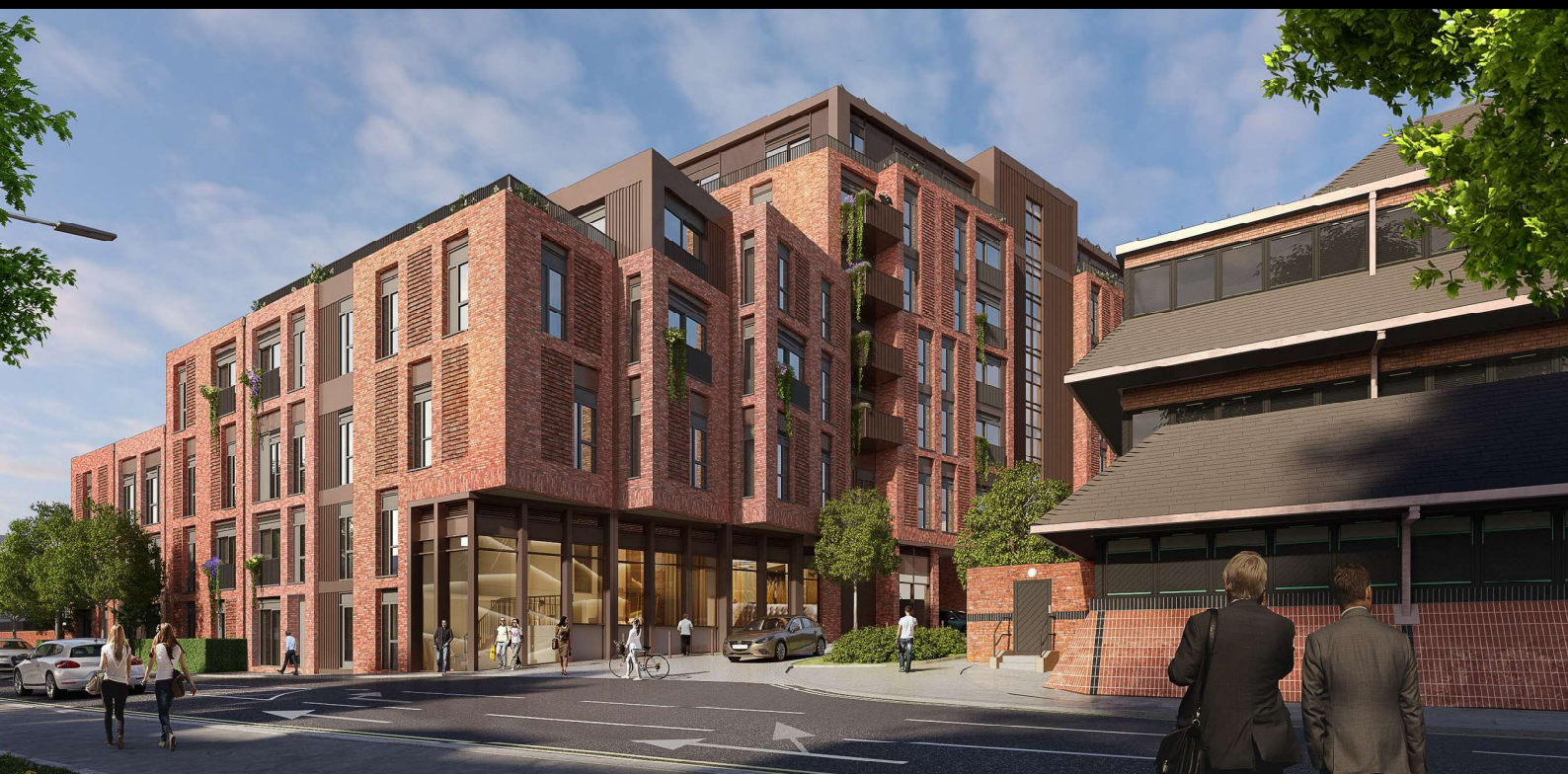
GUILD LIVING @ UXBRIDGE.

Ground Investigation Report

SEPTEMBER 2020

GUILD LIVING | Legal & General



GROUND INVESTIGATION REPORT

ISSUE 1.2

TL1306GIR

01 SEPTEMBER 2020

Final

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EXECUTIVE SUMMARY

Introduction	**Tier Environmental was commissioned by Senior Living Urban (Uxbridge) Limited (Guild Living) to undertake a Ground Investigation of 2-12 Harefield Road, Uxbridge, UB8 1JS ("the Site").The purpose of the investigation was to determine both shallow and deep ground conditions on Site in order to obtain samples for laboratory analysis and to aid with final foundation design. It is understood that the Site is to be redeveloped with the demolition of existing buildings including clearance of site, and erection of 2 No. buildings (A & B) comprised of care units, with associated care suite facilities, wellness, social and leisure areas, in addition to a landscaped podium platform (which joins to the two buildings), undercroft parking facilities, and restaurant/café space. A site investigation was undertaken to determine the nature and extent of soil, bedrock and groundwater beneath the Site for the purposes of environmental and geotechnical assessment.**
Site location	The site is located to the east of Harefield Road and north of Warwick Place within Uxbridge town centre, at UB8 1JS. A site location plan is included as Drawing No. TEL1306/GIR/1 within Appendix A. The Site can be centred on National Grid Reference (NGR) 505448, 184481.
Site history	Historically, the Site has been developed since the earliest available historic map (1866) with a number of different past land uses, including an iron works, unspecified works, garage, motor vehicle repair centre and builders' merchant, electricity substation and an unspecified tank. Pertinent surrounding land uses include motor repair works, unspecified tanks, numerous cutting and infilled ground, a railway terminus and numerous unspecified works.
Fieldwork	Advancement of 11 No. window sample boreholes (WS1 to WS11) to a maximum depth of 2.20m bgl. Advancement of 1 No. hand pit to 1.20m bgl. Advancement of 3 No. cable percussive boreholes to 15.00m bgl with rotary geobore follow-on to a depth of 30.45m bgl to determine the nature and strength properties of the underlying geology to assist with the finalised foundation design.
Laboratory testing	Samples of soil and groundwater were submitted for analysis of a range of metal, other inorganic and organic components. Geotechnical testing was scheduled on selected samples. All testing was undertaken at accredited laboratories.
Ground conditions	Made Ground was encountered at all exploratory locations typically <1.00m bgl with a maximum proven thickness of 1.99m bgl. The base of the Made Ground was not encountered in TWS2, TWS2a, TWS6 (due to obstructions) or HDP1. Made Ground was found to be variable comprising both granular and cohesive deposits with anthropogenic materials including brick, ceramic, concrete, tarmacadam, metals, wood and glass with natural materials including flint, coal, sandstone and limestone. Natural deposits comprised the Lynch Hill Gravel Member, recovered as sandy to very sandy gravel of natural lithologies including flint, with a moderate proportion of cobbles of flint. Underlying these superficial deposits was the Lambeth Group. A mainly cohesive deposit with bands of silty sand observed throughout. Cohesive deposits consisted of firm to very stiff consistency multicoloured, reddish brown, olive brown, light reddish grey, pale brown and grey slightly sandy, slightly silty in places, clay. Granular deposits observed within the Lambeth Group have been reported as generally reddish brown or olive brown slightly clayey in places, slightly silty in places, fine to medium grained sand. Structureless CHALK composed of very soft consistency, light grey and light bluish grey silty, slightly gravelly CLAY or, white and light grey clayey slightly gravelly SILT was observed in 2 No. Locations from 30.00m bgl to a maximum proven depth of 30.45m bgl. During our works, there was no olfactory or visual evidence of hydrocarbon or similar contamination within the Made Ground.
Foundations and floor slabs	A shallow pad or piled foundation solution is recommended depending on the final loads on site. It is anticipated that a ground bearing floor slab is the likely solution.
Sulphate class	Based on chemical results a Design Class of DS-1 and ACEC Class of AC-1 should be used for shallow buried concrete structures on Site. And DS-4, AC-3 for piled foundations.
Contamination	Chemical testing and subsequent statistical analysis of the results suggests that the Made Ground Soils are generally uncontaminated; however, 3 No. areas located by Tier Environmental and 2 No. reported by REC identified the presence of asbestos fibres. With regard to the proposed building, it is understood that much of the Site is to be covered by the associated structure and hardstanding, with only limited areas of soft standing. The result is that Made Ground soils at the Site are to be removed or covered and will therefore not be exposed to the end users of the Site, which effectively removes the identified pollutant linkage to the end users. Where areas of soft landscaping are to be implemented, a minimum 600mm of clean cover, with a protective geotextile will be required in order to break the aforementioned pollutant linkage. The remaining potential human health receptors are adjacent site users, from migration of contaminated dusts during the demolition and excavation of the Site.
Gas protection	Based on gas monitoring visits, the Site has been classed as Characteristic Situation 1, whereby no ground gas protection is required. However; elevated VOCs identified by REC may result in the need for vapour protection on Site.
Radon Requirements	The Site is not located in a Radon Affected Area, as less than 1% of properties are above the Action Level.

Further works	Further site investigation works may be required to further understand the nature of Lambeth Group soils to mitigate the risk of differential settlement in these variable deposits. Further investigation may be required to further determine the nature and extent of a possible unspecified storage tank which has been highlighted to be on site. Site wide trial pitting, especially under the footprint of the current buildings, in order to determine shallow ground conditions and to obtain samples for laboratory analysis.
Waste Soils Classification	Overall, the soils have been assessed as chemically non-hazardous/ inert. Made ground soils at TBH2 (0.50m bgl) have reported copper and zinc in excess of the non-hazardous/ inert waste threshold. Further WAC testing has determined that this material is in fact suitable for disposal at a stable non-reactive hazardous waste cell at a non-hazardous landfill. WAC testing on samples taken from TWS5 (0.40m bgl) and TWS11 (0.50m bgl) has reported that these materials may be suitable for disposal of to an inert landfill. Due to the presence of asbestos in the form of amosite and chrysotile fibre bundles having been reported in the vicinity of TWS2a (0.30m bgl), TWS5 (0.40m bgl) and TWS9 (0.30m bgl) at concentrations <0.1%, this precludes the Made Ground material from being suitable for disposal at an inert waste landfill due to the consistent nature of Made Ground material on Site. These materials should, however, be suitable for disposal within a Stable Non-reactive Hazardous Waste in Non-Hazardous Landfill.

1. INTRODUCTION

Tier Environmental was commissioned by Senior Living Urban (Uxbridge) Limited (Guild Living) to undertake a Ground Investigation Report for an area of land off Harefield Road (Units 1 & 2), Uxbridge, UB8 1JS (the "site").

Information contained within this report has been derived from GIR data for a previous scheme. Taking into account the planned future use of the Site, the objectives of this appraisal were:

- To determine the land use history from review of available historical documentation and maps.
- To establish the environmental setting of the Site.
- To determine soil and groundwater conditions, including whether significant contamination could have resulted from past or current land use(s).
- To determine the potential risks posed by any ground contamination and provide recommendations on remedial measures to manage such risks.
- To determine risks posed to the Site from hazardous ground gases.
- To evaluate whether past mining or other extractive industries could have an influence on the Site.
- To provide advice relating to geotechnical issues associated with the Site.
- To provide foundation recommendations.
- To provide an initial waste soils classification.

The desk-study part of this investigation included the assessment of information provided by Groundsure. The information provided by these organisations is provided in Appendix O.

This report, which was designed to meet the requirements of all relevant current guidance including CLR 11, presents the factual information available during this appraisal, interpretation of the data obtained and recommendations relevant to the defined objectives.

It is understood that the Site has full planning permission for comprehensive redevelopment comprising demolition of existing buildings to provide residential care accommodation (C2), café and nursery € in buildings up to 8 No. storeys, with car parking, landscaping and associated works. In addition, it is assumed that ground levels will not change significantly from those described in this report. If this is not the case, then amendments to the recommendations made in this report may be required.

Where the report refers to the potential presence of invasive plants (such as Japanese Knotweed) or asbestos-containing materials, such observations are for information only and should be verified by a suitably qualified expert.

The comments and opinions presented in this report are based on the findings of the desk study, ground conditions encountered during intrusive investigation works performed by Tier Environmental and the results of tests carried out within one or more laboratories. There may be other conditions prevailing on the Site which have not been revealed by this investigation and which have not been taken into account by this report.

Responsibility cannot be accepted for any conditions not revealed by this investigation. Any diagram or opinion on the possible configuration of the findings is conjectural and given for guidance only. Confirmation of intermediate ground conditions should be undertaken if deemed necessary.

This report has been prepared for the sole use of 'Guild Living'. No other third party may rely upon or reproduce the contents of this report without the written approval of Tier Environmental. If any unauthorised third party comes into possession of this report, they rely on it entirely at their own risk and the authors do not owe them any Duty of Care or Skill.

2. SITE DETAILS AND DESCRIPTION

Table 2.1. Current Site Overview.

