

Northern Arc - Freek's Farm & Maple Drive

Ground Investigation Report

Homes England

Project number: 60578790

9 September 2019

Quality information

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The methodology adopted and the sources of information used by AECOM in providing its services are outlined in this Report, which presents and summarises the factual ground and groundwater profile and geotechnical data available. The Report does not provide any costs assessment of works.

It is possible that available site investigation information has not identified all ground conditions present. Exploratory holes only investigate a small volume of the ground in relation to the size of the worksite. There may be exceptional ground conditions elsewhere which have not been disclosed by investigations. In addition, groundwater levels and groundwater quality can be susceptible to seasonal variation, rainfall and atmospheric pressure. It is further possible that the site investigations failed to identify the presence or significance of contaminative substances.

The interpretation of the geological and hydrogeological conditions at the site is based on an assessment of published information and an extrapolation of point-source information using geological experience. There is a degree of subjectivity in any interpretation. The Client should be advised that the hydrogeological conditions are not constant and that there will be natural fluctuations in groundwater and surface water chemistry, the full ranges of which may not have been observed during the monitoring period.

No liability can be accepted for any inaccuracies in the base information resulting from incorrect data, for example damaged or blocked instrumentation that provides false readings. Where there is limited or no information on groundwater levels other sources of information may be referenced, however reliance cannot be made on more distant or macroscale information provided by third parties.

Any ground risks identified in this report are perceived risks, based on the information reviewed for this report, and are therefore partially based on conjecture from an interpretation of that information. Reference must be made to project risk registers for further details of risks and mitigation measures.

Reference to historical Ordnance Survey (OS) maps and/or data provides invaluable information regarding the land use history of a site. However, it should be noted that historical evidence will be incomplete for the period pre-dating the first edition and between the release of successive maps and/or data.

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1. Executive Summary

AECOM Infrastructure & Environment UK Limited (AECOM) was commissioned to prepare a Ground Investigation Report (GIR) to inform the design of the proposed scheme to support the development of the Northern Arc, Freek's Farm, in Burgess Hill, West Sussex (the "Site"). The reports aim is also to assist on the discharge of the associated contaminated land planning conditions and for this reason include a Phase 2 Generic Qualitative Risk Assessment.

The GI followed a desk study report completed by WYG in 2016 and a Briefing note and site walkover carried out by AECOM in 2018. The ground investigation (GI) was completed by Structural Soils Ltd under the AECOM supervision between the 7th April and 3rd May 2019. The GI comprised nine rotary cored boreholes to up to 20m depth, 21 mechanically excavated trial pits and 18 percussive window samplings. Subsequently, AECOM carried out one round of groundwater / surface water sampling on the 14th May 2019, and four rounds of groundwater level and gas monitoring on the 14th, 23th, 31th May and 7th July 2019.

The GI proved the geology to be fairly consistent across the site, with topsoil overlying Weald Clay Formation with varying weathering increments. Some Alluvium was found in the north west area of the site. This is associated with the River Adur. In the area near maple Drive Landfill Material was encountered overlying the Weald Clay.

An interpretation of the ground conditions based on the field and laboratory results is presented. Ground models for the various areas of the site have been proposed and geotechnical parameters have been derived. The geotechnical risk register has been reviewed and updated accordingly.

The site is classified as a Geotechnical Category 2 in accordance with HD22/08 and BS EN 1997-1:2005.

Contaminated land assessment:

Although some GAC exceedances have been identified, these are considered unlikely to pose a significant risk to identified human health / controlled waters receptors. Ground gas risks to future construction workers and/or site users are also considered unlikely. The conceptual site model has been updated with the findings of the Generic Quantitative Risk Assessment (GQRA). The following is however recommended and/or should be noted for future earthworks.

