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GEO-ENVIRONMENTAL ASSESSMENT REPORT

WIDEWATER PLACE
MOORHALL ROAD
UXBRIDGE
UB9 6NS

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EXECUTIVE SUMMARY

Fprop Offices General Partner Ltd ('The client') commissioned Jomas Associates Ltd to undertake a geo-environmental assessment comprises a desk study and intrusive investigation at the site known as Widewater Place, Harefield.

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

Desk Study	
Site History	A review of historical maps indicates that the site was undeveloped until 1960 when large commercial style buildings are shown on site. By 1971 these are identified as engineering works, with fencing and porcelain works shown immediately north of site at the same time. A new small structure is added in 1989; however by 1992 the site is redeveloped with commercial style buildings and labelled as "Widewater Business Centre" – resembling its current layout. No further changes are shown up tot eh most recent map dated 2014. The surrounding area was predominantly undeveloped agricultural land until approximately 1934 when a residential development is shown approximately 100m north and east of site, and by 1960 large commercial style buildings are shown immediately north of site. As well as a large ground working feature to the west. By 1971 works sites are identified immediately north of site and by 1976 the west and south of site is dominated by large gravel pits and ground working features. Historic landfills are recorded 30m south and 240m north of the site By 1989 the site immediately north has been redeveloped with residential properties.
Current Site Use	The site is currently in use as a business park with 3no office buildings and car parking areas.
Proposed Site Use	Conversion of the existing commercial structures to residential use. It is understood that the three structures on site ("Chaplin House", "Norgine House" and "Musgrave House") will each be converted under separate planning applications.
Site Setting	Information provided by the British Geological Survey indicates that the site is directly underlain by superficial deposits of Alluvium, and theShepperton Gravel Member. The superficial deposits overlie solid chalk deposits of the Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated). The superficial deposits underlain the site are identified as a Secondary A Aquifer, underlain by solid deposits identified as a Principal Aquifer. The site is located within a Source Protection Zone 1, with the nerest potable abstraction reported 228m south-west. The nearest surface water feature is reported 20m west as the Grand Union Canal.

Desk Study	
Ground Investigation	
Intrusive Investigation	6No window sampler holes were drilled to a maximum depth of 6mbgl. 5No combined gas and groundwater monitoring wells were installed. 4No return visits to monitor ground gas concentrations and groundwater levels have been completed.
Ground Conditions	Ground conditions were found to comprise up to 1.9m of Made Ground overlying peat, sandy gravel/gravelly sand and clay interpreted to represent alluvium and Shepperton Gravel Member deposits to a maximum depth of 4.50mbgl, overlying chalk to the base of the boreholes at 6.00mbgl. A hydrocarbon odour was reported within the sand and gravel at WS5 between 3.30mbgl and 4.20mbgl (below the water table). Groundwater was reported between 2.4-3.5mbgl during drilling and between 2.12-2.60mbgl during return monitoring.
Environmental Consideration	Following generic risk assessments and statistical analysis, elevated concentrations of lead, benzo(b)fluoranthene, benzo(a)pyrene and dibenzo(ah)anthracene were reported in excess of their respective assessment criteria. A single sample was found to contain asbestos out of 8No samples screened, in the form of chrysotile fibre bundles. The asbestos content was quantitated as <0.001% asbestos by weight. Quantification indicates a content of <0.001%, below the level at which waste soils would be considered hazardous for the purposes of waste disposal. The site proposal indicates that the majority of the site will remain covered by a combination of the proposed building footprint and hard surfacing. Where this is the case, no formal remedial measures are considered necessary in terms of human health, as the building and hard surfacing are expected to provide a barrier to potential receptors. In areas of soft landscaping, existing soils should be encapsulated by a minimum 600mm clean cover layer of imported sub/topsoil, placed over a geotextile membrane. It is noted however, that parts of the existing soft landscaping comprises strips of dense hedgerows which would not be expected to pose a significant risk to proposed end users. In addition, further soil sampling could be undertaken in areas of soft landscaping to determine if the shallow soils in specific areas are suitable for the proposed use. Groundwater analysis has reported an elevated concentration of arsenic in excess of drinking water standards, and lead and nickel in excess of Environmental Quality Standards. No hydrocarbon compounds were reported above detection limit within groundwater samples. The relatively low level of the exceedances reported and distance to the nearest receptors indicates that the elevated concentrations are unlikely to pose a significant risk to controlled waters. In addition, the proposed change of use at the site will not results in additional areas of soft landscaping and increase rainwater infiltration.

Desk Study	
	Concentrations of carbon dioxide are raised at the site, with corresponding depleted oxygen. Calculating the Gas Screening Value using worst case results indicates Characteristic Situation 1. Further monitoring visits are considered necessary to provide confidence that worst case conditions would not result in a CS2 classification, for which ground gas protection measures would be required. It is recommended that a further five monitoring visits are undertake over a five month period. Should the additional monitoring determine that a CS2 classification is appropriate, it is likely that surveys will be required to determine what level of ground gas protection is present within the existing buildings, and (if necessary) how any such protection could be upgraded to match requirements for CS2. A pollutant linkage via vapour inhalation pathways is not considered to exist. Barrier pipe work may be required for potable water supply pipes. Sampling and analysis of potable water supplies to the existing units may be acceptable to the relevant utility provider to confirm whether existing pipe work is satisfactory. The potable water supply pipe requirements should be discussed with the relevant utility provider. A Remediation Strategy will be required to define the required remedial measures.
Recommended Further Work	The following works are recommended: • Seek approval of the Generic Quantitative Risk Assessment and Soil Gas Assessment from the Local Authority, NHBC and other relevant stakeholders; • Undertake a further five gas monitoring visits over a five month period. • Seek confirmation of the water supply pipe requirements by the appropriate service provider. • If required, undertaken further shallow soil sampling and analysis to allow possible delineation of soft landscaped areas requiring a clean cover system • Production of a Remediation Method Statement (RMS);

1 INTRODUCTION

1.1 Terms of Reference

1.1.1 Fprop Offices General Partner Ltd ("The Client") has commissioned Jomas Associates Ltd, to assess the risk of contamination posed by the ground conditions at a site referred to as Widewater place, Harefield, prior to a change of use from office space to residential land use.

1.1.2 To this end a desk based review and intrusive investigation has been undertaken in accordance with Jomas Associates Limited's email proposal dated 16th June 2017, and email proposal 13th May 2021.

1.1.3 This report was first issued in July 2017, was prepared without a specific development proposal for the site. This reissue is intended to tailor the findings of the original investigation to the new development proposals. No further intrusive works or monitoring have been undertaken in this reissued version; however a new site reconnaissance visit was undertaken in May 2021.

1.2 Proposed Development

1.2.1 The proposed development is to comprise the conversion of the existing commercial structures to residential use. It is understood that the three structures on site ("Chaplin House", "Norgine House" and "Musgrave House") will each be converted under separate planning applications.

1.2.2 Chaplin House will provide 1No 3-bedroom apartment, 33No 2-bedroom apartments and 12No 1-bedroom apartments with roof gardens on the first and second floors.

1.2.3 Norgine House will provide 8No 3-bedroom apartments, 30No 2-bedrooom apartments, and 11No 1-bedroom apartments.

1.2.4 Musgrave House will provide 5No 3-bedroom apartments, 26No 2-bedroom apartments and 5No 1-bedroom apartments with a roof garden on the second floor.

1.2.5 No private soft landscaping is anticipated and therefore for the purposes of the contamination risk assessment, the proposed development is classified as 'residential without plant uptake'.

1.2.6 Proposed development plans are provided as Figures 5-7.

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

- Conventional structures.
- Quantitative investigation and analysis.
- Normal risk.

- No difficult soil and site conditions.
- No difficult loading conditions.
- Routine design and construction methods.

1.3 Objectives

1.3.1 The objectives of Jomas Associates Limited's investigation were as follows:

- To present a description of the present site status, based upon the published geology, hydrogeology and hydrology of the site and surrounding area;
- To review readily available historical information (i.e., Ordnance Survey maps and database search information) for the site and surrounding areas, with respect to potentially contaminative land uses;
- To provide an assessment of the environmental sensitivity at the site and the surrounding area, in relation to any suspected or known contamination which may significantly affect the site and the proposed development;
- To conduct an intrusive investigation, to determine the nature and extent of contaminants potentially present at the site;
- To assess the potential presence of significant pollutant linkages, in accordance with the procedures set out within Part IIA of the Environmental Protection Act 1990, associated statutory guidance and current best practice including the EA report R&D CLR 11;

1.4 Scope of Works

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

- A walkover survey of the site;
- A desk study, which included the review of third party reports (attached in Appendix 2 and Appendix 3);
- Intrusive ground investigation to determine shallow ground conditions, and potential for contamination at the site;
- Undertaking of laboratory chemical and geotechnical testing upon samples obtained;
- The compilation of this report, which collects and discusses the above data, and presents an assessment of the site conditions, conclusions and recommendations.