Site name	**Harefield Road, Uxbridge**
Site address	Land off Harefield Road (Units 1 and 2), Uxbridge, UB8 1JS. A site location plan is included as Drawing No. TL1306GIR1 within Appendix A.
National Grid Reference	505448, 184481
Location description	The site is located to the east of Harefield Road and north of Warwick Place within Uxbridge Town Centre. It is bound by the rear gardens of the residential properties of Harefield Road and Lancaster Road to the north; Warwick Place and Beasley Court to the south; Penfield Estate to the east; and Harefield Road to the west. The surrounding area is characterised by a mix of uses, services and facilities including residential, retail, civic and commercial uses.
Approximate Site area	0.92 ha
Site shape	The Site is broadly rectangular, with an L shaped strip of land running in a general northeast – southwest orientation in the southern section of the Site.
General topography and ground levels	The Site is generally flat lying at an elevation of approximately 42m aod.
Current land use	The site comprises two low density attached retail warehouse buildings (Use Class A1), currently occupied by Wickes (Unit 1) and Halfords (Unit 2). The buildings are set back within the site which includes a large car park situated in front of the buildings. The site benefits from existing landscaping which is generally limited to eastern and northern boundaries. The site is currently raised above Harefield Road which is fronted by a retaining wall to the car park. The site benefits from existing vehicular and pedestrian access from Harefield Road, with a separate access to a loading bay off Warwick Place.
Existing structures	The industrial unit in which Wickes and Halfords are situated takes up a large section of the Site.
Site ground surfaces	Much of the Site is covered in hardstanding associated with a car park and builder's merchant's storage area.
Sub-surface structures	Services are anticipated on Site, service information obtained indicates the presence of low voltage electricity cables, however; additional unrecorded services should be anticipated.
Invasive plant species	No invasive plant species have been reported by Tier Environmental Geoenvironmental engineers, however; the presence/ absence of any invasive plant species should be confirmed by a suitable qualified specialist.

The main Site features are shown on Drawing No. TL1306GIR2 within Appendix A. Relevant Site photographs are presented in Appendix D.

3. ENVIRONMENTAL SETTING

3.1. Site History

Extracts of Ordnance Survey (OS) plans dated from 1866 to 2014 were reviewed. These were obtained as part of the GroundSure report for the Site, which is presented in Appendix O. Table 3.1 presents a summary of the main aspects of the Site from 1866-2014 relevant to the current and proposed future end uses. It is not the intention of this report to describe in detail all the changes that have occurred on or adjacent to the Site, where these are not relevant to the land use.

Table 3.1. Site History.

Source (Map edition, scale)	On-Site features	Off-Site features
1866, 1:2,500	• The north and north-eastern section of the Site are shown to be undeveloped, with areas of vegetation including several trees. • The southern section of the Site has numerous buildings including a number of buildings associated to "Albert Iron Works". • "Penclose House" is annotated along the western boundary of the Site.	• A number of unspecified buildings, possibly residential dwellings are annotated from 90m north. • Immediately north and west of the Site a number of fields are annotated. • A number of unspecified buildings are annotated from 80m south-east surrounding the south and west of the Site, buildings annotated "brewery", "Inn", "Foundry", "Flour Mill", "Yard" surround the Site. • A number of roads are annotated to the east and west of the site, including "High Street" and "Pages Lane". • A possible break in slope is annotated immediately northwest of the Site.
1868, 1:10,560	• No Significant Changes	• No Significant Changes
1877, 1:2,500	• The Site does not appear on the map	• The Site does not appear on the map
1881, 1:10,560	• No Significant Changes	• No Significant Changes
1896, 1:2,500	• "Penclose House" is now annotated with buildings associated with "Wooden Row"	• The break in slope annotated to the northwest is now no longer annotated and is annotated as an area of vegetation. • "Pages Lane" is now annotated as "Harefield Road". • A "Tan Yard" is annotated 130m south west. • "Way's Wharf" and Saw Mills are annotated 250m west.
1879, 1:10,560	• No Significant Changes	• No Significant Changes
1899, 1:2,500	• No Significant Changes	• No Significant Changes
1900, 1:10,560	• No Significant Changes	• No Significant Changes
1912, 1:10.560	• The Site does not appear on the map	• The Site does not appear on the map
1920, 1:10,560	• No Significant Changes	• No Significant Changes
1932, 1:10,560	• The Site does not appear on the map	• The Metropolitan Line is annotated approximately 250m east.
1934, 1:2,500	• No Significant Changes	• Development of possible residential dwellings from 30m north surrounding the Site is annotated.

1938, 1:10,560	• No Significant Changes	• Great Western Rail Terminus and railway line is annotated 130m west in a general north south orientation.
1960, 1:10,560	• A number of alterations to buildings annotated on site has occurred, a large square structure in the northern section of the site is annotated "works".	• No significant changes. • A number of alterations to the buildings surrounding the site have been made. These are mostly unspecified.
1962, 1:1,250	• A number of unspecified buildings are now annotated within the boundary of the site.	• A "Works" is annotated 70m south. • A builder's yard and garage are annotated south of the Site.
1970, 1:10,560	• No Significant Changes	• The Great Western Railway to the west is now annotated as "dismantled" and Frays River is annotated
1974, 1:1,250	• The unspecified structures annotated on Site are now annotated as "Builders Works", "Engineering Works" and "Builders yard"	• Harefield Road is now annotated along the western boundary of the Site.
1981, 1:1,250	• The structures annotated on Site are now annotated as "Builders Merchants" and "Depot"	• A "motor repair works" is annotated along the eastern boundary
1988, 1:1,250	• No Significant Changes	• A Police Station is annotated immediately south of the site.
1990, 1:10,000	• No Significant Changes	• No Significant Changes
1992, 1:1,250	• No Significant Changes	• No Significant Changes
2002, 1:10,000	• Redevelopment of the site to its current layout is now annotated.	• A number of unspecified water courses are annotated from 100m west in a general north south orientation.
2010, 1:10,000	• No Significant Changes	• No Significant Changes
2014, 1:10,000	• No Significant Changes	• No Significant Changes

3.2. Geology

Table 3.2. Geological Summary.

Maps and publications referenced	**England and Wales: Beaconsfield: Scale 1:50,000, Solid and Drift edition Series 5 Published 2005.**
Made ground	Made Ground is anticipated given the historic redeveloped nature of the Site. Information obtained as part of the Groundsure report indicated the presence of "worked ground" in the form of a "void" on Site has been reported.
Drift geology	BGS information indicates that the Site is underlain by the Lynch Hill Gravel Member.
Solid geology	BGS information indicated that the Site is underlain by the London Clay Formation. Nearby BGS logs indicate that this is to be in the region of 10m bgl.
Dip of solid strata	Not established.
Faults	None recorded on or in the immediate vicinity of the Site.
Coal seams	According to information obtained as part of the Groundsure report the Site is not within an area at risk from historic or current coal mining activities.

3.3. Mining and Quarrying

Table 3.3. Coal Mining Activities.

	Yes/No	Comments
Is the Site in an area of potential shallow coal workings?	No	
Are there any known shafts, adits, tips, lagoons, or opencast workings likely to affect the Site?	No	
Is exploratory work required to investigate the potential risk from shallow mining or quarrying?	NO	

Table 3.4. Other Extractive Industries.

	Yes/No	Comments
Superficial drift deposits		
Evidence of extraction on or within 250 m of the Site?	No	
Action required?	No	
Solid Strata		
Any evidence of mineral extraction on or within 250 m of the Site?	Yes	Information obtained as part of the Groundsure report indicates the potential for localised difficult ground conditions a level where they should be considered due to small scale chalk mining that may have occurred.
Action required?	*NA*	

Other, undocumented mineral workings on or close to the Site cannot be completely dismissed.

3.4. Hydrogeology

Table 3.5. Groundwater Occurrence and Abstraction.

	Presence/location	Comments
Depth(s)	Depth to groundwater is unknown.	
Direction of flow	Direction of flow is unknown.	
Licensed abstractions	None recorded within 500m of the Site.	
Private wells	NR	
Source Protection Zones	NR within 500m of the Site.	
Springs	NR	

NR - none recorded.

For definition of Source Protection Zones, see Appendix E.

Table 3.6. Groundwater Vulnerability Status.

	Environment Agency classification	Comments
Groundwater classification	1. On Site – Principal Aquifer 2. On Site – Unproductive Strata	1. Superficial Lynch Hill Gravel Member. 2. London Clay Formation. For terms used by the Environment Agency in defining groundwater vulnerability, see Appendix E.

3.5. Hydrology

Table 3.7. Surface Water Features.

	Presence/location	Comments
Environment Agency GQA classified watercourses	1. Guc (Cowley Reach) 486m northwest.	1. GQA Assessment D
Unclassified watercourse(s)	1. Fray's River – 110m west. 2. Grand Union Canal Regent's Canal – 265m northwest. 3. Shire Ditch – 300m north. 4. River Colne – 305m northwest.	1. Primary River – Status currently undefined.Canal – Status currently undefined.Primary River – Status currently undefined.Primary River – Status currently undefined.
Licensed abstractions	NR within 500m	
Canals, ponds, lakes, etc.	4 No. unspecified surface water features from 108m west to 231m northwest.	
Flood risk status	On Site.	• Environment Agency/Natural Resources Wales Zone 2 floodplains estimate the annual probability of flooding as between 1 in 1000 (0.1%) and 1 in 100 (1%) from rivers and between 1 in 1000 (0.1%) and 1 in 200 (0.5%) from the sea • Risk of flooding from Rivers and the Sea (RoFRas) as indicated by the Environment Agency/ Natural Resources Wales on Site is Very Low (less than 1 in 1000) chance of flooding in any given year. • The British Geological Survey indicates the presence of a groundwater flooding susceptibility area within 50m of the Site.
Surface run-off and Site drainage	NR	
Other	NR	

NR - none recorded

Environment Agency GQA assessments: A = very good to E = poor

3.6. Ecological Features

Table 3.8. Ecological Features.

	Presence/location	Comments
Designated locations	NR within 1Km of the Site.	
Other sensitive locations	NR within 1Km of the Site.	
Land use controls	London Area Greenbelt from 290m northwest.	
Invasive plants	None Reported	A survey by a qualified invasive plant consultant is required to confirm the absence or extent of invasive species.
Trees and shrubs	On Site	Trees and shrubs along the boundaries of the Site and a small number within the car park were observed on Site.
Other features	NR	

NR - none recorded

3.7. Landfill and Waste Management Activity

Table 3.9. Waste Management Activities.

	Presence/location	Comments
Local authority recorded landfills	NR within 1Km of the Site.	
BGS recorded landfills	NR within 1Km of the Site.	
Other licensed waste management facilities within 250 m	NR within 1Km of the Site.	
Is there evidence of other landfilling on or within 250 m of Site?	A total of 29 No. potentially infilled land reports are identified within 250m of the Site.	• Canal – 155m west to 250m northwest, • Burial ground – 155m to 170m southeast, • Cuttings – 160m southeast, 190m east, 210m east, • Fish pond – 190m to 210m southwest, • Gravel Pit – 215m north, • Unspecified Wharf – 240m to 250m west.
Walkover evidence of fly-tipping on Site?	NR	
Is a landfill/ground gas risk assessment required?	Yes	Due to the presence of possible infilled land in the vicinity of the Site, the inferred Made Ground soils, and the granular nature of reported superficial natural deposits on Site the presence of ground gas on Site cannot be discounted.

NR - none recorded

3.8. Local Potentially Contaminative Activities

Other potentially contaminative activities are shown in Table 3.10. The entries relate to activities within *circa* 250 m of the Site, with the exception of COMAH facilities where the assessment is extended to a distance of *circa* 1 km from the Site.

Table 3.10. Other Potentially Contaminative Processes in the Locality.

	Location	Comments
Discharge Consents	• Braybourne Close Uxbridge 218m northwest.	• Sewage Discharges – Pumping Station – Water Company, Permit Version 2, Effective from September 2010, revoked August 2014. • Sewage Discharges – Pumping Station – Water Company, Permit Version 1, Effective from November 1989, revoked September 2010.
Prosecutions relating to controlled waters	NR within 250m	
Substantiated pollution incidents	1. July 2002, 215m north. 2. October 2001, 247m west.	1. Sewage material – Grey Water – Water/Land/Air Impact Category 3 (Minor) 2. Contaminated Water – Water Impact Category 3 (Minor), Land/Air Impact Category 4 (No Impact).
IPPC permits/air pollution controls	NR within 250m	
Registered radioactive substances	NR within 250m	
Prosecutions relating to authorised processes	NR within 250m	
Enforcement and prohibition notices	110m Southwest	L h Jennings, High Street. Respraying of Road Vehicles, Historical Permit Type Part B - No Enforcement notified.
Planning - hazardous substances consents and enforcements	NR within 500m	
COMAH sites	NR	
NIHHS sites	NR	
Fuel station entries	NR within 500m	
Pertinent contemporary trade directory entries	1. On Site 2. 5m southeast 3. 20m southeast 4. 25m southeast 5. 30m northeast 6. 50m east 7. 100m northeast 8. 125m east 9. 195m south 10. 200m northeast 11. 220m southeast 12. 250m west.	1. Vehicle parts and accessories 2. Vehicle hire and rental/ special purpose machinery and equipment 3. Tanks 4. Unspecified works 5. Vehicle repair, testing and servicing 6. Vehicle repair, testing and servicing 7. Electricity substation 8. Vehicle repair, testing and servicing 9. Electricity substation 10. Electricity substation 11. Electricity substation/ bus and coach stations 12. Medical equipment, supplies and pharmaceuticals

Pertinent potentially contaminative entries	1. On site 2. Within 250m surrounding the Site	1. Iron works, unspecified works, unspecified depot, unspecified tank, electricity substation, motor repair works. 2. Unspecified works, railway terminus, railway sidings, cuttings, unspecified commercial/ industrial units, burial grounds, saw mills, gravel pit, unspecified wharf, numerous unspecified tanks, electricity substations, garages and motor repair works.

NR - none recorded

COMAH – Control of Major Accident Hazards (regulations); NIHHS – Notification of Installations Handling Hazardous Substances (regulations)

3.9. Radon Risk

Table 3.11. Radon Risk Status.

