



Fairhurst

Brunswick Camp, Pirbright

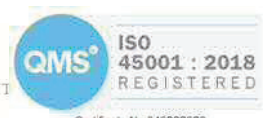
Desk Study and Ground Investigation Report



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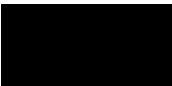

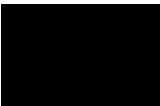




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Brunswick Camp, Pirbright

Desk Study and Ground Investigation Report

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EXECUTIVE SUMMARY

SITE INFORMATION	Client	Fairhurst
	Site Details	The site is currently part of an active military camp, 'Brunswick Camp' comprising numerous single storey accommodation blocks with associated access routes and soft landscaping. The site is approximately 1.1hectares with the centre of the site situated at National Grid Reference of 492360, 156920. The nearest postcode is GU24 0PQ (Figure 1).
	Proposed Development	The proposed development details have not been made available to TEC, at this stage, it is understood that it is proposed to redevelop an area of the camp comprising two storey accommodation structures.
BACKGROUND INFORMATION	Geology	The geological mapping indicates that the site is reported to be underlain by the Camberley Sand Formation comprising of silty fine-grained sand or sandy silt.
	Hydrogeology	The Camberley Sand Formation is deemed a Secondary A Aquifer comprising permeable layers capable of supporting water supplies at a local scale (minor aquifer). The site is not reported to be located within a Source Protection Zone. There are no groundwater abstractions located within 1km of the site.
	Hydrology	The closest surface water course to the site is the Basingstoke Canal, located 150m south of the site. The nearest discharge consent is located 400m south-west of the site and is associated with the Basingstoke Canal. There are no abstractions located within 1km of the site.
	Site History	Earliest available mapping (1873) depicts the proposed development area to be an open and undeveloped woodland until 1938. Aerial photography from 1947 indicates structures, as per the current layout and associated with Brunswick Camp.
GROUND INVESTIGATION	Ground Investigation Rationale	The exploratory ground investigation undertaken was designed to provide general information regarding ground conditions including the assessment of the potential presence of contaminants of potential concern and to provide general foundation design recommendations.
	Scope of Works	Excavation of 5no. dug trial pits, including a single BRE365 soakage test at locations specified by Fairhurst to allow for the collection of geotechnical and geoenvironmental samples for analysis.
	Ground Conditions	Made ground was recorded at a single location (TP01) and was recorded to 0.55mbgl as brown to light brown slightly gravelly silty sand with low cobble content. The gravel and cobbles were recorded as brick and flint. The near surface materials observed at the remaining locations to 0.4mbgl were typically dark brown slightly gravelly sandy silt with frequent rootlets and the gravel noted as fine to medium flint. Further, potentially reworked natural ground was encountered at two locations (TP04 and TP05) to depths of between 0.25m and 0.95mbgl. The material was observed to comprise loose to medium dense light brown to yellowish brown becoming dark grey slightly clayey slightly gravelly silty fine to medium sand. The underlying natural materials were recorded as loose to typically medium dense yellowish brown, grey and light brown slightly clayey silty fine to medium sand to depth of 1.15m to 2.7mbgl. This was recorded to be underlain by medium dense light brown, brown and occasionally yellowish-brown or greenish grey slightly clayey silty fine to medium sand with occasional fine to medium subangular flint gravel.
LAND CONTAMINATION	Contamination Characterisation	Localised exceedances of the GAC have been recorded at a single location (TP02) during the exploratory investigation for PAHs.
	Identified Pollutant Linkages	The relevant pollutant linkages identified were limited to; <ul style="list-style-type: none"> Human health (future site end users and construction workers) - exposure to potential contaminants (PAHs) within made ground/shallow soils at the site via the ingestion, dermal contact and inhalation pathways
	Remediation Appraisal / Likely Remedial Approach	Provision of a clean cover system within areas of proposed soft landscaping. Alternatively, given the limited thickness of made ground and localised nature of the identified contamination, further testing may be undertaken following site preparation works to confirm any requirements for remedial measures.

GROUND ENGINEERING	Foundations	It is considered that conventional foundations may be suitable for the proposed development. The underlying soils have been recorded to be of low volume change potential, requiring a minimum founding depth of 0.75mbgl to be adopted within the design, where foundations are judged to be beyond the influence of proposed, existing, or historic planting (NHBC/LABC). Notwithstanding this, it is considered that foundations are taken to depths of between 0.35m and 2.7mbgl, typically 1.5mbgl, and found within the medium dense encountered granular deposits. When founding at this depth (~1.5mbgl), an allowable bearing resistance of 100kN/m ² would be considered appropriate, with total settlements of less than 25mm anticipated at the assumed pressures.
	Ground Floor Slabs	Given the reported low volume change potential of the underlying ground materials, suitable voids may be required against the foundations and below and against the sides of ground beams, as outlined in the NHBC Standards.
	Drainage	Previously recorded soakage testing undertaken at the site indicated that the ground materials were considered likely to provide a suitable drainage medium.
	Buried Concrete	The site the testing of the made ground and natural soils yielded an Aggressive Chemical Environment (ACEC) of AC-1z requiring a Design Sulphate Class of DS-1.
RECOMMENDED FURTHER WORKS		Localised elevated contaminant concentrations were recorded within a single location during the intrusive works and therefore a potential risk to human health exists that would require remedial works to be undertaken. However, given the limited thickness of made ground within this area, further investigation could be undertaken to potentially refine the remedial requirements within the development area.

1 INTRODUCTION

1.1 Terms of Reference

1.1.1 TEC has been appointed by Fairhurst to undertake a preliminary land contamination and geotechnical assessment of Brunswick Camp, Pirbright. All works were undertaken in accordance with our proposal letter dated 26th October 2020 and referenced ST.1909007.002.

1.2 Background

1.2.1 The site is currently part of an active military camp, 'Brunswick Camp' comprising numerous single storey accommodation blocks with associated access routes and soft landscaping. The site is approximately 1.1 hectares with the centre of the site situated at National Grid Reference of 492360, 156920. The nearest postcode is GU24 0PQ (Figure 1).

1.2.2 Whilst full details of the proposed development have not been made available to TEC, at this stage, it is understood that it is proposed to redevelop an area both areas of the camp comprising two storey structures.

1.2.3 A Preliminary Geoenvironmental and Geotechnical Assessment was undertaken for the area south-west of the current investigation phase, by TEC and is presented within the following report:

- Brunswick Camp, Pirbright – Preliminary Geoenvironmental and Geotechnical Assessment. Prepared by TEC for Fairhurst. Reference 1909007.001.01 dated November 2019.

1.2.4 Reference should be made to the previous assessment for full information, although salient information relating to the site in general is provided in section 2 of this report.

1.2.5 The aim of these works is to provide information on land contamination risk and the ground engineering conditions and constraints associated with the site with regard to the proposed development.

