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DESK STUDY, GROUND INVESTIGATION & BASEMENT IMPACT ASSESSMENT REPORT

ELLERAY HALL & NORTH LANE DEPOT/EAST CAR PARK
TEDDINGTON, TW11

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NON TECHNICAL EXECUTIVE SUMMARY

Richmond and Wandsworth Council ("The Client") has commissioned Jomas Associates Ltd ('Jomas'), to prepare a Desk Study, Ground Investigation and Basement Impact Assessment for a site referred to as Elleray Hall and North Lane Depot/East Car Park.

The aim of this report is to assess whether the ground conditions within the local area represent an impediment to the proposed development.

It should be noted that the table below is an executive summary of the findings of this report and is for briefing purposes only. Reference should be made to the main report for detailed information and analysis.

Desk Study	
Current Site Use	Site is comprised of two separate but neighbouring plots; northern site is currently a car park and disused former works and the southern plot is occupied by a community hall.
Proposed Site Use	Demolition of Elleray Hall and the construction of a two-storey block of flats with soft landscaping, and the construction of a community centre on the currently vacant North Lane Depot/East Car Park plots. Both developments are understood to include the lowering of existing ground levels, rather than the formation of full basements.
Site History	A review of the earliest available (1865) historical maps indicates that the northern plot was occupied by residential/agricultural structures until the late 1800s when only a single structure is shown along the western boundary (use unclear), and with the very north of the site comprising parts of neighbouring gardens. Throughout the first half of the 20th century there are various reconfigurations of the site with commercial style buildings shown along the eastern and southern boundaries, with no usage indicated. By 1963 the east of the site is shown as vacant and by 1988 the east is indicated to be a car park. Structures remain along the western boundary up to the most recent map edition, however the area is shown vacant on an aerial photograph from 2011, indicating demolition between 2008 and 2011. The southern plot was occupied by residential properties and gardens from 1865 until at least 1898; by 1915 the east of the site is occupied by a large "hall" building with a smaller structure identified in the south-west of the site. By 1959 the hall structure is identified as "works", and remains in this use until the 1988 map edition identifies a "hall" once again with an extension to the west of the structure. By 1991 the structure is identified as a "day centre" which remains up to the most recent map edition. The surrounding area has been predominantly residential with occasional industrial features. Industrial features of note include various works, a warehouse, garage and an unspecified tank, all located within 250m of the site.
Site Setting	The British Geological Survey indicates that the site is directly underlain by superficial deposits of the Kempton Park Gravel Member. These superficial deposits are underlain by solid deposits of the London Clay Formation. No artificial deposits are reported within the site.

	Borehole records from approximately 160m northeast of the site indicated sand and gravels extending to approximately 4mbgl, underlain by clay. The superficial deposits underlying the site are identified as a Principal Aquifer with the underlying solid deposits identified as unproductive. A review of the Enviro+Geoinsight Report indicates that there are no source protection zones within 500m of the site and there are no groundwater, surface water or potable water abstractions reported within 1km of the site. No detailed river entries or surface water features reported within 250m of the site and there are no Environment Agency Zone 2 or 3 floodplains reported within 50m of the site.
Potential Sources	• Potential for contaminated ground associated with previous site use – on site (S1) o depot, o works, o car park, o unspecified industrial/commercial • Potential for Made Ground associated with previous development operations – on site (S2) • Potential for asbestos impacted soils from demolition of previous structures – on site (S3) • Previous industrial use – off site (S4) o Works (40m NW, 100m, 180m, 230m W) o Garage (60m NE) • Industrial unit with tanks (240m W)
Potential Receptors	• Construction workers (R1) • Maintenance workers (R2) • Neighbouring site users (R3) • Future site users (R4) • Building foundations and on site buried services (water mains, electricity and sewer) (R5) • Controlled waters - Principal Aquifer (R6)
Preliminary Risk Assessment	The risk estimation matrix indicates a moderate to low risk. It is recommended that an intrusive investigation is undertaken to clarify potential risks to the identified receptors, and assess the extent of Made Ground soils present at the site. Due to the potential for hydrocarbon contamination to be present beneath the site from the identified historical uses as “works” (southern site) and reported depot usage on the northern site, it is recommended that a ground investigation includes provision of gas and groundwater monitoring wells to allow for gas monitoring and groundwater sampling should viable sources be reported during the ground investigation. If deep Made Ground containing significant organic inclusions is encountered, gas monitoring should be undertaken in accordance with CIRIA C655.

Potential Geological Hazards	The Groundsure data identifies only very low to negligible risks – for full details see Section 3. A "moderate" risk from shrink-swell soils has been identified in close proximity to the site, and as such, these soils may encroach into site. Existing hardstanding and foundations will need to be removed and grubbed out ahead of the development. This may require the use of hydraulic breaking. The clearance of the site, including removal of foundations and services is likely to increase the depth of Made Ground on the site. Foundations should not be formed within Made Ground or organic rich material (e.g. topsoil) due to the unacceptable risk of total and differential settlement. Foundations must be designed so as not to load nor undermine adjacent boundary walls and buildings. The presence of Made Ground derived from demolition material may be a source of elevated sulphate, associated with plaster from the previous structures. If such levels are noted, sulphate resistant concrete may be required. The BGS notes disseminated pyrite within the London Clay Formation and as such may be a source of elevated sulphate results. If such levels are noted, sulphate resistant concrete may be required. A geotechnical investigation is recommended to inform foundation design.

Basement Impact Assessment (Screening and Scoping Stage)	
Subterranean (Groundwater) Flow	The investigation should confirm if the site is directly above the Secondary A Aquifer. Groundwater levels should be determined so they can be compared to the relative depths of the basement.
Land Stability	Site and surrounding areas are generally flat and level. Following the investigation an assessment relating to groundwater management and excavation stability should be undertaken.
Surface Flow and Flooding	No specific investigation required.

Ground Investigation	
Ground Conditions	The results of the ground investigation revealed a ground profile comprising Made Ground up to 1.7mbgl overlying both cohesive and granular deposits of the Kempton Park Gravel Member to a maximum depth of 6.60mbgl, overlying London Clay Formation to at least the depth of the deepest borehole at 20.0mbgl. The base of this stratum was not proven.

Ground Investigation	
	During the investigation, groundwater was reported within boreholes BH1 and BH2 at 10.00mbgl and 19.30mbgl respectively. During return monitoring groundwater was reported at depths of between 4.00-4.30mbgl. It is considered that these results represent a shallow ground water table within the superficial Kempton Park Gravel deposits.
Environmental Considerations	<u>Northern Plot</u> Following generic risk assessments, elevated concentrations of naphthalene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(ah)anthracene and C10-C12 aromatic petroleum hydrocarbons were detected in soils in excess of generic assessment criteria for the protection of human health within a "commercial" end-use scenario. No asbestos fibres were detected in the samples analysed in the laboratory. The site proposal indicates that large areas of site will remain covered by a combination of the proposed building footprints and hard surfacing. Where this is the case, no formal remedial measures are considered necessary in terms of human health (beyond the removal of the material described above), as the building and hard surfacing are expected to provide a barrier to potential receptors. In areas of soft landscaping, a cover layer of 450mm of clean imported sub/topsoil should be placed above a geotextile membrane. Exceedances were of generic assessment criteria for potentially volatile compounds (naphthalene and the aromatic hydrocarbon fraction >C10-C12) were detected within made ground soils in WS5, and concentrations of volatile contaminants including BTEX compounds were detected above laboratory method detection limits in the made ground in WS5 and WS3. These concentrations of volatile contaminants were only detected in a sub-stratum of made ground comprising Light to dark brown - dark grey slightly clayey slightly silty very sandy gravel/gravelly sand with gravel consists of flint, brick, concrete, ceramic and asphalt, within which hydrocarbon odours were commonly noted. Pockets of a black tar substance were noted within this substratum in WS5. Given the relatively thin nature of the stratum, and the lack of visual / olfactory evidence of hydrocarbon or volatile contamination in soils underlying the stratum, as well as the low photo-ionisation detector readings recorded in monitoring well headspaces during monitoring events, it is considered unlikely that a significant risk to end users of the development exists via vapour inhalation pathways. A groundwater sample obtained from BH1 in the northern plot did not report any contaminants in excess of generic assessment criteria, and therefore the contaminants identified on site are not considered to be impacting on the groundwater beneath the site. Following four gas monitoring visits, concentrations of carbon dioxide are raised at the site, with corresponding depleted oxygen. Calculating the Gas Screening Value using worst case results indicates Characteristic Situation 1. However, due to the elevated concentrations of carbon dioxide measured in excess of 5%, consideration should be given to upgrading the sites to CS2. Given that no significant sources of ground gases were identified during the desk study, and no significant sources of potential ground gases were identified during the intrusive works it is considered that the site should not be classified as CS2, and a CS1 designation is appropriate (for which no gas protection measures are

Ground Investigation	
	required). Barrier pipe is likely to be required for potable water supply pipes. The requirements should be confirmed with the relevant utility provider. Southern Plot Following generic risk assessments, elevated concentrations of arsenic, lead, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(ah)anthracene and C21-C352 grouped petroleum hydrocarbons were detected in soils in excess of generic assessment criteria for the protection of human health within a "residential with plant uptake" end-use scenario on the southern plot No asbestos fibres were detected in the samples analysed in the laboratory. The site proposals indicate that large areas of the site will be covered by a combination of the proposed building footprint and hard surfacing. Where this is the case, no formal remedial measures are considered necessary in terms of human health, as the building and hard surfacing are expected to provide a barrier to potential receptors. In areas of soft landscaping, a cover layer of 450mm of clean imported sub/topsoil should be placed above a geotextile membrane. It is possible that further soil sampling and assessment may allow for zoning and delineation of areas requiring clean cover in soft landscaped areas. Groundwater analysis of a sample obtained from the southern plot did not report any contaminants contained within the testing suite above the limit of detection. Risks to controlled waters are considered to be low. Following four gas monitoring visits, concentrations of carbon dioxide are raised at the site, with corresponding depleted oxygen. Calculating the Gas Screening Value using worst case results indicates Characteristic Situation 1. However, due to the elevated concentrations of carbon dioxide measured in excess of 5%, consideration should be given to upgrading the sites to CS2. Given that no significant sources of ground gases were identified during the desk study, and no significant sources of potential ground gases were identified during the intrusive works it is considered that the site should not be classified as CS2, and a CS1 designation is appropriate (for which no gas protection measures are required).
Geotechnical Considerations	Based on the findings of this investigation, it is considered that reinforced strip footings of up to 1m breadth may be formed at a minimum depth of 0.75mbgl within the underlying Kempton Park Gravel Member for an allowable bearing capacity of 120kPa. This depth, however, does not take into account the depth of Made Ground (encountered up to 1.7m bgl) or the distance to and species of any previous, existing and proposed trees, and foundations may need to be deepened further accordingly, in accordance with NHBC requirements. It is recommended that a layer of light mesh reinforcement is added to the base of all foundations to mitigate the potential for excessive differential settlement, given the variable properties (cohesive/granular) encountered within the Kempton Park Gravel Member. Alternatively, piled foundations could be considered and preliminary pile carrying capacities are provided in Table 14.2.

Ground Investigation	
	Suspended floor slabs are recommended due to the presence of shrinkable soils and due to the depths of Made Ground encountered. Groundwater was encountered at depths ranging between 4.00m and 4.30mbgl during return monitoring. Any groundwater encountered during construction works should be addressed by conventional pumping from a sump. Excavations during the intrusive works, although open for a relatively short period of time remained reasonably stable. However, it is recommended that the stability of all excavations should be assessed during construction. The sides of any excavations into which personnel are required to enter should be assessed and battered back to a safe angle. Based on the results of chemical testing, the required concrete class for the site is DS-1 assuming an Aggressive Chemical Environment for Concrete classification of AC-1 in accordance with the procedures outlined in BRE Special Digest 1. CBR values of <2.5% and 5% are recommended for use in preliminary design where the formation is within Made Ground and the superficial deposits respectively.

Basement Impact Assessment	
Impact Assessment	The overall assessment of the site is that the creation of the proposed basements/lowered ground floor levels will not adversely impact the site or its immediate environs, providing measures are taken to protect surrounding land and properties during construction. Unavoidable lateral ground movements associated with the basement excavations must be controlled during temporary and permanent works so as not to impact adversely on the stability of the surrounding ground and any associated services. During the construction phase careful and regular monitoring will need to be undertaken to ensure that the property above, is not adversely affected. This may mean that the property needs to be suitably propped and supported. From the studies that have been undertaken so far it is concluded that the construction will not present a problem for groundwater. It is concluded that this site can be successfully developed without causing any problems to the subterranean drainage.

1 INTRODUCTION

1.1 Terms of Reference

1.1.1 Richmond & Wandsworth Council ("The Client") has commissioned Jomas Associates Ltd ('Jomas'), to prepare a Desk Study, Ground Investigation and Basement Impact Assessment at a site referred to as Elleray Hall & North Lane Depot/East Car Park, Teddington.

1.1.2 Jomas' work has been undertaken in accordance with email proposal dated 20 July 2021.

1.2 Proposed Development

1.2.1 The proposed development is to involve the demolition of Elleray Hall and the construction of a two-storey block of flats with soft landscaping to the south of Middle Lane, and the construction of a community centre on the currently vacant North Lane Depot/East Car Park plots to the north of Middle Lane.

1.2.2 Both developments are understood to include the lowering of existing ground levels, rather than the formation of full basements. Based on scaled measurement from the proposed development elevations (Figure 8 in Appendix 1), it appears this will be up to a maximum depth of approximately 1m.

1.2.3 Plans are provided as Figures 8-9.

1.2.4 For the purpose of geotechnical assessment, it is considered that the project could be classified as a Geotechnical Category (GC) 2 site in accordance with BS EN 1997 Part 1. GC 2 projects are defined as involving:

- Conventional structures.
- Quantitative investigation and analysis.
- Normal risk.
- No difficult soil and site conditions.
- No difficult loading conditions.
- Routine design and construction methods.

1.2.5 This will be reviewed at each stage of the project

1.3 Objectives

1.3.1 The objectives of Jomas' investigation were as follows:

- To present a description of the present site status, based upon the published geology, hydrogeology and hydrology of the site and surrounding area;

- To review readily available historical information (i.e., Ordnance Survey maps and database search information) for the site and surrounding areas;
- To conduct an intrusive investigation, to assess ground conditions and obtain geotechnical parameters to inform preliminary foundation design;
- To assess the potential impacts that the proposal may have on ground stability, the hydrogeology and hydrology on the site and its environs.

1.4 Scope of Works

1.4.1 The following tasks were undertaken to achieve the objectives listed above:

- A walkover survey of the site;
- A desk study, which included the review of a database search report (GeoInsight Report, attached in Appendix 2) and historical Ordnance Survey maps (attached in Appendix 3);
- An intrusive investigation to assess the underlying ground conditions;
- A basement impact assessment;
- The compilation of this report, which collects and discusses the above data, and presents an assessment of the site conditions, conclusions and recommendations.

1.5 Scope of Basement Impact Assessment

1.5.1 The site lies within the remit of the London Borough of Richmond Upon Thames. The council has published a Planning Advice Notice: "Good Practice Guide on Basement Developments" (May 2015). This gives a lot of detail on the issues relevant to basements within London Borough of Richmond Upon Thames but does not go into detail as to how these issues should be assessed.

1.5.2 Consequently, Jomas has based the methodology of the BIA on the guidance given in the London Borough of Camden document "Camden Planning Guidance Basements" (CPGB) (January 2021). This document has been used as it is generally accepted that this gives the best available guidance on the practicalities regarding how to the undertake a BIA.

1.5.3 Jomas' BIA covers most items required under CPGB, with the exception of;

- Plans and sections to show foundation details of adjacent structures – no access to adjacent properties was possible.
- Programme for enabling works, construction and restoration.
- Evidence of consultation with neighbours.

- Ground Movement Assessment (GMA), to include assessment of significant adverse impacts and Specific mitigation measures required, as well as confirmatory and reasoned statement identifying likely damage to nearby properties according to the Burland Scale.
- Construction Sequence Methodology.
- Proposals for monitoring during construction.
- Drainage assessment.

1.5.4 This Jomas BIA also takes into account the Campbell Reith pro forma BIA produced on behalf of and published by the London Borough of Camden as guidance for applicants to ensure that all of the required information is provided

1.5.5 A number of the requirements set out in the London Borough of Camden document CPGB may need to be addressed in a construction management plan, this stage is not within the scope of work that Jomas Associates have been commissioned.

1.6 Supplied Documentation

1.6.1 A number of reports previously prepared by Jomas and third parties were available at the commencement of this investigation. Table 1.1 details the documents supplied:

Table 1.1: Supplied Reports

Title	Author	Reference	Date
Desk Study / Preliminary Risk Assessment Report for Elleray Hall & North Lane Depot/East Car Park, Teddington, TW11	Jomas Associates Ltd	P3152J2114 Final	November 2020
Ground Investigation Specification For Elleray Hall & North Lane Depot / East Car Park Teddington TW11	Jomas Associates Ltd	P3152J2114 Final	November 2020
Factual Report	Concept	20/3521/-FR01	9th April 2021
Geo-environmental & Geotechnical Assessment Report for Elleray Hall & North Lane Depot/East Car Park, Teddington	Jomas Associates	P3152J2114 Final	12th May 2021

1.7 Limitations

1.7.1 Jomas Associates Ltd ('Jomas') has prepared this report for the sole use of Richmond & Wandsworth Council in accordance with the generally accepted consulting practices and for the intended purposes as stated in the agreement under which this work was completed. This report may not be relied upon by any other party without the explicit written agreement of Jomas. No other third party warranty, expressed or implied, is made as to the professional advice included in this report. This report must be used in its entirety.

1.7.2 The records search was limited to information available from public sources; this information is changing continually and frequently incomplete. Unless Jomas has actual knowledge to the contrary, information obtained from public sources or provided to Jomas by site personnel and other information sources, have been assumed to be correct. Jomas does not assume any liability for the misinterpretation of information or for items not visible, accessible or present on the subject property at the time of this study.

1.7.3 Whilst every effort has been made to ensure the accuracy of the data supplied, and any analysis derived from it, there may be conditions at the site that have not been disclosed by the investigation, and could not therefore be taken into account. As with any site, there may be differences in soil conditions between exploratory hole positions. Furthermore, it should be noted that groundwater conditions may vary due to seasonal and other effects and may at times be significantly different from those measured by the investigation. No liability can be accepted for any such variations in these conditions.

2 SITE SETTING & HISTORICAL INFORMATION

2.1 Site Information

2.1.1 The site location plan is appended to this report in Appendix 1.

Table 2.1: Site Information

Name of Site	Elleray Hall & North Lane Depot/East Car Park
Address of Site	North Lane/Elleray Road Teddington TW11
Approx. National Grid Ref.	515688 170873
Site Area (Approx.)	0.24ha
Site Occupation	Community centre, disused depot and car park
Local Authority	London Borough of Richmond upon Thames

2.2 Walkover Survey

2.2.1 A site walkover survey was undertaken by Jomas Associates on 2nd November 2020.

Table 2.2: Site Description

Area	Item	Details
On-site:	**Current Uses:**	The site comprises two irregular-shaped plots of land to the north and south of Middle Lane, Teddington. The southern plot is situated adjacent to the junction of Elleray Road and Middle Lane and is occupied by a single storey iron-clad commercial-style building identified as Elleray Hall Social Centre. The building is an operational community hall and also houses a hairdressing salon. There is a car parking area to the west of the building, and a garden area comprising lawn, flowerbeds and paving extending south. The northern plot is located adjacent to the north of Middle Lane and east of North Lane. The western section of this plot is secured with hoarding and appears to be a demolished building although there was not access inside the hoarding at the time of the walkover. The eastern section of this plot is a car parking area accessed off North Lane.
	Evidence of historic uses:	There was no evidence of historic uses of the site. Jomas has been informed by the client that the hoarded off area to the west of the northern site was formerly a depot.

Area	Item	Details
	Surfaces:	The majority of the northern plot is hard covered comprising asphalt surfacing. The hoarded section in the west of this plot appears to be a previously demolished building and overgrown and therefore hardstanding may have been removed in this area. The southern plot is a mixture of hard and soft cover. Hardcover is formed by the building footprint and car parking area comprises concrete and asphalt. The soft-landscaping is formed by the lawn extending south from the building.
	Vegetation:	There is no vegetation on the northern plot car park area except small weeds growing through cracks. Heavily overgrown vegetation in the form of small shrubs and trees (up to 3m high) was observed within the hoarded area in the west of the site – some clearance will be required ahead of intrusive works. Within the southern plot, a birch tree (approx. 7m high) was noted in the lawn to the rear of Elleray Hall along with some small shrubs and bushes around the perimeter of the garden. None of the vegetation observed was exhibiting signs of distress.
	Topography/Slope Stability:	Overall both plots are generally flat and level with the surrounding land.
	Drainage:	Both plots appear to be connected to normal drainage facilities. Drain covers are situated around both plots. No obvious evidence of drainage issues was observed.
	Services:	The Elleray Hall site is operational and appears to be connected to normal services. Water and electricity supply noted. Drainage and streetlights were noted on the North Lane site.
	Controlled waters:	No controlled waters were noted on site.
	Tanks:	No tanks were noted on site.
Neighbouring land:	**North:**	The southern and northern plots are bounded to the north by Middle Lane and residential property respectively.
	East:	Both have residential property immediately adjacent to the east.
	South:	The southern and northern plots are bounded to the south by residential property and Middle Lane respectively.
	West:	Residential property and North Lane bound the southern and northern plots to the west respectively.

