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Feltham Construction Ltd

Ground Investigation

Monks Lane
Newbury
Berkshire
RG14 7TD

Report No: 19.12.021
February 2020

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Project Address	Monks Way, Newbury, Berkshire, RG14 7TD
Project Number	19.12.021
Client	Feltham Construction Ltd

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For and on behalf of ListersGeo, trading name of Listers Geotechnical Consultants Ltd

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EXECUTIVE SUMMARY

Project Reference	19.12.021
Site Location	Monks Lane, Newbury, Berkshire, RG14 7TD
OS Grid Reference	447200, 165220
Development Proposals	Construction of ten residential houses, with associated gardens, and a block of six flats with associated access roads, car parking, soft landscaping, and an amenity area.
Current Site Usage	Public open space crossed by a footpath
Existing Buildings	None
Topography	The general area slopes gently down to the north and south towards the River Kennet in the north and River Enborne in the south, with the site itself generally flat lying. Two large steep vegetated embankments extend into the west and north of the site.
Vegetation	The site is predominantly rough grassland with trees on the northern bank and recently felled trees in the south.
Published Geology	The site is shown to be underlain by superficial Silchester Gravel Member (River Terrace Deposits) over London Clay Formation, which is subdivided into an upper, sand layer and a lower clay layer.
Site History	The site has never been developed and is thought to have previously formed part of an estate's grounds. The earth embankments were formed in the early 2000s.
Unexploded Ordnance	There is considered to be a low risk of encountering Unexploded Ordnance (UXO) at the site.
Hydrology	The nearest watercourse is a tributary of the River Enborne located approximately 250m southwest of the site (downgradient) and flowing southwards.
Hydrogeology	The Silchester Gravel Member is classified as a Secondary (Undifferentiated) Aquifer, the upper London Clay Formation (sand) is a Secondary A Aquifer, and the lower London Clay Formation (clay) is Unproductive Strata. There are no groundwater abstraction licences within 1km of the site, however the site does lie within a broad Zone 3 groundwater Source Protection Zone (SPZ).
Potential Contamination Sources	Potential sources of contamination include the Made Ground associated with the on-site vegetated embankments and footpath.
Ground Conditions Encountered	Topsoil was encountered to between 0.2m and 0.5m below ground level (bgl), over Silchester Gravel Member to between 0.6m and the base of CT03 at 3.5m bgl, underlain by London Clay Formation from between 0.6m and 0.9m bgl to the base of the boreholes at 6.0m bgl.
Groundwater Encountered	Groundwater level was highly variable and was struck from 0.1m to 3.0m bgl during the intrusive works and recorded standing at 0.26m bgl (121.4m AOD) and above ground level during subsequent monitoring.
Risks to Human Health	No significant risks to human health were identified by this investigation.
Ground Gas Risks	No potential sources of ground gas were identified at the site.
Risks to Controlled Waters	No significant risks to Controlled Waters were identified by this investigation.
Remediation Required	None
Chemical Attack on Buried Concrete	A Design Sulphate (DS) class of DS-1 and Aggressive Chemical Environment for Concrete (ACEC) class of AC-1 is considered appropriate for the site.
Geotechnical Hazards	The London Clay Formation is of 'Medium' volume change potential.
Foundations	Shallow strip foundations may be suitable founded in either the superficial Silchester Gravel Member or London Clay Formation.

Allowable Bearing Pressure	An allowable bearing pressure of 150 kPa should be achievable at not less than 1.0m bgl or 0.2m into either the Silchester Gravel Member or London Clay Formation.
Floor Slabs	Ground bearing floor slabs may be suitable within the Silchester Gravel Member, however suspended floor slabs should be used in the London Clay Formation due to the potential for volume change.
Roads and Hardstanding Design	A provisional CBR of 10% is likely to be appropriate for preliminary design purposes for pavement founding on the Silchester Gravel Member.
Infiltration Measures	Soil infiltration testing indicated rates in the order of 10^5 to 10^6 at the locations requested by the Client, however shallow groundwater may preclude the effective use of Sustainable Drainage Solutions (SuDS).
Waste Soil Classification	Site soils have been characterised as non-hazardous waste suitable for inert landfill. Topsoil is unlikely to be suitable for disposal at inert landfill due to its organic content.
Recommendations	Groundwater was recorded to be shallow and early discussion with the EA is recommended for their approval should their use be pursued.

This executive summary should be read in conjunction with the main report.

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INTRODUCTION

A Phase 1 and 2 Ground Investigation has been undertaken for a proposed new residential development on land adjoining Monks Way, Newbury, Berkshire, RG14 7TD. A Site Location Plan is provided in Appendix A. The Ordnance Survey National Grid reference for the approximate centre of the site is 447200, 165220.

Instructions to undertake the investigation were received from the Client, Feltham Construction Ltd, in their email dated 20th December 2019.

This report describes the desk study and intrusive site investigation activities carried out by ListersGeo in order to provide an evaluation of the ground conditions and the extent of any soil, gas or groundwater contamination present on the site. The report presents initial human health and groundwater risk assessments based on the findings of the desk study information and subsequent contamination laboratory testing. Geotechnical implications are discussed with regard to the proposed development based on the findings of the fieldwork and subsequent laboratory testing.

It is understood that the site has not been subject to any previous investigations.

This report has been prepared for the sole use of the client and their professional advisors. This report shall not be relied upon by third parties without the express written authority of ListersGeo. If an unauthorised third party comes into possession of this report they must not rely on it and the authors owe them no duty of care and skill.

SCOPE OF THE INVESTIGATION

The scope of the investigation, as requested by the Client, was to undertake a desk study and walkover survey, and provide an assessment of the geotechnical engineering properties of the ground and the extent of any soil, gas or groundwater contamination on the site.

A contaminated land risk assessment was undertaken based on the Contaminated Land Exposure Assessment (CLEA) and Environment Agency (EA) Remedial Targets Methodology (RTM) guidelines using the source-pathway-receptor risk assessment methodology.

The investigation also includes a preliminary assessment of the feasibility of adopting a soakaway drainage solution at the site, as well as providing parameters to aid pavement design.

PROPOSALS

It is proposed to develop the site to accommodate ten residential houses, with associated gardens, and a block of six flats with associated access roads, car parking, soft landscaping, and an amenity area. It is understood that the public footpath currently crossing the site will remain but be rerouted to accommodate the development. A proposed site layout plan is provided in Appendix A.

If the proposed end use, site levels or layout should alter significantly following issue of this report, then the contents will require re-evaluation.

SITE INFORMATION AND WALKOVER SURVEY

A walkover survey of the site and its immediate surrounds was undertaken on 15th January 2020, preceding the fieldwork. A selection of site photographs is presented in Appendix A along with a plan showing the existing site layout.

The site lies in a predominantly residential area and is currently occupied by an area of public open space. Access to the site was afforded via an unnamed road off Monks Lane.

The site consists of an irregularly-shaped parcel of land, measuring approximately 150m by 55m and covering approximately 0.6 ha in area.

The general topography of the area slopes gently down to the north and south towards the River Kennet in the north and River Enborne in the south. The site itself is generally flat lying with the exception of two steep vegetated embankments in the west and north of the site.

The site is bordered by:

Direction	Feature
North	Vegetated embankments immediately adjacent followed by Monks Lane with residential housing beyond (60m N).
East	Public house immediately adjacent to the southeast. Residential housing (100m E) followed by retail parks (200m NE & E) and a hotel (300m SE).
South	Nursery school immediately adjacent and Newbury College (100m S) with public open space beyond.
West	Agricultural fields.

The site itself comprised an area of rough hummocky grassland with steep vegetated embankments to the north and west, partially extending to within the site bounds. A compacted hardcore footpath crossed the site from the south to northeast of the site where it joins with Monks Lane.

At the time of the walkover the ground was very soft due to recent heavy rains, particularly in the west at the foot of the vegetated bank where standing water was present.

Semi-mature trees were present on the northern vegetated bank and a number of recently felled semi-mature trees were lying on the ground in the south of the site.

The site was open to the north and west and had a wooden post and rail fence along the eastern site boundary, with the adjacent public house, and a close-boarded fence in the south around the adjacent nursery school.

A possible ground ventilation pipe was observed in the east of the site, adjacent to the boundary with the public house (see photo in Appendix A).

No evidence of spills or gross contamination was observed.

DESK STUDY AND BACKGROUND INFORMATION

A desk study review of the site and its history has been undertaken to determine the former land usage and the potential for any historically derived sources of chemical contamination, as well as provide information to aid assessment.

The information provided in the desk study is obtained from independent third-party sources but no guarantee can be given for the accuracy or completeness of the third-party data used. It should be appreciated that such data is not exhaustive and is constantly being updated and reviewed in light of new information and procedures. Therefore, improved practices, technology, and new information may affect the conclusions and hence this report should be referred back to ListersGeo for reassessment if new data comes to light, or changes in legislation/best practise is identified prior to development. Similarly, should the development commence after expiry of one year from publication of this report, then it is recommended that this report is referred back to ListersGeo for reassessment.

The desk study comprises a review of the following consultations and information sources:

- Environment Agency (EA)
- Natural England
- National Geoscience Information Service
- Public Health England
- Centre for Ecology & Hydrology
- British Geological Survey (BGS)
- Contemporary Trade Directories
- Historical Ordnance Survey maps
- Aerial Imagery
- Unexploded Ordnance (UXO) maps

A copy of the desk study information obtained from Landmark is presented in Appendix G of this report.

Information from the above referenced sources has been utilised to develop a conceptual model of the site for use in the geotechnical appraisal and source-pathway-receptor risk assessment.

GEOLOGY

Published Geology

Reference to the BGS 1:50,000 scale map, Sheet 267 for Newbury, dated 2006, and other published geological information on the area indicates that the site is underlain by superficial geology of the Silchester Gravel Member of the Quaternary period above bedrock geology of the London Clay Formation of the Palaeogene period.

