# Phase 1 Desk Study

# and

# Phase 2a Preliminary Ground Investigation

## Phase 2 Home Farm, Park Lane, Pinhoe, Exeter

## Report: GCE01055/R1

## December 2020

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| Report prepared for: | Waddeton Park Ltd<br>Greendale Court<br>Clyst St Mary<br>Exeter<br>EX5 1AW |
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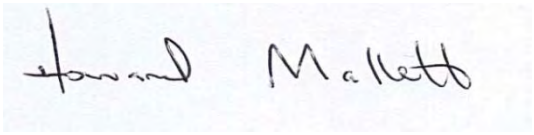
| Report Prepared by: | Howard Mallett BSc., CGeol, Euro Geol, FGS |



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| Report Reviewed by: | David Jackson BSc., CEng, MICE, FGS |

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# EXECUTIVE SUMMARY

| Features | Summary |
|---|---|
| Site Location | The site is located between Church Hill and Park Lane, Pinhoe, Exeter. The nearest post code is EX4 9JG. |
| Proposed development | Residential development. No plan available at time of undertaking the ground investigation. |
| Site Area | The site comprises a large irregular field covering an area of 3.69ha. |
| Topography | The site slopes from the northern corner (approx. 103.7mAOD) down to the south/ south-east (87.8mAOD). |
| Site Surfaces | Undulating surface in central northern area. Linear depression seen in central area of the site running in a north to south direction, possible land drain. Linear depression along the route of the South West Water (SWW) water main. |
| Existing buildings/Structures | None on site. |
| Utility Information | SWW water main located on site running parallel to south-west boundary. Overhead electric cable crosses the site. |
| Trees/ Vegetation | Site comprises a grass field with hedge boundaries. A few mature trees are located in the hedge boundaries. |
| Boundary conditions | Hedges on site boundaries with a few mature trees. Church Hill road on the south-west side of the site is cut into the slope on the lower side of the site. |
| Superficial Geology | Head deposits |
| Bedrock Geology | Carboniferous Crackington Formation. |
| Hydrology | The nearest surface water feature recorded in the Envirocheck data is located 125m south-west and appears to be a drain feature. |
| On-Site History | The historical data review indicates that the site has been in agricultural use since the first available mapping of 1888. |
| Mining | None recorded within 250m of the site. |
| Unexploded Ordnance | From our knowledge of the underlying geology, historic mapping and site history the ground investigation methods proposed indicate a commonly acceptable level of risk. |
| Ground Investigation | The intrusive investigation comprised: trial pitting, large scale infiltration testing, groundwater monitoring, chemical analysis of soils and geotechnical analysis of soils. |
| Made Ground | Not encountered on site. |
| Natural transported engineering soils | Gravelly Clay Head and clayey Gravel Head. |

| Features | Summary |
|---|---|
| Natural In-situ engineering soils. | Weathered Crackington Formation altered to clayey Gravel. |
| In-situ rock | Mudstone slate/Shale and locally in TP2 metamorphosed Siltstone and Sandstone. |
| Groundwater | Groundwater monitoring wells were installed in TP101 to TP104. The groundwater monitoring completed to date has shown groundwater rising to 0.14m bgl to +0.09m agl (artesian), TP103 was recorded as dry, with measured levels ranging from 87.6m to 97.3m AOD. |
| Chemical results above screening levels of background | Chemical analysis has not identified significant levels of contamination within the samples analysed. |
| Pollutant Linkages | None identified. |
| Remediation measures required | If any anomalous Made Ground is encountered during the construction phase this should be assessed separately. |
| Geotechnical index testing | The modified Plasticity Index indicates the silty clays are of low to high volume change potential. |
| Geotechnical Hazards | Volume change potential in cohesive soils.<br>Influence of existing trees on boundaries and proposed trees.<br>Overhead electricity cables may have to be relocated or placed underground.<br>SWW water main on site and close to south-west boundary.<br>Shallow groundwater therefore soakaways unlikely to be viable.<br>Shallow groundwater at 0.14m bgl to +0.09m (artesian) recorded on site, land drainage may to be required to prevent groundwater flooding into foundation trenches and service trenches during excavation and post construction.<br>Development on site may change groundwater flows; land drainage may be required to minimise impact on the cut slope down to Church Hill Road below/ downslope of the site. |
| Foundation Options | Trench Fill foundations likely to be suitable for proposed houses. |
| Floor Slabs | Suspended floor slabs recommended. |
| Buried Concrete | Buried concrete can be designed in accordance with design sulphate class DS-1 ACEC class AC-1 of BRE Special Digest 1(2005), assuming mobile groundwater is present. |
| Road Design CBR | CBR testing should be undertaken when proposed layout plans are available.<br>DCC is likely to require their own investigations for proposed highways. |

| Features | Summary |
|---|---|
| Infiltration Testing | Large scale infiltration testing indicates the infiltration rates are low and whilst one of the four tests achieved 50% drained in 24 hours, the combination of slow rates and potentially high groundwater indicate that infiltration drainage may not be viable. |
| Retaining Structures | Further investigation may be required if retaining structures are required. |
| Earthworks | Further investigation may be required if significant cut and fill is proposed. |
| Slopes | Steep cut slope down to Church Hill road to the south-west of the site may necessitate development stand-off zone to prevent imposition of loading. |
| Additional investigation works required | DCP CBR testing when proposed layout plans are available.<br>Further 8 monthly groundwater monitoring visits are scheduled.<br>Further investigation may be required when proposed layout plans are available if any significant retaining walls and/ or cut and fill is proposed. |

# 1.0 INTRODUCTION

## 1.1 Instruction

Geo Consulting Engineering Ltd (GCEL) was commissioned by Waddeton Park Ltd to undertake a Phase 1 Desk Study and Phase 2a Preliminary Ground Investigation at the site of the proposed residential development.

The works have been carried out in accordance with proposal ref: EGCE1608/P1 dated 1st April 2020 and addressed to Waddeton Park Ltd.

## 1.2 Background

The site comprises one large (3.7ha) field that is being considered for residential development.

## 1.3 Objectives

A preliminary ground investigation is required to provide initial information on the ground and groundwater conditions at the site for a residential development.

Specific client requirements include:

- Undertaking Infiltration testing

## 1.4 Methodology

A phased investigation approach has been adopted, the first stage of which is the Phase 1 Desk Study and walkover survey for development of site characterisation, conceptual model, and sampling and analysis plan. Subsequently, a Phase 2a Preliminary Ground Investigation has been undertaken comprising trial pitting with infiltration testing,

installation of groundwater monitoring wells and geotechnical and chemical laboratory testing.

Eurocode 7 EN 1997-1:2004 identifies the requirements of a ground investigation report, which shall form part of the Geotechnical Design Report. This document is not a Geotechnical Design Report.

### 1.5 Limitations

Subsoils are inherently variable and by their very nature are hidden from view such that no investigation can be exhaustive to the extent that all soil conditions are revealed. Conditions may therefore be present beneath the site that were not apparent from the data available for review. Similarly, this assessment has been based in part on third party data with particular respect to the Phase 1 information. This data has been taken at face value and has not been subjected to any external validation.

Groundwater levels are subject to seasonal variation and therefore may change from the levels recorded during this investigation.

Where areas of a site are overgrown/inaccessible/obscured by buildings or hardstanding, it may not be possible for a walkover inspection to identify features that may subsequently come to light when site clearance is carried out.

Assessment of asbestos in the ground is outside the scope of our report and expertise. The potential for asbestos or other hazardous or deleterious substances in structures and substructures should be assessed by a competent person.

Unless specifically noted to the contrary, it should be assumed that this report has not been submitted to any regulatory authorities for approval.

Recommendations made in this report in respect of land contamination are based on guidance values that are current at the time of writing. Should any extended period of time elapse between the date of this report and the commencement of construction it would be prudent to confirm that the screening values used are current.

## 2.0 SITE DATA

### 2.1 Site Location

The site is located between Church Hill and Park Lane, Pinhoe, Exeter. The nearest post code is EX4 9JG. The National Grid Reference for the approximate centre of the site is 295980, 94970.

A site location plan is presented in Figure 1.

### 2.2 Site Description

A description of the site summarised in the table below. Observations are based on the site walkover carried out on the 17th April 2020.

Site Photographs are enclosed within Appendix A.

| Features | Observations/Descriptions |
|---|---|
| Area, Shape and Size | The site comprises a large irregular field covering an area of 3.69ha. |
| Site Access | There is an access gate off the north corner onto Park Lane |
| Topography | The site slopes from the northern corner (approx. 103.7mAOD) down to the south/ south-east (87.8mAOD). |
| Surface Water Features/ Springs/ Wet Ground | The nearest surface water feature recorded in the Envirocheck report is located 125m south-west. |
| Site Surfaces/ Features | Undulating surface in central northern area. Linear depression seen in central area of the site running in a north to south direction, possible land drain. Linear depression along the route of the South West Water (SWW) water main. |
| Vegetation | Site comprises a grass field with hedge boundaries. A few mature trees are located in the hedge boundaries.<br>Two strips of planted areas were noted along the north and north-west boundaries of the site. |
| Site Boundaries | Hedges on site boundaries with a few mature trees. Church Hill road on the south-west side of the site is cut into the slope on the lower side of the site. |

| Features | Observations/Descriptions |
|---|---|
| Buildings/ Structure/ Services | No buildings on site.<br>A SWW main is located on site and runs along and close to the south/ south-west boundary.<br>A concrete slab was seen on the southern boundary which may be a stand for a water trough. |
| Unusual Features | None identified. |
| Geotechnical Hazards | Potential for fine grained Head deposits overlying the bedrock.<br>Influence of existing and proposed trees.<br>Existing SWW water main running along/ close to the south-west boundary.<br>Potential for shallow groundwater.<br>Potential for groundwater flooding of foundation and service trenches.<br>Potential of slope instability along Church Hill road cutting due to change in groundwater flows or imposition of loading. |
| Potential Sources of Contamination | <u>On-site:</u><br>– Potential for localised fuel spillages (hydrocarbons) and Poly Aromatic Hydrocarbons from historic stubble burning on agricultural land.<br>– Potential for elevated metals from natural soils.<br><u>Off-site:</u><br>None identified |

Neighbouring land uses are summarised in the table below:

| Direction | Features |
|---|---|
| North | Park Lane with residential properties and agricultural field beyond. |
| East | Former field and Home farmyard now under development by Burrington Estates. |
| South | Church Hill with agricultural fields beyond and occasional residential properties. |
| West | Unnamed highway with agricultural field beyond. |

## 2.3 Geology

The following table summarises the strata likely to be encountered at the site location.

| Strata | Type | Source of data |
|---|---|---|
| Bedrock Geology | Carboniferous Crackington Formation comprising Mudstone and Sandstone | British Geological Survey (BGS). |
| Superficial/Drift Deposits (Soils Transported by Water/ Gravity) | None recorded. | British Geological Survey (BGS). |
| | Fine grained Head deposits are expected to mantle the solid geology across the site. | Previous experience. |
| Anthropogenic Soils (Made Ground/ Fill) | None recorded. | British Geological Survey (BGS). Previous experience/ observations. |

## 2.4 Hydrogeology

The following table summarises the available data regarding the hydrogeological classification of the soils, rock and Source Protection Zones.

| Data | Description | Source of data |
|---|---|---|
| Groundwater Vulnerability | High Vulnerability | Envirocheck Report |
| Bedrock geology | Secondary Aquifer A | Envirocheck Report |
| Superficial deposits | No data available | Envirocheck Report |
| Source Protection Zones | None recorded within 1000m. | Envirocheck Report |

## 2.5 Hydrology

The nearest surface water feature recorded in the Envirocheck report is located 125m south-west and appears to be a drain feature.

Environment Agency flood risk information included in the Envirocheck report datasheet and mapping should be viewed for specific details. General conditions indicate no record of flooding from rivers or the sea without defences.