1.3 Scope of Works

1.3.1 The scope of work undertaken as part of this report is presented below:

- **Preliminary Risk Assessment:** this phase of assessment involves development of an initial site conceptual model, based on desk study research and a site reconnaissance survey, in order to establish whether or not there are potentially unacceptable risks.
- **Land Contamination - Generic Quantitative Risk Assessment:** this phase of assessment involves updating the site conceptual model developed as part of the Preliminary Risk Assessment based on the findings of an exploratory ground investigation. Generic assessment criteria and assumptions, if appropriate, are used to identify relevant pollutant linkages.
- **Ground Engineering:** general recommendations in relation to ground engineering for the proposed development are provided on the basis of the findings of the exploratory ground investigation.

1.3.2 The above scope of work has been undertaken in accordance with current guidance such as, LCRM - *Land contamination: risk management* (Environment Agency, 2020), BS10175+A2 (2017) and, where appropriate NHBC and Eurocode 7.

2 PRELIMINARY RISK ASSESSMENT

2.1 Introduction

2.1.1 Information for this preliminary risk assessment (PRA) has been obtained from a site reconnaissance survey and a review of an Envirocheck[®] report obtained for the site wider Brunswick Camp site area (Appendix B and Appendix C) together with published available information where relevant.

2.2 Site Setting

2.2.1 A site reconnaissance survey was undertaken on 18 November 2020. A summary of the observations is presented in Table 2.1. Photographs taken during the site reconnaissance survey are presented in Appendix A.

Table 2.1: Site Details

Feature	Description	
Current Site Use	The site forms a rectangular section of land located within the western area of the larger Brunswick Camp. The proposed development area currently comprises accommodation blocks with access roads and soft landscaping.	
Site Context	The site is located with a the 'Brunswick Camp' MOD site.	
Site Boundary Features	North	Structures associated with Brunswick Camp and rifle ranges beyond
	East	Accommodation and structures associated with Brunswick Camp
	South	Accommodation associated with Brunswick Camp and parade ground beyond
	West	Accommodation associated with Brunswick Camp and forests beyond
Site Topography	The site was noted to slope gently down towards the east. Available Ordnance Survey mapping indicates the west of the site is situated at an approximate elevation of 67.9m Above Ordnance Datum (AOD) sloping down to approximately 66.3mAOD in the east of the site.	
Hard and Soft Landscaping	The site is mainly consisting of hard landscaping of connecting tarmac roads existing accommodation blocks. A small amount of soft landscaping was noted to consist between the accommodation blocks comprising grass.	
Trees	Trees were noted to present along the southern boundary of the site.	
Fuel, Hazardous Chemicals and Waste Materials Storage	No above ground or below ground storage tanks (were observed during the site reconnaissance. In addition, no evidence of hazardous chemical storage or waste materials storage was observed during the site reconnaissance	
Asbestos Containing Materials	At the time of site walkover survey, no evidence of potential Asbestos Containing Material (ACM) was observed on the ground surface of the site. However, when considering the age of the recorded historic structures at the site, the presence of ACM within the building fabric cannot be discounted.	
Site Drainage	Numerous surface water drains and interceptors were noted on site. Also, no standing water were noted during the site work	
Evidence of Potential Contamination	No visual or olfactory evidence of potentially gross contamination was recorded during the site reconnaissance.	

Feature	Description
Ground Stability Hazards	No visual evidence of ground subsidence/ movement was recorded during the site reconnaissance.

2.3 Site History

2.3.1 Details of the history of the site and surrounding area, relevant to this preliminary risk assessment, have been obtained through the review of historical Ordnance Survey (OS) mapping. A summary of potentially significant features is recorded in Table 2.2, which should be read in conjunction with the full map extracts contained within Appendix B.

Table 2.2: Historical Features Summary

On Site Features			OS Dates
Earliest available mapping (1873) depicts the site area to be an open and undeveloped woodland.			1873 - 1938
Numerous structures associated with Brunswick Camp, as per current layout.			1947 - 2020
Surrounding Features	Distance	Direction	OS Dates
London & South – Western Railway; <i>later Southwestern Railway</i>	~400m	South	1877 - 2020
Pirbright Military Rifle Ranges	~120m	North	1897 - 2020
Bisley Deepcut Blackdown Railway runs within an embankment with woodland surrounding	~100m	South-east	1915 – 1938
Development of Brunswick Camp (offices, residential, classrooms and sports ground)	~200m	East	1920 - 2020
Tank	~170m	West	1972 - 1996
Electricity sub-station	~175m	South	1972 - 2006

2.4 Geology

2.4.1 A summary of available geological information for the area is provided in Table 2.3.

Table 2.3: Geological Setting

<i>BGS Geological Mapping (Ref. Solid and Drift 1:50,000 map – Guildford, Sheet 285)</i>		
Geological Unit	Thickness	BGS Description
Made Ground	Unknown	Not recorded on geological mapping but may be present on site
<i>Solid Geology:</i> Camberley Sand Formation	Up to 69m	Uniform sequence of homogeneous, bioturbated, yellow-brown, sparsely to moderately glauconitic silty fine-grained sand, or sandy silt, with some ironstone concretions and masses of white sandstone. Sporadic flint gravel or a gravel bed occur near the base.

BGS Borehole Records			
BGS Reference	Distance/ Direction	Depth	Recorded Strata
SU95NW63	Adjacent west	0.0 – 0.3	Dark brown sandy topsoil.
		0.3 – 1.0	Medium dense mid brown becoming light brown fine sand with roots.
		1.0 – 1.5	Medium dense light brown fine sand with subrounded and subangular flint.
		1.5 – 1.9	Firm grey/brown sandy clay.
SU95NW64	Adjacent west	0.0 -0.45	Dark brown to black sandy topsoil.
		0.45 – 0.8	Medium dense mid brown medium sand.
		0.8 – 1.1	Medium dense yellow/brown medium sand with subrounded and subangular gravel.
		1.1 – 2.5	Medium dense pale yellow fine sand.
BGS Estimated Soil Chemistry			
Element		Estimated Concentration	
Arsenic		<15 mg/kg	
Chromium		<1.8 mg/kg	
Cadmium		60 - 90 mg/kg	
Lead		<100 mg/kg	
Nickel		15 - 30 mg/kg	
Radon			
Radon Potential		Radon Protection Requirement	
Lower Probability Radon Area (less than 1% of homes are estimated to be at or above the Action Level)		None reported to be required	

2.5 Hydrogeology

2.5.1 The Envirocheck® report and Environment Agency information records the following hydrogeological setting of the site.

Table 2.4: Hydrogeological Setting

Aquifer Status			
Geological Unit	Groundwater Vulnerability/ Aquifer Designation	Environment Agency Aquifer Classification	Potential Hydraulic Gradient Direction
Camberley Sand Formation	Medium Vulnerability Secondary A Aquifer	Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.	Predominantly east (following the general topography)
Source Protection Zones			
None recorded within 1km of site			

Groundwater Abstractions
None recorded within 1km of site
BGS Groundwater Flooding Susceptibility
The site is reported to be within an area of limited potential for groundwater flooding

2.6 Hydrology

2.6.1 The hydrological setting of the site is summarised in Table 2.5:

Table 2.5: Hydrological Setting

Nearest Surface Water Features		
Feature	River Quality (GQA Grade)	Distance/ Direction from Site
Basingstoke Canal	-	~150m south
Surface Water Abstractions		
None recorded within 1km of site		
Licensed Discharge Consents		
Receiving Water	Effluent Type	Distance/ Direction from Site
Basingstoke Canal	Trade Discharges – Site drainage	~410m south-west
Pollution Incidents		
None recorded within 1km of site		
Flooding from Rivers or Seas		
The site is not reported to be located within an area at risk of flooding from rivers or sea without defences.		