	Radon protection measures required? (Yes/No)	**Comments**
BRE (1999), Report 211	No	The property in not in a Radon Affected Area, as less than 1% of properties are above the Action Level.
BGS Site-specific report	Not requested	

3.10. Summary

- The site comprises two low density attached retail warehouse buildings (Use Class A1), currently occupied by Wickes (Unit 1) and Halfords (Unit 2);
- Historically, the Site has been developed since the earliest available historic map (1866). The current building layout appears on maps annotated 2002, prior to this a number of different building layouts were annotated;
- Pertinent land uses on site include an iron works, unspecified depot, unspecified warehouse, builders' merchant, garage and vehicle repair centre, unspecified tank and electricity substation;
- Pertinent surrounding land uses include unspecified works, terminus, railway sidings, cuttings, unspecified commercial/ industrial units, burial grounds, saw mills, gravel pit, unspecified wharf, numerous unspecified tanks, electricity substations, garages and motor repair works;
- It is inferred that ground conditions are likely to comprise Made Ground to an unknown depth. Natural soils beneath the Made Ground are likely to comprise granular Lynch Hill Gravel Member deposits (Principal Aquifer) (very high permeability) to unknown depths. The superficial deposits are indicated to be underlain by the London Clay Formation (Unproductive Strata).
- The nearest surface water feature is Fray's River is annotated 110m west of the Site. The site is not located within 1 Km of a Source Protection Area or an environmentally sensitive area i.e. SAC, however; the Site is located within 300m of the London Greenbelt Area.
- The Site lies within a Nitrate Vulnerable Zone.

- There are no recorded landfill sites located within 250m of the Site; however, ground gas monitoring is recommended due to the likely presence of Made Ground beneath the Site, past Site uses including use as an iron works and vehicle repair centre, and the likely infilled ground in the vicinity of the Site.

- The Site is not located in a Radon Affected Area, as less than 1% of properties are above the Action Level.

4. PREVIOUS INVESTIGATION FINDINGS

4.1. "Phase I and II Geo-Environmental Assessment, 2-12 Harefield Road, Uxbridge, UB8 1JS", Report No. 1CO102125P1R0, Resource and Environmental Consultants Ltd (REC), dated September 2016.

Table 4.1 below summarises the information which was considered salient during the review of this report.

Table 4.1 Summary of Phase 1 report

Background	**REC Ltd. was commissioned by BNP Paribas Real Estate UK Canada Life Investments to conduct a geoenvironmental assessment of an area of land at Harefield Road, Uxbridge. at the time of writing, it was understood by REC that the Site was being considered for redevelopment with a residential land use.**
Site History	The desk study conducted by REC states that, from analysis of historical maps, the Site has seen development since the earliest historical maps dated 1866, with several pertinent on-Site features including an Iron Works, Smithy, Saw Pit, Works, Motor Repair Works and electricity substation. Several pertinent off-site features were highlighted, including a motor repair works, garage, unspecified tank, unspecified works, telephone exchange, electricity substation, canal, terminus, railway cuttings and unspecified commercial/ industrial uses.
Geoenvironmental Setting	• The Site was understood to be underlain by both a principal aquifer and unproductive strata. • The Site was not identified to be located within a source protection zone. • The site **is** located within an area designated as a nitrate vulnerable zone. • The nearest surface water features identified by REC included Fray's River, approximately 100m west of the Site. • The nearest groundwater abstraction is located 543m north of the Site. • The Environment Agency Zone 2 and Zone 3 flood affected areas lie within 250m of the site. • The site is located 291m northwest of the London Greenbelt Area.
Site Investigation	The Site investigation conducted by REC consisted of 7 No. window sample boreholes (WS101 to WS107), with 3 No. (WS102, WS106 and WS107) installed with combined gas and groundwater monitoring installations. 1 No. Hand Pit and 1 No. rotary borehole (BH101) installed with a combined gas and groundwater monitoring installation.
Encountered Ground Conditions	The REC investigation determined the Site to be covered in Made Ground soil from ground level to a maximum proven depth of 1.00m bgl, typically comprising asphalt over friable light brown sandy gravel, or soft to firm consistency brown sandy gravelly clay/ silty with a low cobble content of fine to coarse flint, brick, asphalt, concrete, ash and clinker. Organic odours were noticed within WS105. The Made Ground was observed to be underlain by the Lynch Hill Gravel Member, typically comprising very dense sandy gravel or gravelly sand with low cobble content of flint. A hydrocarbon odour and oil-sheen was noticed within BH101 from 1.20m bgl to 7.80m bgl. These granular deposits were in turn underlain by the London Clay Formation comprising firm to very stiff consistency, brown to light blue to reddish brown mottled silty clay. A thickness of 12.20m was encountered in BH101 which does not represent the full thickness of this stratum. Groundwater was encountered during drilling within BH101 at 18.50m and 20.00m bgl which rose to 16.50m and 14.00m bgl respectively after 20 minutes. Ground water was encountered at approximately 5.50m bgl during monitoring visits.

Groundwater and Ground Gas Monitoring	During monitoring visits by REC, Groundwater was encountered during drilling within BH101 at 18.50m and 20.00m bgl which rose to 16.50m and 14.00m bgl respectively after 20 minutes. Ground water was encountered at between 5.17m and 5.50m bgl during monitoring visits. 3 No. ground gas monitoring visits had been conducted when this report was produced, with maximum concentrations of 2.4% v/v CO_2 and <0.1% v/v CH_4 and maximum flow rates less than the instruments limit of detection reported. Additionally, second and third monitoring visits, all wells were screened with a photo-ionisation detector to establish if there were any interferences whether hydrocarbons were present within the vapours from the installations. The maximum reported PID was reported at WS107 during the second monitoring visit with a value of 30.2ppm being reported. These findings indicated an initial Characteristic Situation 1 – Very Low Risk classification for the Site; however, due to elevated VOC's being encountered during the intrusive works, and during subsequent monitoring visits the need for vapour protection measures may be required.
Contamination	Olfactory evidence of contamination, in the form of Organic odours were noticed within WS105. A hydrocarbon odour and oil-sheen was noticed within BH101 from 1.20m bgl to 7.80m bgl. From the laboratory derived concentrations of determinands within the soils underlying the Site, REC concluded that the potential risk to the underlying controlled waters to be moderate, on the basis that the site is underlain by superficial deposit Principal Aquifer with high leaching potential. There are a number of groundwater abstraction points with the closest being 543m north of the Site. The nearest surface water feature being reported as being 110m west of the site with interconnected culverts and tributaries. Furthermore, REC states the site potentially poses a significant risk to human health due to the presence of beryllium, lead, asbestos and dibenzo(a,h)anthracene.
Conclusions and Recommendations	REC recommends; • Installation of a clean cover system within areas of soft landscaping to sever the source/ receptor pathway, • Further WAC testing in order to determine the appropriate waste classification in view of removal and subsequent disposal. • Further ground investigation works around BH101. • Further works to determine whether land gas protection measures are to be incorporated into the proposed scheme. • Further ground investigation works should be undertaken beneath the existing building footprint.

Tier Comments

A Phase I & II Geo-environmental assessment for 2-12 Harefield Road, Uxbridge, Dated September 2016, ref 1CO102125P1R0 has been made available to Tier Environmental prior to investigation works being undertaken.

A summary of the investigation findings are as follows;

- Made Ground soils were identified in all exploratory hole location, typically comprising sandy gravel or sandy gravelly clay, with anthropogenic materials including brick, asphalt, concrete, ash and clinker.
- Lynch Hill Gravel Member deposits were encountered in all exploratory hole locations with a maximum proven thickness of 7.45m.
- London Clay Formation was encountered in one location, comprising firm to very stiff brown to light blue and reddish brown mottled silty clay.
- Groundwater observations reported groundwater strikes within the Lynch Hill Gravel Member, with groundwater resting at approximately 5.50m bgl during monitoring, and within the London Clay Formation at approximately 16.50m bgl and 14.00m during drilling works.
- Based on ground gas monitoring on Site a Characteristic Situation 1 has been determined, however; elevated VOCs reported during monitoring may result in the requirement for vapour protection measures.

- Although there is mention of a number of unspecified tanks being located off site within the vicinity, there is no mention of the unspecified tank which is reported by Groundsure to be on site

- The Site potentially poses a significant risk to human health due to the presence of contaminants including beryllium, lead, dibenzo(a,h)anthracene and asbestos in the form of chrysotile fibres and chrysotile fibres within ACM.

- Elevated Total Petroleum Hydrocarbons (TPH) have been reported within TBH1. An 'oil sheen' and 'hydrocarbon odour' has been reported in the water from BH101 from 1.20m to 3.00m bgl. It is understood that a hand dug pit was advanced from ground level to 1.20m bgl with no reference to any sheens or odours, also there were no reported hydrocarbon odours or such within the Made Ground soils above the odour, nor was there any mention of any such odours within the natural soils within this depth range. It is therefore considered that there is no vertical influence, nor is it considered that this is representative of TPH concentrations coming from groundwater since during monitoring the groundwater was reported at a minimum depth of 5.17m bgl, and the odour and sheen is not observed past 3.00m bgl. It is therefore considered that this 'oil sheen' and 'hydrocarbon odour' may be a result of drilling action as water is initially added to advance the borehole and not representative of contaminated groundwater.

5. PROPOSED DEVELOPMENT

It is understood that the Site is to be redeveloped with demolition of existing buildings including clearance of site, and erection of 2 No. buildings (A & B) comprised of:

- 161 No. private 1, 2 and 3 bed residential units;
- 33 No. care suites;
- 319m^2 of commercial space;
- 760m^2 of amenities inclusive of restaurant and café space;
- 95 No. parking spaces;
- A landscaped podium platform joining the two buildings.

In addition, it is assumed that ground levels will not change significantly from those described in this report. If this is not the case, then amendments to the recommendations made in this report may be required.

The proposed layout of the Site is presented in Appendix A to this report.

6. PRELIMINARY CONCEPTUAL MODEL

Based on the desk study, a combined preliminary conceptual site model and conceptual exposure model has been developed for the proposed future land use. This summarises the understanding of surface and sub-surface features, the potential contaminant sources, transport pathways and receptors. In assessing the likely contaminants present at the Site, reference has also been made to Defra and Environment Agency supporting documentation. A preliminary qualitative risk assessment has also been made of the likelihood of the linkage operating and its potential significance.

6.1. Justification

The following factors are considered pertinent in defining the conceptual model.

Land Use

- The site comprises two low density attached retail warehouse buildings (Use Class A1), currently occupied by Wickes (Unit 1) and Halfords (Unit 2).
- Historically, the Site has been developed since the earliest available historic map (1866). The current building layout appears on maps dated from 2002, prior to this a number of separate buildings were annotated.
- Pertinent land uses on site include an iron works, unspecified depot, unspecified warehouse, builders' merchant, garage and vehicle repair centre, unspecified tank and electricity substation.
- Pertinent surrounding land uses include unspecified works, terminus, railway sidings, cuttings, unspecified commercial/ industrial units, burial grounds, saw mills, gravel pit, unspecified wharf, numerous unspecified tanks, electricity substations, garages and motor repair works.
- From the REC report it is inferred that ground conditions are likely to comprise Made Ground to approximately 1.00m bgl. Natural soils beneath the Made Ground are likely to comprise granular Lynch Hill Gravel Member deposits (Principal Aquifer) (very high permeability) to unknown depths. The superficial deposits are indicated to be underlain by the London Clay Formation (Unproductive Strata).
- The nearest surface water feature is an unspecified feature 108m west. Fray's River is annotated 110m west of the Site. The site is not located within 1 Km of a Source Protection Area or an environmentally sensitive area i.e. SAC, however; the Site is located within 300m of the London Greenbelt Area.
- The Site lies within a Nitrate Vulnerable Zone.

Potential Sources

- Possible metals, PAH, phenol, sulphate and asbestos contamination of on-site Made Ground previous Site uses and demolition of previous structures.
- Possible TPH contamination of on-Site Made Ground associated with the unspecified on-site tank and use as a vehicle repair centre.
- TPH in groundwater as reported by REC.

- Possible metals, fluoride, cyanide, sulphates asbestos and PCB contamination of Made Ground soils associated with the historic Iron works on Site.
- Potential hazardous ground gas generation from on and off-site Made Ground soils, including ground gas generation from any degraded residual petroleum hydrocarbons.

Potential Pathways

- Dermal contact, ingestion and inhalation of contaminants on site.
- Lateral and/or vertical migration of mobile contaminants.
- Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits.
- Contaminated dust migration during demolition/ construction.
- Migration via water pipes.
- Lateral/ vertical migration of contaminants via highly permeable granular Lynch Hill Gravel Member.
- Migration of ground gas via highly permeable granular Lynch Hill Gravel Member/ risk of explosion.

Potential Receptors

- Future, current and adjacent users of the Site.
- Site investigation, demolition and construction staff and future underground service maintenance workers from hazardous short-term exposure.
- Buildings, hardstanding and services.
- Principal Aquifer located beneath the Site.

6.2. Uncertainties

The following uncertainties exist in the preliminary conceptual model.

- The presence of any features unrecorded by the historical maps.
- Any unrecorded geological features.
- Any unreported pollution events during the site's history.

Table 6.1. Preliminary Assessment of Potential Pollutant Linkages.