2.2.2 Key features noted during the walkover are shown on site walkover plans in Figures 2 and 3, together with site photos in Figures 4 and 5.

2.3 Historical Mapping Information

2.3.1 The historical development of the site and its surrounding areas was evaluated following the review of a number of Ordnance Survey historic maps, procured from GroundSure, and provided in Appendix 3 of this report.

2.3.2 A summary produced from the review of the historical map is given in Table 2.3 below. Distances are taken from the site boundary.

Table 2.3: Historical Development

Dates and Scale of Map	Relevant Historical Information	
	On Site	Off Site
1865 - 1868 1:2,500 1:10,560	The northern plot is shown to be occupied by a number of buildings, focused in the east of the site, which appears to be a residential/agricultural property with outbuildings. A garden area extends west from the buildings. The southern plot is occupied by 2No residential-style properties in the north of the site, with garden areas extending southwards and to the east. The south western corner of the plot appears to form the garden area to the southerly adjacent property.	The northern plot is bounded to the south and west by unnamed roads, to the north by undeveloped land and to the east by residential property. The southern plot is bounded to the east west and south by residential property and to the north by an unnamed road. The surrounding area is predominantly residential, with the village of Teddington centred approx. 300m NE. The wider area is predominantly agricultural. A pond is shown 160m NE. A **railway** is located 230m NE. The River Thames is 1km NE.
1894 - 1899 1:1,056 1:2,500 1:10,560	The buildings on the northern plot have been demolished and the site is vacant bar a structure along the western boundary. Residential properties have been constructed to the north, with rear gardens extending into the site. There is no significant change on the southern plot, although the south of site appears to have been separate from two of the three residential properties to the south	The houses adjacent to the east of the northern plot have been demolished and the road adjacent to the west is now identified as North Lane. Elleray Road has been constructed further east, and to the north of the southern plot. There has been some urbanisation of the of the surrounding Teddington area. A **hospital** has been developed 130m N. The pond 160m NE appears to have been **infilled** and built over. **Allotment gardens** are shown 90m and 160m SW.

Dates and Scale of Map	Relevant Historical Information	
	On Site	Off Site
1914 – 1920 1:2,500 (incomplete mapping) 1:10,560	2No small units have been constructed in the west of the northern plot, adjacent to North Lane. The remainder of this plot is vacant. The houses on the southern plot have been demolished and a new unit identified as a Hall constructed in the east of the site. A smaller unit is also shown in the southwest corner of this plot. The south of the site is no longer associated with the neighbouring residential properties to the south. The southern plot appears to be two distinct plots, split east and west.	A row of terrace houses has been constructed adjacent to the east of the northern plot. The road bounding the northern and southern plots to the south and north respectively is now identified as Middle Lane. There appears to have been further residential development of the surrounding area.
1934 - 1938 1:2,500 1:10,560	Residential gardens no longer extend into the north of the northern site, and new structures are shown along the eastern and southern boundary of the northern site. Small structure has been removed from the SW corner of the southern site.	A number of residential-style properties have been developed 50m – 150m S. An **industrial-style** unit has been developed 200m SW, with **tanks** shown 240m SW. **Industrial estate** style development shown from 200m south. Memorial Hospital has been constructed 220m W. A **timber yard** is shown 280m NW.
1948 1:10,560	No significant change.	The National Physical Laboratory has been developed 400m SE.
1959 - 1968 1:1,250 1:2,500 1:10,560	Buildings in the south of the northern plot are no longer shown, and a new small structure is shown adjacent to the northern boundary. Buildings in the east of the northern site are no longer shown on the 1963 map edition. The unit in the east of the southern plot is now identified as a **works.**	**Works** are shown 40m NW, 100m, 180m and 230m W. A **garage** has been developed 60m NE. A residential-style block identified as Queen's House has been developed 100m SW. A **nursery** is shown 240m SW. A large **works** and **depot** are also shown 250m NW.

Dates and Scale of Map	Relevant Historical Information	
	On Site	Off Site
1973 - 1979 1:1,250 1:10,000	No significant changes.	A street of houses 20m – 80m west has been demolished and replaced. A **warehouse/industrial style plot** has been developed 50m NW with a large **industrial-style** unit developed 70m – 100m NW. **Works** are shown 230m and 240m W. An **electricity substation** is shown 50m S. A **garage** and **works** is shown 230m NE.
1988 1:1,250 1:10,000	The eastern section of the northern plot is now identified as a **carpark**. The unit in the east of the southern plot has been extended westwards and is again identified as a Hall. Small new structure is shown in the SE of the southern site.	There appears to have been minor residential redevelopment of the surrounding area.
1991 – 1994 1:1,250 1:10,000	An additional small unit has been constructed adjacent to the northern boundary of the northern plot. A small structure has also been added adjacent to the large structure on the west of site. The unit on the southern plot is now identified as a Day Centre. An additional small unit has also been constructed adjacent to the southern boundary of this plot.	No significant change.
2001 – 2003 1:1,250 1:10,000	No significant change.	No significant change.
2010 – 2020 1:1,250 1:10,000	No significant change.	No significant change.

Dates and Scale of Map	Relevant Historical Information	
	On Site	Off Site
1865 - 1868 1:2,500 1:10,560	The northern plot is shown to be occupied by a number of buildings, focused in the east of the site, which appears to be a residential/agricultural property with outbuildings. A garden area extends west from the buildings. The southern plot is occupied by 2No residential-style properties in the north of the site, with garden areas extending southwards and to the east. The south western corner of the plot appears to form the garden area to the southerly adjacent property.	The northern plot is bounded to the south and west by unnamed roads, to the north by undeveloped land and to the east by residential property. The southern plot is bounded to the east west and south by residential property and to the north by an unnamed road. The surrounding area is predominantly residential, with the village of Teddington centred approx. 300m NE. The wider area is predominantly agricultural. A pond is shown 160m NE. A **railway** is located 230m NE. The River Thames is 1km NE.
1894 - 1899 1:1,056 1:2,500 1:10,560	The buildings on the northern plot have been demolished and the site is vacant bar a structure along the western boundary. Residential properties have been constructed to the north, with rear gardens extending into the site. There is no significant change on the southern plot, although the south of site appears to have been separate from two of the three residential properties to the south	The houses adjacent to the east of the northern plot have been demolished and the road adjacent to the west is now identified as North Lane. Elleray Road has been constructed further east, and to the north of the southern plot. There has been some urbanisation of the of the surrounding Teddington area. A **hospital** has been developed 130m N. The pond 160m NE appears to have been **infilled** and built over. **Allotment gardens** are shown 90m and 160m SW.
1914 – 1920 1:2,500 (incomplete mapping) 1:10,560	2No small units have been constructed in the west of the northern plot, adjacent to North Lane. The remainder of this plot is vacant. The houses on the southern plot have been demolished and a new unit identified as a Hall constructed in the east of the site. A smaller unit is also shown in the southwest corner of this plot. The south of the site is no longer associated with the neighbouring residential properties to the south. The southern plot appears to be two distinct plots, split east and west.	A row of terrace houses has been constructed adjacent to the east of the northern plot. The road bounding the northern and southern plots to the south and north respectively is now identified as Middle Lane. There appears to have been further residential development of the surrounding area.

Dates and Scale of Map	Relevant Historical Information	
	On Site	**Off Site**
1934 - 1938 1:2,500 1:10,560	Residential gardens no longer extend into the north of the northern site, and new structures are shown along the eastern and southern boundary of the northern site. Small structure has been removed from the SW corner of the southern site.	A number of residential-style properties have been developed 50m – 150m S. An **industrial-style** unit has been developed 200m SW, with **tanks** shown 240m SW. **Industrial estate** style development shown from 200m south. Memorial Hospital has been constructed 220m W. A **timber yard** is shown 280m NW.
1948 1:10,560	No significant change.	The National Physical Laboratory has been developed 400m SE.
1959 - 1968 1:1,250 1:2,500 1:10,560	Buildings in the south of the northern plot are no longer shown, and a new small structure is shown adjacent to the northern boundary. Buildings in the east of the northern site are no longer shown on the 1963 map edition. The unit in the east of the southern plot is now identified as a **works.**	**Works** are shown 40m NW, 100m, 180m and 230m W. A **garage** has been developed 60m NE. A residential-style block identified as Queen's House has been developed 100m SW. A **nursery** is shown 240m SW. A large **works** and **depot** are also shown 250m NW.
1973 - 1979 1:1,250 1:10,000	No significant changes.	A street of houses 20m – 80m west has been demolished and replaced. A **warehouse/industrial style plot** has been developed 50m NW with a large **industrial-style** unit developed 70m – 100m NW. **Works** are shown 230m and 240m W. An **electricity substation** is shown 50m S. A **garage** and **works** is shown 230m NE.
1988 1:1,250 1:10,000	The eastern section of the northern plot is now identified as a **car park**. The unit in the east of the southern plot has been extended westwards and is again identified as a Hall. Small new structure is shown in the SE of the southern site.	There appears to have been minor residential redevelopment of the surrounding area.

2.3.4 Aerial photographs supplied as part of the GroundSure Enviro+GeoInsight report range from 1999 to 2019. These show the southern plot to be occupied by a large commercial-style building with a car parking area in the northwest and garden in the southwest of the plot. The early images show an industrial-style unit adjacent to the western boundary of the northern plot with a carpark extending eastwards. By the image dated 2011 this unit appears to have been demolished and a square structure is shown. This is believed to be the existing hoarded area in the west of the site. By the 2015 photograph the west of site appears to be overgrown with vegetation.

2.4 Unexploded Ordnance

2.4.1 Jomas has undertaken a preliminary UXO risk assessment for the site.

2.4.2 During WWII the Site was located in the Municipal Borough (MB) of Twickenham, which officially recorded 532No. High Explosive (HE) bombs with a bombing density of 75.9 bombs per 405 hectares.

2.4.3 Readily available records have been found to indicate that several HE bombs fell in close proximity to the Site.

2.4.4 A detailed UXO threat assessment was undertaken to further assess the risk. The detailed assessment concluded that there is a “low” risk and no further action is required.

2.4.5 The UXO assessment is provided in Appendix 6.

2.5 Sensitive Land Uses

2.5.1 The Bushy Park and Home Park Site of Special Scientific Interest (SSSI) is reported 351m southwest and 436m and 520m southeast.

2.5.2 The site is located within a SSSI Impact Risk Zone. The proposed development is unlikely to require consultation.

2.5.3 No other sensitive land use was identified within 1km of the site.

2.6 Radon

2.6.1 As reported, the site is not within a radon affected area, as less than 1% of properties are above the action level.

2.6.2 Consequently, no radon protective measures are necessary in the construction of new dwellings or extensions as described in publication BR211 (BRE, 2015).

3 GEOLOGICAL SETTING & HAZARD REVIEW

3.1.1 The following section summarises the principal geological resources of the site and its surroundings. The data discussed herein is generally based on the information given within the Groundsure Report (in Appendix 2).

3.2 Solid and Drift Geology

3.2.1 The British Geological Survey indicates that the site is directly underlain by superficial deposits of the Kempton Park Gravel Member.

3.2.2 The BGS describes the Kempton Park Gravel Member as comprising:

> *"Sand and gravel, locally with lenses of silt, clay or peat "*

3.2.3 These superficial deposits overlie solid deposits of the London Clay Formation. These are indicated by the BGS to consist of:

> *"bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay. It commonly contains thin courses of carbonate concretions ('cementstone nodules') and disseminated pyrite."*

3.2.4 Although artificial deposits are not reported within the site, given the identified site history a thickness of Made Ground should be expected.

3.2.5 No faults are reported in close proximity to the site.

3.3 British Geological Survey (BGS) Borehole Data

3.3.1 As part of the assessment, publicly available BGS borehole records were obtained and reviewed from the surrounding area. The local records obtained are presented in Appendix 5.

3.3.2 The nearest such record was located approximately 160m north east of the site, dated December 1978.

3.3.3 This showed the underlying ground conditions to comprise Made Ground to a depth of around 0.6mbgl overlying dense brown sand and gravel (assumed to be Kempton Park Gravel Member) to a depth of around 4.0mbgl, in turn underlain by firm to stiff grey brown silty clay (assumed to be London Clay Formation) to the base of the borehole at approximately 10mbgl.

3.3.4 Standing water level is reported at 3.20mbgl within the sand and gravel.

3.4 Geological Hazards

3.4.1 The following are brief findings extracted from the GroundSure GeoInsight Report, that relate to factors that may have a potential impact upon the engineering of the proposed development.

Table 3.1: Geological Hazards

Potential Hazard	Site check Hazard Rating	Details	Further Action Required?
Shrink swell clays	Negligible	Ground conditions predominantly non-plastic. It should be noted that "moderate" shrink-swell deposits are reported 21m north of site and therefore may encroach onto site.	No
Running sands	Very low	Running sand conditions are unlikely. No identified constraints on land use due to running conditions unless water table rises rapidly.	No
Compressible deposits	Negligible	Compressible strata are not thought to occur.	No
Collapsible Deposits	Very low	Deposits with potential to collapse when loaded and saturated are unlikely to be present	No
Landslides	Very low	Slope instability problems are not likely to occur but consideration to potential problems of adjacent areas impacting on the site should always be considered.	No
Ground dissolution soluble rocks	Negligible	Soluble rocks are either not thought to be present within the ground, or not prone to dissolution. Dissolution features are unlikely to be present.	No
Coal mining	None	The study site is not located within the specified search distance of an identified coal mining area.	No
Non-coal mining	None	The study site is not located within the specified search distance of an identified non-coal mining area.	No

3.4.2 In addition, the GeoInsight report notes the following:

- 2No. historical surface ground working features are reported within 250m of the site. Nearest reported 163m north east of the site for a pond.
- No historical underground working features are reported within 1km of the site.
- 1No Britpits (database maintained by the British Geological Survey of currently active and closed surface and underground mineral workings) is reported within 500m of the site located 279m south of the site for sand and gravel. The operational status is ceased.

3.4.3 Existing hardstanding and foundations will need to be removed and grubbed out ahead of the development. This may require the use of hydraulic breaking.

3.4.4 The clearance of the site, including removal of foundations and services is likely to increase the depth of Made Ground on the site.

3.4.5 Foundations should not be formed within Made Ground or organic rich material (e.g. topsoil) due to the unacceptable risk of total and differential settlement.

3.4.6 Foundations must be designed so as not to load nor undermine adjacent boundary walls and buildings.

3.4.7 The presence of Made Ground derived from demolition material may be a source of elevated sulphate, associated with plaster from the previous structures. If such levels are noted, sulphate resistant concrete may be required.

3.4.8 The BGS notes disseminated pyrite within the London Clay Formation and as such may be a source of elevated sulphate results. If such levels are noted, sulphate resistant concrete may be required.

3.4.9 A geotechnical investigation is recommended to inform foundation design.

4 HYDROGEOLOGY, HYDROLOGY AND FLOOD RISK REVIEW

4.1 Hydrogeology & Hydrology

4.1.1 General information about the hydrogeology of the site was obtained from the Environment Agency website.

Groundwater Vulnerability

4.1.2 Since 1 April 2010, the EA's Groundwater Protection Policy uses aquifer designations that are consistent with the Water Framework Directive. This comprises;

- **Secondary A** - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers;
- **Secondary B** - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.
- **Secondary Undifferentiated** - has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.
- **Principal Aquifer** – this is a formation with a high primary permeability, supplying large quantities of water for public supply abstraction.
- **Unproductive Strata** - These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

Source Protection Zones (SPZ)

4.1.3 In terms of aquifer protection, the EA generally adopts a three-fold classification of SPZs for public water supply abstraction wells.

- Zone I - or 'Inner Protection Zone' is located immediately adjacent to the groundwater source and is based on a 50-day travel time. It is designed to protect against the effects of human activity and biological/chemical contaminants that may have an immediate effect on the source.
- Zone II - or 'Outer Protection Zone' is defined by a 400-day travel time to the source. The travel time is designed to provide delay and attenuation of slowly degrading pollutants.
- Zone III - or 'Total Catchment' is the total area needed to support removal of water from the borehole, and to support any discharge from the borehole.

Hydrogeology

4.1.4 The baseline hydrogeology of the site is based on available hydrogeological mapping, including the BGS online mapping, and generic information obtained from the Groundsure Report.

4.1.5 The available data indicates that the geology of the area consists of the Kempton Park Gravel underlain by the London Clay Formation. It would be expected that a groundwater table would be encountered above or at the interface between the two strata.

Hydrology

4.1.6 The hydrology of the site and the area covers water abstractions, rivers, streams, other water bodies and flooding.

4.1.7 The Environment Agency defines a floodplain as the area that would naturally be affected by flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas.

4.1.8 There are two different kinds of area shown on the Flood Map for Planning. They can be described as follows:

Areas that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5 per cent (1 in 200) or greater chance of happening each year;
- or from a river by a flood that has a 1 per cent (1 in 100) or greater chance of happening each year.

(For planning and development purposes, this is the same as Flood Zone 3, in England only.)

- The additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1 per cent (1 in 1000) chance of occurring each year.

(For planning and development purposes, this is the same as Flood Zone 2, in England only.)

4.1.9 These two areas show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements.

4.1.10 Outside of these areas flooding from rivers and the sea is very unlikely. There is less than a 0.1 per cent (1 in 1000) chance of flooding occurring each year. The majority of England and Wales falls within this area. (For planning and development purposes, this is the same as Flood Zone 1, in England only.)

4.1.11 Some areas benefit from flood defences and these are detailed on Environment Agency mapping.

4.1.12 Flood defences do not completely remove the chance of flooding, however, and can be overtopped or fail in extreme weather conditions.

Table 4.1: Summary of Hydrogeological & Hydrology

Feature		On Site	Off Site	Potential Receptor?
Aquifer	Superficial:	Principal Aquifer	Principal Aquifer	✓
	Solid:	Unproductive	Unproductive	X
Abstractions	Ground water	None reported	8No reported within 2km – closest identified 1025m E for spray irrigation – status active	X
	Surface water	None reported	None reported within 2km	X
	Potable	None reported	None reported within 2km	X
Source Protection Zone		None reported	None reported within 500m	X
Surface Water Features		None reported	None reported within 250m	X
Flood Risk	EA Flood Zone 2	None reported	None reported within 50m	-
	EA Flood Zone 3	None reported	None reported within 50m	-
	RoFRaS	N/A	-	-
	Flood Defences	There are no areas benefiting from Flood Defences within 250m of the study site.		-
	Groundwater flooding	Highest risk rating onsite is “High”, associated with the west of the northern site. Majority of the site areas is “moderate”.		-

4.2 Flood Risk Review

4.2.1 In accordance with the NPPF Guidance, below is a review of flood risks posed to and from the development and recommendations for appropriate design mitigation where necessary. Specific areas considered are based on the requirements laid out in the “Camden Planning Guidance Basements” (CPGB) (January 2021) as this document is generally considered to be the most comprehensive Local Authority Guidance in the London area.

Table 4.2: Flood Risk Review

Flood Sources	Site Status	Comment on flood risk posed to / from the development
Fluvial / Tidal	Site is not within 250m of an Environment Agency Zone 2 or zone 3 floodplain. Risk of flooding from rivers and the sea (RoFRaS) rating very low.	Proposed developments on both plots anticipated to increase proportion of soft cover. Low risk.
Groundwater	The BGS considers the area to be susceptible to groundwater flooding within the superficial deposits. Highest risk rating onsite is "High", associated with the west of the northern site. Majority of the site areas is "moderate".	The proposed development will not increase the potential risk of groundwater flooding. Any below-ground structure is to be fully waterproofed as appropriate to industry standard. Low Risk
Artificial Sources	No surface water features within 250m of site.	Low Risk
Surface Water / Sewer Flooding	No surface water features within 250m of site. Condition, depth and location of surrounding infrastructure uncertain.	Proposed developments on both plots anticipated to increase proportion of soft cover. As SUDS will be required by NPPF, PPG and LLFA policy requirements, these are likely to include attenuation before releasing to the existing sewer network. If permeable paving is used this would likely reduce the risk of surface water flooding. Combined, these are likely to reduce the risk of both surface and sewer flooding to both the site and surrounding properties. Low Risk. No further drainage assessment required.
Climate Change	Included in the flood modelling extents. Site not within climate change flood extent area	Development will not significantly increase the peak flow and volume of discharge from the site Low risk posed to and from the development

4.2.2 Information about the risk to the study site from flooding has been obtained from the Strategic Flood Risk Assessment Level 1 (Metis Consultant, March 2021) produced for London Borough of Richmond Upon Thames. Potential impacts to the site are discussed below.

Flooding from Fluvial/Tidal Sources

4.2.3 No surface water bodies are reported within 250m of the site. In addition, no EA historic flooding events are shown within 500m of site.

Groundwater Flooding

4.2.4 The London Borough of Richmond's Groundwater, Sewer and Artificial Flood Risk Web Map indicates the site to be within an area described as "potential for groundwater flooding to be occur at surface". The EA list the area as within the 75% or more band of susceptibility to groundwater flooding.