## 2.6 Site History

The following table sets out the site history as derived from the available Ordnance Survey mapping. Copies of the maps are included in Appendix B.

| Mapping Date | On-site | Off-site |
|---|---|---|
| **1888-89**<br>*1:10,560* | The site is shown as one large field with the same layout as present. Church Hill Road and Park Lane are shown. | The site is surrounded by fields, with occasional farm and residential structures.<br>The highway network around the site is the same as present.<br>The mapping shows orchards to the south (250m) and south-west (100m) of the site.<br>700m to the north-east is a large open area labelled Poltimore Park (deer park).<br>400m to the east of the site is a large structure labelled Peterfield House.<br>A complex of structures labelled The Laurels is shown approximately 80m north-west of the site. Immediately north-west of 'The Laurels' are a number of structures labelled Beacon Hill Cottages. An unlabelled cluster of structures are shown approximately 80m to the south-east of the site.<br>The village of Pinhoe is shown on the mapping approximately 500m to the south-east, with the London and South West Railway approximately 700m to the south.<br>350m south of the site is a large "U" shaped structure surrounded by orchards labelled Harrington Farm.<br>800m to the south-west of the site is cluster of structures labelled Heath Barton which include Pinbrook Farm and Watton Farm.<br>250m west of the site is St. Michael's church and vicarage. |
| **1889-1890**<br>*1:2,500* | As above. The mapping shows occasional trees along the northern, western and south-western boundaries of the site.<br>A small square feature is marked on the south-east boundary which appears to be a small enclosure. | As above.<br>A well is marked adjacent to the house approximately 120m south-east of the site.<br>A Pump is marked adjacent to Hill Cottages 110m south of the site. |
| **1905**<br>*1:2.500* | As above.<br>The small square enclosure is no longer shown. | As above. The cluster of structures110m to the south-east of site has increased in size.<br>A small feature is shown on the east side of the south-east boundary. |

| Mapping Date | On-site | Off-site |
|---|---|---|
| **1906**<br>*1:10,560* | As above. | The village of Pinhoe has expanded south and eastwards. Approximately 600m to the south-west of the site a clay pit is shown labelled as Poltimore Brick Works. |
| **1932-1933**<br>*1:2,500* | As above. | Adjacent to the eastern boundary along Park Lane a number of residential structures are now shown.<br>The cluster of structures approximately 110m to the south are now labelled Home Farm.<br>Hill cottage is now labelled Woolsgrove and the orchard adjacent to this structure are no long present and a number of structures are now shown on the mapping north-west of this building. |
| **1933**<br>*1:10,560* | As above | As above.<br>A small rectangular enclosure is marked in the field to the north of the site.<br>Pinhoe has developed to the south-east of the site.<br>The quarry 500m to the south-west has expanded and marked as Poltimore Brickworks. |
| **1938**<br>*1:10,560* | As above. | Generally as above. |
| **1962-1963**<br>*1:10,000* | As above. | Generally as above.<br>Pinhoe has developed significantly.<br>The quarry 500m to the south-west has expanded and marked as Works. |
| **1967**<br>*1:10,000* | As above. | Generally as above. |
| **1966-1967**<br>*1:1250* | As above. | Houses are now shown on Church Lane south of the site. |
| **1967-1968**<br>*1:2,500* | As above. | The small rectangular enclosure in the field to the east of the site has now gone. |

| Mapping Date | On-site | Off-site |
|---|---|---|
| **1970-1972**<br>*1:10,000* | As above. | Housing is shown along Church Hill south of the site.<br>Further housing is marked east of the site.<br>Home Farm 50m south-east has more buildings.<br>Pinhoe has developed significantly. |
| **1980**<br>*1:10,000* | As above. | Generally as above. |
| **1982**<br>*1:10,000* | As above. | Generally as above. |
| **1988**<br>*1:1,250* | As above. | Generally as above. |
| **1977-1990**<br>*1:1,250* | As above. | Generally as above. |
| **1991-1992**<br>*1:2,500* | As above. | Generally as above. |
| **1992-1993**<br>*1:10,000* | As above. | Generally as above. |
| **1994**<br>*1:2,500*<br>*1:1,250* | As above. | The field structure west/ south west of the site has changed. |
| **1999**<br>*1:10,000* | As above. | Generally as above. |
| **2006**<br>*1:10,000* | As above. | Generally as above. |
| **2020**<br>*1:10,000* | As above. | Generally as above. |

## 2.7 Environmental Database

An Envirocheck® report was generated on the 07th April 2020. The following table summarises the findings where more detail can be found within the Envirocheck report on the identified page numbers, see Appendix C:

| Data Type | Page Number | On Site | 0 to 250m | 251 to 500m | 501 to 1000m (*up to 2000m) |
|---|---|---|---|---|---|
| **Agency & Hydrological** | | | | | |
| BGS Groundwater Flooding Susceptibility | pg 1 | | | Yes | n/a |
| Contaminated Land Register Entries and Notices | | | | | |
| Discharge Consents | pg 1 | | 1 | 1 | 4 |
| Prosecutions Relating to Controlled Waters | | | n/a | n/a | n/a |
| Enforcement and Prohibition Notices | | | | | |
| Integrated Pollution Controls | | | | | |
| Integrated Pollution Prevention And Control | | | | | |
| Local Authority Integrated Pollution Prevention And Control | pg 2 | | | | 1 |
| Local Authority Pollution Prevention and Controls | pg 2 | | | | 4 |
| Local Authority Pollution Prevention and Control Enforcements | | | | | |
| Nearest Surface Water Feature | pg 3 | | Yes | | |
| Pollution Incidents to Controlled Waters | pg 3 | | | 3 | 31 |
| Substantiated Pollution Incident Register | | | | | |
| Water Abstractions | pg 9 | | 1 | 2 | 4 (*18) |
| Groundwater Vulnerability Map | pg 15 | Yes | n/a | n/a | n/a |
| Groundwater Vulnerability - Soluble Rock Risk | | | n/a | n/a | n/a |
| Bedrock Aquifer Designations | pg 16 | Yes | n/a | n/a | n/a |
| Superficial Aquifer Designations | | | n/a | n/a | n/a |
| Source Protection Zones | | | | | |
| Extreme Flooding from Rivers or Sea without Defences | | | | n/a | n/a |
| Flooding from Rivers or Sea without Defences | | | | n/a | n/a |
| Areas Benefiting from Flood Defences | | | | n/a | n/a |
| Flood Water Storage Areas | | | | n/a | n/a |
| Flood Defences | | | | n/a | n/a |
| OS Water Network Lines | pg 16 | | 8 | 17 | 86 |

Observations:

- One Discharge Consent within 250m: 168m south-east at Home Farm.
- One Abstraction within 250m: 238m north-west at Home Farm - tapped spring.
- Three Pollution Incidents to Controlled Waters within 500m, the closest is 302m south-west relating to a Storm Water Discharge at the former Pinhoe Quarry

| Data Type | Page Number | On Site | 0 to 250m | 251 to 500m | 501 to 1000m (*up to 2000m) |
|---|---|---|---|---|---|
| **Waste** | | | | | |
| BGS Recorded Landfill Sites | | | | | |
| Historical Landfill Sites | pg 29 | | | 1 | 1 |
| Integrated Pollution Control Registered Waste Sites | | | | | |
| Licensed Waste Management Facilities (Landfill Boundaries) | | | | | |
| Licensed Waste Management Facilities (Locations) | pg 29 | | | 1 | 1 |
| Local Authority Landfill Coverage | | 2 | n/a | n/a | n/a |
| Local Authority Recorded Landfill Sites | pg 30 | | | 1 | |
| Potentially Infilled Land (Non-Water) | pg 30 | | | 1 | |
| Potentially Infilled Land (Water) | pg 30 | | | 1 | |
| Registered Landfill Sites | pg 30 | | | | 1 |
| Registered Waste Transfer Sites | | | | | |
| Registered Waste Treatment or Disposal Sites | | | | | |

Observations:

- One Historical Landfill Sites within 500m; 491m south-west – Deposited Waste included Inert Waste (site now redeveloped)
- One Licensed Waste Management Facilities within 500m; 434m south-west – Pinhoe Factory, Tarmac Bricks & Tiles Ltd - licence surrendered, ( site now redeveloped).
- One Local Authority Recorded Landfill Sites within 500m; 496m south-west – Ibstock Bricks Ltd, marked as closed (site now redeveloped).
- One Potentially Infilled Land (Non-Water) within 500m; 476m south-west of Unknown Filled Ground (site now redeveloped).

- One Potentially Infilled Land (Water) within 500m; 468m S of Unknown Filled Ground.

| Data Type | Page Number | On Site | 0 to 250m | 251 to 500m | 501 to 1000m (*up to 2000m) |
|---|---|---|---|---|---|
| **Geological** | | | | | |
| BGS 1:625,000 Solid Geology | pg 31 | Yes | n/a | n/a | n/a |
| BGS Estimated Soil Chemistry | pg 31 | Yes | | Yes | Yes |
| BGS Recorded Mineral Sites | pg 32 | | | 1 | 1 |
| BGS Urban Soil Chemistry | | | | | |
| BGS Urban Soil Chemistry Averages | | | | | |
| CBSCB Compensation District | | | n/a | n/a | n/a |
| Coal Mining Affected Areas | | | n/a | n/a | n/a |
| Mining Instability | | | n/a | n/a | n/a |
| Man-Made Mining Cavities | | | | | |
| Natural Cavities | | | | | |
| Non Coal Mining Areas of Great Britain | pg 32 | Yes | | n/a | n/a |
| Potential for Collapsible Ground Stability Hazards | pg 33 | Yes | | n/a | n/a |
| Potential for Compressible Ground Stability Hazards | | | | n/a | n/a |
| Potential for Ground Dissolution Stability Hazards | | | | n/a | n/a |
| Potential for Landslide Ground Stability Hazards | pg 33 | Yes | Yes | n/a | n/a |
| Potential for Running Sand Ground Stability Hazards | | | | n/a | n/a |
| Potential for Shrinking or Swelling Clay Ground Stability Hazards | pg 33 | Yes | | n/a | n/a |
| Radon Potential - Radon Affected Areas | | | n/a | n/a | n/a |
| Radon Potential - Radon Protection Measures | | | n/a | n/a | n/a |

Observations:

- One BGS Recorded Mineral Site within 500m; 331m west at Pinhoe Quarry – Status: Ceased
- Radon Potential – Radon Affected Areas; site is in the Lower probability radon area.

| Data Type | Page Number | On Site | 0 to 250m | 251 to 500m | 501 to 1000m (*up to 2000m) |
|---|---|---|---|---|---|
| **Industrial Land Use** | | | | | |
| Contemporary Trade Directory Entries | pg 34 | | 1 | 1 | 77 |
| Fuel Station Entries | pg 40 | | | | 2 |
| Points of Interest - Commercial Services | pg 40 | | | | 32 |
| Points of Interest - Education and Health | | | | | |
| Points of Interest - Manufacturing and Production | pg 43 | | | 2 | 19 |
| Points of Interest - Public Infrastructure | pg 45 | | | | 5 |
| Points of Interest - Recreational and Environmental | pg 45 | | | 2 | 6 |
| Gas Pipelines | | | | | |
| Underground Electrical Cables | | | | | |

Observations:

- Two Contemporary Trade Directory Entries within 500m; 187m east named Lusal Rocking Horses – Inactive, and 466m south-east named Ceramics Restored Porcelain Restoration.
- Two Points of Interest - Manufacturing and Production within 500m; 309m and 499m south-west for Clay Pit (site now redeveloped).

| Data Type | Page Number | On Site | 0 to 250m | 251 to 500m | 501 to 1000m (*up to 2000m) |
|---|---|---|---|---|---|
| **Sensitive Land Use** | | | | | |
| Ancient Woodland | pg 47 | | | | 2 |
| Areas of Adopted Green Belt | | | | | |
| Areas of Unadopted Green Belt | | | | | |
| Areas of Outstanding Natural Beauty | | | | | |
| Environmentally Sensitive Areas | | | | | |
| Forest Parks | | | | | |
| Local Nature Reserves | | | | | |
| Marine Nature Reserves | | | | | |
| National Nature Reserves | | | | | |
| National Parks | | | | | |
| Nitrate Sensitive Areas | | | | | |
| Nitrate Vulnerable Zones | pg 47 | 1 | | 1 | |
| Ramsar Sites | | | | | |
| Sites of Special Scientific Interest | | | | | |
| Special Areas of Conservation | | | | | |
| Special Protection Areas | | | | | |
| World Heritage Sites | | | | | |

Observations:

- Site located in an area of Nitrate Vulnerable Zone on-site for surface water.
- Nearest Ancient Woodland 787m north.