Landscaped ground (poorly defined worked and made ground) is mapped approximately 250m east of the site and worked ground mapped approximately 470m to the south-east.

Superficial Deposits

The Silchester Gravel Member is the sixth terrace of the River Terrace Deposits associated with the Kennet and proto-Kennet corridor. It is generally represented by variably clayey and sandy coarse-grained gravel. Beneath the site itself, the deposit is anticipated to be around 5m in thickness.

Bedrock

The London Clay Formation is generally represented by bluish grey, weathering orangish brown, silty clays with the upper layer comprising a bed of sand up to 20m thick. Beneath the site itself, the formation is anticipated to be up to 50m thick in total.

Historical Boreholes

The BGS holds records of historical exploratory holes put down during previous investigations. The records of three historical boreholes, put down approximately 350m north, 550m west, and 580m east of the site within the same geology, have been reviewed to aid the preliminary assessment of the ground conditions.

The boreholes east and west of the site, put down in 1978, recorded clayey gravel to 3.6m and 4.3m below ground level (bgl) over silt of the Bagshot Beds (now regarded as the upper layer of the London Clay Formation) proven to 5m bgl. The borehole north of the site was put down in the early 1900s and encountered Bagshot Beds and London Clay Formation, described as shelly blue clay, to its base at 9.1m bgl. Groundwater was not encountered.

HISTORY OF THE SITE

The history of the site has been assessed by reviewing available historical Ordnance Survey and National Grid maps and aerial imagery of the area. This has established the following:

Time Period	Historical Site Usage	Historical Usage of the Surrounding Area
1880 - 1882	The site is shown to be within a large plot thought to comprise the grounds of the Sandleford Estate.	The surrounding area comprises predominantly large undeveloped plots thought to be agricultural or associated with the Sandleford Estate. Much of the existing main road network is shown to be present (excluding A339) with Monks Lane then known as Monkey Lane. A workhouse is located approximately 280m north of the site. A small old gravel pit is labelled to be present approximately 580m southeast of the site. A large gravel pit is also present approximately 700m northeast of the site.

Time Period	Historical Site Usage	Historical Usage of the Surrounding Area
1899 - 1900		A gravel pit is mapped approximately 440m north of the site and the large gravel pit to the northeast has been extended further towards the site. The old gravel pit southeast of the site is no longer labelled but the pit appears to remain.
1911 - 1913		The gravel pit 440m north of the site appears to have been redeveloped.
1932 - 1938		Residential development has occurred from 80m north of the site beyond Monks Lane, which is now labelled as Monk's Lane, and 480m west of the site. The small old gravel pit southeast of the site is no longer mapped.
1947	Aerial imagery shows the plot of land within which the site lies to be split evenly into four fields with the site comprising the centre of the northeastern plot.	Aerial imagery shows residential development all along Monks Road, north and northwest of the site.
1961-1966		Significant residential development has occurred with the whole area between Monks Lane and Newtown Road, north of the site, now infilled. The workhouse is now labelled as Sandleford Hospital. The large pit 700m northeast of the site is no longer labelled as such and is shown to contain several ponds.
1970 - 1977		A Gravel Grading & Crushing Plant is mapped 680m southeast of the site, near to the former 'old gravel pit', indicating that an unmapped quarry may be present. A number of houses are also shown approximately 430m southeast of the site.
1982		The A339 (road) northeast of the site is mapped with residential expansion eastwards.
1990 - 1991		A superstore and associated petrol filling station are mapped from 270m east of the site. A small pit is shown approximately 340m southeast of the site.
1993 - 1996		A large disused pit is mapped adjacent to the Gravel Grading & Crushing Plant approximately 490m southeast of the site. It is labelled to be a caravan park.
1999	Aerial imagery shows the large plot to no longer be subdivided. It appears to comprise grass and is crossed by two footpaths from southeast to north.	A large retail park is present from approximately 210m northeast of the site.
2003 - 2006	Aerial imagery shows the path across site in its current configuration. The vegetated	Aerial imagery shows the existing college south of the site along with the nursery building immediately adjacent to the site and the access roads.

Time Period	Historical Site Usage	Historical Usage of the Surrounding Area
2009 - 2014	embankments in the north and west of the site also appear to be present along with four smaller mounds in the east of the site and immediately to the southeast.	The large disused pit 490m southeast of the site has been redeveloped as residential housing. A balancing pond is shown in the location of the small pit 340m southeast of the site.
2017 - 2020	The smaller mounds are no longer visible on aerial imagery and the site is shown as present day.	The existing pub immediately east of the site is now mapped.

INTERVIEWS

Discussion with the client's architect's representative on site, indicated that the vegetated embankments are likely to comprise natural ground excavated during construction of the adjacent college in the early 2000s.

UNEXPLODED ORDNANCE AND BOMB SITES

The Zetica bomb risk map shows that the site is located in an area where there is a low risk of unexploded ordnance. Low-risk regions are those with a bombing density of up to 15 bombs per 1,000 acres and there is a low potential for encountering UXO on the site. Works can normally proceed without any special precautions.

HYDROLOGY

The nearest watercourse is a tributary of the River Enborne located approximately 250m southwest of the site (downgradient) and flowing southwards.

The EA's Catchment Data Explorer indicates that the site lies within the 'Kennet and Trib' Management Catchment of the Thames river basin. The nearest downgradient stretch of river tested is the River Enborne, approximately 1.2 km south of the site, which has an overall water body classification of 'Moderate', as recorded in 2016.

The Envirocheck data indicates that the site lies outside of any surface water flood impact zones and is in an area with 'Limited' potential for groundwater flooding to occur. However, this information does not constitute a site-specific Flood Risk Assessment (FRA). It is therefore recommended that further enquiries are made to determine if such an assessment is required to support the planning application for the site.

There are two potentially-active surface water abstractions licensed within 1000m of the site. These relate to abstractions for filling spray irrigation reservoirs at Sandleford Farm, approximately 740m and 800m southwest of the site.

HYDROGEOLOGY

The aquifer designation data is based on geological mapping provided by the BGS. The maps are divided into two different types of aquifer designation:

- **Superficial** - the youngest geological deposits formed during the Quaternary period, resting on Bedrock geology.
- **Bedrock** – the main mass of rocks forming the Earth and present everywhere, either exposed at surface or concealed by Superficial Deposits or water.

For each type there are classifications of Principal, Secondary A and Secondary B Aquifers and Unproductive Strata, each with a decreasing rank of importance.

Information obtained from the EA indicates that the underlying Silchester Gravel Member is classified as a Secondary (Undifferentiated) Aquifer, the upper London Clay Formation (sand) is a Secondary A Aquifer, and the lower London Clay Formation (clay) is Unproductive Strata.

There are no groundwater abstraction licences recorded within 1000m of the site.

According to information provided by the EA the site is located within a broad Zone 3 Source Protection Zone (SPZ) protective of potable groundwater abstractions located approximately 2.5 km northwest, 3 km southeast, and 3.5 km southwest of the site. An SPZ is divided into three zones defined as follows:

- **Zone 1** – Travel time (of water) of 50 days or less to the groundwater source.
- **Zone 2** – Either 25% of the source area or a travel time of 400 days whichever is the greater.
- **Zone 3** – The total area needed to support the discharge and abstraction from the protected groundwater source.

WASTE TREATMENT AND LANDFILL SITES

Reference to records from the EA and the Local Authority indicates that there are three historical landfill disposal sites adjacent to each other, approximately 310m east, 420m east, and 620m northeast of the site. The nearest two landfills are recorded to have accepted a wide range of unrestricted wastes between 1970 and 1990. The further of the three is recorded to have accepted inert and industrial wastes between 1977 and 1980.

The landfill sites are considered to have represented the phased infilling of a quarry within the Silchester Gravel Member. Given the wide range of waste types potentially present, the age of last deposition, and the potential geological connectivity with the site, it is considered possible that these sites have potential to impact the site, particularly the nearer of the three.

Reference to records from the BGS, the EA and the Local Authority indicates that there is one waste transfer site and one waste management facility within 500m of the site area. It is considered unlikely that any of these facilities would significantly affect the site area, as the nearest is an incinerator 310m away.

No other waste sites are recorded within 500m of the site.

ENVIRONMENTAL PERMITS, INCIDENTS AND REGISTERS

There have been no recorded pollution incidents to controlled waters within 250m of the site.

There are two potentially-active discharge consents recorded within 1000m of the site. These relate to discharge of treated sewage effluent to groundwater via soakaways at a commercial property 430m southeast of the site, and a domestic property 610m to the southeast.

There are two Local Authority Pollution Prevention and Control licences and one Integrated Pollution Prevention and Control (IPPC) licence within 2000m of the site. The nearest is for a former petrol filling station 140m northeast of the site.

INDUSTRIAL USAGE SITES

There are five past or present Contemporary Trade Directory entries within 250m from the site. These are all inactive and include a domestic appliance servicer (90m NE), car dealers (140m NE), cleaners (200m NE), and an electricity company (250m NE).

The nearest active fuel filling station is identified as the Tesco filling station on Pinchington Road approximately 340m to the east of the site. Obsolete filling stations are also recorded approximately 90m northeast, 140m northeast, and 340m east of the site.

Historical and Current Site Usage

With the exception of placement of the vegetated embankments in the west and north of the site in the early 2000s, the site is understood to have never been developed. It is understood that these embankments are likely to comprise natural ground excavated during the construction of the adjacent college in the early 2000s and, as such, contamination is unlikely.

WORKED OUT GROUND/MADE GROUND

Worked out ground is recorded 440m north, 340m, 490m, and 580m southeast, and 700m northeast of the site. Evidence of infilling in these areas is shown on the historical mapping for some but not all of these areas.

No other Made Ground is mapped to be present within 1000m of the site.

RADON GAS

Desk study information indicates that the site lies within an area where less than 1% of homes exceed the action level of 200 Bq/m^3 for radon gas. Therefore, in accordance with BR 211, 'Radon: guidance on protective measures for new dwellings', radon protection measures are not necessary in the construction of new dwellings or extensions without underground rooms on this site.

