APPENDIX 9.2

PRELIMINARY GENERIC QUANTITATIVE ENVIRONMENTAL RISK ASSESSMENT REPORT





Preliminary Generic Quantitative Risk Assessment

Beehive Retail Centre; Cambridge Retail Park; and 230 Newmarket Road, Cambridge

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Comments



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Executive Summary

Objectives

Preliminary Generic Quantitative Risk Assessment for ground contamination, for the proposed redevelopment of the three adjacent sites in Cambridge; Beehive Retail Centre, 230 Newmarket Road (230 NMR), and Cambridge Retail Park (CRP).

Conclusions

Overall, the risk rating for the Site is assessed as **Medium**, whereby without implementation of stated recommendations complete contaminant linkages are present. However, at the CRP area where no redevelopment is proposed and the existing structures are to be retained, the risk is **Low**.

Where the recommendations are implemented, the contaminant linkages will be broken, and the Site's overall risk rating will be reduced to **Low**. In addition, the Site is unlikely to be capable of being classified as Contaminated Land under the Environmental Protection Act 1990, thus meeting the requirements of paragraphs 183 to 188 of the National Planning Policy Framework.

Site Setting

History

BRC - Allotments up until the 1960's, then various warehouses and light industrial uses. The northern half redeveloped in the 1980's into the existing Beehive Retail Centre layout, expanding to the remainder of the Site by 1994. Petrol filling station present at the western boundary before being decommissioned by 2003.

230 NMR - Clay pit that extended northwards off-site from at least the 1880's, expanded beneath the south/southeast portion of the Site by the 1920s. Backfilled as a landfill between the 1950's and 1970's. Garages and warehouses constructed on the western boundary with Coral Park Trading Estate constructed across the remainder of the Site. No significant changes until 2010 when the warehouses were demolished and redeveloped into the existing retail centre. CRP - Occupied by the clay pit and associated brick and tile works and coal yard in 1886. By 1927 the clay pit and brick and tile works expanded over this area. Along with a tyre depot, garage, and warehouse in the south-western corner. Clay pit was landfilled between the 1950's and 1970's and replaced with Coral Park Trading Estate. This in turn was redeveloped post 2010 to form the Cambridge Retail Park.

Human Health Risk

Elevated contaminants, and asbestos fibres have been recorded in the Made Ground in areas of existing and proposed hardstanding the pollutant linkage to future site users will be broken and remediation measures would not be required. In areas of proposed soft landscaping a cover layer of sufficient thickness constructed from imported material will be required.

Controlled Waters

Elevated metal contaminants have been recorded in a limited number of exploratory holes marginally above the conservative threshold criteria, identifying their lateral migration as being limited. The low permeability of the underlying deposits is likely contributing to this limited environmental mobility.

Elevated PAH contaminants have been recorded in several exploratory holes across the Site. Given the low solubility and high affinity for organic matter the lateral migration of PAH contaminants off-site is likely to be limited and remedial actions to reduce their concentrations not required.

Elevated BTEX contaminants have been recorded in WBH111 (south corner of the Beehive Retail Centre) with an off-site historical transport depot the likely source. Down hydraulic gradient concentrations are lower by three orders of magnitude indicating the contaminants are attenuating in the environment prior to migrating off-site. Further ground investigation is however required to delineate the extent of the petroleum hydrocarbon contamination at WBH111 and to determine remedial actions are required.

Ground Gas Regime

A significant ground gas regime is absent on the Beehive Retail Centre with built structures not requiring ground gas protection measures.



At 230 Newmarket Road and Cambridge Retail Park elevated ground gas concentrations have been recorded within monitoring wells installed in the former location of the historical landfill. Ground gas concentrations outside the historical landfill have recorded low methane and carbon dioxide concentrations and low ground gas flow rate identifying ground gas as having limited to no lateral migration. The ground gas dataset indicates ground gas protection measures would not be required for built structures outside the former landfill extent, and for proposed built structures within the former landfill extent basic ground gas protection measures consistent with a Characteristic Situation 2 (CS2) ground gas regime would be required.

Further ground investigation and assessment are however required to confirm the ground gas regime and whether ground gas protection measures are required on Cambridge Retail Park or 230 Newmarket Road.

The existing structures on Cambridge Retail Park include ground gas protection measures. The ground gas dataset identified during the ground investigation indicate this ground gas protection system may not be required and could be removed/no longer maintained. Further ground investigation and assessment would however be needed to confirm this assessment.

Vapour Regime

A potential vapour risk is present at the 230 NMR and BRC areas of the Site. Further ground investigation will be necessary to quantify vapour risks, and inform the potential remediation or mitigation measures necessary to break this linkage to future receptors.

Recommendations

- The findings of this initial ground investigation identified hydrocarbon contamination in shallow groundwater, with vapour risk and ground gas risk in areas of the Site. Further investigation works are recommended to fully delineate and assess this contamination:
 - Additional ground investigation and assessment to determine the ground gas regime in areas of proposed development on 230 Newmarket Road and Cambridge Retail Park.
 - Additional ground investigation may be undertaken on Cambridge Retail Park to confirm whether a significant ground gas regime is present, and whether the existing ground gas protection system is required. The current ground investigation dataset indicates it is not however additional information is required to clarify this.
 - Further groundwater sampling to fully delineate the extent of hydrocarbon contamination within the West Melbury Formation aquifer. in particular targeting the hydrocarbon source originating close to WBH111, migrating north-east through the shallow groundwater.
 - Vapour monitoring and sampling at the 230 NMR and BRC areas of the Site to quantify vapour risks to future structures, and inform the potential remediation or mitigation measures necessary to break this linkage to future receptors.
- Construction workers should be provided with appropriate PPE for works involving contaminated soils and groundwater, and use appropriate hygiene measures;
- Asbestos fibres have been detected in shallow Made Ground. Construction works should be undertaken in accordance with the Control of Asbestos Regulation 2012, with an asbestos plan of work developed to prevent impacts from asbestos exposure to construction workers;
- A Foundation Works Risk Assessment should be completed once the development design is finalised and it is known whether or not piled foundations will penetrate the Gault Clay Formation.
- New soft landscaping to be installed as part of 230 NMR and BRC redevelopment should be situated in certified clean topsoil to break contaminant linkage between residual potentially contaminated soils and future Site users in these areas.



1. Introduction

1.1 Objectives

Gardiner and Theobald ("the Client") instructed Waterman Infrastructure & Environment Limited (Waterman) to prepare a preliminary Generic Quantitative Risk Assessment (GQRA) for ground contamination for the proposed redevelopment of the three adjacent sites in Cambridge; Beehive Retail Centre (BRC), 230 Newmarket Road (230 NMR), and Cambridge Retail Park (CRP) (collectively referred to as "the Site").

A plan detailing the three individual Sites which form the Cambridge Development masterplan is included in Appendix A.

This assessment follows on from the three Preliminary Risk Assessment (PRA) reports prepared by Waterman:

- BRC (report reference WIE17469-100-R-5-1-2-PRA)
- 230 NMR (report reference WIE17469-100-R-10-1-1-PRA)
- CRP (report reference WIE17469-100-R-11-1-1-PRA)

The purpose and objectives of the ground investigation are as follows;

- To build on the information included in the three PRA's, with an overall goal of updating the Site's conceptual model;
- Provide a preliminary understanding of the Site's contamination status to inform future ground investigation requirements.
- Provide recommendations related to ground contamination to facilitate the proposed Development;
 and
- Undertake a preliminary waste assessment and classification of excavated soils, to assist a contractor
 in assessing their options and associated costs regarding waste disposal from Site.

Waterman undertook a part-time attendance during the ground investigation and were responsible for scheduling contaminated land and geotechnical samples and the design of monitoring well installations. The ground investigation including post fieldwork monitoring was undertaken by Groundtech as an approved subcontractor to Waterman.

1.2 Proposed Development

The proposed Developments for the three individual Sites are included below. Note the Cambridge Masterplan Development is at an early stage and changes may occur to the proposed Development as part of the design process.

BRC - Beehive Retail Centre

Fourteen building plots, with buildings 1 to 9 storeys for commercial use. Soft and hard communal landscaping is proposed with Sustainable Urban Drainage Systems (SUDs) incorporated into the development scheme. Basements and private soft landscaping are not proposed.



230 NMR - 230 Newmarket Road

Four-storey commercial building in the southern half and a separate single-storey retail unit in the northern half. Soft communal landscaping is proposed with existing trees to be retained on the western boundary. Associated car parking areas are proposed to the northeast and eastern portion of the Site. Basements and private soft landscaping are not proposed.

CRP - Cambridge Retail Park

The existing retail units at the CRP will be retained and used for the relocation of the occupants of the Beehive Retail Centre. The existing Currys located on the northern boundary of CRP will be retained and extended westward into the existing service yard to form an additional warehouse. It is understood Currys will be occupied by Asda. The proposed Development for the small section of land adjacent Henley Road (southern boundary of CRP) is not known at this time.

The CRP is protected by an existing gas protection system in all current structures, installed during original construction of the units on this area of the Site. The protection system was installed to mitigate the potential for gas accumulation due to an identified former landfill beneath this area.

1.3 Planning Context

It is understood planning consent for the proposed Development has not been gained. It is likely additional ground investigation included within a separate report will be required to inform the Site's contamination status and required remedial measures. Post completion of the ground investigation and assessment of the results the associated report would be best suited for submission further to discharging contaminated land planning conditions.

1.4 Constraints

This Environmental Report has been prepared in accordance with the scope agreed between Waterman and Gardiner and Theobald.

The information contained in this report is based on the findings of the PRAs, observations during the ground investigation, exploratory hole logs, soil, groundwater and vapour laboratory results, groundwater level monitoring results, and ground gas and vapour results.

The ground conditions reported relate only to the point of excavation and do not necessarily guarantee a continuation of the ground conditions throughout the non-inspected Site areas. Whilst such exploratory holes would usually provide a reasonable indication as to the general ground conditions, these cannot be determined with complete certainty.

Waterman has endeavoured to assess all information provided to them during this Geo-environmental Report, but makes no guarantees or warranties as to the accuracy or completeness of this information.

The scope of this intrusive investigation includes an assessment of the presence of asbestos containing materials in the ground on the Site, but not within above or below ground structures.

The conclusions resulting from this are not necessarily indicative of future conditions or operating practices at or adjacent to the Site.



2. Procedures

This GQRA report has been undertaken in accordance with the Land Contamination: Risk Management guidance (LCRM – Environment Agency, 19 April 2021). The report includes the following:

- Review and confirmation of the overall objectives;
- · GQRA objectives;
- Outline Conceptual Model for the Site;
- · Results of Intrusive Ground Investigation;
- · Confirmation of Generic Assessment Criteria used to assess risks;
- Assessment of results against Generic Assessment Criteria;
- Formulation of a new Conceptual Model for the Site;
- · Identification of potentially unacceptable risks;
- · Record of findings and recommendations for further action.

This report forms a decision record for the contaminant linkages identified, the generic assessment criteria used to assess risks, the unacceptable risks identified and the proposed next steps in relation to the Site. The report also provides an explanation of the refinement of the outline conceptual Site model following the ground investigation, the selection of criteria and assumptions, an assessment of uncertainties, degree of confidence and limitations, the evaluation of potential risks and the basis for the decision on what happens next.



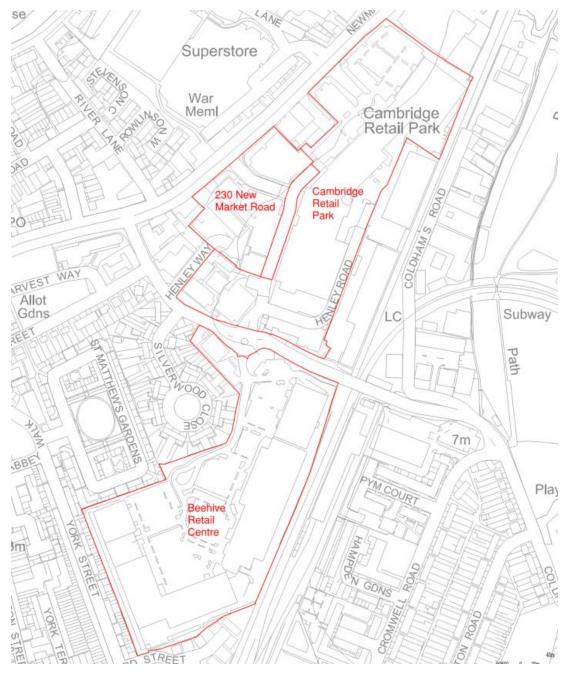
3. Environmental Site Setting

Section 3 provides a brief summary of the Site's environmental setting. For a more detailed review, the three Waterman PRAs completed in 2022 should be reviewed.

3.1 Existing Site

A combined plan showing the locations of the three subject Sites is set out in Figure 1.

Figure 1: Combined Site Plan





BRC - Beehive Retail Centre

This section of the Site is centred at National Grid Reference 546677 258593. The area is 7.22ha and comprises thirteen retail units with associated car parking.

230 NMR - 230 Newmarket Road

This section of the Site is centred at National Grid Reference 546821 259139. It spans 0.45ha and is currently occupied by car parking areas relating to the wider retail park.

CRP - Cambridge Retail Park

This area is centred at National Grid Reference 546791 258964. It occupies 6.19ha and is currently commercial retail units, car parking areas and service yards. Soft landscaping borders are present in the north, west and south of the Site.