2.7 Environmental Data

2.7.1 Additional relevant environmental data from the Envirocheck[®] report for the site is summarised in Table 2.6.

Table 2.6: Additional Environmental Data Summary

Landfill Sites		
No current or historical landfills recorded within 1km of site		
Commercial/ Industrial Land Use (Active Contemporary Trade Directories)		
No significant land uses identified within 500m radius of site		
Hazardous Substances (Authorisations, Consents, Incidents)		
Category	Details	Distance/ Direction from Site
Substantiated Pollution Incident Register	Pollutant not identified. Category 2 Significant - water impact incident.	~490m southwest
Sensitive Land Uses		
Category	Details	Distance/ Direction from Site
Areas of Adopted Green Belt	Guildford Borough Council	On site
Nitrate Vulnerable Zone	Chertsey Bourne	~300m west

Category	Details	Distance/ Direction from Site
Sites of Special Scientific Interest	Basingstoke Canal Colony Bog and Bagshot Heath	~135m north; and ~160m north
Special Area of Conservation	Thursley, Ash, Pirbright and Chobham	~135m north
Special Protected Areas	Thames Basin Heaths	~135m north

2.8 Engineering Considerations

2.8.1 Engineering considerations identified from the Envirocheck® report for the site are summarised in Table 2.7:

Table 2.7: Engineering Considerations

Ground Stability Hazards						
Hazard	Hazard Potential					
	No Hazard	Negligible	Very Low	Low	Moderate	High
Collapsible ground			X			
Compressible ground	X					
Ground dissolution	X					
Landslide			X			
Running sand				X		
Shrink/swell clays	X					
Coal mining	X					
Non-coal mining	X					
BGS Recorded Mineral Sites						
Site Name	Type/Commodity	Status	Distance/ Direction from Site			
Pirbright Common Gravel Pit	Opencast – Sand and Gravel (Camberley Sand Formation)	Ceased	~550m east			
Cow Moor Gravel Pit	Gravel Pit – Sand and Gravel (River Terrace Deposits)	Ceased	~640m north			
Pirbright Common Gravel Pit	Gravel Pit – Sand and Gravel (River Terrace Deposits)	Ceased	~735m north-west			
Blackdown Barracks Gravel Pit	Gravel Pit – Sand and Gravel (River Terrace Deposits)	Ceased	~935m north-west			

2.9 Previous Site Report Summary

2.9.1 Information for the site has also been obtained through a review of the following report previously undertaken by TEC for an area immediately to the north of the current development area:

- Brunswick Camp, Pirbright - Preliminary Geoenvironmental and Geotechnical Assessment. Prepared by TEC for Fairhurst. Reference 1909077.001.01, dated November 2019.

2.9.2 A summary of relevant information from these previous reports, in relation to this assessment, is summarised in Table 2.8. Reference should be made to these previous reports for full information.

Table 2.8: Previous Ground Investigation Summary

Encountered Ground Conditions	<p>The encountered ground conditions were generally recorded to comprise the following:</p> <p>Made ground and near surface material was encountered across the site to depth of 0.9m and generally comprised brown to light brown/dark brown gravelly sandy silt overlying brown and grey gravelly silty fine to coarse sand. The gravel was noted as flint brick and coal.</p> <p>The natural ground was encountered below depths of 0.6m and 0.9m and was generally observed to comprise orange mottled grey slightly gravelly silty/very silty fine to medium sand. The gravel was noted as fine flints.</p>
Groundwater	<p>No groundwater was encountered during the intrusive investigation works to depths of 4.0mbgl.</p>
Contamination	<p>No visual or olfactory evidence of contamination was recorded during the ground investigation works.</p> <p>A Generic Quantitative Risk Assessment completed for the proposed area of land recorded exceedance of PAH concentrations in exceedance of the generic assessment criteria for a residential site end use with homegrown produce.</p> <p>Furthermore, asbestos fibres were recorded within two samples of the mader ground, loose chrysotile fibres. A single marginal exceedance of the EQS values were recorded within a two leachate samples:</p> <ul style="list-style-type: none"> • Copper – 14µg/l and 16 µg/l (10µg/l)
Ground Gas/ Radon	<p>The site is recorded to be within a Lower Probability radon area where less than 1% of homes are estimated to be at or above the Action Level. Therefore, it is reported that no radon protection measures are necessary in the construction of new dwellings or extensions.</p> <p>No further source of ground gas was identified as part of the desk study or ground investigation works.</p>
Relevant Pollutant Linkages	<p>The relevant pollutant linkages identified limited to human health (future site end users and construction workers) - exposure to potential contaminants (PAHs and asbestos fibres) within near surface materials at the site via the ingestion, dermal contact and inhalation pathways.</p>
Ground Engineering	<p>Conventional foundations were considered likely to be suitable for the site founding within the granular deposits from 0.7m to 0.9mbgl. It was recommended that due to the low plasticity clays have been recorded at the site, a minimum founding depth of 0.75m should be utilised.</p> <p>It was recommended that a suspended floor is utilised within the development.</p> <p>Testing of the natural soils yielded an Aggressive Chemical Environment (ACEC) of AC-1 requiring a Design Sulphate Class of DS-1.</p>
Soakage Testing	<p>Infiltration rates of between 1.5×10^{-6} and 1.9×10^{-6} m/s were recorded at the site based upon a single fill. Based on the testing undertaken to date, the generally granular materials encountered at the site may potentially provide a suitable drainage medium.</p>
Regulatory Consultations Summary – Environmental Health: Guildford Council	<p>The Council were contacted for the initial phase of investigation undertaken by TEC in November 2019. A response was not received at the time of reporting. However, the response is presented in Appendix D and summarised below;</p> <ul style="list-style-type: none"> • There are no reported landfill sites, Part B APC authorisations or private water supplies within 500m of the site; • The Council do not hold records of report pollution incidents within 500m of the site and they are not aware of any ongoing contamination issues on site; and • The site has not been identified for Part IIA investigations according to the Council.

2.10 Outline Conceptual Model

2.10.1 In accordance with the Environment Agency Land contamination: risk management guidance, potential source-pathway-receptor pollutant linkages identified from the desk study phase are summarised in the following sections.

2.11 Potential Sources

2.11.1 Potential sources of contamination identified on and within the vicinity of the site are summarised below:

On Site Sources

- Localised areas of made ground of unknown chemical composition;
- On-site activities – military practices;

Off Site Sources

- Limited potentially contaminative land uses have been identified in proximity to the site. In addition, given the distance and scale of these features and the absence of landfills / potential areas of infilled land within proximity to the site, the potential risk of contaminant migration onto site is considered to be unlikely and therefore has not been discussed further within the report.

