Lifecare Residencies Limited

Gondar Gardens, West Hampstead, NW6 1QF

Hydrogeology and Hydrology Assessment

371487-R04 (00)

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RSK GENERAL NOTES

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Title: Hydrogeology and Hydrology Assessment for Gondar Gardens, West Hampstead, London, NW6 1QF

Client: Lifecare Residencies Limited

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Proposed development	The proposed development will comprise the construction of six apartment blocks, consisting of 4 storeys above ground plus 2 levels of basement. The existing reservoir retaining walls will be retained on three sides, (north, west and south), and partly incorporated into the scheme, with the basement and lower basement boxes being constructed within the footprint of the existing reservoir, albeit with the lower (2nd) part basement level being excavated a further 1.4 m below the existing slab level (~71.6 m AOD). The first basement level will occupy the entire internal area of the reservoir. The lower basement level will only occupy the eastern half of the existing reservoir footprint, and house residential apartments that will open out to landscaped gardens across the easternmost part of the site. Because of the limited area occupied by the lower basement level, there will be a significant up-filling across the western extent of the reservoir footprint to raise the existing level to the formation level of the first basement (~75 m AOD). The existing site surface level will be lowered to be consistent with street level to the west such that the new ground floor is level with the existing street level to the west at ~77.5 to 78 m AOD. The six blocks will appear separate from ground level up, but will be joined by a common basement and lower basement level. The development will include areas of soft landscaping, including

	construction of a substantial reinforced earth slope along the northern boundary in the eastern part of the site, and significant cut slopes to the eastern and south-eastern boundaries. The development will include the general reduction of surface level across the site from the existing level of approximately 79.5 m AOD to 80.0 m AOD, to level with the adjacent road on Gondar Gardens at approximately 78 m AOD. The lowering of the second basement level will see the level drop from 72.4 m AOD to 71.0 m AOD across the eastern extent of the development.
Ground / Groundwater conditions	The RSK exploratory holes encountered made ground across the site, ranging from 3.20 m bgl to 10.50 m bgl (76.70 m AOD to 69.54 m AOD). Outside of the footprint of the reservoir the made ground generally comprised brown clay (reworked London Clay). Within the footprint of the reservoir, window samples were terminated at shallow depths upon encountering the roof structure. The made ground generally comprised reworked London Clay, but with occasional layers of brick rubble particularly over the reservoir structure. In one location to the north of the reservoir structure, the made ground was found to comprise predominantly brick rubble with occasional layers of very soft clay, sandy gravelly silt and sandy clay and extended to a depth of 10.50 m bgl (69.54 m AOD). Despite lying in an area of 'Head propensity', no deposits were encountered that could unambiguously be described as 'Head' deposits. The underlying 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 m bgl (72.80 m AOD) and 50.00 mbgl (29.84 m AOD). This was found to initially comprise 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 in the eastern part of the site 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 m bgl (29.84 m AOD). Groundwater monitoring undertaken within BH1 and BH2 in April and May 2017 indicate a standing water level of between 6.62 m bgl (73.22 m AOD) and 7.37 m bgl (72.53 m AOD). This suggest the London Clay is saturated to an elevation of approximately 73.2 m AOD)
Screening and scoping	**Subterranean (ground water):** No potential impacts identified beyond the scoping stage **Surface flow and flooding:** No potential impacts identified beyond the

	scoping stage
Impact Assessment	No impacts have been identified beyond the scoping stage in relation to Hydrogeology and Hydrology.

1 INTRODUCTION

1.1 Instructions

On the instructions of Waterman Structures Limited, on behalf of Lifecare Residencies Limited (the 'Client'), RSK Environment Limited (RSK) have produced a Hydrogeology and Hydrology Assessment for a proposed development at Gondar Gardens, West Hampstead, NW6 1QF, located within the Fortune Green Ward of the London Borough of Camden.

This assessment has been undertaken to provide information for inclusion in a Basement Impact Assessment (BIA) to be submitted to the London Borough of Camden. Waterman Structures Ltd have completed an overarching BIA summary report, (reference STR13472/BIA, dated June 2017) which should be referenced in conjunction with this report.

1.2 Background

By way of background to the current project, a desk study and intrusive site investigation have been undertaken at the site by RSK, as detailed in the report 'Gondar Gardens, West Hampstead, North West London, Geo-Environmental & Geotechnical Site Investigation Report', reference no.371487-R02 (00), dated May 2017. In addition, a Flood Risk Assessement Report (reference 371487-R01 (02), dated May 2017), has been completed for the proposed scheme. The current assessment draws on the results of these reports. For full details reference should be made to the original report, which are appended in the aforementioned overarching BIA report by Watermans Structures Ltd.

In addition, a site investigation was previously undertaken at the site by RSK, when the site was under different ownership and for a different proposed scheme, report reference 23283-1 (00), dated December 2009. This report was made available to RSK for review as part of this study.

A letter report was also produced by RSK, 'Summary of Hydrogeology Letter Report', reference 25113-01L, dated April 2015, again for the previous proposed scheme. This report was also made available to RSK for review as part of this study.

