (waste acceptance criteria) set out in legislation that must be met before that class of landfill can accept the waste. Currently, no WAC are in place for non-hazardous waste.

Soil and other materials that are found not to be hazardous may be classified as either non hazardous or inert. In order to determine whether they can be classed as inert the soil must be tested and found to be below the inert waste acceptance criteria.

7.4.2 Waste sampling plan

Technical Guidance WM3 sets out in Appendix D requirements for waste sampling. It is a legal requirement to correctly assess and classify waste. The level of sampling should be proportionate to the volume of waste and its heterogeneity. At this stage RSK consider that the level of soil sampling is sufficient to provide a preliminary categorisation of the material.

RSK recommends that a Sampling Plan be prepared to support any waste classifications and hazardous waste assessments, prior to development.

7.4.3 Preliminary waste assessment

Envirolab (an RSK company) has developed a waste soils characterisation assessment tool (HASWASTE), which follows the guidance within Technical Guidance WM3. The analytical results have been assessed using this tool for potential off-site disposal of materials in the future. The results are presented in **Appendix L** and indicate that the made ground within both the cover soils, and the main area of excavation for removal will not be classified as hazardous waste.

To further refine this assessment, the samples of made ground recovered from WS2 at 1.25 mbgl and WS6 at 4.00 mbgl were submitted for WAC tasting, the results of which are presented in **Appendix I**. The results obtained are below the leaching limit values for inert waste and therefore the made ground can be classified as inert waste for disposal purposes.

It is important to note that this initial assessment given in this report is for guidance only and it is always necessary to confirm the actual classification with prospective landfill operators prior to disposal.

7.4.4 Asbestos within waste soils

The latest, edition of Technical Guidance WM3, requires that within a mixed waste the separately identifiable wastes be assessed separately. For instance where waste soil contains identifiable pieces of asbestos (visible to the naked eye) the asbestos should, where feasible, be separated from the soil and classified separately.

7.5 Landfill tax

The tax is chargeable by weight (tonnage) and two rates apply, either standard or lower rate. The lower rate only applies to those less polluting wastes as set out in the Landfill Tax (Qualifying Material) Order 2011, which include naturally occurring rock and soil, concrete, some minerals, some furnace slags and ash, and some low-activity organic compounds. Evidence confirming that the waste qualifies for the lower rate will be required, and standard rate tax will apply for the whole waste load for any loads of mixed waste.

Currently (since 1st April 2016), standard rate landfill tax is £84.40 per tonne.

The lower rate of landfill tax applicable to less polluting wastes (i.e. 'inert' wastes) remains at £2.60 per tonne.

Material disposed of at a soil treatment centre will not be subject to landfill tax.

7.6 Groundwater

When there is an intention to discard groundwater, chemical test results will indicate the appropriate disposal options. This could include disposal to treatment facility, via consent (issued by the water authority) to foul sewer or via consent (issued by the EA) to a watercourse or land.

7.7 Recommendations

RSK recommends that consideration as to how potentially waste soils will be dealt with as part of this development is given as early in the project planning process as possible. Such planning can lead to cost savings where potentially waste soils are viewed as a resource and retained on-site as part of the development. We also recommend, where off-site disposal is being considered, that appropriate facilities are identified and discussions initiated to confirm suitability of the facility to take the material. Potentially, these may include soil treatment facilities as well as landfills.

RSK can provide specialist advice to assist in this process, which can be complex and subject to regular regulatory change.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Environmental

The results of the investigation have confirmed that no relevant pollutant linkages are present with respect to human health on the basis of no contamination being found.

The visual inspection at the laboratory identified no materials suspected of potentially containing asbestos and the scheduled laboratory screening for asbestos found no detectable asbestos fibres within the samples of made ground. Notwithstanding this, the possible presence of asbestos in the made ground across other areas of the site cannot be completely ruled out at this stage due to the limited coverage of the investigation and this assessment should be reviewed should any suspected asbestos containing material be encountered during the works.

The results indicate that there are no relevant linkages in respect to water supply pipes. It should be noted that at the time of this investigation, the future routes of water supply pipes had not been established, and hence the investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling/analytical strategy may be required at a later date once the route(s) of the supply pipe(s) are known.

No plausible pollutant linkages have been identified in respect to controlled waters beneath the site.

The conceptual model and results of the ground gas monitoring conducted on site indicate that the site falls into a Characteristic Situation 1, for which no gas protection measures will be required.

The findings indicate that there is no evidence of significant ground contamination nor pollutant linkages on-site in relation to the proposed end-use. Hence, no contamination alleviation measures are required, subject to ensuring that suitable topsoil/subsoil is present in garden and landscaped areas.

It is possible that ground works could encounter different conditions from those revealed by the site investigation. It is therefore recommended that the ground works be monitored for previously undetected suspect materials and if found appropriate additional testing and advice is sought.

The site has been developed previously and the investigation has confirmed the presence of made ground. Therefore, before any excavation works begin on-site, an MMP will need to be prepared, reviewed by a QP; and a Declaration lodged with the EA.

8.2 Waste classification

The results of the investigation indicate that the made ground within both the cover soils, and the main area of excavation for removal will not be classified as hazardous waste.

To further refine this assessment, the samples of made ground recovered from WS2 at 1.25 mbgl and WS6 at 4.00 mbgl were submitted for WAC tasting. The results obtained are below the leaching limit values for inert waste and therefore the made ground can be classified as inert waste for disposal purposes.

It is important to note that this initial assessment given in this report is for guidance only and it is always necessary to confirm the actual classification with prospective landfill operators prior to disposal.

8.3 Geotechnical

The borehole investigation has proven the presence of made ground to depths of between 3.20 mbgl and 10.50 mbgl (76.70 m AOD to 69.54 m AOD), which is underlain by firm, becoming stiff, medium to high strength clay of the London Clay Formation, which extends to the full depth investigated of 50.00 mbgl (29.84 m AOD). Groundwater has been recorded during the post-fieldwork monitoring at depths of between 4.23 mbgl (75.81 m AOD) and 7.55 mbgl (72.35 m AOD), which is believed to represent perched ground water within the made ground in BH3, and general groundwater table within the London Clay in BH2 and BH3.

Given the anticipated columns loads and proposal for a split level basement, it is considered that the use of shallow spread/rafted foundations will be precluded. Piled foundations end bearing in the London Clay at depth are considered the most suitable solution to support the proposed development.

Consideration will need to be given to designing the lower ground and basement level slab to withstand both heave of the underlying clay soils resulting from unloading due to excavation and groundwater pressures.

In order to facilitate basement and lower ground construction on the western part of the building it is considered likely that some form of embedded wall will be required due to the limited space for retaining walls to be constructed in an open cut and due to the presence of groundwater. It may therefore be necessary to construct a contiguous/secant bored pile wall or use temporary steel sheet piles along the northern and southern sides.

In order to prevent damage to adjacent structures, the design of the new retaining walls and basement excavation must address the risk of excessive deformation of the wall and bracing, both in the temporary and permanent conditions, to ensure that the horizontal and vertical soil movement around and below the excavation remain within acceptable levels.

A detailed slope stability assessment should be undertaken for the existing and proposed slopes as part the basement impact assessment report.

The Aggressive Chemical Environment for Concrete (ACEC) Classification is DS3 with a Design Sulphate Class for the site of AC-3 for natural soils.

The ground conditions encountered on site are not suitable for the adoption of soakaways or permeable paving. Additionally, some form of land drainage is likely to be required or waterproof structure to prevent groundwater ponding in external areas at the reduced B2 Level.

BIBLIOGRAPHY

AGS Interim Guidance (2013), 'Site investigation and asbestos risk assessment for the protection of site investigation and geotechnical laboratory personnel', February.

Baker, K., Hayward, H., Potter, L., Bradley, D. and McLeod, C. (2009), *CIRIA Report C682. The VOCs Handbook. Investigating, assessing and managing risks from inhalation of VOCs at land affected by contamination* (London: CIRIA).

Barton, N. J. (1992), *The Lost Rivers of London: A Study of Their Effects Upon London and Londoners, and the Effects of London and Londoners on Them* (London: Historical Publications).

Boyle, R. A. and Witherington, P. J. (2007), 'Guidance on Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present', National House-Building Council and RSK Group.

British Standards Institution (BSI) (1990), 'BS 1377:1990. Methods of test for soils for civil engineering purposes'.

British Standards Institution (1999), 'BS 5930:1999. Code of practice for site investigations'.

British Standard Institution (BSI) (2007), 'BS 8485:2007. Code of practice for the characterization and remediation from ground gas in affected developments'.

British Standards Institution (2011), 'BS 10175:2013. Investigation of potentially contaminated sites: Code of practice'.

British Standards Institution (2013), BS8576:2013. Guidance on investigations for ground gas – permanent gases and volatile organic compounds (VOCs)

Building Research Establishment (BRE) (2001), *BRE Report 414. Protective measures for housing on gas-contaminated land* (London: BRE).

Building Research Establishment (2005), *BRE Special Digest 1: Concrete in aggressive ground* (London: BRE).

Card, G. B. (1995), *CIRIA Report 149. Protecting development from methane* (London: CIRIA).

Chartered Institute for Environmental Health and Land Quality Management (2009), 'The LQM/CIEH Generic Assessment Criteria for Human Health', second edition.

Chartered Institute of Environmental Health (CIEH) and CL:AIRE (2008), *Guidance on Comparing Soil Contamination Data with a Critical Concentration* (London: CIEH).

CL:AIRE (2009), *Soil Generic Assessment Criteria for Human Health Risk Assessment* (London: CL:AIRE).

CL:AIRE (2011), *CL:AIRE Code of Practice. The Definition of Waste: Development Industry Code of Practice, Version 2* (London: CL:AIRE).

Department for Environment, Food and Rural Affairs (2010), *The River Basin Districts Typology, Standards and Groundwater Threshold Values (Water Framework Directive) (England and Wales) Directions 2010* (London: HMSO).

Environment Agency (2013), 'Technical Guidance WM3. Interpretation of the definition and classification of hazardous waste'. 3rd Edition.

Environment Agency (2004a), *Model Procedures for the Management of Contaminated Land. Contaminated Land Report Number 11 (CLR11),* September (Bristol: Environment Agency).

Environment Agency (2004b), 'Policy Number 199_04, dated 9 March 2004, Part IIA – Detailed Quantitative Assessment of Chronic Risks to Human Health from Contaminated Soils'.

Environment Agency (2006a), 'Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination'.

Environment Agency (2006b), 'The Knotweed Code of Practice – managing Japanese Knotweed on development sites'.

Environment Agency (2008), *Science Report SC050021/SR7. Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values* (Bristol: Environment Agency).

Environment Agency (2009a), Contaminated Land Exposure Assessment (CLEA) software, version 1.06.

Environment Agency (2009b), *Human health toxicological assessment of contaminants in soil. Science Report – Final SC050021/SR2*, January (Bristol: Environment Agency).

Environment Agency (2009c), 'Science Report SC050021/benzene SGV, toluene SGV, ethylbenzene SGV, xylene SGV, mercury SGV, selenium SGV, nickel SGV, arsenic SGV, cadmium SGV, phenol SGV, dioxins, furans and dioxin like PCBs SGVs', 'Supplementary information for the derivation of SGV for: benzene, toluene, ethylbenzene, xylene, mercury, selenium, nickel, arsenic, cadmium, phenol, dioxins, furans and dioxin- like PCBs', and 'Contaminants in soil: updated collation of toxicological data and intake values for humans: benzene, toluene, ethylbenzene, xylene, mercury, selenium, nickel, arsenic, cadmium, phenol, dioxins, furans and dioxin- like PCBs', March 2009, May 2009 and September 2009.

Environment Agency (2009d), *Science Report – SC050021/SR3. Updated technical background to the CLEA model* (Bristol: Environment Agency).

Environment Agency (2010a), 'GPLC1 – Guiding Principles of Land Contamination', 'GPLC2 – Frequently Asked Questions, Technical Information, Detailed Advice and References', and 'GPLC3 – Reporting Checklists', all March.

Environment Agency (2010b), 'Horizontal Guidance Note H1 - Environmental risk assessment for permits'.

Environment Agency (2010c), 'Status Report: Management of the London Basin Chalk Aquifer'.

Environment Agency (2011) Chemical Standards Database.

Environment Agency (no date) Freshwater environmental quality standards.

Environment Agency www.environment-agency.gov.uk/.

