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Hydrock

# EXECUTIVE SUMMARY

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| *SITE INFORMATION AND SETTING* | |
| Objectives | To review existing ground investigation data and produce a report evaluating the environmental risk at the site to support QinetiQ in their planning application. |
| Client | QinetiQ |
| Site name and location | QinetiQ Enclave, Fort Halstead, Crow Drive, Halstead, Sevenoaks, Kent. TN14 7BS. |
| Proposed development | The erection of perimeter security fence,  erection of a new reception building, creation of new main site entrance along Crow Road, refurbishment of existing buildings including plant installation, creation of new surface level car parks and access, installation of two explosive magazine stores and surrounding pendine block walls, demolition of existing buildings, installation of 6no. storage containers, installation of new site utilities and arboricultural and ecological works.' |
| *GROUND MODEL* | |
| Desk study summary | The site currently is currently occupied by QinetiQ. QinetiQ provide scientific and technical research to the Ministry of Defence. Within the site there are a series of buildings used for the storage of higher risk explosives. Between the buildings are grassed areas with several mature trees. The area has its own gated access points<br>The current buildings appear to have used potentially asbestos containing building materials in their construction.<br>The wider Fort Halstead site has housed military research and development facilities since 1938 to the present day though structures associated with these facilities are not shown on OS Maps. Prior to its development the site was largely woodland and farmland.<br>The superficial geology comprises the Clay with Flints formation, which is recorded as orange-brown and red-brown sandy clay with abundant nodules and rounded pebbles of flint.<br>The solid geology comprises (undifferentiated) Lewes Nodular Chalk Formation comprising hard to very hard nodular chalks and hardgrounds with interbedded soft to medium hard chalks and marls. The Seaford Chalk Formation comprising firm white chalk with conspicuous semi-continuous nodular and tabular flint seams and Newhaven Chalk Formation comprising soft to medium hard, smooth white chalks with numerous marl seams and flint bands. Solution features are potentially present in the Chalk.<br>The Clay with flints formation is classed by the Environment Agency as unproductive strata, the Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated) is classed as a Principal aquifer. The site is not located within a groundwater Source Protection Zone (SPZ). |
| Ground and groundwater conditions encountered by investigation | The ground conditions as proven by the investigation(s) undertaken at the site comprise:<br>• Made Ground – between ground level and 1.8m below ground level (bgl), comprising gravels and clays with concrete, ash and flint.; over<br>• Clay-with-flints Formation – between 0.4m and >5.0m bgl, comprising red brown mottled orange brown sandy gravelly clay; over<br>• Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated) – between 0.2m and >15m bgl, comprising weak to moderately strong partly weathered white with occasional yellow staining chalk. Closely spaced fractures infilled with soft remoulded chalk fragments (Grade IV).<br>Groundwater was not encountered during the investigation or during subsequent monitoring. |

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| *GEOTECHNICAL CONCLUSIONS* | |
| Conclusions of geotechnical assessment | Obstructions associated with current development, including foundations, floor slabs and services, should be anticipated.<br>Excavation to proposed founding depth generally should be readily achievable with standard excavation plant.<br>Excavations during investigation were generally stable, although slight spalling should be expected from the Made Ground.<br>Water seepages into excavations are likely to be adequately controlled by sump pumping.<br>Deepening of foundations/heave protection is likely to be required to allow for the effects of trees.<br>Shallow soakaway drainage is considered unsuitable for this site. Further investigation recommended.<br>Design Sulfate Class - DS-1 and ACEC Class AC-2z. |
| *GEO-ENVIRONMENTAL CONCLUSIONS* | |
| Conclusions of contamination<br>Generic risk assessment | Human Health;<br>• Asbestos has been encountered in Made Ground and shallow natural soil at various locations across the site.<br>Plant growth:<br>• No significant risk identified.<br>Controlled Waters:<br>• No significant risk identified.<br>Ground gases or vapours:<br>• No significant risk identified.<br>Radon:<br>• The site is not in a Radon Affected Area. |
| Proposed mitigation measures | • Asbestos has been identified within the Made Ground and shallow natural soils at a number of locations across the site. Further site investigation comprising validation sampling and gravimetric analyses to refine the extent to which asbestos fibres are present is required as part of detailed design. Following this, a detailed risk assessment should be undertaken and an appropriate targeted mitigation solution designed. This is likely to entail removal of identifiable asbestos fragments and use of a clean cover capping solution in areas of and landscaping.<br>• Utilities should be placed within clean service corridors. Barrier pipe is considered necessary given the contaminants identified and history of the site.<br>• Management of areas of former explosives should be supervised as a precautionary measure during groundworks.<br>• A remediation method statement and construction environmental management plan should be prepared for the works.<br>• Regulatory agreement should be sought on the works and associated documents. |
| Waste management | Excavated soils to be disposed of as waste, are likely to be classed as non-hazardous. Further confirmatory testing should be carried out on any material that may need to be disposed to landfill. |
| *FUTURE CONSIDERATIONS* | |
| Further work | Following the ground investigation works undertaken to date, the following further works will be required:<br>• pre-demolition asbestos survey;<br>• further site investigation in areas that to date have not been accessible. Beneath building footprints etc; |

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| | • further site investigation during detailed design to delineate the extent of asbestos fibres within shallow soils;<br>• further investigation into the potential for dissolution features and natural chalk cavities beneath the site;<br>• further site investigation during detailed design to provide suitable parameters for foundation (including pile and ground improvement) design and soil characterisation;<br>• infiltration testing at various depths within the chalk formation across the extent of the Site to inform on site drainage strategies including the potential for deep borehole soakaways;<br>• further ground gas assessment;<br>• production of a formal Remediation Method Statement (RMS), detailing the remedial works considered necessary to break the identified potential pollutant linkages;<br>• further assessment and design of engineered cover systems where required as designs are finalised;<br>• foundation depth in relation to trees assessment, following a tree survey to BS 5837:2012;<br>• upon completion of development design, provision of a geotechnical design report for Category 2 structures;<br>• discussions with service providers regarding the materials suitable for pipework etc.;<br>• verification of the remedial works to allow regulatory sign off. |

This Executive Summary forms part of Hydrock Consultants Limited report number 19708-HYD-XX-XX-RP-GE-1000 and should not be used as a separate document.

# 1. INTRODUCTION

## 1.1 Terms of reference

In April 2021, Hydrock Consultants Limited (Hydrock) was commissioned by Carter Jonas on behalf of QinetiQ  (the Client) to undertake geo-environmental data review and assessment comprising a desk study review and assessment of existing historic ground investigation data for the QinetiQ site at Fort Halstead, Crow Drive, Sevenoaks, Kent TN14 7BS.

Hydrock understands that QinetiQ intend to submit a detailed planning application for the site comprising the erection of perimeter security fence,  erection of a new reception building, creation of new main site entrance along Crow Road, refurbishment of existing buildings including plant installation, creation of new surface level car parks and access, installation of two explosive magazine stores and surrounding pendine block walls, demolition of existing buildings, installation of 6no. storage containers, installation of new site utilities and arboricultural and ecological works.'

The works have been undertaken in accordance with Hydrock's proposal referenced (email from Paul Shelley to Jenna Murray of Carter Jonas on 6th April 2021).

## 1.2 Objectives

The objective of the appointed work is;

- to review existing ground investigation data produced by Hydrock and others to refine the conceptual model for the site;
- Generate a report evaluating the environmental risk at the site and support QinetiQ in their planning application.

## 1.3 Scope

The scope of this report is to collate historic data, isolate QinetiQ specific information and undertake ground investigation assessment to reflect the QinetiQ planning application.

## 1.4 Constraints

During the previous ground investigations, the operational nature of the site meant that there were a number of constraints to undertaking the investigation.  These included:

- access to operational areas, proximity around buildings and within buildings;
- the type of investigation methodology appropriate given programme, operational constraints and space limitations; and
- known or suspected services.
- Works have focused on geo-environmental assessment and only preliminary geotechnical parameters have been derived within the scope of the current appointment.  Further geotechnical assessment will be necessary in due course.

## 1.5 Available information

The following have been provided to Hydrock for use in the preparation of this report:

- Aspinwall. April 1999. 'DERA Fort Halstead, Land quality Assessment, Phase I Desk Study', Ref: 10469;

- Environmental Resources Management. July 2001. 'Project Lamb: Phase I Environmental Assessment: Fort Halstead, Kent' UK', Ref: 7923;
- Environmental Resources Management. July 2001. 'Project Lamb: Phase II Environmental Assessment: Fort Halstead, Kent, UK', Ref: 7923;
- Enviros Aspinwall. March 2002. 'DERA Fort Halstead Land Quality Assessment Phase II Site Investigation, Land Quality Assessment Report', Ref: 11469;
- Jacobs. September 2005. 'QinetiQ Fort Halstead, Documents Review and Intrusive Investigations', Ref: J23008G0;
- Waterman. February 2015. 'Data Review, Preliminary and Generic Environmental Risk Assessments', Ref: EED12715-100.R.1.9.1.KH;
- Waterman. February 2015. 'Outline Remediation Strategy', Ref: EED12715-100.S.1.4.1.KH;
- Hydrock, October 2016. 'Ground Investigation and Data Review', Ref: FHK-HYD-XX-GI-RP-G-2.2.1; and
- Hydrock, September 2019. 'Desk Study, Ground Investigation and Data assessment', Ref: 10730-HYD-XX-XX-RP-GE-1000.

## 1.6 Regulatory context and guidance

The investigation work has been carried out in general compliance with recognised best practice, including (but not limited to) BS 5930:2015 +A1:2020, BS 10175:2011+A2:2017 and the AGS (2006) 'Good Practice Guidelines for Site Investigations'.

The methods used follow a risk-based approach, the first stage of which is a Phase 1 desk study and field reconnaissance, with the potential geo-environmental risk assessed qualitatively using the 'source-pathway-receptor contaminant linkage' concept to assess risk as introduced in the Environmental Protection Act 1990 (EPA, 1990). Potential geotechnical risks are also assessed.

Phase 2 comprises intrusive ground investigation work and testing. The factual information from Phase 1 and Phase 2 are used to develop the Conceptual Model (CM). This CM is based on a ground model of the site physical conditions and an exposure model of the possible contaminant linkages. The CM forms the basis for Generic Quantitative Risk Assessment (GQRA) in accordance with current guidelines. This GQRA might lead to more Detailed Quantitative Risk Assessment (DQRA).

Professional judgement is then used to evaluate the findings of the risk assessments and to provide recommendations for the development.

The geotechnical section of this report is prepared in general accordance with BS EN 1997-1+A1: 2013, BS EN 1997-2:2007 and BS 8004:2015 +A1:2020. This report constitutes a Ground Investigation Report (GIR) as described in Part 2 of Eurocode 7 (BS EN 1997-2) (EC7). However, it is not intended to fulfil the requirements of a Geotechnical Design Report (GDR) as specified in EC7.