2.12 Potential Receptor Pathways

2.12.1 Potential receptors identified as part of this preliminary risk assessment are:

- Current/future site users;
- Construction workers;
- Ecological receptors;
- Controlled waters (Secondary A Aquifer);
- Proposed development/ structures.

2.13 Potential Pathways

2.13.1 Potential contaminant pathways relating to the identified receptors and contaminants of concern include:

- Dermal contact – contact with soil, dust or water;
- Ingestion - ingestion of soil, dust or water;
- Inhalation – inhalation of soil, dust or vapours;
- Vertical migration – e.g. seepage of contaminants at the ground surface (i.e. leakage/spillage of hydrocarbons) through cracks in hardstanding and/or leaching of contaminants within the unsaturated zone resulting in vertical contaminant migration; and
- Horizontal migration – e.g. lateral migration of contaminants within the saturated zone and along preferential pathways such as drainage pipe bedding.

2.14 Hazard Assessment and Risk Estimation

2.14.1 Potential pollutant linkages identified as part of this preliminary risk assessment are summarised in the Outline Site Conceptual Model presented in Table 2.9. References to risk estimations are made in accordance with the methodology presented in CIRIA publication C552 (2001) titled 'Contaminated Land Risk Assessment: A Guide to Good Practice' and summarised in Appendix E.



Table 2.9: Outline Conceptual Model

Potential Hazard/ Source	Potential Receptor	Potential Pathway to Receptors	Potential Consequence of Source-Receptor Linkage	Potential Likelihood for Significant Source-Receptor Linkage	Risk Classification
Made ground and potentially contaminative processes – on site	Current and future site users and construction workers	Exposure to potential contaminants through ingestion, inhalation and dermal contact.	Medium	Low Likelihood to Likely: Given the development history recorded on the wider site area and the elevated PAHs and presence of asbestos fibres recorded in proximity to the site, the potential for made ground of unknown thickness and chemical composition cannot be discounted at this stage.	Low to Moderate Risk
	Controlled waters (Secondary Aquifers)	Leaching of potential contaminants from made ground and vertical and lateral migration through the saturated zone to controlled waters.	Medium	Low Likelihood: Given the potential presence of made ground of unknown chemical composition and the recorded aquifer status of the underlying strata (Secondary A Aquifer), a potential risk to controlled waters, whilst likely to be low, cannot be fully discounted. Notwithstanding this, the presence of hardstanding may limit the potential for infiltration and subsequent contaminant migration.	Low Risk
	Future site users and proposed development structures	Risk of harm to human health and buildings	Medium	Low Likelihood: Made ground, if present, may act as a potential source of ground gas, subject to thickness and chemical composition.	Low to Moderate Risk

3 GROUND INVESTIGATION METHODOLOGY

3.1 Background

3.1.1 The exploratory ground investigation undertaken was designed to provide information on the ground conditions to aid with the design of the development; and to investigate the potential pollutant linkages identified as part of the Preliminary Risk Assessment.

3.1.2 All site works were undertaken in accordance with BS5930:2020, BS10175+A2:2017 and, where appropriate, Eurocode 7. Works were supervised by a suitably experienced geoenvironmental consultant from TEC.

3.2 Methodology

3.2.1 A summary of the ground investigation works undertaken and the rationale for each location is provided in Table 3.1, as follows:

Table 3.1: Summary of Ground Investigation Works

Investigation Method	Location	Date(s)	Location Rationale	Purpose
Trial Pitting (JCB 3CX)	TP01 – TP05	18.11.2020	Positioned at approximate locations specified by Fairhurst	Characterisation of shallow ground conditions Collection of geochemical and geotechnical samples for laboratory analysis Soakage testing in general accordance with BRE 365.

3.2.2 Exploratory hole locations are presented on Figure 2. A detailed description of encountered ground conditions are shown on exploratory hole logs presented in Appendix F.

3.3 Field Testing

3.3.1 A summary of in situ field testing undertaken as part of these ground investigation works is provided in Table 3.2

Table 3.2: Summary of Field Testing

Field Test	Purpose
Hand Shear Vane (HSV)	Estimation of undrained shear strengths of cohesive strata
Pocket Penetrometer (PP)	Indication of unconfined compressive strength of cohesive strata

3.4 Chemical Testing

3.4.1 Laboratory testing was scheduled on the basis of the Preliminary Risk Assessment and field observations.

3.4.2 Representative soil and groundwater samples were collected and chemically tested at i2 Analytical Ltd, a UKAS/MCERTS accredited laboratory, for a selection of the following parameters:

Soils (Totals and Leachate)

- Heavy metals and metalloids;
- Total Organic Carbon (TOC);
- Phenols (monohydric);

- *Total Cyanide;*
- *Sulphate, sulphide, elemental sulphur and pH;*
- *Speciated Polyaromatic Hydrocarbons (PAH);*
- *Total Petroleum Hydrocarbons (TPH-CWG), including BTEX and MTBE;*
- *Asbestos Screen; and*
- *Basic Characterisation (including Waste Acceptance Criteria) testing.*

Soils (Leachable)

- *Heavy metals (arsenic, chromium, cadmium, copper, lead, selenium, zinc, barium, mercury, nickel, beryllium, vanadium and boron);*
- *Phenol (monohydric), cyanide (total), sulphate, sulphide, pH; and*
- *Speciated Polycyclic Aromatic Hydrocarbons (PAHs).*

3.4.3 Geochemical certificates of analysis are presented Appendix G.

3.5 Geotechnical Testing

3.5.1 Selected soil samples were submitted for geotechnical analysis at K4 Soils Ltd. Laboratory testing was scheduled upon the basis of field observations for a selection of the following:

- *Atterberg limit tests – natural moisture content, liquid limit and plastic limit;*
- *Particle size distribution (PSD) tests;*
- *BRE SD1 Suite B – Water soluble and acid soluble sulphates, total sulphur and pH.*

3.5.2 Soil geotechnical certificates of analysis are presented in Appendix H.

3.6 General Sampling

3.6.1 Samples were collected in accordance with the following guidance;

- BS5930:2020 – Code of practice for ground investigations;
- BS-EN 1997-2:2007 - Eurocode 7 — Geotechnical design —Part 2: Ground investigation and testing
- BS ISO 10175:2011+A2:2017 - Investigation of potentially contaminated sites – Code of practice;
- BS ISO 18400-105 Soil quality – Sampling - Packaging, transport, storage and preservation of samples; and
- BS ISO 18400-106 Soil quality – Sampling - Quality control and quality assurance.

4 GROUND INVESTIGATION FINDINGS

4.1 Introduction

4.1.1 A summary of encountered ground conditions for the site is provided below.

4.1.2 Detailed descriptions of encountered ground conditions are shown on exploratory hole logs presented in Appendix F. Photographs of the materials encountered are presented within Appendix A.