3.2 Site History

BRC - Beehive Retail Centre

Historical mapping records the Beehive Retail Centre as undeveloped or in use as allotments up until the 1960's whereby various warehouses, a dairy, builders' yards, and a bakery are on-Site. The northern half was redeveloped initially in the 1980's into the existing Beehive Retail Centre layout. The remainder of the Site followed by 1994. A petrol filling station was constructed on the western boundary as part of the initial Beehive Retail Centre before being decommissioned by 2003.

230 NMR - 230 Newmarket Road

Historical mapping records the north/northeast of 230 NMR occupied by a clay pit that extended northwards off-site from at least the 1880's. By the late-1920's the clay pit expanded beneath the south/southeast portion of the Site and joined the Brick and Tile works clay pit to the north. Between the 1950's and 1970's the pit was backfilled as a landfill, with the composition of this landfill material not recorded. From the mid-1970's garages and warehouses were constructed on the western boundary with large industrial units associated with Coral Park Trading Estate constructed across the remainder of the Site. No significant changes until 2010 when the warehouses were demolished and redeveloped into the existing retail centre layout.

CRP- Cambridge Retail Park

Historical mapping records the CRP as predominately being occupied by a clay pit and associated brisk and tile works (northern and central portions) in 1886, the southern portion was occupied by a coal yard. By 1927 the clay pit and associated brick and tile works infrastructure to cover the whole of this area, displacing the coal yard historically present on the southern portion. The 1950 historical maps recorded a tyre depot, garage, and warehouse in the south western corner. Between the 1950's and 1970's the clay pit was landfilled and warehouses and depot constructed known as the Coral Park Trading Estate. The Coral Park Trading Estate was redeveloped post 2010 to form the Cambridge Retail Park which has maintained its current layout up to the present day.



3.3 Anticipated Geology

Anticipated ground conditions within the three Sites are included in Table 1. The geology is as indicated by historical mapping and previous ground investigations.

Table 1: Anticipated Ground Conditions

Stratum	Area Covered	Typical Thickness (m)	Description
Made Ground	230 NMR, CRP	0.5 – 2.5	Brown and dark grey clayey sand and gravel. Coarse fragments of limestone, brick, tile, glass, flint, steel, wood, ash, and concrete, with pockets of soft grey or brown slightly sandy clay.
	Beehive Retail Centre	1.0 – 2.0	Granular material generated during the multiple redevelopment phases. Reworked natural material becoming present with depth.
Landfill Material	230 NMR, CRP	5.0 – 15.0 (230 NMR) 5.0 – 23.7 (CRP)	Wet black loose fill comprising brick, concrete and ash with wood, nails, plastic, metal, pottery, electrical components and bands of stiff grey silty clay.
			Encountered in the east of 230 NMR and the central to south-east of the CRP areas only.
River Terrace Deposits	South western corner of Beehive Retail Centre	3.0 – 5.0	Brown/orange brown slightly clayey/clayey sand/gravel.
West Melbury Chalk Formation	230 NMR, CRP, Beehive Retail Centre	3.0 – 5.0	Grey marly structureless chalk.
Gault Formation	230 NMR, CRP, Beehive Retail Centre	30m	Grey silty clay.
Lower Greensand Formation	230 NMR, CRP, Beehive Retail Centre	>20m	Light brown/grey interbedded sands and sandstone

BRC - Beehive Retail Centre

The Site's historical use identifies two primary redevelopment stages, construction of commercial/industrial uses in the early 20th century before their demolition and construction of the existing Beehive Retail Centre. Made Ground associated with the construction of these redevelopment stages is anticipated. The Made Ground is likely to be granular in nature, becoming a reworked natural deposit with depth.

BGS maps identify the Site as being underlain by a thin River Terrace Deposit in the southwest corner, consistent with the former location of a gravel pit immediately off-site to the west. The extent to which the gravel deposit extends on-Site is unclear. Beyond the southwest Site corner, BGS mapping indicates the remainder of the Site as being underlain by the West Melbury Chalk Formation, underlain in turn by the



Gault Formation. The Gault Formation outcrops in the area surrounding the Site including land immediately north which was a former clay pit, and a former brick and tile works. The Chalk Formation on-Site is expected to be thin and may in some places be absent.

230 NMR (230 Newmarket Road) and CRP (Cambridge Retail Park)

The Site history identifies three phases of redevelopment: the Landfilling of clay pit and construction of large industrial units relating to Coral Park Trading Estate, and the demolition and redevelopment into the existing retail centre. Made Ground and Landfilled ground associated with these redevelopment stages is anticipated and is likely to be similar to the surrounding area in which similar land uses were present.

Material deposited within the landfill was undertaken prior to the 1974 Control of Pollution Act 1974, and therefore was not subject to control by the authority. The clay pit was likely Landfilled from waste material generated in the surrounding area, these included several scrap works, depots, and works, the contents of the landfill are likely to be highly variable. The quantum of domestic waste within the landfill is also unknown. Ground investigation completed within the landfill have generally recorded the fill material as comprising very loose brown, slightly clayey sand with some gravel of varying amounts of limestone, brick, tile, glass, flint, steel, wood, ash and clinker often with pockets of slightly sandy clay. Visual and olfactory evidence of petroleum hydrocarbon contamination was identified, in addition to possible chemical salt deposits (likely associated with off-site gas works) was also identified.

Outside the landfill a relatively thin layer of Made Ground associated with the construction of the various development phases is likely to be present. Previous ground investigations have identified the Made ground as being underlain by a thin deposit of weathered structureless Chalk Formation, underlain in turn by the Gault Clay Formation.

3.4 Controlled Waters

Surface water bodies in the surrounding area include Barnwell Lake (Landfilled clay pit) 150m north east of CRP (Cambridge Retail Park), The River Cam 300m north west of CRP and Cherry Hinton Brook 400m east. Surface water abstraction is absent in the surrounding area.

The Site is underlain by low permeability Made Ground, West Melbury Chalk Formation, and Gault Clay Formation, contaminant migration within these deposits is expected to be heavily restricted. Given the distance to these surface water receptors and intervening potentially contaminated land uses any impact on these receptors is unlikely to be attributable to contaminants originating on-Site.

The EA has classified the hydrogeological status of strata beneath the Site as set out in Table 2.

Table 2: Summary of Hydrogeological Properties of the Main Geological Strata

Stratum	EA Classification	Hydrogeological Significance
Made Ground	Unproductive Strata	Contains insignificant quantities of vertically or laterally extensive groundwater.
River Terrace Deposits	Secondary A Aquifer	May be important in supporting local abstractions
West Melbury Marly Chalk Formation	Principal Aquifer	Regionally important aquifer, likely to be used to support potable abstractions.
Gault Formation	Unproductive Strata	Contains insignificant quantities of vertically or laterally extensive groundwater.



Stratum	EA Classification	Hydrogeological Significance
Lower Greensand Formation	Principal Aquifer	Regionally important aquifer, likely to be used to support potable abstractions.

The Site is not located within a groundwater Source Protection Zone, and active groundwater abstractions are absent on-Site and in the surrounding area.

The Gault Clay Formation is an aquiclude and will restrict the vertical migration of contaminants to the underlying Lower Greensand Formation.

Groundwater flow within the West Melbury Chalk Formation are likely to be influenced by the surface water receptors in the surrounding area, given the absence of groundwater abstractions. Surface water receptors include the smaller Barnwell Lake (northeast), Codhams Brook (east) and Cherry Hinton Brook (east) and the larger River Cam (northwest). The River Cam is therefore expected to be the dominant influence on groundwater flow direction on-Site and in the surrounding area, with a lower effect from the smaller surface waters. Groundwater flow in the West Melbury Chalk Formation is anticipated to be northwest.

3.5 Ground Gas Regime

BRC - Beehive Retail Centre

Significant ground gas generating sources have not been identified on the Beehive Retail Centre. The Made Ground is anticipated to be a thin generally inert deposit and has been in place >25 years. Organic material present in the Made Ground are likely to have degraded and unlikely to be present. Whilst a large landfill was historically present north of the Beehive Retail Centre the lateral migration of ground gas through the cohesive underlying geology is likely to be limited.

230 NMR (230 Newmarket Road) and CRP (Cambridge Retail Park)

Potential exists for a significant ground gas regime requiring ground gas protection measures to be present on 230 NMR and CRP owing to the large historical landfill identified to be present underlying a reasonable portion of 230 NMR and almost all of CRP. A review of the possible ground gas generational potential and underlying geology does however identify the following;

- Material within the landfill has therefore been in place around 50 years during which time readily degradable material is likely to have largely been lost with limited quantities remaining. High levels of ground gas generation within the landfill are unlikely to remain, and a significant ground gas volume is likely to be absent. It is expected whilst high methane concentrations will be recorded within wells installed within the landfill material ground gas flows will be at or approaching zero, identifying a risk of surface emissions as being low. Previous ground investigation ground gas data is largely consistent with this assessment with high ground gas concentrations and no or very low flow rates recorded. The presence of high gas concentrations in the monitoring well are likely being caused by dissolved methane coming out of solution within the monitoring well and accumulating in the monitoring well headspace. Outside of the monitoring well whilst the methane will still come out of solution, however it will only exist in the air spaces immediately above the vadose zone with methane oxidised/diluted above this layer.
- The landfill is founded in the Gault Clay Formation, and a cohesive Made Ground and cohesive low permeability West Melbury Chalk Formation form the shallow and superficial deposits on-Site. Lateral



migration through these deposits will be restricted with and ground gas present in the landfill limited in its lateral migration. Ground gas monitoring as part of previous ground investigations outside the former landfill as generally confirmed this assessment with low ground gas concentrations and flow rates recorded.

Ground gas monitoring as part of the investigations generally confirmed the low ground gas potential
of the Made Ground on-Site outside the former landfill. Made Ground is unlikely to be a significant
ground gas source, however, confirmation of this is required as part of the ground investigation.

3.6 Vapour Regime

BRC - Beehive Retail Centre

Potentially significant vapour sources have been identified on-Site and in the surrounding area and include:

- On-Site Petrol filling station decommissioned in 2003
- Off-site Coldham Model Laundry (250m northeast), petroleum depot (immediately east), Gas works (250m northwest), and various factories and works in surrounding area.

230 NMR (230 Newmarket Road) and CRP (Cambridge Retail Park)

Possible sources of volatile contaminants on-Site and in the surrounding area include;

- Landfill Landfilled by the 1970's in which petroleum hydrocarbon contamination and chlorinated solvents above the laboratory detection limit have been recorded.
- Historic garages in western Site portion (1967 to 1994). Previous reports identify the tanks to have likely have been decommissioned and removed, however confirmation of this was not gained.
- Historic and current industrial land uses surrounding the Site: gas works (24m northwest), garages (40m northeast) and various factories and works in the surrounding area.
- Current and historic tanks (generic) nearest 88m east.
- Obsolete Petrol Station 144m east.
- Coldham Model Laundry (1930's to 1960's) 165m southeast.

3.7 Potentially Significant Pollution Linkages

Potentially significant pollutant linkages identified are as follows;

- Direct contact with contaminants in the Made Ground in soft landscaped areas by future Site users.
- Vapour ingress into the proposed development from potentially contaminated soils and groundwater.
- Potential for contaminated dust to be inhaled by off-site users during redevelopment works.
- Direct contact, ingestion and inhalation of potentially contaminated shallow soils and groundwater by groundworkers and construction workers during redevelopment works.
- Inhalation of vapours by ground workers and construction workers during redevelopment works.
- Mobilisation of contamination to aquifers in the bedrock deposits, notably where piled foundations may penetrate the base of the Gault Clay Formation.



4. Site Activities and Results

The ground investigation scope of works was completed as follows;

- · Beehive Retail Centre
 - 6No. Boreholes to 40mbgl
 - 2No. Ground gas and vapour monitoring, and groundwater level monitoring rounds
 - 1No. Groundwater sample and vapour sample monitoring rounds
- 230 NMR 230 Newmarket Road
 - 4No. Boreholes to 25mbgl
 - 2No. Boreholes to 30mbgl
 - 2No. Ground gas and vapour monitoring, and groundwater level monitoring rounds
 - 1No. Groundwater sample and vapour sample monitoring rounds
- CRP Cambridge Retail Park
 - 4No. Boreholes to 25mbgl
 - 2No. Ground gas and vapour monitoring, and groundwater level monitoring rounds
 - 1No. Groundwater sample and vapour sample monitoring rounds

The ground investigation was undertaken in accordance with the Ground Investigation Specification which should be referred to for a detailed review of the ground investigation methodology. Pertinent details have been included in Section 4 as required only to avoid repetition between documents.

Deviations to the ground investigation specified did not occur.

4.1 Ground Conditions

Geology encountered during the ground investigation is summarised in Table 3.

Table 3: Geology

Strata	Typical Thickness (m)	s Description	
230 NMR – 230 Newmarket Road			
Concrete/Tarmac	0.1	Tarmac or Concrete	
Made Ground and Landfill	1.3 to 1.9	Dark brown sandy clayey angular to subangular fine	
	(Up to 9.9 in Landfilled area encountered at WBH105)	to coarse gravel of mixed lithologies including chert, concrete and slag with moderate cobble content of concrete, brick and plastic. Sand is medium to coarse.	
	,	Encountered down to 10m depth in former gravel pit areas	
West Melbury Formation	2.3 to 4.0	Structureless chalk composed of light brown cream gravelly clay. Clasts are weak low density angular to subrounded.	