GEOTECHNICAL HAZARDS

Geological

The risk of naturally occurring geotechnical hazards at the site is recorded in the Envirocheck report to be as follows:

Ground Stability Hazard	Hazard Potential Rating
Running sand	Very Low to Low
Shrinking and swelling clays	No Hazard to Low
Collapsible deposits	Very Low
Landslides	Very Low
Compressible deposits	No Hazard
Ground dissolution from soluble rocks	No Hazard

Mining and Man-Made Cavities

The desk study information identified that the site does not lie within an area likely to be affected by coal mining or non-coal mining.

BACKGROUND SOIL CHEMISTRY

Information from the BGS is provided in the table below listing the background soil chemistry of some commonly occurring heavy metals in the natural soils in the site area:

Heavy Metal	Level in Rural Soil (mg/kg)
Arsenic	<15
Cadmium	<1.8
Chromium	60 - 90
Lead	<100
Nickel	15 - 30

These concentrations indicate that there are no naturally-elevated background concentrations in the area.

POTENTIALLY SENSITIVE LAND USES

The site is not located in close proximity to any environmentally sensitive land uses.

CONCEPTUAL SITE MODEL

A qualitative Preliminary Risk Assessment (PRA) has been undertaken in line with the EA's new online guidance, Land Contamination: Risk Management (LCRM), published in June 2019. The new guidance is based upon the principles of the EA's CLR11 guidance, *Model procedures for the management of land contamination*, published in 2004.

Potential sources of contamination and potential receptors have been assessed using the source-pathway-receptor principle to create a Conceptual Site Model (CSM). This takes into account the fact that a complete pathway must exist between a potential source of contamination and a potential receptor for there to be considered a risk.

It is understood that the development proposals are for ten residential houses, with associated gardens, and a block of six flats with associated access roads, car parking, soft landscaping, and an amenity area.

POTENTIAL CONTAMINATION SOURCES

Potential Solid-, Liquid- and Vapour-phase Contamination Sources

The results of the desk study and walkover indicate that the following potential sources of soil or groundwater contamination are present at, or in close proximity to, the site:

- Made Ground associated with the on-site vegetated embankments and footpath

Potential Ground Gas Contamination Sources

In consideration of the source-pathway-receptor methodology for ground gas risk assessment set out in CIRIA C665, the sensitivity of the proposed residential development is considered to be high.

The site lies within the potential influence of a historical landfill site. Therefore, the following potential ground gases have been identified for the site:

- Migrating carbon dioxide and methane gases
- Explosive gases

POTENTIAL RECEPTORS

The following potential receptors have been identified at or in close proximity to the site:

Human Health – Long Term Exposure

- End users of the site - the future residents and users of the rerouted footpath crossing the site
- Staff and children at the adjacent nursery school
- Staff and customers of the adjacent public house
- Surrounding residents

Human Health – Short Term Exposure

- Construction workers

Controlled Waters and Environment

- Groundwater of the underlying Silchester Gravel Member - Secondary (Undifferentiated) Aquifer
- Groundwater of the upper layer of the underlying London Clay Formation - Secondary A Aquifer

Infrastructure

- Substructures
- Water supply pipes

POTENTIAL PATHWAYS

It is considered that the following potential pathways may exist between the potential sources and receptors identified above. The viability of these pathways is discussed in the PRA which follows.

Human Health

- Direct soil ingestion in areas of exposed soil
- Ingestion of soil attached to homegrown produce
- Ingestion of homegrown produce with contamination uptake
- Inhalation of indoor and outdoor vapours and dust
- Dermal contact with contaminated soil
- Inhalation of soil gases or vapours migrating through permeable strata into the building

Controlled Waters and Environment

- Migration/leaching of contaminants through the unsaturated zone
- Migration of contaminants through the groundwater
- Movement of contaminants through drains or services runs

Infrastructure

- Direct contact with leachable or corrosive contaminants within the soil
- Direct contact with leachable or corrosive contaminants within the groundwater

PRELIMINARY RISK ASSESSMENT

Based on the desk study research, the following potentially-complete pollutant linkages have been assessed and, in accordance with CIRIA 552, a consequence and probability rating has been applied to each potential contamination source to create an overall risk rating. The results are presented in the following table. Risk to construction workers assumes that appropriate Personal Protective Equipment (PPE) is worn at all times.

ON-SITE SOURCES

Potential Source	Pathway	Potential Receptor	Probability of risk occurring	Consequence of risk occurring	Risk Classification	Explanation
Contaminants within the Made Ground - *Including: heavy metals, PAH, petroleum hydrocarbons, asbestos*	• Ingestion • Dermal Contact • Inhalation	• End Users - residents	Low likelihood	Medium	Moderate / Low	On-site contamination is anticipated to be minimal and much of the site will be surfaced with hardstanding with soft landscaping limited to garden areas and the amenity area.
		• End Users - public • Nursery School • Public House • Surrounding Residents	Unlikely	Medium	Low	
		• Construction Workers	Low likelihood	Mild	Low	Exposure to maintenance and construction workers can be mitigated by use of appropriate PPE and maintaining good hygiene levels.
	• Migration through unsaturated zone • Migration through groundwater • Migration through drains or service runs	• Secondary (Undifferentiated) Aquifer	Low likelihood	Mild	Low	There are no known abstractions within 1000m of the site.
		• Secondary A Aquifer	Low likelihood	Mild	Low	

Potential Source	Pathway	Potential Receptor	Probability of risk occurring	Consequence of risk occurring	Risk Classification	Explanation
	• Direct contact	• Substructures • Water supply pipes	Low likelihood	Mild	Low	The London Clay Formation is known to potentially contain sulphates at concentrations that may accelerate the degradation of buried concrete but anticipated depth to bedrock indicates that foundations are unlikely to extend this far. Limited contamination which may impact pipes is anticipated.

OFF-SITE SOURCES

Potential Source	Pathway	Potential Receptor	Probability of risk occurring	Consequence of risk occurring	Risk Classification	Explanation
Unrestricted and industrial landfills 310m to the east	• Inhalation	• End Users	Low likelihood	Medium	Moderate / Low	It is possible that gases could migrate to the site but are likely to disperse before they reach the site. The possible soil vent pipe identified in the east of the site indicates a potential risk.
	• Accumulation of gases	• On-site buildings	Low likelihood	Severe	Moderate	

The geoenvironmental investigation and risk assessment detailed in the remainder of this report have been conducted to validate this CSM.

GEOTECHNICAL CONCEPTUAL SITE MODEL

Anticipated geology suggests that shallow foundations may be a suitable option, dependent on the strength of the Silchester Gravel Member. Founding on the underlying bedrock, particularly with regard to the block of flats may be necessary due to the increased load.

Historical investigation indicates deep groundwater, however standing water was observed during the site walkover suggesting shallow groundwater may be present. It is therefore considered possible that groundwater may flood excavations and/or affect stability during groundworks.

It is unlikely that the underlying geology will be amenable to conventional Sustainable Drainage Systems (SuDS) given the standing water observed during the site walkover.

The intrusive investigation has been implemented to address these main issues and establish any potential problems for foundations and the general development of the site.

EXPLORATION AND IN-SITU TESTING

A total of twelve exploratory holes were formed at the site on 15th January 2019. These included six machine excavated trial pits, one hand-excavated trial pit, and three continuous tube sample boreholes, two of which had adjacent dynamic probe tests.

Exploratory Hole Type	Reference
Continuous tube sampler boreholes	CT01 to CT03
Dynamic probe tests	SHDP01 to SHDP02
Machine excavated trial pits	TP01 to TP05 and DP02
Hand excavated trial pits	HP01

The positions of all exploratory holes undertaken at the site as part of this investigation can be seen on the Exploratory Hole Location Plans in Appendix A. Logs of all the exploratory holes, including the results of in-situ testing, are provided in Appendix B and the results of geotechnical laboratory testing are provided in Appendix C.

The exploratory excavations were surveyed using a handheld GPS device to the nearest 5m. Elevations have been approximated from a topographic survey drawing by Mitcham Surveys (drawing no 2, dated October 2018) provided by the Client.

Gas and groundwater monitoring was undertaken on two occasions over the first six weeks following the fieldwork. The monitoring results are provided in Appendix B.

Conclusions given in this report are based on data obtained from these sources but it should be noted that variations, which affect these conclusions, may inevitably occur between and beyond the test locations.

SAMPLING STRATEGY

The investigation was undertaken in accordance with the scope of works agreed with the Client. The positions of the trial pits used for dynamic plate tests and soil infiltration testing were selected by the Client. The remaining exploratory holes were selected by ListersGeo to provide a wide coverage of information on the site area based on the proposed site layout at the time of investigation (Pro Vision, drawing no P1-02, dated November 2019) as included in Appendix A.

At the time of the intrusive works, the ground was observed to be saturated in places, particularly towards the base of the western embankment, and exploratory excavations were therefore limited to drier areas where plant access was possible. Access was also limited in the northeast of the site where the bank was densely vegetated. As a result of these access issues, trial pits TP04 and TP05, excavated into the vegetated embankments for waste classification purposes, were located just north of the site boundary.

Additionally, a pressurised sewer was known to cross the site diagonally, and as such a 10m easement within which no exploratory holes were put down was implemented (as shown on drawing in Appendix A).

METHODOLOGY

Prior to commencement, in order to minimise the dangers from/to buried services, the proposed locations were scanned using a Cable Avoidance Tool. At the borehole and probe locations, a service avoidance pit was dug using insulated hand tools to a depth of around 1.2m below ground level (bgl).

Six trial pits were excavated with an 8-tonne rubber-tyred backhoe excavator to depths under the supervision of a geotechnical engineer who made a record of the arisings. Disturbed samples were taken at selected depths down to the base of the holes for subsequent laboratory testing and inspection.