The following table summarises the observations from the available Envirocheck data regarding potential sources of contamination:

| Data | Description |
|---|---|
| Contaminated land entries | None recorded within 1000m |
| Pollution Incidents | Three within 500m, closest 302m (south-west) caused by Storm Water Discharge |
| Landfills | One Historical Landfill within 500m: 491m (south-west) for Deposited Waste included Inert Waste (site now redeveloped)<br>One Local Authority Recorded Landfill Site within 500m: 496m (south-west) for Ibstock Bricks Ltd, Status: Closed (site now redeveloped) |
| Infilled land | Potentially Infilled Land (Non-Water) 476m (south-west) (site now redeveloped)<br>Potentially Infilled Land (Water) 468m (south) |
| Fuel Stations | Two within 1000m, closest 561m (SE) |
| Contemporary Trades | Two within 500m, closest active is 466m (south-east) Classification: Antiques – Repairing & Restoring |
| BGS Mineral Sites<br>*(Potentially infilled land)* | Two within 1000m, 331m (west) and 622m (south-west) |

The following table summarises the observations from the available Envirocheck data regarding potential migration pathways:

| Data | Description |
|---|---|
| Superficial Geology | None recorded |
| Bedrock Geology | Crackington Formation |
| Aquifer Status | Secondary Aquifer A |
| Mining | None recorded within 250m |
| Watercourses | Closest is a stream 126m (south-west) |
| Dissolution Features | None recorded |

The following table summarises the observations from the available Envirocheck data regarding potential receptors:

| Data | Description |
|---|---|
| Source Protections Zones | None recorded within 1000m |
| Surface Water Features | Closest is 125m (south-west) |
| Abstractions | Three within 500m: 238m (north-west) and 330m (north-west) for General Farming and Domestic and 478m (east) for Other Industrial/ Commercial/ Public Services |
| Environmentally Sensitive Areas | Nitrate Vulnerable Zone on site<br>Closest Ancient Woodland 787m (north) |

The following table summarises the observations from the available Envirocheck data regarding potential geotechnical hazards:

| Data | Description |
|---|---|
| Mineral sites | Two within 1000m, 331m (west) and 622m (south-west) |
| Ground Stability | Potential for Collapsible Ground Stability Hazards: Very Low<br>Potential for Compressible Ground Stability Hazards: Very Low<br>Potential for Landslide Ground Stability Hazards: Low |
| Running Sand etc | Potential for Running Sand Ground Stability Hazards: No Hazard |
| Landfills | No landfill sites recorded within 250m of the site. |
| Dissolution Features | Potential for Ground Dissolution Stability Hazards: No Hazard |
| Mining | None recorded within 1000m |

## 2.8 Radon

Building Regulations Approved Document C – "site preparation and resistance to contaminants and moisture", 2004 edition incorporating 2010 and 2013 amendments provides guidance on Radon.

*Section 2.40 Guidance on whether an area is susceptible to radon, and appropriate protective measures can be obtained from BRE Report BR 211. The maps in BR 211 are based on the indicative atlas published by Public Health England (formerly Health Protection Agency) and the British Geological Survey.*

*BR 211 provides guidance on basic radon protective measures appropriate in areas where 3% to 10% of homes, and full radon protective measures in areas where more than 10% of homes are predicted to have radon at or above the Radon Action Level of 200Bq/m$^3$.*

The British Geological Survey Open Report IR/11/044 User Guide for the HPA-BGS Joint Radon Potential Dataset for Great Britain provides Model Questions and Answers.

*4.1 Radon Affected Area*

*Question:*

*Is the property in a radon affected area as defined by the Health Protection Agency (Now Public Health England PHE) and if so what percentage of homes are estimated to be above the Action Level?*

*Answer:*

| Radon Potential Class* | Is the property in a Radon Affected Area? | Additional Information |
|---|---|---|
| 1 | No | The property is in a Lower probability radon area (less than 1% of homes are estimated to be at or above the Action Level). The property is not in a radon affected area. |
| 2 | Yes | The property is in an Intermediate probability radon area (1 to 3% of homes are estimated to be at or above the Action Level). The property is in a radon affected area. |
| 3 | Yes | The property is in an Intermediate probability radon area (3 to 5% of homes are estimated to be at or above the Action Level). The property is in a radon affected area. |
| 4 | Yes | The property is in an Intermediate probability radon area (5 to 10% of homes are estimated to be at or above the Action Level). The property is in a radon affected area. |
| 5 | Yes | The property is in a Higher probability radon area (10 to 30% of homes are estimated to be at or above the Action Level). The property is in a radon affected area. |
| 6 | Yes | The property is in a Higher probability radon area (10 to 30% of homes are estimated to be at or above the Action Level). The property is in a radon affected area. |

*The Radon Potential Class number should not be included in answers.

*Radon affected areas are defined by Public Health England (PHE). PHE recommends a radon 'Action Level of 200 becquerels per cubic metre of air for the annual average of the radon gas concentration in a home. Where 1% or more of homes are estimated to exceed the Action Level (i.e. in an intermediate or Higher probability radon area) the area should be regarded as a Radon Affected Area. PHE advises that radon gas should be measured in all properties within radon Affected Areas and that homes with radon levels above the Action Level should be remediated.*

The BGS geo-report typically advises the following: *If you are buying a new build property in a radon Affected Area, you should ask the builder whether radon protective measures were incorporated in the construction of the property.*

*4.2 Radon Protective Measures*

*Question:*

*England and Wales: Is the property in an area where radon protective measures are required for new buildings or extension to existing ones as described in publication BR211 (2015 edition)?*

*Answers:*

| *Radon Potential Class** | *What level of radon protective measures are required for new buildings in England and Wales?* |
|---|---|
| *1* | *None*** |
| *2* | *None*** |
| *3* | *Basic* |
| *4* | *Basic* |
| *5* | *Full* |
| *6* | *Full* |

**The Radon Potential Class number should not be included in answers.*
***in 2008 HPA recommended that building regulations be amended to ensure that all new buildings, extension etc. include basic radon protective measures. At the time of writing, relevant UK authorities were considering this advice.*

*Guidance:*

*When extensions are made to existing buildings in high radon areas or new buildings are constructed in these areas the Building Regulation for England, Wales and Scotland require that protective measures are taken against radon entering the building.*

*The reports will provide information on whether radon protective measures are required. Depending on the probability of buildings having high radon levels, the Regulations may require either:*

1. *No protective measures*
2. *Basic protective measures*
3. *Full protective measures*

The Envirocheck Report includes source information from the British Geological Survey, National Geoscience Information Service for Radon Potential as copied in the following two tables:

"Requirement for radon protective measures" and "is the property in a radon affected area?"

Envirocheck Report Reference Order Number 240580021_1_1 7th April 2020.

| Are Radon protection measures considered necessary in the construction of new dwellings and extensions? | The estimated probability of the property being above the Action Level for radon is: | Percentage (%) | Distance from site (m) |
|---|---|---|---|
| No | Lower | <1 | 0 |

The Landmark Envirocheck report data included within the desk study information, states that no radon protective measures are required in the construction of new dwellings or extensions at this site.

*The BGS determination follows advice in BR211 Radon: Guidance on protective measures for new buildings (2015 edition), which also provides guidance on what to do if the result indicates that protective measures are required. BR 211 Section 5 Protective measures: technical approach.*

*5.1 Basic radon protection*

*National Building Regulations require protection against moisture from the ground. In some ground floor constructions this protection comprises a barrier laid within the floor or solum construction, which is linked to a damp-proof course (DPC) within the walls of the building. To provide protection from radon, the DPC to a cavity wall should be in the form of a cavity tray to prevent radon entering the building though the cavity. Sealing of joints in the barrier and sealing around service penetrations are also required. It is important that attention is paid to detailing and workmanship in joint of the barrier.*

*If good standards of design and workmanship are applied to the provision of a 1200 gauge damp-proof barrier to the floor sealed to a DPC/ cavity tray through the walls,*

*adequate protection from radon will be provided along with the general function of excluding moisture. However, in areas with higher levels of radon, the additional measures described in Section 5.2 (BR 211) ' Full radon protection, will be required.*

The guidance indicates a residual risk in the intermediate probability zone 1-3% Radon Affected Areas, where radon monitoring of existing buildings is recommended by PHE and remedial measures implemented where the radon levels are above the Action Level (200Bq/$m^3$ ), however, new build does not require basic radon protection measures until such time as radon monitoring indicates the requirement for remedial measures which are likely to be more complex to retrofit than install basic protection measures during the construction. A precautionary approach might therefore include the following:

- Moisture protection DPM 1200 gauge (normal), taped and sealed (additional).
- Sub-floor void below suspended ground floor slab with ventilation to minimum Building Regulations (normal).

DPC connected to DPM (normal) to include cavity tray (additional

## 2.9 Utility Service Providers

The following table lists the standard searches undertaken. It should be noted that other service providers and/ or private infrastructure may be present and not included within the table below.

| Type | Provider | Description |
|---|---|---|
| Telecoms | BT Openreach | A pole is located halfway along the north-east boundary of the site. |
| Water supply / foul drainage | South West Water | **A mains water pipe runs just inside the south-west boundary of the site closest to Church Hill.** |
| | Unknown | A potential land drain has been noted during the walkover survey as evidenced by a linear depression in the field. Private water supplies and drains associated with the farm are unknown. |
| Electricity | Western Power Distribution | 11kV overhead lines go from the north point of the south boundary to halfway along the north-east boundary of the site where another pole is located. |
| | Unknown | Private supplies associated with the farm are unknown. |
| Gas | Wales & West Utilities | None marked on site |

Data returns from the companies consulted are included in Appendix E. It should be noted that services data is liable to change and consequently the information obtained provides a snapshot of the records at the time of enquiry.

## 2.10 Unexploded Ordnance (UXO)

The potential for buried unexploded ordnance (UXO) on any given site presents uncertainty. The site history and location may provide an indication of the degree of risk. A separate UXO desk study would provide an expert view on this area of uncertainty. This would provide pre-construction information necessary under CDM.

| Site Specific Risk Perception | Yes / No |
|---|---|
| From our knowledge of the underlying geology, historic mapping and site history the ground investigation methods proposed indicate a commonly acceptable level of risk.<br>For example: head deposits over rock in an agricultural setting or where housing or buildings were present prior to 1940s and continue largely unchanged on post-war mapping | Yes |
| From our knowledge of the underlying geology, historic mapping and site history the level of risk indicates the requirement for specialist assessment prior to intrusive ground investigation<br>For example: alluvial soils in proximity to potential wartime targets such as railways, factories, military establishments or densely populated areas or, where changes in pre versus post-war mapping are apparent | No |

The above table is based on the knowledge available at the time of the ground investigation and is a judgement based on our perception of the conditions.

## 2.11 Mining

The potential for mining features on any given site presents uncertainty. The site history and location may provide an indication of the degree of risk. A separate archive mining desk study would provide an expert view on this area of uncertainty. This would provide pre-construction information necessary under CDM.

| Site Specific Risk Perception | Yes / No |
|---|---|
| From our knowledge of the underlying geology, historic mapping and site history the ground investigation methods proposed indicate a commonly acceptable level of risk. | Yes |
| From our knowledge of the underlying geology, historic mapping and site history the level of risk indicates the requirement for specialist assessment prior to intrusive ground investigation | No |

The above table is based on the knowledge available at the time of the ground investigation and is a judgement based on our perception of the conditions.