Surface Water Flooding

4.2.5 The site lies within an EA Flood Zone 1. Based on EA mapping, the site and highways surrounding the site are not within an area identified as a high risk for surface water flooding potential; site itself not likely to be inundated.

Sewer/Artificial Flooding

4.2.6 The London Borough of Richmond's Groundwater, Sewer and Artificial Flood Risk Web Map indicates the site to be within an area with "0-10 incidents reported" relating to Thames Water incidents. This is the lowest band of incidents.

Critical Drainage Areas (CDAs)

4.2.7 A critical drainage area is defined in the Town and Country Planning (General Development Procedure) (Amendment) (No. 2) (England) Order 2006 a Critical Drainage Area is "an area within Flood Zone 1 which has critical drainage problems and which has been notified… [to]…the local planning authority by the Environment Agency".

4.2.8 They are where man made drainage infrastructure has been identified as at critical risk of failure, resulting in flooding. Such areas can be completely different or similar, to the areas identified by the Environment Agency as at risk of natural watercourse, river and sea flooding.

4.2.9 8No Critical Drainage Areas (CDA) are located within the London Borough of Richmond Upon Thames. This site is located within the Teddington CDA.

Sustainable Drainage Systems (SuDS)

4.2.10 The proposed developments on both plots are likely to increase the proportion of soft cover and therefore reduce the potential for surface water run-off.

4.2.11 In accordance with the NPPF, PPG and LLFA policy requirements, sustainable drainage systems (SUDS) should be incorporated wherever possible to reduce positive surface water run-off and flood risk to other areas.

4.2.12 Given the expected underlying ground and hydrogeological conditions it is considered that infiltration drainage would likely be suitable. This should be confirmed by a ground investigation.

Conclusion

4.2.13 Based on the available data, the site is considered to be at low risk from identified potential sources of flooding. The proposed development can be constructed and operated safely in flood risk terms without increasing flood risk elsewhere and is therefore considered NPPF compliant.

4.3 Sequential and Exception Tests

4.3.1 The Sequential Test aims to ensure that development does not take place in areas at high risk of flooding when appropriate areas of lower risk are reasonably available.

Sequential Test: within FZ1 and hence pass by default.

4.3.2 Paragraph 19 of PPS25 recognizes the fact that wider sustainable development criteria may require the development of some land that cannot be delivered through the sequential test. In these circumstances, the Exception Test can be applied to some developments depending on their vulnerability classification (Table D.2 of PPS25). The Exception Test provides a method of managing flood risk while still allowing necessary development to occur.

Exception Test: FZ1 hence pass by default and low risk posed to and from other sources

4.4 Flood Resilience

4.4.1 In accordance with general basement flood policy and basement design, the proposed development will utilize the flood resilient techniques recommended in the NPPF Technical Guidance where appropriate and also the recommendations that have previously been issued by various councils.

4.4.2 These include:

- Basement/subsurface structure to be fully waterproofed (tanked) and waterproofing to be tied in to the ground floor slab as appropriate: to reduce the turnaround time for returning the property to full operation after a flood event.
- Plasterboards will be installed in horizontal sheets rather than conventional vertical installation methods to minimise the amount of plasterboard that could be damaged in a flood event
- Wall sockets will be raised to as high as is feasible and practicable in order to minimise damage if flood waters inundate the property
- Any wood fixings on basement / ground floor will be robust and/or protected by suitable coatings in order to minimise damage during a flood event
- The basement/subsurface structure waterproofing where feasible will be extended to an appropriate level above existing ground levels.

- The concrete sub floor as standard will likely be laid to fall to drains or gullies which will remove any build-up of ground water to a sump pump where it will be pumped into the mains sewer. This pump will be fitted with a non-return valve to prevent water backing up into the property should the mains sewer become full.
- Insulation to the external walls will be specified as rigid board which has impermeable foil facings that are resistant to the passage of water vapour and double the thermal resistance of the cavity.

5 SCREENING AND SCOPING ASSESSMENT

5.1 Screening Assessment

5.1.1 Screening is the process of determining whether or not there are areas of concern which require a BIA for a particular project. This was undertaken in previous sections by the site characterisation. Scoping is the process of producing a statement which defines further matters of concern identified in the screening stage. This defining is in terms of ground processes in order that a site specific BIA can be designed and executed by deciding what aspects identified in the screening stage require further investigation by desk research or intrusive drilling and monitoring or other work.

5.1.2 The scoping stage highlights areas of concern where further investigation, intrusive soil and water testing and groundwater monitoring may be required.

5.1.3 This Jomas BIA also takes into account the Campbell Reith pro forma BIA produced on behalf of and published by the London Borough of Camden as guidance for applicants to ensure that all of the required information is provided. Within the pro forma a series of tables have been used to identify what issues are relevant to the site.

5.1.4 Each question posed in the tables is completed by answering "Yes", "No" or "Unknown". Any question answered with "Yes" or "Unknown" is then subsequently carried forward to the scoping phase of the assessment.

5.1.5 The results of the screening process for the site are provided in Table 5.1 below. Where further discussion is required the items have been carried forward to scoping.

5.1.6 The numbering within the questions refers the reader to the appropriate question / section in the London Borough of Camden BIA pro forma

5.1.7 It should also be noted that the London Borough of Richmond Upon Thames may not place the same importance on the issues identified in the London Borough of Camden's guidance documents. It should be noted that the pro forma is mainly concerned with the pond chain on Hampstead Heath, if other ponds/waterbodies may similarly affect the development Jomas will indicate this.

5.1.8 A site investigation is undertaken where necessary to establish base conditions and the impact assessment determines the impact of the proposed basement on the baseline conditions, taking into account any mitigating measures proposed.

Table 5.1: Screening Assessment

Query	Y / N	Comment
Subterranean (Groundwater) Flow (see London Borough of Camden BIA Pro Forma Section 4.1.1)		
1a) Is the site located directly above an aquifer?	Yes	The site is directly underlain by the Kempton Park Gravel Member, identified as a Principal Aquifer.
1b) Will the proposed basement extend below the surface of the water table?	Unknown	The basement/subsurface structure may potentially extend below a water table within the superficial deposits. This should be confirmed by a ground investigation.
2) Is the site within 100m of a watercourse, well (disused or used) or a potential spring line?	No	No surface water features within 250m of site.
3) Is the site within the catchment of any surface water features?	No	No surface water features within 250m of site.
4) Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	No	The proposed developments will likely increase the proportion of soft cover on both plots.
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)?	Unknown	Current and proposed drainage is unknown.
6) Is the lowest point of the proposed excavation (allowing of 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	No surface water features within 250m of site.
Slope Stability ((see London Borough of Camden BIA Pro Forma Section 4.2)		
1) Does the existing site include slopes, natural or manmade, greater than 7 degrees? (approximately 1 in 8)	No	The sites are flat and level with the adjacent plots.
2) Will the proposed re-profiling of landscaping change slopes at the property to more than 7 degrees? (approximately 1 in 8)	Likely	It is understood that retaining walls and/or slopes are proposed at the site boundaries where there is a proposed change in level relative to adjacent plots.
3) Does the developments' neighbouring land include railway cuttings and the like, with a slope greater than 7 degrees? (approximately 1 in 8)	No	Surrounding areas are broadly flat and level.
4) Is the site within a wider hillside setting in which the general slope is greater than 7 degrees? (approximately 1 in 8)	No	Surrounding area is generally flat.
5) Is the London Clay the shallowest strata at the site?	No	The site is directly underlain by superficial deposits of the Kempton Park Gravels, these

Query	Y / N	Comment
		deposits are underlain by the London Clay Formation.
6) Will any trees be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	Unknown, but possible	Small trees on the Elleray Town Hall Site likely to be felled, and replaced as part of the development.
7) Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	Unknown	The site is reported to be in area at negligible risk from shrink-swell clays. No evidence of structural distress caused by seasonal shrink/ swell was noted during the external walkover.
8) Is the site within 100m of a watercourse or a spring line?	No	No surface water features within 250m of site.
9) Is the site within an area of previously worked ground?	No	Sites have held various structures over mapped history, but no evidence of significant ground workings.
10) Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	Unknown	The site is directly underlain by a Principal Aquifer of the Kempton Park Gravel Member, underlain by unproductive London Clay. Ground water level should be assessed by a ground investigation prior to construction to confirm its presence.
11) Is the site within 50m of the Hampstead Heath ponds (or other waterbody)?	No	-
12) Is the site within 5m of a highway or pedestrian 'right of way'?	Yes	Both sites face onto a public pavement and road.
13) Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Unknown	Neighbouring foundations are unknown.
14) Is the site over (or within the exclusion of) any tunnels e.g. railway lines?	No	Nearest railway reported 231m NE.
Surface Flow and Flooding (see London Borough of Camden BIA Pro Forma Section 4.3)		
1) Is the site within the catchment of the pond chains on Hampstead Heath?	No	No surface water features within 250m of site.
2) As part of the site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially different from the existing route?	No	The proposed developments will likely increase the proportion of soft cover on site, potentially increasing infiltration on site.
3) Will the proposed basement development result in a change in the proportion of hard surfaced/paved external areas?	No	The proposed developments will likely increase the proportion of soft cover on site, potentially increasing infiltration on site.
4) Will the proposed basement result in changes to the profile of the inflows (instantaneous and long term) of	No	No surface waters in the area to be impacted.

Query	Y / N	Comment
surface water being received by adjacent properties or downstream watercourses?		
5) Will the proposed basement result in changes to the quality of surface waters being received by adjacent properties or downstream watercourses?	No	No surface waters in the area to be impacted.
6) Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or Strategic Flood Risk Assessment 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	No nearby surface water features and not within an EA flood zone.

5.2 Scoping

5.2.1 Scoping is the activity of defining in further detail the matters to be investigated as part of the BIA process. Scoping comprises of the definition of the required investigation needed in order to determine in detail the nature and significance of the potential impacts identified during screening.

5.2.2 The potential impacts for each of the matters highlighted in Table 5.1 above are discussed in further detail below together with the requirements for further investigations. Detailed assessment of the potential impacts and recommendations are provided where possible.

Subterranean (Groundwater) Flow

5.2.3 A ground investigation is recommended to confirm the ground conditions and groundwater levels (if any) beneath the site. This can then be used to confirm the relative depths of the basement to the groundwater levels.

Land Stability

5.2.4 The site, as with the surrounding area, is generally flat. The Groundsure report has noted that there is a "very low" risk of land instability issues for the site.

5.2.5 The recommended ground investigation should also determine the possibility of encountering groundwater and the possibility of Made Ground and/or clay. Atterberg Limits of the underlying clay should be determined by the ground investigation to assess shrink/swell potential of the soils.

5.2.6 It is noted that the London Borough of Camden's guidance documents requires a Ground Movement Assessment to be undertaken as part of the Basement Impact Assessment. Such an assessment uses a ground model based on a zone of influence equivalent of four times the proposed depth of excavation. Consequently, such a study is recommended.

Surface Flow and Flooding

5.2.7 The proposed basement will underlie the existing hardstanding of the current structure on site; there will be no significant change in surface water run-off.

5.2.8 As SUDS will be required by NPPF, PPG and LLFA policy requirements, this will be provided by surface and above ground attenuation before releasing to the existing sewer network. This will ensure that the proposed development will not increase the potential risk of groundwater flooding.

5.2.9 Plans and maps showing the topography of the site and surrounding area are included as Figure 6.

6 QUALITATIVE RISK ASSESSMENT

6.1 Legislative Framework

6.1.1 A qualitative risk assessment has been prepared for the site, based on the information collated. This highlights the potential sources, pathways and receptors. Intrusive investigations will be required to confirm the actual site conditions and risks.

6.1.2 Under Part IIA of the Environmental Protection Act 1990, the statutory definition of contaminated land is:

"*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:*

(a) significant harm is being caused or there is a significant possibility of such harm being caused; or

(b) pollution of controlled waters is being, or is likely to be, caused."

6.1.3 The Statutory Guidance provided in the DEFRA Circular 01/2006 lists the following categories of significant harm:

- death, disease, serious injury, genetic mutation, birth defects or the impairment of reproduction functions in human beings;
- irreversible adverse change, or threat to endangered species, affecting an ecosystem in a protected area (i.e. site of special scientific interest);
- death, serious disease or serious physical damage to pets, livestock, game animals or fish;
- a substantial loss in yield or value of crops, timber or produce; and
- structural failure, substantial damage or substantial interference with right of occupation to any building.

6.1.4 Contaminated land will only be identified when a 'pollutant linkage' has been established.

6.1.5 A 'pollutant linkage' is defined in Part IIA as:

"A linkage between a contaminant Source and a Receptor by means of a Pathway".

6.1.6 Therefore, this report presents an assessment of the potential pollutant linkages that may be associated with the site, in order to determine whether additional investigations are required to assess their significance.

6.1.7 In accordance with the National Planning Policy Framework, where development is proposed, the developer is responsible for ensuring that the development is safe and suitable for use for the purpose for which it is intended, or can be made so by remedial action. In particular, the developer should carry out an adequate investigation to inform a risk assessment to determine:

- whether the land in question is already affected by contamination through source – pathway – receptor pollutant linkages and how those linkages are represented in a conceptual model;
- whether the development proposed will create new linkages, e.g. new pathways by which existing contaminants might reach existing or proposed receptors and whether it will introduce new vulnerable receptors; and
- what action is needed to break those linkages and avoid new ones, deal with any unacceptable risks and enable development and future occupancy of the site and neighbouring land.

6.1.8 A potential developer will need to satisfy the Local Authority that unacceptable risk from contamination will be successfully addressed through remediation without undue environmental impact during and following the development.

6.2 Conceptual Site Model

6.2.1 On the basis of the information summarised above, a conceptual site model (CSM) has been developed for the site. The CSM is used to guide the investigation activities at the site and identifies potential contamination sources, receptors (both on and off-site) and exposure pathways that may be present. The identification of such potential “pollutant linkages” is a key aspect of the evaluation of potentially contaminated land.

6.2.2 The site investigation is then undertaken in order to prove or disprove the presence of these potential source-pathway-receptor linkages. Under current legislation an environmental risk is only deemed to exist if there are proven linkages between all three elements (source, pathway and receptor).

6.2.3 This part of the report lists the potential sources, pathways and receptors at the site, and assesses based on current and future land use, whether pollution linkages are possible.

6.2.4 Potential pollutant linkages identified at the site are detailed below:

Table 6.1: Potential Sources, Pathways and Receptors

Source(s)	Pathway(s)	Receptor(s)

- Potential for contaminated ground associated with previous site use – on site (S1)
  o depot,
  o works,
  o car park,
  o unspecified industrial/commercial
- Potential for Made Ground associated with previous development operations – on site (S2)
- Potential for asbestos impacted soils from demolition of previous structures – on site (S3)
- Previous industrial use – off site (S4)
  o Works (40m NW, 100m, 180m, 230m W)
  o Garage (60m NE)
  o Industrial unit with tanks (240m W)
	- Ingestion and dermal contact with contaminated soil (P1)
	- Inhalation or contact with potentially contaminated dust and vapours (P2)
	- Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hard standing or via service pipe/corridors and surface water runoff. (P3)
	- Horizontal and vertical migration of contaminants within groundwater (P4)
	- Accumulation and Migration of Soil Gases (P5)
	- Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6)
		- Construction workers (R1)
		- Maintenance workers (R2)
		- Neighbouring site users (R3)
		- Future site users (R4)
		- Building foundations and on site buried services (water mains, electricity and sewer) (R5)
		- Controlled waters - Principal Aquifer (R6)

6.3 Qualitative Risk Estimation

6.3.1 Based on information previously presented in this report, a qualitative risk estimation was undertaken.

6.3.2 For each potential pollutant linkage identified in the conceptual model, the potential risk can be evaluated, based on the following principle:

Overall contamination risk = Probability of event occurring x Consequence of event occurring

6.3.3 In accordance with CIRIA C552, the consequence of a risk occurring has been classified into the following categories:

- Severe
- Medium
- Mild
- Minor

6.3.4 The probability of a risk occurring has been classified into the following categories:

- High Likelihood
- Likely
- Low Likelihood
- Unlikely

6.3.5 This relationship can be represented graphically as a matrix (Table 6.2).

Table 6.2: Overall Contamination Risk Matrix

		Consequence			
		Severe	Medium	Mild	Minor
Probability	High Likelihood	Very High Risk	High Risk	Moderate Risk	Low Risk
	Likely	High Risk	Moderate Risk	Moderate Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate Risk	Low Risk	Very Low Risk
	Unlikely	Low Risk	Low Risk	Very Low Risk	Very Low Risk

6.3.6 The risk assessment process is based on guidance provided in CIRIA C552 (2001) *Contaminated Land Risk Assessment – A Guide to Good Practice*. Further information including definitions of descriptive terms used in the risk assessment process is included in Appendix 4.

6.3.7 The degree of risk is based on a combination of the potential sources and the sensitivity of the environment. The risk classifications can be cross checked with reference to Table A4.4 in Appendix 4.

6.3.8 Hazard assessment was also carried out, the outcome of which could be:

- Urgent Action (UA) required to break existing source-pathway-receptor link.
- Ground Investigation (GI) required to gather more information.

- Watching Brief there is no evidence of potential contamination but the possibility of it exists and so the site should be monitored for local and olfactory evidence of contamination.
- No action required (NA)

6.3.9 The preliminary risk assessment for the site is presented in Table 6.3 overleaf.

Table 6.3: Preliminary Risk Assessment for the Site

Sources	Pathways (P)	Receptors	Consequence of Impact	Probability of Impact	Risk Estimation	Hazard Assessment
• Potential for contaminated ground associated with previous site use – on site (S1) o depot, o works, o car park, o unspecified industrial/commercial • Potential for Made Ground associated with previous development operations – on site (S2) • Potential for asbestos impacted soils from demolition of previous structures – on site (S3) • Previous industrial use – off site (S4) o Works (40m NW, 100m, 180m, 230m W) o Garage (60m NE) o Industrial unit with tanks (240m W)	• Ingestion and dermal contact with contaminated soil (P1) • Inhalation or contact with potentially contaminated dust and vapours (P2) • Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6)	• Construction workers (R1) • Maintenance workers (R2) • Neighbouring site users (R3) • Future site users (R4) • Building foundations and on site buried services (water mains, electricity and sewer) (R5)	Medium	Low	Moderate	GI – Ground Investigation
	• Accumulation and migration of soil gases (P5)		Severe	Unlikely	Low	
	• Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hardstanding or via service pipe/corridors and surface water runoff. (P3) • Horizontal and vertical migration of contaminants within groundwater (P4)	• Neighbouring site users (R3) • Building foundations and on site buried services (water mains, electricity and sewer) (R5) • Controlled waters - Principal Aquifer (R6)	Medium	Low	Moderate	

6.3.10 The risk estimation matrix indicates a moderate to low risk as defined above.

6.3.11 It is understood that the proposed development is to involve the demolition of Elleray Hall and the construction of a two-storey block of flats with communal gardens, and the construction of a community centre on the currently vacant North Lane Depot/East Car Park. Both developments are understood to include the lowering of existing ground levels, rather than the formation of full basements.

6.3.12 A review of the earliest available (1865) historical maps indicates that the northern plot was occupied by residential/agricultural structures until the late 1800s when only a single structure is shown along the western boundary (use unclear), with the very north of the site comprising the end of neighbouring gardens. Throughout the first half of the 20th century there are various reconfigurations of the site with commercial style buildings shown along the eastern and southern boundaries, with no usage indicated. By 1963 the east of the site is shown as vacant and by 1988 the east is indicated to be a car park. Structures remain along the western boundary up to the most recent map edition, however the area is shown vacant on an aerial photograph from 2011, indicating demolition between 2008 and 2011.

6.3.13 The southern plot was occupied by residential properties and gardens from 1865 until at least 1898; by 1915 the east of the site is occupied by a large "hall" building with a smaller structure identified in the south-west of the site. By 1959 the hall structure is identified as "works", and remains in this use until the 1988 map edition identifies a "hall" once again with an extension to the west of the structure. By 1991 the structure is identified as a "day centre" which remains up to the most recent map edition.

6.3.14 The surrounding area has been predominantly residential with occasional industrial features. Industrial features of note include various works, a warehouse, garage and an unspecified tank, all located within 250m of the site.

6.3.15 It is recommended that an intrusive investigation is undertaken to clarify potential risks to the identified receptors, and assess the extent of Made Ground soils present at the site.

6.3.16 Due to the potential for hydrocarbon contamination to be present beneath the site from the identified historical uses as "works" (southern site) and reported depot usage on the northern site, it is recommended that a ground investigation includes provision of gas and groundwater monitoring wells to allow for gas monitoring and groundwater sampling should viable sources be reported during the ground investigation.

6.3.17 If deep Made Ground containing significant organic inclusions is encountered, gas monitoring should also be undertaken in accordance with CIRIA C655.

6.4 List of Key Contaminants

6.4.1 The possible contamination implications for both on-site and off-site sources have been assessed based on the information presented in the report. This has been achieved using guidance publications by the Environment Agency, together with other sources.

6.4.2 In the case of the site uses identified as part of the desk study research, reference to DoE industry profiles would not indicate a specific use reference, although reference has been made to the miscellaneous industries profile.