Strata	Typical Thickness (m)	Description
Gault Clay Formation	>25.8	Dark grey laminated clay
CRP - Cambridge Retail Park		
Concrete/Tarmac	0.1 to 0.27	Tarmac or Concrete
Made Ground and Landfill	0.8 to 4.33	Black clayey sandy angular to subangular fine to
	(Up to 9.4 in Landfilled area encountered at WBH108)	coarse gravel of mixed lithologies including brick. Sand is fine to medium. Contains ceramic, cloth, wood, metal, wire, copper and plastic.
West Melbury Formation	0.6 to 2.0 (Absent in WBH108)	Structureless chalk composed of cream/mottled brownish/yellow gravelly clay with bands of dark grey black silty organic clay. Clasts are weak low density subrounded of chalk and occasional chert. Occasional shells present.
Gault Clay Formation	>22.5	Dark grey silty laminated clay
Beehive Retail Centre		
Concrete/Tarmac	0.1 – 0.3	Tarmac or Concrete
Made Ground	0.1 – 2.5	Light brown/brown silty sandy gravelly clay/sandy gravelly clay. Gravel of subangular to angular fine to coarse chalk, and flint. Fragments of brick and concrete present
River Terrace Gravels	4.65 (Located solely in WBH113 (SW corner))	Light brown gravelly medium to coarse sand (1.75m thick) underlain by a light brown light grey gravelly very sandy clay (2.9m thick)
West Melbury Formation	0.4 – 6.65	Structureless chalk comprised of cream/cream mottled brown gravelly silty clay with low to moderate cobble content.
Gault Clay Formation	>35.8	Dark grey laminated clay

Beehive Retail Centre

Ground conditions recorded at the Beehive Retail Centre are consistent with the anticipated strata. Made Ground consistent with the demolition arisings from previous developments and creation of a working platform overlies a structureless West Melbury Formation, which is in turn underlain by the Gault Clay Formation. The depth of the interface between the Chalk Formation and Gault Formation is generally consistent across the Site, varying dependent on the thickness of the overlying Made Ground.

Within WBH113, 4.65m thickness of River Terrace Gravels were identified consistent with the location of a historical mineral quarry adjacent the Site to the north. The underlying West Melbury Formation was recorded at 0.3m thick.

Both the Chalk Formation and Gault Formation are cohesive deposits through which the lateral and vertical migration of contaminants will be limited.



230 NMR

Ground conditions encountered were generally similar to the adjacent Beehive Retail Centre and CRP, however the River Terrace Deposits were not encountered.

At WBH105 situated in an area of Landfilled former quarry, the Made Ground encountered extended to 9.9m depth as Landfill material.

CRP

As with 230 NMR and Beehive Retail Centre geology encountered was consistent. At WBH108, situated in an area of Landfilled former quarry, the Made Ground encountered extended to 9.5m depth as Landfill, and the underlying West Melbury Formation was absent.

4.2 Historical Landfill information

Geological and historical records indicate the lateral extent of the landfill to occupy the eastern section of 230 NMR, and the centre to south-eastern sections of the CRP. The landfill base and sides are located within the Gault Clay Formation, the lateral and vertical migration of contaminants, ground gas and vapour will therefore be limited.

4.3 Controlled Waters

4.3.1 Groundwater Level

Two rounds of groundwater level monitoring has been completed across the Site. The groundwater level monitoring results and well details are included in Table 4.

Table 4: Groundwater Levels

				Groundwa	ter Level		
Area	Exploratory Hole	Target Strata	Response Zone (mbgl)	mbgl	mAOD	mbgl	mAOD
	Tiole		Zone (mbgi)	Round 1		Round 2	
	WBH101	Made Ground and West Melbury Formation	2.0 to 6.0	2.49	8.93	3.2	8.22
	WBH102	West Melbury Formation	1.0 to 4.0	2.5	7.93	2.25	8.18
000	WBH103	Made Ground	1.0 to 2.0	Dry		Dry	
230 NMR	WBH104 (deep)	Made Ground / Landfill	4.0 to 16.0	2.01	7.61	1.89	7.73
	WBH105 (deep)	Made Ground / Landfill	4.0 to 6.0	2.2	7.47	2.17	7.50
	WBH106	Made Ground and West Melbury Formation	1.0 to 4.0	Dry		Dry	



WBH107 West Melbury Formation 2.0 to 4.0 1.13 8.42 1.67 WBH108 (deep) Made Ground / Landfill 4.0 to 9.5 1.51 7.42 1.48 WBH109 Made Ground, Vest Melbury Formation and Coult Clay 3.0 to 9.0 2.49 6.82 2.67	7.88 7.45 6.64
(deep) Landfill WBH109 Made Ground, West Melbury Formation and 3.0 to 9.0 2.49 6.82 2.67	
CRP West Melbury Formation and	6.64
Gault Clay Formation	
WBH110 Made Ground and 1.0 to 2.0 Dry Dry West Melbury Formation	
WBH111 West Melbury 1.0 to 6.0 0.39 11.25 0.97 Formation	10.67
WBH112 West Melbury 1.0 to 6.0 3.16 8.54 2.95 Formation	8.75
WBH113 River Terrace 1.0 to 7.0 4.09 8.72 3.99 Deposits and Beehive Gault Clay Retail Formation	8.82
Centre WBH114 West Melbury 2.3 to 5.5 3.16 8.86 3.54 (deep) Formation	8.48
WBH115 West Melbury 1.0 to 4.0 2.13 7.84 3.54 Formation	6.43
WBH116 Made Ground and 1.0 to 5.0 1.93 7.63 1.95 West Melbury Formation	7.61

A review of groundwater levels records a north eastern groundwater flow direction identifying the Cherry Hinton Brook and Coldham Brook as being the dominant influence on groundwater flow direction. The Cherry Hinton Brook and Coldham Brook are 350m and 530m north east respectively. A signficant difference in groundwater levels in boreholes installed in the landfill and those in River Terrace Deposits and Chalk Formation is absent.

4.3.2 Groundwater Samples

Two rounds of groundwater sampling were completed in December 2022 and January 2023.

Samples were collected using low-flow methods with groundwater parameters recorded until stabilisation, prior to taking the sample at each well.

Recorded stabilisation parameters at each well were as follows:

- Conductivity (µS/cm)
- Salinity (PSU)
- Density (g/cm³)



- RDO Concentration (mg/L)
- pH (pH units)
- Oxidation-Redox potential (mV)
- Turbidity (NTU)
- Temperature (°C)

Low flow certificates and groundwater laboratory results are included in Appendix B.

4.4 Ground Gas

Two ground gas monitoring rounds were completed alongside the groundwater monitoring. A full record of the ground gas monitoring results is included in the contractor factual report in Appendix B.

4.4.1 Ground Gas Monitoring Results Summary

Monitoring wells create an artificial environment from which to record ground gas concentrations, as with all aspects of contaminated land assessment the ground gas monitoring results should reviewed alongside other lines of evidence to determine the ground gas regime. Several factors may influence ground gas concentrations recorded which may result in unrepresentative monitoring results. As per best practice unrepresentative monitoring results have been excluded from further consideration.

Groundwater

Where groundwater is present in the monitoring well dissolved methane present in the groundwater will preferentially partition from the water to the air until an equilibrium in the well headspace is reached. The methane will be trapped in the well headspace until the next monitoring event when it will be sampled/monitored giving rise to high methane concentrations. The trapping of the gas in the well headspace is 100% effective when the response zone of the well is flooded. Outside a well methane will also partition out into the soil air space, however in the soil outside the well the methane will be oxidised/diluted as it migrates upwards in the soil profile, and a high methane concentration will exist only in the soil air spaces immediately above the groundwater. Thus, the overall methane concentration will be a substantially lower in the unsaturated zone than in the monitoring well headspace where groundwater is present. This effect is further increased when high dissolved methane concentrations are present, potentially caused by hydrocarbon degradation in the ground, carbon dioxide reduction, and within anaerobic groundwater environments.

Petroleum Hydrocarbons

- The degradation of petroleum hydrocarbons in a well headspace caused by the influx of oxygen during installation and monitoring can create high concentrations of carbon dioxide and methane. The degradation process occurs at slow rates and the resultant volume of hydrocarbons present in the well headspace is generally small, resulting in low methane and carbon dioxide volumes being generated. Within the relatively small well headspace volume the low methane and carbon dioxide volumes present are exaggerated giving high methane and carbon dioxide concentrations when monitored. In these situations, whilst a high concentration, is recorded in the monitoring well it relates to only a small ground gas volume and is unrepresentative of the ground gas risk to future built structures.
- Initial high concentration



An initial high concentration of carbon dioxide/methane during the first monitoring round can be caused by the release of trapped previously generated methane pockets in the soil matrix caused by the boreholes being drilled. Once released the pockets of trapped gas are depleted and are not replenished owing to the low ground gas generation potential of the material. In addition, the aerobic conditions created in the well annulus through the borehole drilling may catalyse the breakdown of organic material and temporarily result in an increase in carbon dioxide. In these circumstances once the oxygen is depleted the high organic matter degradation rates decrease along with the carbon dioxide. The initial high concentrations of methane/carbon dioxide may therefore not be representative of normal ground gas regime in a monitoring well.

Infrared analysers

 Ground gas concentrations were monitored using an infrared bulb which can be influenced by petroleum hydrocarbon vapours leading to high methane concentrations which are unrepresentative of methane concentrations.

A full record of the ground gas monitoring results is included in Appendix C.

A summary of the representative ground gas monitoring results across both Site visits completed is included in Table 5.

Table 5: Ground Gas Monitoring Summary

	Exploratory Hole		Steady Concentration Range (% v/v)		Steady Range (I/hr)
Area		Target Strata	Methane	Carbon Dioxide	Flow Rate
	WBH101	Made Ground and West Melbury Formation	<0.1	0.1 to 0.2	<0.1
	WBH102	West Melbury Formation	<0.1	0.2 to 0.8	<0.1
	WBH103	Made Ground	<0.1 - 0.1	0.2	<0.1
230 NMR	WBH104 (shallow)	Made Ground / Landfill	12.3	7.3	<0.1
	WBH105 (shallow)	Made Ground / Landfill	14.8 to 45.7	1.1 to 14.7	0.7 to 1.2
	WBH106	Made Ground and West Melbury Formation	<0.1	0.7 to 1.1	<0.1
CRP	WBH108 (shallow)	Made Ground / Landfill	0.2 to 1.6	0.1 to 3.1	<0.1
CRP	WBH110	Made Ground and West Melbury Formation	<0.1	4.9 to 5.1	<0.1
	WBH112	West Melbury Formation	<0.1	<lod 0.4<="" td="" to=""><td><0.1</td></lod>	<0.1
230 NMR	WBH113	River Terrace Deposits and Gault Clay Formation	<0.1	0.1 to 0.5	<0.1



	Exploratory		Steady Concentration Range (% v/v)		Steady Range (I/hr)
Area	Hole	Target Strata	Methane	Carbon Dioxide	Flow Rate
	WBH114 (shallow)	Made Ground	<0.1	0.2 to 0.6	<0.1
	WBH115	West Melbury Formation	<0.1	0.2 to 0.8	<0.1
	WBH116	Made Ground and West Melbury Formation	<0.1	0.1 to 0.5	<0.1

Ground gas monitoring results from WBH104D, WBH105D, WBH107, WBH108D, WBH109, and WBH111 have not been assessed further given the response zone was wholly flooded preventing the gaining of representative ground gas monitoring results.

Figure 2 details the methane ground gas concentrations recorded in wells installed in landfill deposits, Made Ground, and Chalk. Methane concentrations in flooded monitoring wells unrepresentative of the ground gas regime is circled Green.

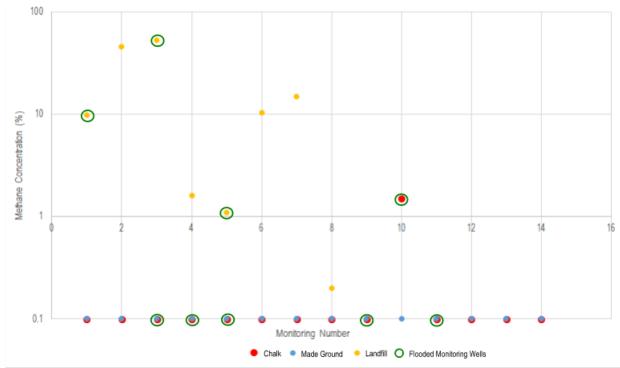


Figure 2: Methane ground gas concentrations

Figure 2 identifies a clear difference in ground gas concentrations in those wells installed in the landfill compared to those installed outside landfill deposits is present. The results show lateral ground gas migration of high gas concentrations from the landfill to adjacent ground is absent. The restriction in lateral ground gas migration is potentially due to absence of a large ground gas volume as identified from the minimal ground gas flow rates, and the low permeability Gault Clay Formation, cohesive Made



Ground, and Structureless Chalk deposits encountered. The ground gas monitoring results are consistent with the desk based assessment in which a significant ground gas generating source is absent.

4.4.2 Ground Gas Sampling Results Summary

A single round of ground gas sampling was completed at available wells in January 2023. Samples were tested for gas constituents (carbon dioxide, carbon monoxide, hydrogen, methane, nitrogen and oxygen), and VOCs.

A summary of results relevant to ground gas are set out in Table 6.