Environmental Permitting (England and Wales) Regulations 2010 (London: HMSO).

Hartless, R. (1991), 'BRE Report 212: Construction of new buildings on gas-contaminated land', Building Research Establishment.

Hazardous Waste Regulations 2005 (London: HMSO).

Knipp, C. V., Lloyd, J. W., Lerner, D. N. and Greswell, R. (1993), *CIRIA Special Publication 92. Rising groundwater levels in Birmingham, and their engineering significance* (London: CIRIA).

Lord, J. A., Clayton, C. R. I. and Mortimore, R. N. (2002), *CIRIA Report C574 Engineering in chalk* (London: CIRIA).

National House-Building Council (1999), 'Chapter 5.2: Suspended Ground Floors' in *NHBC Standards*, revised September 1999, effective January 2000.

Norbury, D. (2010), *Soil and Rock Description in Engineering Practice* (Caithness: Whittles).

Office of the Deputy Prime Minister (2004), *Planning Policy Statement 23: Planning and Pollution Control* (London: The Stationery Office).

Part IIA of the Environmental Protection Act (Contaminated Land Regulations (England) 2002 (London: HMSO).

Rudland, D. J., Lancefield, R. M. and Mayell, P. N. (2001), *CIRIA C552. Contaminated Land Risk Assessment: A Guide to Good Practice* (London: CIRIA).

Simpson, G., Blower, T., Craig, R. N. and Wilkinson, W. B. (1989), *CIRIA Special Publication 69. The engineering implications of rising groundwater levels in the deep aquifer beneath London* (London: CIRIA).

Stone, K., Murray, A., Cooke, S., Foran, J., Gooderham, L., (2009) CIRIA C681, Unexploded Ordnance (UXO). A guide or the construction industry.

The Building Regulations (revised December 2004) 'Approved Document C. Department of the Environment and The Welsh Office'.

The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 (London: HMSO).

The Surface Waters (Dangerous Substances) (Classification) Regulations 1998 (London: HMSO).

The Water Supply (Water Quality) Regulations 1989, 2000 and 2001 (London: HMSO).

Transport and Road Research Laboratory (1970), 'TRRL Road Note 29 (Appendix 1). Road pavement design'.

Transport and Road Research Laboratory (1984), 'TRRL Report LR1132 (Table C1)'.

UK Water Industry Research (2010) *UKWIR Report 10/WM/03/21. Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites* (London: UKWIR).

Water Framework Directive (2000/60/EC).

Wilson, S. A. and Card, G. B. (1999), 'Reliability and risk in gas protection design', *Ground Engineering*, February: 33–6.

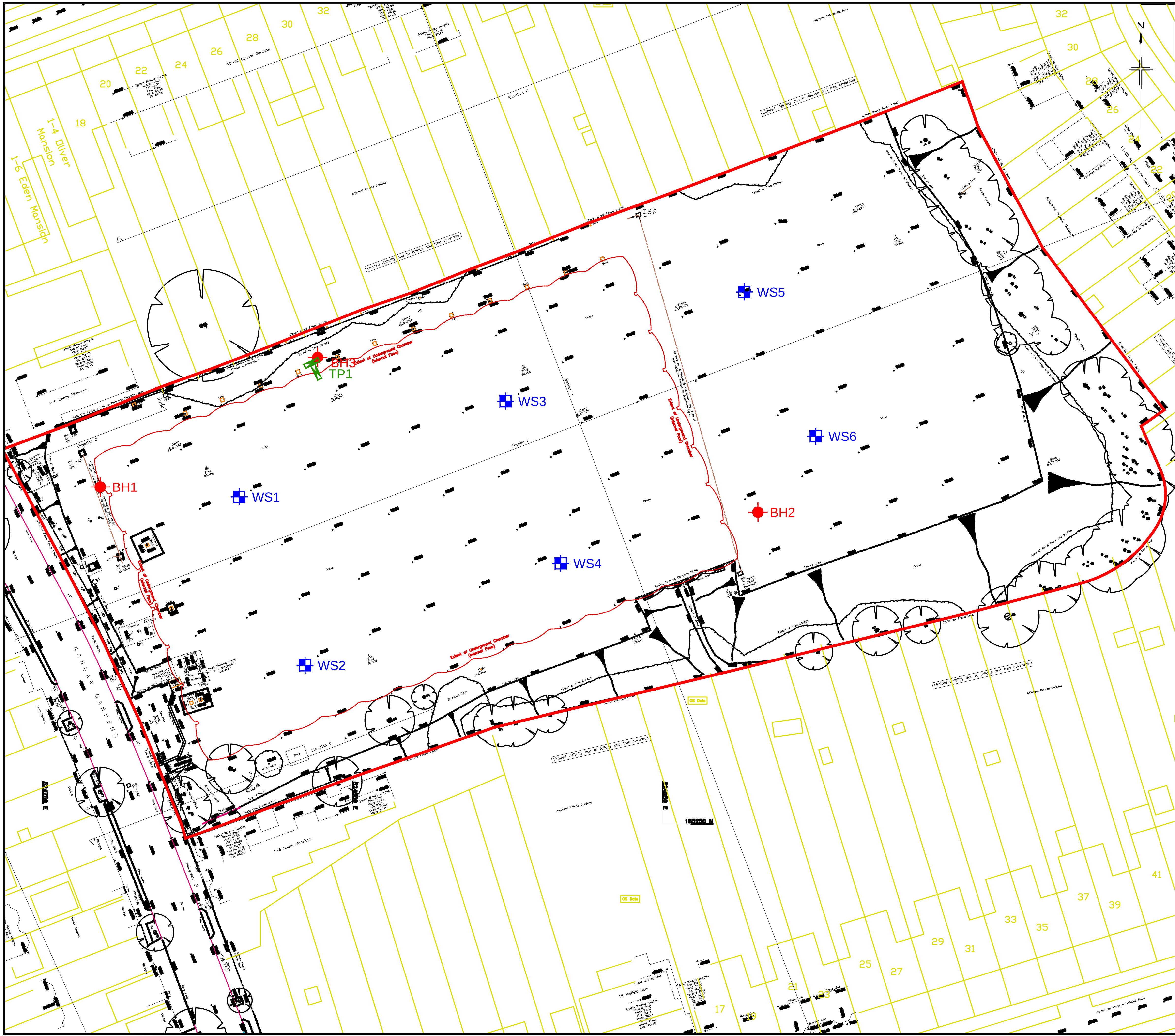
Wilson, S., Oliver, S., Mallet, H., Hutchings, H. and Card, G. (2007), *CIRIA Report C665: Assessing risks posed by hazardous ground gases to buildings* (London: CIRIA).

World Health Organization (2004), *Guidelines for drinking-water quality*, 3rd edn (Geneva: WHO).

WRc plc (2002), 'Polycyclic Aromatic Hydrocarbons (PAH): Priorities for Environmental Quality Standard Development, R&D Technical Report P45'.

FIGURES

RSK	**SITE LOCATION PLAN**	**Client:**	Lifecare Residencies Ltd	**Figure No:**	1
		Site:	Gondar Gardens, West Hampstead	**Job No:**	371487
		Scale:	NTS	**Source:**	



N

LEGEND

- Site Boundary
- Borehole Location
- Window Sample Location
- Trial Pit Location

Rev.	Date	Amendment	Drawn	Chkd.	Appd.

RSK

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Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client

LIFE CARE RESIDENCES LIMITED

Project Title

GONDOR GARDENS, CAMDEN, LONDON

Drawing Title

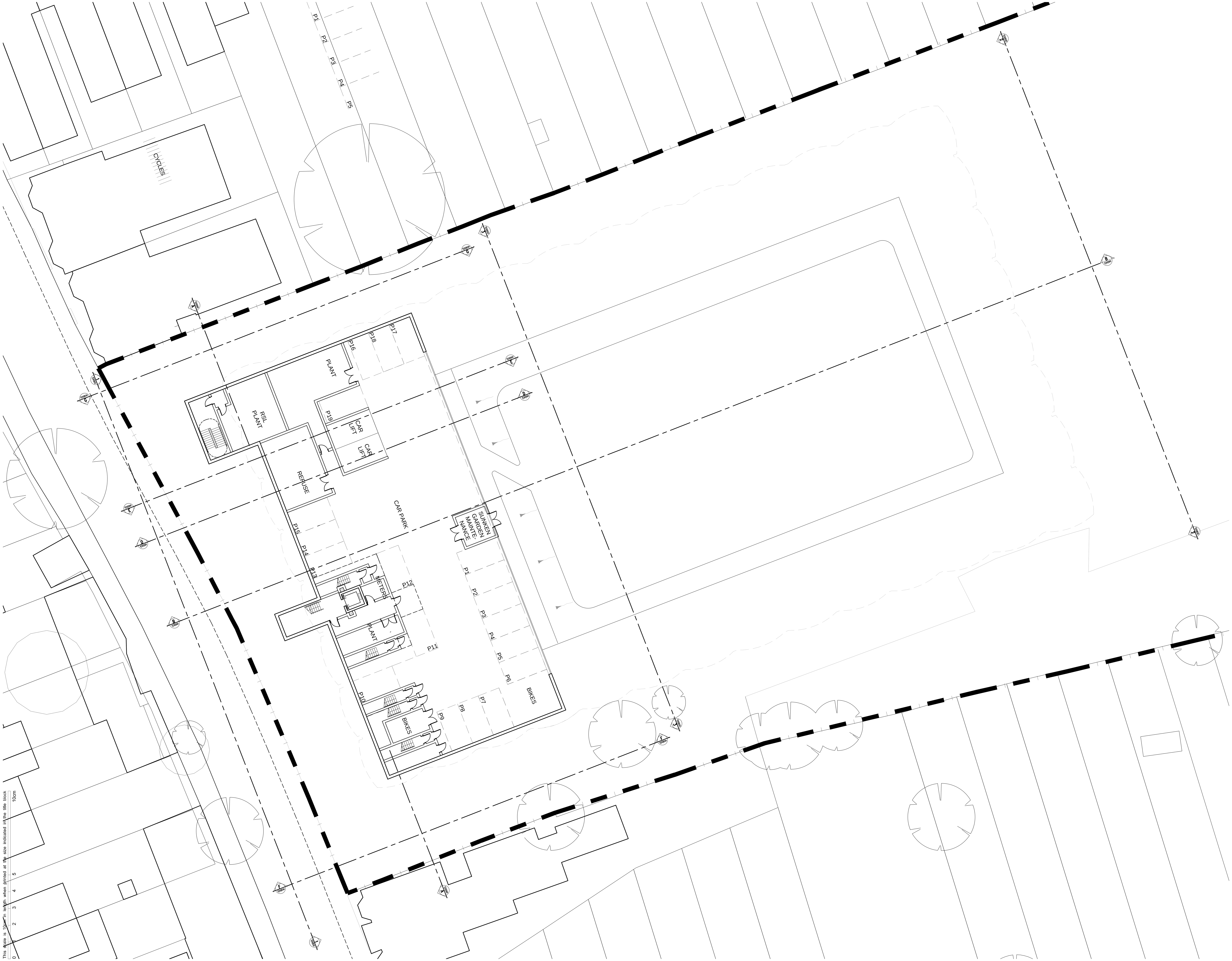
EXPLORATORY HOLE LOCATION PLAN

Drawn	Date	Checked	Date	Approved	Date
ASC	04.05.17	MK	04.05.17	MK	04.05.17

Scale	Orig Size	Dimensions
1:600	A3	m

Project No.	Drawing File
371487 - R01 (00)	371487 (R01-00) Fig 2.dwg

Drawing No.	Rev.
FIGURE 2	P1



NOTES

1. The Contractor must check and confirm all dimensions
2. All discrepancies must be reported and resolved by the Architect before works commence
3. This drawing is not to be scaled
4. All work and materials to be in accordance with current applicable Statutory Legislation and to comply with all relevant Codes of Practice and British Standards

Rev		Date
D	Final planning submission drawings	18/11/13
C	Planning Submission	12/11/13
B	Revised plan	06/11/13
A	Preliminary set	27/09/13

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Client

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Project

GONDAR GARDENS
FRONTAGE SCHEME

Drawing

PLAN
BASEMENT LEVEL

Scale	Date	Status
1:100 (A1)	Sep 13	Planning

Job Number	Drawing Number	Revision
5388	T(20) P0-2	D

G:\5388\T_Series\T20\T20P0-2

NOTES

1 The Contractor must check and confirm all dimensions
2 All discrepancies must be reported and resolved by the Architect before works commence
3 This drawing is not to be scaled
4 All work and materials to be in accordance with current applicable Statutory Legislation and to comply with all relevant Codes of Practice and British Standards