## 2.12 Previous Ground Investigations

Geo Consulting Engineering Ltd has previously undertaken a Phase 1 Desk Study and Phase 2 Site Investigation for the wider Home Farm development for Waddeton Park Ltd/ R B Nelder Trust. Report: GCE00240/R1. The area incorporated in this report was included in the initial report although no site investigation work was undertaken in the area.

# 3.0 PRELIMINARY CONCEPTUAL MODEL

## 3.1 Introduction

The site characterisation attempts to identify potential previous and existing site sources of contamination. The conceptual model links the identified sources likely to cause significant possibility of significant harm via pathways to identified critical receptors. The conceptual model is therefore based on a number of identified source-pathway-receptor scenarios. For land to be classified as contaminated a significant pollutant linkage will need to be identified which will include each component of the conceptual model. The absence or removal of a source or interception of a pathway will 'break' the pollutant linkage.

The conceptual model is characterised by identification of the following:

- On-site sources which may impact on-site receptors via plausible pathways
- On-site source which may impact off-site receptors via plausible pathways
- Off-site sources which may impact on-site receptors via plausible pathways

Potential change of land use will require assessment of the new site development layout within the context of introducing new exposure pathways. The planning regime may require assessment of the site to ensure the new development will not be classed as contaminated land under the definition provided by the Part 2A of the Environment Act 1990 as defined in the Environment Protection Act 1995.

Guidance issued in April 2012 provides four categories of land. New development will aim to be within Category Four where the potential risk of land contamination is assessed to be low or to not exist.

**Normal Presence of Contaminants**

The revised Statutory Guidance for Part 2A of the Environmental Protection Act 1990 came into force in April 2012. This provides the following:

*3.21 The Part 2A regime was introduced to help identify and deal with land which poses an unacceptable level of risk. It is not intended to apply to land with levels of contaminants in soil that are commonplace and widespread throughout England or parts of it, and for which in the very large majority of cases there is no reason to consider that there is an unacceptable risk.*

*3.22 Normal levels of contaminants in soil should not be considered to cause land to qualify as contaminated land, unless there is particular reason to consider otherwise. Therefore, if it is established that land is at or close to normal levels of particular contaminants, it should usually not be considered further in relation to the Part 2A regime and the local authority should have regard to paragraphs 5.2 and 5.4 of this Guidance.*

*3.23 For the purpose of this Guidance, 'normal' levels of contaminants in soil may result from:*

*a) The natural presence of contaminants (e.g. caused by soil formation processes and underlying geology) at levels that might reasonably be considered typical on a given area and have not been shown to pose an unacceptable risk to health or the environment.*

*b) The presence of contaminants caused by low level diffuse pollution, and common human activity other than specific industrial processes. For example, this would include diffuse pollution caused by historic use of leaded petrol and the presence of benzo(a)pyrene from vehicle exhausts, and the spreading of domestic ash in garden at levels that might reasonably be considered typical.*

**The Use of Generic Assessment Criteria**

The revised Statutory Guidance for Part 2A of the Environmental Protection Act 1990 that came into force in April 2012 further provides:

*3.27. It is common practice in contaminated land risk assessment to use generic assessment criteria (Soil Guideline Values SGV) (GACs) as screening tools in generic quantitative risk assessment to help assessors decide when land can be excluded from the need for further inspection and assessment, or when further work may be warranted.*

*3.29. GACs relating to human health risk assessment represent cautious estimates of levels of contaminants in soil at which there is considered to be no risk or, at most, a minimal risk to health. With regard to such GACs:*

*a) They may be used to indicate when land is very unlikely to pose a significant possibility of significant harm to human health. This is on the basis that they are designed to estimate levels of contamination at which risks are likely to be negligible or minimal and far from posing a significant possibility of significant harm.*

*b) They should not be used as direct indicators of whether a significant possibility of significant harm to health may exist. Also, the local authority should not view the degree by which the GACs are exceeded (in itself) as being particularly relevant to this consideration, given that the degree of risk posed by land would normally depend on many factors other than simply the amount of contaminants in soil.*

*c) They should not be seen as screening levels which describe the boundary between Categories 3 and 4 in terms of Section 4 (i.e. the two Categories in which land would not be contaminated land on grounds of risks to human health). In the very large majority of cases, these SGVs/GACs describe levels of contamination from which risks should be considered to be comfortably within Category 4.*

*d) They should not be viewed as indicators of levels of contamination above which detailed risk assessment would automatically be required under Part 2A.*

*e) They should not be used as generic remediation targets under the Part 2A regime. Nor should they be used in this way under the planning system, for example in relation*

*to ensuring that land affected by contamination does not meet the Part 2A definition of contaminated land after it has been developed.*

**Categories of Contaminated Land**

There are four categories of contaminated Land. The NHBC summarise these as follows:

Category 1 – Land where it is clear that there is a significant possibility of significant harm to human health, and intervention under Part 2A is required.

Category 2 – Land where there is a considerable concern that there may be a significant possibility of significant harm to human health and there is a strong case for a precautionary action or intervention being taken under Part 2A.

Category 3 – Land where there may be a possibility of harm to human health but this is not significant, and regulatory intervention under Part 2A is not warranted, but those affected could consider civil action.

Category 4 – Land which should not pose a measurable risk to human health.

New screening values will be required to determine the boundary of Category 4 land. These are likely to be higher than current screening SGV/GAC values.

The same categories apply to potential pollution of controlled waters.

***Source***

The sources are divided into primary and secondary. The primary source is defined as the generic land use and the secondary source is the likely constituents of concern relating to the primary source, which may be affecting the soil, groundwater or soil gas.

***Pathways***

Migration pathways requiring consideration may include:

- Wind-blown dust
- Vapour phase/ground gas migration through the unsaturated zone
- Dissolved phase migration within groundwater
- Light non-aqueous phase migration on surface of groundwater
- Dense non-aqueous phase migration

Exposure pathways requiring consideration may include:

- Soil and indoor dust ingestion
- Home-grown vegetable consumption
- Indoor and Outdoor inhalation of dust
- Indoor and Outdoor inhalation of vapours
- Indoor and Outdoor dermal contact
- Leaching of mobile contaminants to groundwater/freshwater
- Permeation through water supply pipes

***Receptors***

The potential receptors are identified as follows:

- Human beings (construction workers, future site users)
- Groundwater (Controlled Waters)
- Eco-systems
- Building fabric

## 3.2 On-site to On-site

The historical data review indicates that the site has been in agricultural use since the first available mapping of 1888.

The agricultural land use is likely to have resulted in ploughing the fields. This may have included the additional of soil improvers such as ash and lime. It is normal to find the occasional anthropogenic materials within the ploughed soils. Stubble burning may have resulted in ash with low levels of metals and PAHs.

In addition to physical soil additives and burning, the historical use of pesticides and herbicides, may have left traces of chemical contamination within the near surface.

Minor localised spills from farm machinery is possible and field tracks may have been improved with imported materials of unknown provenance, particularly at field gates. Localised burial of farm waste is sometimes encountered. The localised nature of these possible activities is difficult to target and rule out until the end of the construction process.

The disturbed upper layers of ploughed soil may contain anthropogenic materials and may have been subject to stubble burning and therefore the process of investigation is

required to confirm that the site is acceptable for the proposed change of use. The following generic soil analysis is recommended to confirm the anticipated acceptability of the soils:

- Metals/ metalloids
- Sulphates and pH
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Petroleum Hydrocarbons
- Total Organic Carbon
- Asbestos

Made Ground

Made Ground may be present on site which may include infilled farm tracks and fly tipped materials.

The preliminary source-pathway-receptor conceptual site model for on-site sources is presented within Appendix D.

### 3.3 On-site to Off-site

The potential on-site sources are identified in Section 3.2.

| On-site to off-site Risk Perception | Yes / No |
|---|---|
| From our knowledge of the underlying geology, historic mapping and site history the likelihood of on-site potential contaminants impacting off-site potential receptors is low and does not warrant further investigation. | Yes |
| From our knowledge of the underlying geology, historic mapping and site history the likelihood of on-site potential contaminants impacting off-site potential receptors exists and therefore further investigation is required. | No |

### 3.4 Off-site to On-site

The dominant land use surrounding the site is agriculture and residential development, neither of which pose significant risk of off-site to on-site pollutant migration. No historic landfill sites, BGS mineral sites or infilled land were recorded within 250m of the site.

## 4.0 GEOTECHNICAL HAZARD IDENTIFICATION

The following geotechnical hazards have been identified from the preliminary sources reviewed:

| Hazard | Consequence | Location |
|---|---|---|
| Made Ground | Inadequate strength and settlement characteristics, inherent variability. Unsuitable for foundation/infrastructure placement. | May be present on site relating to historical agricultural activities – typically local to gateways. |
| Head deposits of fine-grained soils | Plastic soils with volume change potential resulting in seasonal shrink and swell. | Potential to be present across much of the site within the near surface. |
| Sub-surface water | Requirement for land drainage, risk of localised running sand | May be present site wide. |
| Shallow groundwater | Excavation instability, low bearing capacity due to reduced effective stress | May be present site wide. |
| Variable depth to competent bearing stratum. | Abnormal foundation conditions. | May be present site wide. |
| Sloping ground | Potential need for retaining structures, earthworks cut and fill | Site slopes in the order of 7% to 8% from north to south. |
| Existing and Proposed Trees | Water demand may result in volume change of fine-grained low permeability soils. | Large trees identified in field boundaries. |
| Existing buildings and infrastructure | Buried obstructions, may limit access for investigation | Overhead power lines crossing the site. **Water main on site near the south-west boundary.** |
| Soft ground | Possible increased foundation depth | May be present site wide. |
| Low permeability strata | Soakaway drainage not viable. | May be present site wide. |
| Sulphatic deposits in underlying natural geology | Aggressive conditions for buried concrete | May be present site wide. |

The attached Figure 2 Site Layout details the locations of the above hazards where they are not found site-wide.