Trial pits TP01 to TP03, located within the centre of the site in the proposed access road, were excavated to depths of between 1.9m and 3.5m bgl. Trial pits TP04 and TP05 were excavated horizontally into the vegetated embankments to 0.5m extent to obtain samples for waste classification purposes only. Shallow trial pit HP01, located in the northeast of the site, was excavated by using insulated hand tools to a depth of 1.0m bgl.

In-situ Dynamic Plate testing was undertaken in TP03 and an additional shallow trial pit, DP02, using a Light Weight Deflectometer (LWD) to provide indicative CBR values for pavement design.

On completion, all trial pits were carefully backfilled with arisings in thin layers, ensuring that excavated material was replaced in the same order as it had been removed.

Infiltration testing was undertaken in trial pits TP01 and TP02 in accordance with BRE Digest 365 ‘Soakaway Design’.

Continuous tube sampler boreholes CT01 to CT03 were put down using an Archway Competitor Dart rig to a maximum depth of 6.0m or upon ‘refusal’ on hard strata (CT01, 2.5m bgl; CT03, 3.5m bgl). A near continuous core sample, decreasing from 87mm to 57mm diameter with depth, was recovered for subsequent examination and sub-sampling.

Prior to sampling, dynamic probe tests, SHDP01 to SHDP02, were performed (using the ‘Super Heavy B’ specification) adjacent to the positions of CT01 and CT02 respectively to provide a relative penetration resistance of the ground to a maximum depth of 10.0m or upon ‘refusal’ on hard strata. Standard Penetration Tests (SPTs) were taken at 1.0m intervals down to 3.5m depth during the drilling of CT03.

On completion of the intrusive works, borehole CT02 and trial pit HP01 were installed as monitoring wells with a 50mm diameter slotted uPVC response zone from 1.0m to 4.0m bgl in CT02 and 0.5m to 1.0m bgl in HP01. The slotted section of the standpipe was surrounded with pea gravel and sealed with expansive bentonite. The standpipes were finished with a rubber bung and stopcock cover concreted flush with ground level.

GROUND CONDITIONS

The intrusive investigation determined that the general succession of strata was represented by a layer of topsoil above Silchester Gravel Member overlying the London Clay Formation to the full depth of the investigation at 6.0m.

The Ground Model for the site is summarised in the table below and each strata is described in detail in the following sections.

Stratum	Locations encountered	Top (m bgl)	Base (m bgl)	Average Thickness (m)
Topsoil	All	Ground Level	0.2 - 0.5	0.4
Silchester Gravel Member	All	0.2 - 0.5	0.6 - >3.5	N/A
London Clay Formation	CT02	0.6 - 0.9	>3.5 - >6.0	N/A

TOPSOIL

Topsoil was encountered at each exploratory location from ground level down to depths of between 0.2m and 0.5m bgl, with an average thickness of 0.4m. It comprised soft, dark brown, variably sandy and gravelly, organic clay with occasional rootlets.

SILCHESTER GRAVEL MEMBER

The superficial Silchester Gravel Member was encountered at each exploratory location from between 0.2m and 0.5m depth, down to depths of between 0.6m and the base of CT03 at 3.5m bgl.

The Silchester Gravel Member was represented in general by grey brown, orange brown, or yellow cream, clayey sands and gravels. Gravel was fine to coarse, angular to rounded flint and quartzite.

In the trial pits, the Silchester Gravel Member was assessed to be loose due to the ease of excavation, stability of the trial pit sides and water ingress.

Full laboratory sieve analyses revealed gravel contents between 60% and 78%, sand contents between 13% and 24% and fines (silt/clay) contents between 6% and 27%. Water content ranged from 7% to 26%.

The SPT field 'N' values recorded at CT03 have been corrected to 'N_{60}' values for the effects of energy delivery, in line with the recommendations given in BS EN ISO 22476-3:2005+A1:2011, Annex A. The field 'N' values and the corrected 'N_{60}' values are summarised in the following table.

Test	Range	Comments
SPT Field 'N' Value	16 to >50	Variable with depth
SPT 'N_{60}' Value	18 to >50	

The results of the dynamic probing at CT01 below 1.0m bgl indicate that the penetration resistance of the Silchester Gravel Member varied with depth and the results are interpreted to indicate generally dense soils with a general increase of density with depth and localised denser strata.

LONDON CLAY FORMATION

Bedrock of the London Clay Formation was encountered at TP03 and CT02, in the west of the site, from 0.6m and 0.9m bgl respectively down to the base of the exploratory holes at 3.5m and 6.0m bgl.

The London Clay Formation was found to comprise orange brown mottled grey, locally gravelly, sandy clay. Gravel was fine to coarse, angular to rounded flint and quartzite.

Laboratory testing determined the following results:

Parameter	Range	Comments
Water Content (%)	19 to 29	Typical values
Liquid Limit (%)	38 to 44	CLAY of INTERMEDIATE plasticity (BS5930 Casagrande)
Plastic Limit (%)	17 to 20	
Plasticity Index (%)	19 to 27	
Modified Plasticity Index (%)	13 to 25	Shrinkable soil of LOW / MEDIUM Volume Change Potential (NHBC Standards)
Retained on 425µm sieve (%)	0 to 49	Representing the 'coarse soil' fraction (BS1377)
Passing 63µm sieve (%)	43 to 87	Representing the fines (silt/clay) fraction

The field Pocket Penetrometer tests provided approximate shear strengths of 45 to 120 kPa (conversion factor of 30) indicating 'Medium' to 'High' strength.

The results of the dynamic probing of the London Clay Formation are interpreted to indicate generally high to extremely high strength soils, with a general increase of strength with depth.

OBSERVED SOIL CONTAMINATION

No olfactory or visual evidence of contamination was encountered during the sitework.

GROUNDWATER

Groundwater was encountered in all of the exploratory holes during the intrusive works, as summarised in the following table.

Location	Strike Depth (m bgl)	Standing Level	Stratum
CT01	1.4	1.4	Silchester Gravel Member
CT02	0.1	0.3	Topsoil
CT03	3.0	2.5	Silchester Gravel Member
HP01	0.5	N/A	Silchester Gravel Member

Location	Strike Depth (m bgl)	Standing Level	Stratum
TP01	1.7	N/A	Silchester Gravel Member
TP02	1.9	N/A	Silchester Gravel Member
TP03	2.0	N/A	London Clay Formation

Longer term monitoring recorded a standing groundwater level for a single well (CT02) screened within the London Clay Formation of 0.26m bgl (121.4m above Ordnance Datum; AOD) during the first monitoring visit. During the second monitoring visit, the site was experiencing severe waterlogging following recent storms and the monitoring wells and local area were recorded to be flooded.

CALIFORNIA BEARING RATIO (CBR) TESTS

In-situ Dynamic Plate testing was undertaken in two trial pits using a Light Weight Deflectometer (LWD) at depths of between 0.5m (DP1) and 0.6m (DP2). Result of the testing recorded corresponding equivalent CBR values of 10.9% (DP1) and 8.0% (DP2).

SULPHATE AND PH TESTS

Sulphate and pH analysis was carried out on ten soil samples recovered from the exploratory holes across the site. The values recorded are summarised in the following table:

Stratum	No. of Samples	Water-soluble Sulphate (g/l)	pH	Total Sulphur (%)	Acid-soluble Sulphate (%)
Silchester Gravel Member	5	0.011 - 0.12	6.2 - 8.2	-	-
London Clay Formation	5	0.04 - 0.06	6.2 - 6.9	<0.001	<0.001

INFILTRATION TESTING

Infiltration testing was undertaken in the Silchester Gravel Member encountered at the site, at depths of between 0.9m and 2.0m in TP01 and TP02 in general accordance with BRE Digest 365 ‘Soakaway Design’.

Due to the introduction of water to the loose soils and the suspected gradual ingress of groundwater, the trial pits caved in during testing resulting in a shallower effective depth and affecting the calculated results. At TP02 this is likely to be the reason that the first test was unable to run to completion. For this test, the infiltration rate has been extrapolated, however it should be noted that this is not in line with BRE DG 365 and results should be used with caution. At TP01 effective shallowing of the pit is likely to be at least partly responsible for the fact that the test did not demonstrate sufficient infiltration to provide even an extrapolated infiltration rate.

Location	Test No.	Test Depth (m bgl)	Soil Infiltration Rate (m/s)
TP01	1	0.93 - 1.70	N/A
TP02	1	0.91 - 1.95*	6.7×10^{-6}*
	2	0.87 - 1.78	3.0×10^{-5}

** Rate extrapolated from incomplete test data. Use with caution.*

Infiltration rates generally reduce as the soil become saturated and the worst-case infiltration rate for each test should be used for design.

Full results are included in Appendix B.

GROUND GAS

Ground gas monitoring was carried out at monitoring wells installed in boreholes CT02 and HP01 on two occasions using a Geotech GA 5000 gas analyser.

During the first monitoring visit, groundwater was recorded to be above the top of the response zone at CT02 meaning that the gas results were representative of stagnant gas in the well casing, rather than soil-borne ground gas. During the second monitoring visit on 21st February 2020, the site was observed to be experiencing severe waterlogging following recent storms whereby CT02 was full of water to just above ground level and gas monitoring was not possible for this well.

The results of the monitoring are summarised in the table below:

Parameter	Range	Comments
Oxygen *(%v/v)*	8.3 - 21.4	Minimum at HP01 on 21/02/2020
Carbon Dioxide *(%v/v)*	0.1 - 2.5	Maximum at HP01 on 21/02/2020
Methane *(%v/v)*	<0.1 - 0.1	Maximum at HP01 on 21/02/2020
Flow rate *(l/h)*	0.3	

The generally low methane and carbon dioxide concentrations are indicative of the soils encountered which did not include any significant thicknesses of Made Ground or have any significant quantities of organic matter or materials which can decay. The abnormally low oxygen concentration and higher carbon dioxide and methane concentrations encountered during the second visit on 21st February 2020 are considered to be due to the severe waterlogging impeding the natural gas migration at the site.