6.4.3 Based on recommendations within the guidance publications, an initial soil and water chemical testing suite would need to consider a range of contaminants as follows:

- *Metals*: cadmium, chromium, copper, lead, mercury, nickel, zinc;
- *Semi-metals and non-metals*: arsenic, boron, sulphur;
- *Inorganic chemicals*: cyanide, nitrate, sulphate and sulphide;
- *Organic chemicals*: aromatic hydrocarbons, aliphatic hydrocarbons, petroleum hydrocarbons, phenol, polyaromatic hydrocarbons;
- *Others*: pH, Asbestos.

7 GROUND INVESTIGATION

7.1 Rationale and Scope of Ground Investigation

7.1.1 The Rationale and Scope of the Ground Investigation is detailed with the Ground Investigation Specification prepared by Jomas Associates, ref. P3152J2114, dated 26th November 2020.

7.2 Factual Ground Investigation

7.2.1 The ground investigation was undertaken by Concept Engineering Consultants Limited (Concept) between 22nd February and 5th March 2021, and is reported by Concept in their Factual Report dated 9th April 2021, ref 20/3521 FR01. The full factual report is provided as Appendix 7.

7.2.2 A summary of the fieldwork carried out at the site by Concept is presented in Table 7.1 below. Exploratory locations are shown in Figure 7.

Table 7.1: Scope of Intrusive Investigation

Investigation Type	Number of Exploratory Holes Achieved	Exploratory Hole Designation	Depth Achieved (m BGL)	Limitations
Window Sample Boreholes	10	WS1 – 10	Maximum 2mbgl	All windowless sampler boreholes were terminated at 2.00mbgl due to refusal in very dense granular material interpreted to represent the Kempton Park Gravel Member.
Cable Percussion Boreholes	2	BH1-BH2	20mbgl	No deviation from agreed specification.
Monitoring Wells	6	BH1, BH2, WS1, WS2, WS6, WS10	Maximum 6.3mbgl	Installations within windowless sampler boreholes shallower than proposed due to shallow refusals.
Machine Excavated Trial Pits	3	STP1-STP3	Maximum 2.70mbgl	No deviation from agreed specification.

7.3 Observations by Jomas During Site Works

7.3.1 A Jomas engineer supervised the initial set up of the site works on 21st February 2021. All works observed were in accordance with the agreed specification.

7.4 Laboratory Analysis

7.4.1 A programme of laboratory testing was scheduled by Jomas Associates Limited, based on the ground investigation data obtained by Concept.

Chemical Testing

7.4.2 Soil samples were obtained by Concept and submitted to Eurofins Chemtest Ltd (a UKAS and MCerts accredited laboratory), for analysis.

7.4.3 The samples were analysed for a suite of contaminants as shown in Table 7.2 below:

Table 7.2: Chemical Tests Scheduled

	No. of tests	
Test Suite	**Made Ground / Topsoil**	**Natural**
Basic Suite 3	11	1
Basic Suite 5	9	1
Total Organic Carbon	4	-
Water Soluble Sulphate	11	17
TPHCWG (inc BTEX)	9	1
VOC	9	1
Waste Acceptance Criteria	2	-
Asbestos Screen & ID	16	-

7.4.4 The determinands contained in the Basic Suite 3 are as detailed in Table 7.3 below. Basic Suite 5 contains the same determinands but without the hydrocarbon compounds to avoid overlapping with the hydrocarbon testing.

Table 7.3: Basic Suite of Determinands

DETERMINAND	LIMIT OF DETECTION (mg/kg)	UKAS ACCREDITATION	TECHNIQUE
Arsenic	1	Y (MCERTS)	ICPMS
Cadmium	0.1	Y (MCERTS)	ICPMS
Chromium	1	Y (MCERTS)	ICPMS
Chromium (Hexavalent)	0.5	Y (MCERTS)	"Aquakem 600" Discrete Analyser using 1,5-diphenylcarbazide.
Lead	0.5	Y (MCERTS)	ICPMS
Mercury	0.1	Y (MCERTS)	ICPMS
Nickel	0.5	Y (MCERTS)	ICPMS
Selenium	0.2	Y (MCERTS)	ICPMS
Copper	0.5	Y (MCERTS)	ICPMS

Zinc	0.5	Y (MCERTS)	ICPMS
Boron (Water Soluble)	0.4	Y (MCERTS)	ICPMS
pH Value	4.0	Y (MCERTS)	pH Meter
Sulphate (Water Soluble)	0.01g/l	Y (MCERTS)	Aqueous extraction/ICP-OES
Total Cyanide	0.5	Y (MCERTS)	Colorimetry
Speciated/Total PAH	0.10/5.0	Y (MCERTS)	GCFID
Phenols	0.3	Y (MCERTS)	HPLC
Total Petroleum Hydrocarbons (banded)	10.0	N Y (MCERTS)	GCxGC FID

7.4.5 To support the selection of appropriate tier 1 screening values, 10No samples were analysed for total organic carbon.

Geotechnical Laboratory Testing

7.4.6 In addition to the contamination assessment, soil samples were submitted to Concept's laboratory for a series of analyses.

7.4.7 This testing was specifically designed to:

- classify the samples; and
- obtain parameters (either directly or sufficient to allow relevant correlations to be used) relevant to the technical objectives of the investigation.

7.4.8 The following laboratory geotechnical testing (as summarised in Table 7.4) was carried out:

Table 7.4 Laboratory Geotechnical Analysis

BS 1377 (1990) Test Number	Test Description	Number of tests
Part 2		
3.2	Moisture Content Determination	20
4.3 and 5.3	Liquid and Plastic Limit Determination (Atterberg Limits)	20
9.2 and 9.3	Particle Size Distribution - Sieving	4
Part 7		
8	Determination of the undrained shear strength in triaxial compression with single stage loading and without measurement of pore pressure	8

8 GROUND CONDITIONS

8.1 Soil

8.1.1 Jomas' summary interpretation of the ground profile described by Concept is provided in Table 8.1 below, based on the strata observed during the investigation.

Table 8.1: Ground Conditions Encountered

Stratum and Description	Encountered from (mbgl)	Base of strata (mbgl)	Thickness range (m)
Asphalt (MADE GROUND) Overlying concrete in WS5. (BH1, BH2, WS1, WS3, WS4, WS5, WS6, WS7, WS8, STP1)	GL	0.03 – 0.20	0.10 – 0.20
Paving slabs overlying gravelly sand. Gravel consists of flint. (MADE GROUND) (WS9)	GL	0.10	0.10
Dark brown silty clay with frequent rootlets. (WS2, STP2) (TOPSOIL)	GL	0.15	0.15
Light to dark brown - dark grey slightly clayey slightly silty very sandy gravel/gravelly sand. Gravel consists of flint, brick, concrete, ceramic and asphalt. Hydrocarbon odour reported in BH1, WS3, WS4, WS5, STP1, STP2 (MADE GROUND)	GL – 0.20	0.10 – 1.00	0.10 – 0.90
Greenish-grey to orangish-brown dark brown silty slightly sandy gravelly clay/silt. Gravel consists of flint, brick and concrete. Hydrocarbon odour reported in WS1 (MADE GROUND)	0.10 - 0.90	0.55 - 1.70	0.25 - 0.95
Orangish-brown to greenish-grey clayey sandy gravelly SILT/sandy slightly gravelly CLAY. Gravel consists of flint. (KEMPTON PARK GRAVEL MEMBER – Cohesive)	0.55 - 1.00	1.50 - 2.20	0.70 – 1.35
Orangish-brown to greyish brown sometimes clayey gravelly SAND/sandy GRAVEL. Gravel consists of flint. (KEMPTON PARK GRAVEL MEMBER – Granular)	1.20 - 2.20	>2.00 – 6.60	>0.1 – 5.1
Greyish brown to dark brown silty sandy CLAY with pockets of dark grey silt. Occasional shell fragments and dark grey staining. (LONDON CLAY FORMATION)	6.30 – 6.60	>20.00 (Base not proven)	>13.40 – >13.70 (Thickness not proven)

8.1.2 Given the likely ground strata profile identified in the Desk Study and the BGS descriptions of the materials given in Section 3 of the Desk Study it is considered that the encountered strata represent superficial deposits of the Kempton Park Gravel Member overlying solid deposits of the London Clay Formation. The base of this deposit was not proven.

8.2 Hydrogeology

8.2.1 Groundwater strikes and groundwater monitoring are summarised below in Table 8.2. It is noted that water was added to aid drilling through the Kempton Park Gravel Member in the cable percussive boreholes BH1 and BH2, which may have masked groundwater strikes or seepages.

Table 8.2: Groundwater Strikes During Drilling

Exploratory Hole ID	Depth Encountered (mbgl)	Depth After 20mins (mbgl)	Stratum
BH1	10.00	no rise	London Clay Formation
BH2	19.30	no rise	London Clay Formation
WS1	No water strike		
WS2	No water strike		
WS3	No water strike		
WS4	No water strike		
WS5	No water strike		
WS6	No water strike		
WS7	No water strike		
WS8	No water strike		
WS9	No water strike		
WS10	No water strike		

8.2.2 4No return groundwater monitoring visits were undertaken between 10/03/2021 and 09/06/2021. The results are summarised below.

Table 8.3: Groundwater Monitoring Records

Exploratory Hole ID	Depth Encountered (mbgl)	Depth to Base of Well (mbgl)	Strata targeted by response zone
BH1	4.00-4.15	6.30	Kempton Park Gravel Member
BH2	4.14-4.30	6.30	Kempton Park Gravel Member
WS1	Dry	2.00	Kempton Park Gravel Member
WS2	Dry	2.00	Made Ground/Kempton Park Gravel Member
WS6	Dry	2.00	Kempton Park Gravel Member
WS10	Dry	2.00	Kempton Park Gravel Member

8.2.3 The monitoring results are considered to reflect a groundwater table within the Kempton Park Gravel at a depth of ca 4m bgl, at the time of monitoring.

8.3 Physical and Olfactory Evidence of Contamination

8.3.1 Hydrocarbon odours were reported at the following locations in the northern plot:

- STP1: GL – 0.25mbgl
- STP2: 0.10 – 0.30mbgl
- BH1: 0.10 – 0.30mbgl
- WS1: 0.30 – 0.55mbgl
- WS3: 0.10 – 0.50mbgl
- WS4: 0.10 – 0.50mbgl
- WS5: 0.20 – 0.75mbgl

8.3.2 In addition, a “black tar substance” was reported between 0.20-0.22mbgl in WS5.

8.3.3 Asphalt gravel was reported throughout the Made Ground in the northern plot.

9 RISK ASSESSMENT – ANALYTICAL FRAMEWORK

9.1 Context and Objectives

9.1.1 This section seeks to evaluate the level of risk pertaining to human health and the environment which may result from both the existing use and proposed future use of the site. It makes use of the site investigation findings, as described in the previous sections, to evaluate further the potential pollutant linkages identified in the desk study. A combination of qualitative and quantitative techniques is used, as described below.

9.1.2 The purpose of generic quantitative risk assessment is to compare concentrations of contaminants found on site against screening level generic assessment criteria (GAC) to establish whether there are actual or potential unacceptable risks. It also determines whether further detailed assessment is required. The approaches detailed all broadly fit within a tiered assessment structure in line with the framework set out in the Department of Environment, Food and Rural Affairs (DEFRA), EA and Institute for Environment and Health Publication, Guidelines for Environmental Risk Assessment and Management.

9.1.3 It should be noted that the statistical tests carried out in this report in accordance with CL:AIRE and CIEH (2008) recommendations, are for guidance purposes only and the conclusions of this report should be approved by the local authority prior to any redevelopment works being undertaken.

9.2 Analytical Framework – Soils

9.2.1 There is no single methodology that covers all the various aspects of the assessment of potentially contaminated land and groundwater. Therefore, the analytical framework adopted for this investigation is made up of a number of procedures, which are outlined below. All of these are based on a Risk Assessment methodology centred on the identification and analysis of Source – Pathway – Receptor linkages.

9.2.2 The CLEA model provides a methodology for quantitative assessment of the long term risks posed to human health by exposure to contaminated soils. Toxicological data have been used to calculate Soil Guideline Values (SGV) for individual contaminants, based on the proposed site use; these represent minimal risk concentrations and may be used as screening values.

9.2.3 In the absence of any published SGVs for certain substances, or where the assumptions made in generating the SGVs do not apply to the site, JOMAS have derived Tier 1 screening values for initial assessment of the soil, based on available current UK guidance including the LQM/CIEH generic assessment criteria. Site-specific assessments are undertaken wherever possible and/or applicable. All assessments are carried out in accordance with the CLEA protocol.

9.2.4 CLEA requires a statistical treatment of the test results to take into account the normal variations in concentration of potential contaminants in the soil and allow comparisons to be made with published guidance.

9.2.5 The assessment criteria used for the screening of determinands within soils are identified within Table 9.1.

Table 9.1: Selected Assessment Criteria – Contaminants in Soils

Substance Group	Determinand(s)	Assessment Criteria Selected
Organic Substances		
Non-halogenated Hydrocarbons	Total Petroleum Hydrocarbons (TPHCWG banded)	S4UL
	Total Phenols	S4UL
Polycyclic Aromatic Hydrocarbons (PAH-16)	Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene, Benzo(ghi)perylene	S4UL
Volatile Organic Compounds (VOCs/sVOCs).	Toluene, Ethylbenzene	S4UL
	Benzene, Xylenes	S4UL
Inorganic Substances		
Heavy Metals and Metalloids	Arsenic, Cadmium, Chromium, Lead, Mercury, Nickel, Selenium, Copper, Zinc	S4UL
	Copper, Zinc, Nickel	BS: 3882 (2015).
Cyanides	Free Cyanide	CLEA v1.06
Sulphates	Water Soluble Sulphate	BRE Special Digest 1:2005

9.2.6 As the published reports only offer the option of selecting a SOM value of 1%, 2.5% or 6%, a SOM value of 1% has been used for the selection of generic assessment criteria, as this provides the most conservative assessment.

9.2.7 The proposed development is to involve the demolition of Elleray Hall and the construction of a two-storey block of flats with associated soft landscaping, and the construction of a community centre on the currently vacant North Lane Depot/East Car Park plots.

9.2.8 As a result, the proposed development on the southern site is classified as "residential with plant uptake". The community centre on the northern plot may be considered "commercial". Due to these differing end uses, the results from each pot have been assessed separately against their respective assessment criteria.

9.3 BRE

9.3.1 The BRE Special Digest 1:2005, 'Concrete in Aggressive Ground' is used with soluble sulphate and pH results to assess the aggressive chemical environment of future underground concrete structures at the site.

9.4 Analytical Framework – Groundwater and Leachate

9.4.1 The requirement to protect groundwater from pollution is outlined in Groundwater protection: Principles and practice (GP3, EA, August 2013, v1.1).

9.4.2 Where undertaken, the groundwater quality analysis comprises a Level 1 assessment in accordance with the EA Remedial Targets Methodology Document (EA, 2006).

9.4.3 The criteria used by Jomas' in the Level 1 assessment of groundwater and leachate quality are shown in Table 9.2.

Table 9.2: Selected Assessment Criteria – Contaminants in Water

Substance Group	Determinand(s)	Assessment Criteria Selected
Metals	Arsenic, Copper, Cyanide, Mercury, Nickel, Lead, Zinc, Chromium	EQS/DWS
	Selenium	DWS
PAHs	Sum of Four – benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, indeno(1,2,3-c,d)pyrene	DWS
PAHs	Benzo(a)pyrene,	DWS
PAHs	Remainder	LEC
Total Petroleum Hydrocarbons	Aliphatic C5-C6, Aliphatic >C6-C8, Aliphatic >C8-C10. Aliphatic >C10-C12, Aliphatic >C12-C16, Aliphatic >C16-C21, Aromatic C5-C7, Aromatic >C7-C8, Aromatic >C8-C10, Aromatic >C10-C12, Aromatic >C12-C16, Aromatic >C16-C21, Aromatic> C21-C35	DWS/WHO
Benzene	Benzene	DWS
Toluene	Toluene	EQS
Ethylbenzene	Ethylbenzene	EQS
Xylene	Xylene	EQS

Substance Group	Determinand(s)	Assessment Criteria Selected
Oxygen Demand	Chemical Oxygen Demand and Biological Oxygen Demand	Urban Waste Water Treatment (England and Wales) Regulations

Environmental Quality Standards EQS

Environmental Quality Standards (EQS) have been released by the EA for dangerous substances, as identified by the EC Dangerous Substances Directive. EQS can vary for each substance, for the hardness of the water and can be different for fresh, estuarine or coastal waters.

Lowest Effect Concentration (LEC)

These criteria relate to the concentration of PAHs in groundwater. They are taken from the EA R&D Technical Report P45 – Polycyclic Aromatic Hydrocarbons (PAH): Priorities for Environmental Quality Standard Development (2001).

WHO Health

These screening criteria have been taken from the World Health Organisation Guidelines for Drinking Water Quality (1984). The health value is a guideline value representing the concentration of a contaminant that does not result in any significant risk to the receptor over a lifetime of exposure.

Further criteria have been obtained from 'Petroleum Products in Drinking-water' - Background document for development of WHO Guidelines for Drinking-water Quality (2005).

UK Drinking Water Standards (DWS)

These comprise screening criteria provided by the Drinking Water Inspectorate (DWI) in the Water Supply (Water Quality) Regulations 2006,

Urban Waste Water Treatment (England and Wales) Regulations - UWWT Regs

The Urban Waste Water Treatment (England and Wales) Regulations SI/1994/2841 as amended by SI/2003/1788 sets down minimum standards for the discharge of treated effluent from waste water treatment works to inland surface waters, groundwater, estuaries or coastal waters. Standards of (125mg/L) COD and (25mg/L) BOD have been set.

10 GENERIC QUANTITATIVE RISK ASSESSMENT

10.1 Screening of Soil Chemical Analysis Results – Human Health Risk Assessment

Laboratory analysis for soils obtained by Concept (with laboratory certificates included in their Factual Report) are summarised in the tables below.

Northern Plot (current car park and former depot site): Proposed Commercial Use

10.1.1 The results below represent samples obtained from the northern site, currently in use as a car park and former depot and proposed to be redeveloped to provide a new community centre facility. Based on this proposed end use, comparison of results is made against criteria protective of human health within a "commercial" end use setting.

Table 10.1: Soil Laboratory Analysis Results – Metals, Metalloids, Phenol, Cyanide – Northern Plot

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No. Exceeding
Arsenic	mg/kg	15	S4UL	640	11	30	0
Cadmium	mg/kg	15	S4UL	190	<0.1	3.2	0
Chromium	mg/kg	15	S4UL	8600	3.5	38	0
Lead	mg/kg	15	C4SL	2330	50	1200	0
Mercury	mg/kg	15	S4UL	320	<0.1	5.3	0
Nickel	mg/kg	15	S4UL	980	3.7	36	0
Copper	mg/kg	15	S4UL	68000	8.4	2000	0
Zinc	mg/kg	15	S4UL	730000	33	470	0
Total Cyanide [A]	mg/kg	15	CLEA v 1.06	33	<0.50	12	0
Selenium	mg/kg	15	S4UL	12000	<0.20	0.37	0
Boron Water Soluble	mg/kg	15	S4UL	240000	<0.4	1.8	0
Phenols	mg/kg	15	S4UL	440	<0.3	170	0

Notes: [A] Generic assessment criteria derived for free inorganic cyanide.