Pollutant linkage				Qualitative risk assessment
	Source	**Pathway(s)**	**Receptor(s)**	
1	Possible metals, PAH, TPH, phenol, sulphate, and asbestos contamination of on-site Made Ground from previous Site uses and demolition of previous structures.	Dermal contact, ingestion and inhalation of contaminants including contaminated dust migration. Migration via water pipes	Future site users (residential)	Medium x Likely = Moderate Risk
			Current site users (commercial)	Medium x Low likelihood = Moderate/Low Risk
			Adjacent site users (commercial and residential)	Medium x Low likelihood = Moderate/Low Risk
			Site investigation, demolition and construction staff and future underground service maintenance workers.	Medium x Likely = Moderate Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits.	Adjacent site users (commercial and residential)	Medium x Likely = Moderate Risk
		Lateral and/or vertical migration of mobile contaminants.	Principal Aquifer located beneath the Site	Medium x Likely = Moderate Risk
2	Possible TPH contamination of on-site Made Ground, gravel and groundwater associated with the storage tanks and use as a vehicle repair centre.	Dermal contact, ingestion and inhalation of contaminants including contaminated dust migration. Migration via water pipes	Future site users (residential)	Medium x Likely = Moderate Risk
			Current site users (commercial)	Medium x Low likelihood = Moderate/Low Risk
			Adjacent site users (commercial and residential)	Medium x Low likelihood = Moderate/Low Risk
			Site investigation, demolition and construction staff and future underground service maintenance workers.	Medium x Likely = Moderate Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits.	Adjacent site users (commercial and residential)	Medium x Likely = Moderate Risk
		Lateral and/or vertical migration of mobile contaminants.	Principal Aquifer located beneath the Site	Medium x Likely = Moderate Risk
3	Possible metals, fluoride, cyanide, sulphates asbestos and PCB contamination of Made Ground soils associated with the historic Iron works on Site.	Dermal contact, ingestion and inhalation of contaminants including contaminated dust migration. Migration via water pipes	Future site users (residential)	Medium x Likely = Moderate Risk
			Current site users (commercial)	Medium x Low likelihood = Moderate/Low Risk
			Adjacent site users (commercial and residential)	Medium x Low likelihood = Moderate/Low Risk
			Site investigation, demolition and construction staff and future underground service maintenance workers.	Medium x Likely = Moderate Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits.	Adjacent site users (commercial and residential)	Medium x Likely = Moderate Risk

		Lateral and/or vertical migration of mobile contaminants.	Principal Aquifer located beneath the Site	Medium x Likely = Moderate Risk
4	Potential hazardous soil and gas generation from on and off-site Made Ground including ground gas generation from degraded residual petroleum hydrocarbons.	Inhalation (indoor and outdoor).	Future site users (Residential)	Medium x Low likelihood = Moderate/Low Risk
			Current site users (commercial)	Medium x Low likelihood = Moderate/Low Risk
			Adjacent site users (commercial and residential)	Medium x Low likelihood = Moderate/Low Risk
			Site investigation, demolition and construction staff and future underground service maintenance workers.	Medium x Low likelihood = Moderate/Low Risk
		Migration of ground gas / explosion.	Buildings and services	Severe x Low Likelihood = Moderate Risk

For definition of the terms used in the qualitative risk assessment, please see Appendix F.

7. FIELDWORK

7.1. Scope of Investigation

The information contained in this report is limited to areas of land accessible during the investigation within the Site boundary, as indicated on the Site plan, presented in Appendix A as Drawing No. TL1306GIR2. Tier Environmental scoped the intrusive ground investigation using guidance presented in BS 10175:2011, the remaining CLR document (Defra and Environment Agency) and BS EN 1997:2004 and 2007.

The investigation, which was supervised by a Tier Environmental Geoenvironmental Engineer, took place between 9th October 2017 and 20th October 2017 and comprised:

- Excavation of 11 No. hand excavated pits to a target depth of 1.20m bgl for service clearance purposes (TBH1 to TBH3, TWS1 to TWS11 and HDP1);
- Advancement of 11 No. window sample boreholes (TWS1 to TWS11) to depths between 1.20m (TWS9) and 2.33m bgl (TWS5) to determine shallow ground conditions, enable *in situ* geotechnical testing, obtain samples for laboratory analysis and install combined monitoring wells for both gas and groundwater;
- Advancement of 3 No. rotary Geobore-S boreholes (TBH1 to TBH3) to depths of 30.45m bgl to determine deep ground conditions, enable *in situ* geotechnical testing, obtain samples for laboratory analysis and install combined monitoring wells for both gas and groundwater;
- Excavation of 1 No. hand dug pit (HDP1) to a maximum depth of 1.20m bgl to determine shallow ground conditions and to obtain samples for laboratory analysis.

Permanent monitoring installations for either or both groundwater and ground gas monitoring were installed in;

- TBH1 (25.00m bgl) with response zones within the Lambeth Group in order to facilitate gas and groundwater monitoring.
- TBH2 and TBH3 (10.00m and 8.00m bgl) with response zones within the Lynch Hill Gravel Member, in order to facilitate gas and groundwater monitoring.
- TWS1, TWS5, TWS8 and TWS11 with response zones within the Made Ground soils and Lynch Hill Gravel Member, in order to facilitate both gas and groundwater monitoring.

A second phase of intrusive works were completed between 29th and 30th July 2020 and comprised:

- Drilling of 4 No. window sample boreholes (WS201-WS204) to depths of 0.55-2.00m bgl complete with installations to facilitate falling head testing.
- Completion of falling head tests within both new and previously installed window sample boreholes in order to determine the drainage characteristics of the shallow superficial soils.

Exploratory holes without instrumentation were backfilled with arisings and bentonite seals. The exploratory hole location and current Site features are shown on Drawing No. TE1306GIR2.

Depths and accurate descriptions of strata and groundwater observations made during investigation works, together with details of the samples recovered, are presented on the Engineer's exploratory hole records in Appendix C. Tier Environmental's standard strata description criteria are compliant with BS EN ISO 14688:2002 and 2004 and BS EN ISO 14689:2003. A brief description of field sampling and testing techniques is provided in Appendix J.

7.2. Geotechnical Testing

Geotechnical laboratory testing was scheduled by Tier Environmental on selected samples as presented in Table 7.1. Samples were collected as described in Appendix K. The testing was performed by Professional Soils Laboratory UKAS accredited. Test certificates are presented in Appendix L and discussed in Section 8, below.

Table 7.1. Geotechnical Laboratory Testing Schedule.

Test	Stratum type	Number of tests	Purpose
1. General			
Moisture content	Lambeth Group	12	a) Assist with the determination of consistency of soil with depth. b) Assess desiccation of soils. c) Suitability of materials for reuse within earthworks.
2. Classification			
Atterberg limit	Lambeth Group	12	a) Volume change potential. b) Plasticity assessment (comply with Eurocode 7 description) c) Consistency Index. d) Determine soil type (e.g., clay/silt). e) Use as an empirical guide to soil shear strength
Particle size distribution (wet/dry sieve)	Lynch Hill Gravel Member	4	a) Classify soils for earthworks purposes. b) Establish type of soil (comply with Eurocode 7 description).
	Lambeth Group	4	
3. Chemical tests			
BRE SD1 Suite	Lambeth Group	13	Determine correct class of concrete for both natural and made ground with specific tests for sites potentially containing sulphides (e.g., pyrites) or at low pH.
4. Compressibility			
One-dimensional consolidation	Lambeth Group	4	Determine the long-term consolidation behaviour of cohesive soils.
5. Shear strength (total stress)			
Unconsolidated undrained triaxial ("quick undrained triaxial")	Lambeth Group	7	Quantitative means of determining undrained shear strength of soils for: a) use in bearing capacity calculations; b) modelling the short-term behaviour of slopes and retaining structures; c) pile design; d) determining suitability of cohesive materials for vibro-replacement ground improvement techniques.

Shear box (small)	Lambeth Group	1	Quantitative determination of the shear strength of soils for modelling the behaviour of slopes and retaining structures. Large shear box test normally used for coarse materials (e.g., gravels) and the small for finer grained materials (e.g., sands).

7.3. Chemical Testing

Based upon the historical information available for the Site and the potential pollutant linkages identified for the proposed redevelopment (Sections 3, 4 and 6), Tier Environmental scheduled chemical laboratory testing on selected soil samples. The purpose of the testing was to:

- Determine the concentration and spatial distribution of potential contaminants in any Made Ground.
- Determine the chemical composition and properties of the shallow natural soils.
- Identify the extent of contamination in shallow groundwater; and
- Undertake preliminary waste soils classification

Sampling and QA/QC protocols are presented in Appendix K. Tier Environmental's schedule of chemical laboratory testing is presented in Table 7.2. The testing was carried out by Exova Jones Environmental.

Table 7.2. Schedule of Chemical Testing.

Laboratory analysis	Made Ground	Lynch Hill Gravel Member	Groundwater
Tier Environmental standard soil suite*	13	1	NA
Tier Environmental standard leachate suite*	NA	NA	NA
Asbestos screen	13	NA	NA
Tier Environmental standard groundwater suite*	NA	NA	3
Speciated TPH	4	NA	3
Full WAC suite	4	NA	NA

*For definition of Tier Environmental standard analytical suites, please see Appendix K.

NA - not applicable.

All analyses were undertaken using tests accredited to UKAS and/or MCERTS standards, where available. The analytical laboratory results are presented in Appendix M to this report and discussed in Section 9, below.

8. GROUND CONDITIONS AND MATERIAL PROPERTIES

8.1. Strata Profile

A summary of the strata profile determined at this site is given in Table 8.1.

Table 8.1. Strata Profile.

Strata	Depths recorded (m bgl)	Thickness (m)	General description and comments
Hardstanding	Observed in all locations (except for HDP1 and TWS6), from ground level to depths of between 0.06m and 0.30m bgl.	Between 0.06 and 0.30m.	Concrete Slab (5-9mm reinforcement) (TWS1 to TWS4 and TBH2). Macadam TWS5 to TWS11 (except for TWS10). Brickwork (TWS10).
Made Ground – MG1	Observed in all locations (except for TBH2 and TWS2), from depths of between 0.06m and 0.25m bgl to depths of between 0.25m and 1.05m bgl.	Between 0.08m and 0.96m	Light brown, brown orangey brown (locally reddish or greyish brown), clayey, sandy, very sandy in places GRAVEL, with gravels of brick, limestone, tarmacadam, ceramic and flint. Varying proportions of angular to subangular cobbles of brick and flint.
Made Ground – MG2	Observed in TBH2 and TWS2, from depths of between 0.30m and 0.23m bgl to a maximum proven depth of 0.85m bgl. The base of Made Ground was not encountered at TWS2a	Maximum proven thickness of 0.55m.	Very dark brown and black ashy, gravelly sand, and yellowish brown and dark greenish brown silty gravelly CLAY. Gravels consist of brick, glass and natural lithologies. Occasional cobbles of brick at TWS2a.
Made Ground – MG3	Observed in TBH2 and TWS3 to TWS5, from 0.25m to 0.85m bgl, to depths of between 0.60m and 1.98m bgl	Between 0.32m and 1.19m	Soft to stiff consistency, dark brown, light brown, greyish brown and orangey brown sandy, gravelly, silty in places CLAY. Gravels consist of brick, coal, glass and natural lithologies including flint.
Made Ground – MG4	Observed in TWS6 and HDP1, from ground level to a maximum proven depth of 1.20m bgl	Maximum proven depth of 1.20m bgl	Dark brown clayey sandy gravel and brown clayey gravelly SAND. Gravels consist of chert, rick, concrete, ceramic, polystyrene, plastic and root material. Locally cobbles of brick observed in HDP1.
Lynch Hill Gravel Member	Observed in all locations with the exception of TWS2, TWS2a, TWS6 and HDP1, from depths of 0.45m and 1.98m bgl, to depths of between 6.70m and 9.20m bgl	Proven thickness between 6.20m and 8.00m	Recovered as orangey brown, light brown and greyish brown clayey, sandy, very sandy in places GRAVEL of natural lithologies including flint, A moderate to high proportion of cobbles of mixed natural lithologies were observed throughout.
Lambeth Group – Solid Geology	Observed in TBH1, TBH2 and TBH3 from depths between 6.70m bgl and 9.20m bgl, to a maximum proven depth of 30.23m bgl.	Between 23.30m and 20.80m	Generally recovered as firm to very stiff consistency, slightly sandy slightly silty in places CLAY. Interbedded layers of silty fine to medium sand were observed throughout the Lambeth Group deposits. For detailed descriptions of strata identified and variations in colour observed throughout the Lambeth Group refer to logs.
Chalk Group	Observed in TBH1 and TBH3, from depths between 30.00m bgl and 30.32m bgl, to a maximum proved depth of 30.45m bgl	The base of this deposit was not encountered at any location.	Structureless CHALK composed of very soft consistency, light grey (GLEY1, 7/N) and light bluish grey (GLEY2, 8/1), silty, slightly gravelly CLAY or, white and light grey (GLEY/N, 7/) clayey slightly gravelly SILT. Gravel is subangular of low-density chalk with occasional small nodular flints. Grade Dm Putty Chalk.

NR - not recorded

Made Ground

Hardstanding

Surface macadam was encountered at 8 No. locations to depths between 0.09m and 0.20m bgl.

Surface concrete was encountered at 6 No. locations to depths between 0.17m and 0.30m bgl. The concrete observed on Site was generally observed with 5mm reinforcement bar.

Made Ground

Made Ground was encountered at all exploratory hole locations to depths between 0.25m and 1.99m bgl.

Made Ground was found to be variable comprising both granular and cohesive deposits with anthropogenic materials including brick, ceramic, concrete, tarmacadam, metals, wood and glass with natural materials including flint, coal, sandstone and limestone.

Obstructions

Subsurface structures were observed in TWS2 and TWS6, resulting in the termination and relocation of these locations at 0.30m and 0.65m bgl respectively, possibly indicative of a subsurface services or foundation with respect to TWS2, and possible kerbstone or foundation related to the street lighting/ security cameras with respect to TWS6.

During our works, there was no olfactory or visual evidence of hydrocarbon or similar contamination within the Made Ground.

Drift Deposits

The drift deposits encountered at this Site comprised Lynch Hill Gravel Member deposits. The properties this stratum is described below.