Made Ground/ Near Surface Material

4.1.3 Made ground was recorded locally, TP01 to 0.55mbgl, comprising brown to light brown slightly gravelly silty sand with low cobble content. The gravel and cobbles were recorded as brick and flint. Near surface materials were observed at the remaining locations to 0.4mbgl. These materials were typically dark brown slightly gravelly sandy silt with frequent rootlets and the gravel noted as fine to medium flint.

Solid Geology (Camberley Sand Formation)

4.1.4 Potentially reworked natural ground was encountered within TP04 and TP05 only to depths of between 0.25m and 0.95mbgl. The material was observed to comprise loose to medium dense light brown to yellowish brown becoming dark grey slightly clayey slightly gravelly silty fine to medium sand.

4.1.5 This was recorded to be underlain by loose to typically medium dense yellowish brown, grey and light brown slightly clayey silty fine to medium sand to depth of 1.15m to 2.7mbgl. Which in turn was recorded to be underlain by medium dense light brown, brown and occasionally yellowish-brown or greenish grey slightly clayey silty fine to medium sand with occasional fine to medium subangular flint gravel.

4.2 Generalised Ground Profile

4.2.1 The general ground profile encountered at the site is summarised in Table 4.1 below.

Table 4.1: Generalised Ground Profile

Depth (mbgl)	Encountered Material
MADE GROUND / NEAR SURFACE MATERIAL	
0.0 – 0.25/0.55	Brown slightly gravelly sandy silt underlain by dark grey to black or light brown and yellowish-brown very silt sand. The gravel is flint and brick.
POTENTIALLY REWORKED NATURAL MATERIAL	
0.25/0.40 – 0.35/0.95 (TP02, TP04 & TP05)	Light brown and yellowish brown becoming dark grey slightly clayey silty sand with occasional gravel of flint.
SOLID GEOLOGY – CAMBERLEY SAND FORMATION	
0.35/0.95 – >1.15 / 2.7	Loose typically medium dense, light brown, brown and occasionally yellowish-brown or greenish grey slightly clayey silty fine to medium sand.
0.35 / 2.7 – 1.8 / 3.2	Medium dense light brown, brown and occasionally yellowish-brown and greenish grey slightly clayey silty fine to medium sand with occasional fine to medium subangular flint gravel

4.3 Groundwater

4.3.1 Groundwater observations recorded during the ground investigation works and standing depths within the boreholes recorded as part of subsequent monitoring visits are summarised in Table 4.2 below. Groundwater strikes/ observations are also shown on the exploratory hole logs in Appendix F.

Table 4.2: Summary of Groundwater Conditions

Location	Ingress of Groundwater (mbgl)	Depth of trial pit	Strata
TP02	2.90	3.00	Camberley Sand Formation - seepages
TP03	1.40	3.10	

4.3.2 It should be noted that groundwater conditions recorded during the investigation may not be representative of long-term conditions and that groundwater levels may vary in response to meteorological/ seasonal changes.

4.4 Contamination Observations

4.4.1 No visual or olfactory evidence of potentially gross contamination was recorded during the intrusive works.

5 LAND CONTAMINATION - GENERIC QUANTITATIVE RISK ASSESSMENT

5.1.1 The generic quantitative risk assessment comprises a screening of identified contaminants against generic assessment criteria (GAC) that are appropriate to the site setting and the receptors concerned.

5.2 Human Health

Methodology

5.2.1 Detailed information on the background legislation and selection of the GAC used within this assessment for human health is presented in Appendix I.

5.2.2 The standard land use for the site, for use in this generic assessment, has been defined as “residential with homegrown produce” based on the proposed development and in accordance with current guidance.

5.2.3 As the site investigation methodology involved non-targeted sampling, statistical analysis has been undertaken to identify outliers or hotspots and assess the distribution of the dataset.

Summary of Results

5.2.4 The full human health generic quantitative risk assessment is presented in Appendix I.

Made Ground/ Shallow Soils

5.2.5 The results of the assessment recorded exceedances of the relevant GACs at a single location (TP02) and therefore the following contaminants of potential concern (CoPC) have been identified within the made ground materials on site.

- PAHs - Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene, and Dibenz(a,h)anthracene

5.2.6 An asbestos screen completed on samples of the made ground/ shallow soils at the laboratory recorded no suspected asbestos containing material or detectable asbestos fibres.

5.3 Controlled Waters

5.3.1 Based on the conceptual understanding, the nearest significant controlled waters receptor is considered to be the underlying Secondary A Aquifer.

Summary of Results

5.3.2 Leachate samples were collected from the made ground materials at 2No. locations at the site, the results are presented within Appendix J.

5.3.3 No exceedances of screening values deemed protect of the identified controlled waters have been recorded within the leachate analytical results of the sampled made ground materials.

5.4 Ground Gas

5.4.1 In accordance with BS8485:2019 and CL:AIRE RB17, an assessment of the risk posed by ground gases at the site has been undertaken based on the findings of the desk study and ground investigation and the conceptual side model. The following site-specific information has been considered as part of the assessment;

- No landfills, areas of potentially significant infilled ground or mine openings/ workings have been identified within proximity to the site;

- A localised shallow thickness of made ground has been recorded at the site, to a maximum depth of 0.55m. No significant organic material was observed within these soils, which are likely to be removed as part of site preparation works. Given the composition and limited thickness of the made ground, this is not considered a potential source of significant ground gas generation;
- The natural soils were recorded to comprise the Camberley Sand Formation of typically low organic content, recorded TOC concentration of between <0.1 and 1.5%;
- The site is not located within a radon affected area.

5.4.2 No credible source or pathway for ground gas has been identified at the site as part of these works. Therefore, no further ground gas monitoring or assessment is considered to be required and no specific ground gas protection measures are considered necessary for the proposed development.

5.5 Updated Conceptual Model

5.5.1 The findings of the site investigation and the GQRA have been used to update the conceptual model and confirm the relevant pollutant linkages associated with the proposed development.

Identified Sources

5.5.2 Sources of contamination/ ground gas identified on and within the vicinity of the site are summarised below:

On Site Sources

- Made ground/shallow soils;
- On-site activities – military practices;

Identified Receptors

5.5.3 Receptors identified as part of this updated conceptual model are:

- Current/future site users;
- Construction workers; and
- Controlled waters (Secondary A Aquifer).

Identified Pathways

5.5.4 Potential contaminant pathways relating to the identified receptors and contaminants of concern include:

- Dermal contact – contact with soil, dust or water;
- Ingestion - ingestion of soil, dust or water;
- Inhalation – inhalation of soil, dust or vapours;
- Vertical migration –leaching of hydrocarbon impact within the shallow soils/unsaturated zone resulting in vertical contaminant migration to the underlying aquifer; and
- Horizontal migration – e.g. lateral migration of contaminants within the saturated zone and along preferential pathways such as drainage pipe bedding.

5.5.5 The updated conceptual model is presented in Table 5.1. References to risk estimations are made in accordance with the methodology presented in CIRIA publication C552 (2001) titled 'Contaminated Land Risk Assessment: A Guide to Good Practice' and summarised in Appendix E.