Together these reports provide comprehensive site specific information and are compliant with the data requirements as set out in Appendix G of 'Camden Geological, Hydrogeological and Hydrological Study' produced for Camden by ARUP in November 2010. The conditions at the site have not changed since these reports were commissioned and, therefore, the information within these reports is wholly relevant to the proposed scheme described herein.

1.3 Standards and Limitations

This report is based on information available at the time of writing. This report should be considered in the light of any changes in legislation, statutory requirement or industry practices that may have occurred subsequent to the date of issue.

The opinions and recommendations expressed in this report are based on the ground conditions encountered during the previous site work, the results of field and laboratory testing and interpretation between exploratory holes.

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

2 SITE DETAILS

2.1 Site 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 80m 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 site is marked by an approximately 17-22° slope, which reduces the level from 79 m AOD to 74.5 m AOD, down to rear gardens of residential terraced houses. Visual inspection of the existing slopes was limited at the time of the site walkover due to the heavy vegetation. However, based on the inspection possible no obvious signs of instability were noted.

The southern boundary is marked by an approximately 17-18° 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.

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.

The site lies within a natural hill slope setting, which descends in a general south-easterly direction. Original ground levels in the proximity of the site are anticipated to be approximately 80 m AOD to the northwest and 72 m AOD to the southeast. The site appears to have been historically cut to allow for the construction of the buried

reservoir, with the excavated material used to construct the existing eastern and southern flank slopes, considerably raising the natural ground levels in these parts. The placement of the capping material over the reservoir has resulted in a slightly raised ground level relative to the land to western and northern boundaries.

There are no surface water features within 250 m of the site. The only water feature within 0.5 km of the site is a small unnamed pond located 464 m to the northwest, uphill of the site.

The only buildings adjoining the site boundary are a residential mansion block (Chase Mansions) at the far western end of the northern boundary and another residential mansion block (South Mansions) at the far western end of the southern boundary, although the northern elevation wall to this site is set slightly back from the site boundary by a few metres. No other buildings directly adjoin the site's boundaries.

A search of publicly available planning records (dating back to 1927) on Camden's planning website revealed records of granted permissions for basement/lower ground floor development/extension or other subterranean development (e.g. swimming pool accommodation space) at twenty-four properties in the site area, as indicated on **Figure 3**.

It is noted that many other buildings along these roads appear to have basement/subterranean structures, although these do not appear in the planning history.

2.2 Ground/Groundwater Conditions

2.2.1 British Geological Survey Data

The published 1:50,000 scale geological map (Sheet No. 256 'North London') and 1:10,560 scale geological map (TQ28NE) of the area indicate that the immediate site area is underlain by the London Clay Formation (**Figure 4**).

The London Clay Formation is divided by the British Geological Survey (BGS) into five informal units. The lowest four, denoted A to D, are not mapped, whereas the top part of the formation is mapped as the Claygate Member. The site lies approximately 250 m southwest, and topographically below, a dissected outlier comprising the Claygate Member and the overlying Bagshot Formation (**Figure 4**). It is therefore considered that the site area likely lies within Unit D of the London Clay Formation.

No superficial deposits are shown in the site area, but the 1:50,000 scale geological map indicates that the site lies within an area of 'Head Propensity' ('Head' is a slope related solifluction deposit), which is based on the geotechnical properties of the London Clay.

2.2.2 Site Specific Intrusive Investigation Data

2.2.2.1 RSK Investigations

Two intrusive site investigations have been completed by RSK at the site.

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 summary of the pertinent information regarding ground conditions is below.

This RSK investigation comprised the drilling of seven window sample boreholes to a depth of 4.0 m and a single cable percussion borehole advanced to a depth 20 m bgl. The boreholes 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 m bgl. 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 m bgl. 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 appeared to be desiccated to depths of up to 3.0 m bgl.

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

A further intrusive site investigation was undertaken at the site by RSK in March 2017, details of which are provided within RSK report no.371487-02 (0), dated May 2017. Two cable percussive boreholes were advanced to depths of 50.00 m bgl and a further cable percussion borehole advanced to depth of 15.00 m bgl. Six drive-in sampler boreholes were advanced to depths of depths of up to 7.00 m bgl across the site.

The RSK exploratory holes confirmed the ground conditions as described by the original RSK investigation and encountered made ground across the site, ranging from 3.20 m bgl to 10.50 m bgl (76.70 m AOD to 69.54 m AOD). Outside of the footprint of the reservoir the made ground generally comprised brown clay (reworked London Clay). Within the footprint of the reservoir window samples were terminated at shallow depths upon encountering the roof structure. The made ground here generally comprised reworked London Clay, but with occasional layers of brick rubble. In one location to the north of the reservoir structure, the made ground was found to comprise predominantly brick rubble with occasional layers of very soft clay sandy gravelly silt and sandy clay and extended to a depth of 10.50 m bgl (69.54 m AOD). This increased thickness of made ground in this area is believed to be related to the possible presence of a partially built second reservoir structure close to the northern boundary of the site, with BH3 located in a position between the northern retaining wall of the known reservoir and to the south of wall of the possible second reservoir.