Lynch Hill Gravel Member

Lynch Hill Gravel Member deposits were observed in all locations with the exception of TWS2, TWS2a, TWS6 and HDP1, from depths of between 0.45m bgl (TWS1) and 1.98m bgl (TWS5) to a maximum proven depth of 9.20m bgl (TBH2), the base of this deposit was observed in TBH1 to TBH3, with thickness observed between 6.20m (TBH1) and 8.00m (TBH2).

Lynch Hill Gravel Member deposits were encountered underlying the Made Ground comprising mainly granular sands and gravels with a thin band of very clayey gravel immediately below the Made Ground deposits. Granular deposits consisted of light brown and brown sandy, very sandy in places gravel, with gravels of natural lithology including flint, and varying proportions of subangular to rounded cobbles of natural lithologies including flint. The base of these granular deposits overlay the interbedded clays, silts and sands of the Lambeth Group.

Standard Penetration Tests conducted within the Lynch Hill Gravel Member reported SPT refusals, with SPT N values of N >50, representing very dense deposits. The results of the specified geotechnical testing are presented in Appendix L and summarised in Table 8.2.

During our works, there was no olfactory or visual evidence of hydrocarbon or similar contamination within the Lynch Hill Gravel Member.

Bedrock

Lambeth Group

The Lambeth Group was encountered in all cable percussive and rotary follow-on boreholes, with an upper surface reported between 33.51m (TBH2) and 35.74m AOD (TBH1).

Cohesive deposits consisted of firm to very stiff consistency multicoloured, reddish brown, olive brown, light reddish grey, pale brown and grey slightly sandy, slightly silty in places clay.

Granular deposits observed within the Lambeth Group have been reported as generally reddish brown or olive brown slightly clayey in places, slightly silty in places fine to medium grained sand.

Standard Penetration Tests conducted within the Lambeth Group reported SPT refusals, with SPT N values of N>50, representing very high strength clays.

Due to the variable nature of the Lambeth Group and the requirement to reduce differential settlement to acceptable levels it is envisaged that further site investigation may be required in order to attempt to avoid advancing piled foundations down to the underlying and more consistent chalk bedrock. This will be dependent on groundwater pressures which may be confined within granular layers encountered in the Lambeth Group. This will be confirmed during the ongoing groundwater monitoring.

The results of the specified geotechnical testing are presented in Appendix L.

During our works, there was no olfactory or visual evidence of hydrocarbon or similar contamination within the bedrock.

Chalk

Structureless CHALK composed of very soft consistency, light grey (GLEY1, 7/N) and light bluish grey (GLEY2, 8/1), silty, slightly gravelly CLAY or, white and light grey (GLEY/N, 7/) clayey slightly gravelly SILT. Gravel is subangular of low density chalk with occasional small nodular flints.

Table 8.2. Soil Classification Test Results for Lambeth Group

Exploratory hole	Depth (m bgl)	Stratum	MC (%)	LL (%)	PL (%)	PI (%)	Class
TBH1	10.00	Lambeth Group	17	61	26	35	High Plasticity CH
TBH1	12.50	Lambeth Group	22	56	25	31	High Plasticity CH
TBH1	15.60	Lambeth Group	15	38	19	19	Intermediate Plasticity CI
TBH1	21.50	Lambeth Group	25	64	27	27	High Plasticity CH
TBH1	23.15	Lambeth Group	17	48	23	25	Intermediate Plasticity CI
TBH2	23.44	Lambeth Group	16	50	21	29	High Plasticity CH
TBH2	29.04	Lambeth Group	26	77	29	48	Very high plasticity CV
TBH2	17.90	Lambeth Group	13	45	23	22	Intermediate Plasticity CI
TBH2	25.20	Lambeth Group	28	37	20	17	Intermediate Plasticity CI
TBH3	19.00	Lambeth Group	19	53	24	29	High Plasticity CH
TBH3	27.58	Lambeth Group	20	53	24	29	High Plasticity CH
TBH3	28.53	Lambeth Group	28	87	31	56	Very high plasticity CV

ND - Not determined; MC - Moisture content, LL - Liquid limit, PL - Plastic limit, PI - Plasticity index.

8.2. Determination of pH and Water-Soluble Sulphate

Representative samples of the materials encountered in the exploratory holes were tested to determine their pH and concentrations of water-soluble sulphate (SO_4^{2-}). The results are presented in Appendix M and L and summarised in Table 8.3.

It has been assumed based on the groundwater observations during the ground investigation works that the groundwater is 'mobile' and that the site is 'brownfield' in accordance with BRE SD-1.

The results show that with respect to soils on site, a design sulphate class of DS1 and ACEC class of AC-1 are appropriate for buried concrete on site.

Table 8.3. Results of Soil pH Testing and Water-Soluble Sulphate Determination.

Borehole	Depth (m bgl)	pH	Water-soluble sulphate (g/l)	Design sulphate class	ACEC sulphate class
Made Ground					
TWS1	0.30	12.04	0.004	Mean of the highest 20% calculated in accordance with BRE-SD1 = 0.2167 g/l = 216.7mg/l This places the Site in a DS-1 scenario with respect to Made Ground soils	AC-1
TWS2a	0.30	9.12	0.0503		
TWS3	0.28	11.19	0.2188		
TWS4	0.30	11.99	0.0447		
TWS5	0.40	10.71	0.051		
TWS6	0.40	11.09	0.1771		
TWS7	0.70	8.67	0.0974		
TWS8	0.60	8.35	0.1237		
TWS9	0.30	11.51	0.0223		
TWS11	0.50	8.93	0.0138		
HDP1	0.50	7.6	0.0041		
TBH1	0.20	8.65	0.0015		
TBH2	0.50	10.2	0.2542		
Lambeth Group					
TBH1	10.00	9.0	0.017	Mean of the highest 20% calculated in accordance with BRE-SD1 = 0.0232 g/l = 23.23mg/l This places the Site in a DS-1 scenario with respect to Natural soils	AC-1[d]
TBH1	12.50	8.8	0.014		
TBH1	15.60	9.0	0.010		
TBH1	21.50	8.6	0.019		
TBH1	23.15	8.7	0.021		
TBH2	9.50-10.50	8.1	0.013		
TBH2	17.90	8.8	0.072		
TBH2	23.44	8.7	0.018		
TBH2	25.20	8.5	0.021		
TBH2	29.04	8.8	0.019		
TBH3	19.00	8.7	0.018		
TBH3	27.58	9.1	0.018		
TBH3	28.53	8.9	0.042		

ACEC - Aggressive Chemical Environment for Concrete (see BRE, 2005).

8.3. Groundwater Observations and Monitoring

Sampling from groundwater monitoring installations was performed according to the methods presented in Appendix K.

Groundwater monitoring was performed on 1 No. occasions on the 16th November 2017 The full results of this monitoring are presented in Appendix N. Further groundwater monitoring is planned, which will give a total monitoring period of 6 No visits over a 3 No. month period. The rationale behind this total monitoring period is to allow monitoring of deep groundwater conditions to aid in final foundation design.

These results show a groundwater strike within the Lynch Hill Gravel Member at between 37.26m and 38.13m aod and within the Lambeth Group at approximately 32.21m aod.

Table 8.4. Field Observations of Groundwater.

Borehole	Strike (m bgl)	Rise in groundwater after 20 mins. (m bgl)	During monitoring (m bgl)	Formation	Observations
TBH1	18.70	4.70	Between 10.20m and 13.50m	Lambeth Group	
TBH2	12.00	10.30	Between 4.20m and 4.80m	Lynch Hill Gravel Member	
TBH3	6.20	5.30	Between 4.30 and 7.47m	Lynch Hill Gravel Member	
BH101	NA	NA	Between 5.20 and 5.68m	Lynch Hill Gravel Member	

8.4. Ground Gas Monitoring

Ground gas monitoring installations were constructed in TBH1 to TBH3, TWS1, TWS5, TWS9 and TWS11 with response zones within the Lambeth Group, Lynch Hill Gravel Member and Made Ground soils.

Monitoring comprised measurement of pressure, methane (CH_4), percent of lower explosive limit (LEL), carbon dioxide (CO_2), oxygen (O_2), hydrogen sulphide (H_2S) and gas flow rate.

The ground gas monitoring presented in this report was performed between 6th September 2016 and 19th September 2016 by REC, and the 16th November 2017 to the 6th April 2018 by Tier Environmental. The rationale behind this monitoring period is in accordance with CIRIA C665 for a moderate sensitivity development with a low risk of ground gas generation.

The ground gas monitoring results to date from the installations are presented in Appendix N.

The total atmospheric pressure range of the ground gas monitoring data included in this report was 992 to 1027 mbar. This range covers low, moderate and high atmospheric pressures. Monitoring events included periods of falling, stable and rising pressure.

The results of the ground gas monitoring have been assessed in accordance with the criteria specified for this Site, which were derived as described in Appendix G.

A maximum peak and steady carbon dioxide concentration of 2.4%v/v has been reported by REC at WS102 and 2.2%v/v by Tier Environmental at BH101 during the first round of ground gas monitoring with a corresponding lowest oxygen concentration of 15.00%v/v and 17.1%v/v respectively. A maximum peak and steady concentration of 0.1%v/v has been reported for methane. A maximum flow rate of 0.4l/hr and corresponding steady flow rate 0f 0.3l/hr has been reported in the final monitoring visit at TBH3.

A maximum peak and steady carbon monoxide concentration of 36ppm has been reported at WS107 by Tier Environmental, this reported concentration is slightly above the workplace long term exposure limit (30 ppm) and the workplace short term exposure limit (200 ppm) published be the Health and Safety Executive (EH40/2005 Workplace Exposure Limits) and the WHO long term (24 hours) indoor exposure guideline value (5.68 ppm). However; it is considered that due to this being reported in only one monitoring visits, and the concentration quickly reducing to below the laboratory limit of detection, along with the fact that the maximum steady reported concentration of carbon monoxide is 5ppm, which is below both workplace long term exposure limit and the WHO long term indoor exposure guideline value of 5.68ppm that there is no significant risk with respect to the end land use. No measured concentrations of hydrogen sulphide in excess of the instruments limit of detection have been reported.

A Gas Screening Vale (GSV) of 0.0088l/hr has been calculated in accordance with CIRIA C665 using the maximum reported flow rate assumed to be 0.04l/hr and the maximum reported peak and steady carbon dioxide concentration (2.2%v/v). This places the site in a Characteristic Situation 1 – Very Low Risk Scenario for which basic ground gas protection would not be required.

It must be noted; however, that elevated VOC readings were reported by REC during monitoring visits and therefore further monitoring may be required in order to determine the whether a volatile resistant membrane would be required on site.

9. RESULTS OF CHEMICAL TESTING

Results of chemical analysis are presented in full in Appendix M.

9.1. Data Interpretation Approach

The analytical data obtained were reviewed for completeness and consistency. The data for each sample type was then compiled, screened against the GACs for a residential without home-grown produce end land use and those compounds or elements which were found to have exceedences of the GACs were then subjected to detailed analysis as described below.

No zoning of the Site was undertaken as part of the interpretation. The historic land use and proposed development pattern meant that zoning was not appropriate or beneficial to the site investigation or subsequent data interpretation.

Selection of Generic Assessment Criteria (GAC)

The approach for the selection of the GACs used as screening criteria for this assessment is provided in Appendix G. In short, for the majority of the contaminants of concern, LQM/CIEH Suitable 4 Use Levels (S4ULs) published recently in 2015 have been adopted as GACs for a residential with home grown produce land use. These values are considered as appropriate screening criteria as they incorporate updated assumption exposures derived for the production of C4SLs but within the context of deriving screening criteria above which assessment of the risks or remedial action may be needed (i.e. within the context of the planning regime rather than Part 2A context for which C4SLs were derived).

Based on the proposed development layout drawings, the measured concentrations of determinands have been assessed against GAC appropriate for a residential without home grown produce end land use.

Assessment of outliers and data distribution

Assessment of data distribution and the identification of statistical outliers was performed iteratively, applying appropriate data distribution and outlier tests for the complete and outlier-censored datasets.

The presence of outliers was determined using Grubbs' test working with untransformed values for normally distributed data and natural log-transformed values for non-normally distributed data.

The data were tested for normality by at least two of the following methods:

- Probability histogram
- Probability (q-q) plots
- Shapiro-Wilk normality test

Outliers were considered to form part of the overall site dataset *except* they were not considered to be statistically representative of the shallow soils as a whole.

Calculation of 95% upper confidence limit of the sample mean

Based upon the normality and outlier tests, the 95% UCL of each contaminant of concern was calculated by:

- One-sample Grubb's-test for datasets that are normally distributed or close to normal distribution;
- One-sided Chebyshev test for datasets that are significantly non-normal.

Where both the one-sample Grubbs-test and one-sided Chebyshev 95th percentile results were both below the critical concentration, normality tests were not undertaken, as this would have had no effect upon the final outcome.

9.2. Human Health

Metals and Metalloids

Table 9.1. Calculated 95th percentile upper confidence estimates of the true mean values and comparison to the critical concentration of those determinants which recorded exceedences during initial screening within Made Ground Soils.

Determinant	No. Samples	No. samples in exceedance	GAC	Outliner or representative data set?	95% UCL with outliers removed	Comments
Lead	14	2	310	Representative	305.82	Following analysis of the data using the Chebyshev test on the non-normally distributed data. The 95th percentile *was not* shown to exceed the GAC for lead.
Mercury	14	1	1.2	Outliner	0.94	Following analysis of the data using the Chebyshev test on the non-normally distributed data. The 95th percentile *was not* shown to exceed the GAC for mercury.

1. SGV, generic assessment criterion or site-specific assessment criterion, as appropriate. 2. Outliers only removed where they were not considered to be statistically representative of the shallow soils as a whole.

After initial screening against the relevant GACs 2 No. samples reported lead in excess of the relevant GAC and 1 No. samples reported mercury in excess of the relevant GAC. After further statistical analysis of determinands which exceeded the relevant GAC it is considered that Made Ground at the site should be considered to present a potentially significant risk to human health with respect to metals and metalloids for a residential without home grown produce land use.