- Ground investigation works were carried out before the waste clearance works were completed. It is therefore possible residual contamination hotspots may be present beneath and around some of the waste, dependent on whether soil beneath the waste is removed, however, these are likely to be limited in extent due to the anticipated low permeability of the cohesive superficial deposits and the lack of widespread impact encountered in soils and groundwater during the current GI. Validation works are recommended once all waste is removed and the top surface layer is strip out in the areas where waste was stored.
- A potential infilled area was identified during the initial desk studies in the south western boundary of the site (as shown in historical drawings) which is currently occupied with dense vegetation / trees and the small pond (sampled as part of the current works). Exploratory locations within this area had to be relocated / cancelled due to potential services (sewers) and therefore the area was not possible to be investigated. It is recommended this area is further investigated during earthworks and any infill material which has the potential to generate gas be removed. It is also recommended that integrity testing of the sewers be conducted, prior to their removal.
- A Human Health risk for future users of the Maple Drive link road is considered unlikely assuming there is no direct exposure to the landfill material, though short term risk may be present for construction workers and offsite residents during construction should earthworks involve regrading of this part of the site and potential disturbance of the capping layer. Any waste removed during earthworks will need to be fully characterised and may require offsite disposal at an appropriate landfill, subject to the agreement of the EA. Any disturbance of the existing capping layer will need to be properly reinstated to prevent future risks from dust and/or gas risk for current offsite residents and road users. Further risk and recommendations during future earthworks in Maple Drive are included in section 7.9.

- Anecdotal evidence of a potential buried container of blue asbestos and vehicles at the Freeks Farm site were received after the ground investigation was completed. While no direct evidence of these burials was encountered during the ground investigation, it is noted that the investigations in the fly tipping area were limited by the presence of above ground waste deposits. It is recommended further detail on these potential burials is collected in the first instance, coupled with a geophysical survey of the identified areas of concern to assess the presence of possible ground disturbance and metallic anomalies which could support these claims. Potential animal carcass burning activities and subsequent spreading / burial of ash has been also reported which, dependent on the nature of the carcasses involved and the relative timing of the incineration and disposal activities, may require further investigation (e.g. additional analysis of soils for potential viruses and toxins). It is recommended that this could be incorporated into future soil validation sampling and testing in the vicinity of the former fly tipping area.
- The following risks and possible mitigation measures should be considered for the final design and construction of the proposed Maple Drive link road:
 - Gas monitoring: high methane and CO₂ concentrations measured within landfill waste can accumulate in excavations and future manhole chambers. Monitoring of ground gases and explosive risks is recommended during construction works in the vicinity of the former landfill.
 - Gas migration: Drainages/services that may be installed through the proposed Maple Drive road and to the future development should be sealed to avoid opening a future potential pathway.
 - The selection and construction of future water pipes / services and road foundations should consider potential direct contact with contaminated material.
 - Any excavated landfill material is likely to be classified as waste and may require off-site disposal.
 - If disturbed, the landfill capping layer should be fully reinstated on a like for like basis (e.g. a minimum thickness of 1 m of clean cover placed in engineered lifts etc.).
 - Mitigation measures (dust suppression and asbestos monitoring) may be required to minimise risks to construction workers and the general public if the landfill capping layer is disturbed during construction works

2. Introduction

2.1 Scope and Objective of the Report

AECOM Infrastructure & Environment UK Limited (AECOM) was commissioned to prepare a Ground Investigation Report (GIR) to inform the design of the proposed scheme to support the development of the Northern Arc, Freek's Farm site, in Burgess Hill, West Sussex (the "Site").

This Ground Investigation Report has been prepared in accordance with the requirements of HD 22/08 "Managing Geotechnical Risk" and in general accordance with CLR11 (2014).

The objectives of this report are to:

- Present available information on ground and groundwater conditions for the site;
- Present ground profiles and geotechnical material properties relevant to the geotechnical design of the proposed works;
- Present an initial assessment of potential geotechnical risks associated with the proposed works and communicate information on residual risks to those who may be affected.
- Present a Phase 2 Geo-environmental Generic Qualitative Risk Assessment.

This report aims also to assist on the discharge of the associated contaminated land planning conditions. Testing of potential contaminants in soil and groundwater has been undertaken and a subsequent risk assessment completed to assess the potential risk to identified receptors at the Site.