Despite lying in an area of ‘Head propensity’, no deposits were encountered that could unambiguously be described as ‘Head’ deposits.

The underlying 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 m bgl (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 in the eastern part of

the site 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 m bgl (29.84 m AOD).

Fine to medium gravel sized selenite crystals were noted to depths of between 13.00 m bgl (66.84 m AOD) and 19.50mbgl (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 m bgl (72.84 m AOD) in BH2.

Plasticity classification testing indicates that the clays are of high to very high plasticity, typical of the London Clay.

The locations of the RSK boreholes are shown on **Figure 2** and **2a**.

2.2.2.2 Hydrological/Hydrogeological Conditions Determined by the Site Investigations

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 Section 4 for full information. However, a summary of the hydrogeological and hydrological conditions determined from the aforementioned site investigations is provided below.

The site investigations were 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.

During the original RSK investigation a single groundwater seepage was encountered at a 13.00 m bgl.

Observations made during RSKs recent site works and subsequent groundwater monitoring indicates that water is present at the site in the following settings:

- Perched water was locally encountered during the site works within BH3 at a depth of 4.30m bgl (75.84 m AOD) and may represent a perched body of water behind the existing reservoir wall and between a secondary/additional reservoir buttress.
- Minor seepages were encountered within WS5 and WS6, in the Made Ground at depths of between 3.25 m bgl (76.75 m AOD) and 3.80 m bgl (76.00 m AOD). On completion of drilling these were at 2.60 m bgl (77.30 m AOD) and 6.02 m bgl (73.78 m AOD), respectively.
- Groundwater was encountered at depth in the London Clay in BH1 at 29.50 m bgl (50.40m 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.
- Groundwater monitoring undertaken within BH1 and BH2 in April and May 2017 indicate a standing water level of between 6.62 m bgl (73.22 m AOD) and 7.37 m bgl (72.53 m AOD). This suggest the London Clay is saturated to an elevation of approximately 73.2 m AOD).

3 PROPOSED DEVELOPMENT

The proposed development will comprise the construction of six apartment blocks, consisting of 4 storeys above ground plus 2 levels of basement. The second level of part basement will include the excavation of a further 1.4 m of soil over the eastern portion, below the existing reservoir floor slab level.

The existing reservoir retaining walls will be retained on three sides, (north, west and south), and partly incorporated into the scheme, with the basement and lower basement boxes being constructed within the footprint of the existing reservoir, albeit with the lower (2nd) part basement level being excavated a further 1.4 m below the existing slab level (~71.6 m AOD). The first basement level will occupy the entire internal area of the reservoir, and house a fitness centre, plant room, communal entertainment rooms across the western half, and residential apartments across the central and eastern extent. The lower basement level will only occupy the eastern half of the existing reservoir footprint, and house residential apartments that will open out to landscaped gardens across the easternmost part of the site. Because of the limited area occupied by the lower basement level, there will be a significant up-filling across the western extent of the reservoir footprint to raise the existing level to the formation level of the first basement (~75 m AOD). The existing site surface level will be lowered to be consistent with street level to the west such that the new ground floor is level with the existing street level to the west at ~77.5 to 78 m AOD.

The six blocks will appear separate from ground level up, but will be joined by a common basement and lower basement level.

The development will include areas of soft landscaping, including construction of a substantial reinforced earth slope along the northern boundary in the eastern part of the site, and significant cut slopes to the eastern and south-eastern boundaries. These cut slopes will extend to lower (2nd) basement level. There will be an open outdoor communal landscaped area to the east of the buildings at this level. The proposed slopes will include toe and crest drainage to control surface and groundwater flow through the slopes.

The new structures will be supported on piled foundations. Column loads for the proposed development range from 1500 kN to 3500 kN. Final pile loads are anticipated to be in the region of 1200 kN to 1800 kN.

The development will include the general reduction of surface level across the site from the existing level of approximately 79.5 m AOD to 80.0 m AOD, to level with the adjacent road on Gondar Gardens at approximately 78 m AOD. The lowering of the second basement level will see the level drop from 72.4 m AOD to 71.0 m AOD across the eastern extent of the development.

Proposed engineering plans and sections for the development are included in the aforementioned BIA report by Waterman Group Ltd.

The upper (1st) basement level will be constructed within the confines of the existing retaining walls to reservoirs and it is proposed to prop these in the temporary condition and construct a concrete liner wall in board to provide support in the permanent condition.

Three retained courtyard areas are also proposed where the existing brick retaining wall to the former reservoir will be left exposed. Ground anchors will be installed to provide support to the former reservoir wall in the permanent condition in these locations. The inclusion of reinforced concrete slabs at basement level will form additional rigid propping arrangement in the permanent condition to the existing retaining wall.

In order to facilitate construction of the lower (2nd) basement level, which will include the removal of significant volumes soil, it is proposed to construct new retaining walls along the northern, western and southern elevations of the part basement. It may be possible to construct the retaining walls in an open cut, particularly on the western elevation, but given the presence of groundwater above the basement it is considered likely that some form of embedded wall will be required unless reasonably shallow cut slopes (i.e. 1v:2h) can be accommodated due to the presence of groundwater.