1.5 Supplied Documentation

1.5.1 A number of reports previously prepared by third parties were supplied to Jomas Associates at the commencement of this investigation. Table 1.1 details the documents supplied:

Table 1.1: Supplied Reports

Title	Author	Reference	Date
Phase 5 Remedial Works Report	Environ Aspinwall	ND0020001B	February 2002
Asbestos Survey (Type 2)	Casella Hazmat	MW/5382/030022005	February 2005
Letter	Environment Agency	NI/CL/HF/104	February 2002
Letter	Enviros	Mu099/SHM/bigwreassign	December 2005
Phase 1 Land Quality Assessment	SKM Enviros	JL30547	April 2012

1.6 Limitations

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

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

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

1.6.4 Any reports provided to Jomas Associates Limited have been reviewed in good faith. Jomas Associates Limited cannot be held liable for any errors or omissions in these reports, or for any incorrect interpretation contained within them.

1.6.5 This investigation and report has been carried out in accordance with the relevant standards and guidance in place at the time of the works. Future changes to these may require a re-assessment of the recommendations made within this report.

1.6.6 Our investigations exclude surveys to identify the presence of injurious and invasive weeds.

1.6.7 ***This report is not an engineering design and the figures and calculations contained in the report should be used by the Structural Engineer, taking note that variations may apply, depending on variations in design loading, in techniques used, and in site conditions. Our recommendations should therefore not supersede the Engineer's design.***

2 SITE SETTING

2.1 Site Information

2.1.1 The site location plan is appended to this report as Figure 1.

Table 2.1: Site Information

Name of Site	Widewater Place
Address of Site	Moorhall Road Uxbridge UB9 6NS
Approx. National Grid Ref.	505058, 188836
Site Area (Approx)	1.43ha
Site Occupation	Mixed business and medical

2.2 Walkover Survey

2.2.1 A site walkover survey was undertaken by Jomas Associates on 20th May 2021.

Table 2.2: Site Description

Area	Item	Details
On-site:	**Current Uses:**	The site is currently in use as a business park comprised of three large units (office appearance) and a cafe surrounded by car parking. There are 3 single storey substation buildings located around the site and separate areas with bins for waste disposal. There is a retaining wall along the north side.
	Evidence of historic uses:	There was no evidence of historic uses of the site.
	Surfaces:	Majority of site is covered by buildings or car park – car park surface is brick paving. Some soft landscaping for aesthetic purposes.
	Vegetation:	Several trees were recorded within the car park, approximately 8-9m tall around the boundary of the site.
	Topography/Slope Stability:	There is a slight downward slope to the east along Moorhall Road but the site itself is level. There is a small retaining wall (<0.5m) in the south-west corner of the site.
	Drainage:	Good drainage infrastructure noted in the car park. No obvious sign of drainage issues.
	Services:	Multiple services are known to be present on site (water electricity, data) Two electricity substation noted on site.

Area	Item	Details
	Controlled waters:	Canal located to the west of the site, and a pons located in the centre of the site.
	Tanks:	No tanks were noted on site.
Neighbouring land:	**North:**	Residential.
	East:	Recreational ground
	South:	Moorhall Road and Harefield Marina
	West:	Dense vegetation, canal, and aggregate processing plant.

2.2.2 Key features noted during the walkover are shown on a site walkover plan, together with site photos, in Appendix 1, Figure 2-3.

2.2.3 No significant changes were noted in comparison with the walkover undertaken on the 12th June 2017.

2.3 Historical Mapping Information

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

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

Table 2.3: Historical Development

Dates and Scale of Map	Relevant Historical Information	
	On Site	Off Site
1865 – 1:2,500/10,560	Site is undeveloped. Stream with a sluice is shown cutting across the centre of site running NE-SW. Trees shown on the east of site.	Moorhall Farm shown on neighbouring land to the east with a small pond also shown. Grand Union Canal is shown running broadly N-S immediately adjacent to the west of site with Harefiedmoor Wharf also shown. The surrounding area further afield is almost entirely undeveloped agricultural land except for occasional farm buildings.
1896/97 – 1:2,500/10,560	No significant changes.	**Cement, lime and brick works** is shown approximately 1km north of site.
1912/14 – 1:10,560/2,500	No significant changes.	Small **gravel** pit is shown 150m SE of site. Railway line is shown to approximately 1km to the south of site.

Dates and Scale of Map	Relevant Historical Information	
	On Site	Off Site
1934/35 – 1:2,500/10,560	No significant changes.	Residential development and allotment gardens are shown 100m NE and north. Farm and pond to the east no longer present. Large area of **sand pits** is shown from 750m SE.
1938 – 1:10,560	No significant changes.	Large **commercial development** shown from 750m SW of site. Commercial development 500-750m north, south of works site (now disused).
1949 – 1:10,560	No significant changes.	No significant changes.
1960 – 1:10,560	Large commercial style buildings are shown on site.	Large commercial style buildings are shown immediately north of site. Large possible ground working feature is shown from approximately 100m west to 400m west. Slight expansion of sand pits to the south. Residential development between 500-700m north.
1971 – 1:2,500	**Engineering works** shown on site**.**	**Fencing works** and **porcelain works** shown immediately north of site. A **tank** is shown immediately bordering site to the north. **Tank** is shown 100m SE of site within a moor area alongside area of ground working.
1976 – 1:10,000	No significant changes.	Large number of large **gravel pits** shown in surrounding areas to the south and west.
1989 – 1:10,000	New small structure shown on site.	Site immediately north has been redeveloped with residential properties. Gravel pits have expanded. Industrial site from 750m SW has been redeveloped.
1992 – 1:2,500	Site has been developed as "Widewater Business Centre". Large office style buildings are shown.	No significant changes.
2002 – 1:10,000	No significant changes.	Gravel pits to the west have expanded and are still labelled as gravel pits, but are shown as lakes.
2010 – 1:10,000	No significant changes.	No significant changes.
2014 – 1:20,000	No significant changes.	No significant changes.

Potentially polluting/contaminating uses/activities shown in **bold**

2.3.3 An aerial photograph supplied as part of the GroundSure EnviroInsight report and taken in 2015 generally appears to confirm the comments made regarding the site and surrounding area for that period.

2.4 Historical Industrial Sites

2.4.1 Groundsure have provided some information on historical industrial sites on and in the vicinity of the site. Table 2.4 below, summarises the information provided, which is presented in further detail in the Enviroinsight in Appendix 2. Where the identified

features have appeared on more than one map they have been counted multiple times and therefore the reported numbers are higher than the actual count.

Table 2.4: Industrial and Statutory Consents

Type of Consent/Authorisation	On site	Off-site (within 500m of site, unless stated otherwise)	Potential to Impact Site*
Potentially Contaminative Uses identified from 1:10,000 scale mapping	4No reports for unspecified wharf and works	41No reports, nearest 6m SE for unspecified wharf. Others include unspecified works and gravel pits	✓
Additional Information - Historical Tank Database	None	4No reports, nearest for unspecified tank - 13m NW - 1971	✓
Historical Energy Features Database	None reported by GroudSure. 2No substations observed on site during walkover.	14No reports, nearest for electricity substation 127m NW - 1982	✓
Historical Petrol & Fuel Site Database	None	None	X
Historical Garage & Motor Vehicle Repair Database	None	None	X
Potentially infilled land	2No reports for unspecified wharf	68No reports, nearest 4m west for canal.	✓
Tunnels	None	None	X

2.5 Industrial and Statutory Consents

2.5.1 The Groundsure EnviroInsight Report also provides information on various statutory and industrial consents on and in the vicinity of the site. The following section summarises the information collected from the available sources.

Table 2.5: Industrial and Statutory Consents

Type of Consent/Authorisation	On site	Off-site (within 500m of site, unless stated otherwise)	Potential to Impact Site*
Discharge Consents.	None	7No. for sewage and trade. Nearest 50m SW	✓
Water Industry Act Referrals	None	None	X
Red List Discharges	None	None	X
List 1 and List 2 Dangerous Substances	None	None	X
Control of Major Accident Hazards (COMAH) and Notification of Installations Handling Hazardous Substances (NIHHS) Sites.	None	None	X

Type of Consent/Authorisation	On site	Off-site (within 500m of site, unless stated otherwise)	Potential to Impact Site*
Planning Hazardous Substance Consents	None	None	X
Category 3 or 4 Radioactive substances Authorisations	None	None	X
Pollution Incidents (List 2).	None	6No Nearest 77m SE with minor land impact from general biodegradable materials and wastes	✓
Pollution Incidents (List 1)	None	1No nearest 242m west with major water impact	✓
Contaminated Land Register Entries and Notices.	None	1No reported 457m east of site – pollution for controlled water, landfill gas, 21 significant pollutant linkages identified.	X
Registered Landfill Sites.	None	7No historic landfills identified, nearest 28m SE.	✓
Waste Treatment and/or Transfer Sites.	None	None	X
Fuel Station Entries	None	None	X
Current Industrial Site Data.	6No reports for electrical components, electrical features, medical supplies and pharmaceuticals	6No for moorings and unloading facilities, electrical features, unspecified quarried or mines.	✓
Discharge Consents.	None	7No. for sewage and trade. Nearest 50m SW	✓

* *From a land contamination perspective*

2.6 Previous Reports Overview

2.6.1 The provided reports reference in Table 1.1 are summarised below. Each should be read in its entirety for context.

Phase 5 Remedial Works Report, Environ Aspinall ref ND0020001B, dated February 2002/Environment Agency Letter, 2002

2.6.2 The Environ Aspinall assessment was undertaken to assess potential liabilities associated with site ownership, principally with regards to potential risks to controlled water receptors in the site vicinity, namely a culverted watercourse on the site, adjacent lakes, and a potable public groundwater abstraction located 250m west of the site.

