conisbee | Consulting Structural Engineers
Consulting Civil Engineers

WHBC - New Deck Car Park, Campus West

Flood Risk Assessment and Drainage Strategy

Cambridge
16 Signet Court Swann Road
Cambridge CB5 8LA
Telephone 01223 656 058

London
1–5 Offord Street
London N1 1DH
Telephone 020 7700 6666

Norwich
6 Upper King Street
Norwich NR3 1HA
Telephone 01603 628 074

design@conisbee.co.uk
www.conisbee.co.uk

Ref: 190997/A Marshall

Approved By: A Marshall

Date: 8 April 2021

Status: Issued for planning.

Version: 3

Table of Contents

1.0 INTRODUCTION

1.1.1 Conisbee have been appointed by Welwyn Hatfield Borough Council (WHBC) to produce a Flood Risk Assessment (FRA) and Drainage Strategy to support a planning application for a new multi-storey decked car park at the site of the existing Campus West Car Park in Welwyn Garden City.

1.1.2 Flood zone mapping produced by the Environmental Agency (EA) confirms that the site is located in Flood Zone 1, comprising land assessed as having a less than 0.1% annual probability of river flooding.

1.1.3 The EA Flood Map for Surface Water indicates a small area at the southern end of the existing car park as being at low risk (between 0.1% and 1% annual probability) of surface water flooding.

1.1.4 The purpose of this document is to demonstrate compliance with relevant national and local planning requirements associated with flood risk and the sustainable management of surface water.

1.1.5 The appraisal process has consisted of a site visit, desk study, data research and consultation with regulatory bodies and third parties where appropriate.

1.1.6 Reference has been made to the following policy documents in the production on this FRA and Drainage Strategy:

- National Planning Policy Framework (NPPF, 2019);
- National Planning Practice Guidance – Flood Risk and Coastal Change (NPPG, 2014);
- The Welwyn Hatfield District Plan (WHDP, 2005);
- The Welwyn Hatfield Borough Council Draft Local Plan (Draft LP, 2016);
- Welwyn Hatfield Council Level 1 and 2 Strategic Flood Risk Assessment (SFRA, 2016);
- Hertfordshire County Council LFRMS 2 (LFRMS, 2019);
- Hertfordshire County Council LLFA Summary Guidance for developers (LFFA GfD, 2019).

2.0 EXISTING SITE

2.1 Site location

2.1.1 The site is located to the north-west of The Campus in the centre of Welwyn Garden City, approximately 650m north-west of Welwyn Garden City Railway Station. The site is centred on National Grid Reference TL 23529 13370.

2.1.2 Refer to Figure 2.1 below for the application site boundary.

Figure 2.1 Site location plan

2.1.3 The site is bordered by the Ayot Greenway to the north, a walking and cycling route that runs through a cutting from a former railway line adjacent to the site.

2.1.4 The side is bounded by Woodside House retirement housing to the west, and Campus West leisure and entertainment facilities to the east.

2.1.5 To the south the site is bordered by an area of mature tree planting, with Bridge Road and The Campus beyond.

2.2 Site description

2.2.1 The site extend to approximately 0.75Ha and is currently occupied by a surface car park providing approximately 300 car parking spaces.

2.2.2 A topographical survey of the site was undertaken by Terrain Surveys in July 2019; refer to survey drawing TS19-312-1 attached at **Appendix A**.

2.2.3 The topographic survey shows that site levels fall from north to south, from around 101.5m AOD at the northern boundary, to around 98.5m AOD at the southern edge.

2.2.4 The topographic survey confirms that the existing site is almost entirely made up of impermeable areas comprising ashalt surfacing to the existing car park. There are a number of mature trees within the site, and adjacent to the northern and southern boundaries.

2.3 Geology and hydrology

2.3.1 British Geological Survey (BGS) Mapping indicates that the site is underlain by The Lewes Nodular Chalk Formation, with superficial deposits of the Lowestoft Formation, a chalky till, with outwash sands and gravels,silts and clays.

2.3.2 Ground investigation works were undertaken at the site by White Young Green (WYG) in August 2019; refer to report attached at **Appendix B**. The report identifies the following ground conditions at the site:

- Made Ground (variable soils): Up to 1.4m thick;
- Lowestoft Formation (comprising variable superficial deposits): 2.2 - 11.7m thick;
- White Chalk: to the full depth of the investigation (25.0m bgl).

2.3.3 Groundwater was not encountered during the investigation works (25.0m bgl).

2.3.4 The WYG Ground Investigation Report indentifies evidence of ‘Swallow holes’ (zones of metastability and voiding associated with chalk dissolution) approximately 170m south-east of the site.

2.3.5 The report includes a risk assessment of the chalk bedrock, which concludes that ‘the Site is classified to have a High Risk of metastability and voiding associated with chalk dissolution’.

2.3.6 Aquifer designation mapping published by the EA indicates that the underlying Chalk bedrock is classified as a Principal Aquifer. Principal Aquifers are defined as ‘layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale’.

2.3.7 The superficial deposits are classified as a Secondary 'Undifferentiated' Aquifer. This classification is given in cases where it has not been possible to attribute either category A (permeable layers capable of supporting water supplies at a local scale) or B (predominantly lower permeability layers which may store and yield limited amounts of groundwater) to a rock type.

2.3.8 EA groundwater vulnerability mapping (Environment Agency, 2019) indicates that the site is located within an area of low groundwater vulnerability. This is defined as 'areas that provide the greatest protection to groundwater from pollution. They are likely to be characterised by low-leaching soils and/or the presence of low-permeability superficial deposits.

2.3.9 The site is located within a Groundwater Source Protection Zone - Total catchment (Zone 3). This area is defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source.

2.4 Existing watercourses

2.4.1 Envirocheck mapping indicates the presence of an existing watercourse located approximately 180m to the east of the site. The watercourse conveys flows east to west along the southern boundary of an area of residential properties.

2.4.2 This stream is culverted below the pedestrian access leading into the Town Centre from Gresley Close. The eastern extent of the culvert, and the interface with any former railway drainage systems located north of the site and following the route of the stream, is not confirmed.

2.4.3 An unnamed stream also flows through Sherrardspark Wood approximately 0.50km northwest of the site.

2.4.4 HCC flood risk management mapping does not identify either feature as an ordinary watercourse.

2.5 Existing Drainage

2.5.1 Thames Water asset records indicate the presence of an existing 225mm diameter foul sewer within The Campus to the south of the site. The sewer is approximately 3.0m deep in the vicinity of the site and conveys flows to the south-west towards Bridge Road.

2.5.2 In addition, Thames Water records indicate the presence of a 225mm diameter surface sewer that runs parallel to the foul sewer along The Campus. The sewer conveys flows to the south-west to MH 5304, where it combines with a 375mm diameter surface water sewer from the west, whereby flows are conveyed south towards Bridge Road.

2.5.3 Refer to Thames Water sewer records attached at **Appendix C**.

2.5.4 A CCTV and drainage survey of teh existing drainage systems within the site was carried out by Draincare Environmental Services Ltd on July 2019. Refer to survey drawing attached at **Appendix C**.

2.5.5 The survey identifies an existing below ground drainage system picking up surface water gullies within the existing car park and roof drainage from the adjacent Roller City building.

2.5.6 The survey indicates that flows are conveyed south via a 225mm connection to the Thames Water public sewer in The Campus.

2.5.7 The survey identifies various defects within the existing drainage system, including cracked pipes and resulting root ingress and/or high levels of silt, which would impact on the effective operation of the drainage.

2.6 Existing hydrological site characteristics

The existing hydrological characteristics for the site are as follows:

- M5_60min = 20
- Ratio r = 0.4
- IH 124 Soil Type: 2
- Total Site Area = 0.75 Ha
- Site Drainage Catchment Area = 6.000 m²
- Existing Catchment Impermeable Area = 6.000 m²
- Percentage Impermeable (PIMP) = 100%

Existing runoff rates and volumes for the site, determined using FSR rainfall parameters for the existing site impermeable area and a single 225mm diameter outfall pipe, are set out in Table 2.1 below. Refer to hydraulic modelling results attached at **Appendix D**.

Return Period	Existing peak run off rate / l/s	Existing discharge volume[1] / m³
1 in 1 year	59.7	39.6
1 in 30 years	121.5	73.5
1 in 100 years	144.2	88.2

Table 2.1: Existing hydrological site characteristics

[1] Volume calculations based on 6 hour (360 min) rainfall event.

3.0 PROPOSED DEVELOPMENT

3.1.1 The development proposals comprise the construction of a new decked car park, with an upper car parking deck over parking at ground level. The car park will provide approximately 490 spaces over 2 levels.

3.1.2 The car park will include a single internal ramp providing vehicular access to the upper decks, and two external stair cores for pedestrian access.

3.2 Vulnerability classification

3.2.1 Table 2 in the Technical Guidance to the NPPF does not provide a Flood Risk Vulnerability Classification for car parking.

3.2.2 For the purposes of this FRA, the car park has been considered as ancillary to buildings used for shops; offices and assembly and leisure, and as such is classified as 'less vulnerable' in the Flood Risk Vulnerability Classification.

3.3 Sequential and exception test

3.3.1 The National Planning Policy Framework (NPPF) encourages a sequential risk based approach to determine the suitability of land for development in flood risk areas. It advises local panning authorities to demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed.

3.3.2 Due to the site's location within Flood Zone 1, the proposed development is fully compliant with the requirements of the Sequential Test and the principles of the NPPF.

4.0 DEFINITION OF THE FLOOD HAZARD

4.1 Fluvial flooding

4.1.1 The EA Flood Map for Planning confirms that the site is located within Flood Zone 1, land assessed as having a less than 1 in 1,000 annual probability of river flooding (<0.1%). Refer to Figure 4.1 below.

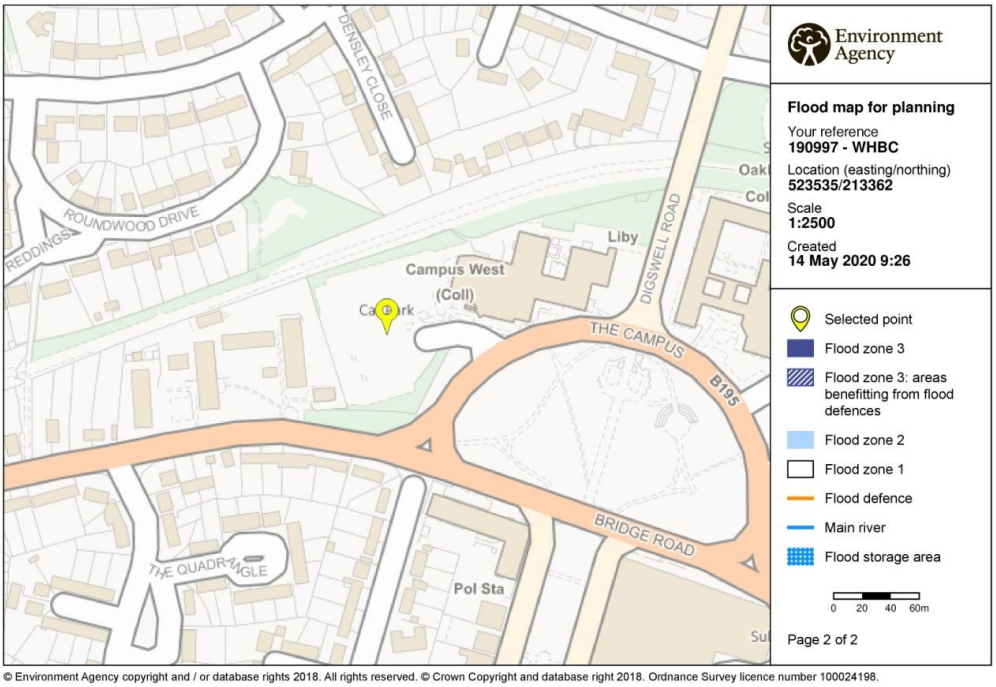


Figure 4.1 EA flood map for planning

4.1.2 Fluvial flood risk is therefore not relevant to this site.

4.2 Tidal Flooding

4.2.1 The site is remote from the coast and the tidal reaches of any watercourses. Tidal flood risk is therefore not relevant to this site.

4.3 Groundwater Flooding

4.3.1 BGS mapping based on the Areas Susceptible to Groundwater Flooding (AStGWf) dataset, which comprises a strategic-scale map showing groundwater flooding areas on a 1km square grid, indicates that the site is located in an area identified as having 'limited potential for groundwater flooding to occur'.

4.3.2 The groundwater flooding susceptibility mapping included at Appendix G of the SFRA indicates that no part of the grid square in which the site is located is identified as being susceptible to groundwater flooding.

4.3.3 As noted in section 2.3, groundwater was not encountered during the site investigation works, which included boreholes to 25.0m bgl.

4.3.4 Due to the depth of groundwater at the site, and the low AStGWf risk rating, it is considered that the site is not at risk of groundwater emergence.

4.4 Surface water flooding

4.4.1 The EA publishes and maintains the national Flood Map for Surface Water (FMfSW). This aims to represent flooding caused by surface runoff from precipitation and is based on a LIDAR digital terrain model and simulated rainfall for return periods up to the 1 in 1000 year event.

4.4.2 Figure 4.2 shows the EA FMfSW relevant to the site. The map indicates that the majority of the site and surrounding area is at very low risk of surface water flooding, which means that each year this area has a probability of surface water flooding of less than 0.1%.

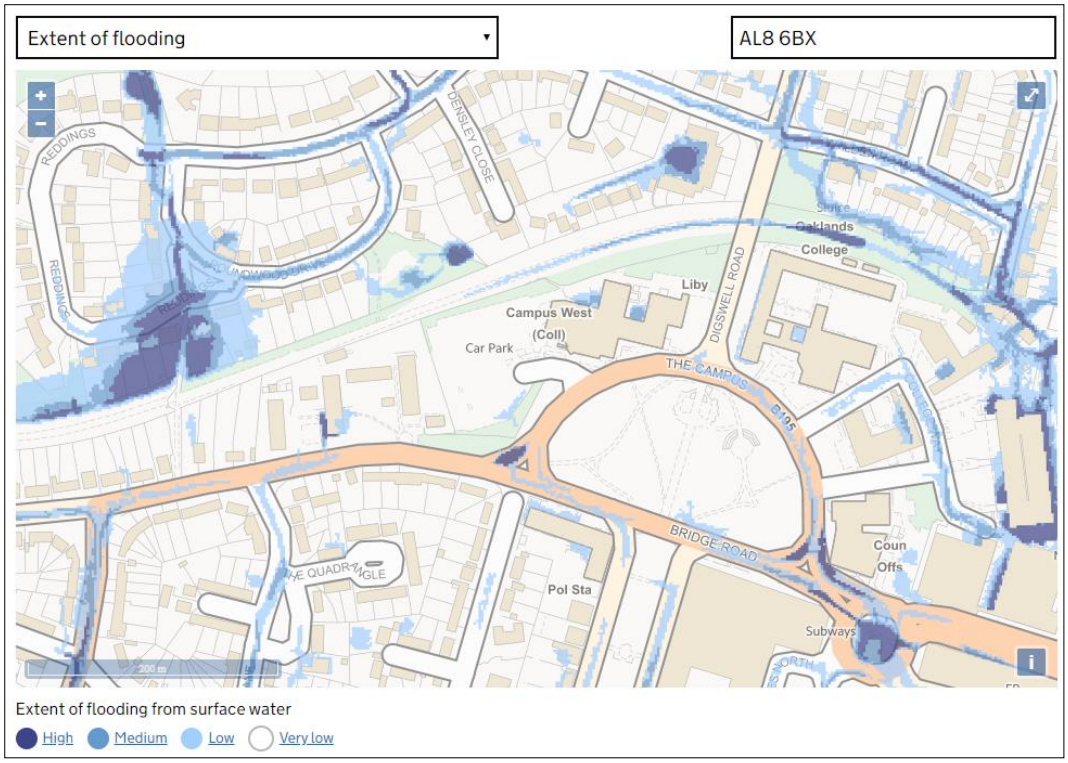


Figure 4.2: EA surface water flood risk map

4.4.3 A small area at the southern end of the site is shown as being at low risk of surface water flooding, which means that each year this area has a probability of surface water flooding of between 0.1% and 1%.

4.4.4 This is consistent with the updated Flood Map for Surface Water (uFMfSW) mapping included at Appendix G of the SFRA, which shows a small area within the site as being affected by the 1000-year flood extent (0.1% annual probability).

4.4.5 The FMfSW and FMfSW mapping follows topographical flow paths identifying low lying areas where there is potential for surface water flooding to occur. The mapping does not indicate any flows paths into the site, which would indicate a risk from surface water runoff from surrounding areas.

4.4.6 The proposed surface water management strategy, set out in Section 6, includes measures to manage surface water runoff within the site in accordance with the Defra Non-statutory technical standards for sustainable drainage systems.

4.4.7 It is noted that the FMfSW mapping indicates areas a medium risk of surface water flooding to the rear of the Roller City and Campus West Theatre buildings to the east of the site. These areas correspond to low lying areas to the rear of the buildings where there is potential for surface water ponding to occur.

4.4.8 A separate appraisal of the existing drainage serving these buildings has been completed for WHBC by EAS and is described further in section 4.5.

4.5 Sewer flooding

4.5.1 Table 4-4 of the SFRA provides a summary of of historical flooding incidents in the study area based on the Thames Water through DG5 register. The table indentifies 8 recorded events in the AL8 6 postcode area, all of which are recorded as code C which indicates 1 incident between 10 to 20-years ago.

4.5.2 Details of the location or severity of these recorded flood events is not provided.

4.5.3 As described in Section 2.2, ground levels within the site and surrounding area fall from north to south. Thames Water sewer records confirm that the existing foul and surface water sewers in the vicinity of the site are all located to the south, where ground levels are lower than those within the site.

4.5.4 In the event of a flooding incident within the adjacent sewer network, flows would therefore be contained within the public highway on The Campus, and conveyed south away from the site towards Bridge Road.

4.5.5 As noted in Section 2.5, there is an existing private below ground drainage system within the site. The system collects runoff from the car park as well as drainage from the adjacent Roller City and Campus West Theatre buildings and external areas.

4.5.6 It is understood that there has been a number of instances of surface water flooding in the drainage system serving the Roller City and Campus West Theatre in recent years. EAS were commissioned by WHBC to undertake an assessment of these issues, including identification of proposed mitigations measures as shown on drawing 2486-SK04 attached at **Appendix E**.

4.5.7 The proposed works identified on drawing 2486-SK04, which are due to be delivered in Sept / Oct 2020, include the provision of attenuation storage using oversized pipes and manholes, as well as the re-lining of damaged sections of pipe work.

4.5.8 Whilst it is understood that the flooding incidents were restricted to the Roller City building and are not known to have affected the car park, the mitigations measures as shown on drawing 2486-SK04 have been taken account to ensure compatibility with the surface water drainage strategy for the proposed car park.