4 STAGE 1 - SCREENING

This section of the report provides information for the purpose of screening in accordance with CPG4 and addresses all questions raised within the relevant sections of that document. The Table summarising the screening flowcharts for Hydrogeology and Hydrology Screening are shown as **Tables 2** and **3**. In accordance with procedure, where a 'yes' or 'unknown' response is returned, the potential issue is taken to the scoping stage in **Section 5**.

Table 2 : Subterranean (ground water) screening

Question		Answer	Evidence/Comment
1	Is the site located directly above an aquifer?	No	The site is underlain by made ground, generally comprising reworked London Clay, extending to depths 3.20 m bgl to 10.50 m bgl (76.70 m AOD to 69.54 m AOD), which is underlain by London Clay, which extended to the full depth investigated of 50.00 mbgl (29.84 m AOD). The latter is classified as a non-aquifer (non-productive stratum). p.19 of the ARUP guidance document (ref: 213923) which supports CPG4, ARUP states: *"Although groundwater is contained within the microscopic pores of the clayey strata of the London Clay, it permeates so slowly, due to the narrow pores, that in practice it is generally considered a barrier to groundwater".* Therefore, the site does not lie above an aquifer.
1a	Will the proposed basement extend beneath the water table surface?	No	The proposed basement level will extend to a maximum elevation of approximately ~71 m AOD. The investigation and monitoring results appear to indicate that the London Clay is saturated to an elevation of approximately 73.2 m AOD. Porosity within this material is so low as to not maintain significant volumes of water and to be 'unproductive'. In this case water recorded within the London Clay records pore water pressure and the concept of a 'groundwater table' does not really apply. Toe drainage will be incorporated into the proposed slope cuttings in the eastern part of the site, which may cause localised draw down of the saturated level within the London Clay. This is considered unlikely to have a significant impact on the saturated zone/level in the wider area, or to significantly affect groundwater flows within London Clay.
2	Is the site within 100 m of a watercourse, well (used/disused) or potential spring line?	No	The site is not located within 100 m of a known watercourse, well or potential spring line, such as typically present at the Claygate Member/London Clay boundary.

Question		Answer	Evidence/Comment
3	Is the site within the catchment of the pond chains on Hampstead Heath?	No	The site lies 1.5 km southwest of the nearest Hampstead Heath drainage catchment and will therefore not impact any catchments.
4	Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	Yes	See Section 4 (Scoping)
5	As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	No	Due to the poor drainage characteristics of the underlying London Clay discharge via soakaways and/or SUDS is not feasible, and recourse is given to using a combination of green roof technologies to reduce the amount of impermeable area post development, and to the attenuation of the surface runoff water in cellular storage tanks, and discharging into existing Thames Water foul drainage network, at rates agreed with Thames Water.
6	Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond (not just the pond chains on Hampstead Heath) or spring line?	No	There are no surface water features within 2 km of the site.

Table 3: Surface flow and flooding screening

Question		Answer	Evidence/Comment
1	Is the site within the catchment of the pond chains on Hampstead Heath?	No	The site lies 1.5 km southwest of the nearest Hampstead Heath drainage catchment and will therefore not impact any catchments.
2	As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run off) be materially changed from the existing route?	No	The ground conditions at the site (thick made ground and impermeable London Clay) are not suitable for the use of SUDS/soakaways and the developer is in discussions with Thames Water to maintain surface water discharge to the existing sewers. The site is currently occupied by a covered reservoir over approximately 40% of the surface area, and can be classed as 'greenfield' across the remainder.

Question		Answer	Evidence/Comment
			As such the ratio of impermeable to permeable is therefore approximately 40:60 in the current case. Whilst the proposed development is envisaged to result in a small net change in the proportion of hard cover across the site, the vast majority of the proposed development (~95%) lies within the footprint of the former covered reservoir. The proposed scheme includes green roofs technologies to reduce the amount of impermeable area post development. Surface run-off from the hard covered portion of the site will be collected in cellular storage and discharged into the Thames Water foul sewer at agreed rates, with the remaining ~50-60% of the site remaining permeable 'greenfield'. The site is also not underlain by an aquifer, so the proposals will not affect any changes to groundwater levels of flows.
3	Will the proposed basement development result in a change in the proportion of hard surfaced/paved external areas?	Yes	See Section 4 (Scoping)
4	Will the proposed basement result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	No	As per point 2 above.
5	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No	As per point 2 above.
6	Is the site in an area known to be at risk from surface water flooding, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?	No	Reference to the EA floodplain maps, North London Strategic Flood Assessment and The London Borough of Camden flood risk management strategy shows that the site does not lie directly within any known flood zones. However, the map shows minor sections surrounding the site that are at risk of flooding from fluival sources. These flow paths, rather than ponding water, follow that of the fluvial flooding risk. As such, the overall risk of pluvial flooding to the site can be considered **Low,** as discussed in the aforementioned FRA report (ref 371487-R1(02)-FRA, dated May 2007) BGS information indicates that the site does not lie within 50 m of a

Question		Answer	Evidence/Comment
			groundwater flooding susceptibility area. The highest susceptibility to groundwater flooding, based on the underlying geological conditions, is indicated to be 'not prone'.