2.6.3 The report references a series of investigations and monitoring works undertaken at the site during the period 1997 – 2002, and some limited remedial works to the culvert in 1998.

2.6.4 It is noted that Jomas Associates have not been provided with specific reports referenced within the Environ Aspinall report, nor have we been provided with copies of the appendices of the report.

2.6.5 The summarised previous investigations indicate that the site is underlain by made ground to a depth of 0.9m to 2.5m (with buried concrete slabs widespread across the site). The made ground is underlain by Alluvium, comprising peat, which in turn overlies River Gravel, comprising gravel. The River Gravels are underlain by the White Chalk Subgroup.

2.6.6 Groundwater within the River Gravels are designated a Secondary A Aquifer. The White Chalk is designated a Principal Aquifer. The site lies within a Zone 1 Source Protection Zone.

2.6.7 The Environ Aspinall report (Doc 1) concluded that:

- Although a potential pathway existed between the site and the potable abstraction, the dilution potential within the aquifer would be such as to render concentrations of contaminants immeasurable;
- Low levels of polyaromatic hydrocarbons (PAHs) and diesel range organics (DRO) in groundwater beneath the site were likely to have originated from localised low levels of contamination in soil beneath the site;
- Concentrations of contaminants detected within waters within the culvert had reduced following removal of oily wastes in an upstream (off-site) ditch leading to the culvert;
- Although the culvert discharges into the fishing lake to the south of the site, and groundwater beneath the site is likely to be in hydraulic continuity with surface waters in the lake, it was considered that there was no evidence that contamination originating at the site was causing contamination of surface waters within the fishing lake; and
- That all monitoring and investigation works could cease at the site.

2.6.8 The February 2002 letter from the Environment Agency agreed with the Environ Aspinall conclusions.

<u>SKM Enviros Phase 1 Land Quality Assessment</u>

2.6.9 The report identified potential contaminant sources, pathways and receptors on and in the vicinity of the site. The assessment also included a review of historic reports pertaining to the site by Environ Aspinall. As part of this review, the assessment noted on several occasions that methodologies employed at the time of Environ Aspinall works undertaken between 1997 and 2002 were not in accordance with those considered best practice in 2012.

2.6.10 However, the SKM Enviros concluded that for the site in its then current use (office buildings with very limited soft landscaping), potential risks to relevant receptors were considered to be moderate/low or lower. The highest risks (considered

moderate/low) were associated with ground gases or vapours originating from made ground on site and a landfill located 30m from the site.

2.6.11 It was considered very unlikely that given the current and historical use of the site, that it would be classified as contaminated land by the Local Authority under Part 2A of the Environmental Protection Act 1990.

2.6.12 It was considered unlikely that a residual liability for historic contamination would be realised at the site given its (then) continued current use as office units and the presence of extensive buildings and hardstanding at the site.

SKM Enviros recommended that:

- In the current (then) context, the need for further site investigation was not foreseen;
- That it may be prudent to consult drainage survey drawings to confirm whether the culvert is being used for site drainage and to consider monitoring to assess whether it is being blocked by silt; and
- That it may be prudent to assess whether the buildings should be assessed for the presence of gas protection measures such as air bricks or other passive ventilation and the sealing of entries into the buildings from the ground, followed by a re-assessment of the risk from ground gases.

2.7 Planning Information

2.7.1 A review of the local authority's planning portal was undertaken on 21st May 2021 at https://planning.hillingdon.gov.uk/OcellaWeb/planningSearch

2.7.2 No planning applications containing contaminated land information or details on ground conditions were identified.

2.8 Unexploded Ordnance

2.8.1 Publicly available information has been assessed regarding the risk of Unexploded Ordnance affecting the site.

2.8.2 The initial data indicates that there is a low risk. No feature was identified during the historical map review that would alter this assessment.

2.8.3 This does not comprise a full UXO risk assessment.

3 GEOLOGICAL & ENVIRONMENTAL SETTING

3.1.1 The following section summarises the principal environmental resources (geological, hydrogeological and hydrological) of the site and its surroundings.

3.1.2 The data discussed herein is generally based on the information given within the EnviroInsight Report and published information provided by the Environment Agency and British Geological Survey.

3.2 Solid and Drift Geology

3.2.1 Information provided by the British Geological Survey indicates that the site is mainly directly underlain by superficial deposits of Alluvium with Shepperton Gravel Memberdeposits outcropping in the south-west corner of the site.

3.2.2 The BGS describes alluvium as consisting of

> *"Normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present."*

3.2.3 Although not reported on site, geological mapping indicates that the alluvium may be underlain by the Shepperton Gravel Member. The BGS descriped the Shepperton Gravel as consisting of:

"Gravel with clay and sand."

3.2.4 The superficial deposits overlie solid chalk deposits of the Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated).

3.2.5 These chalks are described by the BGS as follows:

"Firm white chalk with conspicuous semi-continuous nodular and tabular flint seams. Hardgrounds and thin marls are known from the lowest beds. Some flint nodules are large to very large."

"Composed of soft to medium hard, smooth white chalks with numerous marl seams and flint bands, including abundant Zoophycos flints (notably at levels near the base). The formation is known to contain distinct phosphatic chalks of limited lateral extent. Equivalent beds, the Margate Chalk of north Kent, are marl-free and contain little flint."

3.2.6 No faults are reported within 500m of the site at 1:10,000 scale.

3.3 British Geological Survey (BGS) Borehole Data

3.3.1 No borehole data was available within 250m of the site; however a record was obtained from 350m south.

3.3.2 This log from 1957 indicates a ground profile comprising drift deposits of clay, peat, and gravel to a depth of 7.6mbgl, overlying chalk with flints to the base of the borehole at 91mbgl.

3.3.3 All depths should be viewed as approximate due to the age of the record and conversion from imperial to metric units.

3.3.4 A copy of the log is provided in Appendix 5.

3.4 Hydrogeology & Hydrology

3.4.1 General information about the hydrogeology of the site was obtained from the EnviroInsight and/or MAGIC website.

Groundwater Vulnerability

3.4.2 The EA operates a classification system to categorise the importance of groundwater resources (aquifers) and their sensitivity to contamination. Aquifers were formerly classified as major, minor and non-aquifers, based on the amenity value of the resource. A major aquifer is a significant resource capable of producing large quantities of water suitable for potable supply. Minor aquifers produce water in varying quantities or qualities, and if utilised are of local importance. Non aquifers are low permeability strata, which contain no significant exploitable groundwater and have very limited capacity to transmit contaminants.

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

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

- **Unproductive Strata** - These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

Source Protection Zones (SPZ)

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

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

Hydrology

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

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

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

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

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

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

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

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

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

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

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

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

Table 3.1: Summary of Hydrogeological & Hydrology

Feature		On Site	Off Site	Potential Receptor?
Aquifer	**Superficial:**	Secondary A	Secondary A	✓
	Solid:	Principal	Secondary A (247m east)	✓
Source Protection Zone		Zone 1 (inner catchment)	-	✓
Abstractions		None	Nearest GW 116m west Nearest SW 1314 m south Nearest potable 228m SW	✓
Detailed River Network		None	Grand Union Canal 20m west	✓
Flood Risk	**EA Flood Zone 2**	None	9m west	✓
	EA Flood Zone 3	None	22m south-west	-
	RoFRaS	Very Low	-	-
	Flood Defences	There are no areas benefiting from flood defences within 250m of the study site		-
	BGS	BGS has a "high" confidence that there is the potential at the surface for "clearwater" flooding.		-

3.5 Sensitive Land Uses

3.5.1 The site is located within a Nitrate Vulnerable Zone.

3.5.2 A Nitrate Vulnerable Zone (NVZ) is a conservation designation of the Environment Agency for areas of land that drain into nitrate polluted waters, or waters which could become polluted by nitrates. Nitrate Vulnerable Zones were introduced by the UK government in response to the EU mandate that all EU countries must reduce the nitrate in Drinking Water to a maximum of 50 mg/l.

3.5.3 The NVZs cover large areas of land that have been identified as exceeding or being at risk of exceeding 50 mg NO_3/l.

3.5.4 London area greenbelt is located 13m south-east

3.5.5 The Mid Colne Valley is located 49m west.

3.5.6 An area of ancient woodland is located 757m west.

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

3.6 Radon

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

3.6.2 Consequently, no radon protective measures are necessary in the construction of new dwellings or extensions as described in publication BR211 (BRE, 2007).