Intrusive works were undertaken by Structural Soils Ltd (CDM Principal Contractor) under the supervision of AECOM (CDM Principal Designer) between the 3rd April and 3rd May 2019. A copy of the SSL factual report can be found in Appendix A. Works were carried out in conjunction with the ground investigation at the future proposed highway link from the A273 Isaac's Lane junction through to a new bridge to Freek's Farm.

2.2 Description of Project (Including Site Description)

2.2.1 Proposed Development

The site is characterized by two different proposed developments.

The proposed development in the main part of the site (referred as Freek's Farm) will comprise a residential housing estate with private gardens including a network of distributor roads, buried services, a bridge over the River Adur in the north-western corner of the site, parking areas, soft landscaping areas and potentially balancing ponds.

The proposed development for the south-eastern part of the site (referred to as the 'land off Maple Drive or Maple Drive link road') will be used for a new access road between Maple Drive and Freek's Lane. The construction of drainage and services should be undertaken as works progress, in order to minimise later arisings of landfill material requiring disposal, and to minimise potential for cross-contamination of cover materials. A separate GIR report has been generated for the proposed A273 Isaac's Lane junction and bridge to Freek's Farm.

While the road construction will likely require some earthworks and cut and fill operations, no further details were available at the time of writing for the remaining of the Freek's Farm site.

2.2.2 Site Description

The site comprises approximately 20 hectares (ha) of predominantly agricultural land with areas of woodland and dispersed agricultural development. It is located off Freek's Lane, north of Burgess Hill, West Sussex. The approximate centre of the site lies at National Grid Reference (NGR) 531341 120519.

The south-eastern part of the site (referred as "Land off Maple Drive") is public land (historical landfill) and includes a number of footpaths and a children's playground at its southernmost extent. In the central-eastern part of the site, is located a grassed field with high numbers of disused farm equipment and old vehicles (named as "fly tipping area"). Adjacent to the storage field, residential dwellings, currently used by the tenant farmers, and livestock sheds are located.

The River Adur forms the north-western boundary of the site; with a tributary stream (Worlds End Stream) crossing east-west through the centre of the site. Freek's Lane marks the eastern boundary of the site. Burgess Hill Town

Football Club is located about 220m east of the site. A residential development branching off Maple Drive borders the south of the site. The Bedeland Farm Local Nature Reserve is located c. 370m north east of the site.

Figure 1. Plan Showing the Sire Red Line Boundary



2.3 Geotechnical Category of Project

According to HD 22/08, and considering the complexity of the proposed geotechnical works and the geotechnical risk implications to health and safety, a Geotechnical Category 2 has been established following the guidance in BS EN 1997-1:2004 [5].

Projects within Geotechnical Category 2 include conventional types of geotechnical structures, earthworks and activities, with no exceptional geotechnical risks, unusual or difficult ground or loading conditions. For this category, geotechnical data and analysis will normally be required to ensure that the fundamental requirements are satisfied. Geotechnical risks to the scheme are summarised in the Geotechnical Risk Register, included in Section 8 of this report. The register is a live document that should be developed and refined as the project progresses.

2.4 Other Relevant Information

None

3. Existing Information

A Desk Study Report was carried out in 2016 by WYG [1]. The objective of the report was to review and identify potential geo-environmental issues associated with the proposed site and to devise a preliminary Conceptual Site Model with regard to the risk of contamination. The information reported in this report is summarized in the following sections. For more details refer to the Desk Study [1].

3.1 Topographical Map

A review of the latest available topographical information, dated 2016, was included in the Desk Study Report. This data indicates that the topography of the site is gently undulating, levels across the Site range between 35m AOD at the centre of the Site, falling to 20m AOD towards the River Adur, at the northern boundary of the Site. The southern portion of the Site falls towards the south, to 28.4m AOD.