Table 5.1: Updated Conceptual Model (Hazard Assessment and Risk Estimation)

Identified Hazard/ Source	Identified Receptor	Potential Pathway	Potential Consequence of Source-Pathway-Receptor Pollutant Linkage	Potential Likelihood for Source-Pathway-Receptor Pollutant Linkage	Risk Classification
Localised made ground/ near surface material	Current and future site users and construction workers	Exposure to potential contaminants through ingestion, inhalation and dermal contact.	Medium	Low likelihood to likely: Made ground and near surface materials were encountered across the site to a maximum observed depth of 0.55m bgl. Laboratory analysis of the encountered made ground indicates marginal exceedances for PAHs when compared to the relevant Tier 1 SSVs for a residential site end use at a single location (Tp02). In addition, no asbestos was identified within the made ground material.	Low to Moderate Risk
	Controlled waters (Secondary A Aquifer)	Leaching of potential contaminants from made ground and vertical and lateral migration through the saturated zone to controlled waters.	Medium	Unlikely: A shallow localised area of made ground has been recorded at the site. However no evidence of significant contamination has been recorded within the made ground and near surface materials on site. In addition, laboratory leachate analysis of the encountered made ground materials indicated no exceedances of the relevant assessment criteria. No significant groundwater was encountered during the intrusive investigation and so the risk to controlled water is considered unlikely.	Low Risk
	Current and future site users, construction workers and proposed development	Migration, ingress and accumulation of ground gasses.	Severe	Unlikely: The encountered made ground is considered unlikely to be a potential source of significant ground gas based on its limited thickness and observed composition.	Low Risk

6 LAND CONTAMINATION - CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

- 6.1.1 No visual or olfactory evidence of significant contamination was noted during the ground investigation.
- 6.1.2 Laboratory analytical results of the encountered near surface materials reported both organic and inorganic contaminants to be generally below the relevant GAC for a residential site end use with homegrown produce.
- 6.1.3 However, localised exceedances (TP02) of the GAC have been recorded during the exploratory investigation, including benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, and dibenz(a,h)anthracene.
- 6.1.4 No exceedances of screening values deemed protect of the identified controlled waters have been recorded within the leachate analytical results of the sampled made ground materials.
- 6.1.5 Based on the conceptual site model, the site is considered to be representative of Characteristic Situation 1 and therefore, no specific bulk ground gas protection measures are required within the development.
- 6.1.6 No radon protective measures are considered necessary within the construction of new homes.

6.2 Remedial Appraisal

- 6.2.1 Localised contaminants of potential concern (CoPC) have been recorded within the near surface materials when considering a residential site end use.
- 6.2.2 Therefore, where soft landscaping is proposed in such areas and where made ground remains after finished site levels have been achieved, localised exposure to potential contaminants cannot be discounted and a suitable cover system may be required within areas of soft landscaping. Alternatively, given the limited and localised nature of these exceedances further testing may be undertaken once final site levels are achieved, and final proposed development designs are in place, to determine the requirement for any such remedial measures.

6.3 General Considerations

- 6.3.1 Given the presence of general made ground, good brownfield site working practices should be adopted by construction workers to mitigate against potential risks.
- 6.3.2 Should water supply pipes be placed within the made ground encountered at the site, due consideration would need to be given to the UK Water Industry Research Ltd (UKWIR) guidance.
- 6.3.3 Based on our conceptual understanding of the site to-date, it would be anticipated that similar ground conditions to those encountered as part of this assessment exist across the site areas where access has been possible. However, should significant thicknesses of made ground be encountered, or visual or olfactory evidence of potentially significant contamination be identified during the development works, further investigation and assessment may be required.

7 GROUND ENGINEERING

7.1 Proposed Development

7.1.1 The proposed development details have not been made available to TEC, at this stage, it is understood that it is proposed to redevelop an area of the camp comprising two storey accommodation structures. Therefore, column loads of up to 250kN and line loads of up to 75kN per metre run have been assumed at this preliminary stage and general recommendations with regards to the ground engineering have been made on this basis.

7.2 Site Preparation

7.2.1 A number of utility services exist within close proximity to the proposed development area, consideration to any realignment and/or removal should be given as appropriate.

7.2.2 Consideration will need to be given to the removal of hardstanding encountered on site and to any foundations associated with the current buildings on site.

7.3 Geotechnical Test Data Summary

7.3.1 Laboratory test data are presented in Appendix H while in situ test results are presented on the engineering logs Appendix F.

Plasticity

7.3.2 Atterberg Limit tests were undertaken on a single sample of cohesive material encountered, summarised in Table 7.1 below:

Table 7.1: Summary of Laboratory Test Results

Moisture Content (%)	Plasticity Index (%)	% passing 425µm sieve	Modified Plasticity Index ⁽¹⁾ (%)	Volume Change Potential ⁽¹⁾
23	13	99	12.9	Low

Note 1: Based on recommendations provided in the NHBC Standard

Particle Size Distribution

7.3.3 Classification tests were undertaken on 6no. of the encountered deposits, summarised in Table 7.2 **Error! Reference source not found.** below.

Table 7.2: Summary of Laboratory Test Results

Fine (%)	Sand (%)	Gravel (%)	Cobbles (%)
1.7 – 24.0	52.1 - 98.3	0.0 – 30.6	0.0

7.4 Foundations

7.4.1 It is considered that conventional foundations may be suitable for the proposed development. Field descriptions and geotechnical laboratory testing indicate the encountered soils to be generally non-shrinkable, described as generally being medium dense (based on observations only). However, the underlying soils have locally been recorded to be of low volume change potential, requiring a minimum founding depth of 0.75mbgl to be adopted within the design, where foundations are judged to be beyond the influence of proposed, existing, or historic planting (NHBC/ LABC).

7.4.2 Notwithstanding this, it is considered that foundations are taken to depths of between 0.35m and 2.7mbgl, typically 1.5mbgl, and found within the medium dense encountered granular deposits. When founding at this depth (1.5mbgl), an allowable bearing resistance of 100kN/m² would be considered appropriate, with total settlements of less than 25mm anticipated at the assumed pressures.

7.4.3 Given the reported low volume change potential of the underlying ground materials, suitable voids may be required against the foundations and below and against the sides of ground beams, as outlined in the NHBC Standards.

7.5 Ground Floor Slabs

7.5.1 Given the presence of shrinkable soils, the use of suspended floor slabs may be appropriate for the scheme, which should incorporate the minimum void dimensions as outlined in the NHBC Standards.

7.5.2 Based on the ground condition encountered during the investigation, ground bearing slabs may be appropriate for the proposed development.

7.6 Excavations

7.6.1 Excavations at the site for conventional foundations may be achievable using conventional equipment.

7.6.2 Groundwater seepages were recorded at depths between 1.4m and 2.9m bgl. Based on observations made during the ground investigations, groundwater ingress into excavations is considered unlikely to be significantly problematic although some dewatering may be required, particularly where excavations are left open for any length of time. It would be recommended that formation levels are protected to mitigate against softening associated with any such water ingress.