The geo-environmental and geotechnical aspects are discussed in separate sections. Throughout the report the term 'geotechnical' is used to describe aspects relating to the physical nature of the site (such as foundation requirements) and the term 'geo-environmental' is used to describe aspects relating to ground-related environmental issues (such as potential contamination). However, it should be appreciated that this is an integrated investigation and these two main aspects are inter-related. Designers should take all aspects of the investigation into account.

Remaining uncertainties and recommendations for further work are listed in Section 9 and Section 10.

Reference to the details of the approach and the methodologies adopted are provided in Appendix K.

# 2. PHASE 1 STUDY (DESK STUDY REVIEW)

## 2.1 Introduction

Hydrock has previously provided with a Desk Study for the wider Fort Halstead site (as detailed in Section 1).

Hydrock have undertaken a review of the existing desk study and this chapter assesses the QinetiQ site for potential geotechnical hazards, contaminant sources and receptors.

## 2.2 Site location

The site is located within the southern part of the wider Fort Halstead site on Crow Drive, Halstead, Sevenoaks, Kent. TN14 7BS.

A site location plan is presented in Appendix A.

## 2.3 Site description

The site currently is currently occupied by QinetiQ. QinetiQ provide scientific and technical research to the Ministry of Defence. Within the site there are a series of buildings used for the storage of higher risk explosives. Between the buildings are grassed areas with several mature trees. The area has its own gated access points

The current buildings appear to have used potentially asbestos containing building materials in their construction.

## 2.4 Site history

The wider Fort Halstead site has housed military research and development facilities since 1938 to the present day though structures associated with these facilities are not shown on OS Maps. Prior to its development the site was largely woodland and farmland.

## 2.5 Geology

The superficial geology comprises the Clay with Flints formation, which is recorded as orange-brown and red-brown sandy clay with abundant nodules and rounded pebbles of flint.

The solid geology comprises (undifferentiated) Lewes Nodular Chalk Formation comprising hard to very hard nodular chalks and hardgrounds with interbedded soft to medium hard chalks and marls. The Seaford Chalk Formation comprising firm white chalk with conspicuous semi-continuous nodular and tabular flint seams and Newhaven Chalk Formation comprising soft to medium hard, smooth white chalks with numerous marl seams and flint bands.

## 2.6 Hydrology and Hydrogeology

The Clay with flints formation is classed by the Environment Agency as unproductive strata with low permeability.

The Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated) is classed as a Principal aquifer with high fracture permeability, usually providing a high level of water storage and may support water supply/river base flow on a strategic scale.

There are no mapped watercourses within the site boundary. There are no active licensed surface water abstractions or discharges within 1km of the site. The site is not located within a groundwater Source Protection Zone (SPZ).

The desk study information indicates the proposed development is in Flood Zone 1 (with a low probability of flooding from rivers or the sea). No further consideration of flood risk is undertaken in this report. Specialist flood risk advice should be sought with regard to drainage and flooding.

## 2.7 Chalk quarries

Five historic chalk quarries exist within 500m of the wider Fort Halstead site boundary, an additional potential quarry has been identified outside of the site boundary. All quarries are no longer being worked.

With regard to the quarries, the BGS considers that "sporadic underground mining of restricted extent may have occurred. Potential for difficult ground conditions are unlikely and localised and are at a level where they need not be considered".

Hydrock considers it is unlikely that mine workings exist below the current study site.

## 2.8 Natural ground instability

The British Geological Survey (BGS) hazard rating for natural ground stability data sets at the site are presented in Table 2.1 below.

*Table 2.1: Natural Ground Subsidence Hazard Ratings*

| Ground Stability Hazard | Hazard Rating | Reference |
| --- | --- | --- |
| Ground Dissolution of Soluble Rocks | Moderate | Section 2.10 |
| Landslides | Low/Moderate | Section 2.11 |
| Shrink-Swell clays | Low | Section 2.12 |
| Collapsible Deposits | Very Low | No further consideration in Desk Study |
| Running Sands | Negligible | No further consideration in Desk Study |
| Compressible Deposits | Negligible | No further consideration in Desk Study |

## 2.9 Natural Chalk Cavities

### *Background*

The site is underlain at shallow depth by potentially soluble strata (Chalk), overlain by sandy clay (Clay-with-Flints Formation) with a deep groundwater table.

The environmental database report indicates a 'moderate' risk of soluble rocks, close to surface. The Chalk is noted as being at risk of the formation of voids by the dissolution of the chalk. Groundwater derived from rainwater is naturally slightly acidic from the presence of dissolved carbon dioxide, which forms carbonic acid.

Dissolution features can include voids, collapse sinkholes, and dissolution widened discontinuities in the chalk with dissolution pipes. Subsidence sinkholes are caused by overlying granular materials collapsing into the chalk dissolution features. These often originate by material at depth collapsing into a dissolution void, causing a void to migrate upwards to form a subsidence feature at the surface.

The presence of layers of dense or cemented materials or cohesive layers can prevent or restrict the void reaching the surface, but creating a potential for surface subsidence in the future when conditions change. The collapse of materials into voids can cause either voids, or loosened material which can extend in a zone surrounding the central core of the collapsed material. These features are illustrated in Figure 2.11 of CIRIA C574 which is reproduced as Figure 2.1 below:

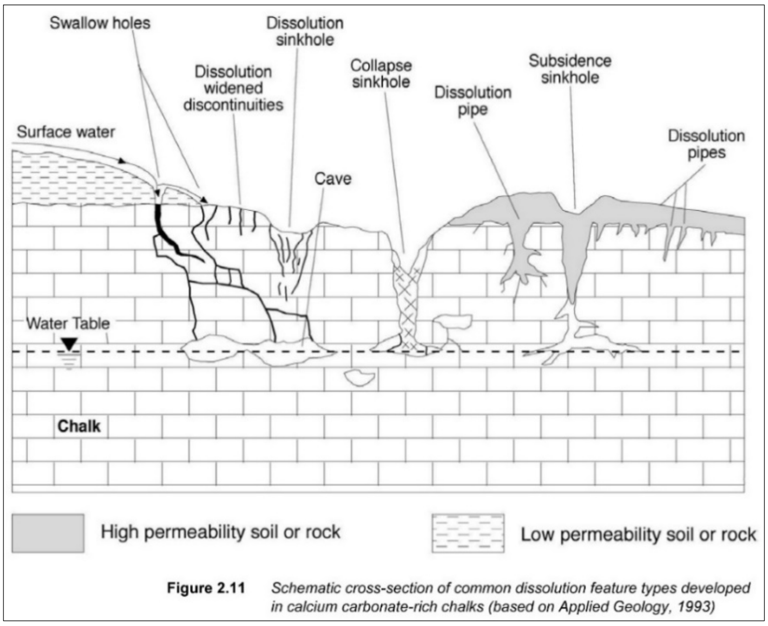


*Figure 2.1: Chalk Dissolution Features (from CIRIA C574 Engineering in Chalk)*

## 2.10 Dissolution of Soluble Rocks

There is documented evidence in the vicinity of the site of ground instability due to the collapse of voids within the gravels and Chalk. On this basis, further consideration of the risk posed by solution features will need to be taken into account at the ground investigation and construction phases.

## 2.11 Landslide Hazard

Records from the BGS database indicate that landslide features are present along the southern extent of the site boundary at the base of existing Chalk Formation slopes. The hazard rating assigned to these features is generally ‘low’ with some features assigned a hazard rating of ‘moderate’ to the east of the northern finger of the site.

The BGS considers that where a moderate hazard is present there may be ‘significant potential for slope instability with relatively small changes in ground conditions’ in some areas.

Further consideration of the risk posed by landslide features will need to be taken into account at the ground investigation, geotechnical design and construction phases.

## 2.12 Shrink – Swell Potential

The Clay-with-Flints Formation is noted by the BGS as having a low potential for shrinking or swelling of clays with ground conditions comprising predominantly medium plasticity soils. Although the hazard potential of shrink-swell on site is noted by the BGS as low, based on experience, Hydrock consider the risk of shrink-swell in the presence of vegetation to be moderate to high and further consideration of shrink-swell potential will need to be taken into account during the design and construction phases.

## 2.13 Waste management

There are no historical waste management sites recorded within 250m of the site. Previous reports note a number of onsite waste management facilities within the wider Fort Halstead site which are not registered in the Environment Agency database.

## 2.14 Regulatory Consultation

Information in the GroundSure Report, relating to various regulatory controls has been reviewed, with a summary presented below in Table 2.2.

*Table 2.2: Regulatory information within 200m of the wider Fort Halstead site boundary*

| Regulatory Data | Distance from Site | Details | Potential Risk | Comment |
|---|---|---|---|---|
| RAS Licence (3 or 4) | Onsite | Ministry of Defence - Disposal of Radioactive Waste 13/5/1994 – Superseded by Variation (Permission Number - BB3786, AY5701, AM5785) | Yes | Radioactive substance |
| | Onsite | Ministry of Defence - Keeping and Use of Radioactive Materials. 21/5/1997 – Effective (Permission Number, AY1480) | Yes | Radioactive substance |
| | Onsite | QinetiQ Ltd - Disposal of Radioactive Waste 13/2/2006– Effective (Permission Number, CA0417) | Yes | Radioactive substance |
| Discharge Consents | Onsite | DSTL - Treated Effluent received by Groundwater via Soakaway 10/02/2009 to present. Permit Number: NPSWQD006490. | Yes | Due to nature of previous land use. |
| | 35m North | DSTL - Treated Effluent received by Groundwater via Soakaway 02/02/2009 to present. Permit Number: NPSWQD006491. | Yes | Due to nature of previous land use. |
| | 94m north, 96m north | 7 Hotel Diner, London Road,<br>Polhill Final - Treated Effluent received by Groundwater via Soakaway 12/05/2010 to present. Permit Number: EPRBP3520XW | No | Due to being down gradient of the site. |
| Pollution Incidents | 41m north west | 16 July 2003, tyres. Category 3 – minor incident (Land Impact only). | No | Due to the Category 3 classification of the incident. |
| | 99m southeast | 15 April 2002, general biodegradable. Category 3 – minor incident. | No | Due to the Category 3 classification of the incident. |
| | 109m north | 16 March 2003, tyres. Category 3 – minor incident (Land Impact only). | No | Due to the Category 3 classification of the incident. |
| | 111m north | 13 December 2002, tyres. Category 3 – minor incident (Land Impact only). | No | Due to the Category 3 classification of the incident. |

## 2.15 Evidence of historical contamination

A number of potentially contaminative historic land uses are identified in the Groundsure Report. Within the wider Fort Halstead site boundary there are plant nurseries, a number of buried tanks and potentially infilled land (Made Ground). In addition, explosive and radioactive materials have been stored and used at the site.

Outside of the site boundary chalk quarries (see Section 2.9) and associated kilns, ground workings, cuttings and the railway line, tunnel and embankments and cuttings associated with these features are also potentially contaminative.

## 2.16 Radon

The radon risk is reported in the environmental data. This indicates that the site is not in a Radon Affected Area and no radon protection measures are required.