Weather reports for the time preceding the testing indicated that rising pressure conditions were encountered prior to the both monitoring visits.

Full monitoring results are provided in Appendix B.

GROUND CONTAMINATION ASSESSMENT

The contamination risk assessment has been undertaken in line with the EA's new online guidance, Land Contamination: Risk Management (LCRM), published in June 2019. The new guidance is based upon the principles of the EA's CLR11 guidance, Model procedures for the management of land contamination, published in 2004.

The assessment has been undertaken in order to validate the PRA using a Generic Quantitative Risk Assessment (GQRA), which is followed by a Detailed Quantitative Risk Assessment (DQRA) if any significant risks are identified.

SOIL TESTING

In total, ten shallow soil samples collected on site during this investigation (three of the Topsoil, five of natural ground, and two of the soils making up the vegetated embankments) were tested for a range of Constituents of Potential Concern (CoPC).

The suite of testing carried out on the samples was decided upon following consultation of R&D CLR Publications, published as part of the CLEA guidelines, a joint venture between the Department for Environment, Food and Rural Affairs (DEFRA) and the EA.

The test suite included a range of:

- Inorganic substances, including metals and metalloids
- Speciated Polycyclic Aromatic Hydrocarbons (PAH)
- Total Petroleum Hydrocarbons (TPH), with eight band split
- Asbestos screening

Unless explicitly stated on the laboratory report, the soil samples were tested to obtain 'Total' values within the soil.

RISK ASSESSMENT GUIDELINES – HUMAN HEALTH

The human health risk assessment has been undertaken using the guidance provided in the EA's LCRM guidance, published in June 2019, and the CLEA guidelines. This assesses risks associated with the ingestion, dermal contact, and vapour inhalation pathways related to contaminated soils and groundwater. Risks associated with the inhalation of Ground Gas, for example that resulting from landfill, is not addressed by LCRM and assessment has been dealt with separately in the Ground Gas Risk Assessment section of this report.

Human health assessment criteria used are based upon the proposed final land use of the site. As the site is proposed to be redeveloped to accommodate residential houses the Generic Assessment Criteria (GAC) for 'Residential with Homegrown Produce' is therefore considered to be representative of the future site usage.

Consideration has also been given to potential risks to groundworkers coming into contact with the soil during demolition or construction phases.

The results of the soil samples tested have been compared to the following published assessment criteria:

Category 4 Screening Levels (C4SLs)

Published in March 2014 by DEFRA, a limited number of generic Category 4 Screening Levels (C4SLs) were produced to support the revised Statutory Guidance to support Part 2A of the Environmental Protection Act 1990, which was published in April 2012. This Guidance introduced a new four-category system for classifying land under Part 2A for cases of a Significant Possibility of Significant Harm to human health, where Category 1 includes land where the level of risk is clearly unacceptable and Category 4 includes land where the level of risk posed is acceptably low.

Although not the primary purpose, the DEFRA letter dated 3rd September 2014 from Lord de Mauley established that the C4SLs are also suitable for use in planning situations, as did the Department for Communities and Local Government (DCLG)'s 'Planning Portal' document from June 2014.

Suitable 4 Use Levels (S4ULs)

To supplement the limited number of C4SLs, a set of generic Suitable for Use Levels (S4ULs) were produced by Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) in 2015 using the EA's CLEA software, version 1.06 released in 2009, and the revised assumptions used in deriving the C4SLs.

The S4ULs are generally more conservative than the C4SLs and are derived to represent the minimal levels of risk to human health as described in the EA's SR2 guidance, with the intention of confirming the land 'suitable for use' under planning.

For S4ULs, a range of generic values have been published for the organic CoPCs based on the soil's organic matter content (1%, 2.5%, and 6%). As the site-specific soil organic content was not determined for the site, where S4ULs have been adopted for the organic CoPCs, analytical results have been compared to the most conservative value, those for 1% soil organic matter (SOM), as a preliminary screening tool.

RISK ASSESSMENT GUIDELINES – GROUNDWATER

The Controlled Waters risk assessment has been undertaken following procedures set out in the EA's RTM, *Hydrogeological risk assessment for contaminated land*, published in 2006.

Controlled Water GAC are based upon the receiving water body and comprise UK Drinking Water Standards (UKDWS), as set out in The Water Supply (Water Quality) Regulations 2016, for potable groundwater receptors and Environmental Quality Standards (EQS), as set out in the Water Framework Directive 2015 (WFD), for a surface water receptor. UKDWS refer to the water directly coming from a consumers tap and EQS refer to water directly discharging into a watercourse.

RESULTS OF SOILS ANALYSIS

Screening for the presence of asbestos did not detect any asbestos containing material (ACM) or fibres in the soil sample tested as part of this investigation.

Certain PAH were detected at concentrations marginally in excess of their GAC protective of human health in a residential setting (benzo[b]fluoranthene: 3.1 mg/kg compared to a S4UL of 2.6 mg/kg; dibenz[a,h]anthracene: 0.29 mg/kg compared to an S4UL of 0.24 mg/kg). These were detected in the sample from TP03 in the centre of the site and were significantly higher than concentrations elsewhere on the site, indicating an isolated hotspot as opposed to elevated levels sitewide.

HUMAN HEALTH RISK ASSESSMENT

The following Generic Quantitative Risk Assessment (GQRA) has been carried out using the source-pathway-receptor principle. Relevant potential sources of contamination identified in the CSM and PRA have been assessed using the CLEA guidelines which takes into account the fact that a complete pathway must exist between a potential source of contamination and a potential receptor for there to be considered a risk.

The potential long-term human receptors evaluated for their individual risk are:

- End users of the site - the future residents and users of the rerouted footpath crossing the site
- Staff and children at the adjacent nursery school
- Staff and customers of the adjacent public house
- Surrounding residents

Risk to construction workers (short-term risk) is discussed separately.

SOIL RISK ASSESSMENT

The soil contamination analysis carried out at this site has detected concentrations of PAH at the interface between the Topsoil and Silchester Gravel Member marginally in excess of their relevant GAC protective of human health in a 'Residential with Homegrown Produce' setting by up to 1.2 times.

The origin of the PAH in the soil can be inferred by the use of a double ratio plot, whereby the ratio of benzo(a)anthracene to chrysene is plotted against the ratio of fluoranthene to pyrene. This analysis indicates that the source of the elevated PAH in this sample is likely to be coal-derived and is therefore attributed to the possible presence of ash or carbonaceous material within the Topsoil.

The main pathway through which these PAH pose a risk to human health is ingestion. This pathway is generally only considered to be present within 0.6m of the final ground level, within which depth contact can be made during play and gardening activities and plant uptake can occur. As this sample location was within the proposed access road, there is no history of potential contamination at the site, and all other testing detected significantly lower concentrations, this pathway is considered not to be applicable in this instance.

As such, there is considered to be no significant possibility of significant harm (SPOSH) to long-term human receptors from PAH at the site.

GROUND GAS RISK ASSESSMENT

In accordance with CIRIA Report C665, the preliminary ground gas risk assessment indicated a potential source of migrating carbon dioxide and methane gases and explosive gases due to nearby landfills.

The results of the gas monitoring identified concentrations of carbon dioxide up to 2.5% v/v and methane up to 0.1% v/v are being produced in the ground. Absolute flow rates of up to ±0.3 l/hr were recorded.

The low concentrations are indicative of the soils encountered which did not include any significant thicknesses of Made Ground or have any significant quantities of organic matter or materials which can decay.

Ground Gas Screening Values

In accordance with BS 8485:2015+A1:2019, the hazardous gas flow rates have been calculated for each monitoring event for each monitoring well separately and compared and considered in relation to the proposed development and conditions observed during monitoring. The calculated rates ranged significantly from <0.001 to 0.008 l/hr, with the highest recorded during a period of severe waterlogging when gas migration is impeded, and are therefore not considered to be consistently representative of the gas regime at the site. Given this, it is recommended that further testing is carried out when water levels have dropped.

In the absence of further monitoring, it is considered that the worst-case hazardous gas flow rate should be adopted as the Ground Gas Screening Value (GSV) for the site, in accordance with the guidance provided in BS 8485:2015+A1:2019. This is calculated using the overall maximum carbon dioxide or methane reading of 2.5% v/v and overall maximum absolute flow rate of 0.3 l/hr to provide a worst-case hazardous gas flow rate of 0.008 l/hr.

Characteristic Situation Classification

Classification of the Characteristic Situation (CS) of the site is dependent on a number of factors including the calculated GSV, maximum concentrations detected, potential perceived risk, and sensitivity of the site.

Whilst a GSV of 0.008 l/hr on its own classifies the site as CS1 and 'Green' with reference to the NHBC Traffic Light system for residential properties, due to the abnormal conditions experienced during the second monitoring round and in the absence of further monitoring, it is considered pertinent to raise the classification to CS2 as a precautionary measure, especially in the block of flats where residents will be living entirely on the ground floor.

Gas Protection Measures

For housing (Type A building) and blocks of flats (Type B building), the gas protection measures required for CS2 must score a total of 3.5 in accordance with Table 4 of BS 8485:2015+A1:2019. This means a combination of two or more of the following gas protection measures should be incorporated in the building construction to achieve a total score of 3.5, with reference to Tables 5, 6, and 7 of BS 8485:2015+A1:2019.

a) Structural barrier - for appropriate types see Table 5 of BS 8485:2015+A1:2019
b) Ventilation measures - for appropriate types see Table 6 of BS 8485:2015+A1:2019
c) Gas resistant membrane - for appropriate types see Table 7 of BS 8485:2015+A1:2019

Advice from a specialist should be sought in selecting the appropriate combination and design for each type of building within the proposed development. The gas protection measures will also need to be approved and verified by an independent body.

It should be noted that it is possible that some of the above criteria may be inherently fulfilled by existing building design proposals and that minimal alterations to existing designs may need to be made in order to comply.