Table 10.2: Soil Laboratory Analysis Results – Polycyclic Aromatic Hydrocarbons (PAHs) – Northern Plot

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Naphthalene	mg/kg	15	S4UL	190	<0.10	370	1No (WS5@0.25mbgl)
Acenaphthylene	mg/kg	15	S4UL	83000	<0.10	66	-
Acenaphthene	mg/kg	15	S4UL	84000	<0.10	59	-
Fluorene	mg/kg	15	S4UL	63000	<0.10	150	-
Phenanthrene	mg/kg	15	S4UL	22000	<0.10	710	-
Anthracene	mg/kg	15	S4UL	520000	<0.10	200	-
Fluoranthene	mg/kg	15	S4UL	23000	<0.10	760	-
Pyrene	mg/kg	15	S4UL	54000	<0.10	680	-
Benzo(a)anthracene	mg/kg	15	S4UL	170	<0.10	360	2No (WS3@0.25mbgl, BH1@0.25mbgl)
Chrysene	mg/kg	15	S4UL	350	<0.10	270	-
Benzo(b)fluoranthene	mg/kg	15	S4UL	44	<0.10	160	6No (WS1@0.30mbgl, WS3@0.25mbgl, WS4@0.10mbgl, WS5@0.25mbgl, BH1@0.25mbgl, BH1@0.40mbgl)
Benzo(k)fluoranthene	mg/kg	15	S4UL	1200	<0.10	160	-
Benzo(a)pyrene	mg/kg	15	S4UL	35	<0.10	340	6No (WS1@0.30mbgl, WS3@0.25mbgl, WS4@0.10mbgl, WS5@0.25mbgl, BH1@0.25mbgl, BH1@0.40mbgl)
Indeno(123-cd)pyrene	mg/kg	15	S4UL	500	<0.10	220	-
Dibenzo(ah)anthracene	mg/kg	15	S4UL	3.5	<0.10	59	6No (WS1@0.30mbgl, WS3@0.25mbgl, WS4@0.10mbgl, WS5@0.25mbgl, BH1@0.25mbgl, BH1@0.40mbgl)
Benzo(ghi)perylene	mg/kg	15	S4UL	3900	<0.10	200	-
Total PAH	mg/kg	15	-		<2.0	4400	-

Table 10.3: Soil Laboratory Analysis Results – Total Petroleum Hydrocarbons (TPH) – Northern Plot

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
C_8-C_{10}	mg/kg	6	S4UL	2000	<1.0	6.7	0
>C_{10}-C_{12}	mg/kg	6	S4UL	9700	<1.0	18	0
>C_{12}-C_{16}	mg/kg	6	S4UL	36000	<1.0	200	0
>C_{16}-C_{21}	mg/kg	6	S4UL	28000	11	1200	0
>C_{21}-C_{35}	mg/kg	6	S4UL	28000	16.7	1520	0
Total TPH	mg/kg	6	-	-	34	3200	-

Note: *The lower value of guidelines for Aromatic/Aliphatics has been selected

Table 10.4: Soil Laboratory Analysis Results – Total Petroleum Hydrocarbons (TPHCWG) – Northern Plot

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
>C_5-C_6 Aliphatic	mg/kg	9	S4UL	3200	<1.0	<1.0	0
>C_6-C_8 Aliphatic	mg/kg	9	S4UL	7800	<1.0	<1.0	0
>C_8-C_{10} Aliphatic	mg/kg	9	S4UL	2000	<1.0	72	0
>C_{10}-C_{12} Aliphatic	mg/kg	9	S4UL	9700	<1.0	120	0
>C_{12}-C_{16} Aliphatic	mg/kg	9	S4UL	59000	<1.0	450	0
>C_{16}-C_{35} Aliphatic	mg/kg	9	S4UL	1600000	20.3	1670	0
>C_5-C_7 Aromatic	mg/kg	9	S4UL	1600000	<1.0	<1.0	0
>C_7-C_8 Aromatic	mg/kg	9	S4UL	26000	<1.0	<1.0	0
>C_8-C_{10} Aromatic	mg/kg	9	S4UL	56000	<1.0	280	0
>C_{10}-C_{12} Aromatic	mg/kg	9	S4UL	3500	<1.0	5200	1No (WS5@0.25mbgl)
>C_{12}-C_{16} Aromatic	mg/kg	9	S4UL	16000	<1.0	9900	0
>C_{16}-C_{21} Aromatic	mg/kg	9	S4UL	36000	27	19000	0
>C_{21}-C_{35} Aromatic	mg/kg	9	S4UL	28000	97	27000	0
Total TPH (Ali/Aro)	mg/kg	9	-		150	67000	-

10.1.2 In addition to the suites above, 9No samples were also screened for the presence of volatile organic compounds (VOCs). VOCs were detected above method detection limits only in samples of the made ground in WS5 and WS3. The table below summarises the results for the compounds reported above detection limit.

Table 10.5: Soil Laboratory Analysis Results – Total Petroleum Hydrocarbons (TPHCWG) – Northern Plot

Volatile Organic Compound	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Benzene	mg/kg	9	S4UL	27	<0.001	0.51	0
Toluene	mg/kg	9	S4UL	56000	<0.001	2.2	0
Ethylbenzene	mg/kg	9	S4UL	57000	<0.001	0.16	0
M & p xylene	mg/kg	9	S4UL	12100	<0.001	2.2	0
o-xylene	mg/kg	9	S4UL	6600	<0.001	1.2	0
Styrene	mg/kg	9	S4UL	3300	<0.001	0.73	0
Isopropylbenzene	mg/kg	9	S4UL	1400	<0.001	0.014	0
1,3,5-trimethylbenzene	mg/kg	9	-	-	<0.001	0.18	0
1,2,4-trimethylbenzene	mg/kg	9	S4UL	42	<0.001	1.1	0

10.2 Vapour Risk Assessment from a Soil Source (Northern Plot)

10.2.1 As outlined in Tables 10.2-10.4, a number of polyaromatic hydrocarbons and a single petroleum hydrocarbon fraction have been found in excess of their generic screening criteria for the protection of human health within a 'commercial' end-use scenario. The generic screening criteria considers all possible pathways between the source and the receptor. In order to assess potential risks from inhalation of vapour, each organic compound that has been found in excess of its GAC will be assessed in terms of the contribution to total exposure from vapour inhalation inside a structure as reported within the LQM/CIEH S4UL document. Where a significant proportion of the total exposure is reported from vapour inhalation, there could be a potential risk from vapour inhalation.

Table 10.6: Soil Laboratory Analysis Results – Contribution to Total Exposure from Vapour Inhalation (Indoor)

Compound	Contribution of Vapour Inhalation to Total Exposure (%)	Screening Criteria (mg/kg)	Maximum recorded value (mg/kg)	Potential Vapour Risk?
Naphthalene	52.3	190	370	✓
Benzo(a)anthracene	<0.1	170	360	X

Compound	Contribution of Vapour Inhalation to Total Exposure (%)	Screening Criteria (mg/kg)	Maximum recorded value (mg/kg)	Potential Vapour Risk?
Benzo(b)fluoranthene	0.1	44	160	X
Benzo(a)pyrene	0.0	35	340	X
Dibenzo(ah)anthracene	0.0	3.5	3.5	X
>C_{10}-C_{12} Aromatic	16.3	3500	5200	✓

10.2.2 As shown in the table above, the concentrations of naphthalene and C10-C12 aromatic hydrocarbons detected in a sample from WS5 at 0.25m bgl theoretically pose a significant risk via vapour inhalation pathways. These exceedances of assessment criteria correlate approximately with the records of "pockets of a black tar substance" reported on the WS5 log between 0.20-0.22mbgl.

Southern Plot (current town hall site): Proposed Residential Use

10.2.3 The results below represent samples obtained from the southern site, currently in use as a town hall/community centre and proposed to be redeveloped to provide a new residential development.

10.2.4 Based on this proposed end use, comparison of results is made against criteria protective of human health within a "residential with plant uptake" end use setting.

Table 10.7: Soil Laboratory Analysis Results – Metals, Metalloids, Phenol, Cyanide – Southern Plot

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No. Exceeding
Arsenic	mg/kg	8	S4UL	37	9.9	39	1No (BH2@0.30mbgl)
Cadmium	mg/kg	8	S4UL	11	<0.10	1.0	0
Chromium	mg/kg	8	S4UL	910	12	23	0
Lead	mg/kg	8	C4SL	200	33	620	3No (WS7@0.30mbgl, WS10@0.30mbgl, BH2@0.20mbgl)
Mercury	mg/kg	8	S4UL	40	<0.10	1.1	0
Nickel	mg/kg	8	S4UL	180	9.6	23	0
Copper	mg/kg	8	S4UL	2400	11	89	0
Zinc	mg/kg	8	S4UL	3700	32	430	0
Total Cyanide [A]	mg/kg	8	CLEA v 1.06	33	<0.50	0.50	0

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No. Exceeding
Selenium	mg/kg	8	S4UL	250	<0.20	0.67	0
Boron Water Soluble	mg/kg	8	S4UL	290	0.58	0.90	0
Phenols	mg/kg	8	S4UL	120	<0.3	<0.3	0

Notes: [A] Generic assessment criteria derived for free inorganic cyanide.

Table 10.8: Soil Laboratory Analysis Results – Polycyclic Aromatic Hydrocarbons (PAHs) – Southern Plot

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Naphthalene	mg/kg	8	S4UL	2.3	<0.10	0.63	0
Acenaphthylene	mg/kg	8	S4UL	170	<0.10	0.80	0
Acenaphthene	mg/kg	8	S4UL	210	<0.10	0.14	0
Fluorene	mg/kg	8	S4UL	170	<0.10	0.43	0
Phenanthrene	mg/kg	8	S4UL	95	<0.10	3.4	0
Anthracene	mg/kg	8	S4UL	2400	<0.10	0.74	0
Fluoranthene	mg/kg	8	S4UL	280	<0.10	10	0
Pyrene	mg/kg	8	S4UL	620	<0.10	9.4	0
Benzo(a)anthracene	mg/kg	8	S4UL	7.2	<0.10	4.5	0
Chrysene	mg/kg	8	S4UL	15	<0.10	4.2	0
Benzo(b)fluoranthene	mg/kg	8	S4UL	2.6	<0.10	7.1	3No (WS7@0.30mbgl, WS10@0.30mbgl, BH2@0.30mbgl)
Benzo(k)fluoranthene	mg/kg	8	S4UL	77	<0.10	2.9	0
Benzo(a)pyrene	mg/kg	8	S4UL	2.2	<0.10	5.5	3No (WS7@0.30mbgl, WS10@0.30mbgl, BH2@0.30mbgl)
Indeno(123-cd)pyrene	mg/kg	8	S4UL	27	<0.10	3.9	0
Dibenzo(ah)anthracene	mg/kg	8	S4UL	0.24	<0.10	1.1	4No (WS9@0.60mbgl, WS7@0.30mbgl, WS10@0.30mbgl, BH2@0.30mbgl)
Benzo(ghi)perylene	mg/kg	8	S4UL	320	<0.10	4.2	0

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Total PAH	mg/kg	8	-	-	<2.0	59	-

Table 10.9: Soil Laboratory Analysis Results – Total Petroleum Hydrocarbons (TPH) – Southern Plot

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
C_8-C_{10}	mg/kg	6	S4UL	27	<1.0	<1.0	
>C_{10}-C_{12}	mg/kg	6	S4UL	74	<1.0	20	
>C_{12}-C_{16}	mg/kg	6	S4UL	140	<1.0	52	
>C_{16}-C_{21}	mg/kg	6	S4UL	260	<1.0	29	
>C_{21}-C_{35}	mg/kg	6	S4UL	1100	<1.0	3420	1No (WS6@0.10mbgl)
Total TPH	mg/kg	6	-	-	<10	5500	-

Note: *The lower value of guidelines for Aromatic/Aliphatics has been selected

Table 10.10: Soil Laboratory Analysis Results – Total Petroleum Hydrocarbons (TPHCWG) – Southern Plot

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
>C_5-C_6 Aliphatic	mg/kg	3	S4UL	42	<1.0	<1.0	0
>C_6-C_8 Aliphatic	mg/kg	3	S4UL	100	<1.0	<1.0	0
>C_8-C_{10} Aliphatic	mg/kg	3	S4UL	27	<1.0	<1.0	0
>C_{10}-C_{12} Aliphatic	mg/kg	3	S4UL	130	<1.0	<1.0	0
>C_{12}-C_{16} Aliphatic	mg/kg	3	S4UL	1100	<1.0	<1.0	0
>C_{16}-C_{35} Aliphatic	mg/kg	3	S4UL	65000	<2.0	<2.0	0
>C_5-C_7 Aromatic	mg/kg	3	S4UL	70	<1.0	<1.0	0
>C_7-C_8 Aromatic	mg/kg	3	S4UL	130	<1.0	<1.0	0
>C_8-C_{10} Aromatic	mg/kg	3	S4UL	34	<1.0	<1.0	0
>C_{10}-C_{12} Aromatic	mg/kg	3	S4UL	74	<1.0	<1.0	0
>C_{12}-C_{16} Aromatic	mg/kg	3	S4UL	140	<1.0	<1.0	0
>C_{16}-C_{21} Aromatic	mg/kg	3	S4UL	260	<1.0	<1.0	0
>C_{21}-C_{35} Aromatic	mg/kg	3	S4UL	1100	<2.0	<2.0	0

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Total TPH (Ali/Aro)	mg/kg	3	-	-	<10	<10	-

10.3 Volatile Organic Compounds

10.3.1 In addition to the suites outlined previously, 3No samples were tested for the presence of volatile organic compounds including BTEX compounds (benzene, toluene, ethylbenzene, xylene). No VOCs were reported above the laboratory detection limit within any tested sample.

10.4 Vapour Risk Assessment from a Soil Source (Southern Plot)

10.4.1 As outlined in Tables 10.8-10.9, a number of polyaromatic hydrocarbons and a single petroleum hydrocarbon fraction have been found in excess of their generic screening criteria for the protection of human health within a 'residential with plant uptake' end-use scenario. The generic screening criteria considers all possible pathways between the source and the receptor. In order to assess potential risks from inhalation of vapour, each organic compound that has been found in excess of its GAC will be assessed in terms of the contribution to total exposure from vapour inhalation inside a structure as reported within the LQM/CIEH S4UL document. Where a significant proportion of the total exposure is reported from vapour inhalation, there could be a potential risk from vapour inhalation.

Table 10.11: Soil Laboratory Analysis Results – Contribution to Total Exposure from Vapour Inhalation (Indoor)

Compound	Contribution of Vapour Inhalation to Total Exposure (%)	Screening Criteria (mg/kg)	Maximum recorded value (mg/kg)	Potential Vapour Risk?
Benzo(b)fluoranthene	<0.1	2.6	7.1	X
Benzo(a)pyrene	0.0	2.2	5.5	X
Dibenzo(ah)anthracene	<0.1	0.24	1.1	X
C21-C35	7.0/0.0*	6500/1100*	3420	X

*aliphatic/aromatic

10.4.2 As shown in the table above, all of the PAHs detected in soils in excess of generic assessment criteria have a negligible contribution to total exposure via inhalation pathway (less or equal to 0.1%).

10.4.3 The petroleum hydrocarbon exceedance relates to a grouped hydrocarbon analysis, not split into aliphatic and aromatic fractions. The total reported hydrocarbons within the fraction in question does not exceed the criteria for aliphatic fractions, for which the contribution to exposure from vapour is 7%, and only exceeds the criteria for aromatic fractions which have a 0% contribution to exposure from vapour. On this basis, the petroleum hydrocarbons identified on the southern site are not considered to pose a significant risk from vapour inhalation.

10.4.4 Therefore, it is considered that there is a negligible risk to end users of the proposed development on the southern plot associated with vapour risk inhalation from soils.

10.5 Asbestos in Soil

10.5.1 15No samples of the Made Ground were screened in the laboratory for the presence of asbestos across the two sites.

10.5.2 No asbestos fibres were reported in samples analysed in the laboratory.

10.6 Screening of Groundwater Chemical Analysis Results

10.6.1 A sample of groundwater obtained from the borehole installation installed within exploratory location BH2 was obtained by low-flow methodology and submitted for analysis. At the time of writing a sample from BH1 was still outstanding due to lack of access to the standpipe during the previous sampling visit.

10.6.2 The results of the laboratory testing are summarised in Tables 10.12 to 10.14 below.

Table 10.12: Groundwater Analysis Results – Metals, Cyanide, Phenol

Determinand	Unit	No. samples tested	Screening Criteria		Result	No of Exceedances
Arsenic	µg/l	1	10	DWS	0.57	0
	µg/l		50	EQS	0.57	0
Cadmium	µg/l	1	5	DWS	<0.12	0
Chromium	µg/l	1	50	DWS	6.9	0
Lead	µg/l	1	10	DWS	<0.50	0
	µg/l		1.2*	EQS	<0.50	0
Nickel	µg/l	1	20	DWS	1.0	0
	µg/l		4*	EQS	1.0	0
Copper	µg/l	1	12	EQS	1.5	0
			2000	DWS	1.5	0
Zinc	µg/l	1	5000	DWS	4.0	0
	µg/l		12.9**	EQS	4.0	0
Mercury	µg/l	1	1	DWS	<0.05	0

Determinand	Unit	No. samples tested	Screening Criteria		Result	No of Exceedances
Selenium	µg/l	1	10	DWS	1.2	0
Boron	µg/l	1	1000	DWS	110	0
	µg/l		2000	EQS	110	0
Cyanide (Total)	µg/l	1	50	DWS	<0.05	0
	µg/l		1	EQS	<0.05	0
Phenols (Total)	µg/l	1	7.7	EQS	<0.030	0

* bioavailable concentration

**bioavailable concentration + ambient background concentration dissolved for Thames Groundwater (2 µg/L)

Table 10.13: Groundwater Analysis Results – Polycyclic Aromatic Hydrocarbons (PAHs)

Determinand	Unit	No. samples tested	Screening Criteria		Result	No. of Exceedances
Naphthalene	µg/l	1	2.4	EQS	<0.10	0
Acenaphthylene	µg/l	1	-	-	<0.10	-
Acenaphthene	µg/l	1	-	-	<0.10	-
Fluorene	µg/l	1	-	-	<0.10	-
Phenanthrene	µg/l	1	-	-	<0.10	-
Anthracene	µg/l	1	0.1	EQS	<0.10	0
Fluoranthene	µg/l	1	0.0063	EQS	<0.10	0
Pyrene	µg/l	1	-	-	<0.10	-
Benzo(a)anthracene	µg/l	1	-	-	<0.10	-
Chrysene	µg/l	1	-	-	<0.10	-
Sum of four Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(ghi)perylene Indeno(123-cd)pyrene	µg/l	1	0.1	DWS	<0.40	0
Benzo(a)pyrene	µg/l	1	0.01	DWS	<0.10	0
Dibenzo(ah)anthracene	µg/l	1	0.00017	EQS	<0.10	0

Table 10.14: Groundwater Analysis Results – TPHCWG – Controlled Waters

Determinand	Unit	No. Samples tested	Screening Criteria		Result	No. of Exceedances
>C5-C6 Aliphatic	µg/l	1	15000	WHO	<0.10	0
>C6-C8 Aliphatic	µg/l	1	15000	WHO	<0.10	0

Determinand	Unit	No. Samples tested	Screening Criteria		Result	No. of Exceedances
>C8-C10 Aliphatic	µg/l	1	300	WHO	<0.10	0
>C10-C12 Aliphatic	µg/l	1	300	WHO	<0.10	0
>C12-C16 Aliphatic	µg/l	1	300	WHO	<0.10	0
>C16-C21 Aliphatic	µg/l	1	-	-	<0.10	-
>C21-C35 Aliphatic	µg/l	1	90	WHO	<0.10	0
>C5-C7 Aromatic	µg/l	1	10	WHO	<0.10	0
>C7-C8 Aromatic	µg/l	1	700	WHO	<0.10	0
>C8-C10 Aromatic	µg/l	1	300	WHO	<0.10	0
>C10-C12 Aromatic	µg/l	1	90	WHO	<0.10	0
>C12-C16 Aromatic	µg/l	1	90	WHO	<0.10	0
>C16-C21 Aromatic	µg/l	1	90	WHO	<0.10	0
>C21-C35 Aromatic	µg/l	1	90	WHO	<0.10	0

10.6.3 In addition to the suite outlined above, the water sample was also analysed for a suite of volatile organic compounds including BTEX. None of the compounds analysed for were reported above the laboratory method detection limit.

10.6.4 The results summarised above are considered to show that no significant harm to groundwater within the Kempton Park Gravel is occurring within the southern plot.

10.6.5 Further assessment of groundwater impacts will be undertaken within the final report once the outstanding water sample has been obtained from the northern plot.

10.7 Screening of Soil Chemical Analysis Results – Potential Risks to Plant Growth

10.7.1 Zinc, copper and nickel are phytotoxins and could therefore inhibit plant growth in soft landscaped areas. Concentrations measured in soil for these determinands have been compared with the pH dependent values given in BS: 3882 (2015).