## 2.17 Suitability of previous data

Data from the historical site investigation reports detailed in Section 1.5 have been taken into account during the preparation of this report where considered to be relevant or appropriate. The section below provides comment as to the applicability of the various data available.

*Geological data*

The geological data from historical works is consistent with the anticipated ground conditions from BGS sources. As the site conditions during all investigations are similar to each other Hydrock consider the geological data is suitable for use and has been utilised in this report.

*Chemical test data*

The 2001 to 2005 data sets will be subject to the limitations in the analytical methodologies of the time (with some testing methods no longer best practice and having been superseded with more accurate methodologies) and the data may be considered less reliable than that achieved via current day techniques. However, it is Hydrock's opinion that the chemical test data do have value as an indicator of expected contamination distributions and, together with other previously acquired information, will help to characterise the site and act as an aid to directing the additional investigations required. Hydrock has utilised the historic soils data during this assessment. However, it is recognised that additional supplementary investigation is required to confirm historical data and delineation will be required during any potential remediation works.

The most recent investigations on the site contains chemical test data that is MCERTS accredited. It is Hydrock's opinion that the chemical test data for soil from historical report(s) are able to be used as part of the current assessment.

*Ground gas data*

There are four rounds of reliable gas data available for the site, one round recorded during the 2016 Hydrock investigation and three rounds during the 2018 Hydrock investigation. This reliable data (Hydrock, 2016 & 2018), has been used as part of the assessment. However, data deemed to be unreliable has not be used in this report.

*Geotechnical data*

Whilst the available geotechnical information is sparse, it will not become out of date and is still relevant as a guide to physical ground conditions.  However, significant supplementary investigations will be required as related to the new development proposals.

# 3. OUTLINE CONCEPTUAL MODEL

## 3.1 Introduction

The outline Conceptual Model (oCM) incorporates evidence from the site walkover, the Desk Study and previous investigations carried out at the site. The formulation of an outline Conceptual Model is a key component of the LCRM methodology. The oCM incorporates a ground model of the site physical conditions and an exposure model of the possible contaminant linkages; it forms the basis for Generic Quantitative Risk Assessment (GQRA) in accordance with current guidelines.

## 3.2 Ground model

The preliminary ground model presented in Section 2 provides an understanding of the ground conditions and is the basis for preparing the preliminary geotechnical hazard assessment (Section 3.3) and the preliminary geo-environmental exposure model (Section 3.4).

## 3.3 Geotechnical hazard identification

### *3.3.1 Context*

The preliminary geotechnical hazard identification has been undertaken in accordance with the general requirements of ICE/DETR Document 'Managing Geotechnical Risk' and the HE documents HD 41/15 and CD 622.

The following section sets out the identified geotechnical hazards and the development elements potentially affected (see Table I.1 in Appendix I for further information).

### *3.3.2 Plausible geotechnical hazards*

Plausible geotechnical hazards identified at the site are:

- Uncontrolled Made Ground (variable strength and compressibility).
- Soft / loose compressible ground (low strength and high settlement potential).
- Shrinkage / swelling of the clay fraction of soils under the influence of vegetation.
- Variable lateral and vertical changes in ground conditions.
- Attack of buried concrete by aggressive ground conditions.
- Obstructions.
- Existing below ground structures to remain
- Solution features in Chalk.
- Cavities in the superficial deposits, due to solution features.

### *3.3.3 Potential development elements affected*

Development elements potentially affected by geotechnical hazards are:

- Buildings – foundations.
- Buildings – floor Slabs
- Roads and pavements.
- Services.

- General slopes.
- Retaining walls.
- Gardens.
- Construction staff, vehicles and plant operators.
- Concrete below ground.

Health and safety risks to site Contractors and maintenance workers have not been assessed during these works and will need to be considered separately during design.

The above plausible geotechnical hazards and development elements affected have been carried forward for investigation and assessment. The investigation is presented in Section 5 and the assessment is presented in Section 7.

## 3.4 Geo-environmental exposure model

### *3.4.1 Context*

The preliminary exposure model is used to identify geo-environmental hazards and to establish potential pollution linkages, based on the source-pathway-receptor (SPR) approach.

A viable pollution linkage requires all the components of an SPR to be present. If only one or two are present, there is no linkage and no further assessment is required.

### *3.4.2 Potential contaminants*

For the purpose of this assessment the potential contaminants have been separated according to whether they are likely to have originated from an on-site or off-site source.

*Potential on-site sources of contamination*

- Made Ground, associated with historical construction activities and imported fill, possibly including elevated concentrations of metals, metalloids, asbestos fibres, Asbestos Containing Materials, PAH and petroleum hydrocarbons (S01).
- Made Ground, potentially containing asbestos fibres and Asbestos Containing Materials from demolition of former structures and redevelopment (S02).
- Explosive's residue. (S03).
- Residual contamination from sewage in the settlement beds that were historically present in the lower northern part of the site, potentially containing elevated metals, detergents, inorganic and organic contaminants and possibly (although unlikely) pathogenic contaminants such as faecal coliforms (S04).
- Ground gases (carbon dioxide and methane) from organic materials in the Made Ground (S05).
- Asbestos within existing buildings (S06).

*Potential off-site sources of contamination*

- Made Ground, associated with historical construction activities and imported fill, possibly including elevated concentrations of metals, metalloids, asbestos fibres, Asbestos Containing Materials, PAH and petroleum hydrocarbons (S07).

- Made Ground, potentially containing asbestos fibres and Asbestos Containing Materials from demolition of former farm structures (S08).
- Explosive's residue. (S09).
- Residue from radioactive storage (S10)
- Residual contamination from sewage in the settlement beds that were historically present in the lower northern part of the site, potentially containing elevated metals, detergents, inorganic and organic contaminants and possibly (although unlikely) pathogenic contaminants such as faecal coliforms (S11).
- PCBs and oils from transformers in the electricity sub-station on site (S12).
- Ground gases (carbon dioxide and methane) from organic materials in the Made Ground (S13).
- Asbestos within existing buildings (S14).

### *3.4.3 Potential receptors*

The following potential receptors in relation to the proposed land use have been identified.

- People (neighbours, site end users, construction workers) (R01).
- Development end use (buildings, utilities and landscaping) (R02).

### *3.4.4 Potential pathways*

The following potential pathways have been identified.

- Ingestion, skin contact, inhalation of dust and outdoor air by people (P01).
- Methane ingress via permeable soils and/or construction gaps (P02).
- VOC and petroleum hydrocarbon vapour ingress via permeable soils and/or construction gaps (P03).
- Root uptake by plant (P04).

Health and safety risks to site development contractors and maintenance workers have not been assessed as part of this study and will need to be considered separately.

The above sources, pathways and receptors have been considered as part of the Preliminary Risk Assessment in accordance with LCRM (2019), are considered to be plausible in the context of this site and have been carried forward for investigation and assessment. The investigation is presented in Section 5 and the assessment is presented in Section 7. An assessment of the Source – Pathway – Receptor linkages is undertaken following the assessment (Section 7) and is presented in Appendix J (Table J.1).

# 4. HISTORICAL GROUND INVESTIGATIONS

## 4.1 Historical Investigations

Historical Ground Investigations undertaken by Enviros Aspinwall (2002) and Jacobs (2005) are detailed in Table 4.1. Locations are shown on drawing 19708-HYD-QQ-ZZ-DR-GE-1002 presented in Appendix A.

*Table 4.1: QinetiQ Area Historical Ground Investigation Details*

| Activity | Method | No. | Max. Depth (m bgl) | Purpose |
|---|---|---|---|---|
| *Enviros Aspinwall (2002) Phase 2 Site Investigation and Land Quality Assessment* | | | | |
| Window Sampling | Window sampler rig | 26 | 6.0 | To assess shallow ground conditions whilst minimising ground disturbance. |
| Trial Pits | Machine Excavated | 5 | 4.0 | To assess shallow ground conditions. |
| *Jacobs (2005) Document Review and Intrusive Investigations Report* | | | | |
| Window Sampling | Window sampler rig | 4 | 5.0 | To assess shallow ground conditions whilst minimising ground disturbance. |
| Hand dug pits | Hand tools | 8 | 1.2 | To assess shallow ground conditions. |

Hydrock completed ground investigations in 2016 and 2018. These are detailed in Table 4.2.

*Table 4.2: Hydrock 2016/2018 Ground Investigation Summary and Rationale*

| Activity | Method | No. | Max. Depth (m bgl) | Purpose | Notes |
|---|---|---|---|---|---|
| Cable Percussive Boreholes | Shell and Auger | 1 | 15 | To assess shallow and deeper ground conditions.<br>To allow collection of samples for contamination testing.<br>In-situ geotechnical testing | Groundwater and ground gas monitoring well installed to 15m bgl. |
| Window Sampling | Window sampler rig | 18 | 5.0 | To assess shallow ground conditions.<br>To allow collection of samples for contamination testing.<br>To allow dynamic probing for strength profiling of soils. | These positions were designed to target the following:<br>• Potential asbestos rubble<br>• Heating oil and solvent stores<br>• Solvent storage<br>• Pink water area<br>• Explosive testing/firing areas<br>Screening of soils with a photo ionising detector (PID) to |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | identify volatile organic compounds (VOC) and semi volatile organic compounds (SVOC) undertaken. |
| Trial Pits | JCB 3CX | 8 | 3.1 | To assess shallow ground conditions.<br>To allow collection of samples for contamination testing. | These positions were designed to target the following:<br>• area of burnt out cars<br>• chemical storage and waste tanks<br>• Downs range<br>Screening of soils with a PID to identify VOCs and SVOCs.<br>Infiltration testing was carried out within TP601. |

The logs from the Hydrock investigations, including details of ground conditions, soil sampling and in situ testing are presented in Appendix B.

## 4.2 Geo-environmental testing

### *4.2.1 Sampling strategy and protocols*

Exploratory hole positions were determined by reference to the site conditions and uncertainties identified in the Initial Conceptual Model.

Certain specific features were targeted for specific investigation, but a reasonably even spacing was used for the remainder of the site.

### *4.2.2 Geo-environmental monitoring*

Hydrock has undertaken four ground gas monitoring rounds across the wider Fort Halstead site. The first round as part of the 2016 investigation and 3 further rounds as part of the 2018 investigation. The results are presented in Appendix G.

### *4.2.3 Geo-environmental laboratory analyses*

The chemical test certificates for testing undertaken by Hydrock are provided in Appendix G. This includes test results from outside of the QinetiQ site as the data assessed in this report is gathered from ground investigations including the wider Fort Halstead site.

Where considered suitable other historic chemical test results have also been used as part of the assessment.

Wherever possible, UKAS and MCERTS accredited procedures have been used.

The geo-environmental analyses undertaken on soils from all investigations to date, are summarised in Table 4.3.