4.5.9 Flooding from Artificial Sources

4.5.10 EA mapping indicates that the site is not within an area at risk of flooding as a result of reservoir failure. This is consistent with flood inundation outlines for the reservoirs located within the Borough shown at Appendix J of the SFRA.

4.5.11 We are not aware of any artificial watercourses within the vicinity of the site.

5.0 CLIMATE CHANGE

5.1.1 Background

5.1.2 The nature of climate change at a regional level will vary. For the UK, more frequent short-duration, high intensity rainfall and more frequent periods of long-duration rainfall could be expected. It is expected that sea levels will also continue to rise.

5.1.3 Development lifespan

5.1.4 The EA Flood Risk Assessments: Climate Change Allowances Guidance published in February 2016 indicates that climate change is expected to result in increased rainfall and rising sea levels. Table 5.1 below shows anticipated changes in extreme rainfall intensity in small urban catchments.

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Central	5%	10%	20%
Upper End	10%	20%	40%

Table 5.1: Peak rainfall intensity allowance in small and urban catchments

5.1.5 The LLFA Climate Change Allowance Note states that 'We now require all flood risk assessments and strategic flood risk assessments, to assess both the central and upper end allowances to understand the range of impact'.

5.1.6 For an assumed 100 year design life for the building, 20% Central and 40% Upper End climate change factors have therefore been considered.

5.1.7 Impact of climate change on the development

5.1.8 The entire site is located well outside of the fluvial floodplain, within Flood Zone 1, in an area where the probability of fluvial flooding is lower than 0.1% in any year. Fluvial flooding is therefore not expected to become an issue at the site even when the impacts of climate change are taken into account.

5.1.9 The surface water drainage strategy outlined in Section 6 has been designed to accommodate run-off during all events up to and including the 100 year return period plus 40% to allow for increases in rainfall intensity due to climate change for the expected 100 year lifespan of the development; this is in line with the recommendations of the NPPF Technical Guidance.

6.0 SURFACE WATER DRAINAGE STRATEGY

6.1.1 The sustainable management of surface water runoff has also been identified as the key issue to be investigated and addressed as part of this FRA. The following section provides a summary of the surface water strategy to be implemented at the site.

6.2 Proposed method of surface water disposal

The Building Regulations (H3) and the NPPG set out the following hierarchy for discharging surface water runoff from a development in order of preference:

- Infiltration into the ground;
- Discharge into a watercourse;
- Discharge into a surface water sewer.

6.2.1 Building Regulations (H3) states that infiltration devices should not be built within 5m of a building or road in areas of unstable land.

6.2.2 As described in section 2.3, the WYG Ground Investigation report states that the site is at High Risk of metastability and voiding associated with chalk dissolution. The site also overlies Secondary A and Principal Aquifers, and is within a Source Protection Zone.

6.2.3 Due to the risks associated with dissolution features and the sensitivity of the underlying aquifers, the use of infiltration techniques for the disposal of surface water has been discounted.

6.2.4 As noted previously, there are no watercourses in the vicinity of the site.

6.2.5 It is therefore proposed that surface water runoff from the proposed development be discharged to the existing Thames Water surface water sewer to the south of the site, as per the current arrangement.

6.2.6 The LLFA guidance for developers' states that '*Peak discharge rates from site will not increase as a result of the proposed development, up to a 1 in 100 chance in any year including an allowance for climate change storm event. We expect all applicants to achieve greenfield runoff rates for greenfield development sites and to aim to provide greenfield run-off rates for all brownfield sites to reduce the impact of the development on the surface water drainage infrastructure'.*

6.2.7 Greenfield runoff rates for the site have been calculated using the IH124 methodology and are set out in Table 6.1 below.

Return Period	Greenfield run off rate / l/s
Qbar	1.29
1 in 1 year	1.10
1 in 30 years	2.98
1 in 100 years	4.13

Table 6.1: Greenfield runoff rates

6.2.8 It is proposed that surface water discharge from the site be restricted using a single hydrobrake flow control device in order to match the Greenfield runoff rates as closely as possible whilst minimising the risk of blockage in the flow control device.

6.2.9 This represents a significant reduction in the estimated current rates of discharge, as set out in Table 2.1.

6.3 SUDs Strategy

6.3.1 In accordance with the NPPF and the SuDS Non-Statutory Technical Standards, the development will incorporate Sustainable Drainage Systems (SUDs) to manage rainfall on site and ensure that the risk of surface water flooding is not increased elsewhere.

6.3.2 Due to the constrained nature of the site the space available for SUDs features is very limited. It is proposed that a geocellular storage structure will be located beneath the car park footprint to provide surface water attenuation storage.

6.3.3 A hydrobrake flow control device will be incorporated to restrict discharge from the system to 5 l/s for all events up to and including the 1 in 100 year rainfall event with 40% climate change allowance.

6.3.4 Refer to Proposed Drainage Strategy drawing 190997-X-00-DR-C-1000 attached at **Appendix F**.

6.4 Water quality

6.4.1 Table 26.2 of the SUDs Manual (2015) provides pollution hazard indices for different land use classifications. The relevant land uses and associated hazard indices from this table are set out in Table 6.2.

Land Use	Pollution Hazard Level	Total suspended solids (TSS)	Metals	Hydrocarbons
Other roofs (typically commercial/ industrial roofs)	Low	0.3	0.2	0.05
Non-residential car parking with frequent change (eg hospitals, retail)	Medium	0.7	0.6	0.7

Table 6.2: Pollution hazard indices from SUDs Manual (2015), Table 26.2

6.4.2 The scheme will incorporate catch pit manholes upstream of the geoceullar storage structure to provide pre-treatment and sediment reduction. A class 1 bypass separator will be incorporated to ensure discharge concentrations do not exceed 5mg/litre of oil under normal conditions.

6.4.3 For the pollution hazard potential identified for the proposed use, the proposals are considered acceptable.

6.5 Design and modelling criteria

6.5.1 The proposed drainage strategy has been analysed using PDS FLOW hydraulic modelling software in conjunction with FSR rainfall parameters for the 1 in 1 year, 1 in 30 year and 1 in 100 year return period event, with an additional 40% allowance for climate change in line with NPPF. The model output files are attached at **Appendix D**.

6.5.2 The proposed runoff characteristics are as follows:

- Total Catchment Area = 7,650 m²
- Proposed Impermeable Area = 6,230 m²

6.5.3 The hydraulic modelling results are summarised in Table 6.3 below.

Return Period	Proposed peak run off rate / l/s	Proposed discharge volume[1] / m^3
1 in 1 yr	2.0	102.2
1 in 30 yr	3.1	147.7
1 in 100 yr + 20%	3.9	139.8
1 in 100 yr + 40%	4.5	150.3

Table 6.3: Proposed hydrological site characteristics

[1] Volume calculations based on 6 hour (360 min) rainfall event.

6.5.4 The model results demonstrate that the proposed strategy can accommodate rainfall events up to and including the 100 year return period event, with an additional 40% allowance for climate change. Therefore ensuring that the risk of surface water flooding to the site and surrounding areas is reduced when compared to the current situation.

6.6 Exceedance flows

6.6.1 In accordance with the Defra Non-statutory technical standards for sustainable drainage systems, the drainage system has been designed to accommodate the 100 year return period event, with an additional 40% allowance for climate change.

6.6.2 Storage volumes for all events up to a 1 in 100 year return period event including an allowance for climate change will be provided on-site.

6.6.3 In the event that the capacity of the below ground surface water drainage system is exceeded, water will be conveyed towards the southern end of the car park via overland flow.

7.0 MAINTENANCE STRATEGY

7.1.1 The purpose of this section is to outline the proposed maintenance schedule for the drainage system and all SUDs features for the proposed redevelopment.

7.1.2 The maintenance schedule set out here complies with the CIRIA SUDs Manual (C753), which is identified as providing current best practice in the industry. The report does not replace manufacturers' requirements and these should be followed for each product in addition to the information in this document.

7.1.3 All proposed drainage features within the bounds of the site will remain in private ownership, and will be maintained by a private maintenance company. Lateral drains connecting the site to the public sewerage system will be maintained by Thames Water

7.2 Gullies, Silt Traps, Manholes, Catchpits & Pipework

7.2.1 On completion of construction, the internal surfaces of the sewers and manholes shall be thoroughly cleansed to remove all deleterious matter, without such matter being passed forward into the existing sewers.

7.2.2 All trapped gullies, silt traps, manholes and catchpits are to be regularly inspected every three months and cleared out on a regular frequency for the first nine months. After this period, the frequency can be reduced to every six months.

7.2.3 All drainage runs will be inspected once a year. The system is to be jetted clear if/when necessary.

7.3 Flow controls (including Hydrobrakes)

7.3.1 The manhole containing the flow control is to be regularly inspected once a year and any debris and silt are to be removed from the sump and manhole.

7.3.2 Hydrobrakes / vortex flow controls should be maintained in accordance with the manufacturer's requirements.

7.4 Class 1 bypass separator

7.5 Regular inspection and maintenance is required in accordance with the Manufacturers' Specification. Alarm system to be regularly tested to ensure effective operation.

7.6 SUDs Features

7.6.1 A typical maintenance schedule for the proposed gecellular storage is provided below. The maintenance schedule complies with the CIRIA SUDs Manual (C753), which is identified as providing current best practice in the industry. The report does not replace manufacturers' requirements and these should be followed for each product in addition to the information in this document.

Maintenance Schedule	**Required Action**	**Frequency**
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for 3 months, then annually.
	Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
	For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae or other matter, remove and replace surface infiltration medium as necessary.	Annually
	Remove sediment from pre-treatment structures.	Annually, or as requested
Remedial actions	Repair/rehabilitate inlets, outlet, overflows and vents.	As required
Monitoring	Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed.	Annually
	Survey inside of the tank for sediment build –up and remove if necessary	Every 5 years or as required

Table 7.1: Operation and maintenance requirements for below ground attenuation tank

8.0 CONCLUSIONS

8.1.1 This FRA and Drainage Strategy has been prepared to support a planning application for a new decked car park at the Campus West Car Park.

8.1.2 The site is located within Environment Agency (EA) Flood Zone 1, comprising land assessed as having a less than 0.1% annual probability of river flooding.

8.1.3 The EA Flood Map for Surface Water indicates a small area at the southern end of the existing car park as being at low risk (between 0.1% and 1% annual probability) of surface water flooding.

8.1.4 Other potential sources of flooding have been considered and discounted, and the sustainable management of surface water runoff within the site has been identified as the key issue to be investigated and addressed as part of this FRA.

8.1.5 Due to the risks associated with dissolution features and the sensitivity of the underlying aquifers, the use of infiltration techniques for the disposal of surface water has been discounted.

8.1.6 It is proposed that surface water runoff from the proposed development will discharge to the existing Thames Water surface water sewer to the south of the site

8.1.7 Surface water runoff will be restricted to a peak rate of 5 l/s for all events up to and including the 100 year return period event, with an additional 40% allowance for climate change. This represents a significant reduction on the estimated current rates of discharge, in accordance with the SuDS Non-Statutory Technical Standards.

8.1.8 A geocellular storage structure will be located beneath the car park footprint to provide surface water attenuation storage for all events up to a 1 in 100 year return period event including an allowance for climate change.

8.1.9 An outline SUDs maintenance strategy has been prepared in line with recommendations of the SUDS Manual (CIRIA C753).

8.1.10 Based on the information provided within this report it is concluded that the site is sustainable in terms of flood risk and is compliant with criteria set out in the NPPF.

APPENDIX A – TOPOGRAPHIC SURVEY

Co-ordinate Table

Station	Easting	Northing	Level
1	523602.868	213364.305	99.097
2	523572.047	213373.817	99.790
3	523566.670	213369.863	100.429
4	523566.595	213419.740	101.273
5	523597.194	213423.462	101.124
6	523621.012	213434.743	101.331
7	523650.769	213435.051	100.244
8	523694.300	213422.565	99.576
70	523653.899	213417.259	101.001

All levels related to Ordnance Survey active GPS network, at survey station 7.

DISCLAIMERS

This survey is related to OSGB36(15) coordinate system by GPS 'rapid static' methods. No scale factor has been applied to the survey information. All horizontal distances taken from this drawing are ground distances.

Every effort has been made to confirm tree species on site, yet it is advised to confirm these details with an arborist before proceeding with any design.

Every effort has been made to confirm drainage run, type and size on site, yet it is advised to check these details against statutory authority records before proceeding with any design.

KEY

Survey control station △ 5
Banking
Gate (single)
Foliage Line
Gate (double)
Drainage run, direction of flow and pipe size — 100
Tree Spread and Girth shown to scale
Approximate Position

ABBREVIATIONS

Air Handling Unit	AHU	Water Meter	WM
Belisha Beacon	BB	Eaves Level	EL
Bollard	BD	Ridge Level	RL
Borehole	BH	Roof Level	RFL
BT Inspection Cover	BT	Soffit Level	SFL
Cable Television Cover	CTV	Threshold Level	THL
Drainage Channel	DC	Parapet Wall Level	PWL
Electricity Cover	EC	Finished Floor Level	FFL
Electricity Pole	EP	Head Level	HL
Earth Rod	ER	Sill Level	SL
Fire Hydrant	FH	Cover Level	CL
Gas Valve	GV	Invert Level	IL
Gate Post	GP	No Visible Pipes	NVP
Gully	GY	Unable to Lift	UTL
Inspection Cover	IC	Foul Water	FW
Junction Box	JB	Sump Level	SUL
Kerb Outlet	KO	Surface Water	SW
Lamp Post	LP	Brick Pavors	BP
Manhole	MH	Concrete	CON
Marker Post	MK	Concrete Paving Slabs	CPS
Post	P	Flower Bed	F\B
Pipe	PE	Shrub Bed	S\B
Road Sign	RS	Tactile Paving	TAC
Rodding Eye	RE	Unsurfaced	U\S
Marker Post	MK	Brick Wall	BW
Sign Post	SP	Retaining Wall	RW
Stop Valve	SV	Chainlink Fence	CLF
Stop Tap	ST	Chestnut Paling Fence	CPF
Telegraph Pole	TP	Iron Railing Fence	IRF
Traffic Light	TL	Metal Security Fence	MSF
Vent Pipe	VP	Post and Chain Fence	PCF
Post and Rail Fence	PRF	Post and Wire Fence	PWF
Wooden Panel Fence	WPF		

Client
WELWYN HATFIELD BOROUGH COUNCIL

Project
CAMPUS WEST, THE CAMPUS, WELWYN GARDEN CITY, HERTS, AL8 6BX

Title
TOPOGRAPHICAL SURVEY

Drawing Number
TS20-006-1

Revision	Description	Date

Scale 1:200@A0 Sheet 1 of 2

Drawn by	Checked by	Date of Survey
AB	PG	JAN 2020

terrain surveys
Tel 01438 841300
enquiries@terrainsurveys.co.uk
www.terrainsurveys.co.uk

Accreditations
chartered ices · THE SURVEY ASSOCIATION · ISO 9001 Certificate Number 7158 ISO 9001 · Constructionline Gold Member · CHAS Accredited Contractor CHAS.co.uk

APPENDIX B – GROUND INVESTIGATION REPORT

WELWYN HATFIELD BOROUGH COUNCIL

Campus West

Ground Investigation Report

A115249

Welwyn Hatfield Borough Council

March 2020

Prepared on behalf of WYG Group Limited

11th Floor, 1 Angel Court, London, EC2R 7HJ
Tel: +44 (0)207 250 7500
Email: info@wyg.com Website: www.**wyg**.com

WYG Group Limited. Registered in England & Wales Number: 06595608
Registered Office: 3 Sovereign Square Sovereign Street Leeds United Kingdom LS1 4ER

Document Control

Document:	Ground Investigation Report
Project:	Campus West
Client:	Welwyn Hatfield Borough Council
Job Number:	A115249
File Origin:	\\londondc02\100SJS\Projects\A110000\A115249 WGC Town Centre\9. Reports and Specifications\Campus West\A115249 WGC Town Centre GIR V1 DRAFT.docx

Revision:	V1 FINAL	
Date:	March 2020	
Prepared by: Agim Tafliku 	Reviewed by: Richard Tonge 	Approved By: Hillary Uffindell-Phillips
Description of revision: Final for client review		
Revision:		
Date:		
Prepared by:	Checked by:	Approved By:
Description of revision:		

Contents

Figures

Appendices

Executive Summary

Site Location and Description	The site is centred on NGR TL 23630 and covers an area of approximately 2.30Ha near the centre of Welwyn Garden City, northwest of the Parkway and The Campus roads. It includes a hardstand Public carpark and the Welwyn Garden City Central Library surrounded by soft landscaping.
Geology	Ground investigation confirmed the following geological sequence anticipated from published information: **Made Ground** (variable soils): **Up to 1.4m thick.** **Lowestoft Formation** (comprising variable superficial deposits)**: 2.20 to 11.70m thick.** Localised **Thanet Sand Formation** (comprising variable superficial deposits)**: >4.80m thick.** **White Chalk** (Grade Dm and Grade Dc): to the full depth of the investigation **(25.00m bgl).** Evidence of '**Swallow holes'** (zones of metastability and voiding associated with chalk dissolution) have been identified locally approximately 170m southeast.
Hydrogeology	The superficial deposits have been classified as a **Secondary Aquifer** (Undifferentiated). The White Chalk has been classified as a **Principal Aquifer**. No groundwater was encountered.
Hydrology	Unnamed streams running through an area of woodland 0.80km northwest of the site. Two lakes and the River Lea present in Stanborough Park, 2.40km south of the site.
Site History	**19th Century:** The Site was occupied by woodland running adjacent to existing railway line. **1920-1940:** Workmen's Camp, Laundry, Sawmills and a rail siding on site. **1960-Present:** The site was redeveloped into Campus West by 1972 and attained its current layout by 1993 with residential and business development to the west and east, Campus ground to the south and the former rail corridor to the north.
UXO	Risk maps show the site to be at **Low risk of UXO**, potential industrial targets beyond northwest of the site deemed Moderate risk.
Licensing Records	**Discharge Consents:** One within 500m. **Prosecutions Relating to Controlled Waters:** None recorded.