Decommissioning of Monitoring Wells

At present, the gas and groundwater monitoring wells are located outside of the footprints of any proposed buildings. However, in the event that the site layout is altered and buildings are proposed over the position of any monitoring well, it should be decommissioned using low permeability cement grout or similar to prevent leaving a preferential pathway for any ground gases to the buildings.

Radon Gas

The BGS advises that radon gas protection measures are not required for buildings without underground rooms at this site.

ADDITIONAL CONSIDERATIONS

Construction Workers

For construction and maintenance workers that are exposed to the ground, there is a short-term exposure risk (at each site they attend contributing to an overall lifetime exposure risk) and the pathways of primary concern are ‘direct soil ingestion’ and ‘dermal contact’. Protective measures that are different to those taken to protect the long-term exposure receptors discussed above (such as end users of the site) are therefore required.

In order to reduce the risks posed from contaminated to as low as reasonably practicable for the site workers it is recommended that appropriate health and safety measures be implemented along with the use of Personal Protective Equipment (PPE). All personnel coming into contact with the soil, ground workers in particular, should be instructed to use gloves when on site to avoid dermal contact and restrict inadvertent hand-to-mouth ingestion. Hand washing facilities should be provided for the site staff and these should be used prior to eating or smoking. Reference should be made to the HSE Document, “Protection of Workers and the General Public during Development of Contaminated Land” (HSE 66, 1991).

Regulatory Approval

It is recommended that the findings of this report, including any additional contamination identified during groundworks, are approved by the Local Authority and building warranty provider prior to any development taking place in order to reduce potential delays to the development should they require any further clarification of this report.

CONTROLLED WATERS RISK ASSESSMENT

The following Controlled Waters risk assessment has been carried out in accordance with the procedures set out in the EA's Remedial Targets Methodology RTM *Hydrogeological risk assessment for contaminated land*, published in 2006. Using the source-pathway-receptor principle, this takes into account the fact that a complete linkage must exist between a potential source of contamination and a potential receptor for there to be considered a risk.

The potential Controlled Waters receptors considered during this risk assessment were:

- Groundwater of the underlying Silchester Gravel Member - Secondary (Undifferentiated) Aquifer
- Groundwater of the upper layer of the underlying London Clay Formation - Secondary A Aquifer

DISCUSSION

The PRA assessed that viable source-pathway-receptor linkages were of low risk, primarily due low likelihood of significant contamination and absence of recorded groundwater abstractions within 1000m of the site.

Given the concentrations of CoPCs detected in the shallow soils, it is considered unlikely that CoPCs are present in significant enough concentrations to migrate from soils into groundwater of the Secondary Aquifers underlying the site and reach the groundwater abstractions over 1000m away, with respect to GAC protective of human health (UKDWS).

There is therefore considered to be no significant risk to Controlled Waters from the site.

REGULATORY APPROVAL

It is recommended that the findings of this report, including any additional contamination identified during groundworks, are approved by the Local Authority prior to any development taking place in order to reduce potential delays to the development should they require any further clarification of this report.

REVISED CONCEPTUAL SITE MODEL

Following GQRA, the CSM has been updated and the Relevant Pollutant Linkages (RPLs) are presented in the following tables.

ON-SITE SOURCES

Potential Source	Pathway	Potential Receptor	Probability	Consequence	Risk Classification	Remediation / Further Investigation Required
Contaminants within the Made Ground - *Including: heavy metals, PAH, petroleum hydrocarbons, asbestos*	• Ingestion • Dermal Contact • Inhalation	• End Users - residents	Unlikely	Medium	Low	None, based on findings from accessible areas investigated.
		• End Users - public • Nursery School • Public House • Surrounding Residents	Unlikely	Medium	Low	None
		• Construction Workers	Low likelihood	Mild	Low	None
	• Migration through unsaturated zone • Migration through groundwater • Migration through drains or service runs	• Secondary (Undifferentiated) Aquifer	Unlikely	Mild	Very Low	None
		• Secondary A Aquifer	Unlikely	Mild	Very Low	None
	• Direct contact	• Substructures • Water supply pipes	Low likelihood	Mild	Low	None

OFF-SITE SOURCES

Potential Source	Pathway	Potential Receptor	Probability	Consequence	Risk Classification	Remediation / Further Investigation Required
Unrestricted and industrial landfills 310m to the east - *Including: CO_2, CH_4*	• Inhalation	• End Users	Unlikely	Medium	Low	Further investigation is recommended when water levels are lower in order to confirm whether CS2 gas protection measures are necessary or whether it could be decreased to CS1.
	• Accumulation of gases	• On-site buildings	Unlikely	Severe	Moderate / Low	

GEOTECHNICAL ENGINEERING CONCLUSIONS

The proposed development is understood to comprise construction of ten residential houses, with associated gardens, and a block of six flats with associated access roads, car parking, soft landscaping, and an amenity area. A plan showing the development proposal is included in Appendix A.

The exploratory and laboratory work from this investigation has proven the general strata sequence to comprise topsoil above loose to dense, clayey sands and gravels of the Silchester Gravel Member overlying clay bedrock of the London Clay Formation, proven to 6.0m bgl.

Laboratory testing undertaken on samples from this investigation indicate that the London Clay Formation underlying the site should be considered as a shrinkable soil of medium volume change potential and intermediate plasticity.

Depth to groundwater varied significantly across the site with groundwater encountered as shallow as 0.1m depth, within the Topsoil, during intrusive works and at above ground level and at a depth of 0.26 bgl (121.4m AOD) during longer term monitoring.

SITE EXCAVATION

Conventional hydraulic plant should be satisfactory for excavating foundation and service trenches within the Silchester Gravel Member and shallow London Clay Formation.

In line with HSE guidelines, all excavations requiring personnel access should be adequately supported to avoid the risk of collapse. Consideration should also be given to the stability of open trenches where personnel are working in close proximity. Excavations below 0.5m in the Silchester Gravel Member were recorded to be unstable and trenches extending beyond these depths will require some side support. During the fieldwork, excavation within the London Clay Formation (TP03) remained stable for the short time that the trial pit was open.

Groundwater could be encountered at any depth below ground level and dewatering is likely to be required. It should be noted, however, that this investigation was undertaken during the winter months and that seasonal variations in groundwater level may exist. It would be prudent to carry out all ground works in the late summer or autumn when groundwater levels and flows are usually at their lowest.

With regard to dewatering, conventional pumping from sumps is unlikely to be successful therefore the installation of a well point system or use of sheet piles may be required. The advice of a specialist dewatering contractor should be obtained. The effects of dewatering on adjacent structures will need to be taken into account as dewatering could result in settlement and induce localised instability. It would be useful to undertake a trial before any final decisions are made.

It should be noted, however, that this investigation was undertaken during the winter months and that seasonal variations in groundwater level may exist. It would be prudent to carry out all ground works in the late summer or autumn when groundwater levels and flows are usually at their lowest.

Consideration should be given to the effects of trees and shrubs on service runs that cross the site. Soil movements brought on by the influence of vegetation can severely disrupt the drain runs and mains services, and measures should be incorporated into the excavations to allow for future ground movements.

It was noted during siteworks that a number of trees had recently been removed from the site. Care should be taken to ensure the root ball of each tree is completely removed from the ground in order to minimise the development of localised areas of soft organic soils due to weathering of remnant root fragments. Where new foundations are placed over a felled tree, consideration should be given to spanning these features to ensure no soft spots result in localised settlement.

FOUNDATION SOLUTIONS

Shallow Foundations

The Silchester Gravel Member and London Clay Formation are considered to be suitable bearing strata for conventional strip foundations at not less than 1.0m bgl or 0.2m into the top of the formation, whichever is the deeper. At this depth, an allowable bearing pressure (or net loading intensity increase) of 150 kPa may be adopted for a strip foundation of 1m width. This allows for a factor of safety of 3.0 and differential and total vertical settlements under these conditions not exceeding 25mm, the majority of which would occur during the construction period within the Silchester Gravel Member and over a number of years within the London Clay Formation. Caution should be taken if using an alternative foundation width, as increased width causes reduction in allowable bearing capacity, and decreased width causes increases potential settlement; either of which may take the development beyond acceptable limits.

Given the plastic nature of the clay soils at founding depth, they may be prone to rapid softening when wetted up. In the event that any delays occur between excavating any foundations within clay strata (likely to be encountered in the west of the site), and pouring of the concrete, a blinding layer of concrete should be placed in the base of the open excavations to prevent the occurrence of localised softening.

Additionally, the clay soils should be considered as being of medium volume change potential and where foundations are sited within clay strata or within influencing distance, in accordance with NHBC Standards, Chapter 4.2, a proprietary compressible layer such as Claymaster or Clayshield should be placed along the sides of foundation excavations in order to accommodate heave forces in the ground.

Care should be taken to ensure that any new planting in the development will not affect the new foundations. Where foundations are to be constructed within the vicinity of trees or shrubs on this site then they will require

GROUND FLOOR SLABS

Provided all the Topsoil is stripped off, ground bearing floor slabs could be constructed on the Silchester Gravel Member placed on a layer of well compacted coarse-grained fill. However, where the London Clay Formation is found to be shallow, it is recommended that the ground floor should be suspended due to the potential for shrinkable soils, in accordance with NHBC guidelines. A void should be left below the floor slab to

accommodate future moisture content related soil movements. This may be achieved by use of a proprietary compressible material such as Clay board or Cellcore.

SUBSURFACE CONCRETE

The concrete design mix recommendations for subsurface concrete have been assessed in terms of BRE Special Digest 1 (SD1; 2005).

The site has no known history of industrial development and may therefore be considered as a natural ground location for the purposes of this assessment. As groundwater is likely to be above foundation depth, the groundwater is considered 'mobile'.

The underlying London Clay Formation is considered to potentially contain sulphates which are aggressive to concrete, however chemical analysis in accordance with BRE SD1, has indicated no significant oxidisable sulphides content and therefore pyrite is considered unlikely to be present. As such, the assessment is based on the presence of 'non-pyritic' ground.