*Table 4.3: Summary of Sample Numbers for Geo-environmental Analyses of Soils*

| Determinand Suite | Made Ground | Natural Soils |
|---|---|---|
| Metals suite of determinands for solids | 36 | 32 |
| Polyaromatic hydrocarbon suite for solids | 26 | 19 |
| Total petroleum hydrocarbons by GC-FID (Hydrock Level 2 suite) | 8 | 12 |

| | | |
|---|---|---|
| Petroleum hydrocarbon suite (C12-C35) | 10 | 3 |
| Benzene, toluene, ethylbenzene and xylene (BTEX) by GC-MS ) | 26 | 19 |

# 5. GROUND INVESTIGATION RECORDS AND DATA

## 5.1 Physical ground conditions

### *5.1.1 Summary of Ground Conditions Encountered*

The following presents a summary of the ground conditions encountered during the Hydrock ground investigations. These observations, in general, concur with the Historical ground investigations.

*Table 5.1: Summary of Ground Conditions*

| Stratum | Brief Description | Depth to Top (m bgl) | Depth to Base (m bgl) |
|---|---|---|---|
| Topsoil | Brown sandy gravelly clayey TOPSOIL. Gravel of fine to coarse angular to sub rounded flint, brick and concrete. | 0.0 | 0.2 |
| Made Ground 1 | Loosely packed black brown slightly clayey GRAVEL. Gravel of fine to coarse angular to sub rounded brick, concrete, ash and flint. | 0.7 | 1.8 |
| Made Ground 2 | Firm light brown sandy gravelly CLAY. Gravel of fine to coarse angular to sub rounded brick, concrete and flint. | 0.1 | 0.8 |
| Clay-with-Flints | Firm to stiff red brown mottled orange brown sandy gravelly CLAY. Gravel of fine to coarse angular to sub rounded flint with frequent flint cobbles. | 0.4 | >5.0 |
| Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated) | Weak to moderately strong partly weathered white with occasional yellow staining CHALK. Closely spaced fractures infilled with soft remoulded chalk fragments (Grade IV). | 0.2 | >15 |

## 5.2 Groundwater

Groundwater was not encountered in any investigation locations.

## 5.3 Surface coverings

Surface material of asphalt or concrete was noted to a maximum depth of 0.4m bgl in ungrassed areas.

## 5.4 Obstructions

A number of trial pits and boreholes across the site, encountered large flint cobbles that hindered progress.

There are several large structures including office buildings and laboratories within this area. No investigation was possible beneath these building footprints. There are also a number of demolished buildings within the area.

## 5.5 Geotechnical Data

Due to a limited amount of geotechnical data available from the historic and previous Hydrock investigations which primarily targeted environmental issues the following section combines geotechnical data from across the wider Fort Halstead site. Hydrock consider this appropriate as ground conditions across the wider site were homogenous. Further investigation will be required to inform detailed design.

### *5.5.1 Topsoil*

For the purposes of this report, topsoil is defined as the upper layer of an in situ soil profile, usually darker in colour and more fertile than the layer below (subsoil), and which is a product of natural chemical, physical, biological and environmental processes, but does not imply compliance with BS 3882:2015.

### *5.5.2 Made Ground*

Made Ground across the site is inherently variable and as such representative values of geotechnical properties are impracticable to determine. On this basis, the only laboratory geotechnical testing that has been undertaken on it is sulfate and aggressive chemical environment classification for buried concrete (BRE SD-1 suite).

### *5.5.3 Clay-with-Flints*

Clay-with-Flints was encountered underlying the Made Ground and/or Topsoil across the whole site. The majority of the exploratory holes were terminated within these materials at depths ranging from 0.50m to 12.4m bgl.

Natural moisture contents in the fine units of these materials range from 10% to 44%, and modified plasticity indices range from 9% to 79%. On this basis, these soils are classified as of low to extremely high plasticity (CL to CE soils) and of low to high volume change potential. For the purposes of design, it is recommended that a high volume change potential be assumed.

Particle size distribution tests were undertaken on samples of the Clay-with-Flints where a considerable gravel component had been noted during the fieldwork. The results indicate that these materials comprise 23 - 92% silt and clay, 1 - 69% sand: 0 - 62% gravel and 0 – 46% cobbles and boulders. These results were in line with the site engineer's descriptions.

Undrained shear strength parameters of the cohesive units of these materials based on in situ testing are presented in Table 5.2.

*Table 5.2: Soil Strength Results and Derived Values*

| Stratum | Shear Strength (Range) | Method | No. of Results |
|---|---|---|---|
| | cu (kPa) | | |
| Clay-with-Flints | 70 - 140 | In situ hand shear vane | 26 |

### 5.5.4 *Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated)*

The Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated) was encountered underlying the Made Ground/Topsoil or the Clay-with-Flints (where fully penetrated), at depths ranging from 0.05m to 12.40m bgl. No notable pattern for the depth to the chalk was identified. However, this type of variation is not uncommon. The chalk was identified to a depth of 15m bgl where the deepest boreholes were terminated.

The cable percussive drilling recovered the chalk as gravel due the drilling method. The chalk generally consisted of a weathered upper horizon, CIRIA weathering Grade Dc. This generally became more competent with depth, CIRIA weathering Grade C.

SPT N-values within these materials range from 3 to 50, generally increasing with depth, averaging between 15 to 25.

The techniques employed were reflective of this and were not suitable to provide a full characterisation of the Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated).

## 5.6 Infiltration tests

The results of the infiltration testing undertaken are summarised in Table 5.1.

Testing was carried out in accordance with Hydrock's 1-day assessment methodology). This is in general accordance with BRE Digest 365 (BRE DG 2016) where infiltration rates allow three test runs during a working day (or where there is no infiltration), but where low infiltration rates were encountered the available time may not have been sufficient to fully comply with the BRE test method.

*Table 5.1: Infiltration test results*

| Stratum | Trial Pit no. | Depth to base of pit (m bgl) | Infiltration rate (m/s) | | | |
|---|---|---|---|---|---|---|
| | | | Run 1 | Run 2 | Run 3 | Range |
| Chalk Formation | TP601 | 2.50 | Failed test. No infiltration. | | | - |

*Where less than three tests were possible in a particular location the results provided should be considered indicative only and should not be used for design purposes. If infiltration is critical to the development of the site, multi-day infiltration testing should be undertaken.

## 5.7 California Bearing Ratio (CBR)

CBR results within the Clay-with-Flints and the chalk formation are summarised in Table 5.4.

*Table 5.2: CBR Results and Derived Values*

| Stratum | Method | No. Tests | CBR (%) (Range) |
|---|---|---|---|
| Clay-with-Flints | Laboratory remoulded sample | 20 | 0.4 - 14 |
| Chalk Formation | Laboratory remoulded sample | 2 | 0.1 – 9.6 |

## 5.8 Sulfate Content

In accordance with BRE (Special Digest 1), the Design Sulfate (DS) classification and the Aggressive Chemical Environment for Concrete (ACEC) classification are presented in Table 5.5. The assessment summary sheets presented in Appendix E.

*Table 5.5: Aggressive Chemical Environment Concrete Classification*

| Stratum | No. Tests | DS | ACEC |
|---|---|---|---|
| Made Ground | 12 | DS-3 | AC-2s |
| Clay-with-Flints | 37 | DS-1 | AC-2z |
| Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated). | 11 | DS-1 | AC-1 |

## 5.9 Groundwater

Groundwater was not encountered during the ground investigations. It is anticipated to be at approximately 90m bgl.

# 6. GEOTECHNICAL ASSESSMENT

Due to a limited amount of geotechnical data available from the historic and previous Hydrock investigations which primarily targeted environmental issues the following section combines geotechnical data from across the wider Fort Halstead site. Hydrock consider this appropriate as ground conditions across the wider site were homogenous. Further investigation will be required to inform detailed design.

It should be noted that desk study identified the potential for natural chalk cavities beneath the site and although a full investigation into dissolution features is outside the scope of this report it is recommended that this is investigated further to fully understand any potential risks to future development.

## 6.1 Geotechnical categorization of the proposed development

Eurocode 7, Section 2 advocates the use of geotechnical categorization of any proposed structures to establish the design requirements. Whilst Hydrock has no information on the proposed structures they are likely to be classed as Geotechnical Category 1 and 2. A Geotechnical Design Report is required for Geotechnical Category 2 structures to finalise designs and measurements of movements of selected points on the structure may be needed.

## 6.2 Groundwork

### *6.2.1 Site preparation*

Prior to the start of the development phase, site preparation works are required. The site is currently occupied by a wide range of buildings and structures including office buildings, boiler houses, warehouses and buildings designed for storage of explosives. There are large areas of hardstanding much of which is anticipated to be a significant thickness of concrete. The explosives storage buildings are also expected to contain significant volumes of concrete. There is also associated infrastructure and underground services. These features will need clearing before development can commence.

### *6.2.2 Groundworks*

Following breaking out of hardstanding and/or obstructions, excavation of shallow soils generally should be feasible by conventional plant and equipment. However, excavation through any buried construction is likely to require heavy-duty excavation and/or the use of specialist breaking equipment.

A risk assessment of the stability of any open excavation should be undertaken by a competent person and appropriate measures adopted to ensure safe working practise in and around open excavations. Further guidance on responsibilities and requirements for working near, and in, excavations can be obtained from the Construction Design and Management Regulations (2015).

Earthworks are anticipated, an earthworks specification will be necessary to ensure the appropriate management and reuse of the existing soils. Once site proposals have been further defined, more specific consideration will need to be given to the reuse of materials and whether an earthworks specification is required. The earthworks may need to be undertaken under a Materials Management

A risk assessment of the stability of any open excavation should be undertaken by a competent person and appropriate measures adopted to ensure safe working practise in and around open excavations. Further guidance on responsibilities and requirements for working near, and in, excavations can be obtained from the Construction Design and Management Regulations (2015); Construction Information Sheet 47: Inspections and Reports (2005) and HSG47: Avoiding Danger from Underground Services.

To ensure no loads are imposed on the sides of the excavation, spoil should not be placed immediately adjacent to the excavation. Spoil should be placed a suitable distance from the side of the excavation (as assessed by a competent person).

### *6.2.3 Earthworks/reuse of site-won materials*

Spoil resulting from excavations within the Made Ground and natural soils may be suitable for reuse as general fill subject to further testing and specification. However, the Made Ground will not be a suitable as a founding stratum, due to its variable nature.

Where it is proposed to reuse site won materials as an engineered fill, it will be necessary to develop an appropriate Site Specific Earthworks Specification as part of the contract documentation. The basis for the Specification should be BS 6031:2009 and the latest version of the SHW, Series 600 Earthworks.

## 6.3 Foundations

Detailed engineering design has not been finalised for the proposed buildings and development. However, an indication of development proposals for the different areas of the site is outlined in earlier sections of this report. Once a final design with finished floor levels and loadings are available, a more detailed appraisal should be undertaken beginning with further site investigation and geotechnical testing to fully characterise the ground conditions. However, based on the available data, it is anticipated that strip/trench fill or pad foundations will be suitable for many of the proposed structures. For heavily loaded commercial structures, piling may be required.

Where deep Made Ground is encountered consideration should be given to piling or ground improvement, dependent on the form of development and required allowable bearing capacity.

The Clay-with Flints soils are of low to high volume change potential, but for design purposes it is recommended that high volume change conditions be assumed across the site.