Following a site walkover carried out on 6th August 2018 by AECOM, it was observed that the fields within the southern part of the site have a generally flat topography and the fields in the centre of the site slope to the south, becoming steeper with proximity to the water course (Worlds End Stream), which cuts across the central part of the site in an east-west direction, and flows into the River Adur which forms the northern and western boundaries of the site.

During the walkover it was noted that part of the bank of the River Adur had collapsed at the western boundary.

3.2 Geological Maps and Memoirs

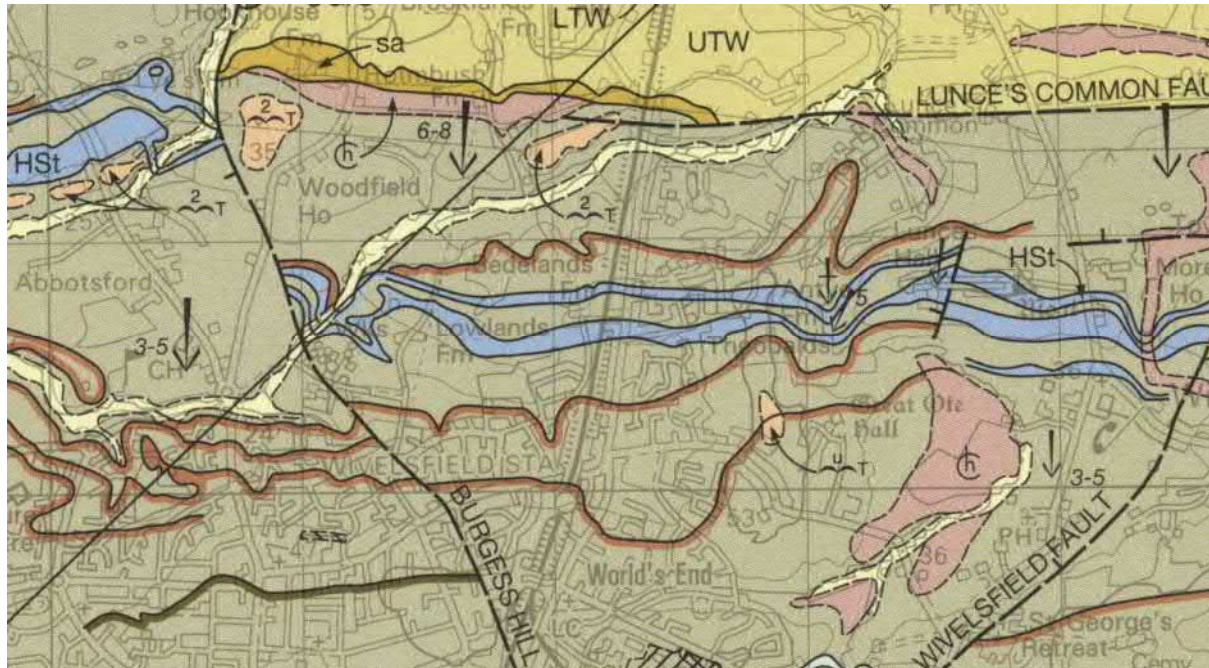
To assess the likely ground conditions beneath the site, AECOM has reviewed the following geological maps, memoirs and resources:

- British Geological Survey (BGS) GeoIndex (Onshore) [5]
- BGS 1:50,000 scale Geological Sheet 318/333 (Brighton & Worthing), 1996 [6]

The published superficial and bedrock BGS mapping information and the online BGS 'GeoIndex' Tool indicates that superficial deposits (Alluvium) are present only along the channel of the River Adur along the western and northern site boundaries. A review of BGS borehole logs from approximately 600m west of the site and adjacent to the River Adur indicates that the Alluvium is comprised of firm to stiff brown / grey silty clay with mudstone fragments.