7.6.3 It should be noted that groundwater levels might fluctuate according to the season and from year to year. This may have implications on recommendations, including those for foundations and excavations. Accordingly, a careful watch should be maintained during any future groundworks and the recommendations presented in this report may be subject to amendment should additional information becoming available.

7.6.4 It is recommended that appropriate shoring/temporary works are used in accordance with current Health and Safety requirements where access for personnel is required into excavations.

7.7 Protection of Buried Concrete

7.7.1 BRE SD1 Suite B testing was undertaken on 5no. samples of the encountered ground materials.

7.7.2 The results of the testing, together with the resulting Aggressive Chemical Environment for Concrete (ACEC) Class and Design Sulphate (DS) Class, as derived in accordance with BRE Special Digest 1, are presented in Table 7.3. The full laboratory results are presented in Appendix G and Appendix H.

Table 7.3: Summary of ACEC

Stratum	No. of tests	pH	Water Soluble Sulphate (mg/l)	Oxidisable Sulphides (%)	Total Potential Sulphates (%)	ACEC	DS
Made Ground	3	5.9 – 8.4	10 - 41	-	-	AC-1	DS-1
Camberley Sand Formation	5	5.5 – 7.9	<20	0.01 – 0.02	0.03 - 0.06	AC-1	DS-1

7.8 Drainage

7.8.1 Soakage testing was undertaken at a single location on site in general accordance with BRE365, at the approximate location specified by Fairhurst in advance of the works. The full results are presented within Appendix K.

- 7.8.2 Unfortunately, the soakage pit collapsed during the monitoring period and therefore recorded the ground water level to rise during the monitoring. As a result, the full BRE365 testing could not be completed within this area of the site.
- 7.8.3 Notwithstanding this, based upon the recorded ground conditions within the current phase of investigation and the previous ground conditions, it is considered that it is likely that similar infiltration rates may be achieved within the current phase of the investigation. Based upon the results from the previous soakage testing undertaken at the site, extrapolated infiltration rates of between 1.5 and 1.9×10^{-6} m/s were recorded.
- 7.9 Waste**
- 7.9.1 Basic Characterisation testing, including WAC testing, has been undertaken on representative samples of encountered made ground materials in accordance with the guidance outlined within the Environment Agency document 'Waste Sampling and Testing for Disposal to Landfill' (EBPRI 11507B; March 2013).
- 7.9.2 Basic Characterisation testing was undertaken in accordance with the guidance outlined within the Environment Agency document 'Waste Sampling and Testing for Disposal to Landfill' (EBPRI 11507B; March 2013). The results are presented within Appendix G. In addition, geochemical testing was undertaken on further samples of the encountered made ground on site as part of the general contamination characterisation.
- 7.9.3 Based upon Table 5.3 (Criteria for granular waste acceptable at landfills) of the guidance, the test results indicate that the sampled made ground may be accepted at an inert landfill.
- 7.9.4 It should be noted that waste characterisation has not been undertaken as part of this scope of works and while the initial assessment gives classifications based on industry guidance, the final decision with regard to waste acceptance is dependent upon the individual waste receiver. Therefore, should site materials require off-site disposal, it would be recommended that the Basic Characterisation test results, WAC tests data, as well as all total contaminant results and background information regarding the waste source and origin (as contained within this report) are forwarded to the selected licensed waste transporter/receiver to gain confirmation with regards to the acceptability of the waste materials that may be generated from the site. Further testing may be required to appropriately characterise any materials proposed for off-site disposal during redevelopment works.
- 7.9.5 It should also be noted that inert, non-hazardous and hazardous waste must be treated before it can be sent to landfill, in accordance with the requirements of the Landfill Directive and in the context of these works treatment could include "source segregation". This would involve careful separation of waste material types on site to demonstrate the minimisation of the disposal of waste to landfill. Waste testing has been restricted to the made ground and near surface material encountered and it cannot be discounted that other wastes which may be produced on site may require further characterisation.
- 7.9.6 Should re-use of excavated materials be proposed, consideration will need to be given to appropriate regulatory guidance.

8 GROUND ENGINEERING - CONCLUSIONS AND RECOMMENDATIONS

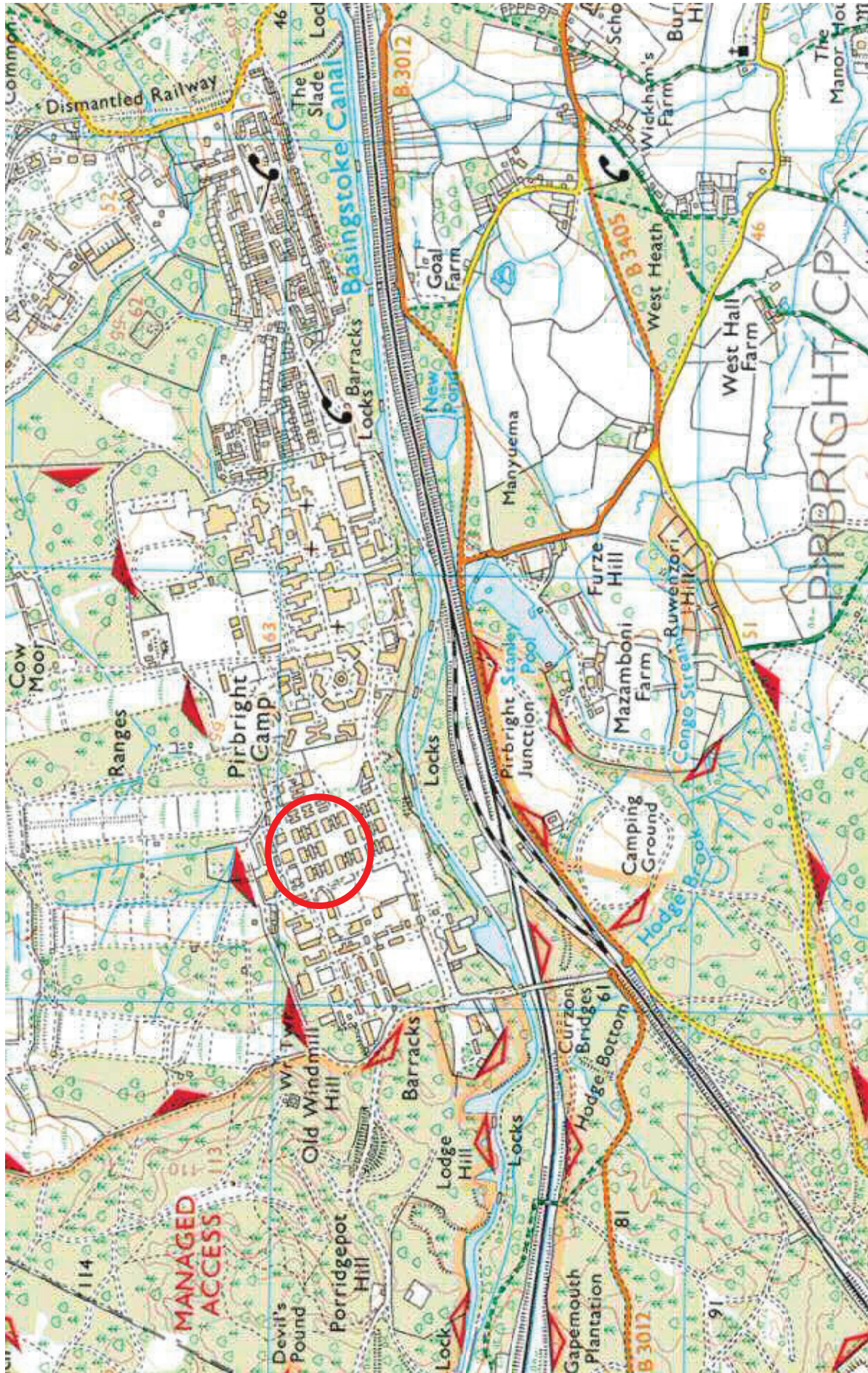
- 8.1.1 It is considered that conventional foundations may be suitable for the proposed development. The underlying soils have been recorded to be of low volume change potential, requiring a minimum founding depth of 0.75mbgl to be adopted within the design, where foundations are judged to be beyond the influence of proposed, existing, or historic planting (NHBC/ LABC).
- 8.1.2 Notwithstanding this, it is considered that foundations are taken to depths of between 0.35m and 2.7mbgl, typically 1.5mbgl, and found within the medium dense encountered granular deposits. When founding at this depth (1.5mbgl), an allowable bearing resistance of 100kN/m² would be considered appropriate, with total settlements of less than 25mm anticipated at the assumed pressures.
- 8.1.3 Given the reported low volume change potential of the underlying ground materials, suitable voids may be required against the foundations and below and against the sides of ground beams, as outlined in the NHBC Standards.
- 8.1.4 The results of the sulphate and pH testing from the soils at the site yield an aggressive chemical environment class (ACEC) of AC-1, requiring a design sulphate class of DS-1.
- 8.1.5 Previously recorded soakage testing undertaken at the site indicated that the ground materials were considered likely to provide a suitable drainage medium.