Trees are noted across the site, although they are of unknown size, species or maturity. Structures (residential or commercial/industrial) constructed within influencing distance of these trees (whether on- or off-site and whether to remain or be removed), should be constructed in accordance with NHBC Standards or (for non-residential buildings) the recommendations of BRE Digest 240 (BRE 1980).

On the basis of the above, minimum founding depths are likely to range from 1.0m bgl to >2.5m bgl. Foundations that are carried deep to allow for the influence of trees may be stepped up, in accordance with the requirements of EC7, BS EN 1997 as long as a suitable founding stratum is present at shallower depth.

If trees are to be removed, the roots should be grubbed out and foundations extended to below the zone of disturbance created by this activity.

The indicative allowable bearing pressures for foundations take into consideration the risk of shear failure of the ground (ultimate limit state) and acceptable limits of settlement (serviceability limit state).

The preliminary foundation designs in this section are based on the parameters given in previous section of this report. Recommendations for Geotechnical Category 2 structures (according to EC7, BS EN 1997) are presented to aid development proposals only. However, selection of geotechnical design parameters should be undertaken in conjunction with the design process and discussed in a separate Geotechnical Design Report.

Foundations which span founding materials of different stiffness (e.g Clay-with-Flints and Chalk) should have mesh reinforcement placed at the top and bottom.

The depth of foundations should be designed, and the formations inspected by, a Geotechnical Engineer. Any sub-formation materials deemed as unsuitable such as soft or loose zones should be excavated and replaced with well compacted suitable granular fill or lean mix concrete.

Foundation excavations, particularly those in Chalk, should be protected from water and inclement weather including frost and any water should be removed by pumping from a sump in the base of the excavation.

The following recommendations are preliminary and further investigation and testing will be required before final recommendations can be made.

### *6.3.1 Strip or Trench Fill Foundations*

Traditional strip or trench fill foundations are considered suitable for low rise (up to 2.5 storey) residential properties and may, dependent on the form of construction and required bearing capacities, be suitable for low rise commercial/industrial buildings.

Where Chalk is encountered at founding level, based on CIRIA Report C574 (Lord et al 2002), as a guide, an allowable net bearing capacity of 125kN/m2 is likely to be available for a strip or trench fill foundation bearing on the natural Grade Dm and above Chalk. This value should result in total settlements of not more than 20mm for foundations up to 1m wide, keeping differential settlements within acceptable limits.

Where Clay-with–Flints is encountered at founding level, as a guide, an allowable net bearing pressure of 125kN/m2 should be available for a strip or trench fill foundation bearing at least 300mm into the founding stratum. This value should result in total settlements of not more than 20mm for foundations up to 1m wide, keeping differential settlements within acceptable limits.

Residential foundations in excess of 2.5m depth should be designed by an Engineer in accordance with the requirements of NHBC Standards.

Excavation of trench fill foundations to depths in excess of 2.5m bgl is unlikely to be economical and may be impracticable to undertake. Care should be taken to ensure the verticality of deep, narrow foundations to prevent eccentric loading.

Should enlarging the foundations be considered (for example because loads are such that the quoted bearing pressure is inadequate based on the size of foundation identified) this will probably lead to increased settlements and the above recommendations should be reviewed.

### *6.3.2 Pad Foundations*

Pad foundations are considered an appropriate solution for the commercial/industrial buildings, dependent on the form of construction and required bearing capacities.

Where Chalk is encountered at founding level, based on CIRIA Report C574 (Lord et al 2002), as a guide, an allowable net bearing capacity of 150kN/m2 is likely to be available for a pad foundation up to 3m square, bearing on the natural Grade Dm and above Chalk. This value should result in total settlements of not more than 25mm, keeping differential settlements within acceptable limits.

Where Clay-with–Flints is encountered at founding level, as a guide, an allowable net bearing pressure of 150kN/m2 is likely to be available for a pad foundation up to 3m square, bearing on the natural Grade Dm and above Chalk. This value should result in total settlements of not more than 25mm, keeping differential settlements within acceptable limits.

Should enlarging the foundations be considered (for example because loads are such that the quoted bearing pressure is inadequate based on the size of foundation identified) this will probably lead to increased settlements and the above recommendations should be reviewed.

### *6.3.3 Piled Foundations*

Where the soils at traditional founding depths are inadequate to provide suitable bearing capacity for the proposed development (such as in the areas of boreholes BH514, 525 and 538A) or where residential foundations (designed in accordance with NHBC Standards) exceed 2.5m, piled foundations should be considered.

Bored piles with the use of casing or CFA piles should be suitable for this site. However, the choice of piling system and detailed design of piles are beyond the scope of this report and should be undertaken by the specialist piling contractor taking into account the following considerations.

- Obstructions in the ground, such as old foundations can cause piles to stop at shallower than design depth, or deviate from the vertical, thereby reducing their capacity. Where penetration to design depth is not possible, the obstructions should be removed, or if this is not practicable, the column layout redesigned to allow foundations to span/cantilever between piles.

- Pile, and in particular bored pile, installation can create preferential pathways for the migration of contaminants to the groundwater.

- Piles should extend a minimum of five pile diameters into the bearing stratum to fully mobilise end-bearing resistance.

- The potential effects of negative skin friction on piles.

- Care should be taken for bored and cast in situ piles taken through the Made Ground where collapse of the pile shaft or running sand conditions could lead to ‘necking’ of the pile.

Piles in Chalk should be designed adopting the parameters and recommendations provided in earlier sections of this report and CIRIA C574 (Lord et al 2002).

### *6.3.4 Ground Improvement*

As an alternative to piling, deep Made Ground may be treated in situ to improve its bearing characteristics to allow shallow foundations to be constructed.

Treatment by vibroreplacement (stone columns) at suitable spacing (to be determined by a specialist contractor) should lead to significant improvement of the soils by the creation of stone columns. Full depth treatment of the Made Ground will be required and pre-boring may be required locally at least to ensure penetration through the denser Made Ground, or to penetrate, push aside or break up, obstructions. Where penetration to full depth is not possible, the obstructions should be removed, or if this is not practicable, the column layout redesigned to allow foundations to span/cantilever over the untreated area.

Following treatment, an allowable net bearing pressure of 125kN/m2 should be available for a ring beam or semi-raft foundation. Confirmation of this allowable net bearing pressure should be confirmed by in situ maintained load testing.

Different VSC contractors use different methods of emplacing the stone columns and it would be prudent to ensure that the method deployed ensures that the soils surrounding the stone columns are given a high level of compaction from horizontal vibrations by the vibrating poker.

Foundations laid on soil reinforced with stone columns are still susceptible to clay volume change and should be designed accordingly where they are within the zone of influence of existing or proposed trees.

Unlike piles, stone columns will not affect consolidation settlement due to the ground level raising. They may, however, shorten the consolidation period by shortening the seepage paths.

#### *6.3.5 Heave Protection*

Deepening of foundations in accordance with NHBC Standards/BRE 298 will be required where foundations are within the zone of influence of existing, removed or proposed trees and proposed shrub planting. For existing (and any known removed) trees this will require a tree survey to be undertaken by an arboriculturist in accordance with BS 5873:2012 which must include off-site trees that could have an effect on foundation design, in addition to trees on site. Where foundations are within the influence of trees and are deeper than 1.5m bgl, a suitable compressible material or void former will be required.

Where piled foundations are constructed on clay soils within the influencing distance of trees including proposed planting, the upper section of the pile (to the recommended minimum founding depth) should be sleeved or overbored to allow for clay volume change.

### 6.4 Drainage

Infiltration testing was carried out at one location and has indicated that shallow drainage systems are unlikely to be suitable at the site. Further investigation and assessment of infiltration rates at various depths including deep borehole soakaways should be considered.

### 6.5 Roads and Pavements

At the time of writing, the final profile of the development is unknown and it is not possible to provide a definitive CBR value for the purpose of pavement design. The CBR achieved will be a function of the material handling and the placement methodology employed during any earthworks. It is recommended that when the formation level is reached, in situ testing should be undertaken to inform the final design.

Proof rolling of the formation level will be required, followed by the removal of any loose or soft spots and replacement with an engineered fill, in accordance with a suitable specification. The formation level will also need to be protected during inclement weather from deterioration. All slopes should be trimmed to falls to shed rainwater and the surface sealed to limit infiltration.

## 6.6 Buried Concrete

Based on guidelines provided in BRE Special Digest 1 (BRE 2005), as a preliminary guide the Clay-with-Flints can be classified as Design Sulfate Class DS-1 and ACEC Class AC-2z. Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated). can be classified as Design Sulfate Class of DS-1 and ACEC Class AC-1.

# 7. GEO-ENVIRONMENTAL ASSESSMENT

## 7.1 Updated conceptual model

### *7.1.1 Updated exposure model*

Following review of the ground investigation, the plausible contaminant sources, receptors and pathways identified in the preliminary geo-environmental exposure model (Section 3), have been updated or confirmed as follows.

*Sources*

No potential sources have been removed from, or added to, the exposure model.

*Receptors*

No potential receptors have been removed from, or added to, the exposure model.

*Pathways*

No pathways have been removed from, or added to, the exposure model.

Using the updated ground model and updated exposure model, generic risk assessment is undertaken as presented below.

## 7.2 Risk assessment approach

Generic risk assessments have been undertaken in accordance with the principles of LCRM (Environment Agency, 2019) using the CM that has been updated following the ground investigation.

Firstly, the risks associated with the identified potential contaminant linkages have been estimated using standardised methods (typically involving comparison of site data with published 'screening values'). Secondly, where screening values are exceeded, the result has been evaluated in an authoritative review of the findings with other pertinent information to determine whether or not the exceedance is, or is not acceptable in the site-specific circumstances. Further explanation is presented in Appendix K.

The data sets used in the assessment comprise the analytical results obtained by Hydrock as listed in Section 4 together with any reliable data from previous investigations as listed in Section 1.

In cases where unacceptable risks are indicated, actions such as more advanced stages of risk assessment or remediation are proposed in Section 7.7.

## 7.3 Human health risk assessment

This is a Tier 2 assessment using soil screening values applicable to the commercial / industrial CLEA land use scenario.

The soil screening values used are generic assessment criteria (GAC). It should be noted that Category 4 Screening Levels (C4SL) for lead have been used as there is no recognised GAC for lead and the use of the term 'GAC' in this report includes the C4SL for lead.

The phrase 'further assessment required' is used to denote soil concentrations that are equal to, or exceed, a GAC. This does not necessarily mean that the soil is 'contaminated' or not otherwise suitable for use. The assessment and any mitigation required are to ensure the site does not pose an 'unacceptable risk'.

The results of the assessment are presented in Appendix G. The results also include testing of samples across the wider Fort Halstead site as all previous investigations incorporated the whole site.

### 7.3.1 Risk estimation (without statistical testing)

#### Metals and PAH

The individual analytical results of the Hydrock investigation and the historical investigations provided to Hydrock have been compared with the relevant GACs in the summary table in Appendix G.