4 POSSIBLE GEOLOGICAL HAZARDS

4.1 Database Information Review

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

Table 4.1: Geological Hazards

Potential Hazard	Site check Hazard Rating	Details	Further Action Required?
Shrink swell	Very low	Ground conditions predominantly low plasticity. No special actions required to avoid problems due to shrink-swell clays. No special ground investigation required, and increased construction costs or increased financial risks are unlikely due to potential problems with shrink-swell clays.	No
Landslides	Very low	Slope instability problems are unlikely to be present. No special actions required to avoid problems due to landslides. No special ground investigation required, and increased construction costs or increased financial risks are unlikely due to potential problems with landslides.	No
Ground dissolution soluble rocks	Very low	Significant soluble rocks are present. Problems unlikely except with considerable surface or subsurface water flow. No special actions required to avoid problems due to soluble rocks. No special ground investigation required or increased construction costs are likely. An increase in financial risk due to potential problems with soluble rocks is unlikely	No
Compressible deposits	Moderate	Significant potential for compressibility problems. Avoid large differential loadings of ground. Do not drain or de-water ground near the property without technical advice. For new build consider possibility of compressible ground in ground investigation, construction and building design. Consider effects of groundwater changes. Extra construction costs are likely. For existing property possible increase in insurance risk from compressibility, especially if water conditions or loading of the ground change significantly.	Yes
Collapsible Rock	Very low	Deposits with the potential to collapse when loaded and saturated are unlikely to be present	No
Running sand	Low	Possibility of running sand problems after major changes in ground conditions. Normal maintenance to avoid leakage of water-bearing services or water bodies (ponds, swimming pools) should reduce likelihood of problems due to running sand. For new build consider possibility of running sand into trenches or excavations if water table is high or	No

Potential Hazard	Site check Hazard Rating	Details	Further Action Required?
		sandy strata are exposed to water. Avoid concentrated water inputs to site. Unlikely to be an increase in construction costs due to potential for running sand. For existing property no significant increase in insurance risk due to running sand problems is likely.	
Coal mining	No	The study site is not located within the specified search distance of an identified mining area.	No
Non-coal mining	-	Localised small scale underground mining may have occurred. Potential for difficult ground conditions are unlikely or localised and are at a level where they need not be considered.	No
Brine affected areas	No	-	No

4.1.2 In addition, the GeoInsight report notes the following:

- 35No historical surface ground working features are reported within 250m of the site. Nearest reported 4m west of the site for a canal.
- No historical underground working features are reported within 1km of the site.
- 19No. BGS Current Ground Working Features are reported within 1km of the site. The nearest is reported 188m east of the site, identified as producing chalkl. The operational status is given as ceased.

5 QUALITATIVE RISK ASSESSMENT

5.1 Legislative Framework

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

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

"*land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that:*

(a) significant harm is being caused or there is a significant possibility of such harm being caused; or
(b) significant pollution of controlled waters is being caused, or there is significant possibility of such pollution being caused."

5.1.3 The Statutory Guidance provided in the DEFRA Circular 04/2012 lists the following categories of significant harm to **human health**:

- death; life threatening diseases (e.g. cancers); other diseases likely to have serious impacts on health; serious injury; birth defects; and impairment of reproductive functions.

5.1.4 Other health effects may also be considered by the local authority to constitute significant harm with a wide range of conditions that may or may not constitute significant harm (alone or in combination) including: physical injury; gastrointestinal disturbances; respiratory tract effects; cardio-vascular effects; central nervous system effects; skin ailments; effects on organs such as the liver or kidneys; or a wide range of other health impacts.

5.1.5 In deciding whether or not land is contaminated land on grounds of significant possibility of significant harm to human health there are four categories to be considered. Categories 1 and 2 would encompass land which is capable of being determined as contaminated land on grounds of significant possibility of significant harm to human health. Categories 3 and 4 would encompass land which is not capable of being determined on such grounds.

5.1.6 For non-human receptors the following types of harm should be considered to be significant harm:

Ecological System Effects

- Harm which results in an irreversible adverse change, or in some other substantial adverse change, in the functioning of the ecological system within any substantial part of that location; or
- Harm which significantly affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location.
- In the case of European sites, harm should also be considered to be significant harm if it endangers the favourable conservation status of natural habitats at

such locations or species typically found there. In deciding what constitutes such harm, the local authority should have regard to the advice of Natural England and to the requirements of the Conservation of Habitats and Species Regulations 2010.

Property Effects

- Crops: A substantial diminution in yield or other substantial loss in their value resulting from death, disease or other physical damage. For domestic pets, death, serious disease or serious physical damage. For other property in this category, a substantial loss in its value resulting from death, disease or other serious physical damage.
- Buildings: Structural failure, substantial damage or substantial interference with any right of occupation. The local authority should regard substantial damage or substantial interference as occurring when any part of the building ceases to be capable of being used for the purpose for which it is or was intended. In the case of a scheduled Ancient Monument, substantial damage should also be regarded as occurring when the damage significantly impairs the historic, architectural, traditional, artistic or archaeological interest by reason of which the monument was scheduled.

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

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

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

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

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

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

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

5.2 Conceptual Site Model

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

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

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

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

Table 5.1: Potential Sources, Pathways and Receptors

Source(s)	Pathway(s)	Receptor(s)
• Potential for contaminated ground associated with previous site use – on site (S1) • Potential for Made Ground associated with previous development operations – on site (S2) • Previous industrial use – off site (S3) • Potential asbestos containing materials within existing buildings – on site (S4) • Potential asbestos impacted soils from demolition of previous buildings – on site (S5) • Potential ground gas generation from alluvial deposits and surrounding ground workings and landfill sites (S6) • PCBs from electrical features identified on site (S7)	• Ingestion and dermal contact with contaminated soil (P1) • Inhalation or contact with potentially contaminated dust and vapours (P2) • Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hardstanding or via service pipe/corridors and surface water runoff. (P3) • Horizontal and vertical migration of contaminants within groundwater (P4) • Accumulation and Migration of Soil Gases (P5) • Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6)	• Construction workers (R1) • Maintenance workers (R2) • Neighbouring site users (R3) • Future site users (R4) • Building foundations and on site buried services (water mains, electricity and sewer) (R5) • Controlled waters – Primary and secondary A aquifers, abstractions, surface water features, culverted river on site. (R6)

5.3 Qualitative Risk Estimation

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

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

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

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

- Severe
- Medium
- Mild
- Minor

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

- High Likelihood
- Likely
- Low Likelihood
- Unlikely

5.3.5 This relationship can be represented graphically as a matrix (Table 5.2).

Table 5.2: Overall Contamination Risk Matrix

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

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

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

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

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

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

5.3.9 The preliminary risk assessment for the site is presented in Table 5.3 below.

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Table 5.3: Preliminary Risk Assessment for the Site

Sources	Pathways (P)	Receptors	Consequence	Probability of pollutant linkage	Risk Estimation	Hazard Assessment
• Potential for contaminated ground associated with previous site use – on site (S1) • Potential for Made Ground associated with previous development operations – on site (S2) • Previous industrial use – off site (S3) • Potential asbestos containing materials within existing buildings – on site (S4) • Potential asbestos impacted soils from demolition of previous buildings – on site (S5) • Potential ground gas generation from alluvial deposits and surrounding ground workings and landfill sites (S6) • PCBs from electrical features identified on site (S7)	• Ingestion and dermal contact with contaminated soil (P1) • Inhalation or contact with potentially contaminated dust and vapours (P2) • Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6)	• Construction workers (R1) • Maintenance workers (R2) • Neighbouring site users (R3) • Future site users (R4) • Building foundations and on site buried services (water mains, electricity and sewer) (R5)	Medium	Low likelihood	Moderate	GI – Ground Investigation
	• Accumulation and migration of soil gases (P5)		Severe	Low likelihood	Moderate	
	• Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hardstanding or via service pipe/corridors and surface water runoff. (P3) • Horizontal and vertical migration of contaminants within groundwater (P4)	• Neighbouring site users (R3) • Controlled Waters (Aquifer) (R6) • Building foundations and on site buried services (water mains, electricity and sewer) (R5) • Controlled waters – Primary and secondary A aquifer, abstractions, surface water features, culverted river on site. (R6)	Medium	Low likelihood	Moderate	

5.3.10 It should be noted that the identification of potential pollutant linkages does not necessarily signify that the site is unsuitable for its current or proposed land use. It does however act as a way of focussing data collection at the site in accordance with regulatory guidance in CLR 11.

5.4 Outcome of Risk Assessment

5.4.1 The risk estimation matrix indicates a moderate to high risk as defined above.

5.4.2 The proposed development is to comprise the conversion of the existing commercial structures to residential use. It is understood that the three structures on site ("Chaplin House", "Norgine House" and "Musgrave House") will each be converted under separate planning applications. No private gardens are anticipated.

5.4.3 Due to the potential presence of asbestos containing materials within existing buildings, an asbestos survey should be undertaken with any asbestos containing materials found removed under suitably controlled conditions. There should be no risk to end users from asbestos if the potential asbestos containing materials are removed by suitably qualified and experienced specialists under controlled conditions.

5.4.4 A review of historical maps indicates that the site was undeveloped until 1960 when large commercial style buildings are shown on site. By 1971 these are identified as engineering works, with fencing and porcelain works shown immediately north of site at the same time. A new small structure is added in 1989; however by 1992 the site is redeveloped with commercial style buildings and labelled as "Widewater Business Centre" – resembling its current layout. No further changes are shown up tot eh most recent map dated 2014.

5.4.5 The surrounding area was predominantly undeveloped agricultural land until approximately 1934 when a residential development is shown approximately 100m north and east of site, and by 1960 large commercial style buildings are shown immediately north of site. As well as a large ground working feature to the west. By 1971 works sites are identified immediately north of site and by 1976 the west and south of site is dominated by large gravel pits and ground working features. Historic landfills are recorded 30m south and 240m north of the site By 1989 the site immediately north has been redeveloped with residential properties.