PAHs

Polycyclic aromatic hydrocarbons (PAHs) are a wide range of over 200 different compounds normally associated with combustion or processing of hydrocarbons and coal. Elevated levels of PAH's can also be found in tarmac. Sixteen PAH"s (usually known as the USEPA 16) comprise the more common individual carcinogenic PAH compounds with a seventeenth (Coronene) included in the assessment of soil for waste disposal at landfill sites. Each of the PAH compounds have different toxicity:

After initial screening against the relevant GACs 1 No. sample reported concentrations of PAHs in excess of the relevant GAC:

Table 9.2. Revised Assessment of Pollutant Linkages.

Determinant	No. Samples	No. samples in exceedance	GAC	Outliner or representative data set?	95% UCL with outliers removed	Comments
Dibenzo(ah)anthracene	14	1	0.31	Outliner	0.197	Following analysis of the data using the Chebyshev test on the non-normally distributed data. The 95th percentile *was not* shown to exceed the GAC for Dibenzo(ah)anthracene.

It is therefore considered that made ground at the site should be considered to present a risk to human health with respect to PAHs for a residential without home grown produce end land use.

Hydrocarbons

No visual or olfactory evidence of hydrocarbon contamination was encountered during the site investigation.

Of the 5 No. soil samples sent for TPH analysis, all recorded detectable concentrations of hydrocarbons in excess of the laboratory limit of detection.

Table 9.2 below shows the concentrations recorded within each equivalent carbon number band against its respective adopted assessment criteria. For this part of the assessment, the results have been screened against the most conservative GAC within each of the bands below from the LQM (2014) GACs for the TPHCWG set of hydrocarbon bands. These are considered the most appropriate set of assessment criteria to be used for the specified land use.

Table 9.3. Detectable concentrations of TPH.

Determinant	Units	Borehole Numbers	LoD	Recorded Result	Critical concentration for the proposed land use and source	Exceedences?
Aliphatics >C16-C21	mg/kg	TBH2	7 mg/kg	8	65000	N/A
Aliphatics >C21-C35	mg/kg	TWS2a	7 mg/kg	43	65000	N/A
		TWS4		16		
		TWS5		67		
		TBH2		44		
Aromatics >EC16-EC21	mg/kg	TBH2	7 mg/kg	15	1900	N/A
Aromatics >EC21-EC35	mg/kg	TWS2a	7 mg/kg	56	1900	N/A
		TWS4		45		
		TWS5		138		
		TBH2		110		

It is therefore considered that Made Ground at the site should be considered to not present a risk to human health respect to Total Petroleum Hydrocarbons for a residential without home grown produce end land use.

PCBs

After initial screening, no measured concentrations of PCBs were reported in excess of the laboratory method detection limit. As such, there is no evidence of any significant concentrations of PCBs that are likely to be indicative of a potentially significant risk to human health or the wider environment.

Asbestos

Asbestos can be present in soil as fragments of bulk Asbestos Containing Materials (ACMs) (e.g. asbestos cement sheeting) and also as discrete asbestos fibres within the soil matrix. This investigation has carried out assessments to determine whether both bulk fragments and / or fibres are present in the soil at the site. The asbestos assessment commenced on site with inspection of the Made Ground by our site staff for the presence of bulk ACMs. During the fieldwork no suspected ACMs were identified.

Of the 14 No. samples which were screened for asbestos, 4 No. were found to contain asbestos fibres in the form of chrysotile fibre bundles (TWS2a 0.30m bgl and TWS9 at 0.30m bgl) and amosite fibre bundles (TWS5 at 0.40m bgl). All samples which reported the presence of asbestos fibre bundles did so at mass <0.1%. It is therefore considered that Made Ground soils on site may pose a potentially significant risk to human health with regards to asbestos.

9.3. Groundwater Sampling

Analytical data for groundwater samples have been evaluated against appropriate GAC values for the surface water sampled. The derivation of the GAC values is described in Appendix I.

In order to assess whether there is an unacceptable risk of pollution of controlled waters, samples of groundwater have been submitted for laboratory chemical analysis. In accordance with Part 2A of the Environmental Protection Act 1990, Tier Environmental has made regard to all of the water quality standards that are relevant to the specific site and a judgment has been made against the most stringent of those relevant standards.

In accordance with best practice consideration of the following sources of water quality standards has been made:

- EQS Directive 2008/105/EC
- Priority Substances Directive 2013/39/EU
- Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
- UK Drinking Water Standards (UK DWS)
- World Health Organisation (WHO Guidelines) for Drinking Water Quality
- Council Directive 98/83/EC on the quality of water intended for human consumption (Drinking water directive)

Further details on the derivation of the GAC values is described in Appendix I.

In some instances, the laboratory method detection limit is greater than the appropriate EQS/UKDWS value. In these instances, only measured concentrations in excess of the laboratory method detection limit have been considered likely to potentially represent a possible significant risk to controlled waters.

For those determinands where the selected water quality standard is dependent on hardness, a hardness value of >250 mg CaCO3/l has been conservatively selected based on the results of groundwater analysis at the Site.

Please note that there is no quantitative criterion for total petroleum hydrocarbons (TPH), or speciated TPH fractions. Historically, standards provided for petroleum hydrocarbons ranges from 10 µg/l (Private Water Supply Regulations 1991, removed from the 2009 regulations) to 50µg/l-1000µg/l (Surface Waters (Abstraction for Drinking Water) Regulations 1989) which related to the degree of treatment of water prior to use as drinking water. Over time, the legislative standards have been rescinded and no alternative standard provided, although the Environment Agency planned to release speciated TPH criteria (Fretwell et al., 2009). In the absence of suitable criteria, Tier Environmental adopts a value of 10 µg/l for more sensitive locations (e.g. unprotected Principal Aquifer, drinking water abstraction), and a value of 50 µg/l for locations considered less sensitive (e.g. low permeability aquifers) or where a site is located in close proximity to a surface watercourse.

The results demonstrate that measured concentrations of nickel, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(ah)anthracene, chrysene, benzo(bk)fluoranthene, benzo(a)pyrene, indeno(123cd)pyrene and benzo (ghi) perylene have been reported in excess of the laboratory limit of detection. With respect to the respective EQS value, there is either no relevant EQS standard to compare against or the exceedences are within 1 No. or 2 No. orders of magnitude, with the exception of fluoranthene which is 3 No. orders higher.

No concentrations of TPH CWG above the laboratory limit of detection have been reported within the groundwater monitoring undertaken by Tier Environmental.

It is considered that the Site does not represent a potentially significant risk to controlled waters based on the following:

- The exceedances are marginal.
- The direction of groundwater flow is as yet unknown.
- There is an absence of any known significant PAH sources in the Made Ground on Site.
- The marginal elevated PAH results within groundwater do not correspond to any reported exceedences within Made Ground soils on Site.
- Historical land use on Site and in the vicinity, that these reported concentrations are representative of background concentrations.

10. REVISED CONCEPTUAL MODEL AND GENERIC QUANTITATIVE RISK ASSESSMENT OF POLLUTANT LINKAGES

The preliminary combined conceptual site model and conceptual exposure model, developed from the desk study information and presented in Section 6, has been revised in light of the ground investigation and the chemical analysis results presented above.

The revised conceptual model has been developed for the proposed future land use. This summarises the understanding of surface and sub-surface features, the potential contaminant sources, transport pathways and receptors.

10.1. Justification

Land Use

- The site is underlain by Made Ground to proven depths of between 0.45m and 1.99m bgl comprising mainly granular materials with occasional cohesive deposits. Anthropogenic materials observed on site included brick, concrete, metal, plastic, glass, ash and polystyrene, with natural materials including coal, limestone and chert.
- The Made Ground was directly underlain by Lynch Hill Gravel Member deposits to proven depths between 6.70m and 9.20m bgl.
- The superficial deposits on site were directly underlain by solid geology consistent with the Lambeth Group, not London Clay Formation as eluded to in the Phase I & II REC Report. These multicoloured interbedded clays, silts and sands were observed from depths between 6.70m and 9.20m bgl to a maximum proven depth of 30.32m bgl. This may present an issue due to the variable nature of Lambeth Group deposits over a relatively short distance.
- Chalk was observed in 2 No. locations from depths between 30.00m and 30.32m bgl to a maximum proven depth of 30.45m bgl.
- Groundwater strikes encountered during Site investigation works have indicated the presence of groundwater bodies within both the Lynch Hill Gravel Member and also the deeper Lambeth Group.
- There was no obvious visual or olfactory evidence of gross contamination on Site; however, an ashy type Made Ground was observed in TBH2.
- Elevated levels of metals and PAHs were reported in 2 No. samples of Made Ground soils; however, further statistical analysis has demonstrated that these may pose a significant risk with respect to human health.
- Asbestos in the form of amosite and chrysotile fibre bundles have been reported in 3 No. of the 14 No. samples obtained at Site by Tier Environmental and 2 No. by REC. It is considered that, without mitigation, asbestos in shallow soils may present a significant risk to human health.
- A Gas Screening Vale (GSV) of 0.0088l/hr has been calculated in accordance with CIRIA C665 using the maximum reported flow rate assumed to be 0.04l/hr and the maximum reported peak and steady carbon dioxide concentration (2.2%v/v). This places the site in a Characteristic Situation 1 – Very Low Risk Scenario for which basic ground gas protection would not be required.

Potential Sources

- Asbestos, in the form of chrysotile and amosite fibre bundles reported in the Made Ground.
- Elevated lead, mercury and PAH's in the Made Ground soils.
- Hazardous ground gases generated from on and off-site Made Ground, infilled ground and ground disturbance in the vicinity of the Site.
- Any locations of contamination not identified during the initial site investigation, or any unreported contamination events during the Sites history.
- Unknown location of unspecified tank noted as being on Site.

Potential Pathways

- Inhalation of contaminants on Site.
- Migration of contaminated dusts during redevelopment works.
- Migration of hazardous soil gases through soil pore spaces to buildings and services.
- Migration of mobile contaminants through water pipes.

Potential Receptors

- Future, current and adjacent users of the Site.
- Site investigation, demolition and construction staff and future underground service maintenance workers from hazardous short-term exposure.
- Buildings, hardstanding and services.

10.2. Uncertainties

The following uncertainties exist in the present conceptual model.

- The results of a completed ground gas monitoring regime.

Table 10.1. Revised Assessment of Pollutant Linkages.

Pollutant linkage				Generic quantitative risk assessment
	Source	**Pathway(s)**	**Receptor(s)**	
1	Made Ground – Ground gas generation	Migration and accumulation within structures or services	Future Site users, residents and visitors.	Mild x Low Likelihood = Low Risk
2	Asbestos in the form of amosite and chrysotile in the Made Ground soils of 5 No. locations (REC and Tier data)	Inhalation of contaminants on Site. Migration of contaminated dusts during redevelopment works.	Future, current and adjacent users of the Site. Site investigation, demolition and construction staff and future underground service maintenance workers from hazardous short-term exposure.	Medium x Likely = Moderate Risk
3	Elevated metals and PAH	Dermal contact, ingestion and inhalation of contaminants including contaminated dust migration. Migration via water pipes	Future site users (residential)	Medium x Likely = Moderate Risk
4			Current site users (commercial)	Medium x Low likelihood = Moderate/Low Risk
5			Adjacent site users (commercial and residential)	Medium x Low likelihood = Moderate/Low Risk
6			Site investigation, demolition and construction staff and future underground service maintenance workers.	Medium x Likely = Moderate Risk
7		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits.	Adjacent site users (commercial and residential)	Medium x Likely = Moderate Risk
8		Lateral and/or vertical migration of mobile contaminants.	Principal Aquifer located beneath the Site	Medium x Likely = Moderate Risk

For definition of the terms used in the qualitative risk assessment, please see Appendix F.

11.CONCLUSIONS AND RECOMMENDATIONS

11.1. General

This Ground Investigation Report has been performed for Land off Harefield Road (Units 1 and 2), Uxbridge, UB8 1JS. It is understood that there is full planning permission for comprehensive redevelopment of the site comprising demolition of existing buildings to provide residential care accommodation (C2), café and nursery (E) in buildings up to 8 storeys, car parking, landscaping and associated works. In addition, it is assumed that ground levels will not change significantly from those described in this report. If this is not the case, then amendments to the recommendations made in this report may be required.

11.2. Flood Risk

The Site is located in an area whereby the Environment Agency/Natural Resources Wales Zone 2 floodplains estimate the annual probability of flooding as between 1 in 1000 (0.1%) and 1 in 100 (1%) from rivers and between 1 in 1000 (0.1%) and 1 in 200 (0.5%) from the sea. Risk of flooding from Rivers and the Sea (RoFRas) as indicated by the Environment Agency/ Natural Resources Wales on Site is Very Low (less than 1 in 1000) chance of flooding in any given year. The British Geological Survey indicates the presence of a groundwater flooding susceptibility area within 50m of the Site.

11.3. Mining and Quarrying

The site is not considered to be at risk from shallow mining. Historical plans do not indicate any quarries, clay pits or other extractive industries in the vicinity of the site. Localised workings of shallow strata cannot be wholly discontented but given the historical use of the Site this is considered unlikely.

11.4. Geotechnical Parameters

The data obtained during the Ground Investigation has been assessed for the recorded soil types in order to provide characteristic values in order to aid the final foundation design.