Based on a direct exceedance of the GAC, the pervasive chemicals of potential concern that require further assessment are summarised in Table 7.1.

*Table 7.1: Pervasive Chemicals of Potential Concern for Which Further Assessment is Required (Human Health)*

| Chemical of Potential Concern | Generic Criterion (mg/kg) | Basis for Generic Criterion | No. Samples | Min. (mg/kg) | Max. (mg/kg) | No. Samples Exceeding Generic Criterion |
|---|---|---|---|---|---|---|
| Benzo(a)pyrene | 14 | GAC | 45 | 0.012 | 49 | 1 |

#### Asbestos

Asbestos (loose fibres of chrysotile, crocidolite and amosite) were detected in four out of the thirty samples tested. Three samples from Made Ground, one from natural soils. These are summarised in Table 7.2 and presented on drawing 19708-HYD-QQ-ZZ-DR-GE-1003 in Appendix A.

*Table 7.2: Asbestos Gravimetric Weighting*

| Location | Depth (m bgl) | Asbestos Fibres Detected | Gravimetric Weighting Value (%) |
|---|---|---|---|
| *Made Ground* | | | |
| BH548 | 0.3 | Amosite | <0.001 |
| BH556 | 0.1 | Chrysotile | <0.001 |
| BH556 | 0.4 | Chrysotile | <0.001 |
| *Natural Soils* | | | |
| BH550 | 0.5 | Chrysotile | <0.001 |

#### Petroleum Hydrocarbons (PHC)

Twenty samples (eight of Made Ground and twelve of natural materials) were scheduled for a Petroleum Hydrocarbon (PHC) assessment (carbon banding with aliphatic-aromatic split). A further thirteen samples (three of Made Ground and ten of natural materials) were scheduled historically for hydrocarbon fractions C12-35. The results have been compared to the relevant GACs. The summary sheets are presented in Appendix G.

No substances exceed the GAC.

BTEX concentrations were also analysed with no results exceeding the relevant GAC's.

*Volatile Organic Substances (VOC)*

Volatile and semi volatile compound concentrations within soils were analysed. No results exceeded relevant GAC.

No visual or olfactory evidence of contamination was identified during the investigation and no readings were recorded with the on site Photo Ionisation Detector.

### 7.3.2 Risk evaluation

The screening exercise identified the following substances at concentrations above the GAC. These are considered further in Table 7.3 to assess if the exceedance may be acceptable with respect to the proposed development and propose mitigation where necessary.

*Table 7.3: Elevated PAH within Made Ground*

| Chemical of Potential Concern | Review | Comment |
|---|---|---|
| Benzo(a)pyrene | Recorded concentrations in one samples of Made Ground slightly exceed the GAC. | The concentration recorded is considered minor and represent a low percentage of the samples tested. Mitigation is not considered merited. |

*Asbestos*

Due to existing structures and areas of vegetation the sample coverage has not been of a density to inform final mitigation measures and no clear pattern is apparent. There is no relevant guideline value for the assessment of asbestos in soils.

Quantification using gravimetric analysis indicated that all positive identifications were at a weighting value of <0.001% per sample.

Further validation sampling will be required pre-construction, to determine the appropriate level of mitigation required. Where asbestos is identified in areas of gardens and open landscaping, it is considered likely that a clean capping layer will be necessary.

*Plant Life*

Priority phytotoxic chemical concentrations have been screened against published values to determine the likely risk to plant growth and the findings presented in Appendix G.

Based on test results that exceed the GAC, the pervasive chemicals of potential concern that require further assessment are summarised in Table 7.4.

*Table 7.4: Pervasive Chemicals of Potential Concern for Which Further Assessment is Required (Risk to Plants)*

| Chemical of Potential Concern | Generic Criterion (mg/kg) | No. Samples | Min. (mg/kg) | Max. (mg/kg) | No. Samples Exceeding Generic Criterion |
|---|---|---|---|---|---|
| *Made Ground* | | | | | |
| Boron | 3 | 36 | 0.2 | 16 | 4 |
| Copper | 135 | 36 | 1 | 320 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Nickel | 75 | 36 | 1 | 174 | 3 |
| *Natural Soils* | | | | | |
| Boron | 3 | 33 | 0.2 | 3.1 | 2 |
| Nickel | 75 | 33 | 1 | 130 | 2 |

Within the Made Ground boron, copper and nickel are elevated when compared to the GAC.

Within the natural soils boron and nickel are elevated when compared to the GAC.

Detriment to plant life is hard to quantify and many of the GACs are based on agricultural crop yields rather than serious harm of death of a species. The number of exceedances compared with the overall volume of samples is very low and vegetation on site did not show any signs of physical distress. Hydrock does not believe any additional consideration is required with regards to risks to plant life.

## 7.4 Ground gases risk assessment

### *7.4.1 Data*

It is judged from the available evidence that the gas generation potential at the site is moderate (due the underlying chalk formation having the potential to generate carbon dioxide) and the sensitivity of the development ranges from low to high (dependant on the proposed end use). Consequently, and in accordance with CIRIA C665 (Table 5.5a and 5.5b), an appropriate minimum monitoring regime is twelve readings over six months, provided other monitoring requirements are also met, such as prevailing atmospheric pressure conditions (for example, BS 8485:2015 suggests monitoring should include a period of falling atmospheric pressure).

Hydrock has undertaken four readings across the wider Fort Halstead site. The first round as part of the 2016 investigation and 3 further rounds as part of the 2018 investigation. As such, the conclusions presented below are considered interim and further rounds will be required to fully characterise the site.

### *7.4.2 Assessment*

The risks associated with the ground gases methane ($CH_4$) and carbon dioxide ($CO_2$) have been assessed using BS 8485:2015 +A1:2019, which cites the guidelines published by CIRIA (Wilson et al 2007) (known as Situation A).

There is an alternative assessment method described by the NHBC (Boyle and Witherington 2007) (known as Situation B). Whilst 'Situation B' may also be suitable for the assessment, it is Hydrock's opinion that the NHBC Guidelines are not at the current time fully aligned with current ground gas risk assessment principles (as described in BS 8485:2015 +A1:2019). As such, 'Situation A' has been chosen as the means by the gas risk will be assessed.

The assessment guidelines published by CIRIA are based on interpretation of the gas concentrations and the gas flow rates, amongst other variables, and are compliant with the model procedures of LCRM. The assessment is presented in Appendix G.

The typical worst case GSV to date have been calculated as <0.04l/hr for carbon dioxide.

The site is provisionally classified as Characteristic Situation 1 (Situation A) and therefore presents a very low risk with respect to ground gases.

## 7.5 Explosives

Within the QinetiQ site pyrotechnic activities were undertaken including burning explosives and obscurants and storage of explosives.

Shallow soils were analysed for traces of explosive residues in seven locations across the site. The testing is summarised in Table 7.5.

*Table 7.5: Summary of shallow samples tested for an extended explosives suite*

| Location | Extended Explosives Suite |
|---|---|
| BH546<br>BH547<br>BH548<br>BH552<br>BH601<br>WS601<br>WS602 | NC Colour:<br>NC Colourimetric;<br>HMX;<br>RDX;<br>EGDN;<br>1, 3, 5 – Trinitrobenzene;<br>Tetryl;<br>1, 3 – Dinitrobenzene;<br>Nitrobenzene;<br>NG;<br>4 – Amino – 2, 6 – DNT;<br>TNT;<br>2 – Amino – 4, 6 – DNT;<br>2, 6 – DNT;<br>2, 4 – DNT;<br>HNS;<br>2 – Nitrotoluene;<br>4 – Nitrotoluene;<br>PETN;<br>3 – Nitrotoluene;<br>Picrite; and<br>Picric Acid. |

Samples were analysed for an extended explosives suite using method ESAL/QC/4 parts a, j and k LCMS soils HPLC soils. Test certificates are presented in Appendix G.

Concentrations of the explosives analysed were below the laboratory limit of detection in all samples tested.

Explosive's residues are therefore not considered a significant risk.

## 7.6 Construction materials risk assessment

### *7.6.1 Water pipelines*

A formal water pipe investigation and risk assessment is beyond the scope of this report. However, the findings of this investigation have been compared to the threshold values in Water UK HBF (2014), Table 1 as far as is practicable, to give an indication of the possible restrictions to the use of plastic pipes for water supply to the site (see the reference in Appendix K for further information).

The site is brownfield.  However, the investigation has not detected organic contamination in exceedance of the threshold values and Hydrock believes standard pipework may be suitable for the site. However, confirmation should be sought from the water supply company at the earliest opportunity.

## 7.7 Findings of the generic contamination risk assessments

The potential sources, pathways and receptors identified in the desk study (Section 2) have been investigated (Sections 4) and assessed (Sections 7). A Source-Pathway-Receptor linkage assessment has been undertaken and is presented in Appendix J (Table J.2).

A summary of the Source-Pathway-Receptor (SPR) contaminant linkages for which the risks may be unacceptable and require mitigation (those that are moderate or higher) are discussed in Table 7.6.

*Table 7.6: Residual risks following risk evaluation*

| Contaminant Linkage | | | | Comments | |
|---|---|---|---|---|---|
| Pollutant Linkage | Sources | Pathways | Receptors | General | Mitigation |
| PL 1. | Asbestos fibres from asbestos-containing materials in the Made Ground and natural soils. | Inhalation of fugitive dust. | Human Health (End users) | Made Ground seen to contain asbestos-containing materials.<br>Asbestos fibres measured in soil samples. | Following further validation sampling to delineate the extent of ACM within soils, mitigation to be provided by way of a clean capping system in areas of gardens and open landscaping. |
| PL 2. | Elevated asbestos fibres. | Inhalation of fugitive dust | Human Health (Neighbours) | Elevated concentrations have been recorded. | Potential for generation of contaminated dust. Suitable mitigation measures for dust suppression should be employed during construction. |

# 8. WASTE AND MATERIALS MANAGEMENT

## 8.1 Introduction

The Waste Framework Directive (WFD) (2009/98/EC) defines waste as '*any substance which the holder discards or intends to discard.*' In a geo-environmental context, the waste is most often 'soil' and the two main scenarios are offsite disposal of the material as a waste and/or reuse of the material on site. For cost and sustainability reasons, reuse is preferred to off-site disposal.

Section 8.2 below describes the key issues relating to off-site disposal to landfill and Section 8.3 considers requirements relating to reuse of soils and materials management.

## 8.2 Waste disposal

### *8.2.1 Principles*

Based on the WFD, any material excavated on site may be classified as waste and it is the responsibility of the producer of a material to determine whether or not it is waste. Where off-site disposal is undertaken, the following guidance applies.