5 STAGE 2 – SCOPING

As defined in CPG4, the scoping stage is used to identify the potential impacts of the proposed scheme for each of the matters of concern identified in the previous screening stage (i.e. those questions answered with a “yes” or “unknown” response). The section below presents statements that define further the matters of concern identified at the screening stage, with respect to Hydrogeology and Hydrology only. The data summarised in **Section 2** and **Section 3** has been used to develop a conceptual ground model to carry out the scoping stage.

5.1 Subterranean (Ground water) Scoping

As part of the Basement Impact Assessment report the Hydrogeology beneath the site will need to be considered.

The published geological map of the area identifies the geology of the site as London Clay Formation, with no overlying superficial Drift deposits. The lithology of the London Clay Formation in the site vicinity comprises stiff grey silty clay, and the stratum extends to a depth in excess of 50 m below ground level. The London Clay Formation is underlain by the Lambeth Group, Thanet Sand Formation and White Chalk Sub-group, the latter at a depth of approximately 100 m below ground level.

The London Clay Formation is classified by the Environment Agency as a Non-aquifer (non-productive strata), reflecting its inability to store and transmit significant quantities of groundwater. Values for the coefficient of permeability for the London Clay Formation typically range from 3 x 10-9 m/s for clay with sand partings and silty clay to 3 x 10-11 m/s for intact clay, indicating the very low permeability of these materials.

At depth, the Thanet Sand Formation and White Chalk Sub-group are designated as Secondary ‘A’ and Principal Aquifers, respectively, and form a regional resource for public supply. However, given the significant thickness of the overlying London Clay Formation, the proposals will have no impact on the deeper groundwater resources.

The results of the ground investigation indicate that the site is underlain by a variable thickness of made ground ranging from 0.5 m to up to 10.60 m and comprises predominantly cohesive silty sandy clay. The variable thickness of made ground reflects the fill materials placed during the construction of the former covered reservoir. The made ground is directly underlain by the London Clay Formation comprising firm, brown mottled grey silty clay, becoming stiff to very stiff grey clay with depth.

Perched groundwater was locally encountered during the site works within BH3 at a depth of 4.30 mbgl (75.84 m AOD), and may represent a perched body of water behind the northern retaining wall of the reservoir and between a secondary/additional reservoir buttress. Minor seepages were also encountered within WS5 and WS6, in Made Ground at depths of between 3.25 m bgl (76.75 m AOD) and 3.80 m bgl (76.00 m AOD), with these rising on completion of drilling to 2.60 m bgl (77.30 m AOD) and 6.02 m bgl (73.78 m AOD) respectively.

Groundwater was encountered at depth in the London Clay in BH1 at 29.50 m bgl (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.

Groundwater monitoring undertaken within BH1 and BH2 in April and May 2017 suggest the London Clay is saturated to an elevation of approximately 73.2 m AOD

The investigation and monitoring results therefore appear to indicate that the London Clay is saturated to an elevation of approximately 73.2 m AOD.

In terms of surface watercourses, there are no known ponds, streams or drainage ditches on or adjacent to the site.

5.1.1 QUESTION: Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?

POTENTIAL IMPACT: In areas of non-aquifers (i.e. London Clay), this may result in changes in infiltration and the degree of ground saturation, which in turn may affect stability.

Whilst the proposed development is envisaged to result in a small net change in the proportion of hard cover across the site, the vast majority of the proposed development (~95%) lies within the footprint of the former covered reservoir. The site is also not underlain by an aquifer, so the proposals will not affect any changes to groundwater levels or flows. Further, the proposed basement lies within the former reservoir so there will be no potential changes in the degree of moisture content of the underlying ground, which in turn could affect stability.

The site is currently occupied by a covered reservoir over approximately 40% of the surface area, and can be classed as ‘greenfield’ across the remainder (60%). As such the ratio of impermeable to permeable is therefore approximately 40:60 in the current case. Whilst the proposed development is envisaged to result in a small net change in the proportion of hard cover across the site, the vast majority of the proposed development (~95%) lies within the footprint of the former covered reservoir. Surface run-off from the hard covered portion of the site will be collected in cellular storage and discharged into the Thames Water foul sewer at agreed rates, with the remaining ~50-60% of the site remaining permeable ‘greenfield’. Therefore there should not be a significant change in the amount of rainfall infiltration in the ‘greenfield’ landscaped areas.

5.2 Surface Flow and Flooding Scoping

5.2.1 QUESTION: Will the proposed basement development result in a change in the proportion of hard surfaced/paved external areas?

POTENTIAL IMPACT: A change in the proportion of hard surface or paved areas of a property will affect the way in which rainfall and surface water are transmitted away from a property.