## 5.0 INTRUSIVE INVESTIGATION

The following table summarises the ground investigation methods:

| Method | Detail | Remarks |
|---|---|---|
| Exploratory hole locations and methods | Investigation and infiltration test locations spread across the site. | Specific limitations include:<br>- Overhead and buried services<br>See Appendix E – Investigation Methods. |
| Trial Pitting | *18th August 2020 – one day*<br>Nine trial pits excavated to between 2.4-3.2mbgl. Trial pits evenly spaced across the site. | See Appendix F – Trial Pit Records |
| Large Scale Infiltration Testing | *18th – 20th August 2020 – three days*<br>Four infiltration tests in TP101 – TP104 at depths of between 2.4 - 3.2mbgl. | See Appendix G – Infiltration Test Results |
| Groundwater monitoring wells | Four monitoring wells installed in TP101 – TP104 to depths of between 2.4 - 3.2m after infiltration tests had been completed. | All monitoring well installations comprised plain from ground level to 1mbgl and slotted pipe from 1mbgl to base, placed within backfilled trial pits. |
| Chemical analysis (soil) | Chemical testing on soil samples comprised:<br>- 8 No. Metals/ metalloids<br>- 8 No. pH soil<br>- 8 No. Asbestos identifications<br>- 8 No. Total Organic Carbon<br>- 8 No. Soluble and total Sulphate,<br>- 8 No. Polyaromatic Hydrocarbons<br>-8 No. Banded Total Petroleum Hydrocarbons (TPH) | See Appendix I – Chemical Analysis (soil) |
| Geotechnical testing | Geotechnical testing on soil samples comprised:<br>- 35 No. Moisture content<br>- 5 No. Liquid & Plastic Limits<br>- 3 No. BRE SD1 suite | See Appendix J – Geotechnical Analysis (soil) |
| Groundwater Monitoring | Twelve monthly visits to determine groundwater depth. Results up to November 2020 included in this report. | See Appendix H – Groundwater Monitoring results.<br><br>Results discussed in Sections 6.2. |

# 6.0 INVESTIGATION FINDINGS

## 6.1 Ground Conditions

The following tables summarise the ground conditions encountered within the exploratory holes:

| Stratum | Depth (mbgl) | | | | | | |
|---|---|---|---|---|---|---|---|
| | TP101 | TP102 | TP103 | TP104 | TP105 | TP106 | TP107 |
| Topsoil/subsoil | GL-0.10 | GL-0.15 | GL-0.10 | GL-0.10 | GL-0.10 | GL-0.10 | GL-0.30 |
| Firm- stiff slightly gravelly silty CLAY (Head) | | | | | 0.10-0.40 | | |
| Stiff slightly gravelly silty CLAY (Head) | 0.1-1.30 | 0.15-2.00 | 0.10-1.00 | 0.10-2.70 | 0.40-0.90 | 0.10-0.90 | 0.30-1.80 |
| Clayey GRAVEL (Head) | 1.30-2.10 | | 1.00-1.50 | | 0.90-1.80 | 0.90-1.40 | 1.80-2.00 |
| Mudstone SLATE/SHALE (Crackington Formation) | 2.10-3.10 | | 1.50-2.40 | 2.70-3.20 | 1.80-2.60 | 1.40-2.90 | 2.00-3.00 |
| Metamorphosed SILTSTONE and SANDSTONE (Crackington Formation) | | 2.00-2.40 | | | | | |

| Stratum | Depth (mbgl) | |
|---|---|---|
| | TP108 | TP109 |
| Topsoil/subsoil | GL-0.15 | GL-0.40 |
| Stiff slightly gravelly silty CLAY (Head) | 0.10-2.10 | 0.40-1.20 |
| GRAVEL (Head) | 2.10-2.50 | 1.20-2.10 |
| Mudstone SLATE/ SHALE (Crackington Formation) | 2.50-3.00 | 2.10-2.50 |

***Topsoil/Subsoil***

Typically encountered as *"Grass over brown, slightly sandy, slightly gravelly silty CLAY with rootlets".*

These materials are likely disturbed by agricultural ploughing, stubble burning and may contain localised anthropogenic materials.

**Clay (Head)**

Encountered in all trial pits to depths of between 0.9-2.70mbgl. Typically described as: "*Stiff, light brown, in places very closely to closely fissured, slightly gravelly silty CLAY*" Gravel comprises angular mudstone slate/shale and occasionally siltstone and sandstone. Consistency is described as stiff for all trial pits apart from TP105 from 0.10-0.40m where it is firm to stiff.

**Clayey Gravel (Head)**

Encountered in all trial pits, apart from TP102 and TP104, to depths of between 1.50-2.50mbgl. Typically described as: "*Angular GRAVEL sized platey red brown, occasionally stained black, mudstone slate/shale, with a little red brown silty clay*". Matrix content ranges from some to much. Seen in TP102 and TP105 with occasional cobble sized clasts of the same material.

**Mudstone/Shale (Crackington Formation)**

Encountered in all trial pits, apart from TP102, and typically described as: "*Extremely weak, medium grey, some red brown, occasionally stained black on fractures, very closely to closely fractured (typically 10-80mm) platey MUDSTONE SLATE/SHALE and metamorphosed SILTSTONE*". A smear of red brown clay between fractures is often noted. Predominant fractures noted to dip approximately 45° north in TP 103.

Encountered in TP106 from 1.40-2.50mbgl as: "*Extremely weak, medium grey and red brown, very closely to closely fractured, platey mudstone slate, altering to GRAVEL sized mudstone slate/shale, with a little red brown clay*".

**Siltstone and Sandstone (Crackington Formation)**

Encountered in TP102 and described as: "*Extremely weak to medium strong, grey and red brown, occasionally stained black on fractures, very closely to closely fractured (typically 20-100mm) metamorphosed SILTSTONE and SANDSTONE*".

Trial Pit Records are attached in Appendix F.

See Figure 3 for Trial Pit Locations.

## 6.2 Groundwater

The following tables detail the depth of any groundwater strikes made during the investigation as well as the results of the groundwater monitoring visits to date:

| Location | Base Depth of Well (mbgl) | Depth of Groundwater (mbgl) | | | | |
|---|---|---|---|---|---|---|
| | | Strike During Excavation | 25/08/2020 | 30/09/2020 | 29/10/2020 | 16/11/2020 |
| TP101 | 3.10 | No | 2.47 | 1.80 | 0.22 | 0.10 |
| TP102 | 2.40 | No | 2.33 | Dry | 0.94 | +0.09* |
| TP103 | 2.40 | No | Dry | Dry | Dry | Dry |
| TP104 | 3.20 | No | 2.92 | Dry | 2.56 | 0.14 |

* Artesian pressure

| Location | Ground Level (mAOD) | Level of Base of Well (mAOD) | Depth of Groundwater (mASD) | | | |
|---|---|---|---|---|---|---|
| | | | 25/08/2020 | 30/09/2020 | 29/10/2020 | 16/11/2020 |
| TP101 | 97.495 | 94.395 | 95.025 | 95.695 | 97.275 | 97.395 |
| TP102 | 90.595 | 88.195 | 88.265 | Dry | 89.655 | 90.685 |
| TP103 | 98.641 | 96.241 | Dry | Dry | Dry | Dry |
| TP104 | 87.836 | 84.636 | 84.916 | Dry | 85.276 | 87.696 |

The results suggest a hydraulic gradient from north-west to south-east.

TP102 shows an artesian groundwater recording on 16/11/2020.

TP103 is at the highest elevation of all the monitoring wells. Groundwater has been below 3.20mbgl on all visits so far.

Four monitoring visits have been undertaken to date. These have shown groundwater levels in TP101 from 2.47-0.10mbgl, TP102 >2.40mbgl to +0.09magl, TP103 >2.40mbgl, TP104 from 2.92 to 0.14mbgl.

It is noted that groundwater monitoring has only been undertaken during the months of August to November; therefore, it is considered likely that the highest groundwater levels have not yet been encountered. It is proposed to undertake groundwater monitoring on a monthly basis until summer 2021 to provide information on seasonal groundwater fluctuation beneath the site.

# 7.0 POTENTIALLY CONTAMINATED LAND ASSESSMENT

The assessment of potentially contaminated land is based on source-pathway-receptor pollutant linkages. The following source characterisation, based on the chemical analysis, provides a basis for assessing the significance of potential pollutant linkages.

## 7.1 Source Characterisation

### 7.1.1 Chemical Analysis – Soils

The Normal Background Concentrations (NBC) based on the principal domain and the LQM/CIEH Suitable for use levels (S4UL) values have been used to provide comparative screening values for residential development with home-grown produce. This provides a stringent first tier screening assessment. Results that exceed these levels require further assessment in relation to the site-specific conditions prior to determining whether a potential pollutant linkage exists.

The LQM/CIEH S4ULs are subject to 'Copyright Land Quality Management Limited reproduced with permission' Publication Number S4UL3432.

Eight soil samples were tested as follows.

| TP | TP101 | TP102 | TP102 | TP103 | TP104 | TP105 | TP109 | TP109 |
|---|---|---|---|---|---|---|---|---|
| Depth (mbgl) | 0.1 | 0.1 | 0.9 | 0.1 | 0.5 | 0.6 | 0.1 | 0.9 |
| Soil | Topsoil | Topsoil | Clay Head | Topsoil | Clay Head | Clay Head | Topsoil | Clay Head |

***Metals***

Eight soil samples collected from across the site were analysed for a generic suite of metals/ metalloids:

| Determinand | Number of samples >LOD | Minimum mg/kg | Maximum mg/kg | Max>NBC | Max>S4UL |
|---|---|---|---|---|---|
| Arsenic | 8 | 9.2 | 19 | No | No |
| Cadmium | 6 | 0.16 | 0.37 | No | No |
| Chromium | 8 | 26 | 48 | NA | No |
| Copper | 8 | 14 | 81 | Yes | No |
| Mercury | 4 | 0.13 | 0.32 | No | No |
| Nickel | 8 | 28 | 49 | Yes | No |
| Lead | 8 | 16 | 54 | No | NA |
| Selenium | 8 | 0.47 | 0.84 | NA | No |
| Zinc | 8 | 46 | 77 | NA | No |

One Copper result from TP104 at 0.50m indicates a result of 81mg/kg which is above the National Background Concentration of 62mg/kg but is well within the S4UL of 2400mg/kg.

Three Nickel results from TP102 at 0.90m, TP104 at 0.50m and TP109 at 0.10m are above the National Background Concentration of 42mg/kg but are all well within the S4UL of 130mg/kg.

The above table shows that none of the results exceeded the Suitable 4 Use Level (S4UL) guidance for residential properties with home grown produce and are therefore of no further concern.

***Banded Total Petroleum Hydrocarbons (TPH)***

Eight soil samples were analysed for banded TPH. All TPH chain lengths were either below the Limit of Detection (LoD) or below the S4UL in all samples tested and therefore of no further concern.

***Polycyclic Aromatic Hydrocarbons (PAHs)***

Eight samples were analysed for a suite of Polycyclic Aromatic Hydrocarbons. All determinands were either below the Limit of Detection (LoD) or below the S4UL in all samples tested and therefore of no further concern.

***Asbestos***

Eight soil samples were tested for the presence of asbestos and no asbestos was detected.

## 7.2 Pathways

The proposed residential end use will provide the following exposure pathways that are considered in the CLEA model for residential development with home-grown vegetable consumption and used to calculate the S4UL values.

- Soil and indoor dust ingestion
- Home-grown vegetable consumption
- Indoor and Outdoor inhalation of dust
- Indoor and Outdoor inhalation of vapours
- Indoor and Outdoor dermal contact

Additional pathways not included in the CLEA model include:

- Permeation through potable water supply pipes.
- Ingress of ground gas into confined spaces and buildings.
- Leaching of mobile contaminants to groundwater/ surface water

### 7.3 Receptors

The following receptors require consideration:

- Construction workers/ future site users/ off-site land users
- Property
- Controlled Waters and associated eco-systems

### 7.4 Pollutant Linkages

The site has been in agricultural use throughout the available mapping. No off-site potential sources were identified within 250m of the site.

The strata encountered on-site do not indicate that potential contaminants will be able to easily migrate to the site, due to the low permeability Head and weathered bedrock soils.

No significant linkages have been identified by the ground investigation, after chemical and geotechnical analysis of soils.

Unexpected Made Ground if encountered during the construction should be assessed separately.

### 7.5 Waste Assessment

The measured soil concentrations from the exploratory holes are classed as non-hazardous. Waste code EWC 17 05 04 may be assigned to waste soils arising from the site that are representative of the strata observed and tested for a generic soil suite. If any soils are to be taken to a landfill site the test results should be forwarded to the landfill site such that they can assess if they can accept the soils.

Topsoil by definition is not inert and as such should be re-used and is not suitable for disposal at an inert landfill site.

If any anomalous Made Ground is encountered during the construction phase this should be assessed separately.

# 8.0 GEOTECHNICAL ASSESSMENT AND RECOMMENDATIONS

## 8.1 Introduction

The British Geological Survey mapping indicates the site is underlain by interbedded sandstones and mudstones of the Crackington Formation.

Ground conditions encountered within the exploratory holes show a Head material of stiff clay over gravels over mudstone slate and metamorphosed siltstone with occasional metamorphosed sandstone.

Groundwater monitoring wells were installed in TP101 to TP104. The groundwater monitoring completed to date has shown groundwater rising to 0.14m bgl to +0.09m agl (artesian), TP103 was recorded as dry, with measured levels ranging from 87.6m to 97.3m AOD.