Licensing Records Continued	**Pollution Prevention and Controls:** Dry Cleaners 337m southeast dated November 2011. **Pollution Incidents:** None within 500m. **Water Abstractions:** One within 500m. **BGS Recorded Mineral Site:** None within 500m. **Hazardous Substances:** None within 500m. **Landfill & Waste Management:** Waste treatment or disposal site 403m east of site. **Contemporary Trade Directory Entries & Fuel Stations (within 500m):** Cleaning Services, Computer Manufacturers, Air Conditioning & Refrigeration, Building Services, Mechanic Services.
Ground Investigation	The ground investigation completed by WYG during December 2019 comprised the following: • Service clearance and GPS • 2No. Cable Percussive and 9No. Window Sample Boreholes up to 25m bgl with sampling and Standard Penetration Testing (SPTs) • Geotechnical and Geo-environmental laboratory assessment; • Installation of standpipe monitoring installations; • 3No. ground gas monitoring and water sampling monitoring visits.
Geo-Environmental Risk Assessment	Based on the updated conceptual model of source, pathway and receptor linkages, the following risk levels established have been identified: • Current site users – **Low** (Low to Moderate in areas of landscaping • Future site users – **Low** (Low to Moderate in areas of landscaping • Construction Site Workers – **Low** (on implementation of CDM) • Adjacent site users – **Low** (Moderate during ground works) • Groundwater (underlying aquifers) – **Moderate** • Surface water (watercourse on site) – **Low to Moderate** • Structures / Services – **Low** (Moderate in mobile groundwater) • Soft Landscaping **- Low**
Land Gas	The site has been assessed to be CS2 (Low Risk).
Geotechnical Risks and Recommendations	Conventional shallow foundations bearing onto the Lowestoft Formation are considered a viable foundation solution in most areas for lighter loads (**up to 140kN/m^2**). The above factors may influence the type of foundation type and piled foundations may need to be considered. For heavier structural loads, or where factors impact on the viability of shallow foundations, piled foundations may need to be considered. Piled foundations will need to be constructed cognisant of local conditions, and critically the variable surface depth and characteristics of the White Chalk associated with the high risk of solution features. Ground improvement will be required to support ground bearing floor slabs. **CBR** Values ranging between **1 to 10%** are considered for near surface soils. A design Sulfate Class of ACEC 1s DS-1 is recommended.

1.0 INTRODUCTION

1.1 Instruction

WYG Environment (WYG) were commissioned by Welwyn Hatfield Borough Council (WHBC) to undertake a ground investigation and assessment at the Campus West site, located near the centre of Welwyn Garden City.

Instructions to proceed were provided in a Purchase Order dated October 2019 (RSE2152595).

1.2 Objective

The ground investigation was initially scoped by Conisbee and further developed by WYG using the findings of the Desk Based Assessment (report ref WGC Campus West DTS V1). The overarching objective was to provide preliminary information relating to the ground conditions, potential ground contamination and geotechnical constraints at the site in relation to the redevelopment of the site to accommodate more carparking facilities.

This report details the ground investigation undertaken, provides a factual record of the conditions encountered, and further develops the conceptual ground model to inform a detailed review of the geo-environmental and geotechnical constraints posed to site development.

1.3 Proposed Development

At the time of compilation of this report (during January 2020), the scheme was at concept stage, the details of which were not available, however it was understood that proposals included the development of a decked, two-storey carpark in the existing carpark area with retention of the existing buildings and landscaped areas.

1.4 Scope

A desk-based assessment undertaken by WYG in November 2019[1] collated publicly available information to enable a review of the risks associated with ground conditions with potential to impact upon the redevelopment of the site for combined residential / commercial use. This information was used to refine the proposed intrusive investigations and the following report covers the following scope of work.

- A geotechnical and ground contamination assessment discussing the results of the investigation cognisant of the desk-based assessment, not only concerning potential on-site geotechnical engineering and contamination conditions/constraints, but also an overview of the potential for migration of contamination onto the site, or off-site to local receptors.
- A geotechnical and ground contamination intrusive investigation.
- Interpretation of the data collected in order to refine the Conceptual Site Model (CSM) and to undertake qualitative risk assessment of potentially complete pollutant linkages in accordance with current guidance.
- Development of an outline geotechnical model with discussion of characteristic geotechnical parameters.
- Provision of geotechnical recommendations pertaining to potential development constraints and management options.

1.5 Terms and Conditions

This report has been prepared for the client, Welwyn Garden City, in accordance with the terms and conditions of this contract, prepared in line with the proposal (ref rt 30Sept19 fplV5), and is subject to the report conditions included as Appendix A.

The recommendations and opinions expressed within this report are based on the information provided and other sources of readily available information. Where reference has been made to other reports or information provided by the client, or

[1] WGC Town Centre DTS Report V1 (October 2019)

from other Third party sources, such data has been reviewed in good faith and it has been assumed that their contents are correct, as it is impractical to fully validate this data. WYG is unable to guarantee any Third-Party Information.

2.0 SITE INFORMATION

2.1 Site Location

The Site covers an area of approximately 2.3Ha near the centre of Welwyn Garden City and is defined by Digswell Road which forms the east boundary, a former rail corridor forming the north boundary, and The Campus (Road) forming the south boundary.

The Site is centred on National Grid Reference TL 23630 13392 and the nearest postcode is AL8 6BX.

A site location plan is provided as Figure 1 of this report.

2.2 Site Description

The Site is broadly rectangular in plan, with straight north, east and west boundaries, and a curved south boundary defined by The Campus.

At the time of the investigation (during October to December 2019) the east side of the site was occupied by the Campus West Arts & Conference Centre and the Welwyn Garden City Central Library. Hardstand parking for approximately 250 cars was located on the west side of the site adjoining the access road connecting to The Campus.

The perimeter of the Site is defined by landscaped areas with mature trees. The landscaping is broken along the south boundary by the access road and pedestrian entrance into the Art Centre.

The Campus West Arts & Conference Centre and the Welwyn Garden City Central Library buildings are flat roofed brick, circa 1980 buildings up to five storeys high occupying approximately 1/3 of the site footprint.

2.3 Surrounding Area

Land use beyond the Site boundary is summarised in Table 2.1.

Table 2.1 Surrounding Land Uses

	Description
North	The north boundary is defined by a former rail corridor (National Route 12) which is now a public footpath within the original rail cutting residing at approximately 3m below the site level. The corridor is densely vegetated with both mature and semi-mature trees growing along the embankments and crest immediately adjacent to the site. Predominantly residential areas of detached and semi-detached houses with associated gardens lie beyond the former rail corridor to the north.
East	Digswell Road forms the east boundary with Welwyn Garden City Theatre and Oaklands College, and a car park further east.
South	The Campus (road) forms the south boundary and encloses a public park further to the south. Welwyn Garden City offices are situated further to the south of the park on the south side of Bridge Road, forming the boundary of the southwest corner of the site.
West	The west boundary of the site is separated from a residential development by a hedgerow. The development comprises four storey blocks of flats and associated landscaped areas

3.0 ENVIRONMENTAL SETTING

3.1 Geology

Information regarding the underlying geology has been obtained from the British Geological Survey (BGS) online GIS database which indicates the Site to be underlain by the following geological sequence.

3.1.1 Made Ground

Although not indicated on published BGS maps, Made Ground is anticipated to be present. Fill materials are likely to underly hardstand areas, and the Site's historic development may have resulted in disturbance to shallow soils, or importation of soils. It is also considered possible that remnant substructures from former developments may exist in localised areas of the site.

3.1.2 Superficial Geology

BGS Geoindex online mapping (1:50,000 scale) indicates that the Site is underlain by the superficial Lowestoft Formation, described by the BGS lexicon of named rock units as "an extensive sheet of chalky till, together with outwash sands and gravels, silts and clays".

3.1.3 Solid Geology

The Lewes Nodular and Seaford Chalk Formations (undifferentiated) are indicated to underlie the superficial deposits.

The Lewes Nodular Chalk Formation is described in the BGS lexicon as "hard to very hard chalk with interbedded soft to medium chalks and marls. Nodular chalks are typically lumpy and iron-stained."

The Seaford Chalk Formation is described as "firm white chalk with nodular and tabular flint seams".

Together these units form part of the White Chalk Sub-Group and are herein referred to as the White Chalk.

Immediately to the north of the Site the Lambeth Group is indicated to overlie the White Chalk. It is possible that this unit may encroach across the north boundary of

the site. The BGS lexicon describes the Lambeth Group as "vertically and laterally variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate".

3.1.4 BGS Borehole Records

The BGS online database show no boreholes located on site. Boreholes located near to the Site have been reviewed and the conditions encountered are summarised in Table 3.1.

Table 3.1 Summary of Historical Borehole Records

BH Ref.	Distance and Direction	Strata *	Depth (m bgl)	Groundwater (m bgl)	Description**
TL21/122	150m N	London Clay Formation	5	No information	No further description given
		Seaford Chalk	36		No further description given
		Lewes Nodular Chalk	70		No further description given
TL21SW/93	240m SE	Topsoil	0.46	Dry	No further description given
		Lowestoft Formation	6.55		Firm brown sandy clay with stones at top, becoming gravel and sand further down and stiff brown clay with stones at base
TL21SW/15	290m E	Anthropogenic Ground**	0.50	28.6	Fill: Reinforced concrete (0.2m) resting on gravel and concrete rubble
		Lowestoft Formation	10.0		Orangish brown clays, sands and gravels, becoming silty with depth. Cobbles up to 125mm at base
		Undifferentiated Chalk	15.0		Clayey, friable and rubbly Chalk. Reworked at top with lenses of variable chalky brown clay with small fragments of stiff brown clay. Becomes rubbly and blocky with orange patches and flint with depth

* Interpretation based on description. ** Soil description extracted from the borehole record

3.2 Risk Assessment of Chalk

Chalk has a high calcium carbonate content, the susceptibility of which to dissolution by water, particularly where pH is low, can lead to the zones of differential and exaggerated weathering of the chalk surface, often presenting as a well-developed weathered horizon of 'Chalk Head'.

Weathering typically exploits zones of weakness within the chalk (e.g. well-developed joints and bedding plains), and therefore the Chalk Head can be variable both in-terms of its thickness and its geotechnical properties. In addition, zones of metastability associated with deep weathering, often described as dissolution features, can in some circumstances include deeply unstable soils and voids / roofed cavities.

The Envirocheck report also lists the coordinates of two 'Natural cavities' which are approximately 250m to the SW of the site.

These features are listed as 'sinkholes' and further information was requested Stantec (formerly Peter Brett Associates (PBA)) who have confirmed that WHBC kept a record of any natural cavity features discovered during development in the 1900s. The location of these features was recorded and marked on a map provided to PBA by WHBC dated 22nd February 1983.

The map shows "swallow holes" that were often found during road, sewer and housing construction in areas where the Glacial Gravels overlay the Chalk at approximately 10-14m bgl. Additionally, it was noted that some of the encountered features had been induced as a result of the construction works.

It was later noted that further clarification was sought on the terminology used within the reports and hence the type of solution feature has since been reclassified as a 'sinkhole' instead of a 'swallow hole'.

Further hazards identified in The Envirocheck Report also identifies the possibility of mining and mineral Sites around the area, possibly related to chalk mining, although none are recorded to occur within 250m of the site, there is considered to be potential for historic deneholes (shallow small-scale mining features).

The likelihood of the chalk being affected by dissolution processes is influenced by several factors including the nature of the cover deposits, the depth of groundwater, and the local topography, and the anticipated site conditions can be qualitatively assessed following methods outlined by C.N. Edmunds (2001) [ref 2].

Following the desk-based risk assessment method[2], the Site is classified to have a **High Risk** of metastability and voiding associated with chalk dissolution. This is primarily driven by the presence of the overlying Lowestoft Formation diamicton and the potential encroachment of Tertiary Deposits (Lambeth Group) in the north of the site which can lower the pH and concentrate groundwater flows potentially accelerating the dissolution of the underlying chalk. The risk assessment is presented in Appendix C.

3.3 Ground Stability Hazards

Table 3.2 provides a summary of ground stability hazards identified from the BGS database. The BGS database designates Ground Stability Hazard risk ratings to spatial areas based on the local geology and soil type as reported within the Envirocheck. These ratings are assigned to areas based on the local geology and soil type identified in regional geographic information systems, and do not necessarily consider hazards relating to localised topography and local variations in ground conditions.

The high risk indicated for ground dissolution is associated with the White Chalk which is susceptible to dissolution, as discussed in detail in Section 3.2.

The Envirocheck Report also identifies the possibility of mining and mineral sites around the area, possibly related to chalk mining, although none are recorded within 250m of the site, there is considered to be potential for historic deneholes (shallow small-scale mining features).

In summary, considering the confirmed presence of local features and the conditions presented by the anticipated ground model, a **High** ground stability risk is identified.

Table 3.2 Ground Stability Hazards

[2] C.N. Edmunds (2001) – Predicting natural cavities in chalk: in 'Land Surface Evaluation for Engineering Practice' British geological Society Special Publication 18.

Ground Stability Hazard	Risk
Collapsible Ground	Very Low
Compressible Ground	No Hazard
Ground Dissolution	High
Landslide Ground Stability	Very Low
Running Sand Stability	Very Low
Shrinking or Swelling Clay	Moderate

3.4 Unexploded Ordnance Risk

Risk maps show that the Site is located within an area considered to be at **Low risk** of having potential buried UXO, although it is noted that there were potential industrial targets adjacent to the northwest of the Town Centre site boundary (ZeticaUXO, 2019).

3.5 Radon

The Site is noted as being in a Lower probability radon area, which is defined by less than 1% of homes being estimated to be at or above the Action Level, according to the British Geological Survey.

3.6 Nitrite Vulnerability

The Envirocheck Report (2019) identifies the Site to be in a Nitrite Vulnerable zone, defined as areas of land that drain into nitrate polluted waters, or waters which could become polluted by nitrates.

3.7 Hydrogeology

3.7.1 Aquifer Classification

The Environment Agency has classified the superficial deposits of the Lowestoft Formation as a Secondary Undifferentiated Aquifer. This classification is given in cases where it has not been possible to attribute either category A or B to a rock type.

The bedrock geology of the White Chalk has been classified as a Principal Aquifer. This classification is defined as layers of rock or drift deposits that have high intergranular and/or fracture permeability and provide a high level of water storage. They may support the public potable water supply and/or base flow on a strategic scale.

3.7.2 Groundwater Source Protection Zone

The Site is located within a Groundwater Source Protection Zone III defined by the EA as the area around a supply source within which all the groundwater ends up at the abstraction point.

3.7.3 Licensed Groundwater Abstractions

No water abstraction permits have been identified within 250m of the site. The nearest water abstraction permit exists 474m east of the site, relating to Rank Xerox Ltd, which allows a daily rate of 2991m^3 of groundwater to be abstracted daily for industrial processing. No expiry date has been provided.

3.8 Hydrology

3.8.1 Surface Water Features

The nearest surface water feature is a stream located approximately 180m to the east of the site flowing east to west along the southern boundary of an area of residential properties. This stream is culverted below the pedestrian access leading into the Town Centre from Gresley Close. The eastern extent of the culvert, and the interface with any former railway drainage systems located north of the site and following the route of the stream, was not confirmed.

Unnamed streams also flow through wooded areas located 0.50km northwest of the Site.

Further to the south of the Site, two lakes are located in Stanborough Park in close proximity to the River Lea approximately 2.40km from the Site boundary.

3.8.2 Flood Risk

The Site is indicated to be within an area designated as Flood Zone 1, which is defined as an area having a less than 1 in 1,000 annual probability of river or sea flooding.

4.0 SITE HISTORY

4.1 Introduction

The historical development of the Site and surrounding area has been assessed using information available from historical Ordnance Survey (OS) maps dating from 1884 to 2019 provided with the Envirocheck Report (Appendix B).

4.2 Summary of Site History

4.2.1 On-site

The earliest available historical map extract, published in 1884, shows the Site to be part of the Sherrardspark Wood and is located immediately south of the Dunstable Branch railway. The wood was then cleared during the period from 1920 to 1940 prior to the establishment of a sawmill and joinery on the Site. These developments were serviced by a rail siding feeding into the northern area of the Site and included workmen's cottages in the southeast. The Site was redeveloped to accommodate the library and Campus West buildings in 1973.

Google Earth Satellite Images / Aerial Photography dating back to 2002 show that the Site has remained largely unchanged through this period to the present date (January 2020).

4.2.2 Off-site

The areas around the site originated as fields and farmland. Some areas have been developed into residential dwellings, whilst other areas have been used for industry purposes, including factories, builders' yards and brick works. These have since been redeveloped, and now largely feature more commercial and residential uses.

4.3 Historical Site Uses

Table 4.1 provides a detailed account of the review of available OS mapping coverage for the site and general area dating back to 1884. The commentary is generally limited to locations within 500m of the site boundaries unless it is considered that activities beyond that range could potentially have an impact on the site.

Table 4.1 Historical Site Review

Map Date & Scale	Within Site Boundary	Surrounding Area
1878 (1:2,500) 1884 (1:10,560) 1898 (1:2,500) 1899 (1:10,560)	The earliest map from 1878 shows the site to be occupied almost entirely with woodland. The woodland is largely unbroken with some tracks marked running through it, and a larger track/road to the south. The northern edge of the site borders a railway line ('Dunstable Branch') constructed within a cutting. The 1884 and 1899 1:10 560 maps show that the woodland is part of the 'Sherrardspark Wood'.	The sites north boundary comprises the Dunstable Branch railway with a pedestrian crossing leading into woodland north of the railway. The area to the northeast and to the south is largely open fields with a few buildings in the southwest. Farms are shown to the northeast and south.
1923 (1:2,500) 1925 (1:10,560)	The woodland has mostly been cleared, 'Saw Mills' are indicated in the southwest, and a 'Workmen's Camp' and 'Laundry' is indicated in the southeast. A railway siding connecting with the Dunstable line to the west runs into the site from the west.	A 'Brick Works' is shown to the northwest, a 'Post Office' to the south and various 'Banks' and 'Council Offices' to the southeast. An 'Electric Power Station' is present to the southeast of the site along with 'Playing fields' and a tennis ground are shown. Residential development roads are shown to the southwest and west. An area of the original woodland to the west of the site is now labelled as the 'Reddings Plantation'. A reservoir is now indicated to the north.
1938 (1:2,500) 1939 (1:10,560)	The Saw Mill is now marked as a 'Joinery Works', with new buildings present in the west of the site.	Digwell Road is shown in its present-day location forming the east boundary of the site and continuing across the railway Dunstable Line (railway) on an overbridge. Further residential development, roads and a school are indicated to the north of the site. Several developments are shown to the south and southeast of the site, including one labelled as a 'Theatre'. Industrial development is shown in the wider areas around the site, including a 'Plastic Powder Works' and 'Sewage Works' to the northeast, an 'Iron Foundry' to the east, and a 'Pumping Station' to the southwest. The electric Power Station is no longer indicated.