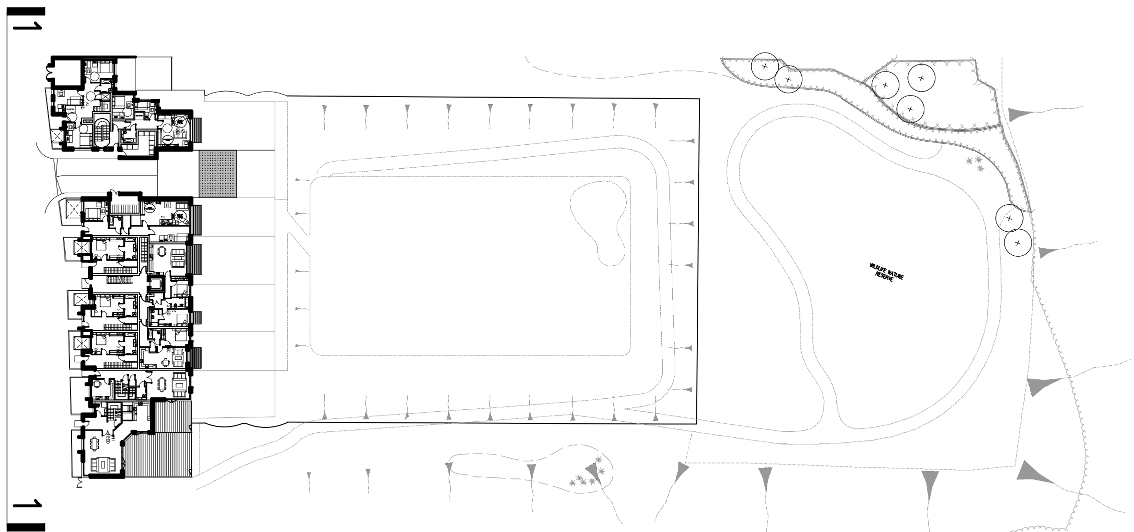
1 GONDAR GARDENS STREET ELEVATION 1–1

SCALE: 1:100 (A1)

Rev		Date
D	Planning Submission drawing	18/11/13
C	Elevation revised, section lines added	06/11/13
B	Elevation revised	28/10/13
A	Preliminary set	27/09/13

2 GONDAR GARDENS STREET ELEVATION 1–1

SCALE: 1:250 (A1)



This scale is 10cm in length when printed at the size indicated in the title block

0 1 2 3 4 5 10cm

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Drawing
ELEVATION
GONDAR GARDENS

Scale	Date	Status
1:100/1:250(A1)	Sep 13	

Job Number	Drawing Number	Revision
5388	T(20) E01	D

G:\5388\T_Series\T20\T20E01

NOTES

1. The Contractor must check and confirm all dimensions
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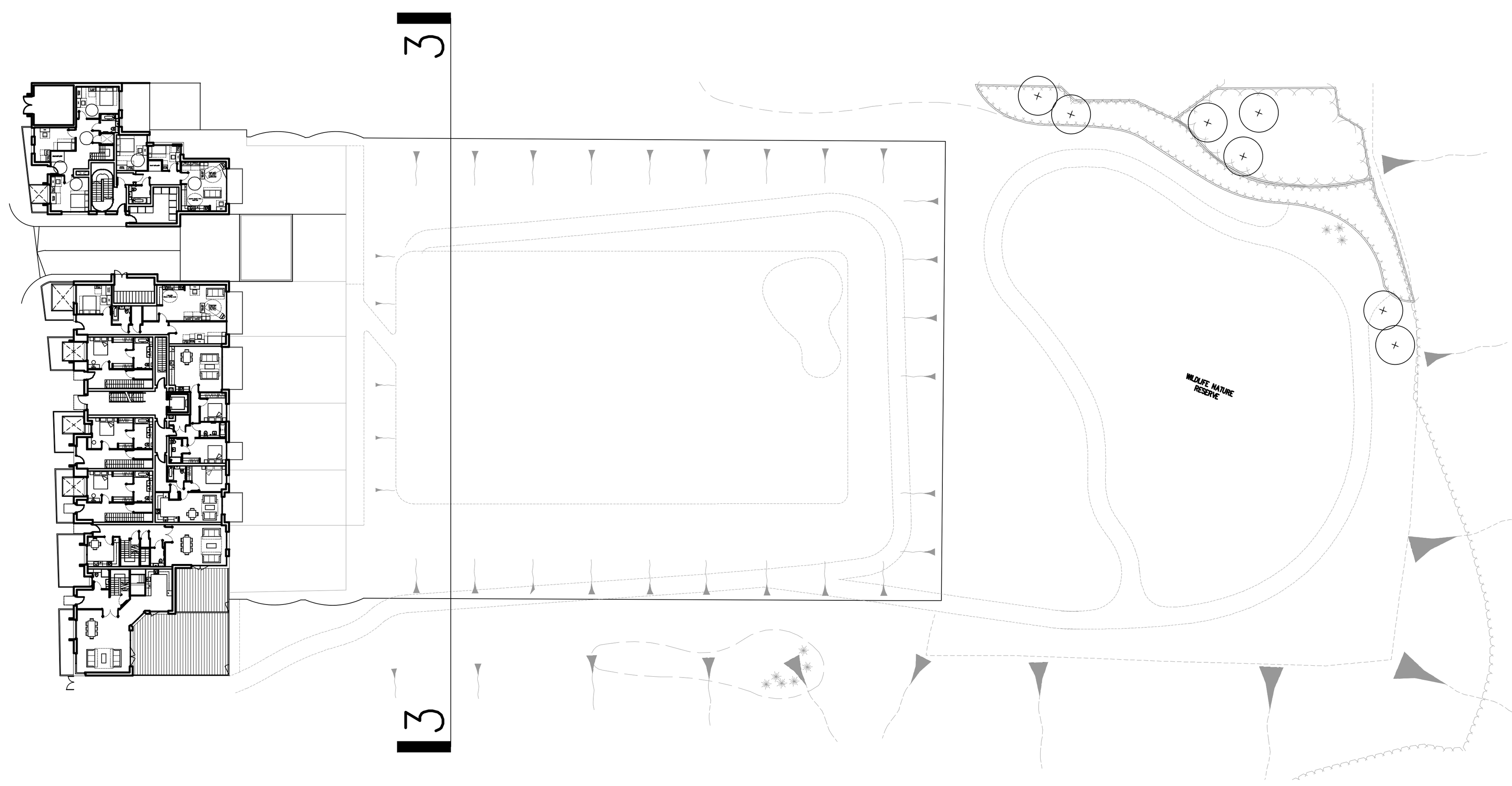
1 GONDAR GARDENS REAR ELEVATION 3–3
SCALE: 1:100 (A1)

2 GONDAR GARDENS REAR ELEVATION 3–3
SCALE: 1:250 (A1)



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Rev		Date
F	Final planning submission drawings	18/11/13
E	Planning Submission	12/11/13
D	Elevation revised, section lines added	06/11/13
C	Elevation revised	03/11/13
B	Elevation revised	28/10/13
A	Preliminary set	27/09/13

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Project
GONDAR GARDENS
FRONTAGE SCHEME

Drawing
ELEVATION
REAR

Scale	Date	Status
1:100/1:250(A1)	Sep 13	Planning

Job Number	Drawing Number	Revision
5388	T(20) E02	F

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SCALE: 1:100 (A1)

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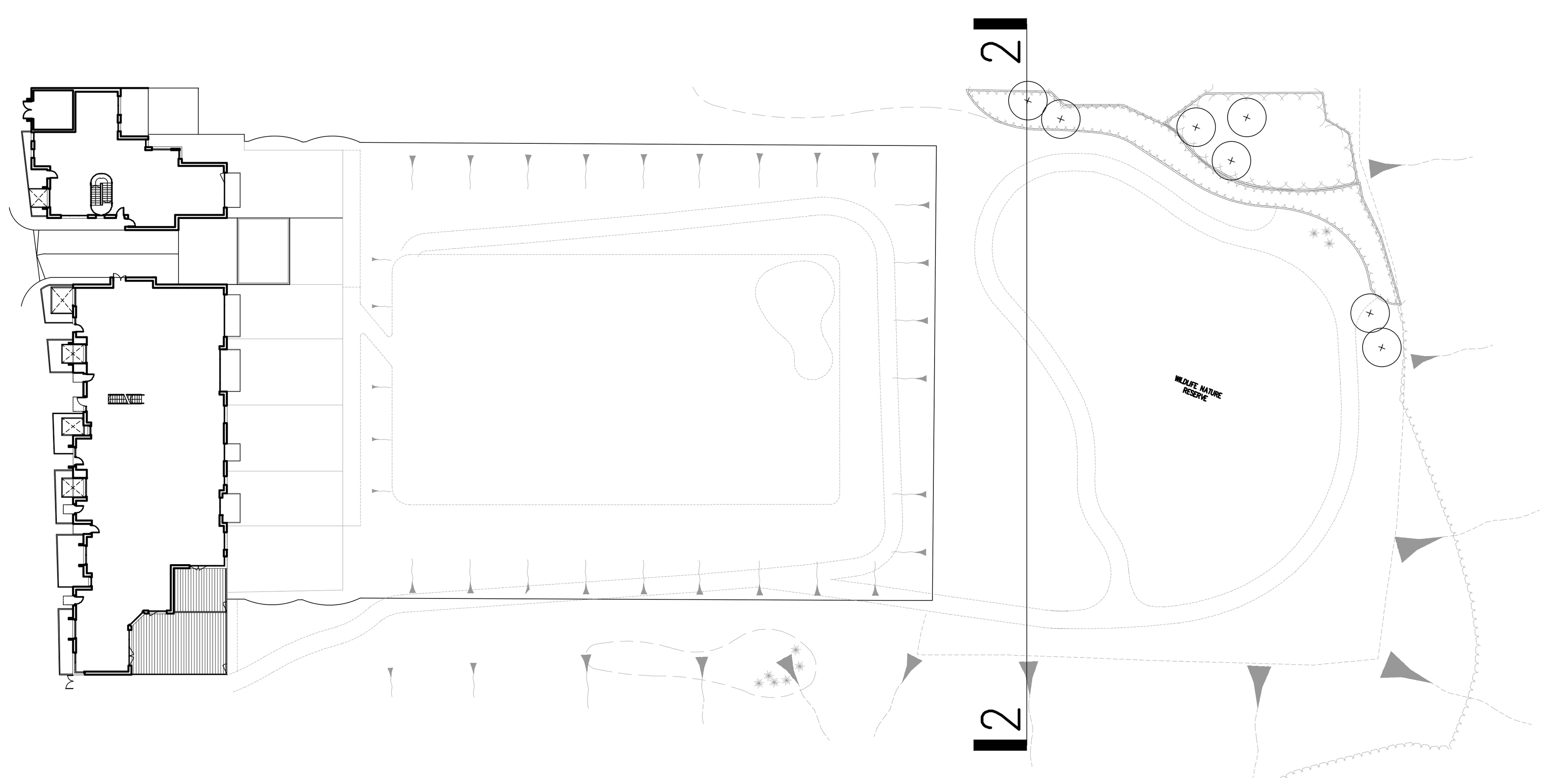
SCALE: 1:250 (A1)



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Rev		Date
F	Final planning submission drawings	18/11/13
E	Planning Submission	12/11/13
D	Elevation revised, secion lines added	06/11/13
C	Elevation revised	03/11/13
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GONDAR GARDENS
FRONTAGE SCHEME