5.4.6 Due to potential presence of contamination from previous on and off site commercial uses, a ground investigation should be undertaken to clarify risks posed to the identified sensitive receptors. The ground investigation should include water sampling to identify any risks posed to the controlled water receptors identified.

5.4.1 Due to the potential for ground gas generation from alluvial deposits on site and ground workings and landfill sites offsite, a programme of soil gas monitoring should be undertaken. This should be undertaken in accordance with CIRIA C665.

5.5 List of Key Contaminants

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

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

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

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

6 GROUND INVESTIGATION

6.1 Rationale for Ground Investigation

6.1.1 The site investigation has been undertaken generally in accordance with Contaminated Land Report 11, BS10175, NHBC Standards Chapter 4.1, and other associated Statutory Guidance. If required, further targeted investigations and remedial option appraisal would be dependent on the findings of this site investigation.

6.1.2 The soil sampling rationale for the site investigation was developed with reference to EA guidance 'Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies for Land Contamination' (Technical Report P5-066/TR).

6.1.3 The sampling proposal was designed in order to gather data representative of the site conditions.

6.2 Scope of Ground Investigation

6.2.1 The ground investigation was undertaken on 1 and 8 July 2017.

6.2.2 The work was undertaken in accordance with BS5930 'Code of Practice for Site Investigation' and BS10175 'Investigation of Potentially Contaminated Sites'. All works were completed without incident.

6.2.3 The investigation focused on collecting data on the following:

- Quality of Made Ground/ natural ground within the site boundaries;
- Presence of groundwater beneath the site (if any), perched or otherwise;
- Determination of the presence or absence of hazardous ground gases;
- Obtaining geotechnical parameters to allow initial design to take place.

6.2.4 A summary of the fieldwork carried out at the site, with justifications for exploratory hole positions, are offered in Table 6.1 below.

Table 6.1: Scope of Intrusive Investigation

Investigation Type	No. of Exploratory Holes Achieved	Exploratory Hole Designation	Depth Achieved (m BGL)	Justification
Window Sample Boreholes	6	WS1-5, WS8	Up to 6mbgl	Positioned for general site coverage. To obtain shallow samples for chemical testing.
Monitoring Wells	5	WS2, WS3, WS4, WS5, WS8	Up to 6mbgl	Combined soil gas and groundwater monitoring wells.

Investigation Type	No. of Exploratory Holes Achieved	Exploratory Hole Designation	Depth Achieved (m BGL)	Justification
				WS2 - response zone in sand and gravel/chalk. WS3 - response zone in Made Ground/clay/sand and gravel WS4 – response zone in Made Ground/clay/sand and gravel. WS5 – response zone in Made Ground/peat/clay/sand and gravel. WS8 – response zone in sand and gravel/chalk

6.2.5 The exploratory holes were completed to allow soil samples to be taken in the areas of interest identified in Table 6.1 above. In all cases, all holes were logged in accordance with BS5930:2015.

6.2.6 Exploratory hole positions were located with reference to known site features as shown in the exploratory hole location plan presented in Appendix 1, Figure 4. The exploratory hole records are included in Appendix 6.

6.2.7 Where monitoring well installations were not installed, the exploratory holes were backfilled with the arisings (in the reverse order in which they were drilled) and the ground surface was reinstated so that no depression was left.

6.3 Sampling Rationale

6.3.1 Our soil sampling rationale for the site investigation was developed with reference to EA guidance 'Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies for Land Contamination' (Technical Report P5-066/TR).

6.3.2 The exploratory holes were positioned by applying a combined non-targeted sampling strategy, as well as sample locations positioned with reference to sources identified from the desk study.

6.3.3 Soil samples were taken from across the site at various depths as shown in the exploratory hole logs.

6.3.4 Jomas Associates Limited's engineers normally collect samples at appropriate depths based on field observations such as:

- appearance, colour and odour of the strata and other materials, and changes in these;
- the presence or otherwise of sub-surface features such as pipework, tanks, foundations and walls; and,
- areas of obvious damage, e.g. to the building fabric.

6.3.5 A number of the samples were taken from the top 0-1m to aid in the assessment of the pollutant linkages identified at the site. In addition, some deeper samples were taken to aid in the interpretation of fate and transport of any contamination identified.

6.3.6 Groundwater samples were obtained by low flow methodology.

6.3.7 Samples were stored in cool boxes (<4°C) and preserved in accordance with laboratory guidance.

6.3.8 Soil samples were taken from across the site at various depths as shown in the exploratory hole logs (copies of which are provided in Appendix 6). The methodology used and type of samples taken were chosen to allow the Sampling category to be A or B according to EN ISO 22475-1. This in turn allows suitable geotechnical testing to be carried out.

6.3.9 Groundwater strikes noted during drilling, are recorded within the exploratory hole records in Appendix 6.

6.4 Sampling Limitations

6.4.1 WS1 was terminated at 0.60mbgl due to a concrete obstruction.

6.4.2 WS6 and WS7 were not undertaken due to time constraints.

6.4.3 The remaining boreholes were drilled to the proposed depths.

6.5 Laboratory Analysis

Chemical Testing

6.5.2 Soil samples were submitted to The Environmental Laboratory Ltd, East Sussex and i2 Analytical (both UKAS and MCerts accredited laboratories), for analysis.

6.5.3 The samples were analysed for a wide range of contaminants as shown in Table 6.2 below:

Table 6.2: Chemical Tests Scheduled

Test Suite	No. of tests	
	Made Ground / Topsoil	Natural
Basic Suite 3	3	3
Total Organic Carbon	3	1
Hydrocarbon Suite	7	0
Reduced Basic Suite	7	0
PCBs	3	0
Asbestos Screen & ID	9	0

6.5.4 The determinands contained in the basic suite are as detailed in Table 5.3 below:

Table 6.3: Basic Suite of Determinands

DETERMINAND	LIMIT OF DETECTION (mg/kg)	UKAS ACCREDITATION	TECHNIQUE
Arsenic	1	Y (MCERTS)	ICPMS
Cadmium	0.5	Y (MCERTS)	ICPMS
Chromium	5	Y (MCERTS)	ICPMS
Chromium (Hexavalent)	0.02	N	Colorimetry
Lead	5	Y (MCERTS)	ICPMS
Mercury	0.5	Y (MCERTS)	ICPMS
Nickel	5	Y (MCERTS)	ICPMS
Selenium	1	PENDING	ICPMS
Copper	5	Y (MCERTS)	ICPMS
Zinc	45	Y (MCERTS)	ICPMS
Boron (Water Soluble)	0.5	N	ICPMS
pH Value	0.1 units	Y (MCERTS)	Electrometric
Sulphate (Water Soluble)	0.02g/l	Y (MCERTS)	Ion Chromatography
Total Cyanide	1	Y (MCERTS)	Colorimetry
Speciated/Total PAH	0.1/0.4	Y (MCERTS)	GCFID
Phenols	5	Y (MCERTS)	HPLC
Total Petroleum Hydrocarbons (banded)	1	N	Gas Chromatography

6.5.5 To support the derivation of appropriate tier 1 screening values, 4No. samples were also analysed for total organic carbon.

6.5.6 Laboratory test results are summarised in Section 9, with raw laboratory data included in Appendix 7.

7 GROUND CONDITIONS

7.1 Soil

7.1.1 Ground conditions were logged in accordance with the requirements of BS5930:2015. Detailed exploratory hole logs are provided in Appendix 6. The ground conditions encountered are summarised in Table 6.1 below, based on the strata observed during the investigation.

Table 7.1: Ground Conditions Encountered

Stratum and Description	Encountered from (m bgl)	Base of strata (m bgl)	Thickness range (m)
Paving over sand and sub-base overlying concrete and concrete and brick gravel/gravelly clay. (MADE GROUND).	GL	>0.60-1.90	>0.60-1.90
Dark brown gravelly SAND/Sandy GRAVEL. (ALLUVIUM/SHEPPERTON GRAVEL MEMBER)	1.10-4.50	3.50->6.00	2.40->4.2
Brown silty CLAY. (ALLUVIUM/SHEPPERTON GRAVEL MEMBER)	1.40-2.80	1.80-4.50	0.5-2.60
Dark brown PEAT with occasional clay pockets. (WS5 only) (ALLUVIUM)	1.50	2.80	1.40
White CHALK, sometimes gravelly. Gravel consists of flint. (SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)).	3.50-4.00	>6.00	>2.00->2.50

7.1.2 Given the likely ground strata profile identified and the BGS descriptions of the materials given in Section 3 it is considered that the encountered strata represent superficial deposits of alluvium and/or Shepperton Gravel Member, overlying solid deposits of the Seaford and Newhaven Chalk Formations (undifferentiated).