Map Date & Scale	Within Site Boundary	Surrounding Area
1950 (1:10,560)	No changes indicated.	Further development comprising new streets of houses is shown to the southwest, southeast and north.
1960 (1:10,000) 1961-1985 (1:1,250) 1966 (1:10,000) 1969 (1:1,250)	The buildings formerly associated with the Joinery Works are no longer shown. The 1961-1985 (1:1,250) map shows the "Campus West" development (built in 1973) in the east of the site.	The joinery works is now labelled as a 'Builder's Yard'. New developments are indicated to the east across from Digswell Road which is the Mid-Herts College of Further Education and a nearby library. 'Allotment Gardens' and tennis courts are indicated to the northeast. Further development is indicated to the southeast including roads, car parks, the theatre is now labelled as a 'Cinema'. Expansion of road running over the railway line to the southeast of the site. New road constructed by 1966, to the east of the railway line, running approximately N-S.
1972 (1:2,500) 1976 (1:10,000)	Campus West is not shown on the 1972 (1:2,500) map. The site is shown to be clear of development with wooded areas and footpaths. Campus West is shown on the 1976 (1:10,000) map with open car parking in the west and the site has more or less attained its present-day layout.	The 1976 (1:2,500) shows significant residential development of the open fields and farmland to the northeast. Further development and expansion of the local road and rail network together with further residential development is shown. Continued development has occurred to the southeast of the site, creating a higher density of buildings. The reservoirs to the northwest of the site appear to have been expanded.
1989 (1:10,000) 1992 (1:1,250) 1993 (1:1,250)	No changes indicated.	Much of the industrial development to the northeast is no longer shown. Further residential and commercial / retail development is shown in the wider area, with only minor changes to previously developed areas. Some changes to the buildings to the southeast of the site are shown, whilst a 'Dismantled Railway' is shown to the west.

Map Date & Scale	Within Site Boundary	Surrounding Area
1999 (1:10,000)	No changes indicated.	Further developments in the area formerly occupied by factories to the northeast us indicated.
2019 (1:10,000)	No changes indicated and the site is shown in its present-day layout.	No changes indicated and the surrounds are shown in their present-day layout.

5.0 LICENSING RECORDS

5.1 Discharge Consents

The Envirocheck Report, provided in full in Appendix B, provides a record of licences, consents, permits applicable to potentially contaminative activities in the Site vicinity. The following summary is generally limited to locations within 500m of the Site boundaries unless it is considered that installations or activities beyond that range could potentially have an impact on the site or be affected by the redevelopment of the Site.

5.2 Discharge Consents

A single discharge consent has been identified within 500m of the Site relating to Cbx (making of computers and electronics) 475m east of the Site, permitted in October 2991 and revoked in March 1996.

5.3 Prosecutions Relating to Controlled Waters

No records of any prosecutions relating to the pollution of controlled waters have been identified within 1km of the Site.

5.4 Pollution Prevention and Controls

A single Local Authority Pollution Prevention and Control measures is in place within 500m of the Site. It relates to Welwyn Dry Cleaners, 337m SE permitted from 1st November 2011.

5.5 Pollution Incidents

No incidents of pollution into controlled waters or substantiated pollution incident register entries recorded within 500m of the Site.

5.6 Water Abstractions

A single water abstraction permit has been identified within 500m of the Site. This is operated by Rank Xerox Ltd at a distance of 474m east, under licence

29/38/02/0074. It is reported that 2991m^3 of groundwater is extracted daily. Both the authorised start date and end date have not been supplied.

5.7 BGS Recorded Mineral Site

There are no recorded BGS Mineral Sites within 500m of the Site.

5.8 Hazardous Substances

There are no Control of Major Accident Hazards Sites (COMAH) or Notification of Installations Handling Hazardous Substances (NIHHS) sites within 500m.

5.9 Landfill & Waste Management

Hertfordshire County Council has supplied landfill data for a location within the bounds of the Site, although no further details have been provided. WHBC does not have any landfill data to supply.

There are two records of licenced waste management facilities within 1km of the Site as summarised in Table 5.1.

Table 5.1 Summary of Licensed Waste Management Facilities within 1km of The Site

Operator	Type	Location	Permit No.	Issue Date	Expiry Date
WGC Metals Ltd	Vehicle depollution factory	850m E	102412	February 2011	Not supplied
WHBC	Special waste transfer station	961m E	80190	May 1999	Not supplied

A registered landfill site is present within 1km of the site, as summarised in Table 5.2.

Table 5.2 Summary of Registered Landfill Sites located within 1km of The Site

Operator	Type	Location	Permit No.	Issue Date	Expiry Date
Polycell Products Ltd	Landfilling (soakaway) of aqueous effluent and effluent treatment sludge – up to 10,000 tonnes per year	689m SE	79/078	June 1979	Not supplied

There are four records of recorded waste treatment or disposal sites within 1km of the Site as summarised in Table 5.3.

Table 5.3 Registered Waste Treatment or Disposal Sites within 1km of the site

Operator	Type	Distance from site boundary	Permit No.	Issue Date	Expiry Date
Rank Xerox Ltd	Treatment of acids, alkalis, flammable solvents, industrial effluent sludge, metasilicate solution, oil/water mixtures, toxic/poisonous wastes, waste solvents and contaminated water at an input rate between 10,000 and 25,000 tonnes per year	403m E	82/134 (preceded by 78/042)	May 1984	Not supplied
Polycell Products Ltd	Storage of aqueous effluent waste	885m SE	79/078	June 1979	Not supplied
British Lead Mills	Lead scrapyard with allowed input rate between 25,000 and 75,000 tonnes/a	889m SE	92/302	January 1993	Not supplied
Roche Products Ltd	Drummed storage of chlorinated and unchlorinated solvents (A and B) – max input less than 10,000 tonnes/a	966m SE	86/203	June 1986	Not supplied

5.10 Contemporary Trade Directory Entries & Fuel Stations

The Envirocheck Report provides details of industrial and commercial land uses that are considered to be potentially contaminative within the vicinity of the site.

An abundance of records has been found, relating to historical retail, commercial and light industrial land use which also includes fuel stations. A selection of records considered most relevant, which may aid in giving an impression of typical historic and present-day land use within 500m of the site, are presented in Table 5.4. No active directory entries were found within 100m of the site, although three active entries have been identified within 500m of the site are presented in Table 5.4.

Table 5.4 Contemporary Trade Directory Entries

Name	Distance and Direction from Site (m)	Classification	Status
Done and Dusted	73 NW	Cleaning Services - Domestic	Inactive
I B M (UK) Ltd	88 S	Computer Manufacturers	Inactive
Alpha Air Conditioning	296 NE	Air Conditioning /Refrigeration	Active
United Carpet Cleaning Masters	296 S	Carpet, Curtain and Upholstery Cleaners	Inactive
Mixamate Holdings Ltd	306 S	Concrete Ready Mixed	Inactive
R & R Cleaning Services	355 W	Commercial Cleaning Services	Active
Sketchley Retail Ltd	377 SE	Dry Cleaners	Inactive
Supasnaps	377 SE	Photographic Processors	Inactive
London Boys Scrap Yards	384 SE	Car Breakers & Dismantlers	Inactive
Scrap Car Now Today	396 SE	Car Breakers & Dismantlers	Inactive
Advanced Diagnostic	408 SE	Scientific Apparatus & Instruments - Manufacturers	Inactive
Amalgamated Chartered	408 SE	Commercial Cleaning Services	Inactive
Snappy Snaps	438 SE	Photographic Processors	Inactive
Welwyn Garden City Ltd	482 S	Car Body Repairs	Inactive
Mr Mop Office Cleaning	495 SW	Commercial Cleaning Services	Active

One fuel station has been recorded within 500m of the Site. This relates to the now obsolete Central Garage, located 430m south of the Site.

Two further fuel stations have been identified within 1km of the site, one relating to the Tesco Head Office, 820m northeast and the open Mfg Eastbridge 917m southeast.

6.0 GROUND INVESTIGATION

6.1 Summary of Scope

Ground investigation works were undertaken between the 1st November and 3rd December 2019. The completed investigation consisted of the following scope of work.

- Service clearance using Ground Penetrating Radar and CAT Scanning and surveying using GPS of all exploratory locations.
- Hand excavated inspection pits to a depth of 1.20m bgl at all exploratory hole locations.
- 2No. Cable Percussive Boreholes to depths of 20.00m bgl (BH7) and 25.00m bgl (BH8) with Standard Penetration Testing (SPTs) and recovery of disturbed and undisturbed samples.
- 9No. Windowless sample Boreholes to depths ranging between 3.00 and 6.45m bgl with Standard Penetration Testing (SPTs) and recovery of disturbed samples.
- Installation of 50mm diameter dual-purpose Groundwater and ground gas standpipe monitoring installations; and
- 3No. ground gas monitoring and water sampling monitoring visits.

Exploratory hole locations are indicated on Figure A115249 LDN-N-02-Exploratory Hole Location Plan.

Factual information relating to the work is provided in Appendix D to I.

Standards employed during the investigation were in general accordance with BS5930:2015.

6.2 Summary of Ground Conditions

The encountered ground conditions compared well to those anticipated from published geological maps, and in summary comprised Made Ground, Superficial Deposits, localised Thanet Sand Formation and the White Chalk in deepening succession.

A summary of strata depths and thicknesses is provided in Table 6.1. Detailed soil descriptions provided on the Engineering Logs included in Appendix D.

Table 6.1 Summary of Strata Depths and Thicknesses

Location	Topsoil / Surface Hardstanding		Made Ground		Lowestoft Formation		Thanet Sand Formation		White Chalk	
	From (m bgl)	Thickness (m)	From (m bgl)	Thickness (m)	From (m bgl)	Thickness (m)	From (m bgl)	Thickness (m)	From (m bgl)	Thickness (m)
BH07	GL	0.20	0.20	1.30	1.50	11.70	Not Present		>13.00	7.00
BH08	GL	0.20	0.20	0.50	0.70	15.80	Not Present		>16.30	8.70
WS10	GL	0.27	0.27	0.32	1.26	0.95	2.21	>4.79	Not Encountered	
WS11	GL	0.29	0.29	1.00	1.29	>6.00	Not Encountered			
WS12	Not Present		0.00	1.26	1.26	>2.60	Not Encountered			
WS13	GL	0.05	0.05	1.35	1.4	>5.60	Not Encountered			
WS14	0.00	0.05	0.05	0.24	0.24	2.20	2.64	>2.36	Not Encountered	
WS15	0.00	0.11	0.11	0.27	0.38	3.00	3.00	>1.00	Not Encountered	
WS16	0.00	0.30	0.30	0.86	1.16	2.38	3.54	>3.40	Not Encountered	
WS17	0.00	0.19	Not Present		0.19	2.61	2.80	>3.65	Not Encountered	
WS18	GL	0.20	0.20	1.00	1.20	>3.00	Not Encountered			

6.3 Topsoil / Surface Hard Standing

Topsoil was encountered from ground level in most of the exploratory holes undertaken within areas of soft landscaping. The Topsoil varied in thickness between 0.05 and 0.30m and typically comprised dark brown sandy gravelly clay with rootlets.

Surface hard standing was encountered at ground level in all exploratory holes drilled through the car park and comprised a 0.05 to 0.20m thick layer of bitumen bound macadam (asphalt). In the west of the site (BH07 and WS11) the asphalt overlay a localised 0.08m to 0.22m thick layer of concrete. The surfacing was noted to be in relatively good condition with no excessive cracking or wear noted.

6.4 Made Ground

With the exception of WS17 (located in the north of the site), which encountered Superficial Deposits below the Topsoil layer, the Made Ground was encountered in all exploratory hole locations.

The deposit was variable in composition and comprised a 0.32 to 1.30m thick layer of both predominantly coarse and predominantly fine soils.

With the exception of a fragment of fused ash encountered in the northeast of the carpark area, no significant visual or olfactory signs of contamination were identified.

6.4.1 Made Ground - Coarse

Predominantly coarse soils present below the surface hardstanding in the carpark area comprised a 0.20 to 0.50m thick layer of compacted sandy flint and limestone gravel with occasional brick fragments, which is considered typical of Type 1 road stone subbase layer. WS10 and WS11 (in the NW of the site) encountered a deeper 0.31m to 0.58m thick layer of coarse soils below surface concrete. These soils were variable in composition and comprised brick fill and gravelly sand layers with glass and fused ash fragments.

6.4.2 Made Ground - Fine

Predominantly fine soils were encountered below the coarse Made Ground at depths ranging between 0.20 and 0.60m bgl in the carpark, and where present, below the topsoil at depths ranging between 0.05 and 0.30m bgl in the landscaped areas.

These fine soils varied in thickness between 0.40 and 1.26m and typically comprised yellowish/orangish brown to dark brown sandy gravelly clay. Gravel comprised flints and chalk with brick and concrete fragments. Anthropogenic materials (suggestive of Made Ground) were not encountered in BH07 and WS18, however signs of disturbance were noted, including the presence of chalk gravel, and therefore these soils have been classified as Made ground.

6.5 Superficial Deposits - Lowestoft Formation

Superficial Deposits (the Lowestoft Formation) were encountered below the Made Ground at depths of between 0.19 and 1.50m bgl in all the locations that penetrated the Made Ground. The deposit ranged in thickness between 0.95 and 15.80m bgl and the full thickness was not established in four locations (WS11, WS12, WS13 and WS18). However it was confirmed to be typically significantly thinner in the northeast of the site where the deposits were underlain by the Thanet Sand Formation.

The deposit was variable in composition and typically comprised an upper predominantly fine soil horizon over a lower predominantly coarse soil horizon.

6.5.1 Lowestoft Formation – Fine

The upper predominantly fine Lowestoft Formation soil horizon was confirmed to be between 7.80 and 8.80m thick in BH07 and BH08 in the west of the site respectively.

The deposit typically comprised firm to stiff (and locally soft at shallow levels), orangish brown / grey brown and reddish brown sandy gravelly clay. Gravel comprised sub-angular to rounded, fine to coarse flint and chalk.

6.5.2 Lowestoft Formation – Coarse

Predominantly coarse soils were encountered as both discrete horizons occurring at shallow levels within the fine soils, and as a lower and more substantial soil horizon which was encountered at deeper levels within the cable percussive boreholes.

The shallow, discrete coarse soil horizons typically comprised sandy gravels with subordinate flint gravel occurring within or overlying the predominantly fine soils in WS10, WS13, WS14 and WS17 measuring up to 1m thick. Gravels consisted of angular to rounded, fine to coarse and occasionally cobble size flint.

The depth of these units varied between each location and are therefore assumed to represent discontinuous lenses of sands / gravels within the predominantly fine soils.

The deeper cable percussive boreholes (BH7 and BH8) encountered a 1.6 to 6.8m thick layer of coarse soil overlying the White Chalk. It is considered likely that these lower deposits are closely associated with the underlying White Chalk, potentially forming from extensive weathering and wash out of fines at the surface of the chalk, the variable thickness of which are representative of the typical karstic chalk surface.

These deeper soils comprised reddish brown sand / gravel and sandy gravel. Gravels comprised fine to coarse, angular to rounded flints, with the occasional nodular flint cobbles.

6.6 Lambeth Group - Thanet Sand Formation

Published BGS geological mapping shows encroachment of the Thanet Sand Formation (Lambeth Group) close to the north east site boundary. Localised soils resembling the Thanet Sand Formation in terms of composition were encountered in five locations (WS10, WS14, WS15, WS16 and WS17) within the north and eastern portion of the site at depths ranging from 2.21 to 3.54m bgl.

All exploratory locations progressed into the Thanet Sand Formation were terminated within this unit. The composition of this formation comprised yellowish/orangish brown clayey fine sand or very sandy clay with occasional gravel lenses.

6.7 White Chalk

The White Chalk was encountered in BH07 and BH08 at a depth of 13.00m bgl (87.75mAOD) and 16.30m bgl (82.75m AOD). The deposit persisted to the maximum depth of the investigation (25m bgl) and consequently the full thickness of the deposit was not established.

From the engineer's descriptions the borehole arisings have been described as creamy white structureless chalk composed of slightly gravely sandy silt. Gravel comprised weak fine to coarse chalk fragments with frequent black specks.

The weathering grade of the chalk, as defined in CIRIA C574[3] , was rendered difficult to determine due to the high level of disturbance of samples recovered during cable percussive drilling. However, based on tentative correlations with SPT N (see Section 7.7), and the materials recovered, it is considered likely that the chalk comprises Grade Dm (matrix dominated) structureless chalk.

6.8 Groundwater

Groundwater was not encountered in any of the exploratory holes during the ground investigation.

6.9 Standard Penetration Testing (SPTs)

SPTs were undertaken in all cable percussion boreholes and window samples. The results are presented on the exploratory hole logs included in Appendix D.

6.10 Falling Head Tests

Falling head tests were not carried out within the exploratory holes during the ground investigation. The rationale supporting the decision to omit falling head tests from the scope was based on the amount of water introduced to the boreholes during drilling. Between 100 and 200 litres of clean water was introduced into each borehole to facilitate drilling through the Lowestoft Formation and this water would fully permeate within 120 seconds. Based on this rapid permeation, indicative permeable characteristics can be assumed across the range of soil strata

[3] CIRIA C574 Engineering in Chalk

encountered, although it should be noted that shallow fine soils may have reduced permeability.

6.11 Monitoring

Dual Purpose land gas and groundwater monitoring standpipes were installed within some Windowless sample boreholes WS10, WS11, WS14, WS16, WS18 and in both Cable Percussion boreholes (BH07 and BH08). Installations were constructed using slotted 50mm diameter HDPE standpipe with 325micron filter wrap and 10mm pea-shingle surround. Response zone depths were designed upon the completion of each borehole and are summarised in Table 6.2.

Three return monitoring visits were carried out during the period December 2019 to January 2020.

Groundwater depths recorded during each visit are summarised in Table 6.2 and a detailed record of ground water monitoring in included in Appendix E.

Table 6.2 Summary of Borehole Installation Depths and Groundwater Monitoring

Location ID	Response Top (m bgl)	Response Base (m bgl)	Water Depth Round 1 06.12.2019 (m bgl)	Water Depth Round 2 13.12.2019 (m bgl)	Water Depth Round 3 20.12.2019 (m bgl)
WS10	1.00	2.00	Dry	Dry	Dry
WS11	1.00	3.00	Dry	Dry	Dry
WS14	1.00	3.00	Dry	Dry	2.72
WS16	1.00	6.00	Dry	Dry	Dry
WS18	1.00	6.00	Dry	Dry	Dry
BH07	13.50	19.50	18.53	18.54	18.84
BH08	10.00	16.00	Dry	15.93	15.87

Table 6.3 Summary of Measured Land Gas & Vapour Concentrations

Date of Monitoring	Methane Concentration (% by Vol.)			Carbon Dioxide Concentration (% by Vol.)			Carbon Monoxide Concentration (ppm)			Atmospheric Pressure Trend
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	
06/12/2019	0.10	<0.01	0.03	9.00	4.00	6.21	7.00	<1	1.43	Falling
13/12/2019	0.20	0.10	0.11	11.6	3.00	6.85	4.00	<1	0.71	Rising
20/12/2019	0.30	0.30	0.30	10.4	2.60	2.34	2.00	<1	0.29	Falling

Land gases including methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide were measured during three monitoring rounds using a GA5000 infra-red land gas analyser. All land gas monitoring results to date are presented in Appendix E and summarised in Table 6.3.