As noted above, the proposed development is envisaged to result in a small net change in the proportion of hard cover across the site, the vast majority of the proposed

development (~95%) lies within the footprint of the former covered reservoir. The site is currently occupied by a covered reservoir over approximately 40% of the surface area, and can be classed as ‘greenfield’ across the remainder (60%). As such the ratio of impermeable to permeable is therefore approximately 40:60 in the current case. Whilst the proposed development is envisaged to result in a small net change in the proportion of hard cover across the site, the vast majority of the proposed development (~95%) lies within the footprint of the former covered reservoir. Surface run-off from the hard covered portion of the site will be collected in cellular storage and discharged into the Thames Water foul sewer at agreed rates, with the remaining ~50-60% of the site remaining permeable ‘greenfield’. Therefore, there should not be a significant change in the amount of rainfall infiltration in the ‘greenfield’ landscaped areas.

6 STAGE 3 – SITE INVESTIGATION AND STUDY

As previously noted, a full desk study, and two intrusive site investigations and monitoring programmes was undertaken at the site by RSK between December 2009 and March 2017, as detailed in the report 'Gondar Gardens Geo-environmental and Geotechnical Assessment, (ref 23283-1 (00), dated December 2009), and Gondar Gardens Geo-Environmental/Geotechnical Site Investigation Report (ref 371487-02(01), dated May 2017). The investigations are compliant with the data requirements as set out in Appendix G of 'Camden Geological, Hydrogeological and Hydrological Study' produced for Camden by ARUP in November 2010.

The results of reports have been utilised to inform the scoping stage of the BIA and the current assessment draws on the results of that report. For full details, reference should be made to the original report.

FRA report

7 STAGE 4 - IMPACT ASSESSMENT

This stage is concerned with evaluating the direct and indirect implications of the proposed basement development. It involved describing, quantifying and aggregating the effects of the development on those attributes or features which have been identified in the scoping stage as being potentially affected.

No impacts relating to Hydrogeology or Hydrology have been identified beyond the scoping stage, as such no further consideration is required.

FIGURES

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

LEGEND

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

Rev.	Date	Amendment	Drawn	Chkd.	Appd.