Chemical testing has recorded a characteristic soil soluble sulphate concentration of 100 mg/l which corresponds to a Design Sulphate (DS) Class of DS-1. The characteristic pH was 6.2 which, when considered in combination with the DS Class, corresponds to an Aggressive Chemical Environment for Concrete (ACEC) class of AC-1.

ACCESS ROADS AND PARKING

The structural design of a road or hard standing is based on the strength of the subgrade, which is assessed on the California Bearing Ratio (CBR) scale.

With reference to Transport and Road Research Laboratory Report, LR1132, the in-situ test results, and the laboratory classification tests it is recommended that for formation prepared in the Silchester Gravel Member, a subgrade CBR value of 10% is adopted for preliminary design purposes. The site conditions should be reassessed at the time of construction and the CBR/pavement design updated accordingly if considered necessary.

Any areas of soft or deleterious material should be excavated and replaced with a properly compacted coarse-grained fill.

The London Clay Formation is unlikely to be frost susceptible, however the Silchester Gravel Formation is and a suitable minimum pavement thickness will therefore need to be specified for pavement founding on this stratum depending upon the proposed pavement usage.

INFILTRATION MEASURES

Appropriately designed Sustainable Drainage Systems (SuDS) are more sustainable than using piped drainage to local sewer systems. However, infiltration measures close to buildings may result in undermining of foundations and softening of soils leading to instability. Attenuation measures should be located at suitable

distances from foundations (minimum 5m; NHBC, 2020) and infrastructure and consideration given to the effects on slopes, flooding, and mobilisation of contaminants.

Infiltration rates generally reduce as the soil become saturated and the worst-case infiltration rate for each test should be used for design. Due to the presence of shallow groundwater and loose strata, limited infiltration data was able to be obtained, however they indicate infiltration rates of 6.7×10^{-6} m/s to 3.0×10^{-5} m/s, with the slower of these extrapolated from incomplete data. The worst-case infiltration rate (6.7×10^{-6} m/s), indicates soils of medium to low permeability comprising poor infiltration media in accordance with CIRIA C753.

Ideally a buffer of 1m of unsaturated soils are required beneath the base of SuDS, however standing groundwater was recorded at a maximum depth of 0.26m bgl and the site was flooded on another occasion.

As such, the shallow groundwater levels may preclude the effective use of SuDS and early discussion with the EA is recommended for their approval should their use be pursued.

UNDERGROUND SERVICES

It should be noted that the utility companies often have their own local guidelines and standards on levels of shallow soil contamination in the ground that may or may not be acceptable for the installation of below ground services. These standards are different to those specified for assessing risks to human health and groundwater.

The local requirements should be obtained from the particular service supply company as soon as possible to avoid unexpected delays or additional development costs.

Approval from the local water company should be sought for the type of pipes proposed before they are installed.

RE-USE AND DISPOSAL OF ARISINGS

It is likely that the excavations on site from foundation and services trenches may produce arisings, some of which may be able to be re-used on-site and some of which will be surplus to requirement.

RE-USE OF MATERIAL ON SITE

Currently, if surplus arisings are 'fit for re-use' on the site and have not been treated, its re-use is allowed within the planning law. If it needs treating prior to re-use, exemptions can be sought from the EA to allow this activity.

A recent voluntary code of practice published by CL:AIRE, in conjunction with the EA, (the Definition of Waste: Development Industry Code of Practice, Version 2) endorses the re-use of arisings on and off the site of origin without the need for exemptions from the EA, dependent on whether it is "fit for purpose".

Based upon the human health and Controlled Waters risk assessments, the soils on this site are considered to be suitable to be re-used on site for soft-landscaping, subject to agreement of the Local Authority, or for earthworks purposes, subject to appropriate compaction testing results.

WASTE CLASSIFICATION

Under current waste management legislation any arisings that are surplus to requirement is classed as waste and needs disposing to a licensed facility. Records must be kept of where the waste is taken upon leaving site and its final destination.

The classification is a two-fold process using the soil chemical testing results and the European Waste Catalogue for removal from the site, followed by testing under the Waste Acceptance Criteria (WAC) specifically for landfill disposal.

EUROPEAN WASTE CATALOGUE DETERMINATION

Soils

Any soil classified as waste requires classification of the chemical constituents prior to leaving site in accordance with the European Waste Catalogue.

The 'Total' soil contamination test results from this investigation, excluding asbestos, have been used in conjunction with the HazWasteOnline spreadsheets and the Technical Guidance WM3 published by the EA in order to determine whether the waste soils are deemed hazardous or non-hazardous.

All of the soils tested have been classified as 'Non-hazardous' waste.

The assessment report is provided in Appendix F.

Asbestos

No obvious visual evidence of asbestos containing material (ACM) was noted in the soils during the fieldwork nor was any detected during laboratory analysis.

Technical Guidance WM3 states that 'if the waste contains fibres that are free and dispersed then the waste will be hazardous if the waste as a whole contains 0.1% w/w or more asbestos'. It also states that 'where the waste contains identifiable pieces of asbestos (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then the waste is hazardous if the concentration of asbestos in the pieces alone is 0.1% or more'.

In soils where asbestos pieces visible by the naked eye are encountered, this soil is considered as mixed waste and must be separated whenever possible and each separate waste stream classified accordingly.

WASTE ACCEPTANCE CRITERIA (WAC) TESTING RESULTS

If it is decided that the surplus arisings will be disposed of at a landfill facility, the implementation of the Landfill Directive means that the waste soil requires additional classification under the Waste Acceptance Criteria (WAC) to determine whether it should be destined for an Inert, Non-Hazardous, Stable Non-Reactive Hazardous, or Hazardous landfill, or whether an alternative disposal method must be sought.

WAC testing has been carried out on one representative sample of the shallow Silchester Gravel Member collected from 0.5m bgl in TP02 and from the two soil vegetated embankments in the west and north of the site (TP04 and TP05 respectively). The laboratory testing results are presented in Appendix F.

The samples were initially classified as 'Non-Hazardous' waste and the WAC testing indicates that the soil passes the criteria to be acceptable at 'Inert' landfill. Topsoil is unlikely to be accepted at 'Inert' landfill due to its organic content.

Waste Stream	EWC Classification	Landfill Category	Comments
Embankment soils	Non-hazardous	Inert	
Topsoil	Non-hazardous	Non-hazardous	Due to organic content
Silchester Gravel Member	Non-hazardous	Inert	
London Clay Formation	Non-hazardous	Inert*	*If clearly separated and uncontaminated, otherwise WAC testing required.

Analytical results relevant to the materials being disposed of should be provided to the waste management contractors and landfill operators to confirm whether it meets their license agreements and to confirm tipping costs.

Different categories of waste soils must not be mixed. The action of mixing hazardous waste with non-hazardous waste to dilute hazardous concentrations or to dispose of one waste type as/with another is illegal.

Should any soils be encountered that differ from those encountered during this investigation, further testing and waste classification of those soils will be required. It is recommended that when access allows and/or prior to disposal, the embankment soils are investigated further to confirm their content. Dependant on the amount requiring disposal, additional WAC tests may also be required at this time.

Uncontaminated soil and stones, including naturally occurring sands and clays, may be accepted in an inert landfill without testing, provided that it is not topsoil or peat and excludes soil from contaminated sites. Inert waste should not undergo change, will not burn, react, biodegrade or adversely affect human health or the environment. It should not contain metals or plastics.

LANDFILL DISPOSAL

Landfill disposal costs have risen considerably in recent years. With this in mind, alternative foundation solutions, that produce less waste, may be more cost-effective than significant landfill disposal.

Waste Treatment

The Landfill Regulations dictate that all waste must be treated before going to landfill. This treatment should fulfil all of the following three criteria:

- Physical, thermal, chemical or biological process including sorting.
- Change the characteristics of the waste.
- Reduce the volume, reduce the hazardous nature, facilitate its handling or enhance its recovery.

The most basic method of pre-treatment is sorting of the waste and re-cycling any possible materials, many waste disposal companies will have on-site recycling facilities that will be able to undertake this process at the landfill site. However, if treatment would not reduce its quantity or the hazards it poses to human health or the environment, then all three steps may not be necessary. The exception is inert waste for which treatment may not be technically feasible.

The EA expect all landfill operators to obtain written evidence that the waste they accept has been pre-treated. It is recommended that a signed certificate should be obtained describing the treatment to give to the receiving landfill. Further testing may be required after the treatment before the soil is accepted by the relevant landfill.

It should be noted that in May/June 2012, HMRC issued Briefs 15/12 and 18/12 clarifying how construction spoil and excess soils will be assessed for landfill tax purposes. Detailed accurate descriptions of waste are required for all wastes to support the landfill tax assessment. Uncontaminated naturally occurring soils will remain inert by default and eligible for the lower rate of landfill tax. Similarly, ‘reworked soils’ and demolition ‘stone’ comprising ONLY materials listed in the Schedule of the Landfill Tax (Qualifying Material) Order 2011 (SI 2011/1017) will also be eligible for the lower rate of landfill tax.

RECOMMENDATIONS

No significantly elevated concentrations of contaminants were recorded by this investigation and based on the findings discussed herein, there is considered to be no significant risk of significant harm from contamination to the identified human health and controlled waters receptors.

Whilst there is considered to be a low risk of contamination at this site, it is prudent to bear in mind that some areas of the site have not been investigated. Soil is a heterogeneous material and variations, which affect the conclusions, may inevitably occur between and beyond the test locations. Should ground conditions vary noticeably from the Ground Model, particularly with respect to the earth embankments, then it is recommended that work is ceased until further assessment by a suitably qualified person has been carried out.

Alternatively, to reduce the risks of encountering unexpected contamination, supplementary investigation would be undertaken when the water levels have sufficiently subsided and clearance has been carried out on the embankments to allow greater site access.