Atmospheric pressure ranged between 969 to 997 mbar during the monitoring rounds which were generally conducted during falling pressure on the first monitoring visit (6th December 2019), rising pressure on the second monitoring visit (13th December 2019) and falling pressure on the third monitoring visit (07th January 2020).

6.12 Geotechnical Laboratory Analysis

Laboratory geotechnical testing was scheduled by WYG and carried out by PSL in accordance with their UKAS accreditation as summarised in Table 6.4. Results and laboratory test certificates are provided in Appendix G.

Table 6.4 Summary of Laboratory Geotechnical Testing

Test	Standard	No.
Moisture Content	BS1377: Part 2: Clause 3.2: 1990	15
Liquid and Plastic Limits of soil	BS1377: Part 2: Clauses 4.4, 5.3 & 5.4: 1990	11
Particle Size Distribution	BS1377: Part 2: Clause 9.2: 1990	9
Dry Density and Saturation Moisture Content	BS1377: Part 2: Clause 7.3: 1990	2

Quick Undrained Triaxial	BS1377: Part 2: Clause 8.1: 1990	9
Point Load	ISRM: 2007	0*
pH /SO4	BRE SD1	4
Chemical Testing	**Standard**	**No.**
BRE SD1 Suite	BRE SD1, BS1377: Part 3: 1990	4
Organic Matter Content	BS 1377-3:1990	3

* Samples were found unsuitable to carry out testing

6.13 Chemical Laboratory Analysis

The environmental chemistry of the soil samples was investigated by specialist chemical analysis of selected samples, scheduled by WYG, and carried out by ALS Laboratories (ALS) as summarised in Table 6.5.

The suite of testing undertaken was selected to address contaminants commonly occurring on brown field sites and light industrial historical activities.

ALS are an approved supplier in accordance with the requirements of WYG quality system and are themselves UKAS and MCERTS accredited for a range of chemical analyses.

Samples were submitted to the laboratory in six batches during the investigation works. Results and laboratory test certificates are provided in Appendix G.

Table 6.5 Summary of Laboratory Environmental Testing

Test Suite	Determinants	No. Scheduled
WYG Soil Suite B	Arsenic, Boron Cadmium, Chromium (total & hexavalent), Copper, Lead, Mercury, Nickel, Selenium, Zinc, Cyanide (free & total), PAH by GCMS, Total Organic Carbon, pH and Asbestos (screen), Phenols by HPLC and BTEX, TPH CWG.	12

7.0 GROUND MODEL AND GEOTECHNICAL PARAMETERS

7.1 Summary Ground Model

In summary, the following sequence of strata is characteristic of the overall site ground model;

- 1.5m thick Hard Standing / Topsoil / Made Ground;
- Variable thickness of Fine Superficial Deposits;
- Variable thickness of Coarse Superficial Deposits;
- Localised Thanet Sand Formation (North East areas of the Site);
- >15m thick Structureless Grade Dm White Chalk.

No groundwater was encountered during the investigation.

Full descriptions of the soils encountered are provided on the engineering logs with commentary provided in Section 6.0.

7.2 Soil Properties

The ranges of the various soil properties measured via in situ and laboratory testing are summarised in the following sections. Where characteristic values are provided, these are reasonably conservative estimates of a measured or assessed property, usually based on the lower quartile or average value that may be used to represent the overall behaviour of the material.

7.3 Made Ground

The Made Ground was variable and comprised both predominantly coarse and fine soils. A coarse 0.20 to 0.50m thick subbase layer was typically present below the hardstanding carpark areas. However, these were underlain by 0.20 to 0.60m of disturbed fine soils which occurred from ground level in the landscaped areas. In general, there was no other obvious lateral or vertical continuity across the site in terms of composition and these soils are therefore deemed to be uncharacterisable.

7.4 Fine Superficial Deposits (Lowestoft Formation)

Particle size distribution (PSD) testing undertaken on a selection of samples of fine Superficial Deposits has confirmed the engineer's description of the soils as

predominantly fine (clay and silt) with occasional horizons of predominantly coarse soils as indicated on the engineering logs (Appendix D). A summary of PSD tests is provided in Table 7.1.

Table 7.1 Summary of Particle Size Distribution Testing Fine Superficial Deposits

Range Min – Max (%)			
Clay/Silt	**Sand**	**Gravel**	**Cobbles**
74 - 89	10 - 18	0 - 8	0

Atterberg limits, including estimates of material properties [ref 4] obtained using published correlations were determined on 11 samples of Fine Superficial Deposits as summarised in Table 7.2.

Table 7.2 Summary of laboratory test results for the Fine Superficial Deposits

	Range (min-max)	Average	Lower quartile	Upper quartile	Characteristic
Moisture Content (%)	15 - 30	19.62	17.5	21	17
Liquid Limit (LL)	34 - 44	39.09	37	42	37
Plastic Limit (PL)	17 - 25	19.55	18	21	18
Plasticity Index (PI)	11 - 23	19.55	19	22	19
Modified PI (PI')	8.2 – 21.56	17.11	16.56	19.8	16
ϕ' (°)*	22.3 - 26.1	23.4	23.5	22.6	23

The characteristic properties indicated in Table 7.2 correspond to fine soils of intermediate plasticity and low volume change potential.

[4] Based on correlations provided in BS8002: 2015 Code of Practice for Earth Retaining Structures

The range of SPT N obtained from the Fine Superficial Deposits is plotted against depth in Figure 3 and this chart demonstrates a clear increase in both SPT N derived undrained shear strength (Cu) [ref 5] and laboratory determined Cu with depth.

It is noted that the ground conditions were not conducive to the recovery of undisturbed samples and quick undrained assessment of remoulded samples has been undertaken in their absence. Therefore, laboratory determined CU is likely to be conservative, and the weighting apportioned to laboratory Cu in the derivation of characteristic Cu parameters has been reduced.

A best fit linear relationship has therefore been used to derive characteristic Cu as indicated in Table 7.3.

Table 7.3 Summary of SPT N and Cu - Fine Superficial Deposits

	No. of results	Range (min-max)	Average	Lower Quartile	Characteristic Cu vs depth
SPT N x 4.5 (kPa)	51	30 - >250	107.15	63	Depth(m)/0.0309
Cu (kPa)	9	44-165	92	68	

7.5 Coarse Superficial Deposits (Lowestoft Formation)

Particle size distribution (PSD) testing undertaken on a selection of samples of Coarse Superficial Deposits has confirmed the engineer's description of the soils as predominantly coarse (sand and flint gravel) with occasional horizons of predominantly fine soils as indicated on the engineering logs (Appendix D). A summary of PSD tests is provided in Table 7.4.

Table 7.4 Summary of Particle Size Distribution Testing Coarse Superficial Deposits

Range Min – Max (%)			
Clay/Silt	Sand	Gravel	Cobbles
0 - 37	12 - 80	8 - 69	0

[5] Stroud and Butler, The Standard Penetration Test and the Engineering Properties of Glacial Materials, 1975

The range and variation of SPT N obtained from Coarse Superficial Deposits is summarised in Table 7.5. The lower SPT N values recorded in the deeper levels of this horizon often correspond to the boundary between the Lowestoft Formation and the highly weathered White Chalk. These lower values have therefore not been considered in the characterisation of these soils, which overall, based on correlation with SPT N, are medium dense to dense. However this contrast zone helps to illustrate the significant change of parameters occurring at this boundary. Table 7.5 also includes characteristic estimates of the angle of shearing resistance (ϕ) based on the correlation by Peck, Hanson and Thornburn [ref 6.]

Table 7.5 SPT N values Coarse Superficial Deposits

	No. of results	SPT N Range (min-max)	SPT N Average	SPT N Lower Quartile	Characteristic Value*
SPT N	9	19 - >50	40.44	31.5	31
ϕ (°)[7]		32.8 - >41.0	38.8	36.5	36

7.6 Thanet Sand Formation

Particle size distribution (PSD) testing undertaken on two samples of the Thanet Sand Formation has confirmed the engineer's description of variable soils comprising predominantly coarse (clayey sand) in WS10 and fine (sandy clay). A summary of PSD tests is provided in Table 7.6.

Table 7.6 Summary of Particle Size Distribution Testing Thanet Sand Formation

Min – Max (%)			
Clay/Silt	**Sand**	**Gravel**	**Cobbles**
12 - 87	13 - 80	0 - 8	0

The range and variation of SPT N and derived characteristics of both fine and coarse Thanet Sand Formation soils is summarised in Table 7.7. SPT N values correlations

[6] Foundation Engineering, 2nd Edition. Ralph B. **Peck**, Walter E. **Hanson**, Thomas H. **Thornburn**. 1974

and laboratory determined Cu have compared well with the engineer's description of dense to very dense coarse soils and stiff consistency fine soils.

Table 7.7 SPT N values Thanet Sand Formation

	No. of results	SPT N Range (min-max)	SPT N Average	SPT N Lower Quartile	Characteristic Value*
SPT N	17	14 - >50	34.11	26.5	26
ϕ (°)[7]		31.3 - >41.0	37.2	35.1	35
Cu		Based on Cu = SPT N * 5			175kPa

Classification testing undertaken on a single sample of the fine Thanet Sand Formation determined the following; LL 42%, PL 20%, PI 22% and PI'% 20.60 indicated intermediate plasticity soil of a medium volume change potential.

7.7 White Chalk

The cable percussive boreholes have confirmed that the depth to the White Chalk varies within 60m between 13.00m bgl (87.75mAOD) in BH07 and 16.30m bgl (82.75m AOD). This emphasises the stratums undulating profile which is considered typical of the White Chalk. This profile is also associated with variable degrees of weathering to variable depths and therefore a detailed characterisation of the White Chalk is hindered by this limited preliminary scope of work.

Given the parameters of the overlying coarse soils which display a typically high relative density, and the relatively low strength of the chalk, this variable depth will need to be a key consideration for the ground model and the development of the design of deep sub structures such as piles

From inspection of the recovered highly disturbed soils the White chalk was confirmed to be relatively uniform in composition (Section 6.7). The general absence of flint is considered important in characterisation as flint horizons can exaggerate SPT N values obtained within a weak chalk matrix. Table 7.8 summarises the range of SPT N values obtained from the White Chalk and it is emphasised that no obvious vertical trend in SPT N value was discernible.

Table 7.8 Summary of SPT N White Chalk

	No. of results	Range (min-max)	Average	Lower Quartile	Characteristic Value*
SPT N	11	4 – 18	11.37	9	9

Point load index (on recovered chalk gravel), intact dry density and saturation moisture content were determined on 2 samples of White Chalk as summarised in Table 7.9.

Table 7.9. Summary of Laboratory Assessment - White Chalk

	Range (min-max)	Average	Characteristic value
Moisture Content (%)	27 - 32	29.5	29
Dry Density (Mg/m^3)	1.46 – 1.51	1.49	1.49
Saturated Moisture Content (%)	29 -31	30	30

From the in-situ testing, laboratory assessment and engineers' descriptions the chalk grade, in accordance with CIRIA C574 is confirmed to be low density Grade Dm throughout the depths investigated.

7.8 Concrete Classification

Chemical tests were undertaken on 10 representative samples from the top 6.00m to determine corresponding Design Sulfate Class (DS), as defined in BRE SD1[ref 7] and the Aggressive Chemical Environment for Concrete (ACEC) is summarised in Table 7.10.

[7] **BRE** Special Digest I Concrete in aggressive ground (**SD1**: 2005)

Table 7.10 Summary of Chemical Analysis

Range (min – max)			
Acid Soluble Sulfate as % SO_4	**Aqueous Extract Sulfate as mg/l SO_4**	**pH**	**Total Sulfur %**
0.0195– 0.0327	9.3 – 55.1	4.58 - 7.8	0.0032-0.0131

The Design Sulfate class is well within the range of DS1 and the pH range of corresponds to an ACEC class within the AC-1s range which would assume a static water condition.

It is noted that the groundwater levels where beyond the depth investigated, however deeper proposed sub structures such as piles may need to consider conditions below the groundwater table where low pH conditions in mobile groundwater would need to be reviewed in line with BRE SD1.

8.0 CONCEPTUAL SITE MODEL AND QUALITATIVE RISK ASSESSMENT

8.1 Introduction

Under the current UK environmental legislation (Environment Act 1995, Water Resources Act 1994, Environmental Protection Act 1990 (as amended), Health and Safety at Work Act 1994, Town and Country Planning Act 1990 and Building Regulations 1985), land is defined as contaminated if there is a significant 'pollutant linkage'. This requires evidence of the presence of a contaminant "source", a "pathway" through which contaminants could travel, and a "receptor" that could be harmed by the contaminant. In addition, the type of receptor and any harm must meet the descriptions of significant harm given in the statutory guidance. A site where a contaminant is causing, or is likely to cause, significant pollution of controlled waters also constitutes contaminated land.

This section of the report presents a Conceptual Site Model (CSM), which includes a qualitative assessment of environmental risks associated with each of the pollutant linkages identified. The tabulated and illustrated CSM is provided in Appendix C.

The qualitative risk assessment is achieved by classifying the likely significance or severity of the risk and the probability of the risk actually occurring, to determine an overall risk for that particular pollutant linkage. The assessment has been undertaken with cognisance of:

- The nature, volume and extent of any identified contamination source;
- The potential pathways;
- Identified primary receptors; and
- Due regard to the current site status and potential future site redevelopment.

8.2 Ground Contamination Tier 1 Screening Assessment

The objective of the Tier 1 Screening Assessment presented herein is to identify the chemical constituents analysed which might potentially pose unacceptable levels of risk to sensitive on-site and off-site receptors. Measured concentrations in soil have been compared with various sets of Tier 1 Screening Values (TSVs). Where measured concentrations exceed these levels, this does not necessarily indicate a

requirement for remediation; it can however, be the trigger for the undertaking of a more detailed quantitative assessment in accordance with the current UK tiered risk assessment framework.

8.2.1 Human Health

Soils

In March 2014, DEFRA published the 'C4SLs' within the 'Policy Companion Document: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination' (SP1010). The purpose of the C4SLs is to identify a concentration in soil indicative of Category 4 status as defined by Part 2a Statutory Guidance[8] on the definition of contaminated land. In September 2014, further clarification was published in a letter from Lord DeMauley to Local Authorities instructing them to use C4SLs in planning. Where available C4SLs have been used as the preferred choice of screening criteria.

For those constituents where no C4SL has been published by the EA / DEFRA, WYG have screened soil against Suitable for Use Levels (S4ULs)[9].

For the purposes of this risk assessment human health criteria for soils applicable to a residential end use have been used in order to screen the site data. This is considered conservative in the context of the proposed carpark area, which will retain a hardstand barrier between potential source and human receptors, however it is considered appropriate where continued use of landscaped and soft verge areas will present exposure pathways to the public.

A number of TSVs are dependent on the Soil Organic Matter (SOM) content, and as such TSVs are typically calculated for a SOM of 1%, 2.5% and 6%. SOM of 1.57% was calculated for samples taken from the topsoil and a mean SOM of 0.72% was calculated for samples taken in superficial deposits. For this reason, GACs corresponding to a SOM of 1% have been used for the screening of the samples.

[8] Published by DEFRA in 2012 the guidance defines four categories of Category 4 is considered the least contaminated; "there is no risk or that the level of risk posed is low"

[9] Nathaniel C.P., McCaffrey, C., Gillet, A.G., Ogden R.C., and Nathaniel, J.F. 2015. *The LQM/CIEH S4ULs for Human Health Risk Assessment*

8.2.2 Tier 1 – Soil Screening

12No. soil samples obtained from the near surface materials on site were submitted for chemical laboratory analysis. Full copies of laboratory certificates for all soil analysis are included as Appendix H and these results have been screened against the values detailed in Table 8.1.

Based on the proposed end land use for the development the most appropriate screening criteria defined as Residential without plant uptake and a 1% Soil Organic Matter content.

Table 8.1 below summarises the determinands present in the soil samples which exceed their respective screening criteria.

Table 8.1 Soil Screening Results

Contaminant	Units	GAC	No. Samples	No. > GAC	Exceedance Concentration	Location and depth (m bgl)of exceedance
pH		<5, >9	17	4	4.58 4.89 4.91 4.73	WS10 (1.2) WS11 (0.7e) WS17 (0.2-0.3) WS18 (0.7)
Beryllium	mg/kg	1.7	17	1	1.83	WS11 (0.7)
No further exceedances to GAC						

8.2.3 Asbestos Screening

12No. samples were analysed for the presence of asbestos comprising samples from a range of depths. Potential Asbestos Containing Materials (ACMs) were not identified in any sample.

8.2.4 Controlled Waters Reference Criteria

The superficial geology is classified by the Environment Agency (EA) as a Secondary Undifferentiated Aquifer whilst the underlying bedrock is defined as a Principal Aquifer. The nearest groundwater abstraction permit exists 474m east of the site,

relating to Rank Xerox Ltd, allowing abstraction for industrial processing. The site is located within a groundwater Source Protection Zone III.

Groundwater was not encountered during the investigation and therefore no groundwater samples were collected and submitted for laboratory analysis. It is also noted that soil screening confirmed limited evidence of contamination sources within the soils overlying the aquifer (Section 8.2.1), and therefore no further laboratory assessment of the potential for mobilisation of any contamination encountered (e.g. via leachate assessment) has been undertaken.

9.0 GROUND GAS ASSESSMENT

9.1 Introduction

Three return visits to the site were made on the 06th December 2019, 13th December 2019 and 07th January 2020 to undertake land gas monitoring.

A full factual record of the monitoring visits is presented in Section 6.11 and Appendix E.

9.2 Potential Sources

Based on the information obtained as part of the desk study assessment and the findings of the site investigation three potential sources of soil gas have been identified on the site and in the surrounding areas.

As such the potential sources of soil gas are considered to be:

- Made Ground;
- And the underlying White Chalk outgassing via dissolution processes.

9.3 Data Summary

Table 9.1 summarises the minimum and maximum soil gas concentrations and flows obtained during the three monitoring visits. Using the CIRIA C665 guidance on Ground Gas the greatest flow rate and greatest concentrations of ground gases are combined to reflect a worst-case scenario. The ranges of concentrations at each location do not necessarily correspond to the same monitoring date but represent the maximum readings across the monitoring programme to allow an assessment the gas concentrations on a worst case scenario basis.