Drawing
ELEVATION
REAR

Scale	Date	Status
1:100/1:250(A1)	Sep 13	Planning

Job Number	Drawing Number	Revision
5388	T(20) E03	F

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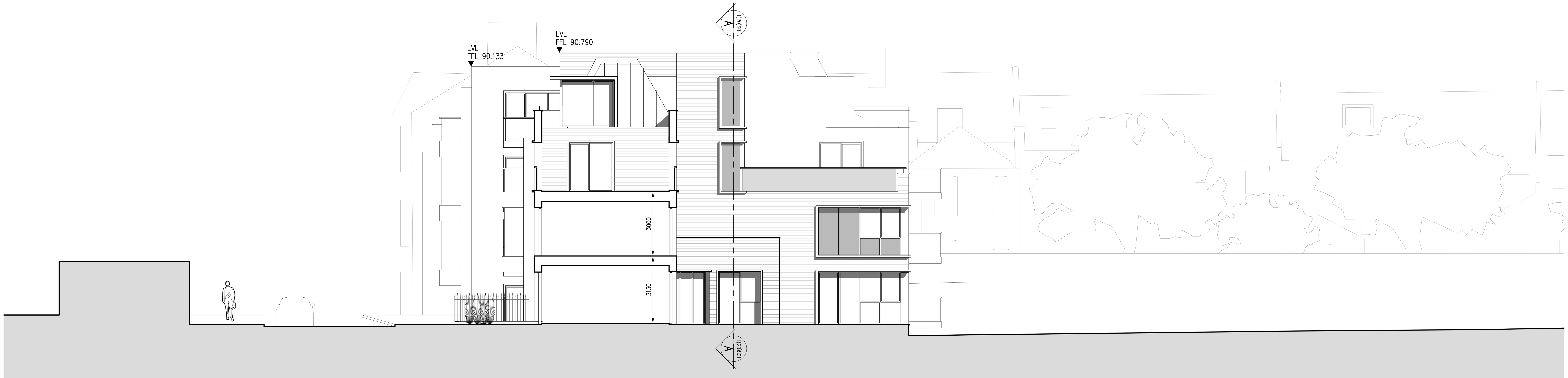

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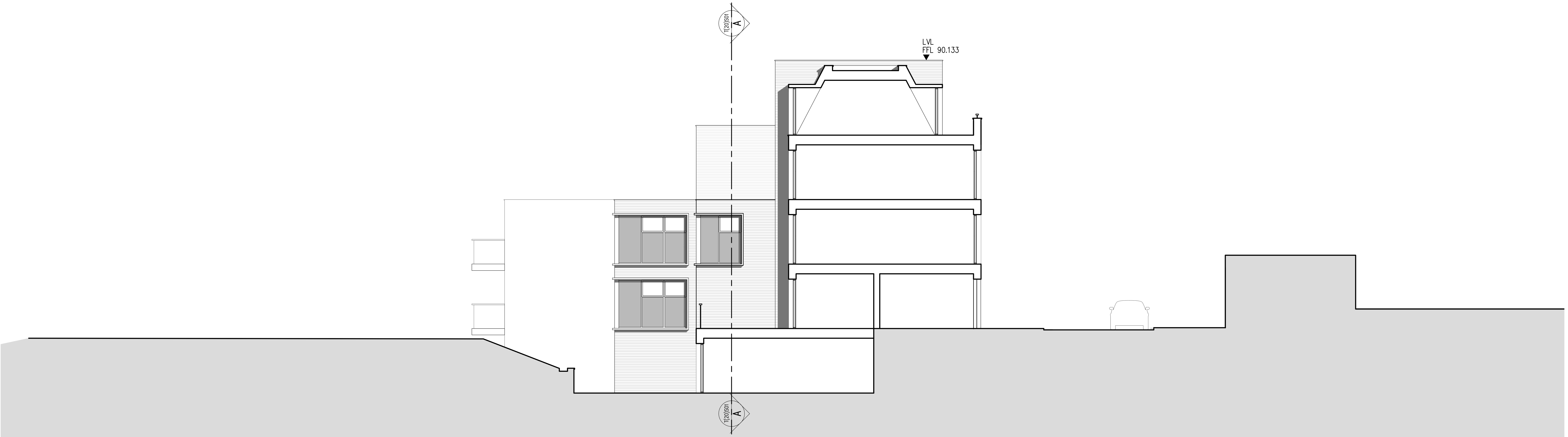

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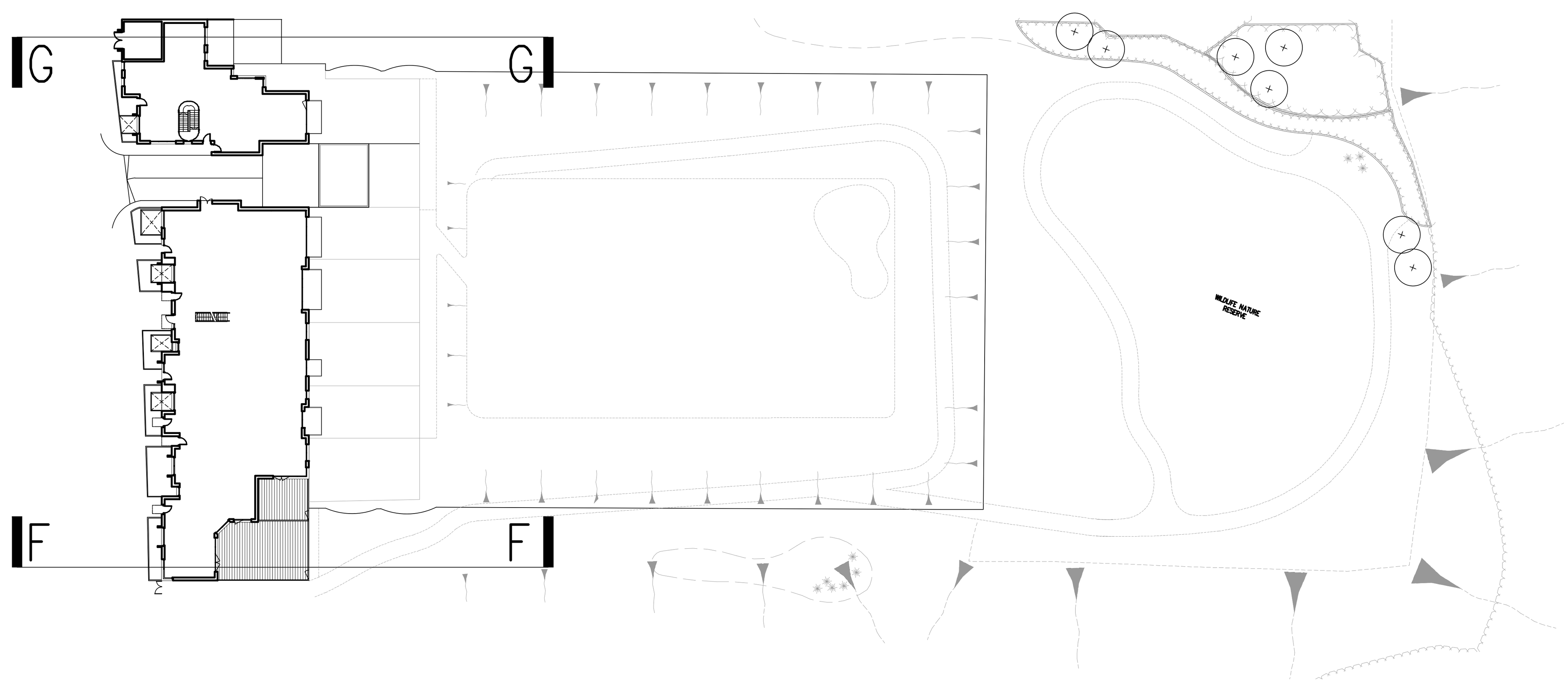

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Rev		Date
E	Final planning submission drawings	18/11/13
D	Planning Submission	12/11/13
C	Side section/elevation revised, section lines added	06/11/13
B	Side section/elevation revised	28/10/13
A	Preliminary set	27/09/13

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GONDAR GARDENS FRONTAGE SCHEME

Drawing

ELEVATION/SECTION

Scale	Date	Status
1:100(A1)	Sep 13	Planning

Job Number	Drawing Number	Revision
5388	T(20) E04	E

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Rev		Date
E	Final planning submission drawings	18/11/13
D	Planning Submission	12/11/13
C	Plan revised	06/11/13
B	Plan revised	28/10/13
A	Preliminary set	27/09/13

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Project
GONDAR GARDENS
FRONTAGE SCHEME

Drawing
PLAN
FIRST FLOOR LEVEL

Scale	Date	Status
1:100 (A1)	Sep 13	Planning

Job Number	Drawing Number	Revision
5388	T(20) P01	E

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NOTES

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Rev		Date
E	Final planning submission drawings	18/11/13
D	Planning Submission	12/11/13
C	Plan revised	06/11/13
B	Plan revised	28/10/13
A	Preliminary set	27/09/13

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Project
GONDAR GARDENS
FRONTAGE SCHEME

Drawing
PLAN
GROUND LEVEL

Scale	Date	Status
1:100 (A1)	Sep 13	Planning

Job Number	Drawing Number	Revision
5388	T(20) P00	E

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Rev		Date
D	Final planning submission drawings	18/11/13
C	Planning Submission	12/11/13
B	Revised plan	06/11/13
A	Preliminary set	27/09/13

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Project
GONDAR GARDENS
FRONTAGE SCHEME

Drawing
PLAN
LOWER GROUND LEVEL

Scale	Date	Status
1:100 (A1)	Sep 13	Planning

Job Number	Drawing Number	Revision
5388	T(20) P0-1	D

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NOTES

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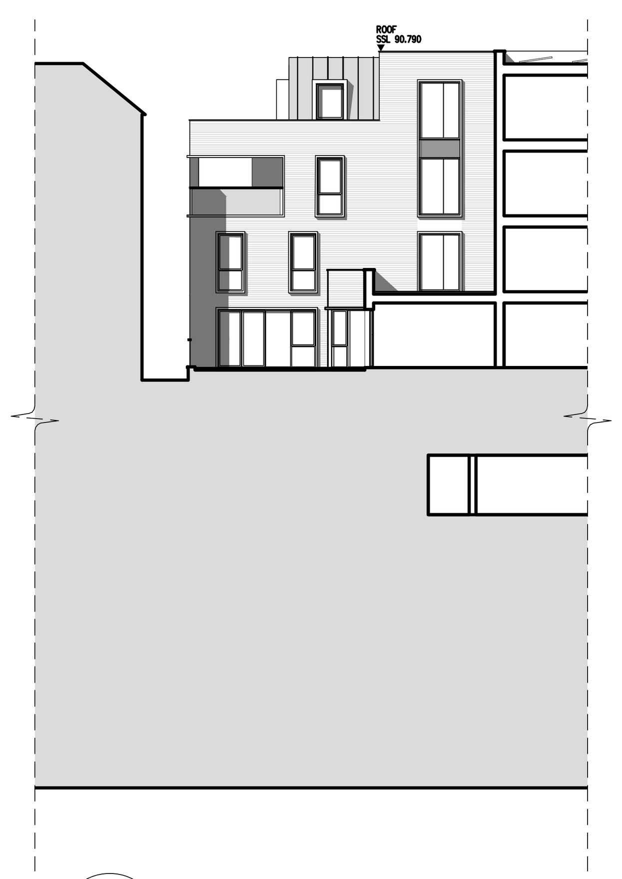

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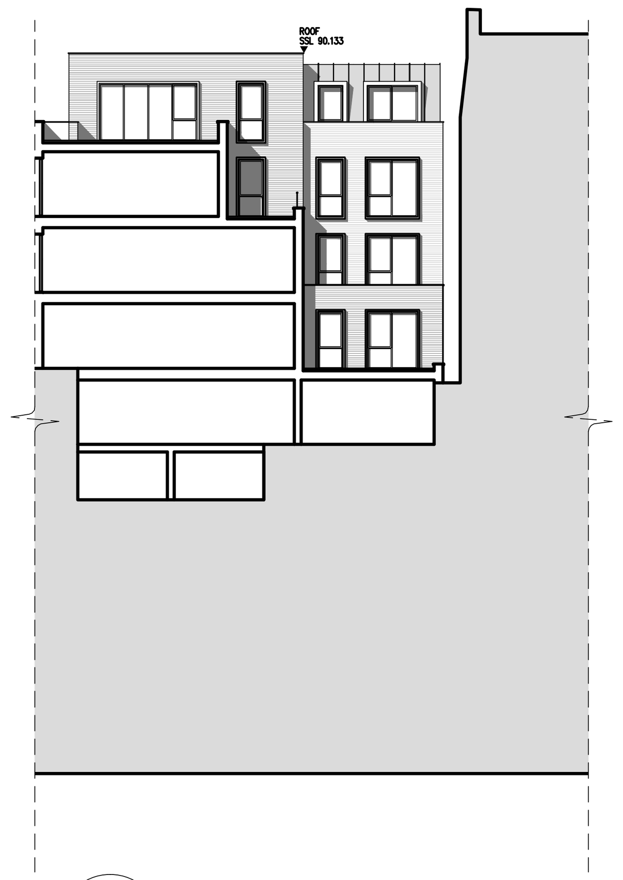