Classification is a staged process:

- A hazardous waste is defined under the WFD as one which possesses one or more of fifteen defined hazardous properties. If a waste is not defined as hazardous, then it is non-hazardous.
- Where the materials are soil, it is then be assigned using the 'List of Waste Codes', which classifies the material as either:
- hazardous (17-05-03), which is defined as "*soil and stones containing hazardous substances*"; or
- non-hazardous (17-05-04), which is defined as "*soil and stones other than those mentioned in 17-05-03*".
- Hydrock utilise the proprietary assessment tool, HazWasteOnline™ to undertake this assessment.
- Waste Acceptance Criteria (WAC) testing is then undertaken if required, and are only applicable following classification of the waste, and only where the waste is destined for disposal to landfill. The WAC are both qualitative and quantitative. The WAC and the associated laboratory analyses (leaching tests) are not suitable for use in the determination of whether a waste is hazardous or non-hazardous.

It should be noted that some non-hazardous wastes may be suitable for disposal at an inert landfill as non-hazardous waste, subject to meeting the appropriate waste acceptance criteria.

It should be noted that classification must be undertaken on the waste produced, by the waste producer. Necessary sampling frequency to adequately characterise a soil population is defined within WM3.

Further discussion with regards to the characterisation process for different scenarios and waste types is provided below.

*Topsoil and Peat*

Topsoil and peat are biodegradable, therefore if they are surplus to requirements and cannot be re-used in accordance with a Materials Management Plan, they cannot be classified as inert. As such, topsoil and peat need to be classified by a staged assessment and sampling process and would either be classified as hazardous or non-hazardous, depending upon the results of the assessment.

*Greenfield Sites*

Waste from completely greenfield sites may be accepted at a landfill as inert waste if it meets the requirements of paragraph 10 (wastes acceptable without testing at landfills for inert waste) of the Landfill (England and Wales) (Amendment) Regulations (2005) ('the Regulations') can be met. Paragraph 10 of the Regulations states, "*soils may be able to be classified as inert waste without testing, if:*

- they are single stream waste of a single waste type;
- there is no suspicion of contamination and they do not contain other material or substances such as metals, asbestos, plastics, chemicals, etc….."

As such, where the site is greenfield and the waste producer is confident about the quality of a soil (i.e. naturally occurring and uncontaminated), further sampling and laboratory testing is not necessary for the Basic Characterisation and this can be undertaken on qualitative Waste Acceptance Criteria testing.

In this instance the waste producer can characterise the waste based on visual assessment and written description of the waste in addition to supporting evidence such as a desk study assessment of the greenfield status. However, it should be noted this characterisation is subject to agreement by the landfill operator who may require testing to be undertaken to confirm classification.

*Contaminated or potentially contaminated sites*

If the site is brownfield, contaminated or potentially contaminated, the waste must undergo an initial waste classification exercise using background information on the source and origin of the waste and assessment of chemical test data in accordance with Environment Agency Technical Guidance WM3.

If following the initial waste classification exercise, the soils are acceptable for disposal to a non-hazardous landfill, further qualitative Waste Acceptance Criteria (WAC) testing is not required.

However, if soils are potentially able to be disposed to an inert landfill as non-hazardous waste, or require testing to determine if they can be disposed of to a stable non-reactive hazardous or hazardous class of landfill, the next stage of assessment is to undertake qualitative WAC testing. This will determine the Basic Characterisation and the landfill category at which the soils can be accepted.

Hazardous material must be subjected to WAC testing to determine whether it requires treatment before it can be accepted at the hazardous landfill, while non-hazardous material can be tested to determine whether it may be suitable for placement in an inert landfill.

### 8.2.2 HazWasteOnline™ assessment

Based on the site history and the HazWasteOnline™ assessment (see Appendix H), if suitable segregation of different types of waste is put in place, for soils to be disposed of, it is considered that:

- the natural soils are likely to be classified as non-hazardous waste and may be able to be disposed of at an inert landfill.
- the general Made Ground where not containing asbestos >0.1% is likely to be classified as non-hazardous waste and may be able to be disposed of at an inert landfill.

Any soils containing > 0.1% asbestos or visible asbestos containing materials would be considered as hazardous.

It should be noted that:

- The above preliminary assessment has been made on the basis of the soils tested as part of the ground investigation for the wider Fort Halstead site to build up a data set. Prior to disposal, the characteristics of the actual soils to be disposed of will need testing and classification in consultation with landfill sites and waste disposal Contractors. The receiving landfill will make the final decision on the classification and acceptability of the waste.
- Non-hazardous soils require pre-treatment (separation, sorting and screening) prior to disposal.
- The costs for disposal of non-hazardous and hazardous soils are significant compared to disposal of inert material.
- In addition to disposal costs, landfill tax will be applicable.

### 8.2.3 General waste comments

It should be noted that:

- It is the waste producer's responsibility to segregate the waste at source and waste producers must not mix waste materials/streams or dilute hazardous components, for example by mixing with less or non-hazardous waste on site to meet WAC limit values.
- The above preliminary assessment has been made on the basis of the soils tested as part of the ground investigation, using the HazWasteOnline™ assessment. However, the formal classification of waste can only be undertaken on the material to be disposed of, and by the waste producer and the receiving landfill as license conditions vary from landfill to landfill.
- Basic Characterisation should be undertaken in accordance with Environment Agency guidance by the waste producer. Hydrock can assist if required and this report will assist the characterisation. However, Basic Characterisation does not form part of the current commission and would require further assessment and testing on the wastes actually to be disposed.
- Once the waste producer has undertaken an initial Basic Characterisation on each waste stream, they can manage the soils as part of the on-site processing programme (for example, stockpiling, treatment, screening and separation). The waste producer and landfill operator will then need to agree the suite of compliance testing for regularly generated waste to demonstrate compliance with the initial Basic Characterisation prior to disposal.
- At the time of disposal, additional testing on the excavated soils to be disposed of, will likely be necessary.

- Non-hazardous and hazardous soils require pre-treatment (separation, sorting and screening) prior to disposal.
- The costs for disposal of non-hazardous and hazardous soils are significant compared to disposal of inert material.
- In addition to disposal costs, landfill tax will be applicable. Non-hazardous and hazardous waste will generally be subject to the Standard Rate Landfill Tax. Inert or inactive waste will generally be subject to the Lower Rate Landfill Tax. The landfill tax value changes each April and can be found at https://www.gov.uk/government/publications/rates-and-allowances-landfill-tax/landfill-tax-rates-from-1-april-2013.
- Before a waste producer can move waste to a landfill site for disposal, they need to check the landfill site has the appropriate permit and must have completed the following1:
- Duty of care transfer note / Hazardous Waste consignment note, including comment as to if pre-treatment has been undertaken; and
- Basic Characterisation of the waste, to include: description of the waste; waste code (using list of wastes); composition of the waste (by testing, if necessary) and; WAC testing (if required).

## 8.3 Materials management

### *8.3.1 Introduction*

Soils that are to remain on site, should be managed and reused in accordance with a Materials Management Plan (MMP), prepared in accordance with 'The Definition of Waste: Development Industry Code of Practice', Version 2 (CL:AIRE), known as the DoWCoP. Where all aspects of the DoWCoP are followed the soils are considered not to be waste, because they were never discarded in the first place.

Version 2 of the DoWCoP clearly sets out the principles and an outline of the requirements of a MMP. The following compliance criteria must be seen to apply to the MMP for the site:

- Factor 1: Protection of human health and protection of the environment.
- Factor 2: Suitability for use, without further treatment.
- Factor 3: Certainty of Use.
- Factor 4: Fixed Quantity of Material.

The reuse of soils at sites should be considered during the planning and development design process so that compliance with issues such as fixed quantity and certainty of use clearly relate to agreed site levels. Suitability of Use is normally evident from the remediation strategy or the design statement, which form an integral part of a MMP. However, some soils may need to be tested post-excavation to prove they are suitable for use.

Once the MMP is finalised, it must be declared by a Qualified Person (QP). The Declaration is an on-line submission as part of which the QP is required to confirm that the declaration is being made before the relevant works have commenced (i.e. it is not a retrospective application).

[1] ENVIRONMENT AGENCY. November 2010. Guidance on waste acceptance procedures and criteria. Waste acceptance at landfills. The Environment Agency.

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Once all material movements have been completed in accordance with the MMP a verification report must be produced, kept for 2 years and provided to the EA on request.

It should be noted that failure to comply with the requirements of the DoWCoP when re-using materials has potentially significant consequences for the waste holder. The risk is that the reused materials are still regarded as a waste that has been illegally deposited. From 1 April 2018, the scope of Landfill Tax has been extended to sites operating without the appropriate environmental disposal permit, and operators of illegal waste sites will now be liable for Landfill Tax. Further information is available at: https://www.gov.uk/government/publications/landfill-tax-disposals-not-made-at-landfill-sites/landfill-tax-disposals-not-made-at-landfill-sites.

If soils are excavated and reused on sites (or moved to another site) without a MMP, exemption, or appropriate Permit in place, anyone who knowingly facilitates the disposal may be '*jointly and severally liable'* to any assessment of tax, fines or prosecution.

# 9. UNCERTAINTIES AND LIMITATIONS

## 9.1 Site-specific comments

The scheduled monitoring is complete but is insufficient at this stage to fully characterise the site in accordance with CIRIA Report 665. Whilst the monitoring completed to date provides a preliminary indication of the gas regime, additional monitoring is required to fully classify the site.

## 9.2 General comments

Hydrock Consultants Limited (Hydrock) has prepared this report in accordance with the instructions of QinetiQ (the Client), dated April 2021 under the terms of appointment for Hydrock, for the sole and specific use of the Client and parties commissioned by them to undertake work where reliance is placed on this report. Any third parties who use the information contained herein do so at their own risk. Hydrock shall not be responsible for any use of the report or its contents for any purpose other than that for which it was prepared or for use of the report by any parties not defined in Hydrock's appointment.

The report has been prepared by Hydrock on the basis of available information obtained during the study period. Although every reasonable effort has been made to gather all relevant information, not all potential environmental constraints or liabilities associated with the site may have been revealed.

Hydrock has used reasonable skill, care and diligence in the design of the investigation of the site and in its interpretation of the information obtained. The inherent variation of ground conditions allows only definition of the actual conditions at the locations and depths of trial pits and boreholes at the time of the investigation. At intermediate locations, conditions can only be inferred.

Groundwater data are only representative of the dates on which they were obtained and both levels and quality may vary.

Unless otherwise stated, the recommendations in this report assume that ground levels will remain as existing. If there is to be any re-profiling (e.g. to create development platforms or for flood alleviation) then the recommendations may not apply.

Information provided by third parties has been used in good faith and is taken at face value; however, Hydrock cannot guarantee its accuracy or completeness.

Where the existing report(s) prepared by others have been provided by the Client, it is assumed that these have been either commissioned by the Client, or can be assigned to the Client, and can be relied upon by Hydrock. Should this not be the case Hydrock should be informed immediately as additional work may be required. Hydrock is not responsible for any factual errors or omissions in the supplied data, or for the opinions and recommendations of others. It is possible that the conditions described may have since changed through natural processes or later activities.

The work has been carried out in general accordance with recognised best practice. The various methodologies used are referenced in Appendix K. Unless otherwise stated, no assessment has been made for the presence of radioactive substances or unexploded ordnance. Where the phrase 'suitable for use' is used in this report, it is in keeping with the terminology used in planning control and does not imply any specific warranty or guarantee offered by Hydrock.