Soil Classification

Cohesive Soils

Moisture content and Atterberg Limit testing was undertaken on samples from cohesive superficial material at the site. A summary of the results is shown in Table 11.1 below

Table 11.1. Summary of Natural Moisture Content and Atterberg Limits

Parameter	No. Tests	Minimum	Maximum	Average
Natural MC %	12	13%	28%	21%
Plastic Limit %	12	19%	31%	24%
Liquid Limit %	12	37%	87%	56%
Plasticity Index	12	17%	56%	31%

A total of 12 No. Atterberg Limit Tests were performed on samples of identified cohesive soil. All samples returned results which confirm that the material is clay of intermediate to very high plasticity.

Figure 11.1 below and shows the results from Standard Penetration Tests (SPT) conducted within boreholes have reported in the range of SPT N = 16 and N= 50. It can be observed in Figure 11.1 that the granular deposits of the Lynch Hill Gravel Member (LGHM) generally report refusal, with N = 50, so do the cohesive and granular deposits of the Lambeth Group (LG). There is; however, between approximately 31.00m and 36.00m AOD a reduction in SPT N value is reported, both within the Lynch Hill Gravel Member and the Lambeth Group. It is considered that this reduction in SPT N value is a result of the weathering process of the underlying Lambeth Group. It is considered that this reduction in N Value is likely to extend across the entire site at the LHGM – LG interface.

Figure 11.1 Plot of SPT N Value against reduced level

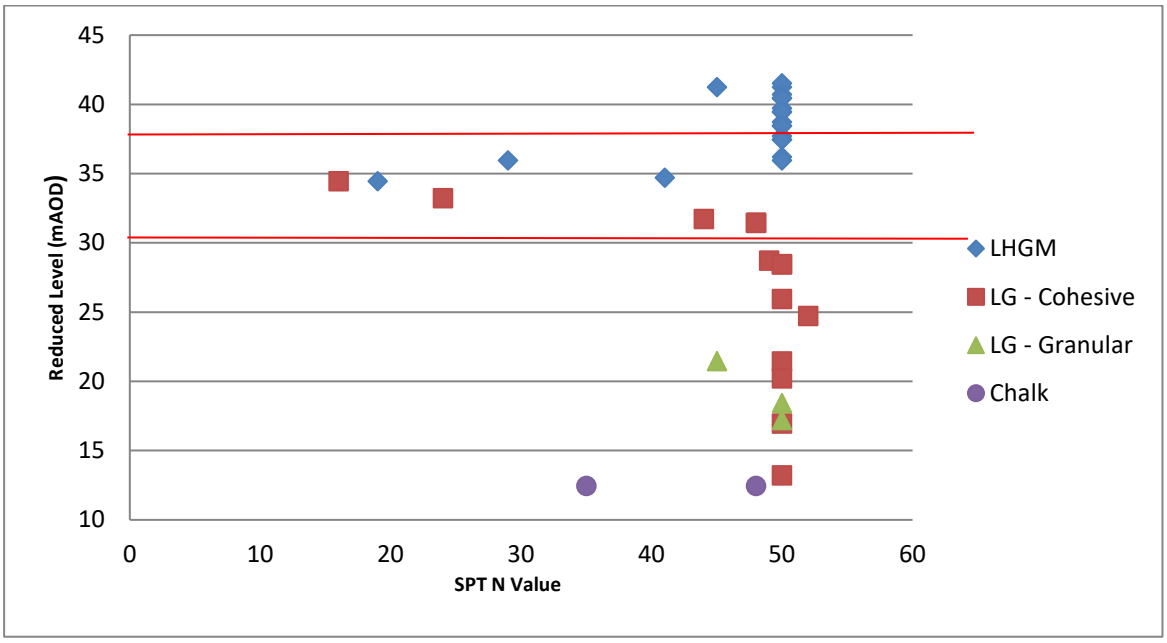


Figure 11.1 shows a plot of reduced SPT N value against reduced level, with the red line boundary between 30.00m and 38.00m AOD highlighting a zone of reduced SPT N value at the base of the Lynch Hill Gravel Member and the top of the Lambeth Group.

Granular Soils

4 No. samples of the Lynch Hill Gravel Member strata, and 2 No. samples of the Lambeth Group were submitted for Particle Size Distribution tests. The tests show a distinction between the strata types. Samples of the Lynch Hill Gravel Member strata were generally recorded as slightly silty sandy gravel whereas the test results from the Lambeth Group strata were recorded as a slightly sandy to very sandy silt.

Shear Strength Parameters

A total of 6 No. total stress undrained triaxial tests were performed on the natural clay strata encountered within the exploratory holes. Single stage tests were performed and these yielded value of undrained shear strength (Cu). A summary of the test results obtained for the natural clay strata is given in Table 11.2 overleaf.

Table 11.2. Summary of undrained shear strength values for natural clay strata

Location	Depth (m bgl)	Shear Strength Cu (kPa)	Mode of Failure
TBH1	27.54	149	Brittle
TBH2	12.50	195	Intermediate
TBH2	23.44	182	Intermediate
TBH2	29.04	162	Plastic
TBH3	19.00	140	Plastic
TBH3	27.58	119	Intermediate

Standard Penetration Tests (SPT) were carried out in all of the boreholes. The undrained shear strength of the natural clay strata tested has been estimated using the relationship developed by Stroud, where:

Cu = f1 x SPT N60 value

The value of f1 is dependent on the Plasticity Index (Ip). By using the moderately conservative Plasticity Index of 35%, a characteristic value of f1 = 4.2 has been derived.

Based on this a conservative shear strength value of between 145kPa and 210kPa have been reported. Both results obtained by undrained triaxial testing and SPT N Value seem to show no obvious correlation between shear strength and depth.

A single consolidated drained shear box test within TBH3 at 23.50-25.00m bgl, reported as slightly sandy silt reported an angle of shearing resistance of 33°and effective cohesion of 5kPa.

One Dimensional Consolidation Testing

A total of 4 No. one dimensional consolidation tests were carried out on samples of the Lambeth Group. Table 11.2 below summarises the results of m_v (m^2/MN) and Cv (m^2/yr) based on the depth from which the sample has been taken.

Table 11.3. Summary of one dimensional consolidation testing on natural clay strata

Location	Depth (m bgl)	Pressure Range (kPa)		m_v (m^2/MN)	Cv (m^2/yr)
		(from)	(to)		
TBH1	15.60	312	624	0.047	33.470
TBH2	12.50	250	500	0.112	56.933
TBH1	27.54	550	1101	0.031	8.129
TBH3	22.55	451	902	0.031	7.769

Foundation Recommendations

The Site is underlain by a maximum proven thickness of 1.99m of Made Ground, overlying a layer of the Lynch Hill Gravel Member. This gravel was generally recorded as a very dense light brown very sandy subangular to rounded fine to coarse gravel of flint. It was encountered in all exploratory locations with the exception of TWS2/2a, TWS6 and HDP1.

Given the encountered ground conditions and anticipated loads associated with the proposed development, two foundation solutions are proposed, which will need to be revisited and finalised on receipt of the final column loads.

Pad Foundations

Shallow pad foundations within the Lynch Hill Gravel Member designed on a safe bearing resistance of 250kPa are considered as a possible foundation solution depending on the anticipated final loads as long as there is no risk of unacceptable differential settlement across the Site.

If pad foundations are the preferred foundation solution, it is recommended that additional ground investigation and settlement testing should be undertaken across the Site.

Piled Foundations

Piles are likely to be the most appropriate solution if loads are to be too high to allow shallow pad foundations due to the absence of a suitable strata at shallow depth; however, it must be noted that the Lambeth Group soils can be highly variable over relatively short distances, which may result in an increased risk of differential settlement occurring between pile groups. Advice from a specialist piling contractor should be sought.

The localised high density of the drift deposits suggests that driven piles may refuse at shallow depth and, as such, it is considered that a bored piles or CFA piled solution would be most appropriate. In order to use the load carrying capacity attributable to both shaft friction and end bearing. The final design figures should be checked to ensure that the ultimate shaft friction is greater than or equal to the allowable working load, otherwise end bearing only should be used.

Due to the variable nature of the Lambeth Group and the requirement to reduce differential settlement to acceptable levels, it is envisaged that further site investigation may be required in order to attempt to avoid advancing piled foundations down to the underlying and more consistent chalk bedrock. This will be dependent on groundwater pressures which may be confined within granular layers encountered in the Lambeth Group. This will be confirmed during the ongoing groundwater monitoring.

The construction of a piled foundation is a specialist job and the advice of a reputable local contractor familiar with the type of ground and groundwater conditions encountered on this site should be sought prior to finalising the design. The actual working load for proposed piles will depend on the particular type of pile and method of installation adopted.

Portions of the Site are covered by former or existing facilities on the site, e.g., hardstanding, floor slabs and foundations. This material is unsuitable for foundations and relict foundations and floor slabs should be broken out to avoid the formation of hard spots.

Groundworks, Excavation Stability and Groundwater Dewatering

In our opinion, there should be no particular difficulties in excavating the strata indicated in the boreholes utilising an appropriate and suitably sized mechanical excavator. Excavations into existing Made Ground and the underlying natural soils should be assumed to be unstable. No man entry into

unsupported excavations should be allowed without an appropriate risk assessment. Reference to CIRIA report 097 (1983) should be made to establish suitable means of support or battering of excavation sides.

It is recommended that all excavations to greater than 1.20 metres depth, or for shallower excavations where groundwater is encountered above this level are closely supported, especially where man entry is required. Alternatively, where space permits, the excavations might be battered back to an appropriate angle. Should groundwater seepages occur, and water accumulate in shallow excavations, it should be able to be removed by pumping from a filtered sump. However, groundwater control by more robust means, such as well pointing, may be required locally.

It should be noted that should a deep basement is to be constructed as part of the development then we would recommend that the standpipes are monitored for groundwater levels for an extended period of time and take into consideration seasonal variations and periods of very wet weather to measure the fluctuation of the standing water levels. It should be noted that groundwater inflows and levels are likely to be subject to seasonal and climatic variations. Great care will need to be taken if reducing groundwater levels to ensure that adjoining nearby buildings, structures and services are not affected.

Floors

With regard to the design and construction of normal ground bearing floor slabs, it must be noted at the outset, that due to the thickness and nature of Made Ground, unless appropriate measures are taken there will be a risk of significant total and differential settlements, the extent of which will be a matter of chance rather than being assessable by calculation. All formation levels should be proof rolled, with any soft or otherwise unsuitable materials and replaced with well compacted, granular material.

Drainage Design

Falling Head Testing was completed within both new and previously installed window sample borehole wells with response zone between 0.40-2.00m bgl. Testing was completed by filling the wells with clean potable water and measuring the reduction in level over time. An infiltration rate (k value) is calculated between 2 No. depths once results are plotted on a logarithmic scale. An intake factor was derived for each installation case from BS5920 Section.4, Figure 7. Results are tabulated below:

Table 11.4. Falling Head Test Results for testing on 29th July 2020

Location	Test	Infiltration Rate K (m/s)
TWS01	1	4.54E-05
	2	2.53E-05
	3	5.01E-05
TWS05	1	1.75E-05
	2	1.15E-05
TWS09	1	1.26E-05
	2	1.07E-05

Table 11.5. Falling Head Test Results for testing on 30th July 2020

Location	Test	Infiltration Rate K (m/s)
TWS01	1	2.10E-05
	2	1.68E-05
TWS05	1	1.01E-05
	2	1.27E-05
TWS11	1	1.47E-05
	2	1.18E-05
	3	1.70E-05
WS201	1	**4.11E-06**
	2	**3.78E-06**
WS203	1	3.10E-05
	2	2.39E-05
	3	1.46E-05
WS204	1	1.03E-05
	2	**9.96E-06**

A site wide average of $1.79x10^{-5}$ has been determined. A couple of tests breached the 10^{-6} possibly due to localised fines. Results would initially suggest these soils would be suitable for use of traditional shallow soakaways. Full results can be found in Appendix L.

Sulphate Attack

Based on the samples tested, a Design Sulphate Class of DS-1 and an ACEC Class of AC-1 should be used for buried concrete structures; however, a single reported sulphate result presented by REC at BH101 9.00m bgl has classified the Site as DS-4/ AC3s within the Lambeth Group. It must be noted that within the oxidised zone at the upper surface of the clay there can be an increase in sulphates present. It is therefore recommended that piles should be designed to DS-4/AC3 and shallow concrete structures to DS-1/AC-1.

Gross hydrocarbon contamination can also have an adverse impact on the setting of concrete, which may affect foundation construction and piling. Based on the measured concentrations of hydrocarbons at the site there is no risk of these affecting the setting of concrete.

11.5. Soil and Groundwater Contamination

Risk Evaluation for the Proposed Land Use

Human health receptors

Chemical testing and subsequent statistical analysis of the results suggests that Made Ground soils are generally uncontaminated; however, five localised areas have been shown to be impacted by asbestos fibres. With regard to the proposed building, it is understood that the ground surface will be either covered in hardstanding or the proposed development which extends over the entirety of the Site. The result is that Made Ground soils at the site are to be covered and will not be exposed to end users of the site, which effectively removes the identified pollutant linkage to end users.

The remaining potential human health receptors are adjacent site users, from migration of contaminated dusts during the excavation of the site. In order to mitigate the environmental impacts of the works on nearby residents and sensitive areas, a programme of measures will be implemented during the development works which will need to be detailed in development statement for the site.

Contamination may pose a short-term (acute) or long-term (chronic) risk to workers during construction and maintenance. The potential risks must be specifically assessed as part of the health and safety evaluation for the works to be performed in accordance with prevailing legislation.

Controlled waters receptors

No potential pollutant linkages to controlled waters have been identified for the Site. In addition, the proposed development will comprise residential development which will incorporate hardstanding across much of the Site that will reduce infiltration.

Ecological receptors

No potential pollutant linkages to ecological receptors have been identified for the Site.

Utilities

It is recommended that the results of the chemical testing and details of the proposed remedial works are provided to the appropriate utility companies to determine the necessity for service protection.