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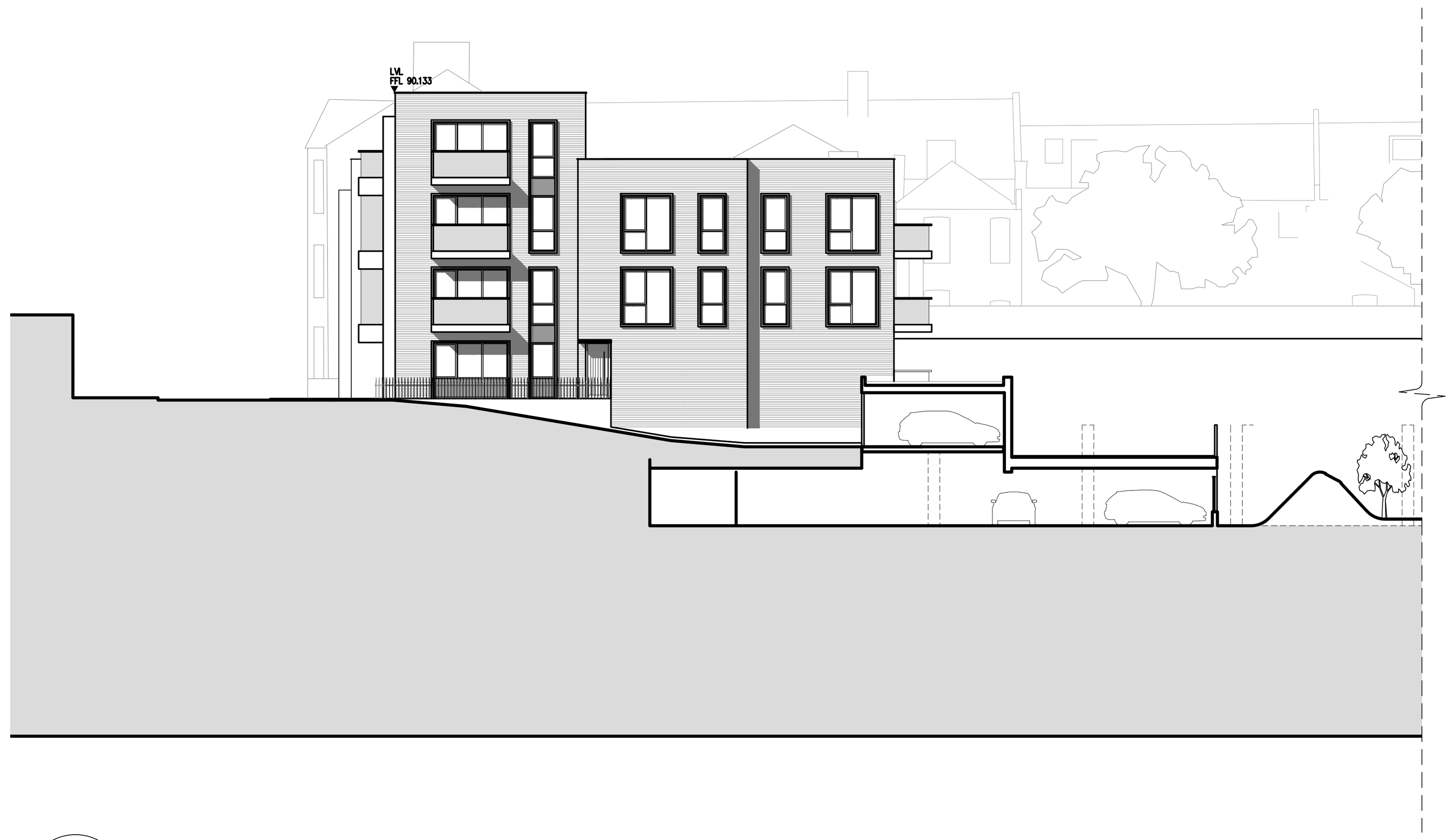

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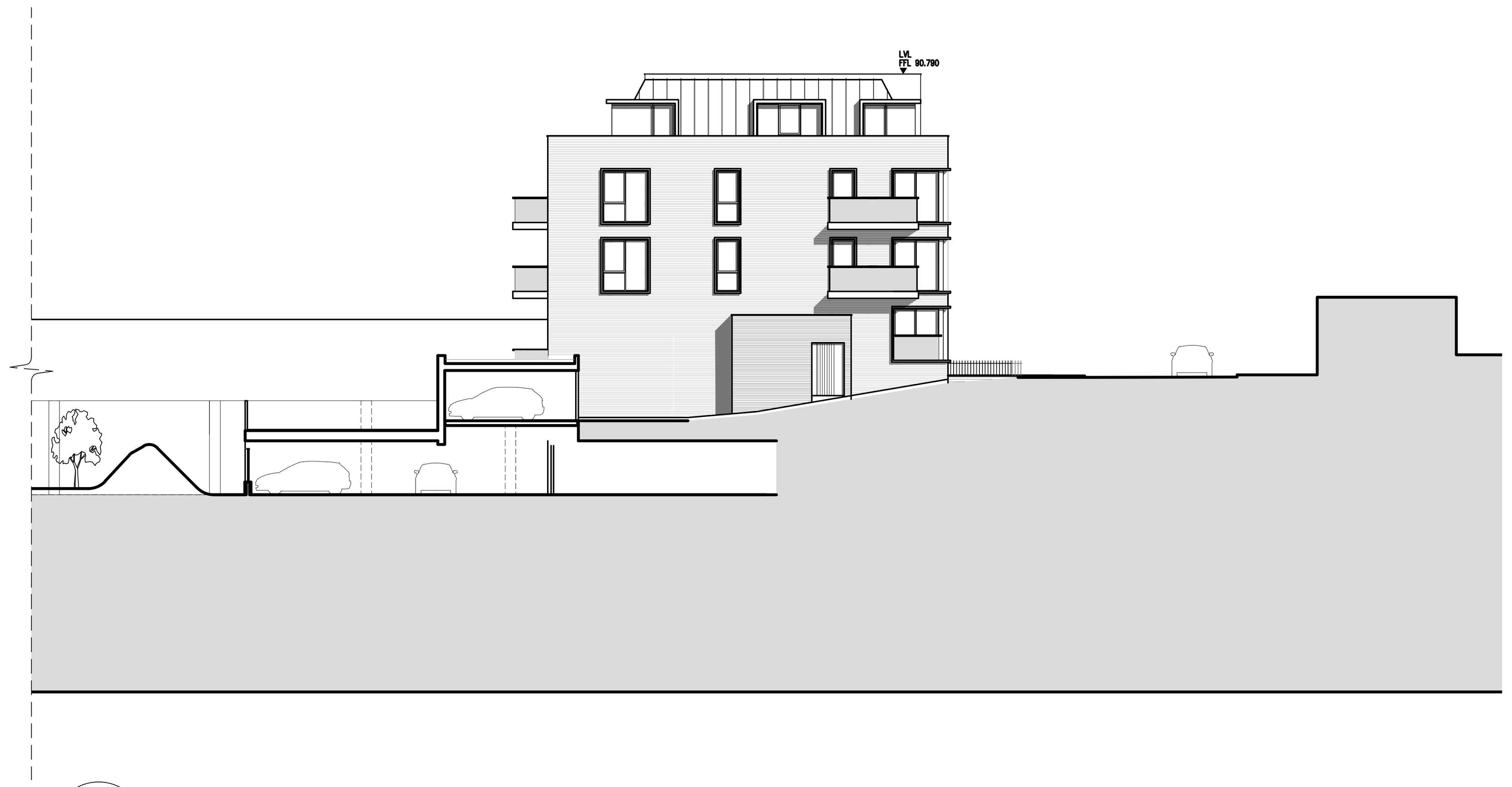

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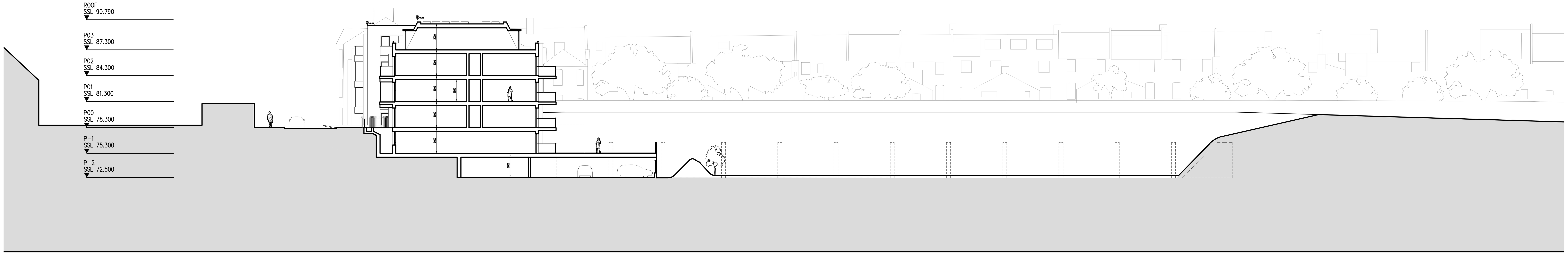

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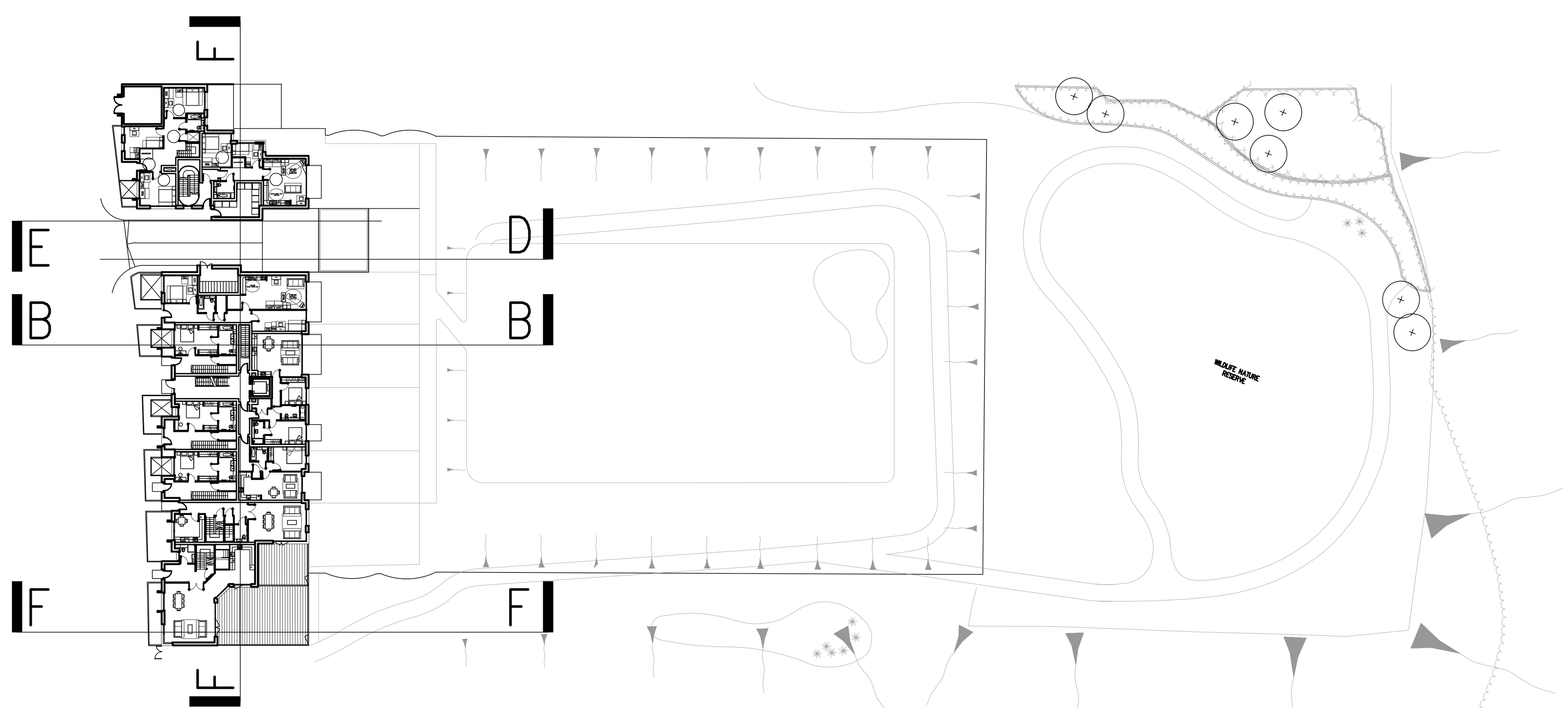