Table 6: Ground Gas Sampling Results Summary

Area	Exploratory Hole	Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)
	WBH102	<0.1	0.53	17.4
230 NMR	WBH103	<0.1	0.07	20.4
	WBH106	<0.1	0.78	17.6
CRP	WBH109	<0.1	0.10	20.6
BRC	WBH111	<0.1	0.07	20.6
	WBH112	<0.1	<0.1	20.8
	WBH113	<0.1	0.37	20.2
	WBH114S	<0.1	0.12	20.6
	WBH116	<0.1	<0.1	20.7

4.4.3 TOC Analysis

Total Organic Carbon (TOC) analysis was undertaken on Made Ground samples from across all areas of the Site, and Landfill samples collected from the former gravel pit area. Whilst forensic description of the Made Ground was not undertaken the relative homogeneity of the Made Ground, and absence of bulk material typically associated with domestic landfills (wood, branches, textiles, cloth, vegetable matter etc) indicates the TOC fractions recorded are representative of the material.

230 NMR - 230 Newmarket Road

TOC values for samples collected at 230 NMR ranged from 0.3% to 4.31%, with an average of 1.67%.

CRP - Cambridge Retail Park

TOC within samples from the CRP ranged between 0.3% and 1.82%, with an average of 0.84%.

BRC - Beehive Retail Centre

TOC ranged from 0.11% to 3.2% with an average of 0.68%.

Across each of the three areas of the Site, TOC values recorded were not elevated significantly. As detailed in BS8485 (2015+A12019) and in the 2012 CL:AIRE RB17 document a TOC concentration of around 1.0% as consistent with a CS1 classification.



In several of the samples petroleum hydrocarbon contamination was also recorded which is likely to have skewed the TOC concentrations from the proportion of readily degradable material in the soil which would be present and would contribute to significant ground gas generation.

The relatively low TOC Concentration is consistent with a Made Ground which has a low ground gas generation potential. This is supported by low flow rates being recorded, with an overall trend of flow rates below the equipment's detection limit. This shows while low levels of carbon dioxide and methane may be present in the soil pore space current ground gas generation is not sufficient to create a positive pressure in the well. The reason significant ground gas generation is not occurring is due to the lack of degradable material.

4.5 Vapours

The Site's vapour regime will be assessed through multiple lines of evidence using visual observations during the intrusive works, vapour monitoring, volatile soil and groundwater laboratory analysis, and vapour sample results. A qualitative review of the ground investigation data is included below.

4.5.1 Visual and Olfactory Contamination

During ground works evidence for hydrocarbon contamination was recorded at three exploratory holes

- Hydrocarbon odour and solvent odours in Made Ground at WBH108 (CRP area) between 8.0m bgl and 8.5m bgl (within landfilled former quarry area);
- Strong hydrocarbon odour in Made Ground within WBH104 (230 NMR) between 8.0m bgl and 13.0m bgl (within landfilled former quarry area);
- Solvent odour in West Melbury Formation chalk at WBH111 (BRC area) between 0.5m bgl and 2.5m

The visual and olfactory evidence of contamination identifies solvent odour within the West Melbury Chalk Formation on BRC in the south east corner, and a petroleum hydrocarbon odour within the base of the landfill material located on 230 NMR and CRP area.

4.5.2 Soil Laboratory Analysis

A review of the petroleum hydrocarbon carbon distributions records the majority as being within the long chain aliphatic and aromatic carbon bands (aliphatic C21 – C35, aromatic C16 – C21, aromatic C21 – C35, aromatic C35 – C44). These long chain carbon bands have a low volatility and are unlikely to pose a significant vapour risk. The highest petroleum hydrocarbon concentrations were generally recorded within the landfill with lower concentrations within the Made Ground.

4.5.3 Groundwater Laboratory Analysis

Benzene, toluene, ethyl benzene, and xylene above the laboratory detection limit are detailed in Table 7.



Table 7: Groundwater BTEX Concentrations Summary

Site Area	Monitoring Well	Maximum concentration recorded (μg/l)						
Aica		Total TPH	Benzene	Toluene	Ethylbenzene	Xylenes		
CRP	WBH107	<lod< td=""><td>0.6</td><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<>	0.6	<lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""></lod<></td></lod<>	<lod< td=""></lod<>		
	WBH108	81	3.9	<lod< td=""><td>2</td><td>3</td></lod<>	2	3		
	WBH111	1,459	1,081.8	94	<lod< td=""><td>876</td></lod<>	876		
BRC	WBH112	<lod< td=""><td>1</td><td><lod< td=""><td><lod< td=""><td>2</td></lod<></td></lod<></td></lod<>	1	<lod< td=""><td><lod< td=""><td>2</td></lod<></td></lod<>	<lod< td=""><td>2</td></lod<>	2		
Ä.	WBH113	14	2.1	<lod< td=""><td>3</td><td>5</td></lod<>	3	5		
	WBH114D	<lod< td=""><td>0.7</td><td><lod< td=""><td>1</td><td>2</td></lod<></td></lod<>	0.7	<lod< td=""><td>1</td><td>2</td></lod<>	1	2		

4.5.4 Vapour Monitoring Results

Follow-up vapour testing was completed at all monitoring wells using a photoionization detector (PID). Peak values were not recorded above 2.3ppm at any of the three areas of the Site, across both the monitoring visits.

Hydrocarbon concentrations as BTEX and speciated TPH were recorded as part of ground gas sampling undertaken across the Site in January 2023. The works identified elevated benzene, toluene and xylene concentrations across all monitoring wells, along with raised volatile hydrocarbons. Table 9 summarises the principal hydrocarbon findings from this sampling.

Table 8: Vapour Sampling Results Summary

Area		Maximum concentration recorded (µg/m³)						
	Monitoring Well	Sum of volatile TPH	Benzene	Toluene	Ethyl- benzene	Xylenes		
	WBH102	1729.1	78.3	20	<lod< td=""><td>10</td></lod<>	10		
230 NMR	WBH103	921.5	29.7	15.4	<lod< td=""><td>7.8</td></lod<>	7.8		
	WBH106	1,585.9	70.9	28.3	<lod< td=""><td>10</td></lod<>	10		
CRP	WBH109	3,108.6	119.8	20	<lod< td=""><td>10</td></lod<>	10		
BRC	WBH111	104,463.3	1526	70.8	23	35.6		
	WBH112	13.4	<lod< td=""><td>10.6</td><td><lod< td=""><td>6.9</td></lod<></td></lod<>	10.6	<lod< td=""><td>6.9</td></lod<>	6.9		
	WBH113	89.3	<lod< td=""><td>19.2</td><td><lod< td=""><td>13.9</td></lod<></td></lod<>	19.2	<lod< td=""><td>13.9</td></lod<>	13.9		
	WBH114S	14.8	<lod< td=""><td>11.7</td><td><lod< td=""><td><6.5</td></lod<></td></lod<>	11.7	<lod< td=""><td><6.5</td></lod<>	<6.5		
	WBH116	144.4	<lod< td=""><td>25.6</td><td>7.4</td><td>39.9</td></lod<>	25.6	7.4	39.9		



5. Human Health Risk - Soil

5.1 Generic Assessment Criteria – Soil

The proposed Development will be commercial across the entirety of the Beehive Retail Centre, 230 NMR and Cambridge Retail Park areas of the Site. Decorative soft landscaping is proposed at 230 NMR, whilst landscaping at BRC will be communal amenity space.

Given the proposed soft landscaping use on 230 NMR, Generic Assessment Criteria (GAC) for land with a proposed commercial end-use have been used to assess the risk. Considering the proposed soft landscaped amenity space at the Beehive Retail Centre, assessment criteria for Public Open Space close to Residential Housing (POSRESI) have been selected to assess the risk at this section of the Site.

Where there are exceedances of the GAC, further assessment has been undertaken to assess whether the Site and its proposed Development specifically would still indicate a risk.

Off-site Residents and Users

Residential housing bounds the Site. The risk to receptors in the surrounding area has been assessed through analysis of soil, groundwater, and vapour levels, and their potential for migrating off-site.

Construction Workers

Quantitative risk assessment criteria have not been developed for construction workers. As such, a qualitative assessment has been completed.

5.2 Quantitative Risk Assessment - Soil

Soil Chemical Results

Soils results collected from the Made Ground, Landfill material, West Melbury Formation and Gault Clay Formation were compared against assessment criteria for commercial land with an average 1% soil organic matter (SOM). SOM values were calculated for the Made Ground/Landfill material at each section of the Site, as follows:

Table 9: Soil Organic Matter Averages and Ranges

Site Area		SOM (%)	
	230 NMR	CRP	BRC
Average	2.87%	1.44	1.6
Range	0.5 to 7.4	0.5 to 3.1	<0.2 to 5.5

A SOM value of 1% was used for underlying natural strata based on an aggregation of the results for these strata.

Assessment of the soil laboratory results against relevant criteria did not identify any contaminant exceedances at the 230 NMR and Cambridge Retail Park areas of the Site.

At the Beehive Retail Centres, concentrations of some PAHs were recorded above the POS_{RESI} GAC at WBH116, detailed in Table 11.



Table 10: Soil Laboratory Result Exceedances

Exploratory Hole BRC	Depth (m bgl)	Determinant	Concentration (mg/kg)	GAC (mg/kg)
		Benzo(b)fluoranthene	9.84	7.10
WBH116	0.5	Benzo(a)pyrene	5.90	5.70
		Di-benzo(a.h.)anthracene	0.75	0.57

Asbestos Fibres

No visual evidence for fragments of asbestos or asbestos containing materials (ACMs) was identified during the ground investigation works. However, at laboratory stage several Made Ground/Landfill samples collected from the 230 NRM and Cambridge Retail Park sections of the Site were identified as contaminated with asbestos as follows:

Table 11: Identified Asbestos

Exploratory Hole	Depth (m bgl)	Asbestos Type	Quantification (%)					
230 NMR – 230 Newmarket Road								
WBH101	0.6	Chrysotile traces	<0.001					
WBH103	1.6	Chrysotile free fibres and bitumen products	<0.001					
WBH104	1.0	Chrysotile and amosite fibre bundles	<0.001					
WBH105	4.0	Chrysotile fibre bundles	<0.001					
CRP - Cambridge Retail Park								
WBH107	1.5	Chrysotile fibre bundles	<0.001					

Asbestos was not identified in any of the samples collected from the BRC.

Risks to Future Site Users - 230NMR

Elevated contaminants have not been recorded, however asbestos fibres have been recorded. In the absence of suitable mitigation measures a risk to future human health receptors will be present. In areas of hardstanding the future site users will be restricted from coming into direct contact with the identified asbestos contamination breaking the pollutant linkage. In areas of proposed soft landscaping a cover layer of suitable thickness utilising certified clean topsoil and subsoil will be required to ensure future Site users are unable to come into direct contact with contaminants and the pollutant linkage will be broken. The cover layer will require construction of imported material given the absence of suitable material onsite. Threshold criteria will require development for the imported material to ensure it does not pose a risk to future Site users post importation.



Risks to Future Site Users - CRP

Elevated contaminants have not been recorded, however asbestos fibres have been recorded in the Made Ground. The proposed Development for the CRP will largely be retained with minimal structural alterations intended only, the exception to this being the extension of the existing Currys (northern Sin portion of CRP), and possible new Development on the southern section of CRP. In areas of new and proposed hardstanding the future site users will be restricted from coming into direct contact with the identified asbestos contamination breaking the pollutant linkage. In areas of proposed soft landscaping a cover layer of suitable thickness utilising certified clean topsoil and subsoil will be required to ensure future Site users are unable to come into direct contact with contaminants and the pollutant linkage will be broken. The cover layer will require construction of imported material given the absence of suitable material on-site. Threshold criteria will require development for the imported material to ensure it does not pose a risk to future Site users post importation.

Risks to Future Site Users - BRC

Elevated contaminants have been recorded. In the absence of suitable mitigation measures a risk to future human health receptors will be present. In areas of hardstanding the future site users will be restricted from coming into direct contact with the identified asbestos contamination breaking the pollutant linkage. In areas of proposed soft landscaping a cover layer of suitable thickness utilising certified clean topsoil and subsoil will be required to ensure future Site users are unable to come into direct contact with contaminants and the pollutant linkage will be broken. The cover layer will require construction of imported material given the absence of suitable material on-site. Threshold criteria will require development for the imported material to ensure it does not pose a risk to future Site users post importation.

development for the imported material to ensure it does not pose a risk to future Site users post importation.

Risks to Off-site Human Health Receptors

Proposed development construction may include earthworks, with stockpiling of excavated Made Ground possible. This has the potential to cause potentially contaminated dust and asbestos fibres to become airborne, or be mobilised through runoff during rainfall events.

To mitigate this risk, mitigation measures will be required throughout the development construction, notably during earthworks to minimise the creation and migration of contaminants or asbestos fibres. Details on how this will be managed during enabling works will be set out in a Construction Environmental Management Plan (CEMP).

As identified during the previous remediation works and as established from the ground investigation, potentially odorous material may be exposed during enabling works. Whilst the odour is unlikely to pose a significant risk to surrounding receptors it may pose a nuisance, which will require management to minimise odours as far as is reasonably practicable.

Risks to Construction Workers

Asbestos present in the Made Ground and Infill poses a risk to construction workers if robust health and safety measures are not employed. All construction works should be undertaken under a risk assessment which accounts for the ground conditions identified during previous remedial work and subsequent ground investigations. In addition, all works should be completed in accordance with the Control of



Asbestos Regulations 2012 (CAR 2012) and an Asbestos Plan of Work completed and kept up to date as a live document throughout the works. Workers should be provided with personal protective equipment (PPE) where necessary.



6. Human Health Risk - Vapours

6.1 Generic Assessment Criteria - Vapours

The risk from vapours to future Site users has been assessed qualitatively through using soil headspace analysis, the VOC laboratory testing of soils and groundwater, and results of two rounds of ground gas and vapour sampling.