Table 9.1 Summary of Maximum Monitored Ground Gas Concentrations

Location	Atmos-pheric Pressure (m bar)	Max CH4 (peak) (% vol)	Max CO2 (peak) (% vol)	Min O2 (steady) (% vol)	Max CO (steady) (ppm)	Max H2S (steady) (ppm)	Max BH flow (peak) (l/h)
WS10	1012	0.3	7.6	13.2	<1	<1	0.2
WS11	1012	0.3	9.6	3.3	<1	<1	0.2
WS14	1012	0.3	11.6	9.7	<1	<1	0.4
WS16	1014	0.3	7.6	17.5	<1	<1	0.3
WS18	1012	0.3	7.8	15.0	<1	<1	0.3
BH07	1011	0.3	6.2	3.9	4.0	<1	0.7
BH08	1012	0.3	6.3	13.6	7.0	0.0	-1.3

9.4 Ground Gas Risk Assessment Methodology

The key reference documents which have been used to undertake the semi-quantitative land gas assessment presented in this report are as follows;

- BS 8485 (2015) Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings; and
- CIRIA C665 (2007) Assessing risks posed by hazardous ground gases to buildings.

These documents provide a framework for assessment of land gas risk to buildings/structures with a range of foundation designs. The collected data has been used for the purposes of undertaking a semi-quantitative assessment in accordance with BS8485 methodology, a worst-case assessment has been undertaken with the peak soil gas concentrations recorded during all the monitoring visits used in conjunction with the maximum flow rate.

The calculation used to calculate the borehole hazardous gas flow rate for the site, together with the relevant definition of units, is as follows:

GSV	***=***	***flow rate***	***x***	***gas concentration***
Q_{hg}	=	**q**	x	C_{hg}
(litres of gas/hr)		(litres per hour)		(volume/100)

9.5 Ground Gas Risk Assessment

Based on the maximum flow recorded of 1.3 l/h and the maximum concentrations of methane and carbon dioxide recorded during the soil gas monitoring the following Hazardous Gas Flow Rates have been calculated (Table 9.2).

Table 9.2 GSV Calculation

Type	Maximum Concentration (%)	Maximum Flow Rate (l/hr)	Qhg (l/hr)	Characteristic Situation
Methane	0.3	1.3	0.0039	CS1 (Very Low Risk)
Carbon Dioxide	11.6	1.3	0.1508	CS2 (Low Risk)

Based on this initial risk assessment the site is considered to be representative of Characteristic Situation 2 (Low Risk).

9.6 Summary

Ground gas monitoring indicates the presence of elevated concentrations of carbon dioxide, up to a maximum concentration of 11.6% v/v. Only minimal flow rates have been recorded (-1.3 l/hr).

Elevated CO_2 levels were also recorded in the deep installation within the White Chalk (BH07) suggesting that the White Chalk is a CO_2 source and that high levels recorded at shallower levels within Made Ground have a natural origin, which is also suggestive of a hydraulic continuity between these materials.

The resultant GSV calculations indicate the site is representative of Characteristic Situation 2, and therefore in the event that buildings are proposed within the development, ground gas protection measures in line with the CS2 classification are likely to be required.

10.0 CONCEPTUAL SITE MODEL

10.1 Introduction

A preliminary conceptual site model (CSM) and qualitative risk assessment was provided as part of the WYG Desk Study Report[10]. Updates to the CSM and risk assessment of potential contamination linkages to receptors made based on the intrusive site investigation works, monitoring and laboratory assessment are discussed as follows.

10.2 Summary of Potential Ground Contamination Risk

Based on the review of the available information and ground investigation results, the following potential sources have been identified pertaining to the site.

10.2.1 On-site Sources

The only confirmed source of onsite contamination is the Made Ground within which a single minor exceedance of beryllium was encountered (WS11) and soils have been established to be slightly acidic in localised area of the site. The soils generally showed limited significant visual / olfactory evidence of contamination.

Low pH occurred in 4No. locations but is not considered to present a significant risk to human health as it is only marginally below the general acceptance criteria. After prolonged contact with soils the slightly acidic conditions could cause skin irritation, and the low pH has also been considered in the context of the aggressive chemical conditions for concrete (Section 7.8).

The slight exceedance of Beryllium presents a potential risk in the form of contact, ingestion and primarily dust exposure, which although considered low given the marginal exceedance, does raise the potential of further and more significant localised contamination occurring. It is also noted that although exploratory holes were positioned along the route of the rail siding indicated on historic maps (WS10 and WS18), there was no obvious evidence of the remnants of the railway

[10] WGC Campus West DTS V1 (November 2019)

encountered. Further investigation would be required to confidently confirm the presence / absence of any localised impact from historic activities.

10.2.2 Off-site Sources

Offsite sources can influence on-site soil and groundwater quality in addition to ground gases affecting the site, *if a viable pathway is present*. Potential contaminative sources offsite include the following:

- The adjacent major roads which run next to the site have the potential to have impacted the ground through the introduction of imported soil, or for soils/waters to have been directly impacted from spills on the road.
- The adjacent railway line which historically used asbestos in buildings and infrastructure, imported soils, and fused ash removed from furnaces which can include heavy metals and hydrocarbons.
- Other off-site sources of contamination include the electric power station identified to the southeast of the site, the industrial units to the northeast, the sewage works to the east, and the brick works to the northwest which are all associated with a wide range of contaminants.
- Numerous recorded waste facilities in the areas surrounding the site.

The absence of obvious significant visual / olfactory evidence of contamination during the investigation and the limited exceedance of GAC during tier 1 screening for contaminants typically associated with the above suggests limited potential for impact to the site from the above sources.

10.3 Risk Pathways

Key environmental pathways and exposure routes by which potentially contaminative substances can reach environmental and human health receptors are considered to be:

- Lateral and vertical transport of potentially mobile contaminants as dissolved phase (i.e. leaching through unsaturated strata or lateral transport through advective groundwater flow and/or diffusion which can be facilitated via service ducts and drainage infrastructure).

- Lateral/vertical transport of liquid products (i.e. under gravity via path of least resistance);
- Lateral and vertical migration of gases/vapours via advective flow or through diffusion;
- Atmospheric transport (and potential inhalation) of airborne dusts, vapours and fibres;
- Surface run-off;
- Chemical attack from aggressive contaminants;
- Dermal contact and ingestion of soil and soil derived dust; and
- Plant uptake.

10.4 Receptors

The following are considered to be sensitive receptors:

Human Health Receptors:

- Current Site Users ;
- Construction Workers;
- Future Site Users;
- Adjacent land Users (commercial, residential, industrial);
- Groundwater (Principal and Secondary Aquifers);
- Surface waters (including a stream located 180m E of the site);
- Building materials (concrete foundations and potable water pipes); and
- Soft Landscaping (areas of planting – trees and shrubs).

Appendix C sets out the Qualitative Risk Assessment methodology used to determine the risks levels discussed as follows and summarised in Table C.4 (Appendix C).

10.4.1 Current Site Users

The site currently comprises public and commercial buildings, roads, pavements, carparks with associated managed soft landscaped areas. Much of the site is covered with hardstanding providing a barrier to contact with the underlying Made

Ground. Pathways for direct contact with Made Ground exist in the soft landscaped areas. Therefore, a **Low** (unlikely and mild consequence event) risk has been identified on site from the limited Made Ground source. This is locally upgraded to **Low to Moderate** in areas of managed soft landscaping.

10.4.2 Future Site Users

Although detailed development plans are not available at the time of this assessment, likely proposed Future site users could include car park users and pedestrians in the paved and landscaped areas residents, managed soft landscaping and workers. Only limited potential for areas of contaminated Made Ground and historic contaminant sources have been identified, and it was found that there were elevated levels of CO_2 in the ground from ground gas assessments. This, however, is expected to be from the underlying chalk rather than anthropogenic sources (see Section 9).

Following intrusive investigation and monitoring, no significant sources of contamination have been identified underlying the site and it is appropriate to reduce the risk rating from Moderate in the preliminary assessment, to **Low** (unlikely and mild consequence event) with the assumption that much of the hard stand covering is likely to remain. This is locally upgraded to **Low to Moderate** in areas of managed soft landscaping and this risk can be managed through the importation of adequate Topsoil in landscaped areas. Additionally, the remaining factors of concern, such as the elevated CO_2 levels have been assumed to be mitigated through appropriate design of the proposed car park to current standards of ventilation to deal with exhaust fumes, which will also deal with landgases.

10.4.3 Construction Site Workers

Limited evidence of contamination sources associated with Made Ground and historic industrial activity has been identified on site, however residual risks would still require mitigation during groundworks, where contractors have the potential to be exposed to contaminated soils (including potential asbestos).

Potential exposure to contamination could occur through dermal contact, inhalation and ingestion of soil / dust / fibres (e.g. dermal contact with low pH soils and inhalation of Beryllium dust). Construction workers (including groundworks

contractors) are also potentially at risk of exposure to ground gases, and the potential for hazardous accumulation of gases within excavations should be considered. No significant sources of contamination were identified during the site investigation and the monitoring rounds only identified elevated concentrations of CO_2 which may be occurring naturally as a result of chalk dissolution in the ground.

Any potential exposure to contamination by groundworkers at the site is likely to be of relatively short duration and exposure can be mitigated through implementation of controls, e.g. the implementation of a Construction Environmental Management Plan, including Personal Protective Equipment (including gloves). As a result of these factors, it is considered appropriate to reduce the risk rating to **Low to Moderate**.

10.4.4 Adjacent Land Users

Immediately adjacent land use is primarily residential (west), commercial (east) with landscaped / wooded areas to the north and south. Based on the limited potential for transportation pathways to be present, the risk posed by the site to adjacent land users is considered to be **Low** (unlikely probability of medium consequence event)**.**

The depth, flow direction and baseline condition of the ground water has not been established, however residual risks are largely mitigated by the anticipated depth of the groundwater (>20m bgl), and the presence of a fine soil layer which limits hydraulic continuity. These conditions are likely to continue beyond the site boundary into the immediate surrounds, limiting the risk of exposure.

Note that potential risk of harm to health is perceived as rising to **Moderate** during any future groundworks undertaken as part of site redevelopment due to the potential for dust generation and transport of contaminants as windblown dusts (e.g. Beryllium) / fibres particularly if extensive groundworks are required. It should be possible however to mitigate against these risks by development and implementation of appropriate working strategies and employing relatively basic mitigation measures (dust suppression, stockpile management, boundary monitoring).

10.4.5 Groundwater

Referring specifically to the Superficial Deposits and White Chalk, the Site overlies Secondary A and Principal Aquifers within a Source Protection Zone. These aquifers were identified as sensitive receptors and were therefore considered to be key targets of the scoped intrusive investigations. However, the groundwater proved to be below the limits of the investigation (greater than 25m bgl) and therefore the chemical quality could not be assessed to confirm its quality and whether there has been any historic impact from mobilised contamination.

Notwithstanding the above, only limited potential for contamination sources has been identified by laboratory analysis of the soil samples, and this potential is confined to the Made Ground. Furthermore, pathways to the underlying aquifers are limited by the presence of a layer of low permeability Superficial Deposits and the extent of the separation layer between the Made Ground and the aquifers.

Therefore, the residual risk is considered to be **Moderate** (Unlikely but of a severe consequence). This conservative classification is cognisant of the groundwater depth which was beyond the scoped depth of the investigation, preventing the recovery of groundwater samples and associated laboratory assessment which has resulted in a relatively high degree of uncertainty.

10.4.6 Surface Water

It has not been confirmed whether the nearest surface water feature (located 180m E of the site) is covered, i.e. within a culvert or closed drainage system or remains an open watercourse. Either way, due to the fall in level between the Site and the railway cutting to the north, and the potential connectivity between the carpark storm drain infrastructure and the local watercourses, the risk to surface waters is considered to be **Low to Moderate** (Likely and medium consequence event) and is largely dependent on a well maintained and adequate drainage interceptor system to contain flows of storm water potentially picking up fuel / oil spills and dust washed from the hardstand areas of the carpark.

10.4.7 Building Materials and Services

Building materials in the form of concrete, such as foundations, and services such as potable water pipes may be subject to chemical attack and degradation from

contaminants within near surface soils (aggressive ground), although this is considered unlikely due to the limited evidence of contamination encountered Characteristic parameters for concrete design are discussed further in Section 12.7.

The risk to building materials is therefore considered to be **Low to Moderate** (low likelihood of a mild consequence event) based on slightly acidic soil conditions having the potential to degrade services.

10.4.8 Soft Landscaping

Trees and shrubs may be affected by phytotoxic contaminants within near surface soils, however there is considered to be limited potential for contaminant sources to be present at the site, and no obvious visual signs of stress to vegetation was noted. Therefore, the risk to soft landscaping across most of the site is considered to be **Low** (low probability of a mild consequence event), providing phytotoxicity of soils is considered for future planting and a suitable growing medium / topsoil is provided where required.

11.0 GEOTECHNICAL CONSIDERATIONS

11.1 Proposed Development

At the time of compilation of this report (during January 2020), the scheme was at concept stage, the details of which were not available, however it was understood that proposals included the development of a decked, two-storey carpark in the existing carpark area with retention of the existing buildings and landscaped areas.

11.2 Chalk Dissolution Features

A key consideration for the selection of foundation types adopted for future large-scale development relates to the potential for weathering features within the White Chalk which could affect the stability of the soils underlying foundations.

A risk assessment indicates that the site has a High risk of chalk dissolution feature related metastability and subsidence (Section 3.2).

With respect to the ground conditions encountered during the investigation, the depth to the surface of the chalk has been confirmed to be of variable depth and in excess of 13.0m bgl in some areas. This variable depth is considered typical of karstic type environments where possible dissolution features, characterised by bedrock depressions, have been identified by the limited deeper investigation information.

CIRIA C574 draws attention to the fact that dissolution of the chalk can cause zones of metastability within the chalk and the overlying superficial deposits, particularly when concentrated groundwater flows are also present.

It is however noted that groundwater was not encountered during the investigation and although the White Chalk surface was variable and displayed variable geotechnical properties, this variance and potential voiding was confined to deeper levels within the chalk itself and the overlying superficial deposits where confirmed to provide a cover of at least 10m of soils which displayed relatively consistent geotechnical properties across the site.

On this basis, when considering conventional shallow foundations, the risks posed by chalk solution metastability are reduced. However it is recommended that conservative parameters (lower bound values) are taken into consideration for the

White Chalk for deeper substructures such as piles (discussed in Section 12.4), and that further local investigation is undertaken to confirm the anticipated conditions to appropriate depths to provide information for detailed design of specific structures.

11.3 Conventional Spread Foundations

Given the discussion presented in Section 11.2, the adoption of conventional spread foundations (e.g. pad or strip foundations) are likely to be viable for smaller scale structures and light broadly distributed loads.

Due to potential variability in composition and consistency of the Topsoil and Made Ground it is anticipated that these soils, if loaded, may gave rise to unpredictable and unacceptable total and differential settlements. It is therefore recommended that foundations pass through the Made Ground and bear onto the underlying Superficial Deposits.

In consideration of allowable bearing pressures alone, calculations based on the Brinch Hansen method [ref 11] have estimated that a net allowable bearing capacity (NBC) of the order of **140kN/m^2** would limit settlement to less than 25mm and could be achieved for a 2m wide strip foundations bearing at a depth of 1.50m bgl within the Lowestoft Formation.

It is noted that this calculation has adopted the conservative parameters of the lower consistency fine soils encountered in the landscaped areas of the site (where characteristic Cu = 50kn/m^2). Higher NBCs are potentially achievable at deeper levels where consistencies typically increase, or in localised areas of the Site where predominantly coarse soils are more prevalent at shallow depth.

It is also noted that the fine Superficial Deposits were determined to be of low volume change potential. Therefore, developments planned within the vicinity of existing trees (or areas of planned tree planting) need consider the recommendations in the document NHBC Chapter 4.2 [ref 12] which details the foundation depth required to avoid the zone of influence of various tree types.

---

[11] Brinch Hansen (1970) Referenced in Foundation Design and Construction *M.J. Tomlinson* (*2001)*

[12] Chapter 4.2 'Building near trees' - NHBC Standards 2011

11.4 Piled Foundations

Piled foundations will be required to support more extensive developments where foundation loads are too high for the adoption of conventional shallow foundations. A choice of pile type of various lengths and diameters can be designed to bear into the strata encountered beneath the site. However general site conditions, environs and proximity to adjacent extant structures and foundations are all influential in choice of piling system.

In consideration of the prevailing conditions and the anticipated scale of the scheme, Continuous Flight Auger (CFA) piles are likely to provide a practical and cost-effective solution due to limited generation of arisings and relatively quick installation. It is noted that certain practical constraints apply, for example when considering the incorporation of pile reinforcement or geothermal exchange systems, and pile emplacement in ground with potential obstructions.

There is also the risk of collapse or necking of the pile bore should the flights be withdrawn and the hole left unsupported (most notably within the coarse Lowestoft Formation and weathered White Chalk). For these reasons it is recommended that a competent and experienced specialist piling contractor undertakes all piling works, adopting appropriate controls and that their advice should be sought at the earliest opportunity.

To provide an indicative assessment of pile capacities for the purposes of this illustrative exercise, variations in strata thickness have been averaged in a simplified model of ground conditions and characteristics as indicated in Table 11.1.

Table 11.1 Ground Model and Parameters used for Preliminary Pile Assessment

Stratum	Made Ground	Lowestoft Formation		White Chalk (Grade Dm)
		Fine	Coarse	
Thickness (m)	2.0	7.0	5.0	10
SPT N	-	20	30	<25
Nq	-	-	60	-
Nc	-	9	-	-
Cu (kN/m^2)	-	90	-	-
Q Base (kN/m^2)	-	-	-	600
γ (kN/m^3)	17	19	19	18
α	-	0.45	-	0.45
β	-	-	0.30	

Nq, Nc: Bearing capacity factors, Cu: Undrained shear strength, γ bulk density, α: adhesion, β : shaft friction coefficient value, Q base: limited to recommended CIRIA values (Chalk only)

It is anticipated that seasonal variations in groundwater levels may occur but that these variations would not be of sufficient magnitude to cause significant short-term effective stress variations. The ground model has consequently assumed an equilibrated groundwater table below the assessment depth.

The competency of the soil profile used for these calculations is based on in situ testing, principally SPTs, where estimation of undrained shear strengths (Cu) of the encountered fine soils have been calculated using the empirical correlation Cu (kN/m^2) = 5 x SPT N, and the results of direct laboratory determination of shear strength by undrained triaxial compression tests conducted on samples of fine soils.

An adhesion factor (α) of 0.45 has been adopted for the fine soils and chalk and is considered constant and independent of the weathering grade of the chalk.

A key factor influencing the pile capacity is the variable depth of the chalk, and the associated parameters of this stratum will need to be considered in pile capacity assessments at deeper levels, particularly when considering the end bearing contribution to the pile capacity assessment.

CIRIA C574 [ref 13] recommends that the unfactored allowable unit area base resistance is restricted to between 600 kN/m^2 and 800 kN/m^2 for low density chalk, i.e. where SPT N values are generally less than 25. Based on the low N values determined during the investigation, this limiting parameter applies universally across the site to the maximum depth investigated, and therefore, a value of 600kN/m^2 has been used for this indicative assessment.

It has been assumed that little or no positive skin friction will be obtained from the Made Ground.