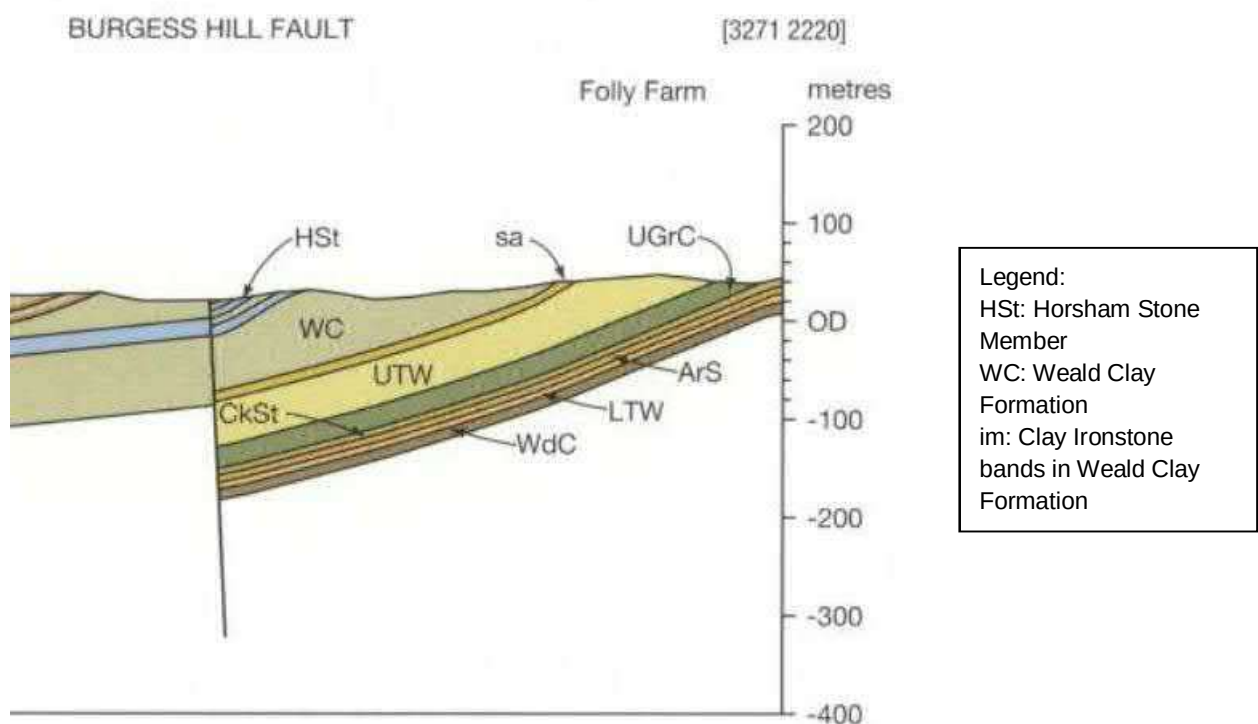
Based on a review of published geological maps (Geological Map 318/333 Brighton & Worthing) and British Geological Survey (BGS) Onshore Geoindex, the geology of the site is affected by the Burgess Hill Fault with the near surface geology becoming the Horsham Stone Member together with Weald Clay Formation. The former is characterised by sandstone and is indicated to cross the northern part of the site. The latter is characterised by dark grey mudstones with subordinate siltstones, sandstones, and includes clay ironstones; the precise thickness of the Weald Clay Formation in the eastern part of the site is not identified in the published geological maps. Clay ironstones are shown to be present crossing the southernmost and northernmost parts of the site.

Figure 2. Geological Map Extract from BGS 1:50,000 Scale Geological Sheet 318/333



"Reproduced from Geological Sheet 318/333 (Brighton & Worthing), 1996 by permission of British Geological Survey. ©NERC. All rights reserved 2019."

Figure 3. Geological Cross Section Extract from BGS 1:50,000 Scale Geological Sheet 318/333



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Burgess Hill Fault runs northwest to southeast with the downthrow to the southwest, 350m southwest of the site. Whilst the fault itself is outside of the site the irregular shape of the Horsham Stone Member bands and

northernmost clay-ironstone band in the western half of the site could be associated with disturbance due to the fault.

3.3 Aerial Photographs

Review of aerial photography shows the majority of the site area to be occupied by fields and sporadic farm buildings. An area of open storage, possibly vehicles or farm machinery, is evident to the north of Freek's Farm.