Additional gas and groundwater monitoring is recommended to confirm the need for gas protection measures at the site. If this is not undertaken, it is recommended that gas protection measures suitable for a CS2 site are installed. It should be noted that it is possible that some of the required deign measures may be inherently fulfilled by existing building design proposals and that minimal alterations to existing designs may need to be made in order to comply.

Depending on the volume of soil to be disposed from the site, particularly with regard to the embankments, additional waste classification may be required.

Groundwater was recorded to be shallow and any SuDS will require considered design by a drainage engineer.

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APPENDIX A
PLANS & PHOTOGRAPHS

Extract of 1:50,000 Ordnance Survey Explorer Map

Key: Approximate Site Location

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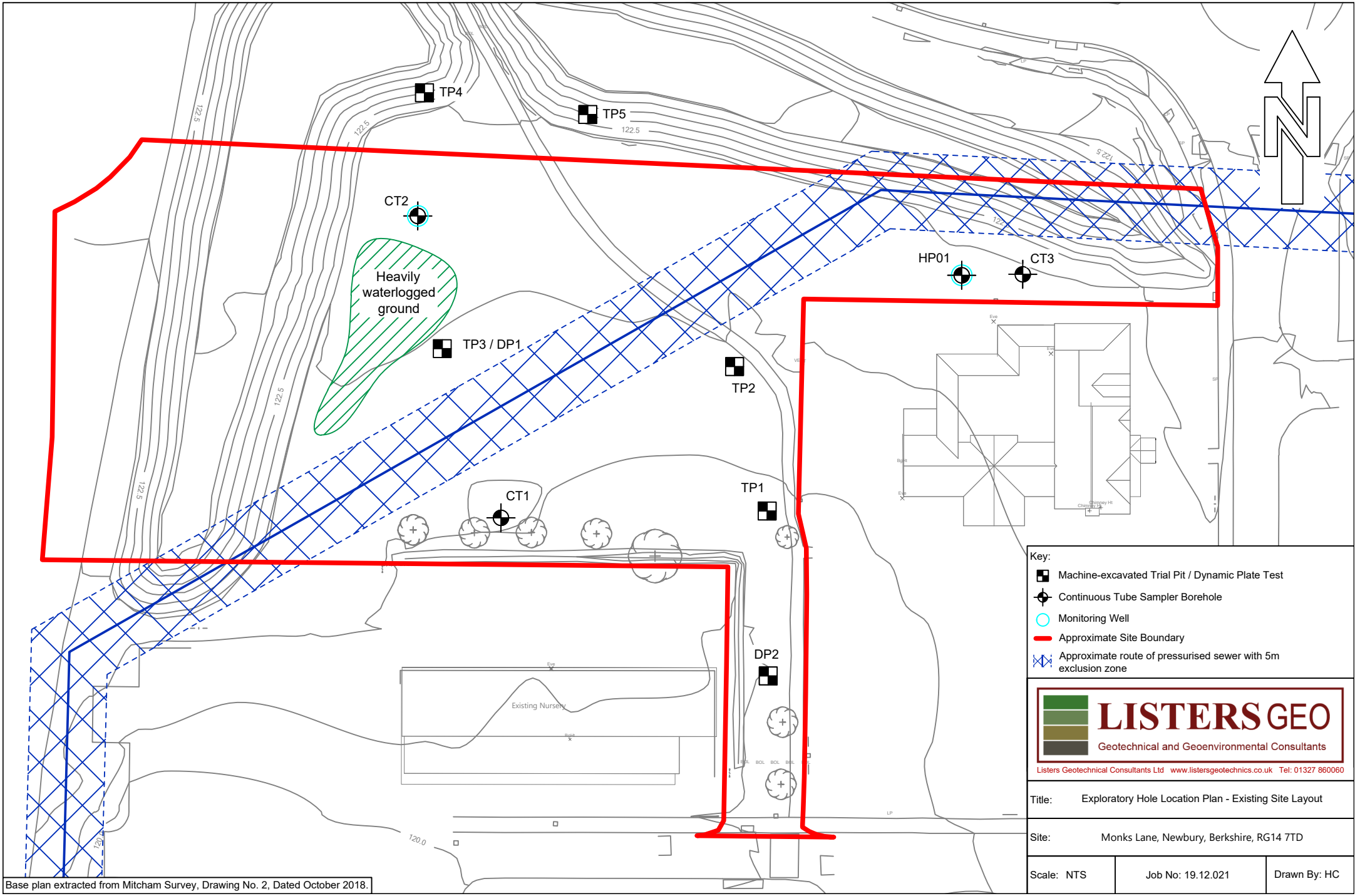
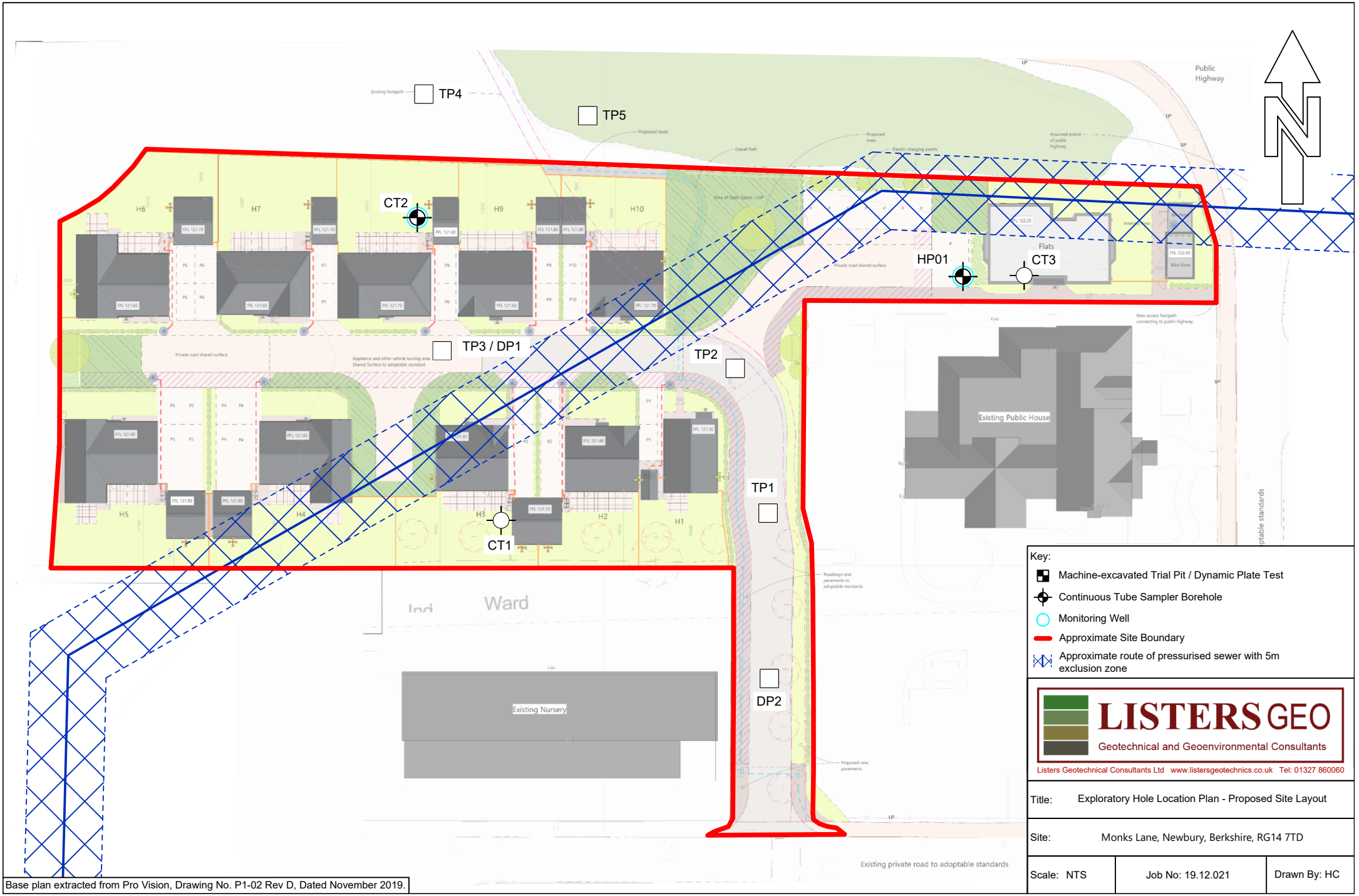
Title:	Site Location Plan	
Site:	Monks Lane, Newbury, Berkshire, RG14 7TD	
Scale: NTS	Job No: 19.12.021	Drawn By: HC

N


TP4
TP5
122.5
CT2
Heavily waterlogged ground
TP3 / DP1
TP2
HP01
CT3
CT1
TP1
DP2
Existing Nursery
120.0
N
Key:
Machine-excavated Trial Pit / Dynamic Plate Test
Continuous Tube Sampler Borehole
Monitoring Well
Approximate Site Boundary
Approximate route of pressurised sewer with 5m exclusion zone
LISTERS GEO
Geotechnical and Geoenvironmental Consultants
Listers Geotechnical Consultants Ltd www.listersgeotechnics.co.uk Tel: 01327 860060
Title: Exploratory Hole Location Plan - Existing Site Layout
Site: Monks Lane, Newbury, Berkshire, RG14 7TD
Scale: NTS
Job No: 19.12.021
Drawn By: HC
Base plan extracted from Mitcham Survey, Drawing No. 2, Dated October 2018.



Base plan extracted from Pro Vision, Drawing No. P1-02 Rev D, Dated November 2019.

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Title:	Exploratory Hole Location Plan - Proposed Site Layout	
Site:	Monks Lane, Newbury, Berkshire, RG14 7TD	
Scale: NTS	Job No: 19.12.021	Drawn By: HC

View south towards entrance from eastern site boundary (note recently felled trees)

View along southern site boundary with nursery school (view to west)

Site Photographs	Report No. 19.12.021