10.7.2 Adopting a pH value of greater than 7, as indicated by the results of the laboratory analysis, the following is noted;

Table 10.15: Soil Laboratory Analysis Results – Phytotoxic Determinands – Northern Plot

Determinand	Threshold level (mg/kg)	Min (mg/kg)	Max (mg/kg)	No. Exceeding
Nickel	110	3.7	36	0
Copper	200	8.4	2000	1No

Determinand	Threshold level (mg/kg)	Min (mg/kg)	Max (mg/kg)	No. Exceeding
				(WS2@0.30mbgl)
Zinc	300	33	470	2No (WS1@0.60mbgl, WS2@0.30mbgl)

Table 10.16: Soil Laboratory Analysis Results – Phytotoxic Determinands – Southern Plot

Determinand	Threshold level (mg/kg)	Min (mg/kg)	Max (mg/kg)	No. Exceeding
Nickel	110	9.6	23	0
Copper	200	11	89	0
Zinc	300	32	430	1No (WS10@0.30mbgl)

10.8 Screening for Water Pipes

10.8.1 The results of the analysis have been assessed for potential impact upon water supply pipes. Tables 10.17-10.18 below summarise the findings of the assessment:

Table 10.17: Screening Guide for Water Pipes – Northern Plot

Determinand	No. of tests	Threshold adopted for PE (mg/kg)	Value for site data (mg/kg)		No of Exceedances
			Min	Max	
Total VOCs	9	0.5	ND	8.294	1No (WS5@0.25mbgl)
BTEX	9	0.1	ND	6.27	1No (WS5@0.25mbgl)
MTBE	9	0.1	ND	ND	0
EC5-EC10	15	1	ND	352	7No (WS3@0.25mbgl, WS5@0.25mbgl, WS5@0.40mbgl, BH1@0.25mbgl, BH1@0.40mbgl, STP1@0.10mbgl, STP2@0.40mbgl)
EC10-EC16	15	10	ND	15670	11No (WS1@0.30mbgl, WS2@1.0mbgl, WS3@0.25mbgl, WS3@1.00mbgl,

Determinand	No. of tests	Threshold adopted for PE (mg/kg)	Value for site data (mg/kg)		No of Exceedances
			Min	Max	
					WS4@0.10mbgl, WS5@0.25mbgl, WS5@0.40mbgl, BH1@0.25mbgl, BH1@0.40mbgl, STP1@0.10mbgl, STP2@0.40mbgl)
EC16-EC40	15	500	ND	47670	11No (WS1@0.30mbgl, WS3@0.25mbgl, WS4@0.10mbgl, WS5@0.25mbgl, WS5@0.40mbgl, BH1@0.25mbgl, BH1@0.40mbgl, STP1@0.10mbgl)
Naphthalene	15	5	ND	370	6No (WS3@0.25mbgl, WS3@1.00mbgl, WS5@0.25mbgl, WS5@0.40mbgl, BH1@0.25mbgl, BH1@0.40mbgl)
Phenols	15	2	ND	170	1No (WS5@0.25mbgl)

ND – None detected

Table 10.18: Screening Guide for Water Pipes – Southern Plot

Determinand	No. of tests	Threshold adopted for PE (mg/kg)	Value for site data (mg/kg)		No of Exceedances
			Min	Max	
Total VOCs	3	0.5	ND	ND	0
BTEX	3	0.1	ND	ND	0
MTBE	3	0.1	ND	ND	0
EC5-EC10	9	1	ND	1.4	2No (WS6@0.10mbgl, WS8@0.60mbgl)
EC10-EC16	9	10	ND	72	2No (WS6@0.10mbgl, WS8@0.60mbgl)
EC16-EC40	9	500	ND	5349	1No (WS6@0.10mbgl)
Naphthalene	9	5	ND	0.63	0

Determinand	No. of tests	Threshold adopted for PE (mg/kg)	Value for site data (mg/kg)		No of Exceedances
			Min	Max	
Phenols	9	2	ND	ND	0

ND – None detected

10.8.2 The above suggests that upgraded pipe work is likely to be required across both plots.

10.8.3 Alternatively, it may be possible to utilise other protection methods including (but not limited to):

- diversion of the pipe,
- localised remediation
- embedding the pipe in a sufficient thickness of clean granular material

10.8.4 The water supply pipe requirements for this site should be discussed at an early stage with the relevant utility provider.

10.9 Waste Characterisation and Disposal

10.9.1 The following comments are given as guidance and should be confirmed by the waste disposal facility accepting the waste. The waste disposal facility may have their own classification methodology and are under no obligation to honour the comments given below.

10.9.2 Samples from WS5 – 0.25mbgl (northern plot) and BH2 – 0.6mbgl (southern plot) were scheduled for single stage WAC analysis.

10.9.3 The sample from WS5 – 0.25mbgl was reported to exceed the hazardous waste landfill limits for total organic carbon and therefore may require treatment before disposal. Inert waste landfill criteria were also exceeded for total petroleum hydrocarbons and total polyaromatic hydrocarbons.

10.9.4 The sample from BH2 -0.60mbgl was reported to exceed inert waste thresholds for antimony and fluoride. Criteria for "stable non-reactive hazardous waste in non-hazardous landfill" were not exceeded.

11 SOIL GAS RISK ASSESSMENT

11.1 Soil Gas Results

11.1.1 Four return monitoring visits have been undertaken by Concept between 10th March 2021 and 24th March 2021, to monitor wells installed within boreholes at the site for soil gas concentrations and groundwater levels..

11.1.2 Atmospheric pressures recorded during the existing monitoring visits ranged between 1009 and 1032 mbar.

11.1.3 The results of the monitoring undertaken are presented in full in the Concept Factual Report and summarised in Table 11.1 below.

Table 11.1: Summary of Gas Monitoring Data

Hole No.	CH_4 (%)	CO_2 (%)	O_2 (%)	H_2S (ppm)	VOCs (ppm)	Steady Flow Rate (l/hr)	Peak Flow Rate (l/hr)	Depth to water (mbgl)	Depth of installation (mbgl)
Northern Plot									
BH1	<0.1	0.0-4.6	18.7-19.3	<0.1	1.1-1.7	<0.1	<0.1	4.06-4.15	6.30
WS1	<0.1	0.0-5.2	18.1-19.8	<0.1	0.5-4.3	<0.1	-0.3-<0.1	Dry	2.00
WS2	<0.1	0.0-5.8	16.2-19.9	<0.1	0.4-2.8	<0.1	<0.1	Dry	2.00
Southern Plot									
BH2	<0.1	0.0-4.1	19.1-20.1	<0.1	0.2-2.7	<0.1	<0.1	4.15-4.24	6.30
WS6	<0.1	0.0-5.3	19.7-20.2	<0.1	0.9-4.6	<0.1	<0.1	Dry	2.00
WS10	<0.1	0.0-0.8	19.3-20.2	<0.1	0.7-3.9	<0.1	<0.1	Dry	2.00

11.2 Screening of Results

11.2.1 As shown in Table 11.1, no methane has been reported to date. Carbon dioxide has been reported to a maximum concentration of 5.8% v/v. Screening of the monitoring well headspaces with a photo-ionisation detector (PID) has detected maximum Volatile Organic Compound (VOC) concentration to a maximum level of 3.2ppm. A maximum flow rate of -0.3l/hr has been reported.

11.2.2 In the assessment of risks posed by hazardous ground gases and selection of appropriate mitigation measures, BS8485 (2015) + A1 (2019) identifies four types of development, termed Type A to Type D.

11.2.3 Type A buildings are defined as

"private ownership with no building management controls on alternations to the internal structure, the use of rooms, the ventilation of rooms or the structural fabric of the building. Some small rooms present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises."

11.2.4 Type A has been adopted as the relevant category for the proposed development on the southern plot.

11.2.5 Type B buildings are defined as

" private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including the gas protection measures. Multiple occupancy. Small to medium size rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres) and parts of hotels."

11.2.6 Type B has been adopted as the relevant category for the proposed development for the northern plot.

11.2.7 The soil gas assessment method is based on that proposed by Wilson & Card (1999), which was a development of a method proposed in CIRIA publication R149 (CIRIA, 1995). The method uses both gas concentrations and borehole flow rates to define a characteristic situation based on the limiting borehole gas volume flow for methane and carbon dioxide. In both these methods, the limiting borehole gas volume flow is renamed as the Gas Screening Value (GSV).

11.2.8 The Gas Screening Value (litres of gas per hour) is calculated by using the following equation

GSV = (Concentration/100) X Flow rate

Where concentration is measured in percent (%)
and flow rate is measured in litres per hour (l/hr)

11.2.9 The Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

11.2.10 To accord with C665, worst case conditions are used in the calculation of GSVs for the site.

11.2.11 A worst case flow rate of 0.3l/hr (maximum reported) will be used in the calculation of GSVs for the northern plot, and 0.1l/hr will be used for the southern plot. The Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

11.2.12 To accord with C665, worst case conditions are used in the calculation of GSVs for the site. These have been summarised below in Tables 11.2-11.3.

Table 11.2: Summary of Gas Monitoring Data – Northern Plot

Gas	Concentration (v/v %)	Peak Flow Rate (l/hr)	GSV (l/hr)	Characteristic Situation (after CIRIA C665)
CO_2	5.8	0.3	0.0174	**1**
CH_4	0.1	0.3	0.003	**1**

Table 11.3: Summary of Gas Monitoring Data – Southern Plot

Gas	Concentration (v/v %)	Peak Flow Rate (l/hr)	GSV (l/hr)	Characteristic Situation (after CIRIA C665)
CO_2	5.3	0.1	0.0053	**1**
CH_4	0.1	0.1	0.001	**1**

11.2.13 As shown in the tables above, on the basis of the data obtained, both sites could be considered Characteristic Situation 1, for which no formal gas protection measures are considered necessary; however, in accordance with BS8485, as both sites have reported carbon dioxide concentrations in excess of 5%, consideration should be given to upgrading the sites to CS2.

11.2.14 Given that no significant sources of ground gases were identified during the desk study, and no significant sources of potential ground gases were identified during the intrusive works it is considered that the site should not be classified as CS2, and a CS1 designation considered appropriate (for which no gas protection measures are required). Although no ground gas monitoring events were completed at atmospheric pressures of <1000 mbar, it is considered that this should not materially affect the conclusion that the site can be considered as CS1, given the absence of identified, significant sources.

11.2.15 PID screening of the monitoring well headspace has revealed maximum concentrations of VOCs of 3.9ppm. It is considered that the PID screening of monitoring well provides an additional supporting line of evidence to a conclusion that risks to human health receptors via vapour inhalation pathways are low.

12 SUMMARY OF RESULTS

12.1 Risk Assessment - Land Quality Impact Summary

12.1.1 Following the ground investigation, the following is noted:

- The proposed development is to involve the demolition of Elleray Hall and the construction of a two-storey block of flats with communal gardens (southern plot), and the construction of a community centre on the currently vacant North Lane Depot/East Car Park plots (northern plot).

  Northern Plot

- Following generic risk assessments, elevated concentrations of naphthalene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(ah)anthracene and C10-C12 aromatic petroleum hydrocarbons were detected in soils in excess of generic assessment criteria for the protection of human health within a “commercial” end-use scenario.

- No asbestos fibres were detected in the samples analysed in the laboratory.

- The site proposal indicates that large areas of site will remain covered by a combination of the proposed building footprints and hard surfacing. Where this is the case, no formal remedial measures are considered necessary in terms of human health, as the building and hard surfacing are expected to provide a barrier to potential receptors. In areas of soft landscaping, a cover layer of 450mm of clean imported sub/topsoil should be placed above a geotextile membrane.

- Exceedances of generic assessment criteria for potentially volatile compounds (naphthalene and the aromatic hydrocarbon fraction >C10-C12) were detected within made ground soils in WS5, and concentrations of volatile contaminants including BTEX compounds were detected above laboratory method detection limits in the made ground in WS5 and WS3. These concentrations of volatile contaminants were only detected in a sub-stratum of granular made ground with various anthropogenic inclusions, within which hydrocarbon odours were commonly noted. Pockets of a black tar substance were noted within this substratum in WS5. Given the relatively thin nature of the stratum, and the lack of visual / olfactory evidence of hydrocarbon or volatile contamination in soils underlying the stratum, as well as the low photo-ionisation detector readings recorded in monitoring well headspaces during monitoring events, it is considered unlikely that a significant risk to end users of the development exists via vapour inhalation pathways.

- Following groundwater sampling and laboratory analysis from monitoring wells BH1, a pollutant linkage to controlled waters is not considered to exist.

- Following four gas monitoring visits, concentrations of carbon dioxide are raised at the site, with corresponding depleted oxygen. Calculating the Gas Screening Value using worst case results indicates Characteristic Situation 1. However, due to the elevated concentrations of carbon dioxide measured in excess of 5%, consideration should be given to upgrading the sites to CS2. Given that no significant sources of ground gases were identified during the desk study, and no significant sources of potential ground gases were identified during the intrusive works it is considered that the site should not be classified as CS2, and a CS1 designation is appropriate (for which no gas protection measures are required).

- Barrier pipe is likely to be required for potable water supply pipes. The requirements should be confirmed with the relevant utility provider.

Southern Plot

- Following generic risk assessments, elevated concentrations of arsenic, lead, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(ah)anthracene and C21-C352 grouped petroleum hydrocarbons were detected in soils in excess of generic assessment criteria for the protection of human health within a “residential with plant uptake” end-use scenario on the southern plot.

- No evidence of a possible source of volatile contaminants was detected in the southern site.

- No asbestos fibres were detected in the samples analysed in the laboratory.

- The site proposals indicate that large areas of the site will be covered by a combination of the proposed building footprint and hard surfacing. Where this is the case, no formal remedial measures are considered necessary in terms of human health, as the building and hard surfacing are expected to provide a barrier to potential receptors. In areas of soft landscaping, a cover layer of

450mm of clean imported sub/topsoil should be placed above a geotextile membrane.

- It is possible that further soil sampling and assessment may allow for zoning and delineation of areas requiring clean cover in soft landscaped area.

- Following groundwater sampling and laboratory analysis from monitoring wells BH2, a pollutant linkage to controlled waters is not considered to exist.

- Following four gas monitoring visits, concentrations of carbon dioxide are raised at the site, with corresponding depleted oxygen. Calculating the Gas Screening Value using worst case results indicates Characteristic Situation 1. However, due to the elevated concentrations of carbon dioxide measured in excess of 5%, consideration should be given to upgrading the sites to CS2. Given that no significant sources of ground gases were identified during the desk study, and no significant sources of potential ground gases were identified during the intrusive works it is considered that the site should not be classified as CS2, and a CS1 designation is appropriate (for which no gas protection measures are required).

General Comments

12.1.2 As with any ground investigation, the presence of further hotspots between sampling points cannot be ruled out. Should any contamination be encountered, a suitably qualified environmental consultant should be informed immediately, so that adequate measures may be recommended.

12.1.3 Remedial strategies will be required for the proposed developments.

12.1.4 The above conclusions are made subject to approval by the statutory regulatory bodies.

12.2 Review of Pollutant Linkages Following Site Investigation

12.2.1 The site CSM has been revised and updated from that suggested in the desk study in view of the ground investigation data, including soil laboratory analysis results. Table 8.1 highlights whether pollutant linkages identified in the original CSM are still relevant following the risk assessment, or whether pollutant linkages, not previously identified, exist.

Table 12.1: Plausible Pollutants Linkages Summary (Pre Remediation)

Potential Source (from desk study)	Pathway	Receptor	Relevant Pollutant Linkage?	Comment
- Potential for contaminated ground associated with previous site use – on site (S1) o depot, o works, o car park, o unspecified industrial/commercial - Potential for Made Ground associated with previous development operations – on site (S2) - Potential for asbestos impacted soils from demolition of previous structures – on site (S3) - Previous industrial use – off site (S4) o Works (40m NW, 100m, 180m, 230m W) o Garage (60m NE) o Industrial unit with tanks (240m W)	- Ingestion and dermal contact with contaminated soil (P1) - Inhalation or contact with potentially contaminated dust and vapours (P2) - Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6)	- Construction workers (R1) - Maintenance workers (R2) - Neighbouring site users (R3) - Future site users (R4) - Building foundations and on site buried services (water mains, electricity and sewer) (R5)	Y	See section 8.1 above for remedial measures. The findings of this report should be included in the construction health and safety file, with adequate measures put in place for the protection of construction and maintenance workers. Contact should be made with relevant utility providers to confirm if upgraded materials are required. The concrete classification to protect buried concrete is discussed in Section 10.6
	- Accumulation and migration of soil gases (P5)		X	Site is considered Characteristic Situation 1 and no formal gas protection measures are considered necessary.
	- Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hardstanding or via service pipe/corridors and surface water runoff. (P3) - Horizontal and vertical migration of contaminants within groundwater (P4)	- Neighbouring site users (R3) - Building foundations and on site buried services (water mains, electricity and sewer) (R5) - Controlled waters - Principal Aquifer (R6)	X	Groundwater analysis from both plots did not report any elevated contaminant concentrations. The concrete classification to protect buried concrete is discussed in Section 10.6

13 GEOTECHNICAL GROUND INVESTIGATION

13.1 Proposed Development

13.1.1 The proposed development is to involve the demolition of Elleray Hall and the construction of a two-storey block of flats with communal gardens, and the construction of a community centre on the currently vacant North Lane Depot/East Car Park plots.

13.1.2 Preliminary foundation plans and unfactored anticipated loads have been provided for the proposed new community centre site (northern plot); however, no detailed structural engineering design information, with respect to the type of construction and associated structural loadings was provided for the proposed residential development (southern plot) at the time of preparing this report. Consequently, a detailed discussion of all the problems that may arise during the proposed redevelopment scheme is beyond the scope of this report.

13.1.3 Practical solutions to the difficulties encountered, both prior to, and during construction, are frequently decided by structural constraints or economic factors. For these reasons, this discussion is predominantly confined to remarks of a general nature, which are based on site conditions encountered during the intrusive investigations.

13.2 Geotechnical Classification

13.2.1 At the Desk Study stage this development was deemed to be a GC2 development in accordance with BS EN: 1997.

13.2.2 The findings of the investigation undertaken and discussed previously do not change this assessment.

13.2.3 As the site and the proposed development has been deemed to be a GC2 project, and each plot is a single-build (i.e. there are not proposed to be multiple structures on the same site) it is not considered necessary at this point to require a Geotechnical Feedback Report following construction. However, this will need to be confirmed within the Geotechnical Design Report (to be undertaken by others).

13.3 Geotechnical Ground Investigation Report

13.3.1 This report should only be read as a Geotechnical Ground Investigation Report (as defined by BS EN 1997) and as such outlines and discusses Geotechnical Derived Parameters for a range of geotechnical parameters that have been obtained and are discussed in the various sections below.

13.3.2 These derived values have been determined using a combination of field tests (see Section – Insitu testing), laboratory testing (see Section 3.6) or by "theory, correlation or empiricism from test results" (EN 1997-1). Laboratory analysis to determine Derived Geotechnical Parameters was undertaken as described in Section 3.6.

13.3.3 Suggestions for characteristic parameters are provided to be carried forward to determine design parameters in the final geotechnical design report (to be carried out by others).

13.3.4 It should be noted that if other parts of the development have not been designed to Eurocodes then the following comments may not be relevant or may need revising.

13.3.5 Practical solutions to the difficulties encountered, both prior to, and during construction, are frequently decided by structural constraints or economic factors. For these reasons, this discussion is predominantly confined to remarks of a general nature, which are based on site conditions encountered during the intrusive investigations.

13.4 Ground Investigation Summary

13.4.1 A summary of ground conditions obtained from the ground investigation is provided in Table 8.1.

13.4.2 The interpretation and name given to the various strata are used for identification purposes in the rest of this report.

13.4.3 The results of the ground investigation revealed a ground profile comprising Made Ground up to 1.7mbgl overlying both cohesive and granular deposits of the Kempton Park Gravel Member to a maximum depth of 6.60mbgl, overlying London Clay Formation to at least the depth of the deepest borehole at 20.0mbgl. The base of this stratum was not proven.

13.4.4 The derived geotechnical parameters, from in-situ and laboratory testing, empirical correlations and literature review are discussed below.

13.4.5 A summary of ground conditions obtained from the ground investigation and the recommended characteristic geotechnical parameters, is provided in Table 13.1 below.

13.5 Atterberg Limits

13.5.1 Samples of the cohesive Made Ground, Kempton Park Gravel Member and London Clay Formation deposits were subjected to Atterberg analysis using the 4-point methodology in accordance with BS1377-2: 1990: Clause 4.3 & 5: Definitive Method to determine the Liquid Limit, Plastic Limit and Plasticity Index as well as Moisture Content.

13.5.2 In addition, the moisture contents of the samples subjected to determination of the undrained shear strength using the quick undrained triaxial methodology were also determined as part of the analysis.

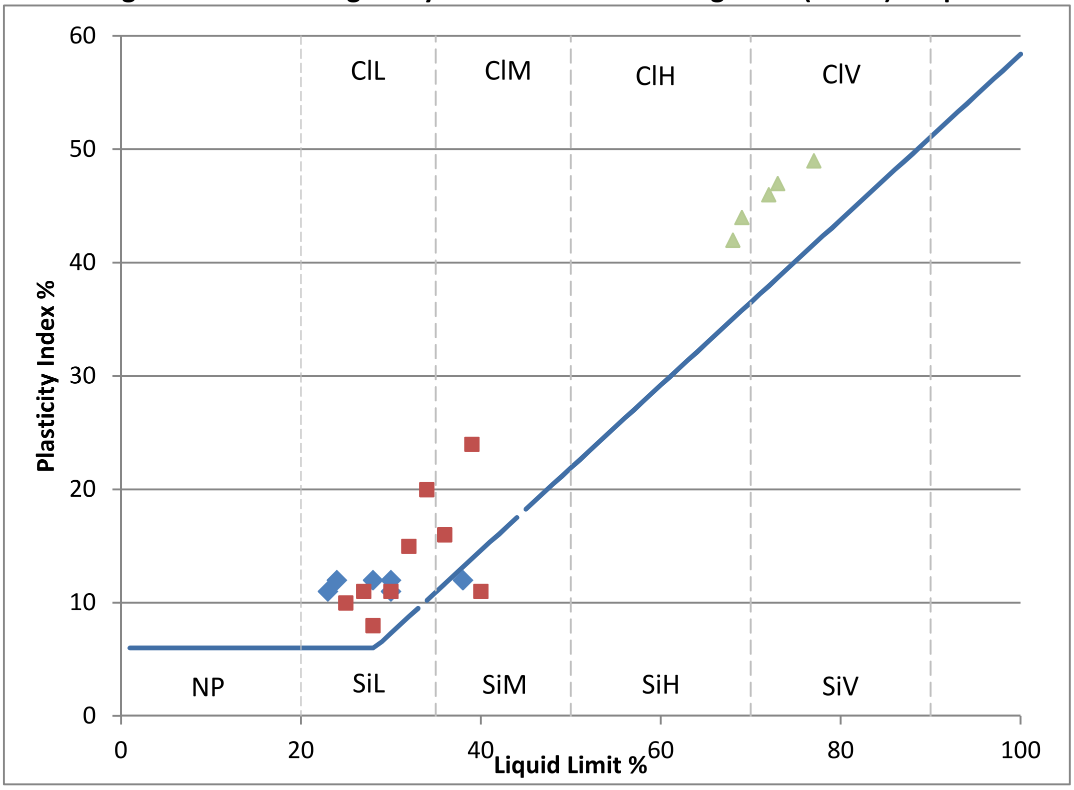
13.5.3 The results are summarised below in Table 13.1 below. The NHBC Volume Change Classification has been determined using Chapter 4.2 of the NHBC Guidelines.