3.4 Records of Mines and Mineral Deposits

The Envirocheck report included in the WYG desk study indicates that the risk of non coal mining on and around the site is highly unlikely.

The site does not lie within a BGS Recorded Mineral Site. The Envirocheck report indicates the nearest recorded mineral site, which was for a brick field, is 110m from the site but its use has now ceased. There are no active mineral sites within 1km of the site.

3.5 Land Use and Soil Survey Information

A review of historical Ordnance Survey (OS) maps dated between 1876 and 2016 from a site specific Envirocheck report was undertaken as part of the Desk Study produced by WYG [1].

The historical mapping indicated that the majority of the Site has been occupied by fields and sporadic farm buildings, with contamination sources on these areas limited to potential applications of pesticides and fertilizers for agricultural purposes.

An area of open storage and fly tipping with numerous vehicles and pieces of farm machinery was evident to the north of Freek's Farm.

The south eastern area of the site ("Land of Maple Drive") is occupied by a historical landfill site that operated between 1970 and 1986, and accepted waste types including inert, commercial and household waste. The landfill material is covered by a clayey capping layer (based on current and previous investigations), it's grassed, open to public and has a children playground area to the southernmost area. The landfill site is approximately 250 x 200m and covers a section of the proposed development (Maple Drive link road).

Potential sources of contamination adjacent to the Site include a landfill site to the south east (partially under the proposed Maple Drive link road) and a sewage works and household waste recycling centre to the west (with a potentially associated landfill site). Other outside sources include small infilled pond, farmland, farm buildings and yards where fuel and agricultural materials may have been stored. Made ground may be present in the proximity of the farms.

3.6 Archaeological and Historical Investigations

A separate Archaeological desk based assessment and setting assessment has been carried out by White Young Green, and is reported in ref. A078699-1 dated November 2016.

3.7 Existing Ground Information

In 2017 WYG carried out a ground investigation for Rydon Homes at the Land of Maple Drive area. Eight dynamic samples holes were advanced to depths of up to 4m bgl in the south-eastern part of the site (land off Maple Drive). The geology encountered during the dynamic sampling is summarised in Table 1.

Table 1. Summary of Geological Strata Beneath South Eastern Part of the Site Based on WYG 2017 Investigation

Strata	Description	Minimum Depth Encountered (m bgl)	Maximum Depth Encountered (m bgl)
Top Soil	Firm dark brown to reddish brown gravelly clay.	0.0	0.4
Made Ground (clean cover)	Firm reddish-brown gravelly clay. Gravel is fine to coarse quartzite and flint.	0.0	>3.0

Strata	Description	Minimum Depth Encountered (m bgl)	Maximum Depth Encountered (m bgl)
Made Ground (landfill)	Stiff black to dark brown gravelly clay. Gravel is fine to coarse concrete, brick, glass and plastic.	0.9	3.7
Weald Clay Formation	Soft to firm light brown / grey clay and stiff light brown gravelly clay. Gravel is fine to coarse quartzite.	1.2	>4.0

The following was concluded / recommended in the WYG geo-environmental report for the land off Maple Drive [2]. :

- The corrected SPT N60 values obtained show the site to have highly variable ground conditions. All dynamic sample boreholes returned SPT values of 50 within the natural stiff clay.
- Low water soluble sulphate results combined with near neutral soil conditions indicate that protection of concrete from sulphate attack should not be required. The Design Sulphate class was assessed as DS-1, ACEC Class AC-1.
- The laboratory CBR values ranged between 5.1% and 5.9%, with the TRL results ranging from 3.8% to 86.9%.
- Asbestos (chrysotile) was identified at low concentration in two samples (one Made Ground landfill, one clean cover). Consideration of control measures to minimise airborne fibres during ground disturbance is recommended. Further testing of surface soils, to assess any risk to users of the Public Open Space (POS) area, may be appropriate
- The landfilled wastes were found to be locally contaminated by PAHs and petroleum hydrocarbons, at concentrations which may represent a human health risk if the material were to be exposed at the surface.
- Landfill material excavated during the road construction is likely to require disposal as Hazardous Waste.