The chemical analyses reported were scheduled for the purposes of risk assessment with respect to human health, plant life and controlled waters as discussed in the report. Whilst the results may be useful in applying the Hazardous Waste Assessment Methodology given in Environment Agency Technical Guidance WM3, they are not primarily intended for that purpose and additional analysis will be required at the time of disposal to fully classify waste. Discussion and comment with regards to waste classification are preliminary and do not form the requirements of 'Basic Characterisation' as required.

Assessment and testing for the presence of coal tar has only been completed at the locations of exploratory holes undertaken for risk assessment purposes. This investigation is not designed to provide a definitive assessment of the risk from coal tar, nor the waste classification for bituminous bound pavement arisings at the site.

Unless otherwise stated, at the time of this investigation the future routes of water supply pipes had not been established. This investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling and chemical testing may be required at a later date once the routes of the supply pipes are known. In addition, it is recommended that the relevant water supply company be contacted at an early stage to confirm its requirements for assessment, which may not necessarily be the same as those recommended by UKWIR.

Whilst the preliminary risk assessment process has identified potential risks to construction workers, consideration of occupational health and safety issues is beyond the scope of this report.

Please note that notwithstanding any site observations concerning the presence or otherwise of archaeological sites, asbestos-containing materials or invasive weeds, this report does not constitute a formal survey of these potential constraints and specialist advice should be sought.

Any site boundary line depicted on plans does not imply legal ownership of land.

# 10. RECOMMENDATIONS FOR FURTHER WORK

Following the ground investigation works undertaken to date, the following further works will be required:

- pre-demolition asbestos survey;
- further site investigation in areas that to date have not been accessible. Beneath building footprints etc;
- further site investigation during detailed design to delineate the extent of asbestos fibres within shallow soils;
- further investigation into the potential for dissolution features and natural chalk cavities beneath the site;
- further site investigation during detailed design to provide suitable parameters for foundation (including pile and ground improvement) design and soil characterisation;
- infiltration testing at various depths within the chalk formation across the extent of the Site to inform on site drainage strategies including the potential for deep borehole soakaways;
- further ground gas assessment;
- production of a formal Remediation Method Statement (RMS), detailing the remedial works considered necessary to break the identified potential pollutant linkages;
- further assessment and design of engineered cover systems where required as designs are finalised;
- foundation depth in relation to trees assessment, following a tree survey to BS 5837:2012;
- upon completion of development design, provision of a geotechnical design report for Category 2 structures;
- discussions with service providers regarding the materials suitable for pipework etc.;
- verification of the remedial works to allow regulatory sign off.

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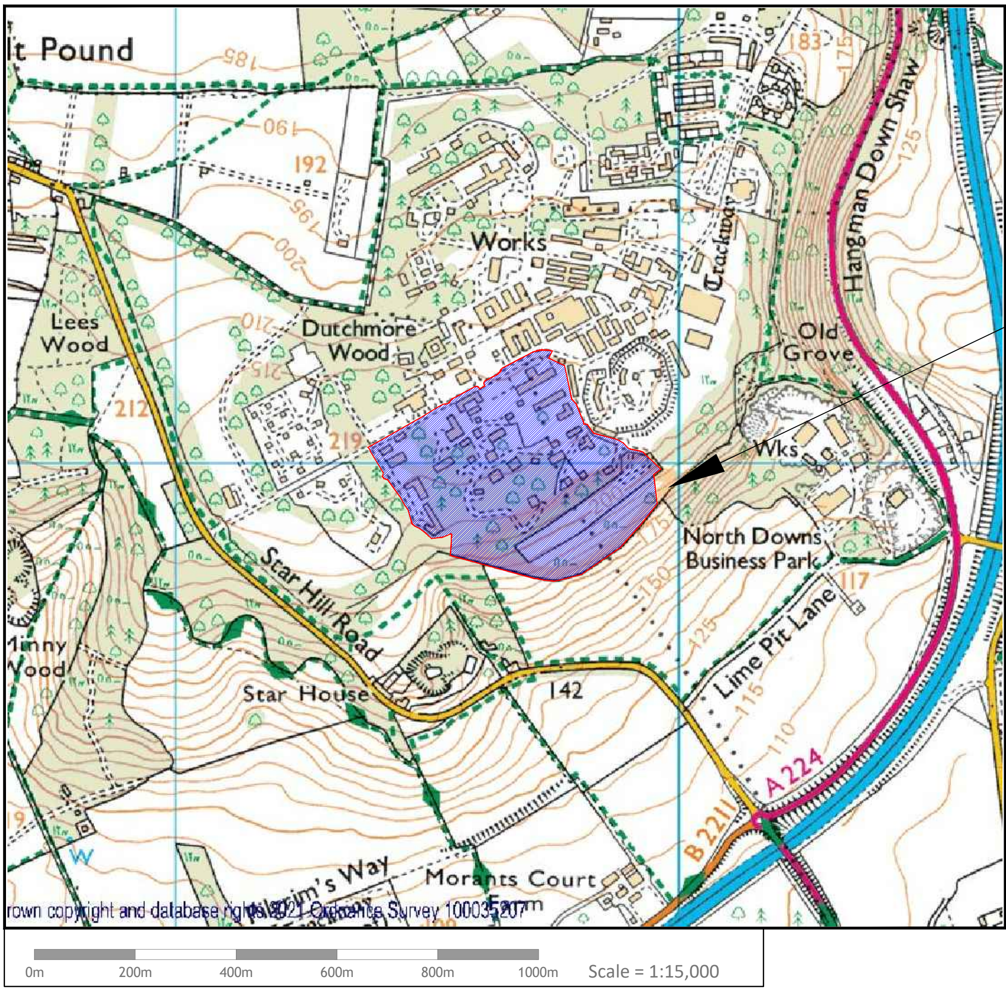
# Appendix A

# Drawings

OS NORTH


THE SITE


THE SITE

| REV. | REVISION NOTES/COMMENTS | | | | | |
|---|---|---|---|---|---|---|
| P01 | FIRST ISSUE | | | | | |
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CLIENT
QinetiQ

PROJECT
Fort Halstead QinetiQ

TITLE
SITE LOCATION PLAN

| HYDROCK PROJECT NO. | SCALE @ A4 |
|---|---|
| C-19708-C | See Drawing |

| PURPOSE OF ISSUE | STATUS |
|---|---|
| SUITABLE FOR INFORMATION | S2 |

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|---|---|
| 19708-HYD-QQ-ZZ-DR-GE-1001 | P01 |


KEY

Site boundary

NOTES

1. All dimensions are to be checked on site before the commencement of works. Any discrepancies are to be reported to the Architect & Engineer for verification. Figured dimensions only are to be taken from this drawing.

2. This drawing is to be read in conjunction with all relevant Engineers' and Service Engineers' drawings and specifications.

3. This drawing has been based on the following drawings and information: Topographical Survey drawing No: 10323 Master Rev 1 by: Greenhatch Group. Survey dated: 11/12/2007.

## LEGEND

### Hydrock 2018

BHXX Cable Percussion Borehole

TPXX Trial Pit

WSXX Window Sampler Borehole

### Hydrock 2016

TPXX Trial Pit

BHXX Window Sampler Borehole

HPXX Hand Dug Trial Pit

### Historical Investigations

XXX Window Sampler Borehole

XXX Hand Dug Trial Pit

XXX Window Sampler Borehole

XXX Machine Dug Trial Pit

| | | | | | | |
|---|---|---|---|---|---|---|
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QinetiQ

PROJECT

Fort Halstead QinetiQ

TITLE

Exploratory Hole Location Plan

| HYDROCK PROJECT NO. | SCALE @ A1 |
|---|---|
| C-19708-C | 1:1250 or as shown |

| PURPOSE OF ISSUE | STATUS |
|---|---|
| SUITABLE FOR INFORMATION | S2 |

| DRAWING NO. (PROJECT CODE-ORIGINATOR-ZONE-LEVEL-TYPE-ROLE-NUMBER) | REVISION |
|---|---|
| 19708-HYD-QQ-ZZ-DR-GE-1002 | P01 |


KEY

Site boundary

NOTES

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3. This drawing has been based on the following drawings and information: Topographical Survey drawing No: 10323 Master Rev 1 by: Greenhatch Group. Survey dated: 11/12/2007.

LEGEND

Asbestos

Gravimetric weighting <0.001% (below LOD)

Hydrock 2018

BHXX Cable Percussion Borehole

TPXX Trial Pit

WSXX Window Sampler Borehole

Hydrock 2016

TPXX Trial Pit

BHXX Window Sampler Borehole

HPXX Hand Dug Trial Pit

Historical Investigations

XXX Window Sampler Borehole

XXX Hand Dug Trial Pit

XXX Window Sampler Borehole

XXX Machine Dug Trial Pit

| | | | | | | |
|---|---|---|---|---|---|---|
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PROJECT

Fort Halstead QinetiQ

TITLE

Asbestos Detection Plan

| HYDROCK PROJECT NO. | SCALE @ A1 |
|---|---|
| C-19708-C | 1:1250 or as shown |

| PURPOSE OF ISSUE | STATUS |
|---|---|
| SUITABLE FOR INFORMATION | S2 |

| DRAWING NO. (PROJECT CODE-ORIGINATOR-ZONE-LEVEL-TYPE-ROLE-NUMBER) | REVISION |
|---|---|
| 19708-HYD-QQ-ZZ-DR-GE-1003 | P01 |


KEY

Site boundary

NOTES

1. All dimensions are to be checked on site before the commencement of works. Any discrepancies are to be reported to the Architect & Engineer for verification. Figured dimensions only are to be taken from this drawing.

2. This drawing is to be read in conjunction with all relevant Engineers' and Service Engineers' drawings and specifications.

3. This drawing has been based on the following drawings and information: Topographical Survey drawing No: 10323 Master Rev 1 by: Greenhatch Group. Survey dated: 11/12/2007.

## LEGEND

Location of explosives test sample

**Hydrock 2018**

- BHXX Cable Percussion Borehole
- TPXX Trial Pit
- WSXX Window Sampler Borehole

**Hydrock 2016**

- TPXX Trial Pit
- BHXX Window Sampler Borehole
- HPXX Hand Dug Trial Pit

**Historical Investigations**

- XXX Window Sampler Borehole
- XXX Hand Dug Trial Pit
- XXX Window Sampler Borehole
- XXX Machine Dug Trial Pit

| | | | | | | |
|---|---|---|---|---|---|---|
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PROJECT

Fort Halstead QinetiQ

TITLE

Explosives testing in shallow soils
Sample Locations

| HYDROCK PROJECT NO. | SCALE @ A1 |
|---|---|
| C-19708-C | 1:1250 or as shown |

| PURPOSE OF ISSUE | STATUS |
|---|---|
| SUITABLE FOR INFORMATION | S2 |

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|---|---|
| 19708-HYD-QQ-ZZ-DR-GE-1004 | P01 |

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# Appendix B

# Ground Investigation Plan and Exploratory Hole Logs