## 8.2 Geotechnical Test Results

*Plasticity Index*

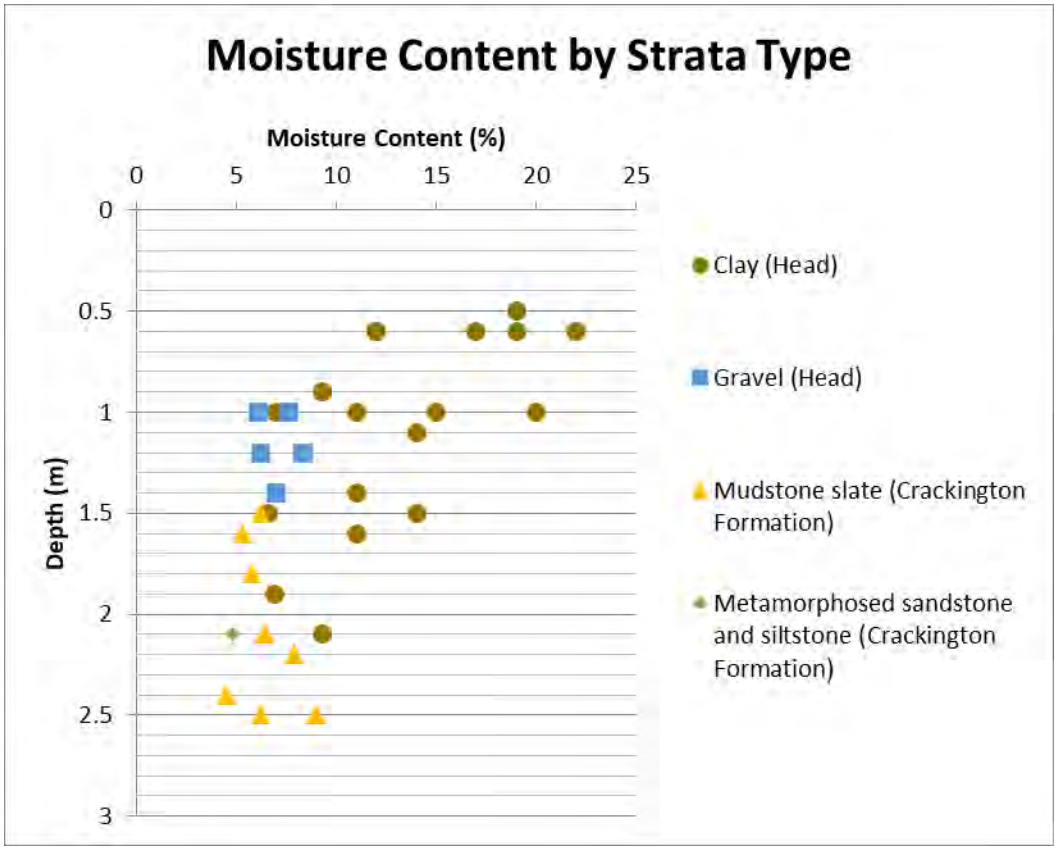
Five soil samples were tested for Plasticity Index (PI). The table below also provides the Liquid Limit (LL), Plastic Limit (PL), modified Plasticity Index, equivalent moisture content (We), and Consistency Index (CI):

| Location | Depth (m) | Stratum | Wn% | LL% | PL% | PI | %pass 0.425 | PI mod | We% | CI |
|---|---|---|---|---|---|---|---|---|---|---|
| TP101 | 0.6 | Clay Head | 22 | 70 | 17 | 53 | 100 | 53 | 22 | 0.91 |
| TP102 | 1 | Clay Head | 15 | 62 | 17 | 45 | 83 | 37 | 18 | 0.98 |
| TP104 | 1.4 | Clay Head | 11 | 28 | 16 | 12 | 84 | 10 | 13 | 1.24 |
| TP107 | 1.0 | Clay Head | 7 | 43 | 16 | 27 | 85 | 23 | 8 | 1.29 |
| TP109 | 0.6 | Clay Head | 19 | 67 | 17 | 50 | 86 | 43 | 22 | 0.90 |

The modified Plasticity Index indicates the silty clays vary from low to high volume change potential. The Consistency Index results confirm the stiff to very stiff field description. The Liquid Limit of the samples is variable, with values from 28% to 70%.

*Moisture Content*

Thirty-five soil samples were tested to determine their moisture content (Wn). The moisture content results are shown in the plot below which shows depth versus moisture content by stratum:




The above plot shows moisture content percentages ranged from 4.5% to 22%. There is a clear correlation in the clay strata of decreasing moisture content with depth. Moisture content within the gravel and Crackington Formation strata remains similar and does not appear to have any correlation with depth.

Overall, the results indicate that moisture content decreases with depth.

*BRE SD1 Suite*

Three samples were selected for BRE SD1 suite testing, the table below shows the results:

| Sample location | Depth (mbgl) | Stratum | pH | Acid Soluble Sulphate (%SO4) | Water Soluble Sulphate (g/lSO4) | Total Sulphur (%S) | Total Potential Sulphate (%SO4) | Oxidisable Sulphides (%SO4) |
|---|---|---|---|---|---|---|---|---|
| TP101 | 1.00 | Clay (Head) | 7.3 | 0.29 | 0.03 | 0.13 | 0.39 | 0.10 |
| TP103 | 1.00 | Gravel (Head) | 7.46 | 0.29 | 0.04 | 0.13 | 0.39 | 0.10 |
| TP109 | 0.60 | Clay (Head) | 7.39 | 0.27 | 0.05 | 0.12 | 0.36 | 0.09 |

The pH and Sulphate results indicate that buried concrete can be designed in accordance with design sulphate class DS-1 ACEC class AC1 of BRE Special Digest 1(2005), assuming mobile groundwater is present.

## 8.3 Geotechnical Risk Assessment

Risk classification and required action:

| Likelihood (L) | | Severity (S) | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | | Minor | Moderate | Serious | Major | Catastrophic |
| 1 | Extremely unlikely | 1 | 2 | 3 | 4 | 5 |
| 2 | Unlikely | 2 | 4 | 5 | 8 | 10 |
| 3 | Likely | 3 | 6 | 9 | 12 | 15 |
| 4 | Extremely likely | 4 | 8 | 12 | 16 | 20 |
| 5 | Almost certain | 5 | 10 | 15 | 20 | 25 |

| Potential severity of harm occurring | | |
|---|---|---|
| 1 | Minor | Minor damage or loss – (no human injury) |
| 2 | Moderate | Moderate damage or loss – (slight injury illness) |
| 3 | Serious | Substantial damage or loss – (serious injury or illness) |
| 4 | Major | Major damage or loss – (fatal injury) |
| 5 | Catastrophic | Catastrophic loss or damage – (Multiple fatalities) |

| Risk Classification | |
|---|---|
| Low (1-8) | Ensure assumed control measures are maintained and reviewed as necessary. |
| Medium (9-19) | Additional control measure needed to reduce risk rating to a level that is equivalent to a test of 'reasonably required' for |
| High (20-25) | Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable level. |

| Risk ID | Hazard | Consequence | L | S | R | Mitigation | L | S | Residual risk |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Shallow Groundwater | Foundation and service trenches inundated with groundwater | 4 | 4 | 16 | Pumping likely to be required from any trenches excavated on site.<br><br>Foundations trenches are likely to have to be excavated and concreted on the same day and not left open overnight. | 3 | 3 | 9 |
| 2 | Shallow Groundwater | Potential spring development and service trenches inundated with groundwater | 4 | 4 | 16 | Land drainage likely to be required on site and likely required around proposed houses due to very shallow groundwater recorded (artesian flows in TP102 at +0.09m).<br>Service trenches may act as preferential pathways for groundwater. Consideration will have to be given to draining the site starting at the lower end and working upslope, | 2 | 3 | 8 |
| 3 | Shallow Groundwater | Infiltration drainage features inundated with groundwater | 3 | 4 | 12 | Soakaways unlikely to be viable. | 2 | 3 | 6 |
| 4 | Clay strata with volume change potential. | Seasonal variation in moisture content resulting in shrink and swell of the soils within the moisture unstable zone, which is dependent on groundwater levels, vegetation and volume change potential of the clay strata and natural variability. | 3 | 4 | 12 | The modified Plasticity Index indicates low to high volume change potential.<br>Follow NHBC Chapter 4.2 in relation to building near trees and volume change potential. | 2 | 3 | 6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5 | Development on site changes groundwater flows on site and shallow groundwater and surface water is directed towards the cut slope down to Church Hill Road below/ down slope of the site. | Slope instability/ collapse of cut slope to road | 3 | 4 | 12 | Install land drains to prevent flow towards the cut slope.<br><br>The SWW water main is located along the south west boundary of the site and may be acting as a drain within the backfilled trench. | 2 | 3 | 6 |
| 6 | Existing land drainage at unknown locations. | Shallow groundwater conditions. Earthworks and construction works cut through established land drainage resulting in concentrated sub-surface water entering excavations or future development. | 3 | 4 | 12 | Land drainage to be identified when encountered during groundworks.<br>Provision for a simple land drainage system to be incorporated into the development scheme.. | 2 | 3 | 8 |
| 7 | Former hedge lines with deep roots and possible trees now removed. | Heave potential of moisture unstable soils to greater depths subject to water demand trees and species. | 3 | 4 | 12 | The modified Plasticity Index indicates low to high volume change potential.<br>Follow NHBC Chapter 4.2 in relation to building near trees and volume change potential.<br>Removal of roots and associated strata to greater depths. | 2 | 3 | 6 |
| 8 | Head deposits | Thicker deposits of unconsolidated strata with higher moisture contents and potential for settlement under additional applied stress. | 2 | 4 | 8 | Place trench fill foundations on competent stiff Clay Head. | 2 | 3 | 6 |

## 8.4 Excavations and Groundwater

The following table summarises the ground related hazards associated with excavation:

| Excavation depth | Ground condition | Ground Hazard | Groundwater depth range | Likely/ Possible / Unlikely | Mitigation |
|---|---|---|---|---|---|
| above GW | Unsaturated clay with fissures | Small localised failure possible with need to re-dig. | >1.5 | Possible | Consider benched excavation, trench fill or temporary shoring with trench box or similar if not backfilled quickly or if entry required. |
| above GW | Unsaturated sands/gravels with pockets of perched sub-surface water | Small localised failure probable with need to re-dig. | >1.5 | Possible | Consider benched excavation, trench fill or temporary shoring with trench box or similar if not backfilled quickly or if entry required. |
| below GW | Saturated clay with fissures. | Large failure and sidewall collapse possible. | <1.5 | Likely | Trench box required with sump pumping to control sub-surface water. |
| below GW | Unsaturated clay with fissures overlying water bearing sands or gravels | Large failure and sidewall collapse possible. Base heave, boiling or piping. | <1.5 | Possible | Re-design invert levels and foundation levels or use of pile foundations. Consider cut-off drainage and groundwater monitoring prior to excavations. Water pumping may result in loss of fines and subsidence. Trench box required with filter sump pumping to limit loss of fines. Base heave, boiling or piping requires consideration. |
| below GW | Water bearing sands or gravels | Large failure and sidewall collapse possible. Base heave, boiling or piping. | <1.5 | Possible | Re-design invert levels and foundation levels or use of pile foundations. Consider cut-off drainage and groundwater monitoring prior to excavations. Water pumping may result in loss of fines and subsidence. Trench box required with filter sump pumping to limit loss of fines |

Slight spalling was recorded in all trial pits.