7.2 Hydrogeology

7.2.1 Groundwater strikes and groundwater monitoring are summarised below.

Table 7.2: Groundwater Strikes During Drilling

Exploratory Hole ID	Depth Encountered (mbgl)	Depth After 20mins (mbgl)	Stratum
WS2	Wet from 2.2mbgl	-	Gravel
WS3	3.5	-	Clay
WS4	Wet from 2.2mbgl	-	Sand and gravel
WS5	2.5	-	Peat
WS8	2.4	-	Sand and gravel

Table 7.3: Groundwater Monitoring Records

Exploratory Hole ID	Depth Encountered (m bgl)	Depth to Base of Well (m bgl)	Strata targeted by response zone
WS2	2.32-2.46	5.12	Alluvium/Shepperton Gravel Member/Chalk
WS3	2.12-2.25	5.70	Made Ground/Alluvium/Shepperton Gravel Member
WS4	2.46-2.60	5.81	Made Ground/Alluvium/Shepperton Gravel Member
WS5	2.28-2.34	4.87	Made Ground/Alluvium/Shepperton Gravel Member
WS8	2.24-2.34	5.61	Alluvium/Shepperton Gravel Member/Chalk

7.3 Physical and Olfactory Evidence of Contamination

7.3.1 A hydrocarbon odour was reported within the sands and gravels at WS5 between 3.30mbgl and 4.20mbgl (below the water table).

8 RISK ASSESSMENT – ANALYTICAL FRAMEWORK

8.1 Context and Objectives

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

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

8.2 Analytical Framework – Soils

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

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

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

8.2.4 The assessment criteria used for the screening of determinands within soils are identified within Table 8.1.

Table 8.1: Selected Assessment Criteria – Contaminants in Soils

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

8.3 BRE

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

8.4 Analytical Framework – Groundwater and Leachate

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

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

8.4.3 The criteria used by Jomas' in the Level 1 assessment of groundwater and leachate quality are shown in Table 8.2.

Table 8.2: Selected Assessment Criteria – Contaminants in Water

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

Environmental Quality Standards EQS

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

Lowest Effect Concentration (LEC)

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

WHO Health

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

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

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

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

8.5 Site Specific Criteria

8.5.1 The criteria adopted in the selection of correct screening criteria from published reports as previously described, are provided within Tables 8.3.

Table 8.3: Site Specific Data

Input Details	Value
Land Use	Residential without plant uptake
Soil Type	Sand
pH	9
Soil Organic Matter	1%

8.5.2 As the published reports only offer the option of selecting an SOM value of 1%, 2.5% or 6%, an SOM value of 1% has been used for the generation of generic assessment criteria, as 0.62% was the mean value obtained from laboratory analysis. It is noted that a single sample returned a TOC of 11%, however this has been removed to avoid distorting the average and to keep screening criteria conservative.

8.5.3 It is understood that the site is to be converted to provide residential units with no private soft landscaping proposed. As a result, the site has been assessed as residential without plant uptake.

9 GENERIC QUANTITATIVE RISK ASSESSMENT

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

9.1.1 To focus on the contaminants of potential concern (COPC), the results have been compared with the respective SGV/GAC. Those contaminants which exceed the SGV/GAC are considered to be the COPC. Those which do not exceed the respective SGV/GAC are not considered to be COPC and as such do not require further assessment in relation to the proposed development of the site.

9.1.2 Laboratory analysis for soils are summarised in Tables 9.1 to 9.4. Raw laboratory data is included in Appendix 7.

Table 9.1: Soil Laboratory Analysis Results – Metals, Metalloids, Phenol, Cyanide

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No. Exceeding
Arsenic	mg/kg	13	40	S4UL	6.8	45.0	1No (WS2@0.50mbgl)
Cadmium	mg/kg	13	85	S4UL	<0.2	3.6	0
Chromium	mg/kg	13	910	S4UL	12.0	160	0
Lead	mg/kg	13	300	S4UL	14	750	1No (WS2@0.50mbgl)
Mercury	mg/kg	13	1.2	S4UL	<0.3	0.7	0
Nickel	mg/kg	13	180	S4UL	9.2	72	0
Copper	mg/kg	13	7100	S4UL	16	1000	0
Zinc	mg/kg	13	40000	S4UL	26	860	0
Total Cyanide [B]	mg/kg	13	33	CLEA v 1.06	<1.0	8	0
Selenium	mg/kg	13	430	S4UL	<1.0	5.0	0
Boron Water Soluble	mg/kg	13	11000	S4UL	<0.5	3.5	0
Phenols	mg/kg	13	750	S4UL	<1.0	<5.0	0

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

Table 9.2: Soil Laboratory Analysis Results – Polycyclic Aromatic Hydrocarbons (PAHs)

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Naphthalene	mg/kg	13	S4UL	2.3	<0.05	0.19	0
Acenaphthylene	mg/kg	13	S4UL	2900	<0.05	0.36	0
Acenaphthene	mg/kg	13	S4UL	3000	<0.05	0.95	0
Fluorene	mg/kg	13	S4UL	2800	<0.05	0.94	0
Phenanthrene	mg/kg	13	S4UL	1300	<0.05	19.0	0
Anthracene	mg/kg	13	LQM GAC	2300	<0.05	4.67	0
Fluoranthene	mg/kg	13	S4UL	1500	<0.05	28.2	0
Pyrene	mg/kg	13	S4UL	3700	<0.05	23.8	0
Benzo(a)anthracene	mg/kg	13	S4UL	11.0	<0.05	14.0	1No. (WS3@1.00mbgl)
Chrysene	mg/kg	13	S4UL	30	<0.05	12.9	0
Benzo(b)fluoranthene	mg/kg	13	S4UL	3.9	<0.05	13.2	1No. (WS3@1.00mbgl)
Benzo(k)fluoranthene	mg/kg	13	S4UL	110	<0.05	13.3	0
Benzo(a)pyrene	mg/kg	13	S4UL	3.2	<0.05	16.6	1No. (WS3@1.00mbgl)
Indeno(123-cd)pyrene	mg/kg	13	S4UL	45	<0.05	13.5	0
Dibenz(ah)anthracene	mg/kg	13	S4UL	0.31	<0.05	7.34	3No. (WS3@1.00mbgl, WS5@0.80mbgl. WS8@1.00mbgl)
Benzo(ghi)perylene	mg/kg	13	S4UL	360	<0.05	2.35	0
Total PAH	mg/kg	13	-		<0.80	180	-

Table 9.3: Soil Laboratory Analysis– Total Petroleum Hydrocarbons (TPH)

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
C_8-C_{10}	mg/kg	6	S4UL	27	<0.1	<0.1	0
>C_{10}-C_{12}	mg/kg	6	S4UL	130	<1.0	<2.0	0
>C_{12}-C_{16}	mg/kg	6	S4UL	1100	<1.0	<4.0	0
>C_{16}-C_{21}	mg/kg	6	S4UL	1900	<1.0	15	0
>C_{21}-C_{35}	mg/kg	6	S4UL	1900	<10	77	0
Total TPH	mg/kg	6	-	-	<17.1	92	-

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

Table 9.4: Soil Laboratory Analysis Results – Total Petroleum Hydrocarbons (TPHCWG)

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
>C_5-C_6 Aliphatic	mg/kg	7	S4UL	42	<0.001	<0.01	0
>C_6-C_8 Aliphatic	mg/kg	7	S4UL	100	<0.001	<0.001	0
>C_8-C_{10} Aliphatic	mg/kg	7	S4UL	27	<0.001	2.3	0
>C_{10}-C_{12} Aliphatic	mg/kg	7	S4UL	130	<1.0	3.2	0
>C_{12}-C_{16} Aliphatic	mg/kg	7	S4UL	1100	<2.0	17	0
>C_{16}-C_{35} Aliphatic	mg/kg	7	S4UL	65000	11	681	0
>C_5-C_7 Aromatic	mg/kg	7	S4UL	70	3.3	16.5	0
>C_7-C_8 Aromatic	mg/kg	7	S4UL	130	<0.001	<0.01	0
>C_8-C_{10} Aromatic	mg/kg	7	S4UL	34	<0.001	<0.01	0
>C_{10}-C_{12} Aromatic	mg/kg	7	S4UL	74	<0.001	2.3	0
>C_{12}-C_{16} Aromatic	mg/kg	7	S4UL	140	<1.0	<1.0	0
>C_{16}-C_{21} Aromatic	mg/kg	7	S4UL	260	<2.0	7.7	0
>C_{21}-C_{35} Aromatic	mg/kg	7	S4UL	1100	<10	119	0
Total TPH (Ali/Aro)	mg/kg	7	-	-	480	190	-

9.2 Volatile Organic Compounds (VOCs)

9.2.1 7No soil samples were also scheduled for testing against a range of volatile organic compounds. No VOCs were detected in any sample tested.

9.3 Polychlorinated Biphenyl (PCB) Concentrations

9.3.1 In addition to the suites outlined previously, 4No soil samples were analysed for the presence of PCBs. Within a single sample (WS5 0.80mbgl) PCBs were detected to a maximum level of 0.02mg/kg (PCB 138) and a total of 7 congeners of 0.07mg/kg.

9.3.2 No specific UK guidance for PCB compounds tested could be found, however the United States Environmental Protection Agency have published values for "high risk polychlorinated biphenyls" – the lowest published value for which is 0.23mg/kg. On the basis that the total PCBs reported within the single sample was 0.07mg/kg, a significant risk is not believed to be posed by PCBs to current or future site users.