Table 13.1 Moisture Content and Atterberg Limit Analysis

Property	Made Ground	Kempton Park Gravel Member (Cohesive)	Kempton Park Gravel Member (Granular)	London Clay Formation
Moisture Content (%)	13-24	10-22	10-13	24-29
Liquid Limit (%)	23-28	25-40	30-34	68-73
Plastic Limit (%)	12-26	15-29	14-19	25-26
Plasticity Index (%)	11-15	8-24	11-20	42-47
Plasticity term	Low to medium	Low to medium	Low to medium	High to Very High
Corrected Plasticity Index (%)	5.06-10.2	6.0-14.64	6.82-15.4	42-47
NHBC Volume Change Classification	None – Low	None – Low	None - Low	High

13.5.4 Due to the range of values determined for the Atterberg limit results they have been plotted onto a Casagrande A-Line graph.

Figure 13.1 Atterberg Analysis Plotted onto a Casagrande (A-line) Graph



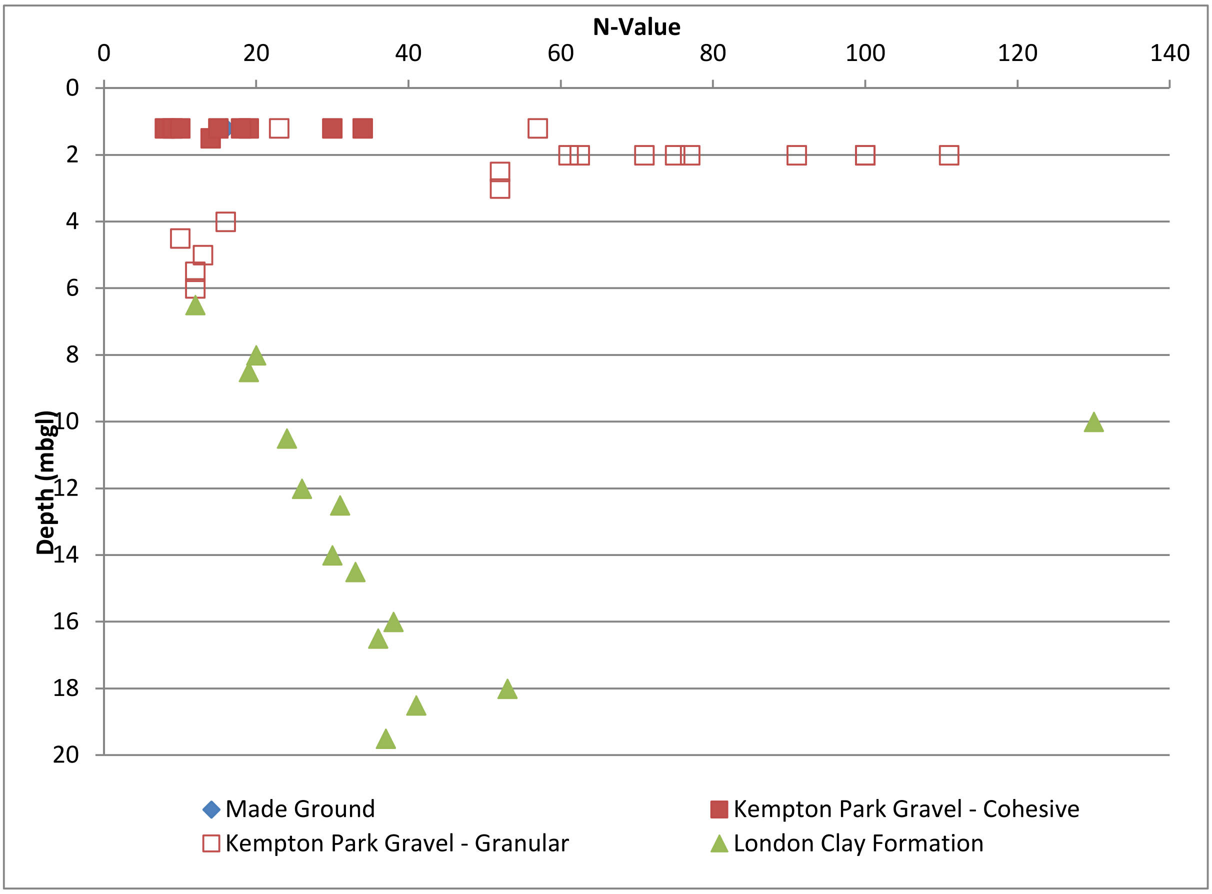
13.6 Standard Penetration Tests

13.6.1 Standard Penetration Tests were undertaken at regular intervals throughout the window sampler holes and cable percussive boreholes. The results of the SPTs are plotted against depth in Figure 13.2 below.

13.6.2 The strata have been grouped into "Made Ground", "Kempton Park Gravel Member – Cohesive", "Kempton Park Gravel – Granular", and "London Clay Formation".

13.6.3 N_{equi} results have been calculated where the full 300mm of penetration could not be achieved for 50 or more blows.

Figure 13.2: SPT 'N' Value v Depth



13.6.4 The results are broadly consistent between the two sites, as would be expected between two plots in close proximity with very similar geology. The N-values increase sharply within the granular superficial deposits, before dropping within the London Clay Formation where they start to increase with depth.

13.7 Undrained Shear Strength

13.7.1 As discussed above the N values recorded in the clay vary with depth, this infers that the undrained shear strength of the clay similarly varies. Figure 13.3 below shows the undrained shear strength inferred by the correlation suggested by Stroud (1974),

$c_u = f_1 \times N$ can be applied,

in which

c_u= mass undrained shear strength (kN)

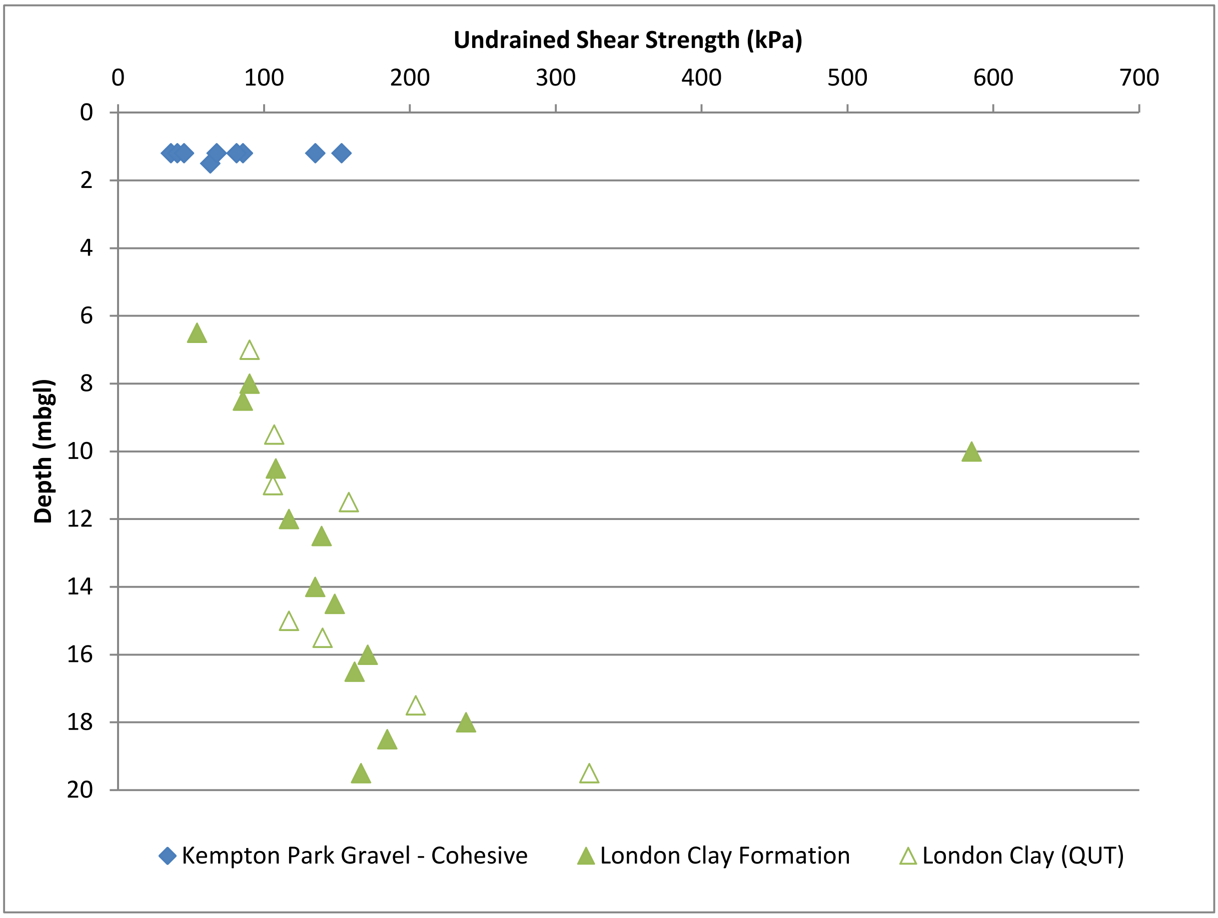
f_1 = constant

N= SPT Value achieved during boring operations

13.7.2 In the above equation f_1 is dependent on the plasticity of the material that the SPT is being carried out in. As the plasticity indices were shown to be greater than 27% a value for f_1 of 4.5 has been adopted after Tomlinson (2001).

13.7.3 The graph below shows the shear strength profile of the London Clay Formation encountered at the site, based on the SPT to shear strength correlation described above, as well as the results of undrained triaxial tests on undisturbed samples taken from the boreholes.

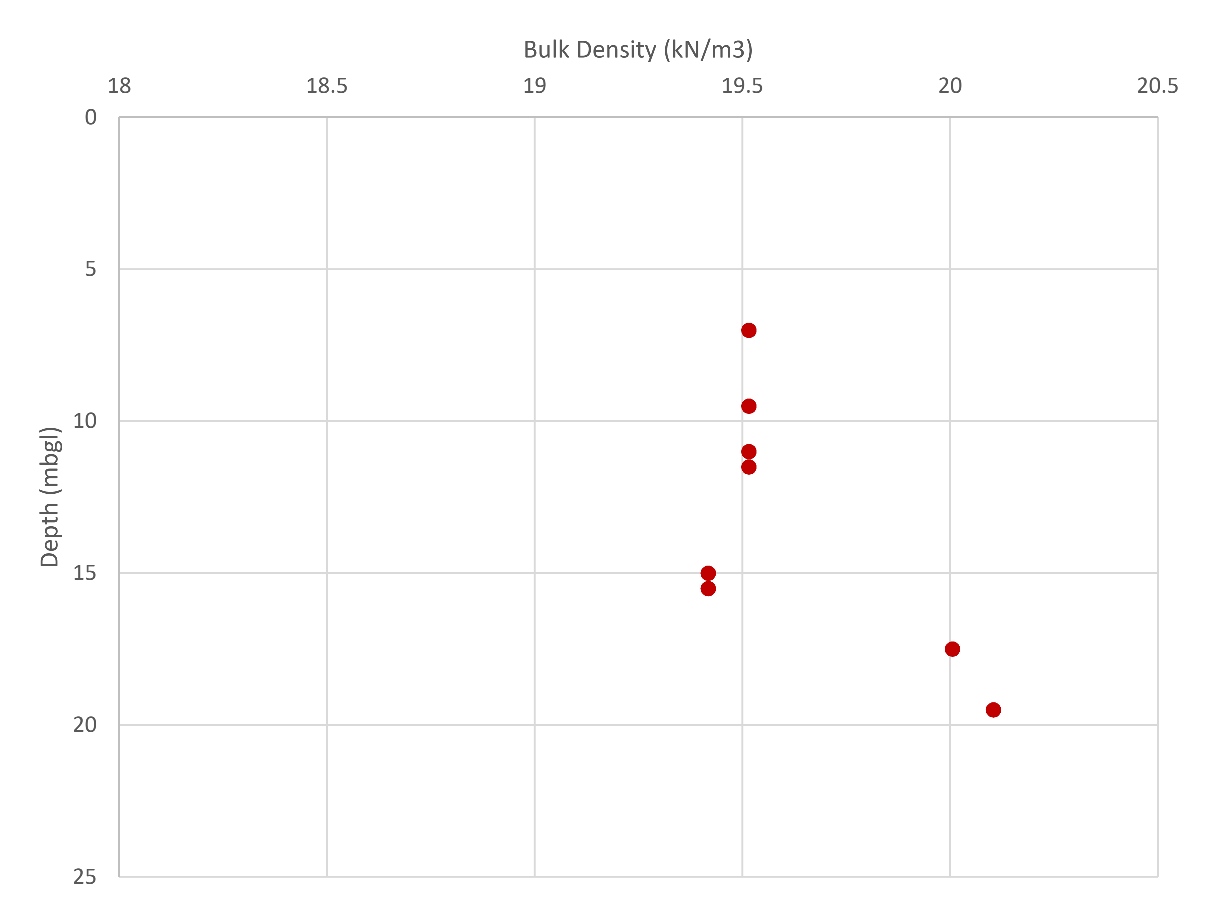
Figure 13.3: Undrained Shear Strength v Depth



13.8 Bulk Density

13.8.1 In order to calculate the undrained shear strength of undisturbed sample of London Clay, using the quick undrained triaxial methodology, the bulk density of the materials has to be calculated. These values are provided on the quick undrained triaxial testing certificates in the Concept Factual Report. These results are summarised in the figure below.

Figure 13.4: Bulk Density of London Clay v Depth



13.8.2 For materials encountered other than the London Clay, the correlations and suggested values for both cohesive and granular materials given in Carter and Butler (1991) have been used. The derived bulk densities are summarised below in Table 13.2.

Table 13.2 – Derived Bulk Densities

Strata	Bulk Density (kN/m^3)
Made Ground	16
Kempton Park Gravel Member - Cohesive	19.5
Kempton Park Gravel Member - Granular	21.5

13.9 Coefficient of Compressibility

13.9.1 Stroud and Butler (1974) developed a relationship between the coefficient of compressibility (m_v) and SPT 'N' value.

$m_v = 1/ f_2 \times N$ can be applied,

in which

m_v = coefficient of compressibility (m^2/MN)

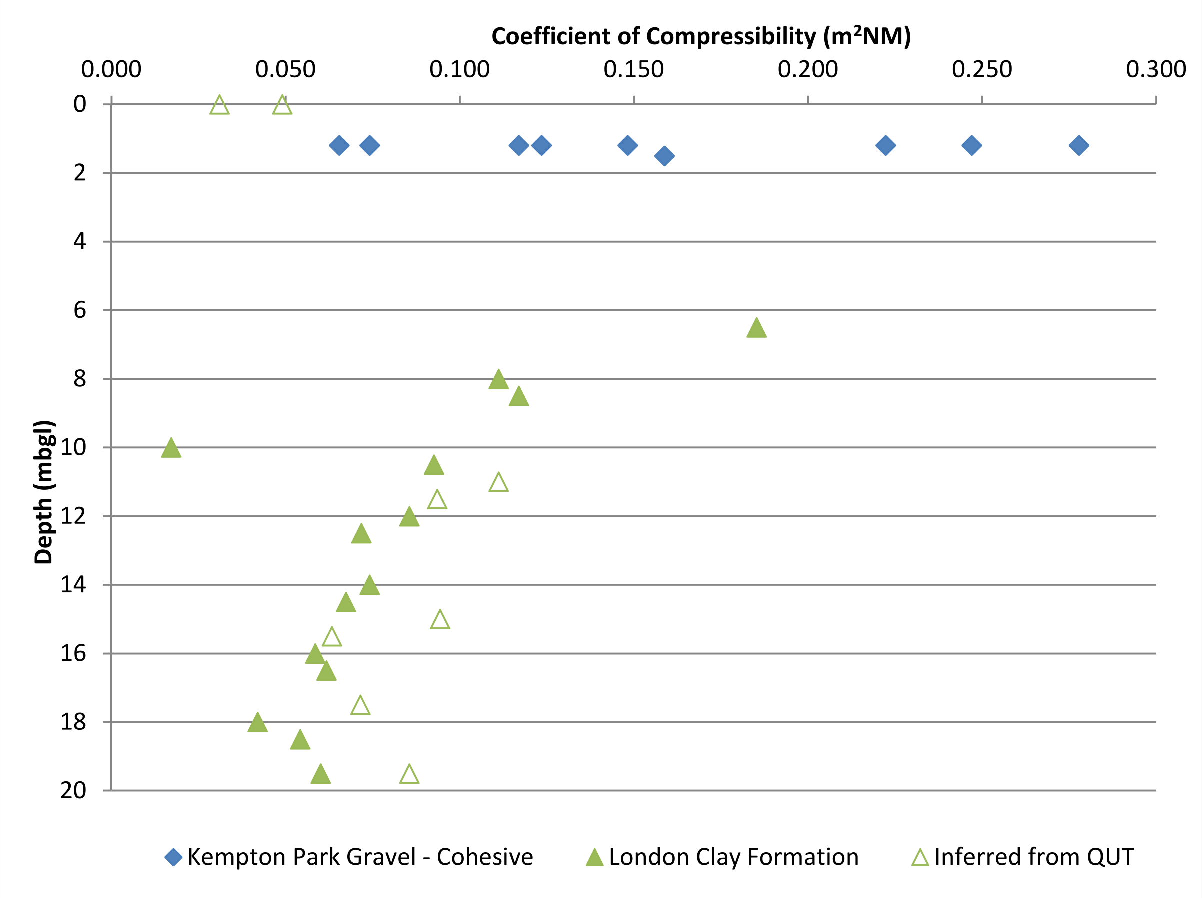
f_2 = constant dependant on the plasticity index

N = SPT Value achieved during boring operations

13.9.2 Using the plasticity indices obtained (See Table 13.1) and the graphs provided in Tomlinson (2001) a value of f_2 of 0.45 has been taken and used with the SPT 'N' values to infer coefficient of compressibility (m_v).

13.9.3 Where the undrained shear strength of the clays was obtained using the quick undrained triaxial methodology, the m_v value has been obtained by rearranging the equations for f_1 and f_2 and substituting in the measured undrained shear strength. These are plotted against depth below in Figure 13.5.

Figure 13.5: Coefficient of Volume Compressibility (m_v) v Depth



13.9.4 As would be expected, the results reduce with depth as the clay increases in strength and the over burden increases, reducing the potential for compressibility.

13.9.5 The results from of the London Clay are generally of "low compressibility" with some near surface clays of "medium compressibility". This is due to the lack of overburden pressure at shallow depth allowing the clays to relax and so compress slightly when loaded.

13.10 In-Situ CBR Testing

13.10.1 Concept undertook California Bearing Ratio tests using a Dynamic Cone Penetrometer (DCP) at each windowless sampler location across both sites as shown on the exploratory position plan provided as Figure 7.

13.10.2 The results have then been used to calculate CBR values using the methodology outlined in Interim Advice Notice 73/06 and using the method laid out in the Transport Research Laboratory document TRL 587.

13.10.3 The recorded penetration and the calculated CBR values from each position are included in the Concept Factual Report.

13.10.4 The results are summarised in the table below, however, it is noted that the DCP often reports a higher than true CBR value due to the nature of the test and due to possible effects from coarse grained inclusions.

Table 13.3: CBR Test Results

Position	CBR (%)	From/To (mm)	Stratum
WS1	39	20 – 286	Made Ground
	7	286 – 1021	Made Ground/Cohesive Kempton Park Gravel Member
	10	1021 - 1623	Cohesive Kempton Park Gravel Member
WS2	30	20 – 450	Topsoil/Made Ground
	6	450 – 680	Made Ground
	16	680 – 1285	Made Ground
	32	1285 – 1615	Made Ground/Granular Kempton Park Gravel Member
	57	1615 - 1745	Granular Kempton Park Gravel Member
WS3	46	20 – 91	Made Ground
	6	91 – 855	Made Ground/Cohesive Kempton Park Gravel Member
	63	855 – 1245	Cohesive Kempton Park Gravel Member

Position	CBR (%)	From/To (mm)	Stratum
	29	1245 – 1400	Cohesive Kempton Park Gravel Member
WS4	40	20 – 150	Made Ground
	87	150 – 305	Made Ground
	7	305 – 1040	Made Ground
	40	1040 - 1485	Made Ground/Granular Kempton Park Gravel Member
WS5	84	20 – 360	Made Ground
	33	360 – 590	Made Ground
	9	590 – 1325	Made Ground
	39	1325 – 1740	Made Ground/Granular Kempton Park Gravel Member
WS6	27	20 – 360	Made Ground
	3	360 – 1430	Made Ground/Cohesive Kempton Park Gravel Member
	12	1430 – 1725	Cohesive Kempton Park Gravel Member
	53	1725 – 1840	Cohesive Kempton Park Gravel Member
WS7	20	20 – 135	Made Ground
	7	135 – 835	Made Ground
	12	835 – 1245	Made Ground/Cohesive Kempton Park Gravel Member
	41	1245 - 1350	Cohesive Kempton Park Gravel Member
WS8	2	20 – 695	Made Ground/Cohesive Kempton Park Gravel Member
	5	695 – 1055	Cohesive Kempton Park Gravel Member
	13	1055 – 1245	Cohesive Kempton Park Gravel Member
	43	1245 – 1415	Cohesive Kempton Park Gravel Member
WS9	1	20 – 700	Made Ground
	2	700 – 992	Made Ground
	20	992 – 1415	Made Ground/ Cohesive Kempton Park Gravel Member
WS10	3	20 – 786	Made Ground/ Cohesive Kempton Park Gravel Member
	2	786 – 1400	Cohesive Kempton Park Gravel Member
	11	1400 – 1710	Cohesive Kempton Park Gravel Member

13.11 BRE 365 Soakage Tests

13.11.1 Concept undertook BRE365 soakaway testing at the site.

13.11.2 3No tests were undertaken at STP1 and STP3, 2No tests were completed at STP2.