Service capacities for a range of possible founding depths and pile dimensions have been calculated for CFA piles as outlined below in Table 11.2.

Table 11.2 Ground Model and Parameters used for Preliminary Pile Assessment

Base Strata	Pile Embedment Length (m)	Pile Diameter (m)		
		0.30	0.45	0.60
		Service Capacities (kN)	Service Capacities (kN)	Service Capacities (kN)
Lowestoft Fm - Coarse	10.0	370	750	1250
White Chalk	15.0	310	500	730
White Chalk	20.0	490	790	1110

FOS Applied : 1.5 QShaft, 3.5 QBase

Table 11.2 demonstrates that the contribution to the factored shaft capacity from the upper levels of the pile installed through the superficial deposits may not compensate for the potential loss of factored base contribution for piles embedded at deeper levels into the White Chalk.

This results in a 'punch through' effect which leads to initially lower capacities for piles installed into the chalk. In normal circumstances and depending on the dimension and axial load on the pile, a superficial cover depth of at least 5m below

[13] CIRIA C574: Engineering in Chalk (CIRIA Lord et. al 2002)

the base of the pile would be required to safely ignore the factored and potentially reduced contribution to the base capacity from the underlying chalk.

11.5 Floor Slabs

Ground bearing floor slabs will be susceptible to differential settlements induced by the variable Made Ground and seasonal volume changes which are potentially above typical design tolerance levels. Therefore, based on the current assessment of risk for such features, it is recommended that consideration is given to suspended floor slabs until further development footprint specific testing is undertaken and the risk rating reviewed.

Should the risk of such features be reduced following further localised, structure specific investigation or remedial ground improvement work, floor slabs constructed to bear directly onto the Superficial Deposits and possibly the Made Ground could be considered providing that soils are checked for consistency at formation level.

Owing to the silt content, ground bearing floor slabs for unheated or open structures should be considered to be frost susceptible near to ground level and should therefore incorporate a 300mm layer of compacted granular material to mitigate the potential for damage due to frost heave during extended periods of freezing conditions.

11.6 Pavements

Based on the assessment of available data and with reference to the Design Manual For Roads and Bridges [ref 14] indicative CBR values are likely to be variable across the site and will be influenced by the presence by the existing areas of hardstanding and subbase.

Within the existing carpark area, a CBR of greater than10% might be considered viable within the coarse Made Ground (subbase). However, consideration will also need to be given to the variable composition and thickness of these soils, as there is a risk of localised areas of significantly lower CBR introduced by localised pockets of fine or loose soils.

[14] Highways Design 25/94 Volume 7 Section 2 Table 2.1

A reduced CBR of 1% to 2% will need to be adopted for predominantly fine soils in peripheral landscaped areas of the site.

Ultimately, the risk of local variance is considered to be high and therefore CBR design values will need to be confirmed from in-situ testing along the routes of proposed pavements, with arrangements for stripping and replacement with compacted engineered fill where required in place during earthworks.

11.7 Chemical Attack on Buried Concrete

In summary it is recommended that DS-1 ACEC 1s classification concrete us used for the construction of substructures.

This classification assumes a static groundwater condition as it is considered unlikely that building materials will come into contact with significant groundwater. It is noted however that the groundwater levels where beyond the depth investigated, and deeper proposed sub structures such as piles may therefore need to consider conditions below the groundwater table where potentially low pH conditions in mobile groundwater would need to be reviewed in line with BRE SD1.

11.8 Temporary Works

Shallow excavations remained stable during the investigation, however, owing to the variability of the shallow soils, there is potential for excavations to be unstable. It is therefore likely that temporary excavations will require battering back during excavation, and in line with good working practices, man entry into excavations greater than 1.2m deep should only be carried out where shoring is in place.

Shallow groundwater was not encountered during the investigation; however, it is anticipated given the nature of shallow depth material, that there is a high potential for perched water ingress particularly after prolonged periods of precipitation and dewatering may therefore be a requirement. It is recommended that dewatering is undertaken in accordance with the guidelines of CIRIA C515 Groundwater control – Design and Practice.

12.0 CONCLUSIONS

12.1 Risk Assessment Summary

Geoenvironmental

Based on the conceptual site model and qualitative assessment of pollutant linkages discussed in Section 10 the following risk levels have been assigned. These risks relate to future long-term use of the site and temporary risks during redevelopment activities. The risk levels have been assigned without consideration of remediation / risk management activities:

- Current Site Users – **Low** (Low to Moderate in areas of landscaping)
- Future Users – **Low** (Low to Moderate in areas of landscaping)
- Construction Site Workers – **Low** (on implementation of CDM)
- Adjacent Site Users – **Low** (Moderate during ground works)
- Groundwater – **Moderate**
- Surface Waters – **Low to Moderate**
- On-site buildings and services – **Low** (Moderate in mobile groundwater conditions)
- Soft Landscaping – **Low**

It should be noted that where a range of risks were identified in relation to a receptor, a worst-case scenario has been adopted. In summary, the overall risk to the human health of present and future site users and environmental receptors in terms of ground contamination present by this site is considered to be **Low** as a result of the limited contamination encountered and the range of potential contaminant sources, both on and off the defined site.

The most significant residual risk is associated with the underlying aquifer, and regulators may need further information to review this risk at planning stage. Further intrusive investigations may therefore be required to establish the baseline condition and any potential impact from the Made Ground and leachable contaminants to the aquifer, particularly if piled foundations are considered which could create additional pathways from the Made Ground.

Ground gas risks will be mitigated through adherence to CIRIA guidance and the general venting typical of this kind of development, however further consideration may be required where enclosed spaces are proposed.

Geotechnical

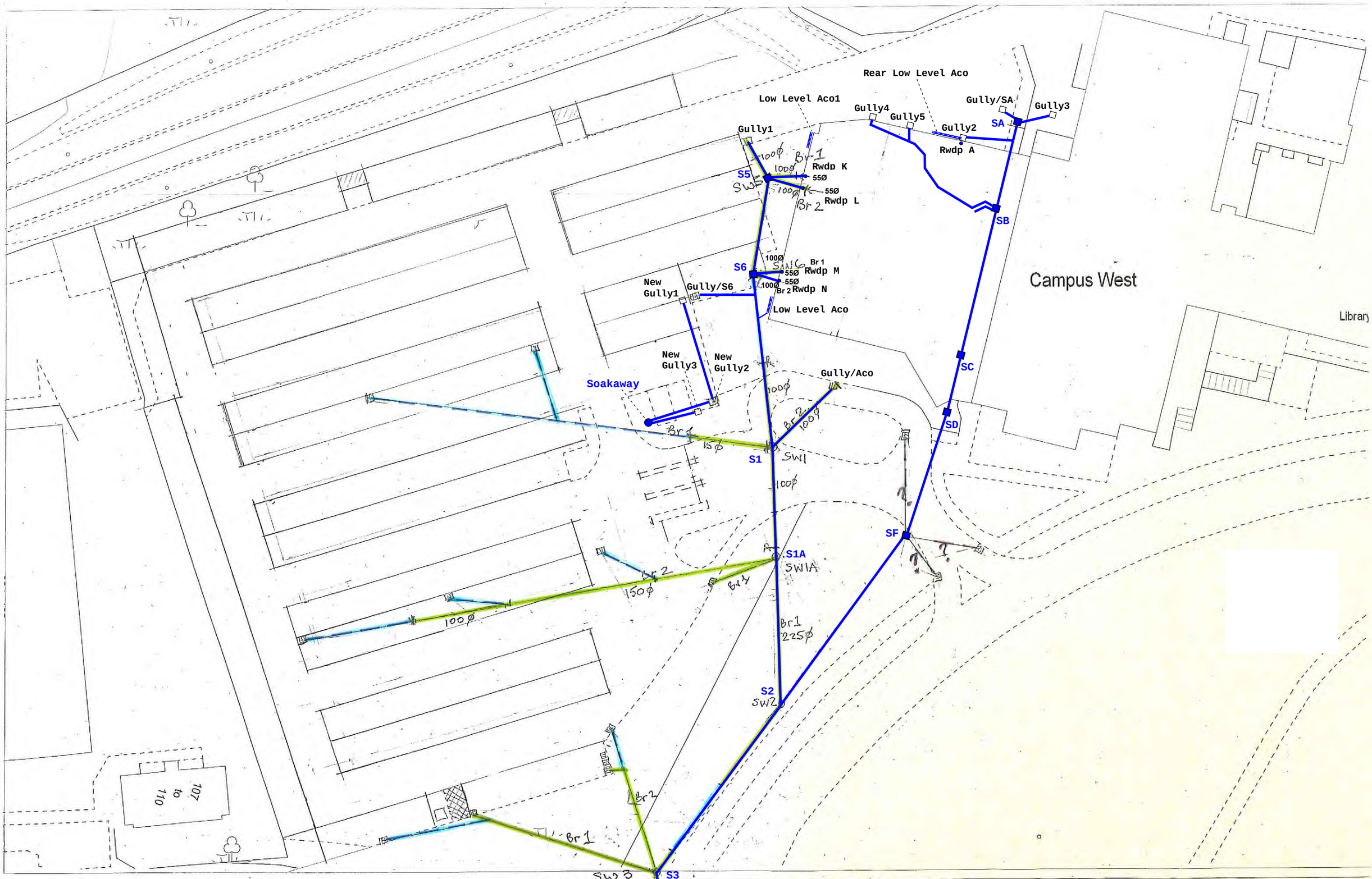
It is understood that a two-storey decked carpark development is proposed and the loads and load configuration have not been confirmed at this stage.

Based on the encountered conditions key geotechnical risks are summarised as follows:

- Metastability (chalk solution features) – **High**
- Variable soils (Made Ground/ Superficial Deposits **– Low to Medium**
- Remnant Substructures (hard spots and voids) **– Medium**
- Shrinkable soils (near to existing / proposed trees) **– Medium**

Depending on the type of structure and load distribution, the investigation has shown that near surface soils may have sufficient bearing capacity for use of traditional shallow foundations. However, where structural loads are beyond the capacity of conventional shallow foundations constructed to bear upon near surface soils, piled foundations may need to be considered. Piled capacities will be dependent on localised conditions, most notably the depth and characteristics of the underlying chalk, and further local investigation may be required to inform detailed design of piles at specific locations.

APPENDIX C– THAMES WATER RECORDS AND CCTV DRAINAGE SURVEY



WELWYN HATFIELD BOROUGH COUNCIL

Council Offices, The Campus,
Welwyn Garden City, Herts. AL8 6AE

Title:

Project:

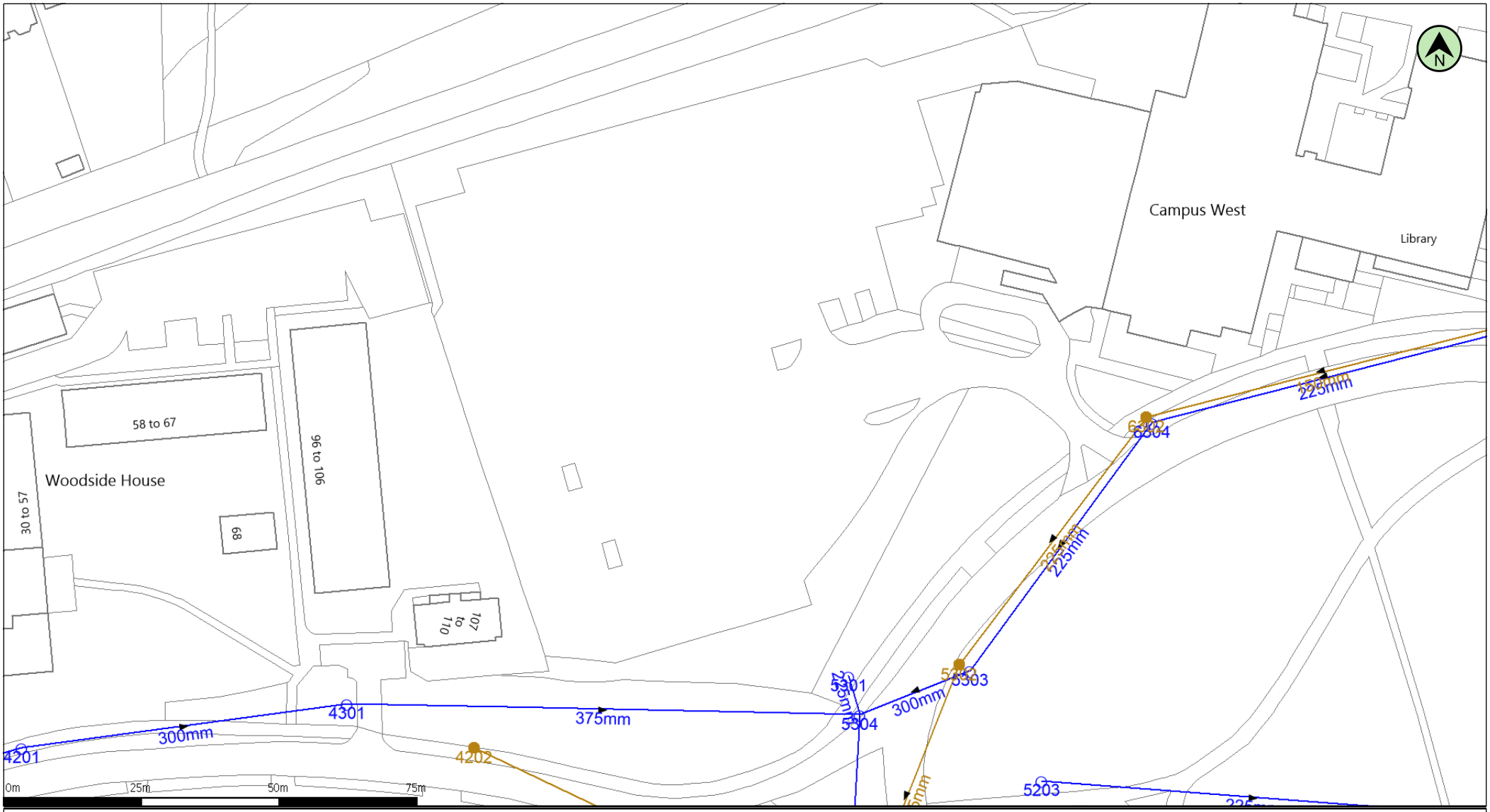
Scale:

Date: 15th December 2009

Drawn:

Notes:

Drawing Number:



(c) Crown Copyright and database rights 2012 Ordnance Survey 100019345 | Date: 09/11/17 | Scale: 1:972 | Map Centre: 523543.2,213359.2 | Data updated: 04/09/17 | Wastewater Plan A4

This plan is produced by Thames Water Utilities Ltd (c) Crown copyright and database rights 2017 Ordnance Survey 100019345. This map is to be used for the purposes of viewing the location of Thames Water plant only. Any other uses of the map data or further copies are not permitted. The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. This information is valid for the date printed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified on site before any works are undertaken.

Foul Sewer		Foul Manhole	
Surface Sewer		Surface Manhole	
Combined Sewer		Combined Manhole	
Abandoned Sewer		Abandoned Manhole	
Pressure Main		Other Manhole	
Private Asset (Colour denotes effluent type)		End Item	
Proposed Asset (Colour denotes effluent type)		S104 Boundary	

shannen.powers@hertfordshire.gov.

Thames Water

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
4201	S	97.51	95.66	1.85
4202	F	98.26	96.09	2.17
4301	S	98.35	95.36	2.99
5203	S	96.04	94.08	1.96
5301	S	97.31	95.84	1.47
5302	F	97.36	94.4	2.96
5303	S	97.35	94.8	2.55
5304	S	96.94	94.31	2.63
6302	F	98.37	94.85	3.52
6304	S	98.36	95.29	3.07

APPENDIX D – PDS FLOW HYDRAULIC MODELLING OUTPUT

Design Settings

Rainfall Methodology	FSR	Maximum Time of Concentration (mins)	30.00
Return Period (years)	5	Maximum Rainfall (mm/hr)	200.0
Additional Flow (%)	0	Minimum Velocity (m/s)	1.00
FSR Region	England and Wales	Connection Type	Level Soffits
M5-60 (mm)	20.000	Minimum Backdrop Height (m)	0.500
Ratio-R	0.400	Preferred Cover Depth (m)	1.200
CV	0.750	Include Intermediate Ground	✓
Time of Entry (mins)	4.00	Enforce best practice design rules	✓

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
S5	0.150	4.00	101.030	1200	523576.145	213408.746	1.425
S1			99.400	1200	523577.218	213368.932	1.425
S1A			99.200	1200	523578.592	213352.590	1.699
S2			98.400	1200	523579.275	213330.808	1.500
S3	0.150	4.00	97.500	1200	523561.266	213305.813	1.500
S4			97.310	1200	523562.366	213298.808	1.500
1	0.150	4.00	99.630	1200	523565.262	213370.613	1.425
2	0.150	4.00	99.110	1200	523560.559	213348.888	1.425

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	S5	S1	39.828	0.600	99.605	97.975	1.630	24.4	100	4.42	95.8
1.001	S1	S1A	16.400	0.600	97.975	97.576	0.399	41.1	100	4.65	93.9
1.002	S1A	S2	21.793	0.600	97.501	96.900	0.601	36.3	225	4.82	92.6
1.003	S2	S3	30.807	0.600	96.900	96.000	0.900	34.2	225	5.05	90.8
1.004	S3	S4	7.091	0.600	96.000	95.810	0.190	37.3	255	5.10	90.4
2.000	1	S1	12.074	0.600	98.205	97.975	0.230	52.5	225	4.11	98.5
3.000	2	S1A	18.409	0.600	97.685	97.576	0.109	168.9	225	4.31	96.8

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)
1.000	1.568	12.3	38.9	1.325	1.325	0.150	0.0
1.001	1.206	9.5	76.3	1.325	1.524	0.300	0.0
1.002	2.179	86.6	112.9	1.474	1.275	0.450	0.0
1.003	2.243	89.2	110.7	1.275	1.275	0.450	0.0
1.004	2.327	118.9	147.1	1.245	1.245	0.600	0.0
2.000	1.809	71.9	40.0	1.200	1.200	0.150	0.0
3.000	1.003	39.9	39.3	1.200	1.399	0.150	0.0

Simulation Settings

Rainfall Methodology	FSR	Analysis Speed	Normal
FSR Region	England and Wales	Skip Steady State	x
M5-60 (mm)	20.000	Drain Down Time (mins)	240
Ratio-R	0.400	Additional Storage (m³/ha)	20.0
Summer CV	0.750	Check Discharge Rate(s)	x
Winter CV	0.840	Check Discharge Volume	x

Storm Durations

15	30	60	120	180	240	360	480	600	720	960	1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	0	0	0
30	0	0	0
100	0	0	0