RSK

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Client

LIFE CARE RESIDENCES LIMITED

Project Title

GONDOR GARDENS,
CAMDEN,
LONDON

Drawing Title

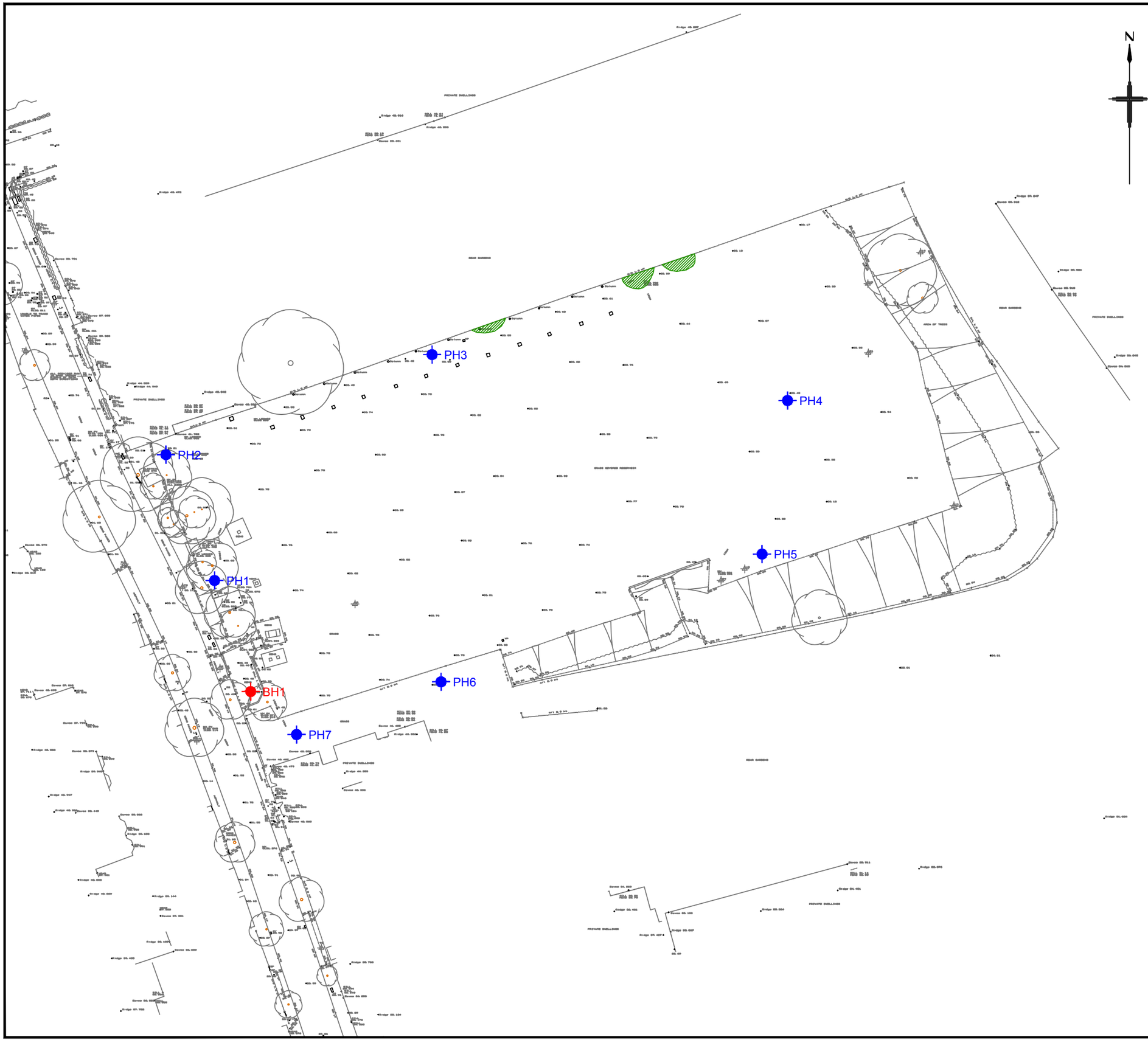
EXPLORATORY HOLE LOCATION PLAN

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



LEGEND

- Borehole Location
- Probehole Location
- Japanese Knotweed Identified

Rev.	Date	Amendment	Drawn	Chkd.	Appd.
P1	23.11.09	FIRST ISSUE	MDW	NT	NT

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Client

LINDEN WATES LIMITED

Project Title

GONDAR GARDENS, LONDON

Drawing Title

SITE PLAN

Drawn	Date	Checked	Date	Approved	Date
MDW	23.11.09	NT	23.11.09	NT	23.11.09

Scale	Orig Size	Dimensions
1:750	A3	m

Project No.	Drawing File
23283 (L01)	23283 (L01).dwg

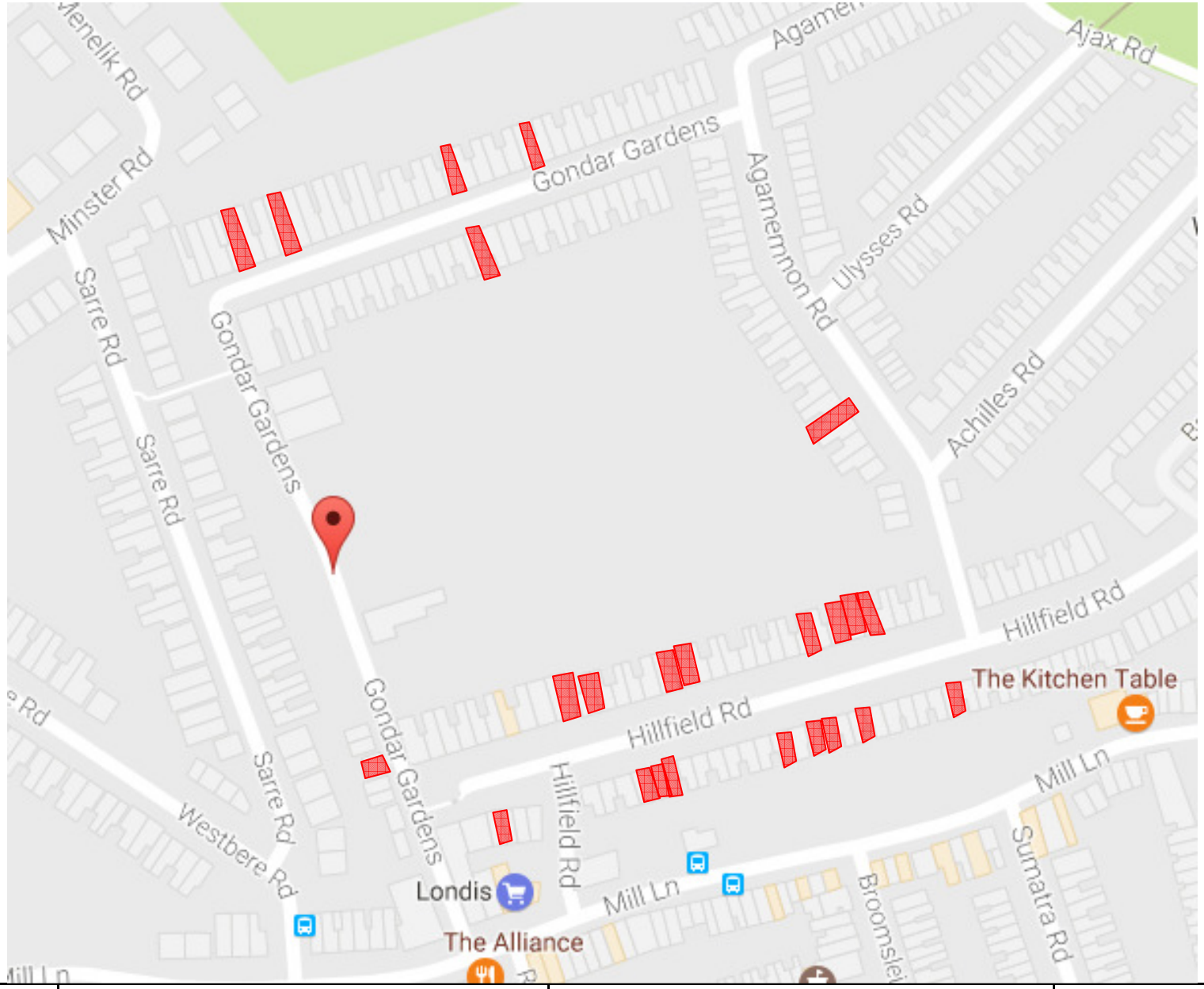