A quantitative assessment has been completed through comparison of the groundwater sample results against the Society of Brownfield Risk Assessment (SoBRA) derived vapour GAC (VAP_{GW}), and through comparison of vapour sample results against calculated modified Health Criteria Values (HCV) for a commercial end use in accordance with CIRIA C682.

The SoBRA VAP_{GW} builds in several precautionary assumptions into its model, including;

- No biodegradation is occurring between the source term, and the receptor;
- The groundwater is at 0.65mbgl;
- The subject geology is a sandy stratum; and
- The omission of capillary fringe between the saturated and unsaturated zones.

Given the differences in the proposed Development and ground conditions on-Site relative to the SoBRA model, the geological and hydrogeological conditions comparison of the groundwater results against the SoBRA VAP_{GW} will be conservative.

The calculated modified HCV for the inhalation exposure pathway will be derived from either a Tolerable Daily Intake (TDI) for threshold compounds (non-carcinogenic) or an Index Dose (ID) for non-threshold compounds (carcinogenic), Where TDI for soil are not available, the TDI for inhalation/oral pathways will be used.

In accordance with CIRIA C682 the identified TDI/ID will be modified into an acceptable air concentration (μ g/m³) to allow comparison against the vapour phase concentration. The most sensitive end use is commercial, which will therefore be used to assess the risk. A female adult receptor of weight 70kg and inhalation rate of 14.8m³/day will therefore be used in the modified HCV calculations.

Direct assessment of the vapour sampling results against the mHCV will be a conservative assessment with several factors not accounted for including the dispersion and degradation of vapours in the vadose aerobic zone, and the physical barrier the proposed development would provide. Direct assessment against the mHCV will provide an indication of which contaminants may pose a significant vapour risk to future proposed built structures.

Vapour results for samples collected across all three areas of the Site are summarised against GAC in Table 13. Values exceeding GAC are highlighted in red.



Table 12: Summary of Vapour Sampling Results Against Inhalation GAC.

Determinant	Inhalation GAC	230 NMR		CRP	BRC					
	GAC	WBH102	WBH103	WBH106	WBH109	WBH111	WBH112	WBH113	WBH114S	WBH116
1,2- Dichloroethane	0.57	<lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>25.9</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td><lod< td=""><td>25.9</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td>25.9</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td>25.9</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	25.9	<lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""></lod<></td></lod<>	<lod< td=""></lod<>
Benzene	6.62	78.3	29.7	70.9	119.8	1,526	<lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""></lod<></td></lod<>	<lod< td=""></lod<>
Trichloroethene	2.7	<lod< td=""><td><lod< td=""><td><lod< td=""><td>13.4</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td>13.4</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td>13.4</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	13.4	<lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td><lod< td=""></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""></lod<></td></lod<>	<lod< td=""></lod<>
Toluene	6,615.41	20	15.4	28.3	20	70.8	10.6	19.2	11.7	25.6
Ethylbenzene	350.16	<lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>23</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>7.4</td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td><lod< td=""><td>23</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>7.4</td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td>23</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>7.4</td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td>23</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>7.4</td></lod<></td></lod<></td></lod<></td></lod<>	23	<lod< td=""><td><lod< td=""><td><lod< td=""><td>7.4</td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td>7.4</td></lod<></td></lod<>	<lod< td=""><td>7.4</td></lod<>	7.4
m/p-Xylene	276.76	10	7.8	10	10	35.6	6.9	13.9	<lod< td=""><td>39.9</td></lod<>	39.9
o-Xylene	276.76	<lod< td=""><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>18.7</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>14.8</td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td><lod< td=""><td>18.7</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>14.8</td></lod<></td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td>18.7</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>14.8</td></lod<></td></lod<></td></lod<></td></lod<></td></lod<>	<lod< td=""><td>18.7</td><td><lod< td=""><td><lod< td=""><td><lod< td=""><td>14.8</td></lod<></td></lod<></td></lod<></td></lod<>	18.7	<lod< td=""><td><lod< td=""><td><lod< td=""><td>14.8</td></lod<></td></lod<></td></lod<>	<lod< td=""><td><lod< td=""><td>14.8</td></lod<></td></lod<>	<lod< td=""><td>14.8</td></lod<>	14.8
Aliphatic >C6-C8	11,824.32	822	434	679	1,346	23,754	<41	<41	<41	<41
Aliphatic >C8-C10	685.81	<53	<53	<53	<53	<53	<53	<53	<53	<53
Aliphatic >C10- C12	685.81	<65	<65	<65	<65	<65	<65	<65	<65	<65
Aromatic >C5-EC7	6,608.11	78.3	29.7	70.9	119.8	1,526	<4.8	<4.8	<4.8	<4.8
Aromatic >C7-C8	6,586.49	20	15.4	28.3	20	70.8	10.6	19.2	11.7	25.6
Aromatic >C8-C10	141.89	<49	<49	<49	<49	118	<49	54	<49	93

6.2 Quantitative Risk Assessment - Vapours

230 NMR Vapour Risk Assessment

Results of soil sampling undertaken across the 230 NMR area identified elevated TPH concentrations within the Made Ground at location WBH103 up to 1,745mg/kg, along with slightly raised levels in WBH101, WBH104 and WBH105. Groundwater samples collected from locations WBH101 to WBH105D recorded elevated concentrations of PAHs, however none exceeding SoBRA assessment values for vapour emissions risk.

Vapour field measurements collected from monitoring wells using a PID as part of ground gas sampling did not record any evidence for vapour emissions to surface, with a peak of 2.3ppm.

Vapour sampling found elevated benzene, raised toluene and short chain fractions of TPH in all locations sampled. Results from vapour samples collected at WBH102, WBH103 and WBH106 were compared against inhalation criteria for a commercial development, with benzene concentrations exceeding this GAC at all locations.

These initial lines of evidence examined indicate a potential vapour risk is present across the 230 NMR area of the Site. Further ground investigation and detailed assessment will be necessary to examine the potential for vapour risk to the proposed future development in this area, and inform the potential remediation or mitigation measures necessary to break this linkage to future receptors. Its noted the direct assessment against the mHCV is a conservative assessment which does not account for a number of factors which would potentially prevent signficant vapour concentrations as being recorded.



Cambridge Retail Park (CRP) Vapour Risk Assessment

Soil sampling in the north and southern extents of the CRP identified elevated TPH concentrations in the Made Ground and Landfill at all exploratory hole locations, up to a maximum of 1,447mg/kg in WBH108 in the far south of the Site. Elevated PAHs were detected in groundwater samples collected from WBH108 and WBH109, however these did not exceed SOBRA criteria.

Field monitoring for vapours did not record any concentration exceeding the equipment LOD. A vapour sample collected from WBH109 identified elevated benzene above inhalation GAC, along with slightly elevated xylene and toluene below the inhalation criteria. Trichloroethene was also recorded slightly above this GAC at WBH109.

Proposed development includes construction of an extension to the existing Curry's in the location of borehole WBH109 and potential for new development construction in the southern extent of CRP in the current location of WBH107 and WBH108. The vapour results indicate a potentially signficant vapour regime is present in areas of new development Further ground investigation and detailed assessment will be necessary to examine the potential for vapour risk.

It is understood the existing units on CRP are installed with a gas protection system which is likely to provide sufficient protection to the elevated vapour concentrations recorded.

Beehive Retail Centre Vapour Risk Assessment

Soil samples from the BRC area recorded elevated TPH in the Made Ground and Landfill at WBH114 up to 289mg/kg, and in the Made Ground at WBH116 at 383mg/kg. Elevated PAHs were detected in groundwater at WBH111, WBH114D and WBH116, with elevated TPH up to 1,459µg/l also recorded at WBH111. However, none of the groundwater results exceeded the relevant SOBRA criteria.

Vapour field monitoring did not record any concentrations above LOD. Vapour sampling recorded significantly elevated benzene and TPH aliphatic C6-C8 at WBH111 above vapour inhalation assessment criteria. Elevated TPH, and slightly elevated xylene and toluene were also recorded in vapour samples for all monitoring locations across the BRC, however not at concentrations exceeding the vapour inhalation GAC.

Overall review of the lines of evidence for the BRC indicate a signficant vapour regime is absent for the majority of the BRC, however around the petroleum hydrocarbon hotspot identified in results from WBH111 (southern Site corner) a potentially signficant vapour regime is present. Further ground investigation and detailed assessment will be necessary to examine the potential for vapour risk to the proposed future development close to WBH111, and inform the potential remediation or mitigation measures necessary to break this linkage to future receptors.



7. Human Health Risk - Ground Gas

7.1 Generic Assessment Criteria – Ground Gas

The ground gas risk has been assessed utilising the results of TOC testing from soil sampling, and ground gas monitoring results.

The TOC concentrations will be assessed in accordance with the requirements of CLAIRE Research Bulletin, November 2012, A Pragmatic Approach to Ground Gas Risk Assessment as an additional line of evidence to support the ground gas monitoring data.

The ground gas monitoring results will be assessed through calculation of the Site's Gas Screening Value (GSV) in accordance with the CIRIA C665. At all stages in the assessment only ground gas monitoring results representative of the Site's ground gas regime will be used.

7.2 Quantitative Risk Assessment - Ground Gas

As identified in the CL:AIRE 2012 RB17 guidance document and CIRIA C665 ground gases only pose a risk to developments when the following can be satisfied, which is in line with source – pathway – receptor model followed by LCRM.

- An accumulation of a large volume of gas in the ground in or near the buildings (source).
- A pathway that allows gas to migrate through and/or out of the ground into a building or other structure sufficiently quickly to allow it to build up inside the building (pathway).
- A confined space within the building or structure where gas can build up to unacceptable levels (receptor).

For a risk from ground gases a source – pathway – receptor linkage needs to be present. This requires sufficient gas to pose a hazard and one or more pathways by which it may cause significant harm to people. For sustained gas migration to occur gas must be replenished at the source to negate the effects of attenuating factors such as oxidation of the methane/carbon dioxide to oxygen in the aerobic zone or low permeability soils decreasing the migration potential. Therefore, sustained high levels of gas generation are required for ground gas to migrate via advective or diffusive flow and cause high ground gas concentrations at the surface/within built structures. The volume of ground gas is therefore the principal factor which should be considered rather than the ground gas concentration present in the ground (or monitoring well) which is commonly mistaken as posing a risk to future Site users.

230 NMR Ground Gas Risk Assessment

230 NMR is underlain partly by landfill deposits and partly underlain by cohesive Made Ground Deposits and low permeability structureless Chalk Deposits. The low permeability Gault Clay Formation underlies the Chalk outside the landfill, and directly underlies the landfill. Ground gas concentrations in boreholes relevant to 230 NMR and representative of the ground gas regime record the following maximum Q_{HG} (borehole hazardous gas flow rate) within and outside the landfill;

- Q_{HG} Outside the landfill methane 0.0001l/hr, carbon dioxide 0.0011 l/hr
 - Characteristic Situation 1
- Q_{HG} Within the landfill methane 0.32l/hr, carbon dioxide 0.10l/hr
 - Characteristic Situation 2



The ground gas monitoring results for 230 NMR identify in areas outside the landfill a CS1 classification (very low risk – no ground gas protection measures) would be relevant, in areas within the former landfill a CS2 classification (low risk – basic ground gas protection measures) would be relevant. The ground gas monitoring results are consistent with the CSM in which the ground gas generation potential of the historical landfill is low, low permeability surrounding deposits restricting lateral migration, and low ground gas generational potential of the general Made Ground outside the landfill.

As part of the proposed Development design the extent of the known landfill based on historical and current ground investigation information and historical plans should be compared against the location of proposed buildings. Where the building is located outside the former landfill ground gas protection measures are unlikely to be required. Further ground investigation and assessment to confirm the ground gas regime outside the former landfill is however required.

Should the proposed building/buildings be located within the landfill curtilage additional investigation and assessment would be required to determine the ground gas protection measures required. Where further ground investigation information is available a reduction in the ground gas regime classification and requirement for ground gas protection measures may be possible.

Cambridge Retail Park - Ground Gas Risk Assessment

Cambridge Retail Park is largely underlain by landfill deposits with limited areas outside the landfill. Ground gas concentrations in boreholes relevant to Cambridge Retail Park including those installed in landfill deposits located within 230 NMR boundary and representative of the ground gas regime record a maximum Q_{HG} of 0.32l/hr (methane) and 0.10l/hr (carbon dioxide). Based on the Q_{HG} a CS2 classification would be determined, low risk requiring basic ground gas protection measures.

Existing buildings at the Cambridge Retail Park have a gas protection system installed. As no redevelopment is currently proposed at the Cambridge Retail Park, this system will remain in place further mitigating any potential ground gas risk.

Should future redevelopment at the Cambridge Retail Park be proposed, further ground gas monitoring should be taken to confirm the assessed risk to structures. Findings of further monitoring may also allow for the Cambridge Retail Park gas protection system to be decommissioned at the existing buildings.

Beehive Retail Centre - Ground Gas Risk Assessment

The Beehive Retail Centre is not underlain by the former landfill. Ground gas monitoring results did not record any flow rates from the two boreholes monitored in this area, with methane and carbon dioxide not encountered above 0.4% v/v. Results of this monitoring calculate the Qhg for this area at 0.004, corresponding to Characteristic Situation 1 – Very Low Risk.

Furthermore, ground gas sampling did not record methane or carbon dioxide concentrations significantly above the LOD. Soil sampling from this area did not detect TOC above 1% total sample volume.