9.4 Statistical Analysis

9.4.1 Where samples tested exceeded the selected screening criteria, and the minimum numbers of samples were more than six in the upper 1m of Made Ground, statistical analyses of the dataset are undertaken.

9.4.2 The CL:AIRE/CIEH Guidance 'Guidance on Comparing Soil Contamination Data with a Critical Concentration' (2008) describes the new approach to statistical analysis of datasets generated through the investigation of contaminated land. This includes differing statistical methodologies for the analysis of normally and non-normally distributed data. Different approaches to datasets being analysed under Part IIA and under the planning regime are also presented.

9.4.3 Chemical data from the laboratory testing has been assessed in accordance with the CL:AIRE/CIEH Guidance under a planning scenario. The purpose of the assessment is to determine if the land is suitable for the proposed development. Under the planning scenario, the key question is 'is there sufficient evidence that the true mean concentration of the contaminant within the data set (μ) is less than the critical concentration (Cc, in this instance the derived GAC). This is assessed by calculation of the upper confidence limit (UCL). The statistical test assesses the 95th percentile of contaminant populations across a site, and compares this value against the relevant GAC. Furthermore, the test determines statistically whether contaminants exceeding the soil guideline value could be regarded as outliers. Outliers are contaminant values which indicate a localised area of contamination or error in sampling, and may not be a member of the underlying population.

9.4.4 The statistical tests were run for:

- Arsenic
- Lead
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(a)pyrene
- Dibenzo(ah)anthracene

9.4.5 The results of statistical tests are presented in Appendix 9. Table 9.5 below provides the summary of statistical tests.

Table: 9.5 Statistical Test Results

Determinand	95% UCL	Cc/GAC	GAC Exceeded
Arsenic	22.06	40	X
Lead	522.7	300	✓
Benzo(a)anthracene	8.982	11.0	X
Benzo(b)fluoranthene	8.734	3.9	✓
Benzo(a)pyrene	11.88	3.2	✓
Dibenzo(ah)anthracene	2.527	0.31	✓

9.4.6 As summarised in the table above, a number of the contaminants analysed were found to have 95% upper confidence limits in excess of the screening criteria, and therefore the risks posed by the elevated contaminant concentrations should be considered potentially significant.

9.5 Asbestos in Soil

9.5.1 8No samples of the Made Ground were screened in the laboratory for the presence of asbestos. The results of the analysis is summarised below in Table 9.6 below

Table 9.6: Asbestos Analysis – Summary

Sample	Screening result.	Quantification result (%)	Comments
WS2 – 0.50mbgl	None detected	-	-
WS3 – 0.30mbgl	None detected	-	-
WS3 – 1.00mbgl	None detected	-	-
WS4 – 0.25mbgl	None detected	-	-
WS4 – 1.00mbgl	None detected	-	-
WS5 – 0.20mbgl	None detected	-	-
WS5 – 0.80mbgl	Detected	<0.001	Chrysotile fibre bundles
WS8 – 1.00mbgl	None detected	-	-
WS2 – 0.50mbgl	None detected	-	-

9.5.2 As shown above, a single sample was shown to contain asbestos fibres in the form of chrysotile fibre bundles. Quantification indicates a content of <0.001%, below the level at which waste soils would be considered hazardous for the purposes of waste disposal.

9.6 Screening of Groundwater Chemical Analysis Results

9.6.1 Samples of groundwater obtained from the borehole installations installed within exploratory locations WS2, WS3, WS4, WS5, and WS8

9.6.2 The samples were obtained by low flow methodology.

9.6.3 The results of the laboratory testing are summarised in Tables 9.7 to 9.9 below, with the raw chemical testing data presented in Appendix 7.

Table 9.7: Groundwater Laboratory Analysis Results

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No of Exceedances
Arsenic	µg/l	5	10	DWS	4.9	12	1No (WS5)
	µg/l		50	EQS	4.9	12	0
Cadmium	µg/l	5	5	DWS	<0.08	<0.08	0
Chromium	µg/l	5	50	DWS	<0.4	4.0	0
Lead	µg/l	5	10	DWS	1.9	7.4	0
	µg/l		1.2*	EQS	1.9	7.4	5No (WS2, WS3, WS4, WS5, WS8)

Table 9.7: Groundwater Laboratory Analysis Results

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No of Exceedances
Nickel	µg/l	5	20	DWS	2.6	11	0
	µg/l		4*	EQS	2.6	11	3No (WS2, WS4, WS8)
Copper	µg/l	5	12	EQS	1.2	7.8	0
			2000	DWS	1.2	7.8	0
Zinc	µg/l	5	5000	DWS	2.3	15	0
	µg/l		12.9**	EQS	2.3	15	1No (WS5)
Mercury	µg/l	5	1	DWS	<0.5	<0.5	0
Selenium	µg/l	5	10	DWS	<4.0	<4.0	0
Boron	µg/l	5	1000	DWS	36	130	0
	µg/l		2000	EQS	36	130	0
Cyanide (Total)	µg/l	5	50	DWS	<1.0	<1.0	0
	µg/l		1	EQS	<1.0	<1.0	0
Phenols (Total)	µg/l	5	7.7	EQS	<10	<10	0

Table 9.8: Groundwater Analysis Results – Polycyclic Aromatic Hydrocarbons (PAHs)

Determinand	Unit	No. samples tested	Screening Criteria		Min.	Max.	No. of Exceedances
Naphthalene	µg/l	5	2.4	EQS	<0.01	<0.01	0
Acenaphthylene	µg/l	5	-	-	<0.01	<0.01	0
Acenaphthene	µg/l	5	-	-	<0.01	<0.01	0
Fluorene	µg/l	5	-	-	<0.01	<0.01	0
Phenanthrene	µg/l	5	-	-	<0.01	<0.01	0
Anthracene	µg/l	5	0.1	EQS	<0.01	<0.01	0
Fluoranthene	µg/l	5	0.0063	EQS	<0.01	<0.01	0
Pyrene	µg/l	5	-	-	<0.01	<0.01	0
Benzo(a)anthracene	µg/l	5	-	-	<0.01	<0.01	0
Chrysene	µg/l	5	-	-	<0.01	<0.01	0
Sum of four Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(ghi)perylene Indeno(123-cd)pyrene	µg/l	5	0.1	DWS	<0.04	<0.04	0
Benzo(a)pyrene	µg/l	5	0.01	DWS	<0.01	<0.01	0
Dibenzo(ah)anthracene	µg/l	5	0.00017	EQS	<0.01	<0.01	0

Determinand	Unit	No. samples tested	Screening Criteria		Min.	Max.	No. of Exceedances
Total PAH	µg/l	5	-	-	<0.16	<0.16	0

Table 9.9: Groundwater Analysis Results (Round 2) – TPHCWG – Controlled Waters

Determinand	Unit	No. Samples tested	Screening Criteria		Min.	Max.	No. of Exceedances
>C5-C6 Aliphatic	µg/l	3	15000	WHO	<1.0	<1.0	0
>C6-C8 Aliphatic	µg/l	3	15000	WHO	<1.0	<1.0	0
>C8-C10 Aliphatic	µg/l	3	300	WHO	<1.0	<1.0	0
>C10-C12 Aliphatic	µg/l	3	300	WHO	<1.0	<1.0	0
>C12-C16 Aliphatic	µg/l	3	300	WHO	<1.0	<1.0	0
>C16-C21 Aliphatic	µg/l	3	-	-	<1.0	<1.0	-
>C21-C35 Aliphatic	µg/l	3	90	WHO	<10	490	0
>C5-C7 Aromatic	µg/l	3	10	WHO	<1.0	<1.0	0
>C7-C8 Aromatic	µg/l	3	700	WHO	<1.0	<1.0	0
>C8-C10 Aromatic	µg/l	3	300	WHO	<1.0	<1.0	0
>C10-C12 Aromatic	µg/l	3	90	WHO	<10	<10	0
>C12-C16 Aromatic	µg/l	3	90	WHO	<10	<10	0
>C16-C21 Aromatic	µg/l	3	90	WHO	<10	<10	0
>C21-C35 Aromatic	µg/l	3	90	WHO	<10	<10	0

9.6.4 In addition to the suite outlined above, the five water samples were also analysed for a suite of volatile organic compounds. None of the compounds analysed for were reported above the laboratory method detection limit.

9.6.5 Similarly for the BTEX (Benzene, Toluene, Ethylbenzene and Xylene) compounds, none of the results were reported above the laboratory method of detection.

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

9.7.1 Zinc, copper and nickel are phytotoxins and could therefore inhibit plant growth in soft landscaped areas. Concentrations measured in soil for these determinands have been compared with the pH dependent values given in BS3882:2007.