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Project
GONDAR GARDENS
FRONTAGE SCHEME

Drawing
SECTIONS
GONDAR GARDENS

Scale: 1:250(A1)
Date: Sep 13
Status:

Job Number: 5388
Drawing Number: T(20) S01
Revision: E

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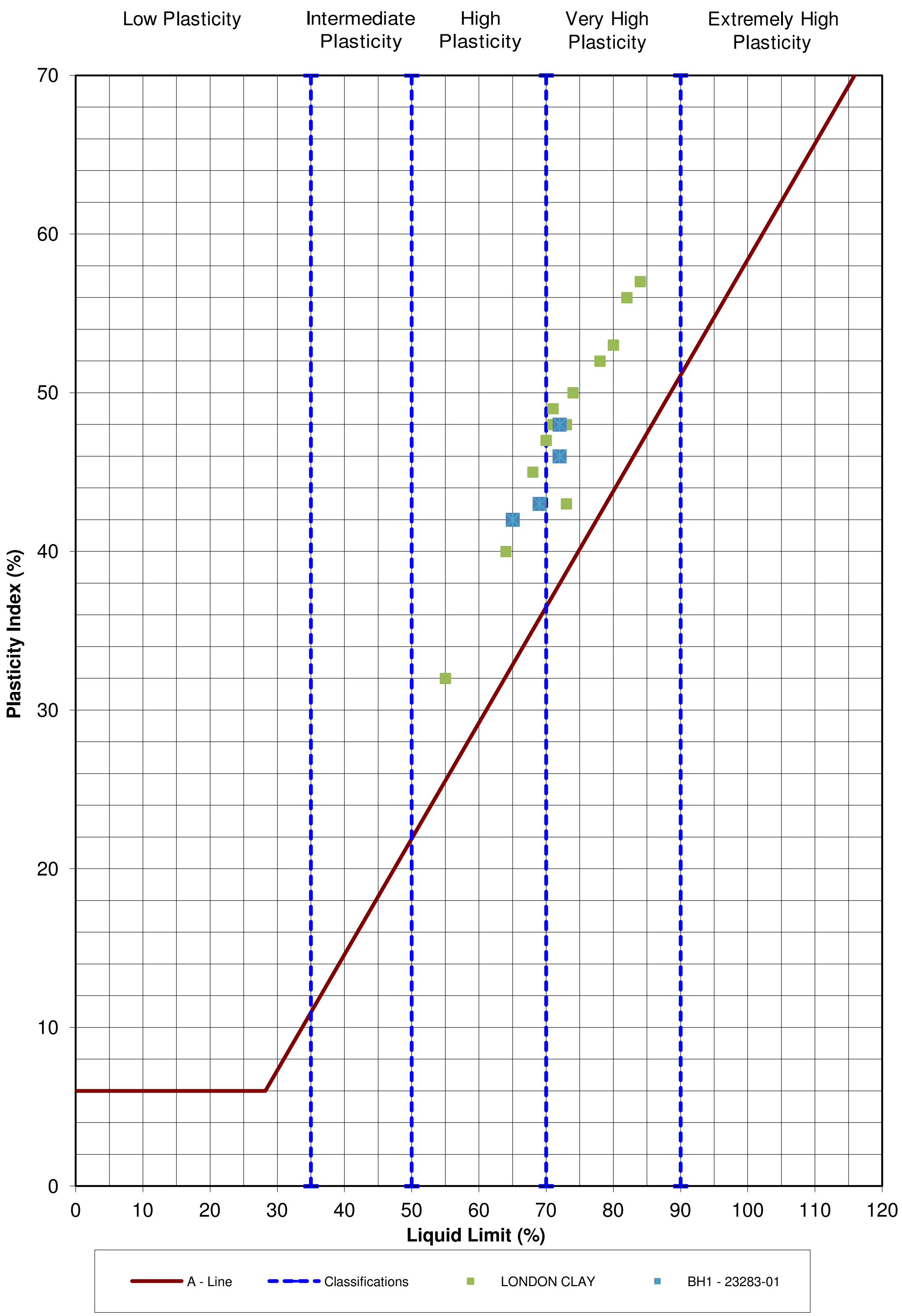
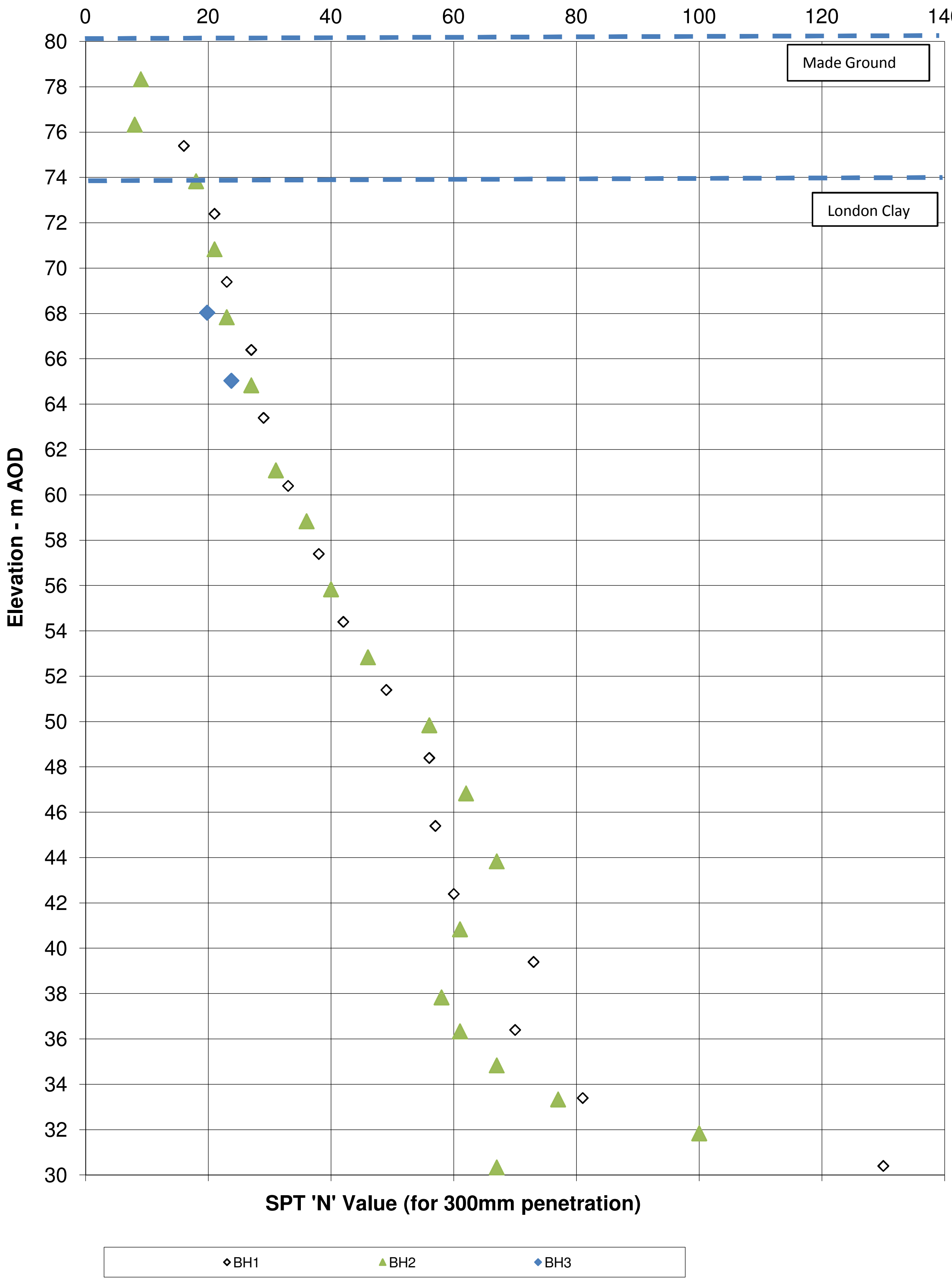
PLASTICITY CLASSIFICATION CHART

Site:	Client:	Job Number:	371487
Gondor Gardens, West Hampstead	Lifecare Residencies Ltd	Figure:	4



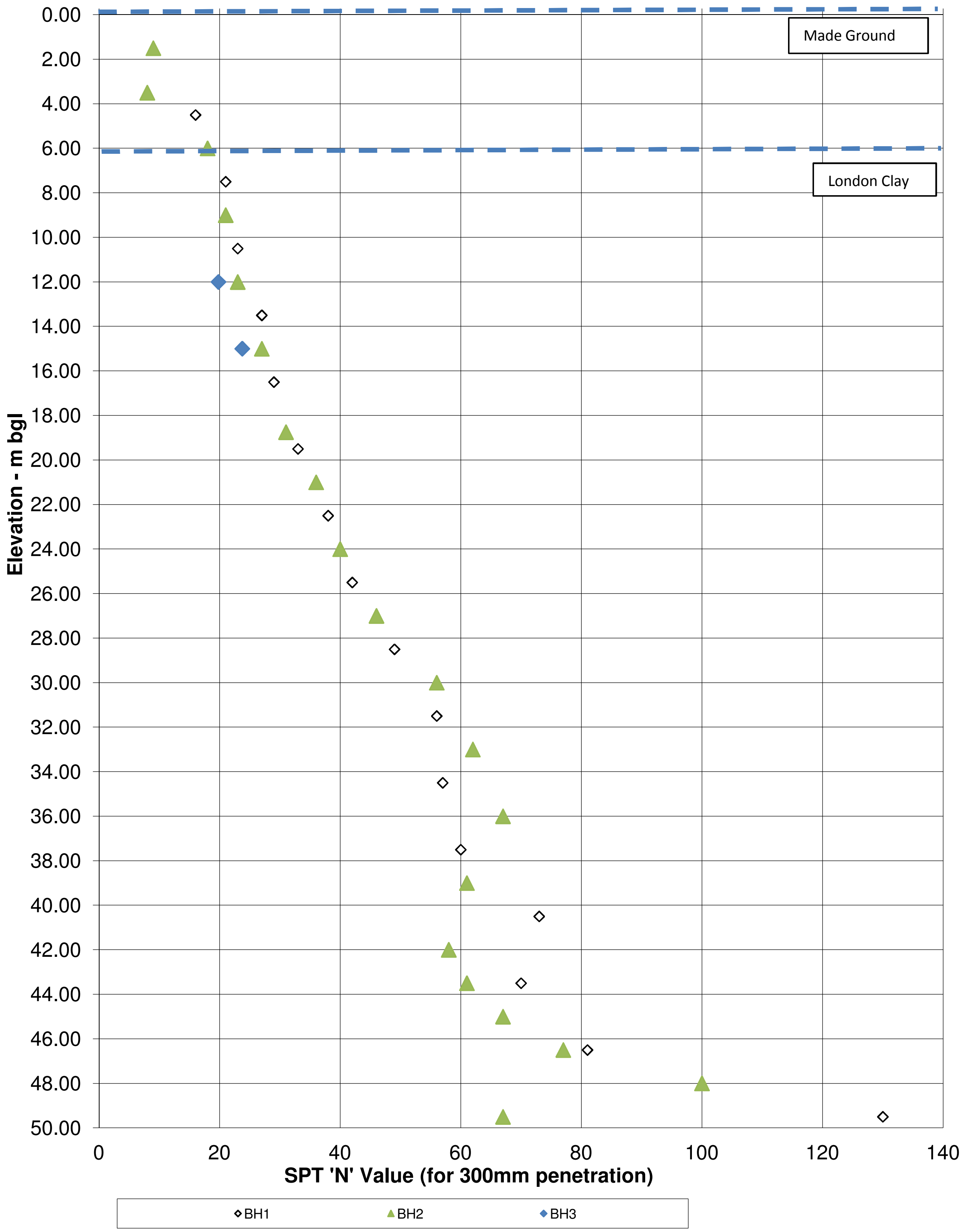
SPT 'N' VALUES vs ELEVATION

Site:	Client:	Job Number:	371487
Gondor Gardens, West Hampstead	Lifecare Residencies Ltd	Figure:	5