Overall, the results for this area do not indicate a potential ground gas risk is present. Ground gas protection measures would not be required in built structures.

Off-Site Residents and Users

WBH104 and WBH105 within the former landfill area recorded elevated methane, carbon dioxide and positive gas flow rates. All other wells both inside and outside the landfill recorded negligible concentrations of methane, carbon dioxide, and flow rate at or close to limit of detection.



Records demonstrate the former landfill area of the Site is underlain and surrounded by clayey strata, preventing migration of contaminants including ground gas beyond its confines. Monitoring wells installed outside the landfill area have not demonstrated significantly elevated ground gas concentrations.

As such, no risk to off-site users from ground gas originating on-Site is identified.



8. Controlled Waters

8.1 Generic Assessment Criteria – Controlled Waters

The Site is not located within a groundwater Source Protection Zone with no active groundwater abstractions on-Site or in the surrounding area. The Gault Clay Formation forms an aquiclude separating the shallow River Terrace Deposits Secondary A Aquifer and West Melbury Marly Chalk Formation Principal Aquifer from the Lower Greensand Formation Principal Aquifer. This barrier prevents potential groundwater contamination reaching the deeper aquifers. Whilst development foundation designs have not been finalised, it is not anticipated that the proposed development works will penetrate this layer.

As such, the primary potential receptors for potential groundwater contamination are the River Terrace Deposits and West Melbury Marly Chalk Formation extending beyond the wider Site boundary.

Surface water receptors down hydraulic gradient of the Site (north east) include the Cherry Hinton Brook and Coldhams Brook 350m and 530m north east of the Site respectively. Given the distance to these surface water receptors and intervening potentially contaminated land uses any impact on these receptors is unlikely to be attributable to contaminants originating on-site. In addition given the distance potential for signficant attenuation in the environment prior to impacting these receptors is expected. These surface water receptors have been removed as potential receptors in the Conceptual Site Model (CSM).

Groundwater results have been compared against European Quality Standard (EQS) criteria for surface waters (fresh). The base EQS values for bioavailable contaminants have been applied given the absence of relevant surface water samples. This approach retains conservatism.

The EQS for benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene is based on the toxicity of benzo(a)pyrene, with the EQS for these PAH identifying the use of benzo(a)pyrene as a marker for these PAH. This approach will be followed with the assessment of benzo(a)pyrene as a marker of the risk posed by benzo(k)fluoranthene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene.

The threshold criteria are applicable at the surface water receptor, and do not account for contaminant attenuation along the migration pathway. Exceedances of the threshold criteria does not necessarily indicate a risk exists and means further qualitative/quantitative assessment of the results are required.

8.2 Quantitative Risk Assessment – Controlled Waters

Groundwater results for all areas of the Site were compared against EQS criteria for water bodies not abstracted for drinking purposes. Exceedances of these criteria for each area of the Site are summarised in Table 13.



Table 13: Elevated Groundwater Concentrations

Contaminant	Threshold Value (µg/l)	Number of Samples Tested	No. of Samples above EQS	Max. Concentration Recorded (µg/l)	Location for Max. Concentration Result
230 NMR					
Lead	1.2	10	1	22	WBH105D, screening Made
Anthracene	0.10	10	3	0.347	Ground and Landfill
Nickel	4.0	10	4	6	WBH102, screening West Melbury Formation
Benzo(a)pyrene	0.00017	10	4	0.643	WBH104, screening Made Ground and Landfill
CRP					
Nickel	1.2	5	3	16	WBH109, screening Made Ground, West Melbury Formation and Gault Clay Formation.
Fluoranthene	0.00630	5	4	0.098	WBH108, screening Made Ground and Landfill
BRC					
Nickel	4.0	6	5	54	
Naphthalene	2.0	6	2	22.2	_
Benzene	10	6	2	1081.8	WBH111, screening West
Toluene	74	6	1	94	Melbury Formation
p/m-Xylene	30	6	2	876	-
o-Xylene	30	6	2	407	
Fluoranthene	0.00630	6	4	0.049	WBH116, screening Made
Benzo(a)pyrene	0.00017	6	3	0.016	Ground and West Melbury Formation

Metal

Elevated metal contaminant concentrations include nickel and lead. The elevated metal concentrations are in limited exploratory hole locations identifying the contamination as localised in its extent and the Site as not posing a significant off-site nickel or lead risk. Remedial actions to reduce metal concentrations would not be required.

Poly-cyclic Aromatic Hydrocarbons

Marginally elevated PAH concentrations have been recorded on-site within a number of exploratory holes, including benzo(a)pyrene and fluoranthene. PAH have a low environmental mobility have a low



solubility and high affinity for organic matter with high organic partition co-efficient values (KOC). The environmental mobility of these PAH is low and are unlikely to pose a significant off-site migration risk.

Petroleum Hydrocarbon Contamination

Consistent with visual and olfactory observations and soil laboratory results elevated petroleum hydrocarbon concentrations have been recorded at WBH111 during both groundwater sampling rounds. Naphthalene and BTEX contaminants have been recorded (Table 14). A maximum Total TPH concentration of 7,102µg/l has been recorded.

Table 14: Groundwater BTEX Concentrations BRC

Monitoring		Maximum concentration recorded (µg/l)					
Well	Total TPH	Benzene	Toluene	Ethylbenzene	Xylenes		
WBH111	1,459	1,081.8	94	<lod< td=""><td>876</td></lod<>	876		
WBH112	<lod< td=""><td>1</td><td><lod< td=""><td><lod< td=""><td>2</td></lod<></td></lod<></td></lod<>	1	<lod< td=""><td><lod< td=""><td>2</td></lod<></td></lod<>	<lod< td=""><td>2</td></lod<>	2		
WBH113	14	2.1	<lod< td=""><td>3</td><td>5</td></lod<>	3	5		
WBH114D	<lod< td=""><td>0.7</td><td><lod< td=""><td>1</td><td>2</td></lod<></td></lod<>	0.7	<lod< td=""><td>1</td><td>2</td></lod<>	1	2		

A review of historical maps and the location of WBH111 (Figure 3) and given a north eastern groundwater flow direction within the West Melbury Chalk Formation indicates an historical transport depot 25m south with associated tank is more likely than not the principal contaminant source.

Petroleum hydrocarbons in WBH112 down hydraulic gradient of WBH111 have recorded benzene (1µg/l) and xylene (2µg/l) above the laboratory detection limit only. BTEX concentrations decrease by three orders of magnitude over a distance of 115m identifying an off-site migration risk as likely being absent. As part of further ground investigation the hydrocarbon contamination identified at WBH111 should be delineated to confirm the conclusion an off-site migration risk is absent.



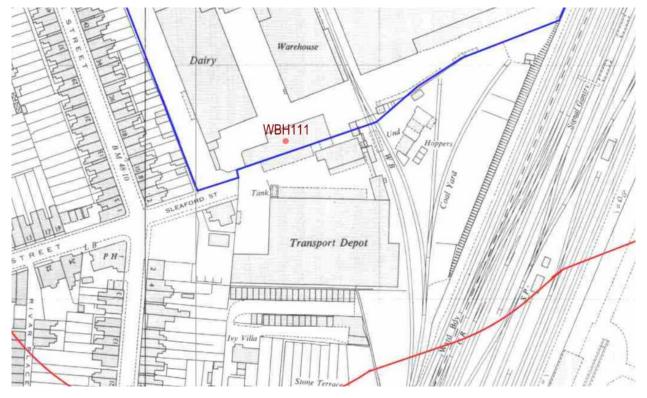


Figure 3: 1967 Historical map and WBH111 location

BTEX concentrations above the laboratory limit of detection but below the EQS threshold concentrations have been recorded in WBH113 (Table 7). Borehole WBH113 is located south west of a former petrol station which operated on-site between 1989 and 2003 (

Figure 4). Whilst groundwater flow direction is north east a preferential pathway could be causing petroleum hydrocarbon contamination to have migrated south east and impacted the groundwater recorded at WBH113. It is noted at WBH114 down hydraulic gradient of the former fuel filling station, BTEX concentrations have reduced to below laboratory detection limits or marginally above.

Further ground investigation is required to establish the presence/absence associated with the former fuel filling station and delineate its extent and risk to controlled water receptors where present.



Works

Warks

Filling
Station

Figure 4: Former Fuel Filling Station Location

Risk to Deeper Aquifers

The Gault Formation is present underlying the entire Site and wider off-site area. This formation is comprised of clayey strata, forming an aquiclude preventing shallow potentially contaminated groundwater reaching the deeper Greensands Formation principal aquifer.

Should piled foundations be proposed to support future developments, a foundation works risk assessment should be completed to determine if these piles will penetrate the Gault Formation and create a preferential pathway to the Greensands Formation.



9. Preliminary Waste Classification Assessment

9.1 Introduction

A Preliminary Waste Classification Assessment has been undertaken on soil samples recovered from exploratory holes undertaken as part of the contaminated land assessment for the wider Site. The process of waste classification is set out in Appendix E.

The samples collected from each location are discreet and have not been sampled in strict accordance with UK Environment Agencies guidance WM3 "Guidance on the classification and assessment of waste" (1st Edition v1.2.GB 2021) (hereafter "WM3"). The assessment should be regarded as indicative only. Further assessment will be required once it is known how the waste will arise, and what off-site recovery or disposal options are available.

This assessment firstly identifies whether or not the waste displays hazardous properties, and secondly, should landfill disposal be a potential off-site option for the wastes, the findings of additional waste acceptance criteria (WAC) testing.

The hazardous property assessment has been undertaken using HazWasteOnline™, a web-based tool for classifying hazardous waste. The tool follows the latest Environment Agencies guidance and European regulations. A summary of the assessment results are provided below.

9.2 Hazardous Property Assessment

The dry soils chemical analysis results from samples collected at the BRC, CRP and 230 NMR have been entered into HazWasteOnline[™]. Table 15 details the samples from each location and strata which were screened for hazardous properties.

Table 15: HWOL Sampling Summary

Area	Number Of Samples Per Strata					
	Made Ground / Landfill	River Terrace Deposits	West Melbury Formation	Gault Clay Formation		
230 NMR	9	N/A	5	1		
CRP	6	N/A	2	1		
BRC	9	1	6	2		

Results from the HazWasteOnline™ assessment are included in Appendix E.

A single Made Ground sample collected from 230 NMR at 1.6m bgl depth was identified as containing hazardous properties by HazWasteOnlineTM due to Total TPH concentrations present. This sample was determined hazardous due to the following properties:

- HP 7: Carcinogenic "waste which induces cancer or increases its incidence"; and
- HP 11: Mutagenic "waste which may cause a mutation, that is a permanent change in the amount or structure of the genetic material in a cell".



All other samples from the Made Ground/Landfill and underlying natural strata screened were recorded as having no hazardous properties.

Fragments of asbestos or ACMs were not identified during ground works. However, at laboratory stage several Made Ground/Landfill samples collected from the 230 NRM and CRP sections of the Site were identified as contaminated with asbestos:

Table 16: Identified Asbestos

Exploratory Hole	Depth (m bgl)	Asbestos Type	Quantification (%)
230 NMR			
WBH101	0.6	Chrysotile traces	<0.001
WBH103	1.6	Chrysotile free fibres and bitumen products	<0.001
WBH104	1.0	Chrysotile and amosite fibre bundles	<0.001
WBH105	4.0	Chrysotile fibre bundles	<0.001
CRP			
WBH107	1.5	Chrysotile fibre bundles	<0.001

Asbestos was not identified in any of the samples collected from the BRC.

Whilst no visible fragments of asbestos containing materials were identified in Made Ground during the ground investigation the presence of free fibres in samples identified by the laboratory indicate the potential for fragments to exist elsewhere in the soils. The presence of asbestos fibres can be indicative of the presence of weathered asbestos containing materials in the soil.

9.3 Waste Acceptance Criteria

In addition to the HazWasteOnline[™] assessment, Waste Acceptance Criteria (WAC) analysis was undertaken on five samples to indicate suitability for disposal as inert waste or, if they contain hazardous properties, whether they are suitable for disposal to hazardous waste landfill without further treatment.

Table 17: HWOL Sampling Summary

Sample Reference	Depth (m)	Strata	Area Of Site	Hazardous Properties identified?
WBH102	1.0	Made Ground	230 NMR	Yes
WBH106	1.6	Made Ground	230 NMR	No
WBH110	0.8	Made Ground	CRP	No
WBH112	0.5	Made Ground	BRC	No
WBH113	0.8	Made Ground	BRC	No



Four of the five samples analysed for WAC did not contain any hazardous properties. The fifth sample, collected from the 230 NMR area at WBH102 failed the inert WAC for Sulphate as SO₄ and Total Dissolved Solids.

The Preliminary Waste Classification Assessment has indicated that the relevant Waste Catalogue code for the disposal of the materials as shown in Table 18:

Table 18: Summary of Likely Waste Streams

Material	WC Code	EWC Code Description	Description of Material
Made Ground containing hazardous properties (WBH102 sample)	17 05 03*	Soils and stones containing hazardous substances.	Made Ground with hydrocarbon staining, containing clay, brick, concrete.
Made Ground containing no hazardous properties All other WAC samples collected)	17 05 04	Soils and stones other than those mentioned in 17 05 03	Made Ground containing clay, brick, concrete.

9.4 Options Appraisal

It is considered that the removal of soils from the Site can be minimised by their re-use on Site to facilitate filling where required, provided they are chemically and geotechnically suitable.