9 RECOMMENDED FURTHER WORKS

9.1.1 Localised elevated contaminant concentrations were recorded within a single location during the intrusive works, therefore a potential risk to human health exists. Given the limited thickness of made ground within this area, further investigation could be undertaken to potentially refine any remedial requirements within this area.

TEC

Figures and Drawings



Approximate Site Location:

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tec
The Old Chapel
35a Southover
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BA5 1UH
Tel: 01749 67769
Email: info@tecon.co.uk
Web: www.tecon.co.uk

Site Name:
Brunswick Camp, Pirbright

Drawing Name:
Site Location Plan

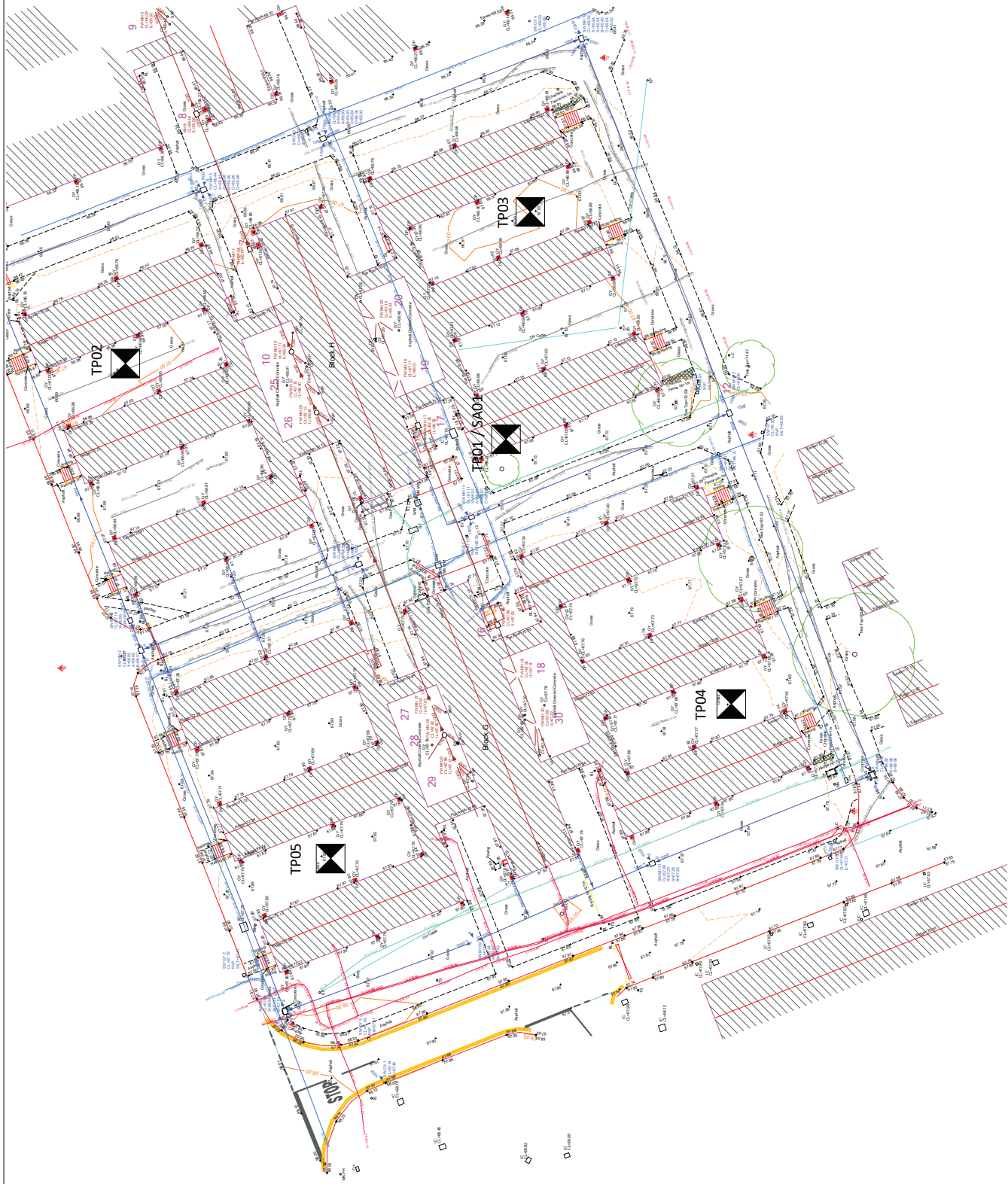
Client Name:
Fairhurst

Project No:
1909007.002


Figure No:
1

Date:
December 2020

Scale:
NTS



Key:

 Trial Pit Location

*All locations are approximate

Extract from Brunel Surveys Ltd 'Accommodation Block G, H & J Brunswick Camp - Utilities Survey', Dwg No. - 22392-200-01 Utilities, November 2020.

 TEC The Old Chapel 35a Southover Wells, Somerset BA5 1UH	Site Name: Brunswick Camp, Pirbright	Drawing Name: Exploratory Hole Location Plan	Client Name: Fairhurst	Project No: 1909007.002	Figure No: 2	Date: December 2020	Scale: NTS
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