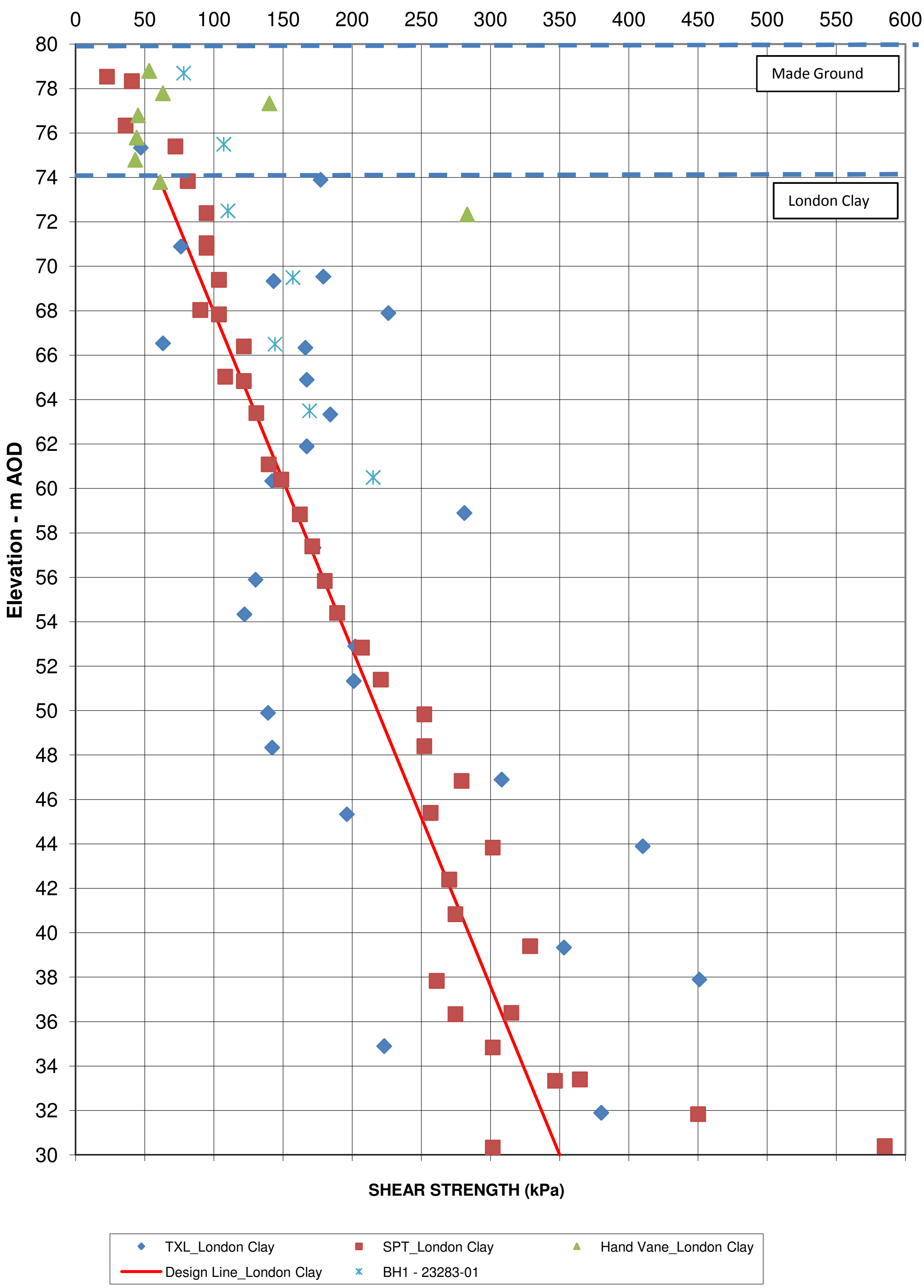


SPT 'N' VALUES vs DEPTH

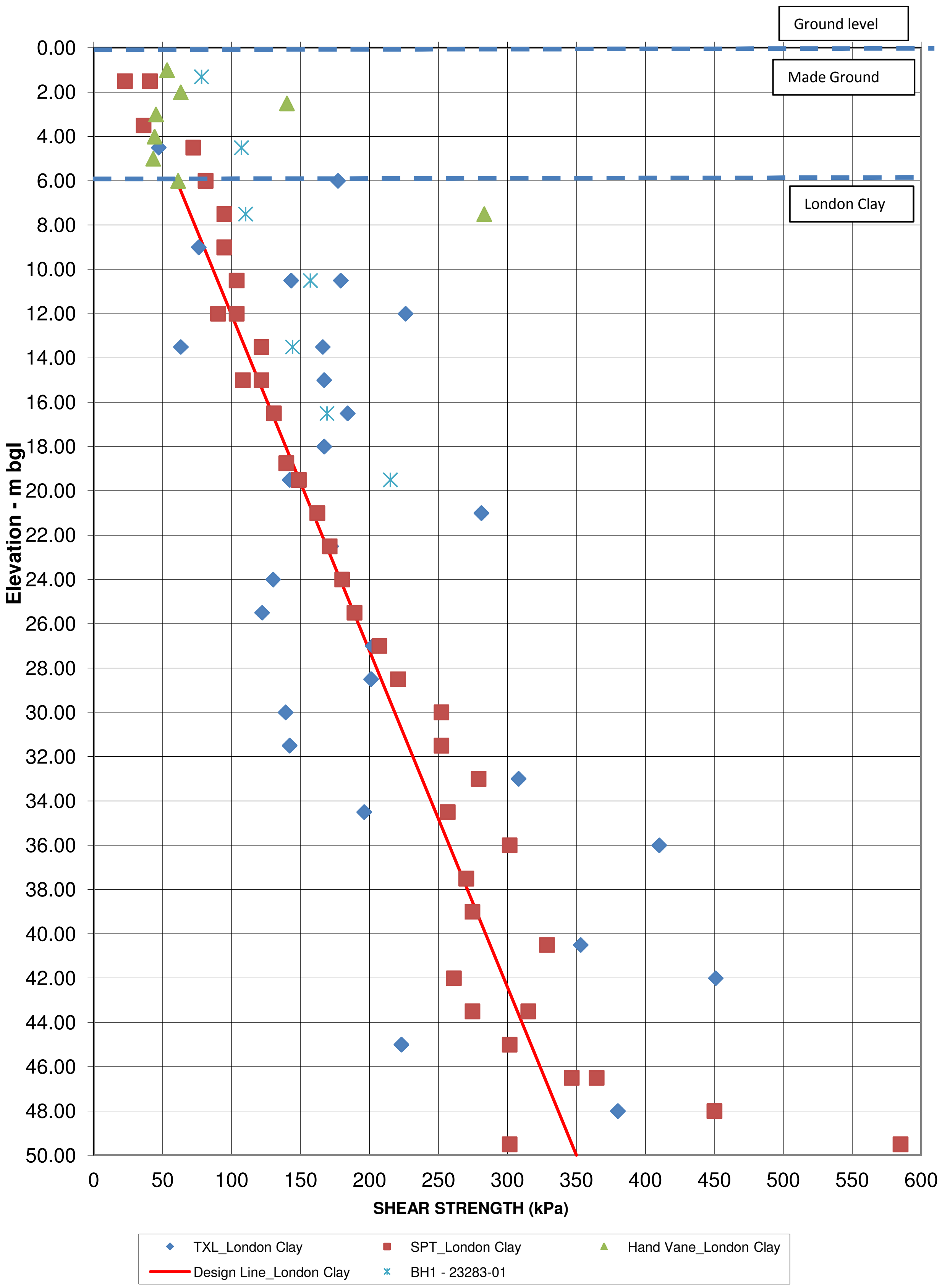
Site:	Client:	Job Number:	371487
Gondor Gardens, West Hampstead	Lifecare Residencies Ltd	Figure:	6



RSK	SHEAR STRENGTH vs ELEVATION		
Site: Gondor Gardens, West Hampstead	**Client:** Lifecare Residencies Ltd	**Job Number:**	371487
		Figure:	7



RSK	SHEAR STRENGTH vs DEPTH		
Site: Gondor Gardens, West Hampstead	**Client:** Lifecare Residencies Ltd	**Job Number:**	371487
		Figure:	8



APPENDIX A
SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Lifecare Residencies Limited the "client") in accordance with the terms of a contract between RSK and the "client", dated 30th September 2015. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.

2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.

3. Unless otherwise agreed in writing the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**

4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.

5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.

6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.

7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

8. The intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (boreholes, trial pits etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.

APPENDIX B
SUMMARY OF LEGISLATION AND POLICY RELATING TO CONTAMINATED LAND

Part IIA of the Environmental Protection Act 1990 (EPA) and its associated Contaminated Land Regulations 2000 (SI 2000/227), which came into force in England on 1 April 2000, formed the basis for the current regulatory framework and the statutory regime for the identification and remediation of contaminated land. Part IIA of the EPA 1990 defines contaminated land as 'any land which appears to the Local Authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land, that significant harm is being caused, or that there is significant possibility of significant harm being caused, or that pollution of controlled waters is being or is likely to be caused'. Controlled waters are considered to include all groundwater, inland waters and estuaries.

In August 2006, the Contaminated Land (England) Regulations 2006 (SI 2006/1380) were implemented, which extended the statutory regime to include Part IIA of the EPA as originally introduced on 1 April 2000, together with changes intended chiefly to address land that is contaminated by virtue of radioactivity. These have been replaced subsequently by the Contaminated Land (England) (Amendment) Regulations 2012, which now exclude land that is contaminated by virtue of radioactivity.

The intention of Part IIA of the EPA is to deal with contaminated land issues that are considered to cause significant harm on land that is not undergoing development (see Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance, April 2012). This document replaces Annex III of Defra Circular 01/2006, published in September 2006 (the remainder of this document is now obsolete).

Water Framework Directive (WFD)

The Water Framework Directive 2000/60/EC is designed to:

- enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands that depend on the aquatic ecosystems
- promote the sustainable use of water
- reduce pollution of water, especially by 'priority' and 'priority hazardous' substances
- ensure progressive reduction of groundwater pollution.

The WFD requires a management plan for each river basin be developed every six years.

Groundwater Directive (GWD)

The 1980 Groundwater Directive 80/68/EEC and the 2006 Groundwater Daughter Directive 2006/118/EC of the WFD are the main European legislation in place to protect groundwater. The 1980 Directive is due to be repealed in December 2013. The European legislation has been transposed into national legislation by regulations and directions to the Environment Agency.

Environmental Permitting Regulations (EPR)

The Environmental Permitting (England and Wales) Regulations 2010 provide a single regulatory framework that streamlines and integrates waste management licensing, pollution prevention and control, water discharge consenting, groundwater authorisations, and radioactive substances regulation. Schedule 22, paragraph 6 of EPR 2010 states: 'the regulator must, in exercising its relevant functions, take all necessary measures - (a) to prevent the input of any hazardous substance to groundwater; and (b) to limit the input of non-hazardous pollutants to groundwater so as to ensure that such inputs do not cause pollution of groundwater.'

Water Resources Act (WRA)

The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009 updated the Water Resources Act 1991, which introduced the offence of causing or knowingly permitting pollution of controlled waters. The Act provides the Environment Agency with powers to implement remediation necessary to protect controlled waters and recover all reasonable costs of doing so.

Priority Substances Directive (PSD)

The Priority Substances Directive 2008/105/EC is a 'Daughter' Directive of the WFD, which sets out a priority list of substances posing a threat to or via the aquatic environment. The PSD establishes environmental quality standards for priority substances, which have been set at concentrations that are safe for the aquatic environment and for human health. In addition, there is a further aim of reducing (or eliminating) pollution of surface water (rivers, lakes, estuaries and coastal waters) by pollutants on the list. The WFD requires that countries establish a list of dangerous substances that are being discharged and EQS for them. In England and Wales, this list is provided in the River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. In order to achieve the objectives of the WFD, classification schemes are used to describe where the water environment is of good quality and where it may require improvement.