Any re-use of soils on Site should be in accordance with the CL:AIRE Definition of Waste: Development Industry Code of Practice (DoWCoP), subject to appropriate sampling and testing, risk assessment and compliance with the requirements of the DoWCoP.

Further validation and waste classification pursuant to WM3 in particular Appendix D on waste sampling should be undertaken on materials to be removed from Site to confirm the most appropriate waste classification and receiving facility. In accordance with the waste hierarchy, preference should be given to receiving facilities able to recover value from the excavation wastes rather than landfill disposal facilities.

Acceptance of waste is at the discretion of the receiving facility. Natural uncontaminated soils may be acceptable as inert waste without testing at some landfills. It is recommended that the receiving facility operator is consulted at the appropriate time to discuss the conditions of its Environmental Permit.

Segregation of different waste streams would be required prior to disposal of materials off-site.



10. Conclusions and Risk Evaluation

Following the implementation of the ground investigation, the contaminant linkages identified during the Preliminary Environmental Risk Assessment have been re-evaluated and reclassified in relation to the additional information obtained. The results of the reassessment are summarised in Table 19.

Overall, the risk rating for the Site is assessed as **Medium**, whereby without implementation of the recommendations in Section 11 complete contaminant linkages are present. However, at the CRP area where no redevelopment is proposed and the existing structures are to be retained, the risk is **Low**.

Where the recommendations are implemented, the contaminant linkages will be broken, and the Site's overall risk rating will be reduced to **Low**. In addition, the Site is unlikely to be capable of being classified as Contaminated Land under the Environmental Protection Act 1990, thus meeting the requirements of paragraphs 183 to 188 of the National Planning Policy Framework.



Table 19: Final Conceptual Model

Receptor	Potential Sources	Pathways	Risk	Justification	Residua Risk
Human Health					
Future Site users	Soils and groundwater contamination	Direct contact via future soft landscaping	Medium	Elevated contaminants have been encountered in the Made Ground including asbestos fibres. A significant risk exists where future Site users can come into direct contact with these contaminants. In areas of hardstanding and building footprints the pollutant linkage will be broken through pathway removal. In soft landscaped areas a pollutant linkage will exist which will require implementation of a robust cover layer to mitigate the risk.	Low
				Buildings at the CRP area are to be retained, and include an existing ground gas protection system which will continue to protect future users in this area.	
	Future Site users	Ground gas	Accumulation in	Medium	At 230 NMR, monitoring indicates a gas risk may be present within the landfill, but is not consistently elevated. No gas risk is identified outside the landfill area. Further ground gas monitoring should be undertaken to specifically delineate the extent of the high methane concentrations, and fully quantify the potential risk to future new structures in this area.
		confined spaces with inhalation by residents, or explosion		The BRC is not underlain for former landfill, and evidence from ground gas monitoring and sampling does not indicate an emissions risk here.	
	Vapours		Medium	A potential vapour risk is present at the 230 NMR and BRC areas of the Site. Further ground investigation will be necessary to quantify vapour risks, and inform the potential remediation or mitigation measures necessary to break this linkage to future receptors.	Low
				At the CRP, the existing gas protection system will protect these structures and occupants from vapour accumulation.	



Wider West Melbury Formation		Lateral migration via shallow West Melbury Formation	Medium	groundwater samples, however an off-site migration risk is considered absent. These minor hot-spots are not assessed as posing a significant risk to the larger aquifer off-site. A potential hydrocarbon source close to WBH111 has been identified, migrating north-east through the West Melbury Chalk Formation shallow groundwater. Further ground investigation and assessment is required to confirm the source an off-site migration risk.	Low
Controlled Waters				Elevated metal and PAH contaminants have been recorded in	
Off-site human health receptors	Vapours	Migration off-site, accumulation in confined spaces with inhalation by residents, or explosion	Medium	Anticipated flow direction for shallow groundwater of the West Melbury Chalk Formation is to the north-west, with risk of vapour source migration through this aquifer to impact off-site buildings to the north-west. Redevelopment works will likely involve remediation or mitigation of the shallow groundwater to reduce vapour risk to future development structures. This in turn will reduce the risk to off-site receptors.	Low
	Contaminated soils exposed during construction works	Inhalation of dust or vapours, or contact with surface run-off from exposed soils	Medium	To mitigate this risk, measures will be required throughout the development construction, notably during earthworks to minimise the creation and migration of contaminants or asbestos fibres. Details on how this will be managed during enabling works will be set out in a Construction Environmental Management Plan (CEMP).	Low
	or vapours	vapours.		Works should be completed in accordance with the Control of Asbestos Regulations 2012 (CAR 2012) and an Asbestos Plan of Work completed. Workers should be provided with personal protective equipment (PPE) where necessary.	
Construction workers	Contaminated soils including asbestos, groundwater, ground gas	Direct contact during excavation works, and inhalation of dust or	Medium	Metals, hydrocarbon contamination and asbestos have been detected in the Made Ground and Landfill. All construction works should be undertaken under a risk assessment which accounts for the ground conditions identified during previous remedial work and subsequent ground investigations.	Low



Dooper Creeneende			The Gault Formation is present underlying the entire Site and wider off-site area. This formation is comprised of clayey strata, forming an aquiclude preventing shallow potentially contaminated groundwater reaching the deeper Greensands Formation principal aquifer. Should piled foundations be proposed to support future developments, a foundation works risk assessment should be completed to determine if these piles will penetrate the Gault Formation and create a preferential pathway to the Greensands Formation. This will inform any mitigation required to prevent impacts to this deep aquifer.		
Deeper Greensands Formation Principal Aquifer	Downward migration	Medium	developments, a foundation works risk assessment should be completed to determine if these piles will penetrate the Gault Formation and create a preferential pathway to the Greensands Formation. This will inform any mitigation required	Low	



11. Recommendations

The following actions are recommended to address the potentially unacceptable risks that remain:

- The findings of this initial ground investigation identified hydrocarbon contamination in shallow groundwater, with vapour risk and ground gas risk in areas of the Site. Further investigation works are recommended to fully delineate and assess this contamination:
 - Additional ground investigation and assessment to determine the ground gas regime in areas of proposed development on 230 Newmarket Road and Cambridge Retail Park.
 - Additional ground investigation may be undertaken on Cambridge Retail Park to confirm whether a signficant ground gas regime is present, and whether the existing ground gas protection system is required. The current ground investigation dataset indicates it is not however additional information is required to clarify this.
 - Further groundwater sampling to fully delineate the extent of hydrocarbon contamination within the West Melbury Formation aquifer. in particular targeting the hydrocarbon source originating close to WBH111, migrating north-east through the shallow groundwater.
 - Vapour monitoring and sampling at the 230 NMR and BRC areas of the Site to quantify vapour risks to future structures, and inform the potential remediation or mitigation measures necessary to break this linkage to future receptors.
- Construction workers should be provided with appropriate PPE for works involving contaminated soils and groundwater, and use appropriate hygiene measures;
- Asbestos fibres have been detected in shallow Made Ground. Construction works should be undertaken in accordance with the Control of Asbestos Regulation 2012, with an asbestos plan of work developed to prevent impacts from asbestos exposure to construction workers;
- A Foundation Works Risk Assessment should be completed once the development design is finalised and it is known whether or not piled foundations will penetrate the Gault Clay Formation.
- New soft landscaping to be installed as part of 230 NMR and BRC redevelopment should be situated
 in certified clean topsoil to break contaminant linkage between residual potentially contaminated soils
 and future Site users in these areas.



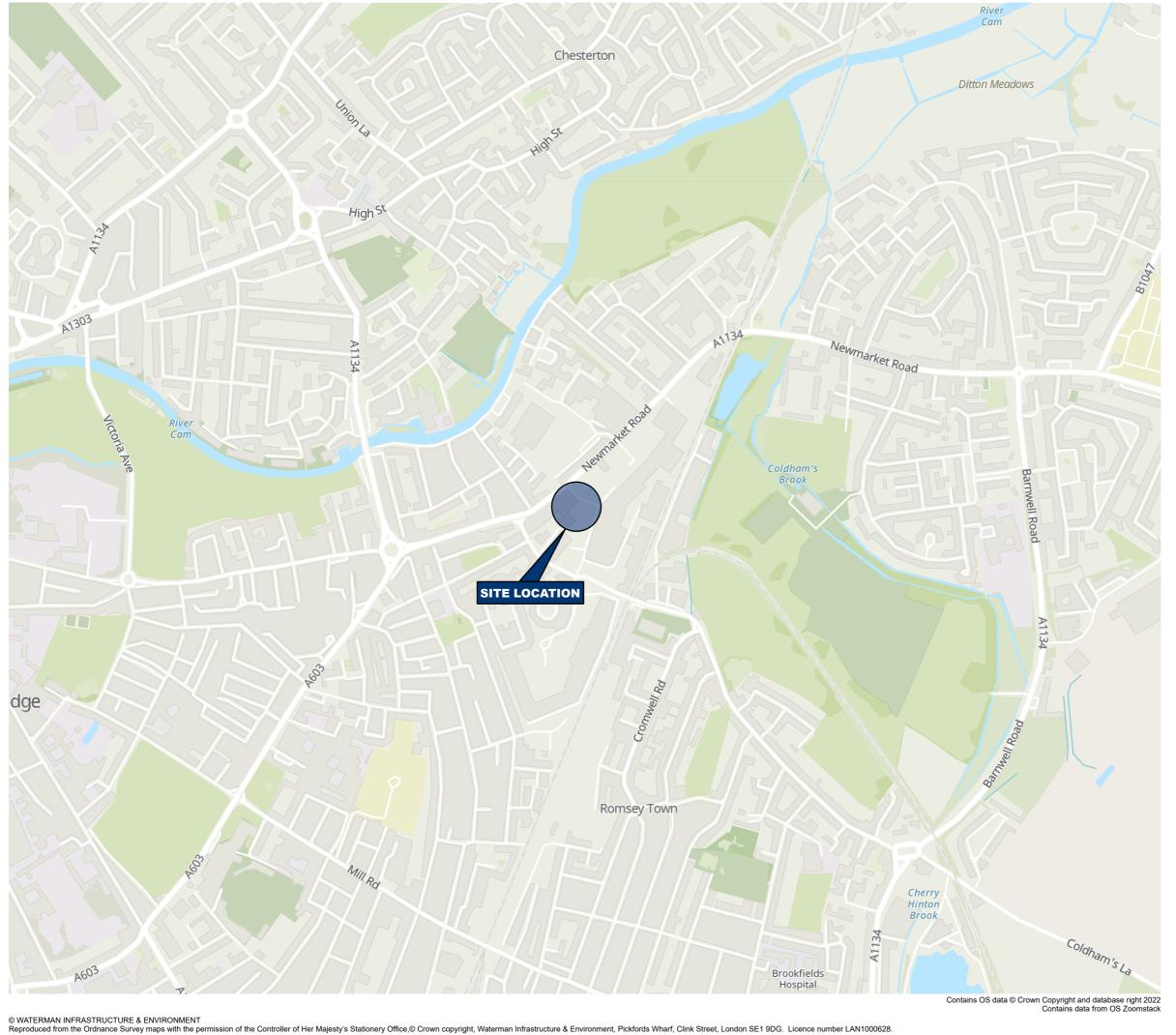
APPENDICES



Appendix A Site Plans

- A1: Site Location Plan
- A2: Site Boundary Areas Plan
- A3: Former Landfill Extent Plan
- A4: Ground Investigation Plans