The following tables detail groundwater observations during drilling and the four monitoring visits completed to date.

| Location | Base Depth of Well (mbgl) | Depth of Groundwater (mbgl) | | | | |
|---|---|---|---|---|---|---|
| | | Strike During Drilling? | 25/08/2020 | 30/09/2020 | 29/10/2020 | 16/11/2020 |
| TP101 | 3.10 | No | 2.47 | 1.80 | 0.22 | 0.10 |
| TP102 | 2.40 | No | 2.33 | Dry | 0.94 | +0.09* |
| TP103 | 2.40 | No | Dry | Dry | Dry | Dry |
| TP104 | 3.20 | No | 2.92 | Dry | 2.56 | 0.14 |

* Artesian pressure

| Location | Ground Level (mAOD) | Level of Base of Well (mAOD) | Depth of Groundwater (mASD) | | | |
|---|---|---|---|---|---|---|
| | | | 25/08/2020 | 30/09/2020 | 29/10/2020 | 16/11/2020 |
| TP101 | 97.495 | 94.395 | 95.025 | 95.695 | 97.275 | 97.395 |
| TP102 | 90.595 | 88.195 | 88.265 | Dry | 89.655 | 90.685 |
| TP103 | 98.641 | 96.241 | Dry | Dry | Dry | Dry |
| TP104 | 87.836 | 84.636 | 84.916 | Dry | 85.276 | 87.696 |

Groundwater levels have risen significantly during the 4 months of monitoring and was recorded at very shallow depth and in TP102 was recorded an artisan groundwater, on 16/11/2020

Provision should be made for groundwater pumping due to the shallow groundwater observed during monitoring.

Further groundwater monitoring is scheduled to continue until summer 2021.

### 8.5 Foundations

The application of an increased load through foundations of a structure results in deformation of the ground and settlement. Foundation design should ensure that foundation movements are within limits that can be tolerated by the structure without impairing its function. Foundation movements occur from the application and removal of load and ground movement independent of load. The following conditions may result in movements resulting from the application or removal of load:

- Shear deformation and failure (EC7 Ultimate Limit State condition)
- Settlement (EC7 Serviceability Limit State condition)

Shear deformation and failure may be guarded against using the traditional methods by determining the ultimate bearing capacity and application of a factor of safety of between 2 and 3 to limit deformation.
Settlement may result from immediate elastic settlement and primary consolidation settlement and in some cases secondary settlement of fine grained low permeability strata, subject to the stress history. Differential settlement may result from non-uniform soil conditions, made ground or fill, peaty and organic soils and non-level sites. The magnitude of tolerable settlement defines the allowable bearing pressure and is therefore the value provided within the report.

Eurocode 7: Geotechnical design Part 1: General Rules (BS EN 1997-1:2004) provides the following:

- Principle rules (P) are general statement and definitions for which there is no alterative; requirements and analytical models for which no alternative is permitted unless specifically stated.
- Application rules are examples of generally recognised rules, which follow the principles and satisfy their requirements.
- EC7 design requirements: P for each geotechnical design situation it shall be verified that no relevant limit state, as defined by EN 1990:2002, is exceeded.
- EC7 design situations: P Both short-term and long-term design situation shall be considered.
- EC7 Durability: P At the geotechnical design stage, the significance of environmental conditions shall be assessed in relation to durability and to enable provisions to be made for the protection or adequate resistance of materials.
- Geotechnical design by calculation: (1)P design by calculation shall be in accordance with the fundamental requirements of EN 1990:2002 and with the particular rules of the standard. (2) It should be considered that knowledge of the ground conditions depends on the extent and quality of the geotechnical investigations. Such knowledge and the control of workmanship are usually more significant to fulfilling the fundamental requirements than is precision in the calculation method.
- EC7 Actions: (1) P The definition of actions shall be taken from EN 1990:2002. The values of actions shall be taken from EN1991, where relevant. (2) P The values of geotechnical actions to be used shall be selected, since they are known before a calculation is performed; they may change during that calculation. (3) Any interaction between the structure and the ground shall be taken into account when determining the actions to be adopted in the design.
- EC7 Ground properties: (1) P Properties of soil and rock masses, as quantified for design calculation by geotechnical parameters, shall be obtained from test results, either directly or through correlation, theory or empiricism, and from other relevant data. (2) P Values obtained from test results and other data shall be interpreted appropriately for the limit state considered. (3) Account shall be

taken of the possible differences between the ground properties and the geotechnical parameters obtained from the test results and those governing the behaviour of the geotechnical structure. (6) Calibration factors shall be applied where necessary to convert laboratory or field test results according to EN 1997-2 into values that represent the behaviour of the soil and rock in the ground, for the actual limit state, or to take account of correlations used to obtain derived values from test results.

- EC7 Geometrical data: P The level and slope of the ground surface, water levels, levels of interfaces between strata, excavation levels and the dimensions of the geotechnical structure shall be treated as geometrical data.
- EC7 Characteristic Values of actions: (1) P Characteristic and representative values of actions shall be derived in accordance with EN 1990:2002 and the various parts of EN 1991.
- EC7 Characteristic values of geotechnical parameters: (1) P The selection of characteristic values for geotechnical parameters shall be based on results and derived values from laboratory and field tests, complemented by well established experience. (2) P The characteristic value of geotechnical parameter shall be selected as a cautious estimate of the value affecting the occurrence of the limit state. (12) When using standard tables of characteristic values related to soil investigation parameters, the characteristic value shall be selected as a very cautious estimate.

The following conditions influencing foundation design are independent of load:

| Condition | Yes/ No | Requirements |
|---|---|---|
| Seasonal volume change | Yes | Low to high volume change potential requiring a minimum founding depth of 1.00m where outside the influence of trees or bushes. |
| Building near trees | Yes | NHBC Chapter 4.2 Guidance should be followed. Selected and controlled planting would require minimum depth of 1.50m, deeper for adjacent medium to high water demand trees. |
| Frost Heave | Yes | Minimum construction depth 0.45m. |
| Application of artificial heat or cold to supporting ground | No | None. |
| Changes in groundwater level. | Yes | Groundwater monitoring has indicated variations in groundwater levels with groundwater rising to near ground level and artesian flows recorded in TP102. Allowance should be made for groundwater pumping. Further groundwater monitoring to be undertaken in wet winter months.<br>Land drainage to be required to prevent groundwater flooding.<br>It should be noted that service trenches may act as preferential pathways for groundwater. Consideration will have to be given to draining the site starting at the lower end and working upslope, |
| Loss of ground due to erosion (internal erosion) or solution by percolating water or pumping. | Unlikely | Soakaways unlikely to be deemed viable for the site. |
| Changes in state of stress due to adjacent structures, dredging, scour or erosion by streams or floods (loss of support) or due to erection of adjacent structures. | Yes | Foundations to be placed below adjacent service pipes, taking account of adjacent foundation stress zones. |

| Condition | Yes/ No | Requirements |
|---|---|---|
| Continuing settlement of natural deposits or fill | No | None. |
| Soil creep or landslides, ground sloping >1v:10h | No | Site slopes from north to south/ south-east, typically at 7-8 degrees. |
| Movement of ground resulting from sink or swallow holes or underground workings (including mining and tunnelling) | No | None. |
| Vibration including seismic disturbances | No | None. |
| Deterioration of Made Ground or fill | No | None. |
| Deterioration of the structure | Unlikely | BRE Special Digest 1 testing undertaken for buried concrete design. Mix design to be in accordance with SD1 recommendations where the ground has not been disturbed. |
| Alteration of the properties of the ground due to natural or artificial processes | No | None. |
| Coast erosion | No | None. |
| Existing foundations | No | None. |

## Foundation Options

The following table identifies typical foundation types and limitations:

| Foundation Type | Typical depth to bearing stratum (m) | Application | Limitations | Use at this site |
|---|---|---|---|---|
| Raft and Box | <1 | Limits applied stress to prevent excessive settlement. Shallow groundwater prevents deep excavation. | Construction time and costs increase due to detail for edge thickening, removal and replacement of volume change potential soils.<br>May require ground improvement. | Not required. |
| Shallow strip | <1 | Shallow competent ground of granular soils or weathered rock without volume change potential or on low volume change potential soils without trees. | Shallow groundwater, weak unstable or fissured ground resulting in collapse of excavation. | Unlikely to be used as foundations at least 1m deep due to high volume change potential of cohesive soils. |
| **Trench fill** | **1-2.5** | **Competent soils/ strata within 2.5m of construction depth, where excavation stand-up time allows excavation and inspection/ approval prior to pouring concrete.** | **Shallow groundwater, weak unstable or fissured ground resulting in collapse of excavation.<br>Installation of heave precautions.** | **Suitable across the site subject to groundwater levels at the time of construction.** |

| Foundation Type | Typical depth to bearing stratum (m) | Application | Limitations | Use at this site |
|---|---|---|---|---|
| Pile and beam | >2.5m | Weak/ loose/ soft and unstable ground combined with high groundwater near surface with little realistic potential for trench excavation/inspection/ approval of soils within upper 2.5m or where competent strata is >2.5m below the construction surface. | Pile construction method requires consideration of the actual ground conditions identified by boreholes | Not likely to be required. |

The following limitations are normally applied to the depth and selection of foundations:

- Foundation stratum should be continuous across the footprint of the building to minimise differential settlement.
- Foundation depth should be below adjacent service trenches for utilities and drainage.
- Foundation depth will be subject to volume change potential of soils combined with proximity of trees.

The site-specific ground conditions indicate the foundation types are limited to the following:

- Trench Fill foundations are anticipated to be appropriate across the site.

## Bearing Stratum and Allowable Bearing Capacity

The following table summarises the typical strata, characteristics and allowable bearing capacity:

| Strata | Example | Characteristics | Use as bearing stratum | Foundation construction requirements | Allowable Bearing Capacity | Site specific |
|---|---|---|---|---|---|---|
| Made Ground | Anthropogenic soils | Variable, unpredictable | Not recommended. | Excavation trench support, potential for contamination, unacceptable waste arisings. If deep consider pile foundations. | Not recommended. | Not encountered during the investigation. |
| Very soft, soft and soft to firm clay/silts | Alluvium/ Valley Head deposits | Very low (<10kPa); low strength 20-40kPa); soft-firm (40-50kPa) moderate to high compressibility, highly variable. May be overlain by unsaturated firm clays creating a risk of punching shear or consolidation settlement. | Not recommended without ground improvement. Raft or box foundation with ground improvement or no net load. | Excavation trench support, potential for shallow groundwater. If deep consider pile foundations. | Not recommended. Not encountered on site. | Not encountered during the investigation. |

| Strata | Example | Characteristics | Use as bearing stratum | Foundation construction requirements | Allowable Bearing Capacity | Site specific |
|---|---|---|---|---|---|---|
| Loose sands/silts/gravels | Alluvium/ Valley Head | Variable may contain soft clay/silt layers, running sand potential in combination with shallow or perched groundwater. | Technically feasible for shallow foundations above shallow groundwater where the absence of soft clay/silt or VCP soils can be verified. | Excavation trench support, potential for shallow groundwater. If deep consider pile foundations. | Not recommended. Subject to plot specific ground conditions and construction proposals. | Not encountered during the investigation. |
| Firm clays | Head deposits<br><br>Localised firm to stiff completely weathered mudstone. | Firm silty clays and slightly gravelly to gravelly clays exhibiting volume change potential, with minimum undrained shear strength of 50kPa. Potential for localised soft spots. May be underlain by soft compressible strata. | Depth subject to VCP and proximity and type of trees. | VCP and building near trees will determine foundation depth. Step detail required for localised soft spots. If underlain by soft compressible clays consider pile or raft. | Typical ABP = 100kPa*. This may be reduced to 60kPa for wider foundations <2m with layers of soft to firm clay.<br>Plot specific detail for raft foundations | Encountered locally at shallow depth during the investigation. Not recommended for founding strata. |