Construction and Maintenance Workers

Contamination may pose a short-term (acute) or long-term (chronic) risk to workers during construction and maintenance. The potential risks must be specifically assessed as part of the health and safety evaluation for the works to be performed in accordance with prevailing legislation. Site practices must conform to the specific legislative requirements and follow appropriate guidance (e.g., HSE, 1991; CIRIA, 1996).

On the basis of the results obtained, the following potential exposure risks to construction and maintenance workers are highlighted:

- Presence of asbestos fibre bundles (amosite and chrysotile) in the Made Ground soils at 5 No. locations.

The Control of Asbestos Regulations 2012 should be adhered to. A summary of complying with CAR: risk assessments, licensing and training is provided in Appendix Q.

Ground Gas

Based upon currently available data, the overall Site ground gas regime has been assessed as Characteristic Situation 1 – Very Low Risk. This assessment has been based on a GSV of 0.002l/hr. This categorisation indicates that gas protection measures will not be required.VOC concentrations were detected in the ground gas during RECs initial ground gas monitoring. Therefore, further analysis may be required in order to determine whether specific protective measures are to be required, such as a volatile resistant membrane.

Basic radon protection measures are not currently required for the proposed development on this site.

11.6. Invasive Plants

Invasive plant species were not observed on this Site. It is recommended that the presence of invasive plant species is confirmed by a qualified consultant ecologist and their advice taken on appropriate treatment. Treatment of any invasive species should take place in advance of the proposed construction works.

11.7. Preliminary Soil Waste Classification

If materials are disposed off-Site, then material exported from the Site to landfill shall be hauled to a registered waste carrier in accordance with Duty of Care Regulations, 1991 and the Hazardous Waste Regulations, 2005.

It will be necessary to register the Site in advance of the intended reclamation works with the Environmental Agency before disposal to landfill can take place. There will be requirement for the waste producer to provide appropriate Waste Acceptance Criteria (WAC) testing of the soils for disposal to ensure that the soils are appropriately classified and that the landfill is licensed to receive such soils. A consignment note shall be completed, signed and retained by all parties involved. The consignment note shall state the volume of waste, a physical description of the material and statement of its chemical composition. The waste consignment notes shall be kept by the contractor for a period of at least two years.

Tier Environmental has assessed the chemical results in terms of basic characterisations of soils for waste. This provides a preliminary assessment of whether a material is potentially either inert/non-hazardous or hazardous waste, with the final outcome being determined by WAC testing.

Overall, the soils have been assessed as chemically non-hazardous/ inert. Made Ground soils at TBH2 (0.50m bgl) have reported copper and zinc in excess of the non-hazardous/ inert waste threshold. Further WAC testing has determined that this material is in fact suitable for disposal at a stable non-reactive hazardous waste cell at a non-hazardous landfill.

WAC testing on samples taken from TWS5 (0.40m bgl) and TWS11 (0.50m bgl) has reported that these materials may be suitable for disposal of to an inert landfill.

Due to the presence of asbestos in the form of amosite and chrysotile fibre bundles having been reported in the vicinity of TWS2a (0.30m bgl), TWS5 (0.40m bgl) and TWS9 (0.30m bgl) and within the REC exploratory holes, this precludes the Made Ground material from being suitable for disposal at an inert waste landfill due to the consistent nature of Made Ground material on Site. These materials should, however, be suitable for disposal at a Non-Hazardous Landfill.

Determination of the final disposal route of any waste soils should be determined via further Waste Acceptance Criteria (WAC) testing. Final categorisation is the responsibility of the producer or holder of the waste. Additionally, liaison with the intended landfill operator may be required to confirm the receipt of the waste.

11.8. Further Regulatory Requirements

It is considered that the regulatory authorities are likely to require the following documentation with regard to the redevelopment of the Site:

- Materials Management Plan (MMP) if site won soils are to be reused on-site; or,
- Exemption from Environmental Permitting (Environment Agency) if only a small volume of site won soils is to be reused on-site;
- Details of WRAP Protocol to be followed for the reuse of construction/demolition materials during the redevelopment works;
- Ground Gas Verification Plan for the installation of the ground gas protection measures; and,
- Remediation Strategy.

11.9. Further Works

Further site investigation should be conducted on after demolition of the existing structure on site to determine shallow ground conditions and to obtain samples for laboratory analysis.

Due to the variable nature of the Lambeth Group it is considered that further intrusive site investigation may be required to determine the ground conditions in order to undertake laboratory analysis of soil samples to allow safe design of foundations.

12.REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the findings of the site investigation. However, these cannot be guaranteed to gain regulatory approval and, therefore, the report should be passed to the appropriate regulatory authorities and/or other organisationsfor their comment and approval prior to undertaking any works on site.

It is recommended that conditions placed on any planning permission are discharged prior to commencement of site works.

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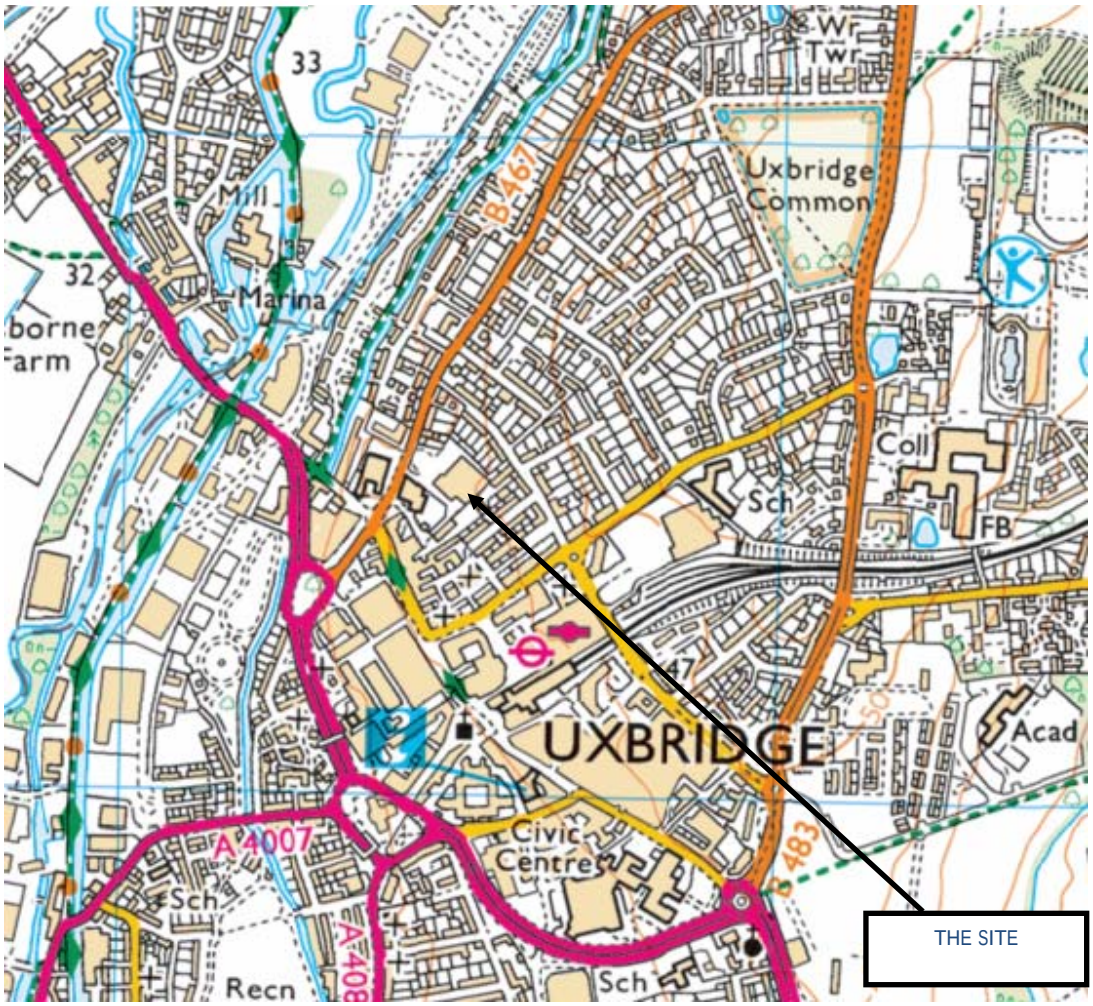
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APPENDIX A – FIGURES AND DRAWINGS

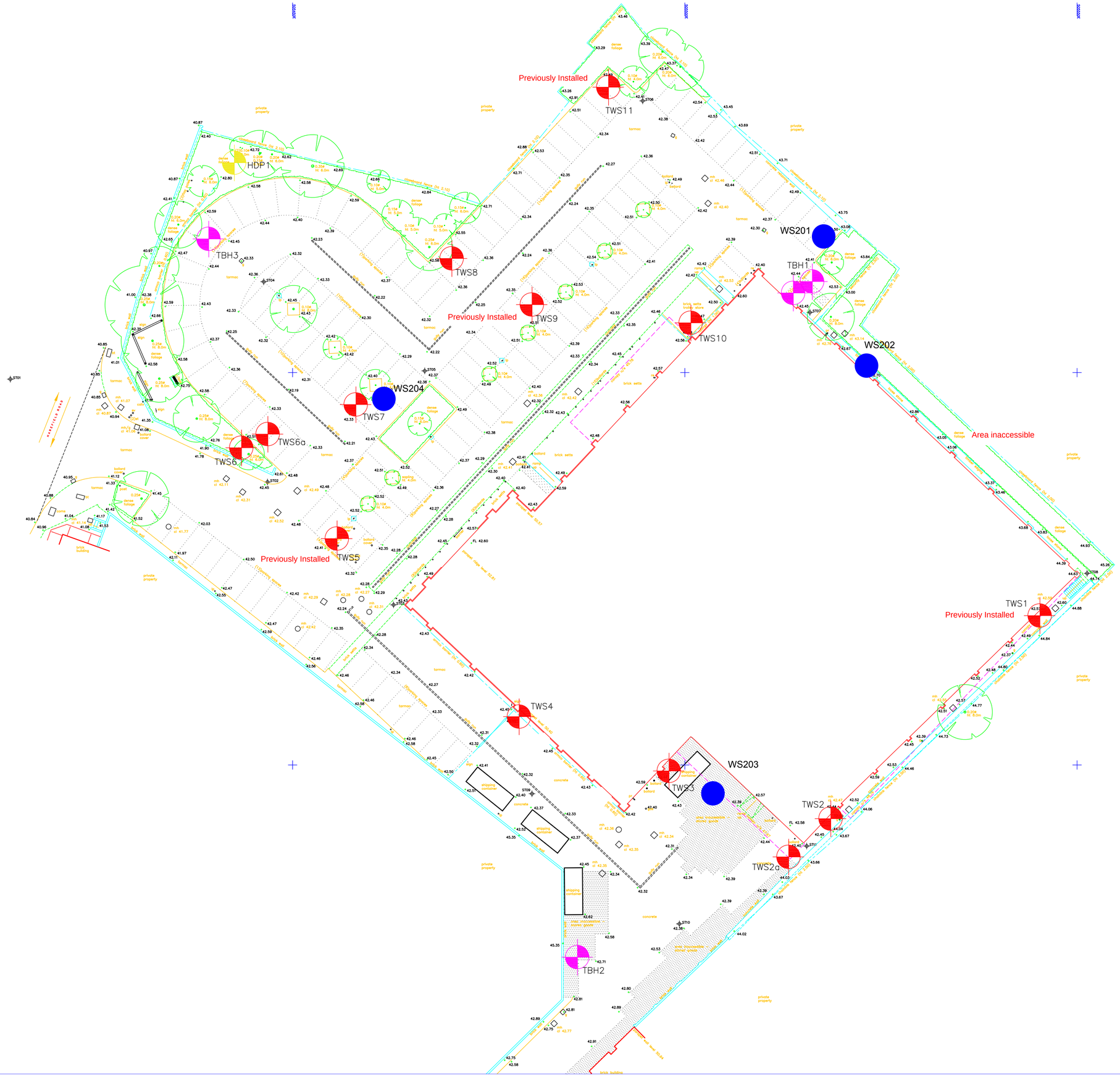
Contract Number	TL1306GIR
Contract	A GROUND INVESTIGATION REPORT FOR LAND AT 2-12 HAREFIELD ROAD, UXBRIDGE
Client	Cast Real Estate & Construction Consultancy

Site Location Plan



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Scale	1:25, 000		
Drawn by	SM	Approved	SL
Drawing Number	TL1306GIR/1		



Notes

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT ARCHITECTS, ENGINEERS AND SPECIALISTS DRAWINGS TOGETHER WITH THE APPROPRIATE SPECIFICATIONS.
IT IS THE CONTRACTORS RESPONSIBILITY TO CHECK ALL DIMENSIONS ON SITE. DIMENSIONS MUST NOT BE SCALED FROM THIS DRAWING. ANY DISCREPANCIES TO BE BROUGHT TO THE IMMEDIATE ATTENTION OF THE ARCHITECT IN WRITING.
ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
ALL LEVELS ARE IN METRES, UNLESS NOTED OTHERWISE

Previous Intrusive Locations

Tier Window Sample Location (Oct 2017)

Tier Borehole Location (Oct 2017)

Tier Hand Dug Pit Location (Oct 2017)

Tier Window Sample Location (July 2020)

Rev	Date	By	Description	Appd

Revisions

Status

Final

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Client

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Architect

Project

Guild Living, Uxbridge

Title

Proposed Exploratory Hole Location Plan

Scale	Drawn	Revision
NTS	SM	1.0
Date	Checked	
04/07/20		

Drawing Ref :
Project no~~originator~~-volume-level

TL1306 GIR2.0