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WIE17469-100: Project Otter

Project Details

Figure Title

Figure A1: Site Location Plan

Figure Ref

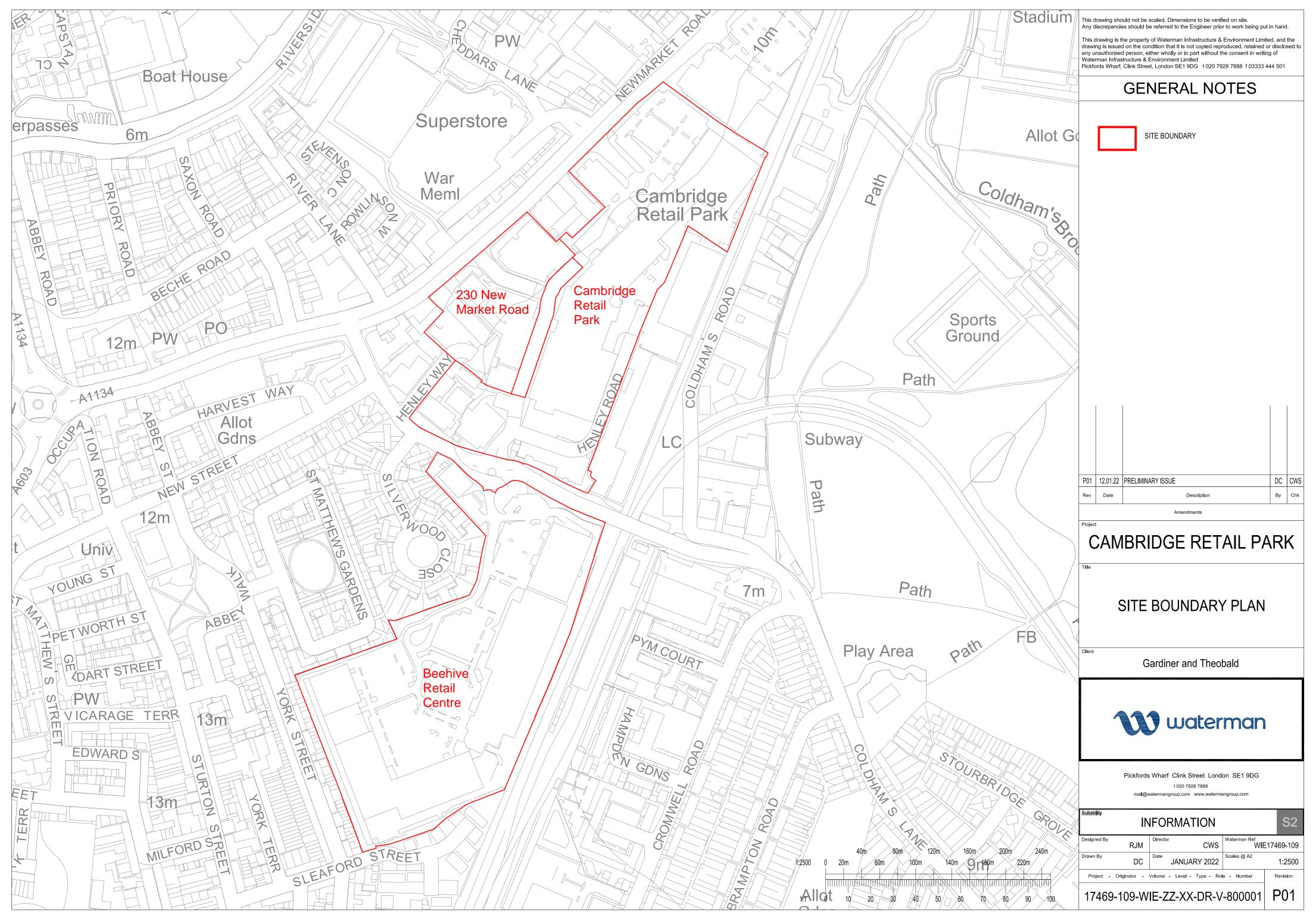
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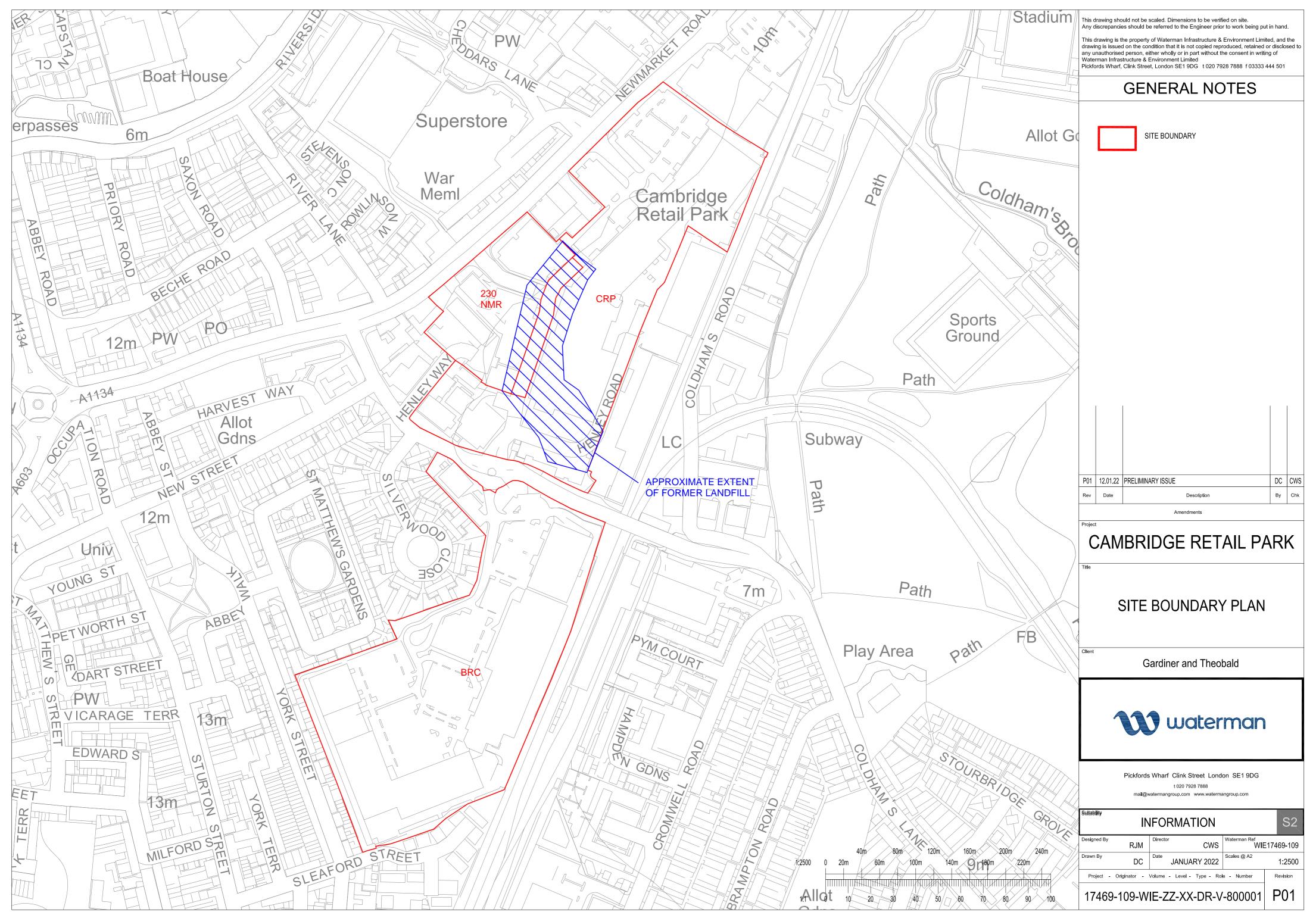
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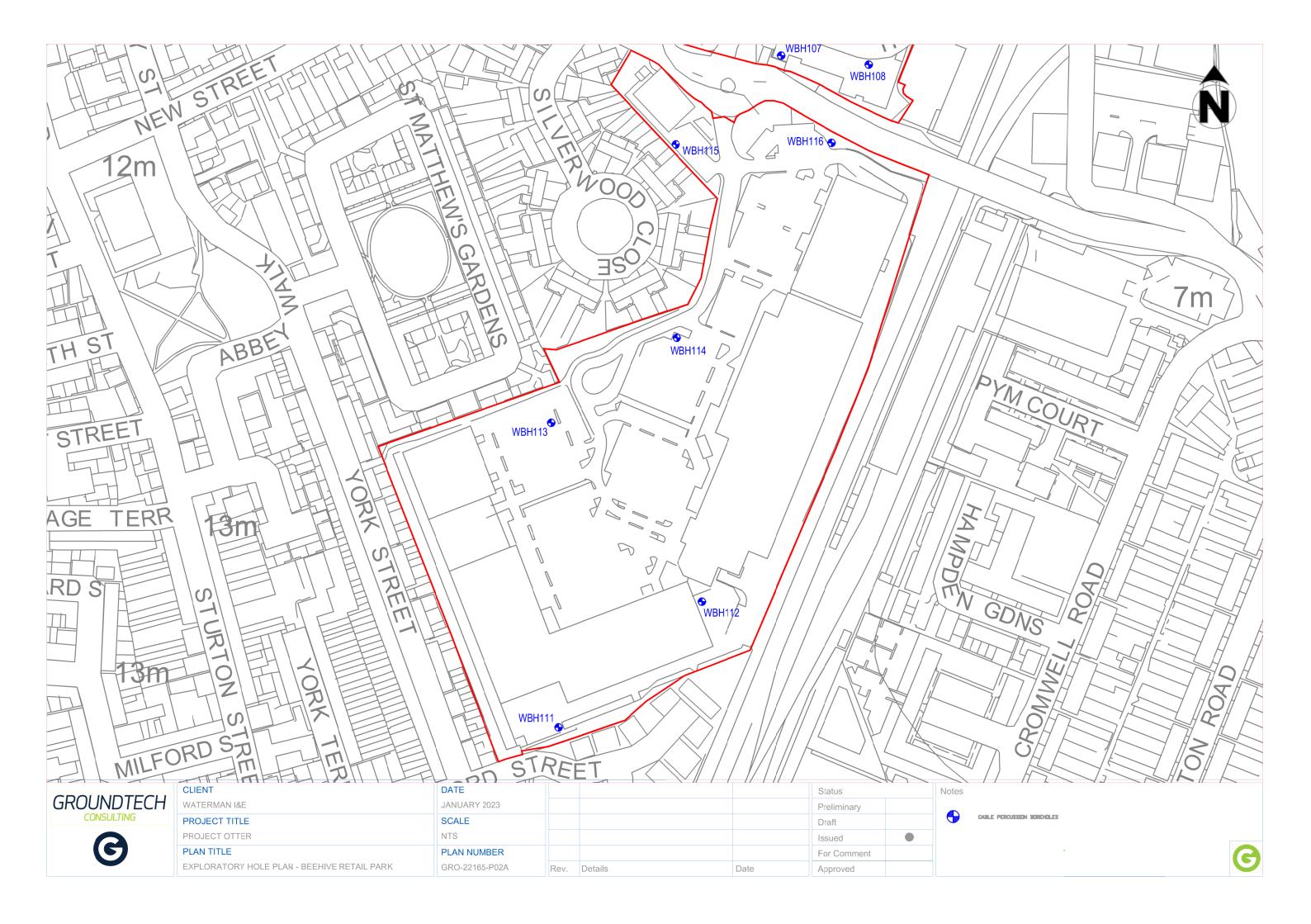
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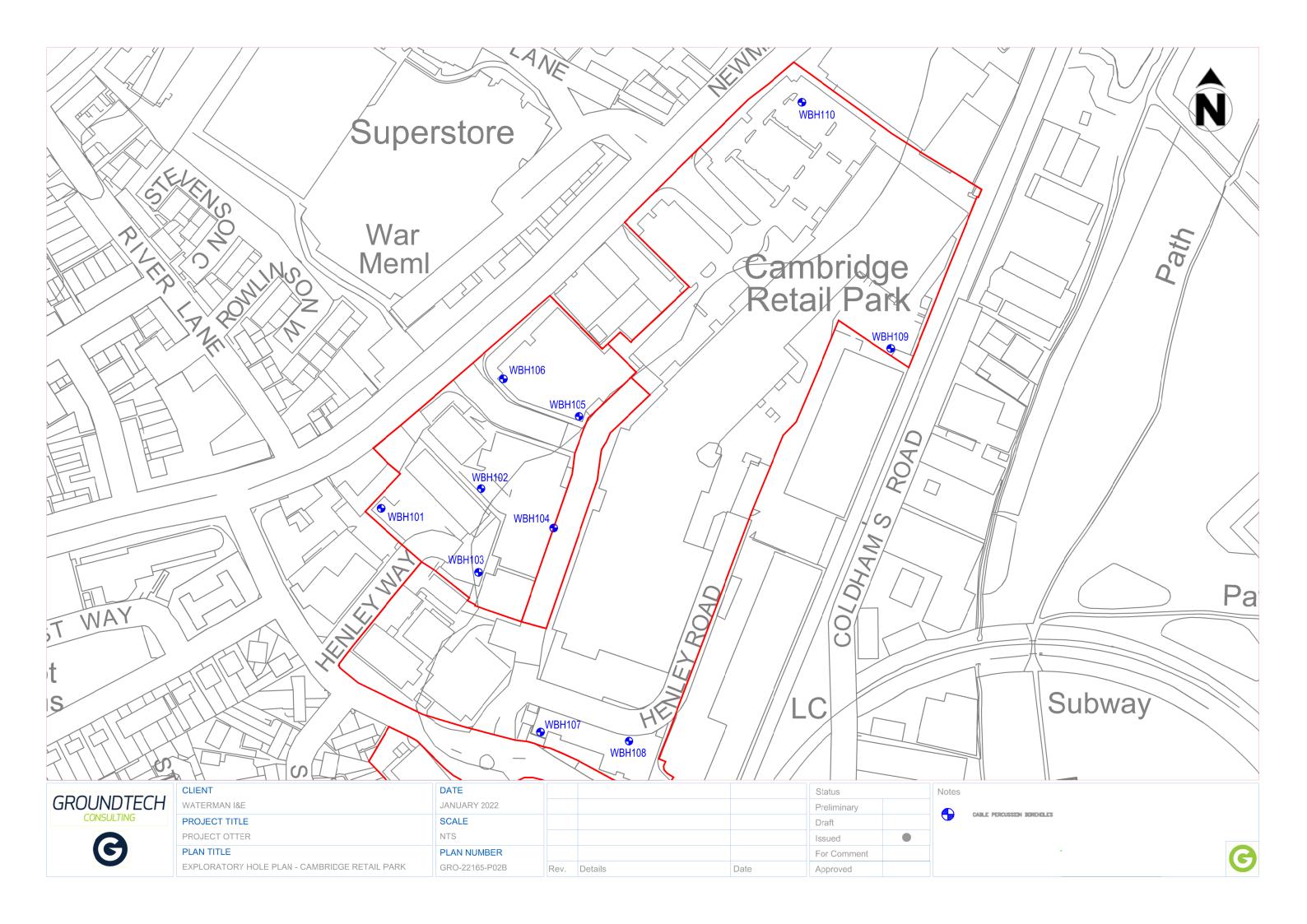
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Appendix B Factual Information

- B1: Groundtech Consulting Factual Report (reference GRO-22165-4080)
- B2: Soils Chemical Results
- B3: Groundwater Chemical Results
- B4: Ground Gas Chemical Results