13.11.3 The recorded results and calculations included in the Concept Factual Report, with the results summarised in Table 13.4 below.

Table 13.4: Summary of Calculated Infiltration Rate and Permeability

Test Location	Calculated Infiltration Rate (m/s)			Relative Permeability	Drainage Conditions
	Test 1	Test 2	Test 3		
STP1	$1.32x10^{-4}$	$8.45x10^{-5}$	$7.73x10^{-5}$	Medium - Low	Good
STP2	$6.70x10^{-6}$	$7.09x10^{-6}$	-	Low	Good
STP3	$5.34x10^{-5}$	$4.42x10^{-5}$	$8.36x10^{-5}$	Medium - Low	Good

13.11.4 All drainage for the site should be designed by a suitably qualified and experienced specialist in accordance with the recommendations provided in BRE DG 365 (2015).

13.12 Geotechnical Characteristic Parameter Summary

13.12.1 BS EN 1997-1 defines the Geotechnical Characteristic Parameter as being selected taking into account "worst credible (most conservative) results" from the investigation and derived results, which are "complemented by well-established experience".

13.12.2 By definition, as well as being based on the Geotechnical Derived Parameters, accepted published values for specific strata can also be included.

13.12.3 These values are selected with regards to the limit state that is being designed for and the structure that is being designed. Their selection is therefore part of the design process. It therefore follows that until the final limit state and structure is known the following Geotechnical Characteristic Parameters should only be used for guidance.

13.12.4 A summary of ground conditions obtained from the ground investigation and subsequently chosen Geotechnical Characteristic Parameters for each plot provided in the tables below

Table 13.5: Ground Conditions and Characteristic Geotechnical Parameters

Parameter	Material			
	Made Ground	Kempton Park Gravel Member - Cohesive	Kempton Park Gravel Member - Granular	London Clay Formation
Undrained Shear Strength (kPa)	-	65	NA	Cu = (z – 3.75)/0.0722
Moisture content (%)	20	15	-	27
Liquid Limit (%)	26	32	32	68
Plastic Limit (%)	18	20	16	26
Plasticity Index (%)	13	11	15	45
Corrected Plasticity Index (%)	8.0	11	10	43
NHBC Volume Change Classification	Low	Low	Low	High
Coefficient of Compressibility m_v (m^2NM)	-	0.156	NA	0.07
Internal Angle of Friction	0° (undrained cohesive) ≤30° (granular)	27°	30°	21°
Bulk Density (kN/m^3)	16*	19.5	21.5	19.6
California Bearing Ratio (%)	≤2.5	5	5	NA
Permeability (m/s)	N/A	N/A	6.1x10^{-5}	N/A

Where z = depth below ground level in metres

14 GEOTECHNICAL ENGINEERING CONSIDERATIONS

14.1 Design Methodologies

14.1.1 This is not a Geotechnical Design Report and as such will not "design" any item or provide Geotechnical Design Values (see Section 11.2 below). The purpose of this section is to identify geotechnical issues that may affect the development and the subsequent design process.

14.1.2 There are four design methodologies that are allowed under EC7. These are:

- Design by calculation;
- Design by prescriptive measures;
- Design by the observational method;
- Design based on experimental models or site / load tests.

14.1.3 The first three methodologies will be generally used within this section. The use of experimental models or load tests is only really relevant where the specialist contractor can demonstrate similar results in similar ground conditions or where a structure is being converted with little or no change to the imposed loads.

14.1.4 The final two can be used to confirm and complement the recommendations made by the first two methodologies.

14.1.5 BS EN 1997 (Eurocode 7 (EC7)) requires the consideration of 5No separate limit states to ensure that the proposed design is suitable. Jomas has not been supplied with sufficient information to undertake these. The design principle laid out in EC7 is iterative, i.e. a solution is analysed, if that works then something of reduced capacity is analysed. The comments made below are there to aid the design and are not meant to provide designed solutions.

14.2 Geotechnical Design values

14.2.1 Geotechnical Design Values, sometimes referred to as Factored Parameters, will need to be selected as part of the Geotechnical Design Report by applying partial factors as outlined in BS EN 1997. These partial factors will depend on the Design Approach (normally taken as UK Design Approach 1 (DS1) within the UK), and which design case (Case A – C) applies to the item being designed.

14.2.2 For the verification of serviceability limit state, the Geotechnical Characteristic Parameter and the actions (both permanent and variable) are used without having been factored.

14.2.3 It should be noted that different cases and therefore Geotechnical Design values for the same parameter may be used for different parts of the design and may depend on the particular case being modelled.

14.2.4 The comments below are indicative only based on limited ground investigation data. Foundations should be designed by a suitably qualified Engineer. Once structural loads have been fully determined a full design check in accordance with BS EN 1997 should be undertaken to confirm suitability of the proposed design values.

14.3 Building Near Trees

Design Methodology:

- Design by prescriptive measures – NHBC Standards, Chapter 4.2

Notes:

14.3.2 The underlying soil conditions have been shown to be of "low" volume change potential at shallow depth, with "high" volume change potential in the London Clay Formation.

14.3.3 Using the geotechnical testing obtained (summarised in Table 13.1) and with reference to NHBC Standards Chapter 4.2 it can be seen that a minimum founding depth of 0.75m will be required.

14.3.4 Presence of existing and proposed trees may increase this minimum depth. It is recommended that a tree survey that should include: location, species and height of all trees on and near to the proposed development is recommended.

14.3.5 Although geotechnical laboratory testing has indicated the London Clay Formation to be of high volume change potential, given that this stratum is reported in excess of 6m bgl, it is considered highly unlikely that the clay would exhibit significant shrink/swelling due to limited changes in moisture content at this depth.

14.3.6 Guidance is also given in relation to other aspects of construction where the shrink / swell potential of the soils may be needed to take into consideration. This guidance is summarised in the appropriate sections below.

14.4 Shallow Foundations

Design Methodology:

- Design by prescriptive measures – NHBC Standards, Chapter 4.2
- Design by calculation

Notes:

14.4.2 Foundations should not be formed in either the Made Ground or the topsoil due to the unacceptable risk of total and differential settlement.

14.4.3 It should be noted that the demolition and removal of existing structures, foundations and services may increase the depth of Made Ground on the site.

14.4.4 Traditional shallow foundations may be appropriate to support at least part of the proposed structures.

14.4.5 Drawings provided to Jomas indicate that the proposed development on the northern plot will impose unfactored loads of up to 50kN/m for strip footings and up to 132kN for pad foundations.

14.4.6 Based on the findings of this investigation, it is considered that reinforced strip footings of up to 1m breadth may be formed at a minimum depth of 0.75mbgl within the underlying Kempton Park Gravel Member for an allowable bearing capacity of 120kPa.

14.4.7 This depth, however, does not take into account the depth of Made Ground or the distance to and species of any previous, existing and proposed trees, and foundations may need to be deepened further accordingly, in accordance with NHBC requirements.

14.4.8 It is recommended that a layer of light mesh reinforcement is added to the base of all foundations to mitigate the potential for excessive differential settlement, given the variable properties (cohesive/granular) encountered within the Kempton Park Gravel Member.

14.4.9 Where foundations need to change levels, the foundations should be stepped. These steps should be no deeper than half of the width of the foundation and each step should not exceed 0.5m. For practical purposes, steps are unlikely to be less than 0.15m deep. The steps should be suitably reinforced for an adequate distance either side of the step.

14.4.10 It is recommended that formations are inspected by a geotechnical engineer prior to the pouring of concrete to confirm the bearing capacity.

14.5 Piled Foundations

Design Methodology:

- Design by calculation
- Design based on experimental models or site / load tests.

Notes:

14.5.2 If a greater bearing capacity is required for the proposed development, a piled foundation solution extended into the underlying London Clay Formation could be considered.

14.5.3 The piled foundations will carry their working load in a combination of skin friction along the sides of the pile and end bearing at the base of the pile. The piles should be designed by a suitably qualified and experienced piling specialist using a suitable factor of safety with the settlement at working load specified to meet any structural requirements. Table 14.2 provides indicative capacities for a single pile for the diameter and depths shown.

14.5.4 In order to calculate the provided indicative allowable pile capacities, the following ground model and characteristic ground parameters, separated for each plot, were used.

Table 14.1: Characteristic Parameters Used to Calculate Allowable Indicative Pile Carry Capacities

Strata	Depth (m bgl)	Bulk Density (kN/m³)	Design c_u or N
Made Ground	GL to 1.7	16	
Kempton Park Gravel Member – Cohesive	1.7 to 2.2	19.5	cu = 65
Kempton Park Gravel Member - Granular	2.2 to 6.3	21.5	N = 30
London Clay	6.3 to 20	19.6	Cu = (z – 3.75)/0.0722
Groundwater	4	9.81	

Table 14.2: Indicative Piles Capacities (kN)

Pile toe depth (m bgl)	Pile diameter (m)				
	0.3	0.45	0.6	0.75	0.9
	Indicative Allowable Pile Capacity (kN)				
9	165	215	275	350	440
10	180	235	305	395	495
11	190	255	340	435	550
12	205	280	370	475	600
13	215	295	395	515	650
14	225	315	420	550	695
15	235	330	445	580	735

14.5.5 To comply with BS EN 1997 and the guidance given by the Federation of Piling Specialists the ground must be proven to a minimum of 5m below the proposed toe of the piles. Consequently, the above table is limited to 15mbgl.

14.5.6 It should be noted that the above assumes a bored piling system. Other methods of piling and equipment may provide different results.

14.5.7 An alternative approach to piling could be to consider ground improvement techniques.

14.5.8 The use of a piling foundation solution will require the emplacement of an engineered granular piling mat to support the piling rig and prevent overturning. This should be designed and constructed in accordance with BRE 470.

14.5.9 The above comments are indicative only based on limited ground investigation data. Foundations should be designed by a suitably qualified Engineer. Once structural loads have been fully determined a full design check in accordance with BS EN 1997 should be undertaken to confirm suitability of foundation choice.

14.6 Concrete in the Ground

Design Methodology:

- Design by prescriptive measures – BRE SD-1
- Design by prescriptive measures and Design by Calculation BS EN 1992-1-1:2004+A1:2014 (Eurocode 2)

Notes:

14.6.2 Sulphate attack on building foundations occurs where sulphate solutions react with the various products of hydration in Ordinary Portland Cement (OPC) or converted High-Alumina Cement (HAC). The reaction is expansive, and therefore disruptive, not only due to the formation of minute cracks, but also due to loss of cohesion in the matrix.

14.6.1 In accordance with BRE Special Digest 1, the characteristic values of sulphate used to determine the concrete classification are determined using the methodology summarised in the tables below for each plot.

Table 14.3: Concrete in the Ground Classes

No. Samples in the dataset	Method for determining the sulphate characteristic value
1 - 4	Highest value
5-9	Mean of the top 2no. highest results
10 or greater	Mean of the top 20% highest results

14.6.2 Tables 14.4 summarise the analysis of the aggressive nature of the ground for each of the strata encountered within the ground investigation.

Table 14.4: Concrete in the Ground Classes

Stratum	No. Samples	pH range	Characteristic WS Sulphate (mg/l)	Design Sulphate Class	ACEC Class
Made Ground	19	7.2-9.3	230	DS-1	AC-1
Kempton Park Gravel Member – Cohesive	6	7.6-8.7	85	DS-1	AC-1
Kempton Park Gravel Member – Granular	5	8.3-9.0	17.5	DS-1	AC-1
London Clay Formation	7	8.7-8.9	174	DS-1	AC-1

14.6.3 It should be noted that the BGS description of the London Clay Formation notes that it includes “disseminated pyrite”. It is therefore common practice to ensure that buried concrete formed in London Clay Formation has a Design Sulphate Class of at least DS-2.

14.6.4 The concrete structures, including foundations, will need to be designed in accordance with BS EN 1992-1-1:2004+A1:2014.

14.7 Ground Floor Slabs

Design Methodology:

- Design by prescriptive measures – NHBC Standards, Chapter 4.2
- Design by calculation

Notes:

14.7.2 Due to the presence of cohesive ground with a low volume change potential, and presence of Made Ground in excess of 600mm in thickness, in accordance with NHBC Standards Chapter 4.2, a suspended floor slab is recommended. The depth of clear void beneath the suspended floor slab will be dependent on the floor type used.

14.7.3 Under suspended in-situ concrete ground floor a minimum void of 50mm is required; under suspended precast concrete and timber floors a minimum of 200mm is required.

14.7.4 The loadings from the suspended floor slab will need to be carried by the foundations, which will need to be designed to not only carry the structural loadings but the additional floor loadings.

14.7.5 Alternatively, a ground bearing floor slab, could be used if emplaced on a blanket of suitable granular materials. The granular blanket should be at least 50% of the foundation depth and no more than 1.25m deep (measured from ground level). Assuming that there the proposed and current trees do not increase the required depth for shallow foundations this would mean a blanket of granular material between 0.5m and 1.25m thick.

14.7.6 The granular blanket should extend beyond the edge of the foundation by a distance equal to its natural angle of repose, plus 0.5m. The angle of repose will depend on the material used.

14.7.7 It is possible that following simple sorting and processing that demolition waste could be used for this purpose.

14.8 Excavations

Design Methodology:

- Design by calculation
- Design by the observational method
- Design based on experimental models or site / load tests

Notes:

14.8.2 It is likely that some shallow excavations will be required at the site for services etc., in addition to larger excavations during the remediation and construction works. These are anticipated to remain stable for the short term only.

14.8.3 The stability of all excavations should be assessed during construction. The sides of any excavations into which personnel are required to enter should be assessed and fully supported or battered back to a safe angle.

14.8.4 Any vertically sided excavations require support to provide safe man access and to support the sides of the excavation. Supports should be installed as excavation proceeds. For service excavations, overlapping trench sheets could be used as close support in the Made Ground deposits to minimise ground loss. Alternatively, consideration could be given to the use of trench boxes provided excavations take place within the boxes.

14.9 Pavement Design

Design Methodology:

- Design by prescriptive measures – Interim Advice Notice 73/06
- Design by prescriptive measures – Transport Research Laboratory document TRL 587
- Design by calculation
- Design based on experimental models or site / load tests

Notes:

14.9.2 The CBR value is dependent on the condition of the strata and could be different upon excavation to the formation, subject to seasonal conditions.

14.9.3 Clay sub grades will be liable to deteriorate if exposed to poor weather conditions (including extreme temperature (hot or cold with clays likely to be frost susceptible) or excessive site traffic. Therefore, care should be taken to protect prepared formations by minimising their exposure to the elements and ensuring the prompt placement of sub-base layers. All formation levels should be proof rolled and any 'soft spots' removed and replaced with suitably engineered granular material.

14.9.4 Due to the potential presence of mixed strata at formation level, the use of a geotextile is recommended where variable ground conditions are encountered, or across changes in strata, to protect against potential differential settlement.

14.9.5 It is recommended that a CBR value of <2.5% is adopted for pavement design on Made Ground.

14.9.6 Based on the in-situ test results and taking into account the variability of the results and ground conditions (i.e. cohesive and granular materials) it is recommended that a CBR value of 5% be used for pavement construction within the superficial deposits.

14.9.7 Proof rolling/compaction of granular materials may provide a greater result.

14.9.8 Additional CBR testing should be undertaken after detailed design is complete to confirm suitability.

14.10 Groundwater Control

Design Methodology:

- Design by calculation
- Design based on experimental models or site / load tests.

Notes:

14.10.2 During the investigation, groundwater was reported within boreholes BH1 and BH2 at 10.00mbgl and 19.30mbgl respectively.

14.10.3 During return monitoring groundwater was reported at depths of between 4.00-4.30mbgl. It is considered that these results represent a shallow ground water table within the superficial Kempton Park Gravel deposits.

14.10.4 Subject to seasonal variations, any groundwater encountered during site works could be readily dealt with by conventional pumping from a sump used to collate waters.

14.10.5 Surface water or rainfall ingress is likely to freely drain through the granular materials. If this does not occur, then they too could be dealt with by traditional sump and pump.

15 BASEMENT IMPACT ASSESSMENT

15.1 Proposed Changes to Areas of External Hardstanding

15.1.1 The proposed developments on both sites are likely to increase the proportion of soft cover on the site, reducing the potential for surface water run-off.

15.1.2 It is not considered necessary to undertake any further investigations, studies or impact assessment in relation to the proposed changes to areas of external hard-standing.

15.1.3 Low risk.

15.2 Past Flooding

15.2.1 The National Planning Policy Framework sets strict tests to protect people and property from flooding which all local planning authorities are expected to follow.

15.2.2 When assessing the site specific flood risk and the potential for historic flooding to reoccur the above guidance recommends that historic flooding records and any other relevant and available information including flood datasets (e.g. flood levels, depths and/or velocities) and any other relevant data, which can be acquired are assessed.

15.2.3 The EA historic flood map extents are provided on the London Borough of Richmond upon Thames Fluvial and Tidal Flood Risk Map. The site is not in an area which has been knowingly affected by flooding in the past, nor is it located within 250m of a known area of flood risk.

15.2.4 Low risk.

15.3 Geological Impact

15.3.1 The published geological maps indicate that the site is directly underlain by superficial deposits of the Kempton Park Gravel Member and solid deposits of the London Clay Formation. This was confirmed by the intrusive investigation.

15.3.2 Full height basements are not anticipated as part of either development. At the depths that the basements/subsurface structures are likely to be constructed, this is likely to be within either granular or cohesive Kempton Park Gravel Member deposits and not reach the London Clay Formation. The volume change potential of the superficial deposits has been shown to be “low” to “none”.

15.3.3 Low risk.

15.4 Hydrology and Hydrogeology Impact

15.4.1 Based on all the information available at the time of writing, the risk of flooding from groundwater is considered to be low. The proposed basement/subsurface structure is unlikely to have a detectable impact on the local groundwater regime. Appropriate water proofing measures should be included within the whole of the proposed wall/floor design as a precaution.

15.4.2 The proposed dwelling will lie outside of flood risk zones and is therefore assessed as being at a very low probability of fluvial flooding.

15.4.3 There are no surface water features on or in the immediate vicinity of the site. It is therefore not anticipated that the site will make any impact upon the hydrology of the area.

15.4.4 The information available suggests that the site lies in an area that is not at risk of surface water flooding. Flooding via this source is therefore considered to be low.

15.4.5 The proposed development is considered unlikely to create a reduction of impermeable area in the post development scenario.

15.4.6 No risk of flooding to the site from artificial sources has been identified.

15.4.7 Low risk.

15.5 Impacts on Adjacent Properties and Pavement

15.5.1 It will be necessary to ensure that the basements/subsurface structures are designed in accordance with the NHBC Standards and take due cognisance of the potential impacts highlighted above. This may be achieved by ensuring best practice engineering and design of the proposed scheme by competent persons and in full accordance with the Construction (Design and Management) Regulations. This will include:

- Establishment of the likely ground movements arising from the temporary and permanent works and the mitigation of excessive movements;
- Assessment of the impact on any adjacent structures (including adjacent properties and the adjacent pavement with potential services);
- Determination of the most appropriate methods of construction of the proposed basements;
- Undertake pre-condition surveys of adjacent structures;
- Monitor any movements and pre-existing cracks during construction;
- Establishment of contingencies to deal with adverse performance;
- Ensuring quality of workmanship by competent persons.

Full details of the suitable engineering design of the scheme in addition to an appropriate construction method statement should be submitted by the Developer to the London Borough of Richmond upon Thames.

15.6 Conclusion

15.6.1 The overall assessment of the site is that the creation of the proposed basement/lowered ground floor levels will not adversely impact the site or its immediate environs, providing measures are taken to protect surrounding land and properties during construction.

16 REFERENCES

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APPENDICES

APPENDIX 1 – FIGURES

APPENDIX 2 – GROUNDSURE REPORTS

APPENDIX 3 – OS HISTORICAL MAPS

APPENDIX 4 – QUALITATIVE RISK ASSESSMENT METHODOLOGY

APPENDIX 5 – BGS BOREHOLE RECORDS

APPENDIX 6 – UXO ASSESSMENT

APPENDIX 7 – FACTUAL REPORT

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