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

Table 9.10: Soil Laboratory Analysis Results – Phytotoxic Determinands

Determinand	Threshold level (mg/kg)	Min (mgkg)	Max (mg/kg)	No. Exceeding
Zinc	300	26	860	2No (WS2@0.50mbgl, WS4@1.00mbgl)
Copper	200	16	1000	1No (WS2@0.50mbgl)
Nickel	110	9.2	72	0

9.8 Screening for Water Pipes

9.8.1 The results of the analysis have been assessed for potential impact upon water supply pipes. Table 9.11 below summarises the findings of the assessment:

Table 9.11: Screening Guide for Water Pipes

Determinand	No. of tests	Threshold adopted for PE (mg/kg)	Value for site data (mg/kg)		No of Exceedances
			Min	Max	
Total VOCs	7	0.5	<0.056	<0.056	0
BTEX	7	0.1	<0.05	<0.05	0
MTBE	7	0.1	<0.01	<0.01	0
EC5-EC10	13	1	<0.002	<0.02	0
EC10-EC16	13	10	<6	27.9	0
EC16-EC40	13	500	<11	1006.5	0
Naphthalene	13	5	<0.05	0.19	0
Phenols	13	2	<1	<5*	0

9.8.2 The above suggests that upgraded pipe work may be required.

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

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

9.8.4 Sampling and analysis of potable water supplies to the existing units may be acceptable to the relevant utility provider to confirm whether existing pipe work is satisfactory. The potable water supply pipe requirements should be discussed with the relevant utility provider.

9.9 Waste Disposal

9.9.1 The classification of materials for waste disposal purposes was outside the scope of this report. Should quantities of material require off-site disposal, Waste Acceptance Criteria testing will be required.

10 SOIL GAS RISK ASSESSMENT

10.1 Soil Gas Results

10.1.1 Four return monitoring visits have been undertaken to date to monitor wells installed within boreholes at the site for soil gas concentrations and groundwater levels.

10.1.2 The results of the monitoring undertaken are summarised in Table 10.1 below, with the monitoring records presented in Appendix 8.

Table 10.1: Summary of Gas Monitoring Data

Hole No.	CH_4 (%)	CO_2 (%)	O_2 (%)	H_2S (ppm)	VOCs	Peak Flow Rate (l/hr)	Depth to water (mbgl)	Depth of installation (mbgl)
WS2	<0.1	4.3-5.5	14.9-15.4	0	1-29	+0.3-+0.4	2.32-2.46	5.12
WS3	<0.1	3.2-5.1	13.0-15.7	0	0-33	<0.1-+0.5	2.12-2.25	5.70
WS4	<0.1	9.5-11.9	8.1-10.8	0	2-33	+0.3-+0.4	2.46-2.60	5.81
WS5	0.0-0.1	0.9-1.3	16.8-17.5	0	4-16	+0.1-+0.3	2.28-2.34	4.87
WS8	<0.1-0.1	3.0-5.4	15.4-17.4	0	1-38	+0.3-+0.4	2.24-2.34	5.61

10.2 Screening of Results

10.2.1 As shown in Table 10.1, methane has been reported to a maximum concentration of 0.1%. Carbon dioxide has been reported to a maximum concentration of 10.7% v/v. Volatile organic compounds (VOCs) to a maximum concentration of 38ppm have been reported. A maximum flow rate of 0.5l/hr has been reported.

10.2.2 In the assessment of risks posed by hazardous ground gases and selection of appropriate mitigation measures, BS84985 (2015) identifies four types of development, termed Type A to Type D.

10.2.3 Type B buildings are defined as

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

10.2.4 Type B has been adopted as the relevant category for the proposed development.

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

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

GSV = (Concentration/100) X Flow rate

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

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

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

10.2.9 A worst case flow rate of +0.4l/hr (maximum reported) will be used in the calculation of GSVs for the site. The Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

10.2.10 To accord with C665, worst case conditions are used in the calculation of GSVs for the site. These have been summarised below in Table 10.2

Table 10.2: Summary of Gas Monitoring Data

Gas	Concentration (v/v %)	Peak Flow Rate (l/hr)	GSV (l/hr)	Characteristic Situation (after CIRIA C665)
CO_2	11.9	0.4	0.0476	**1**
CH_4	0.1	0.4	0.0004	**1**

10.2.11 The methodology set out in BS 8485 (2015) has been used for determining the required gas protection measures. For a Type B development on a CS1 no formal gas protection measures are considered necessary.

10.2.12 Further monitoring visits are considered necessary to provide confidence that worst case conditions would not result in a CS2 classification, for which ground gas protection measures would be required. It is recommended that a further five monitoring visits are undertake over a five month period.

10.2.13 Although PID readings of up to 33ppm were recorded within the ground gas monitoring wells headspaces, the soil and water test results showed no VOCs present above detection limit, and no significant source of potentially volatile contamination has been detected on site. Therefore, a pollutant linkage via vapour inhalation pathways is not considered to exist.

11 SUMMARY OF RESULTS

11.1 Risk Assessment - Land Quality Impact Summary

11.1.1 Following the site investigation, the following is noted:

- The proposed development is to comprise the conversion of the existing commercial structures to residential use. It is understood that the three structures on site ("Chaplin House", "Norgine House" and "Musgrave House") will each be converted under separate planning applications.
- Following generic risk assessments and statistical analysis, elevated concentrations of lead, benzo(b)fluoranthene, benzo(a)pyrene and dibenzo(ah)anthracene were reported in excess of their respective assessment criteria.
- A single sample was found to contain asbestos out of 8No samples screened, in the form of chrysotile fibre bundles. The asbestos content was quantitated as <0.001% asbestos by weight.
- Quantification indicates a content of <0.001%, below the level at which waste soils would be considered hazardous for the purposes of waste disposal.
- The site proposal indicates that the majority of the site will remain covered by a combination of the proposed building footprint and hard surfacing. Where this is the case, no formal remedial measures are considered necessary in terms of human health, as the building and hard surfacing are expected to provide a barrier to potential receptors. In areas of soft landscaping, existing soils should be encapsulated by a minimum 600mm clean cover layer of imported sub/topsoil, placed over a geotextile membrane. It is noted however, that parts of the existing soft landscaping comprise strips of dense hedgerows which would not be expected to pose a significant risk to proposed end users. In addition, further soil sampling could be undertaken in areas of soft landscaping to determine if the shallow soils in specific areas are suitable for the proposed use.
- Groundwater analysis has reported an elevated concentration of arsenic in excess of drinking water standards, and lead and nickel in excess of Environmental Quality Standards. No hydrocarbon compounds were reported above detection limit within groundwater samples. The relatively low level of the exceedances reported and distance to the nearest receptors indicates

that the elevated concentrations are unlikely to pose a significant risk to controlled waters.

- In addition, the proposed change of use at the site will not results in additional areas of soft landscaping and increase rainwate infiltration.

- Concentrations of carbon dioxide are raised at the site, with corresponding depleted oxygen. Calculating the Gas Screening Value using worst case results indicates Characteristic Situation 1.

- Further monitoring visits are considered necessary to provide confidence that worst case conditions would not result in a CS2 classification, for which ground gas protection measures would be required. It is recommended that a further five monitoring visits are undertake over a five month period.

- Should the additional monitoring determine that a CS2 classification is appropriate, it is likely that surveys will be required to determine what level of ground gas protection is present within the existing buildings, and (if necessary) how any such protection could be upgraded to match requirements for CS2.

- A pollutant linkage via vapour inhalation pathways is not considered to exist.

- Barrier pipe work may be required for potable water supply pipes. Sampling and analysis of potable water supplies to the existing units may be acceptable to the relevant utility provider to confirm whether existing pipe work is satisfactory. The potable water supply pipe requirements should be discussed with the relevant utility provider.

- A Remediation Strategy will be required to define the required remedial measures.

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

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

11.2 Review of Pollutant Linkages Following Site Investigation

11.2.1 The site CSM has been revised and updated from that suggested in the desk study in view of the ground investigation data, including soil laboratory analysis results. Table 11.1 highlights whether pollutant linkages identified in the original CSM are still relevant following the risk assessment, or whether pollutant linkages, not previously identified, exist.

Table 11.1: Plausible Pollutants Linkages Summary (Pre Remediation)

Potential Source (from desk study)	Pathway	Receptor	Relevant Pollutant Linkage?	Comment
• Potential for contaminated ground associated with previous site use – on site (S1) • Potential for Made Ground associated with previous development operations – on site (S2) • Previous industrial use – off site (S3) • Potential asbestos containing materials within existing buildings – on site (S4) • Potential asbestos impacted soils from demolition of previous buildings – on site (S5) • Potential ground gas generation from alluvial deposits and surrounding ground workings (S6) PCBs from electrical features identified on site (S7)	• Ingestion and dermal contact with contaminated soil (P1) • Inhalation or contact with potentially contaminated dust and vapours (P2) • Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6)	• Construction workers (R1) • Maintenance workers (R2) • Neighbouring site users (R3) • Future site users (R4) • Building foundations and on site buried services (water mains, electricity and sewer) (R5)	**Y**	See 11.1 above for remedial measures. The findings of this report should be included in the construction health and safety file, with adequate measures put in place for the protection of construction and maintenance workers.
	• Accumulation and migration of soil gases (P5)		**?**	Further monitoring recommended to classify the site in terms of ground gas risk.
	• Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hardstanding or via service pipe/corridors and surface water runoff. (P3) Horizontal and vertical migration of contaminants within groundwater (P4)	• Neighbouring site users (R3) • Building foundations and on site buried services (water mains, electricity and sewer) (R5) • Controlled waters – Primary and secondary A aquifers, abstractions, surface water features, culverted river on site. (R6)	**Y**	No significant risk to controlled waters identified. Contact should be made with relevant utility providers to confirm if upgraded materials are required.

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APPENDICES

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