Drawing No.	Rev.
FIGURE 2a	P1

Scale 1 : 750

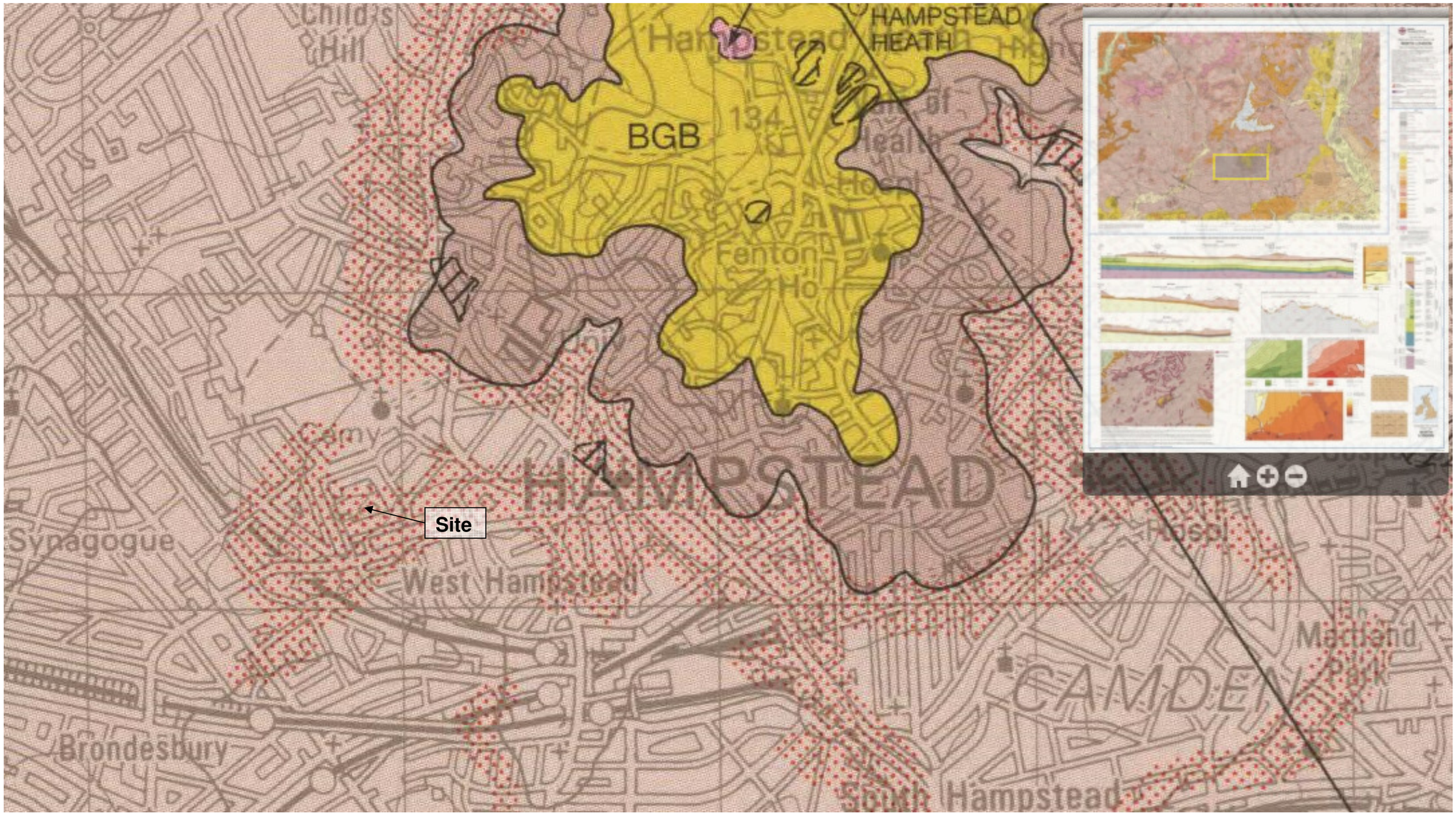
0 10 20 30 40 50m

Buildings with historical planning approvals for alterations to existing basements or new basements /subterranean structures

NB: many more buildings along all local roads have basements but that do not have planning history records



RSK	**SITE AREA PLAN – Buildings with Basement Planning History**	**Client:**	Lifecare Residencies Ltd	**Figure No:**	3
		Site:	Gondar Gardens	**Job No:**	371487
		Scale:	NTS	**Source:**	Google Mapping



RSK	**GEOLOGICAL MAP EXTRACT**	**Client:**	Lifecare Residencies Limited	**Figure No:**	4
		Site:	Gondar Gardens	**Job No:**	371487-03 (00)
		Scale:	NTS	**Source:**	BGS 1:10560 Sheet TQ28NE

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.