| Strata | Example | Characteristics | Use as bearing stratum | Foundation construction requirements | Allowable Bearing Capacity | Site specific |
|---|---|---|---|---|---|---|
| **Stiff and very stiff clays/silts** | **Head deposits/ completely weathered mudstone.** | **Stiff slightly gravelly/gravelly clays or silty clays. Stiff clays have a minimum undrained shear strength of clays 75kPa to maximum 150kPa. Very stiff clays 150-300kPa.** | **Depth subject to VCP and proximity and type of trees.** | **VCP and building near trees will determine foundation depth. Step detail required for localised soft spots.** | **Typical ABP = 125 to 150kPa*. Plot specific detail for raft foundations.** | **ABP of 125kPa. Encountered site wide.** |
| **Medium dense gravels** | **Granular Head** | **Low compressibility, potential for excavation side collapse in combination with shallow groundwater creating running sand.** | **Favourable above shallow groundwater where the absence of soft clay/silt or VCP soils can be verified.** | **Excavation trench support, potential for shallow groundwater.** | **ABP**=125kPa to 150kPa** | **ABP of 150kPa. Encountered site wide.** |
| Dense sand and gravel | As above | Low compressibility, potential for excavation side collapse in combination with shallow groundwater creating running sand. | Favourable above shallow groundwater where the absence of soft clay/silt or VCP soils can be verified. | Excavation trench support, potential for shallow groundwater. | ABP=150kPa to 250kPa | Not encountered during the investigation. |

| Strata | Example | Characteristics | Use as bearing stratum | Foundation construction requirements | Allowable Bearing Capacity | Site specific |
|---|---|---|---|---|---|---|
| **Weathered rock** | **Mudstone, shale** | **Argillaceous rock may weather to stiff clays exhibiting VCP.** | **Foundation stratum depth potentially variable due to differential weathering.** | **Differential weathering with variable depth and VCP soils. Localised hard spots may require breakout.** | **ABP*** range of 100kPa-250kPa, may increase in competent rock.** | **ABP of 150kPa. Encountered site wide at depth.** |
| Weathered rock | Slates/ meta-sandstones | Hard rock with little potential for volume change. | If shallow consider strip foundations, if deep may require pile with rock socket. | Variable depth due to differential weathering. Localised hard spots may require breakout. | ABP*** range of 250kPa – 300kPa, may increase in competent rock. | **ABP of 150kPa.** Encountered locally in TP102 during the investigation. |

* Subject to undrained shear strength, compressibility and foundation dimensions, Strip or trench 0.6m wide, 1m deep.

** Strip or trench fill foundations 1m deep <1m width, Allowable bearing pressure subject to relative density and effective stress.

*** Allowable bearing pressure subject to fracture frequency and degree of weathering.

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**Depth of Foundations**

NHBC Chapter 4.2 building near trees provides the following guidance regarding fine grained soils that exhibit volume change potential:

| Volume change potential | Modified Plasticity Index | Minimum foundation depth no trees | Minimum foundation depth with selected planting | Building near trees |
|---|---|---|---|---|
| **High** | **>40%** | **1** | **1.5** | **NHBC Chapter 4.2** |
| Medium | 20-40% | 0.9 | 1.25 | NHBC Chapter 4.2 |
| Low | 10-<20% | 0.75 | 1.0 | NHBC Chapter 4.2 |

The modified Plasticity Index of between 10% to 53% indicates low to high volume change potential and therefore a high volume potential should be adopted for design purposes with a site-wide minimum founding depth of 1.00m deepened accordingly in the vicinity of trees.

EC7 requirements include a Geotechnical Design Report, which should include the identification of supervision and monitoring.

## 8.6 Floor Slabs

The selection of ground bearing or suspended floor slabs will be subject to the proposed floor level of the particular plot relative to the original ground level. The requirements of the building regulations and NHBC should be satisfied in the selection of the ground floor slab.

The use of ground bearing floor slabs is possible in the following conditions:

- In-fill less than 600mm, this includes the backfilling of the foundation trench.

- Effect of sloping ground on the depth of in-fill is less than 600mm.
- Uniform non-shrinkable soils across entire area of floor slab.
- Non-frost susceptible soils within the upper 450mm.
- Topsoil and organic soils removed, including root penetrated sub-soils.
- Localised soft-spots and hard-spots removed to prevent differential settlement.
- No contaminated ground, water-logged ground or sulphates.
- Ground is unlikely to settle under the design floor loading.
- No radon protection measures required.
- No ground gas protection measures required.
- Where existing land-drains are captured and diverted to a suitable outfall.

The use of suspended floor slabs is recommended in the following conditions:

- Depth of in-fill, including backfilled foundation trench is equal to or more than 600mm.
- Relatively level site without the need for stepped floor construction.
- Soils exhibit Modified Plasticity of 10% or greater, requiring the adoption of the NHBC heave protection measures.
- Where frost susceptible soils exist.
- Where variable ground exists or potential for soft spots and/or hard spots creating either hogging or sagging ground.
- Where root penetration into the sub-soils is possible.
- Where shallow sub-surface water and/or groundwater is or could be present.
- Where contaminants and/or sulphates create potential for heave or expansive reactions.
- Where radon protection measures are required in combination with passive ventilation.
- Where ground gas protection measures require passive ventilation.
- Where moisture protection measures are required with passive ventilation.

- Where the design loading conditions indicate potential for ground movement and settlement of the bearing stratum.
- Where first time inundation of the placed and compacted fill could result in collapse settlement.

Suspended floor slabs are recommended due to the potential for volume change in the near surface clay soils, due to the presence of Head deposits and natural weathering of the underlying argillaceous geology encountered as weathered Mudstone/Shale.

The following table provides the NHBC recommended void dimensions for potential ground movement based on volume change potential of the fine-grained soils:

| **Volume change potential** | **Against side of foundation/ ground beam** | **Underground beam and suspended in-situ concrete ground floor** | **Pre-cast concrete and suspended timber floors** | **Drainage construction minimum allowance for potential movement** |
|---|---|---|---|---|
| | mm | mm | mm | mm |
| **High** | **35** | **150** | **300** | **150** |
| Medium | 25 | 100 | 250 | 100 |
| Low | 0 | 50 | 200 | 50 |

The modified Plasticity Index indicates the near surface soils are characterised as low to high volume change potential.

It is recommended, for planning and budgeting purposes, to assume suspended floor slabs.

## 8.7 Buried Concrete

The pH and Sulphate results indicate that buried concrete can be designed in accordance with design sulphate class DS-1 ACEC class AC1 of BRE Special Digest 1(2005), assuming mobile groundwater is present.

## 8.8 Infiltration Testing

Large-scale infiltration testing was carried out in TP101, TP102, TP103, and TP104. The following table summarises the results of the testing:

| Location | Test Range (mbgl) | Infiltration Rate ($ms^{-1}$) |
|---|---|---|
| | | Test 1 |
| TP101 | 1.01 – 2.45 | Water level dropped from 1.01m to 1.10m in 46.85 hours. |
| TP102 | 0.76 – 2.40 | Water level dropped from 0.76m to 1.81m in 46.70 hours. |
| TP103 | 1.11 – 2.40 | Water level dropped from 1.11m to 1.34m in 46.40 hours. |
| TP104 | 1.25 – 3.20 | Water level dropped from 1.25m to 1.89m in 46.00 hours. |

Testing indicates the infiltration rates are low and whilst one of the four tests achieved 50% drained in 24 hours, the combination of slow rates and potentially high groundwater indicate that infiltration drainage may not be viable.

## 8.9 Road Pavement Design

The sub-grade CBR is normally used to select the minimum capping thickness for road foundation construction. Testing is confined to the near surface soils and the preliminary sub-grade CBR is based on the soils below the topsoil, organic rich layers, soft spots or Made Ground. It is assumed that the topsoil, organic rich layers, soft spots and Made Ground will be removed. The removal of this may increase the thickness of capping

required to make up the finished road level, which is not known at the time of this investigation.

The Specification for Highway Works provides guidance on the methods normally adopted for road construction. Useful details may be found in, but not limited to, Series 200 Site Clearance details the requirements for clearance of the site and removal of existing trees, hedges and bushes; Series 500 Drainage and Service Ducts provides details for drainage excavation, backfilling and land drains; Series 600 Earthworks identifies unacceptable materials and provides details for sub-formation capping materials and prohibits the use of the sub-formation and formation for construction traffic without appropriate protection in addition to weather protection.

Road construction in cutting or embankment would require additional consideration outside the scope of this report.

The sub-grade CBR will be a function of soil type and moisture sensitivity. The effectiveness of sub-surface water drainage and the surface water conditions during construction can also affect the actual sub-grade strength and stiffness at the time of construction. TRRL 1132 Appendix C Table C1 provides equilibrium suction index CBR values based on the Plasticity Index of soil, road construction thickness and the depth to groundwater. It is recommended that in-situ test results are calibrated with the site conditions when selecting a design CBR value.

When a proposed layout plan is available insitu DCP CBR probe testing should be undertaken.

The modified Plasticity Index ranges from 10% to 53%. The moisture contents ranged from 4.5% to 22%. TRRL 1132 Appendix C Table C1 provides equilibrium suction index CBR values based on the Plasticity Index of soil, road construction thickness and the depth to groundwater. A CBR of 2.5% for high groundwater and 3% for low groundwater. Higher values may be present in favourable construction conditions.

The need to remove Made Ground or weak, organic rich soils or disturbed ground is often a requirement of the local authority or the management company assuming the road is built to an adoptable standard.

A typical minimum non-frost susceptible construction thickness of 450mm is assumed, this may be relaxed by the local highway authority or management company.

The surface soils will be subject to exposure and deterioration during wet weather and therefore protection layers and early placement of capping layers is essential.

For preliminary budgeting purposes a CBR of 2% may be assumed, whilst recognising the need to remove localised soft spots/ disturbed or Made Ground if encountered.

The removal of old hedge lines or trees will often require the removal of large roots and organics to the approval of the adopting authority. This can result in greater excavation depth to an acceptable sub-grade layer.

The local authority may require undertaking their own investigation for the highway if it is to be adopted.

The use of a geotextile separator and geogrid reinforcement may be required in addition provision for a starter layer is suggested below earthworks or capping construction for the roads.

## 9.0 CONCLUSIONS

The historical data review indicates that the site has been in agricultural use since the first available mapping of 1888 and remains in that use at present.

The British Geological Survey mapping indicates the site is underlain by interbedded Sandstones and Mudstones of the Crackington Formation.

The intrusive investigation comprised: trial pitting, large scale infiltration testing, groundwater monitoring, chemical analysis of soils and geotechnical analysis of soils.

The ground investigation has identified the site to have a cover of topsoil/subsoil over stiff slightly gravelly clay Head material, over clayey gravel Head material over mudstone slate/shale and metamorphosed siltstone with occasional metamorphosed sandstone of the Crackington Formation.

Groundwater monitoring wells were installed in TP101 to TP104 to a depth of up to 3.20mbgl. Four monitoring visits have been undertaken to date. These have shown groundwater levels in TP101 rising from 2.47m to 0.10mbgl, TP102 >2.40mbgl rising to +0.09magl, TP103 >2.40mbgl, TP104 rising from 2.92m to 0.14mbgl. A further eight monthly groundwater monitoring visits are to be undertaken to explore seasonal variation.

Chemical analysis has not identified significant levels of contamination within the samples analysed.

Geotechnical analysis has identified the fine-grained soils on site to be of low to high volume change potential.

The Landmark Envirocheck report indicates no radon protection measures are required for new developments.

Trench fill foundations can be adopted within the stiff clay Head and gravel Head. An allowable bearing pressure of 125kPa is recommended for stiff clays, 150kPa for the medium dense gravels and weathered mudstone/shale.

Due to very shallow groundwater levels recorded at -0.14 to +0.09m (artesian), land drainage is likely to be required for the site to prevent groundwater flooding. It should be noted that service trenches may act as preferential pathways for groundwater. Consideration will have to be given to draining the site starting at the lower end and working upslope.

Suspended ground floor slabs are recommended.

Large scale infiltration testing indicates the infiltration rates are low and whilst one of the four tests achieved 50% drained in 24 hours, the combination of slow rates and potentially high groundwater indicate that infiltration drainage may not be viable.

Buried concrete can be designed in accordance with design sulphate class DS-1 ACEC class AC-1 of BRE Special Digest 1(2005), assuming mobile groundwater is present.

## FIGURES