Results for 1 year Critical Storm Duration. Lowest mass balance: 98.40%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	S5	13	100.556	0.951	22.4	3.0788	0.0000	SURCHARGED
15 minute winter	S1	13	99.333	1.358	20.4	1.5357	0.0000	FLOOD RISK
15 minute winter	S1A	10	97.612	0.111	38.4	0.1257	0.0000	OK
15 minute winter	S2	11	97.002	0.102	38.2	0.1157	0.0000	OK
15 minute winter	S3	10	96.153	0.153	60.2	0.4795	0.0000	OK
15 minute winter	S4	10	95.937	0.127	59.7	0.0000	0.0000	OK
15 minute winter	1	13	99.337	1.132	22.4	3.6627	0.0000	FLOOD RISK
15 minute winter	2	10	97.812	0.127	22.4	0.4115	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	S5	1.000	S1	11.5	1.488	0.933	0.3116	
15 minute winter	S1	1.001	S1A	18.2	2.326	1.922	0.1270	
15 minute winter	S1A	1.002	S2	38.2	2.067	0.441	0.4027	
15 minute winter	S2	1.003	S3	38.2	1.689	0.429	0.7117	
15 minute winter	S3	1.004	S4	59.7	2.083	0.502	0.2030	39.6
15 minute winter	1	2.000	S1	10.3	0.771	0.143	0.4802	
15 minute winter	2	3.000	S1A	22.4	1.006	0.561	0.4093	

Results for 30 year Critical Storm Duration. Lowest mass balance: 98.40%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
30 minute winter	S5	16	101.030	1.425	41.2	4.6113	9.7136	FLOOD
30 minute winter	S1	15	99.400	1.425	52.4	1.6117	14.5188	FLOOD
15 minute winter	S1A	10	97.673	0.172	72.6	0.1948	0.0000	OK
15 minute winter	S2	11	97.072	0.172	72.5	0.1944	0.0000	OK
15 minute winter	S3	11	96.410	0.410	125.7	1.2837	0.0000	SURCHARGED
15 minute summer	S4	11	96.068	0.258	120.1	0.0000	0.0000	OK
15 minute summer	1	10	99.589	1.384	54.9	4.4801	0.0000	FLOOD RISK
15 minute winter	2	10	98.011	0.326	54.9	1.0536	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
30 minute winter	S5	1.000	S1	11.6	1.477	0.938	0.3116	
30 minute winter	S1	1.001	S1A	18.6	2.373	1.960	0.1270	
15 minute winter	S1A	1.002	S2	72.5	2.296	0.837	0.7067	
15 minute winter	S2	1.003	S3	71.9	1.863	0.806	1.1141	
15 minute winter	S3	1.004	S4	121.5	2.380	1.022	0.3620	73.5
15 minute summer	1	2.000	S1	54.9	1.380	0.763	0.4802	
15 minute winter	2	3.000	S1A	54.1	1.369	1.356	0.6987	

Results for 100 year Critical Storm Duration. Lowest mass balance: 98.40%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
30 minute winter	S5	14	101.030	1.425	53.9	4.6113	18.6925	FLOOD
30 minute winter	S1	13	99.400	1.425	64.9	1.6117	24.1712	FLOOD
15 minute winter	S1A	11	97.985	0.484	81.6	0.5471	0.0000	SURCHARGED
15 minute winter	S2	11	97.367	0.467	80.3	0.5278	0.0000	SURCHARGED
15 minute winter	S3	10	96.551	0.551	146.0	1.7246	0.0000	SURCHARGED
30 minute winter	S4	19	96.068	0.258	123.8	0.0000	0.0000	OK
15 minute winter	1	9	99.630	1.425	71.1	4.6113	1.3152	FLOOD
15 minute winter	2	11	98.319	0.634	71.1	2.0509	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
30 minute winter	S5	1.000	S1	11.6	1.477	0.938	0.3116	
30 minute winter	S1	1.001	S1A	18.6	2.373	1.960	0.1270	
15 minute winter	S1A	1.002	S2	80.3	2.301	0.926	0.8667	
15 minute winter	S2	1.003	S3	79.6	2.002	0.892	1.2252	
15 minute winter	S3	1.004	S4	144.2	2.824	1.213	0.3595	88.2
15 minute winter	1	2.000	S1	60.5	1.520	0.840	0.4802	
15 minute winter	2	3.000	S1A	63.6	1.601	1.596	0.7321	

APPENDIX E – EAS DRAWING 2486-SK04

PROPOSED SURFACE WATER SEWER TO CONVEY RUN-OFF FROM EXTERNAL FORECOURT AREA TO EXTERNAL SW DRAINGE SYSTEM

OVERSIZED MANHOLE CHAMEBR TO PROVIDE ATTENUATION FOR THE ADDITIONAL CATCHMENT AREA.

OVERSIZED PIPE TO PROVIDE ATTENUATION FOR THE ADDITIONAL CATCHMENT AREA.

EXISTING SECTION OF PIPE FROM S5 TO S6 TO BE REMOVED

S5 (REMOVED)

S6 (REBUILT)

RE-DIRECT EXISTING GULLY TO OUTFALL INTO NEW SURFACE WATER SEWER

CCTV DRAINAGE SURVEY HAS NOT BEEN ABLE TO CONFIRM WHERE THIS ACO DRAIN OUTFALLS TO. IT APPEARS TO BE TOO DEEP TO OUTFALL INTO S5 AS SUCH IT IS ASSUMED IT IS DIRECTED INTO THE INTERNAL DRAINAGE SYSTEM.

RAINWATER DOWN PIPES TO BE RELOCATED TO EXTERNAL FACE OF BUILDING AND OUTFALL INTO IMPROVED EXTERNAL DRAINAGE SYSTEM

IT IS ADVISED THAT THIS TREE IS REMOVED TO PREVENT ANY FUTURE DAMAGE TO THE IMPROVED EXTERNAL DRAINAGE SYSTEM

PROPOSED ACO CHANNEL DRAIN TO COLLECT SURFACE WATER RUN-OFF FROM EXTERNAL FORECOURT AREA TO REAR OF THEATRE

REPLACE DROPPED KERB WITH FULL HEIGHT KERB

ACCORDING TO CCTV DRAINAGE SURVEY, OUTFALL PIPE FROM GULLY HAS SIGNIFICANT ROOT INGRESS. RATHER THAN RE-LINE PIPE, IT IS SUGGESTED THAT A NEW GULLY AND OUTFALL PIPE ARE PROVIDED

CCTV DRAINAGE SURVEY SHOWS A SPIKE THROUGH THIS SECTION OF PIPE. PIPE TO BE REBUILT OR SPIKE REMOVED AND PIPE RE-LINED

ACCORDING TO THE CCTV DRAINAGE SURVEY, THIS SECTION OF PIPE HAS SIGNIFICANT ROOT INGRESS, PIPE CRACKS AND FRACTURES. IN ADDITION A SPIKE HAS BEEN DRIVEN THROUGH THE PIPE.
IT IS THEREFORE STRONGLY RECOMMENDED THAT THIS SECTION OF PIPE IS REMOVED AND REPLACED WITH NEW OR, IF POSSIBLE, RE-LINING METHODS TO BE USED.

S1 (RETAINED)

ACCORDING TO THE CCTV DRAINAGE SURVEY, THIS SECTION OF PIPE IS FRACTURES AND HAS CROSS-SECTIONAL AREA LOSS DUE TO SETTLED DEPOSITS AND ROOT INGRESS. IT IS THEREFORE RECOMMENDED THAT THIS SECTION OF PIPE IS JETTED, CLEARED AND RE-LINED.

SD (RETAINED)

ACCORDING TO THE CCTV DRAINAGE SURVEY, THIS SECTION OF PIPE HAS 25% CROSS-SECTIONAL AREA LOSS DUE TO SETTLED DEPOSITS. IT IS THEREFORE RECOMMENDED THAT THIS SECTION OF PIPE IS JETTED AND CLEARED.

S1A (RETAINED)

SF (RETAINED)

ACCORDING TO THE CCTV DRAINAGE SURVEY, THERE WERE NO VISIBILE DEFECTS ON THIS SECTION OF PIPE

ACCORDING TO THE CCTV DRAINAGE SURVEY, THIS SECTION OF PIPE IS FRACTURED AND HAS 50% CROSS-SECTIONAL AREA LOSS DUE TO ROOT INGRESS. IT IS THEREFORE RECOMMENDED THAT THIS SECTION OF PIPE IS JETTED, CLEARED AND RE-LINED.

S2 (RETAINED)

ACCORDING TO THE CCTV DRAINAGE SURVEY, THIS SECTION OF PIPE IS FRACTURED AND HAS 30% CROSS-SECTIONAL AREA LOSS DUE TO ROOT INGRESS AND SETTLED DEBRIS. IT IS THEREFORE RECOMMENDED THAT THIS SECTION OF PIPE IS JETTED, CLEARED AND RE-LINED.

S3 (RETAINED)

523600E

REV	DATE	BY	DESCRIPTION	CHK	APD

DRAWING STATUS:
FOR DISCUSSION

EAS
Unit 23, The Maltings, Stanstead Abbotts, Hertfordshire, SG12 8HG
Tel: 01920 871777
www.eastp.co.uk

CLIENT:
WELWYN & HATFIELD DISTRICT COUNCIL

ARCHITECT:

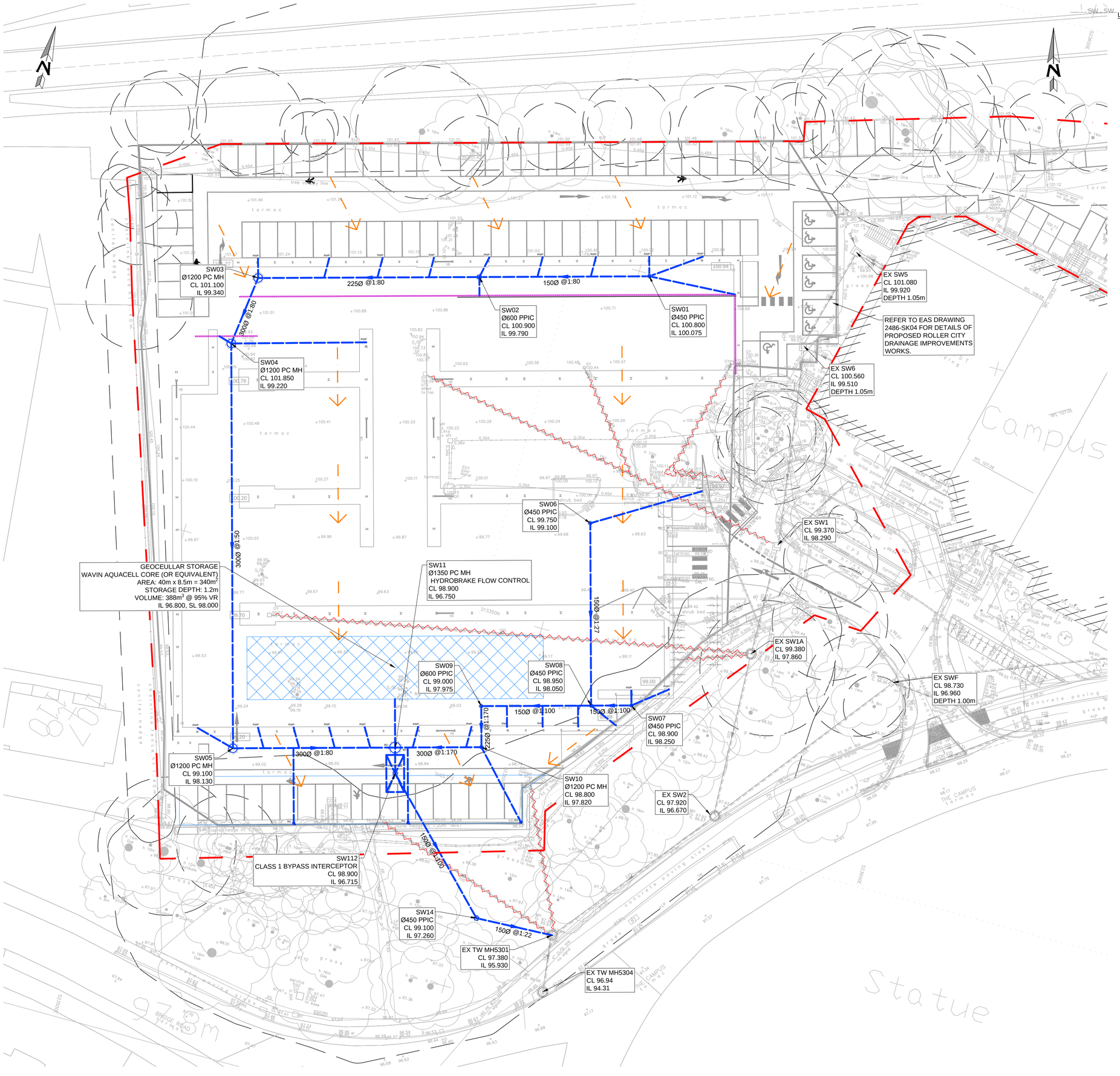
PROJECT:
ROLLER CITY AND CAMPUS WEST,
EXISTING DRAINAGE ASSESSMENT

TITLE:
OPTION 1
ATTENUATION AND REPAIRS
EXTERNAL SW DRAINAGE SYSTEM

SCALE @ A2:	DESIGN-DRAWN:	DATE:
1:250	MD	09.12.2019

PROJECT No:	DRAWING No:
2486	SK04

APPENDIX F – DRAINAGE STRATEGY



LEGEND

- DEVELOPMENT BOUNDARY
- RETAINED TREE ROOT PROTECTION ZONE
- EXISTING SURFACE WATER DRAIN / SEWER
- EXISTING SURFACE WATER DRAIN TO BE ABANDONED
- PROPOSED SURFACE WATER DRAIN
- PROPOSED PRIVATE SURFACE WATER MANHOLE / INSPECTION CHAMBER
- RWP — RAINWATER PIPE
- LINEAR DRAINAGE CHANNEL
- RG — ROAD GULLY
- GEOCELLULAR STORAGE AREA = 40m x 8.5m = 340m² STORAGE DEPTH: 1.2m VOLUME: 388m³ @ 95% VR
- OVERLAND FLOW ROUTE

GENERAL NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS, ENGINEERS AND SPECIALIST DRAWINGS AND SPECIFICATIONS
2. DO NOT SCALE FROM THIS DRAWING IN EITHER PAPER OR DIGITAL FORM. USE WRITTEN DIMENSIONS ONLY.
3. THIS DRAWING IS BASED ON BOURNE PARKING DRAWING W&HC-BPL-XX-XX-DR-X-002, AND TOPOGRAPHIC SURVEY BY TERRAIN SURVEYS, REF TS19-312-2.
4. DETAILS OF EXISTING TREES AND ASSOCIATED ROOT PROTECTION ZONES (RPZ) BASED ON TMA TREE SURVEY DRAWING 191026-P-10.
5. METHOD STATEMENT FOR DRAINAGE WORKS WITHIN RPZ TO BE AGREED WITH TMA.
6. DETAILS OF EXISTING DRAINAGE BASED ON CCTV SURVEY BY DRAINCARE ENVIRONMENTAL SERVICES LTD, PROJECT REF. 3220.
7. POSITION OF EXISTING THAMES WATER FOUL AND SURFACE WATER SEWERS IS BASED ON SEWER RECORD INFORMATION.
8. EXISTING MANHOLES EX SW1A, EX SW2, AND EX TW MH 5301 TO BE SURVEYED TO CONFIRM POSITION, COVER LEVEL, INVERT LEVEL AND INTERNAL ARRANGEMENT.
9. TOPOGRAPHIC SURVEY OF ROUTE OF PROPOSED CONNECTION TO MANHOLE EX SW2 TO BE UNDERTAKEN TO CONFIRM VIABILITY.
10. ALL PROPOSED DRAINAGE FEATURES WITHIN THE BOUNDS OF THE SITE WILL REMAIN IN PRIVATE OWNERSHIP.
11. ALL DRAINAGE SHALL COMPLY WITH THE TYPICAL DETAILS AND REQUIREMENTS OF BS EN 752 AND PART H OF THE BUILDING REGULATIONS.
12. INVERT LEVELS AND POSITIONS OF EXISTING DRAINS / CHAMBERS / SEWERS WHERE NEW CONNECTIONS ARE TO BE MADE MUST BE CHECKED AND CONFIRMED TO THE ENGINEER PRIOR TO THE COMMENCEMENT OF ANY WORKS.
13. ALL DRAINAGE SHALL COMPLY WITH THE TYPICAL DETAILS AND THE REQUIREMENTS OF BS EN 752 AND PART H OF THE BUILDING REGULATIONS.
14. ANY PART OF THE EXISTING DRAINAGE SYSTEM TO BE RETAINED AS PART OF THE NEW SCHEME SHALL BE CLEANED AND INSPECTED. ANY STRUCTURAL DEFECTS SHALL BE REPAIRED USING APPROPRIATE AND APPROVED MEANS.
15. ALL RWP CONNECTIONS SHALL BE 100MM DIAMETER UNLESS OTHERWISE SPECIFIED.
16. COVER LEVELS ARE TO BE ADJUSTED LOCALLY TO SUIT FINISHED GROUND LEVELS.
17. EXISTING DRAINAGE TO BE REMOVED IS TO BE BROKEN OUT TO BED LEVEL AND VOID BACKFILLED WITH GRANULAR MATERIAL, COMPACTED IN LAYERS NOT EXCEEDING 250MM.
18. ALL RWP'S TO BE LAID 1:80 MIN UNLESS OTHERWISE STATED.
19. WHERE NEW SEWERS ARE CONSTRUCTED WITHIN 5M OF A NEW OR EXISTING TREE THE SEWER SHALL BE CONCRETE ENCASED AGAINST ROOT INTRUSION. REFER TO DRAINAGE DETAILS.
20. ALL NEW DRAINAGE TO BE JETTED AND CCTV SURVEYED ON COMPLETION. CONTRACTOR TO MAKE SURE THAT THE DRAINAGE IS FULLY OPERATIONAL. REFER TO DRAINAGE MAINTENANCE MANUAL FOR MAINTENANCE DETAILS

NOT FOR CONSTRUCTION

Rev	Date	Description	Drawn	Check
P03	26.03.21	ISSUED FOR PLANNING	RAD	AM
P02	29.05.20	REVISED LAYOUT	AC	AM
P01	18.05.20	FIRST ISSUE	AC	AM

conisbee | Consulting Structural Engineers Consulting Civil Engineers
London • Cambridge • Norwich
1-5 Offord St London N1 1DH
Telephone 020 7700 6666
www.conisbee.co.uk

Drawing Status
PRELIMINARY

Project
WHBC CAMPUS WEST
NEW DECKED CAR PARK

Title
DRAINAGE STRATEGY

Drawing No
190997-X-00-DR-C-1000

Date MAY 20
Scale 1:250@A1
Drawn AC
Engineer AM
Project No **190997**
Revision **P03**