Planning Policy

Contaminated land is often dealt with through planning because of land redevelopment. This approach was documented in Planning Policy Statement: Planning and Pollution Control PPS23, which states that it remains the responsibility of the landowner and developer to identify land affected by contamination and carry out sufficient remediation to render the land suitable for use. PPS23 was withdrawn early in 2012 and has been replaced by much reduced guidance within the National Planning Policy Framework (NPPF).

The new framework has only limited guidance on contaminated land, as follows:

- *"planning policies and decisions should also ensure that:*

- *the site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation;*
- *after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and*
- *adequate site investigation information, prepared by a competent person, is presented".*

APPENDIX C
RISK ASSESSMENT METHODOLOGY

CLR11 outlines the framework to be followed for risk assessment in the UK. The framework is designed to be consistent with UK legislation and policies including planning. Under CLR11, three stages of risk assessment exist: preliminary, generic quantitative and detailed quantitative. An outline conceptual model should be formed at the preliminary risk assessment stage that collates all the existing information pertaining to a site in text, tabular or diagrammatic form. The outline conceptual model identifies potentially complete (termed possible) pollutant linkages (contaminant–pathway–receptor) and is used as the basis for the design of the site investigation. The outline conceptual model is updated as further information becomes available, for example as a result of the site investigation.

Production of a conceptual model requires an assessment of risk to be made. Risk is a combination of the likelihood of an event occurring and the magnitude of its consequences. Therefore, both the likelihood and the consequences of an event must be taken into account when assessing risk. RSK has adopted guidance provided in CIRIA C552 for use in the production of conceptual models.

The likelihood of an event can be classified on a four-point system using the following terms and definitions based on CIRIA C552:

- highly likely: the event appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution
- likely: it is probable that an event will occur or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term
- low likelihood: circumstances are possible under which an event could occur, but it is not certain even in the long term that an event would occur and it is less likely in the short term
- unlikely: circumstances are such that it is improbable the event would occur even in the long term.

The severity can be classified using a similar system also based on CIRIA C552. The terms and definitions relating to severity are:

- severe: short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short-term risk to an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000)
- medium: chronic damage to human health ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem
- mild: pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000). Damage to sensitive buildings, structures or the environment
- minor: harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

Once the probability of an event occurring and its consequences have been classified, a risk category can be assigned according to the table below.

		Consequences			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**Highly likely**	Very high	High	Moderate	Moderate/low
	Likely	High	Moderate	Moderate/low	Low
	Low likelihood	Moderate	Moderate/low	Low	Very low
	Unlikely	Moderate/low	Low	Very low	Very low

Definitions of these risk categories are as follows together with an assessment of the further work that may be required:

- Very high: there is a high probability that severe harm could occur or there is evidence that severe harm is currently happening. This risk, if realised, could result in substantial liability; urgent investigation and remediation are likely to be required.
- High: harm is likely to occur. Realisation of the risk is likely to present a substantial liability. Urgent investigation is required. Remedial works may be necessary in the short term and are likely over the long term.
- Moderate: it is possible that harm could arise, but it is unlikely that the harm would be severe and it is more likely that the harm would be relatively mild. Investigation is normally required to clarify the risk and determine the liability. Some remedial works may be required in the longer term.
- Low: it is possible that harm could occur, but it is likely that if realised this harm would at worst normally be mild.
- Very low: there is a low possibility that harm could occur and if realised the harm is unlikely to be severe.

APPENDIX D
EXISTING REPORTS

Waterman Structures Limited

Gondar Gardens Reservoir, London

Structural Investigation

288627-01 (00)

APRIL 2017

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RSK DOCUMENT CONTROL

Report No.: 288627-01 (00)

Title: Gondar Gardens Reservoir, London, Structural Investigation

Client: Waterman Structures Limited

Date: 20 April 2017

RSK Office: 18 Frogmore Road, Hemel Hempstead, Hertfordshire, HP3 9RT

Status: Final

Author	Mark Richardson Project Manager	**Technical reviewer**	Kate Andrews Operations Manager
Signature		Signature	
Date:	20 April 2017	Date:	20 April 2017

Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK Environment Ltd.

All opinions and interpretations expressed herein are outside the scope of UKAS accreditation

Samples are retained for ONE month from the issue of the final report. Should you wish us to retain the samples for a longer period, or should you wish to collect the samples please could you advise us at your earliest convenience.

1 INTRODUCTION

On the instructions of Mr Barry Dobbins of Waterman Structures Limited ('the Client'), RSK Environment Limited (RSK) has carried out a structural investigation of the former reservoir.

The structure located at Gondar Gardens, West Hampstead, is a disused underground reservoir. The roof is a vaulted masonry arch barrel supported by masonry crucible columns and masonry retaining walls. The floor is a ground bearing concrete slab.

The site work was carried out between the 20th and 23rd March 2017.

2 PURPOSE OF INVESTIGATION

The purpose of the investigations was to provide specific data of the dry reservoir to assist in the design analysis of the proposed reservoir structure.

3 EXTENT OF INVESTIGATION

The site works comprised of the following:

- Establish the thickness of the top of the arch barrel,
- Extraction of 10 No. bricks and mortar samples from the internal reservoir structure,
- Establish the make-up of the foundations at two internal column locations (trial pits).

4 METHODS

4.1 Site Work

4.1.1 Access/Egress

A confined space safe system of work was implemented on site that included monitoring of the air within the structure for hazardous gases, entry and exit log of personnel accessing the structure, and a designated 'Top Man' to maintain communication with the confined space operatives and to contact the emergency services if required.

Adequate task lighting was installed to ensure safe access/egress and ensure the work areas were adequately lit at all times.

The access door was left open during the works and there are vent points positioned around the perimeter of the reservoir so it was therefore assumed to be well ventilated.

4.1.2 Arch Barrel Thickness

A 20mm diameter hole was drilled through the crown of the masonry arch barrel, utilising the hand dug trial pit from the top, to establish the thickness. The thickness of the barrel arch was measured using a steel tape measure and recorded on to a standard proforma.

4.1.3 Extraction of Brick and Mortar Samples

Representative column locations within an area highlighted by the client were selected for the intrusive sampling.

A hand held percussive breaker fitted with a special brick chisel bit was used to breakout the mortar between the bricks to be sampled. During this process, samples of mortar were collected and sealed in polythene bags and given a unique reference number.

When the mortar had been removed from around the brick, the brick was carefully eased away from the structure in one intact piece.

4.1.4 Column Foundations

In two locations, a trial pit was carefully excavated using hand tools. The concrete slab was broken out using a pneumatic breaker.

The excavation proceeded with a range of digging tools appropriate for the conditions.

4.2 Laboratory Testing

4.2.1 Compressive Strength of Brick Samples

Compressive strength was determined in accordance with BS EN 772-1: 2000.

4.2.2 Mortar Designation of Mortar Samples

The mortar samples were chemically analysed by the methods specified in BS 4551:2005.

5 RESULTS

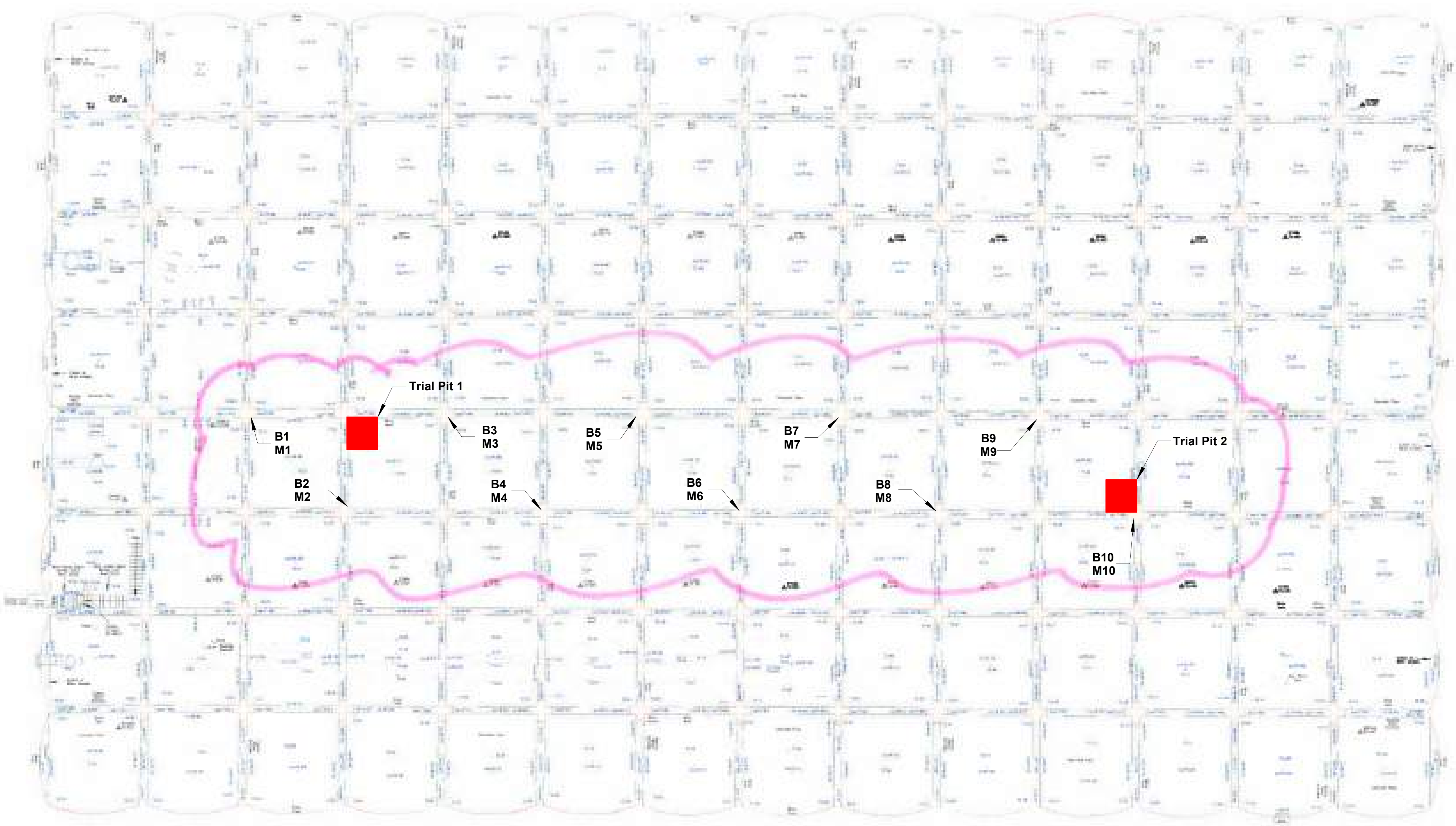
Table 5.1 – Summary of Laboratory Testing

Sample Ref	Location	Brick type	Comp. strength (N/mm^2)	Normalised Comp. strength (N/mm^2)	Mortar type	Mortar desig./ mix propor'n [(1)]
B1/M1	Column	Yellow, coarse, clay, regular, single frog bricks	5.7	4.8	Damp, red, very soft and friable	iv and v
B2/M2	Column		13.2	11.4	Damp, red,moderately soft and friable	iii and iv
B3/M3	Column		15	12.8	Damp, red,moderately soft and friable	iii
B4/M4	Column		7.2	6.2	Damp, red,moderately soft and friable	iii
B5/M5	Column		13.6	11.6	Damp, red,moderately soft and friable	iv and v
B6 /M6	Column		15.9	13.8	Damp, red,moderately soft and friable	iv and v
B7/M7	Column		16.7	14.3	Red, soft and friable	iv and v
B8/M8	Column		12	10.2	Brown, moderately soft	iv and v
B9/M9	Column		11.3	9.6	Damp, red, very soft and friable	iv and v
B10/M10	Column		7	5.9	Red, moderately soft	iv and v

Note:
B – Brick Sample
M - Mortar Sample
(1) Assuming sand/cement mix

APPENDIX A - SITE LOCATION PLAN

This appendix contains 2 pages, including this one



DO NOT SCALE

Key:

B1 = Brick Sample

M1 = Mortar Sample

■ = Trial Pit Location

RSK Environment Ltd
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

CLIENT:	**Waterman Structures Ltd**
SITE:	**Gondar Gardens Reservoir**
TITLE:	**Location Plan**
PREP BY:	CY
DATE:	March 2017
JOB NO:	**288627**
FIG NO:	**A1**

APPENDIX B -
SITE RECORD SHEETS

This appendix contains 5 pages, including this one