3.8 Consultation with Statutory Bodies and Agencies

None

3.9 Flood Records

The Long Term Flood Risk Information maps provided on the Gov.uk website indicate that the River Adur East and its immediate surrounds (up to an approximate width of 70m in the proposed bridge location) is identified as having a Medium Risk of flooding from rivers, and a High Risk of flooding from surface water. A High Risk of flooding is defined by the Gov.uk website as an area where each year there is “a chance of flooding of greater of 3.3%”. A Medium Risk of flooding is defined as an area where each year there is “a change of flooding between 1% and 3.3%”.

The End World stream crossing east to west the site and its immediate surroundings (up to 10m approximate width) is identified as having a High Risk of flooding from surface water only.

Three channels with a Low to Medium Risk of flooding from surface water are shown in the western area of the Site connecting some of the identified ponds on site (dry during GI works). A Low Risk of flooding is defined as an area where each year there is “a chance of flooding of between 0.1% and 1%”.

The majority of Site is identified as a Very Low Risk of flooding, defined as an area where each year there is “a chance of flooding of less than 0.1%”.

For more information, refer to the Desk Study Report [1].

3.10 Contaminated Land

The following potential sources of contamination were identified as part of the Desk Study [1]:

- On-site

- o Agricultural activities and potential use or disposal of agrochemicals;
- o Large-scale open storage of disused farm equipment and waste in the north-eastern part of the site (named fly tipping area) and along some areas of Freek's Lane;
- o Infilled ponds in the northern and southern parts of the site; and
- o Former landfill in the south-eastern part of the site.
- Off-site
 - o Former landfill adjacent to the east of the southern area of the site;
 - o Sewage work and household waste recycling centre to the west of the southern area of the site (including a potential associated landfill site);
 - o Former gasworks approximately 250m to the south of the site; and
 - o Former brickfields and brickworks approximately 250m to the south of the site.

Based on the identified historical and current land uses, the main potential on site source of contamination is considered to be the open storage and waste spread in the fly tipping area and along some sections of Freek's Lane, as well as the former landfill in the south-eastern part of the Site. Previous investigation of this area have confirmed the presence of contaminants within the landfill layer.

The following contaminants of concern were identified based on the information provided by the EA/NHBC/CIEH 'Guidance for the Safe Development of Housing on Land Affected by Contamination', together with the Department of the Environment Industry Profiles and AECOM experience from the investigation of similar sites:

- Pesticides and fertilizers - associated with the agricultural land;
- Petroleum hydrocarbons - associated with the made ground, fly tipped waste, farmyards, former sewage works and former landfill site.
- Solvents and other liquid chemicals - associated with the made ground, fly tipped waste, former sewage works and former landfill site.
- Polycyclic Aromatic Hydrocarbons (PAHs) - associated with made ground, fly tipped waste, farmland and former landfill site; and
- Metals - associated with made ground, sewage works and former landfill site; and
- Ground gases – methane, carbon dioxide and hydrogen sulphide generated in the former landfill sites and sewage works.

Migration of contaminants in the subsurface is likely to be restricted by the presence of low permeability Weald Clay formation, which underlies the majority of the Site, with Secondary A Aquifers associated with the Horsham Stone Member limited to small outcrops in the central part of the Site.

According to the BGS the estimated soil chemistry in the area of the study is as presented in Table 2.

Table 2. Estimated Soil Chemistry

Chemical	Concentration (mg/kg)
Arsenic	14.1 – 18.0
Cadmium	0 – 0.33
Copper	21.6 – 35
Lead	47.1 – 99.5
Nickel	31.9 – 40.1

It should be noted that the estimated soil chemistry presented in Table 2 is associated with the broad soil types indicated to be present within the study area and not specific identified sources of contamination such as the historical pit or the railway.

Table 3 shows the potential source, pathway, receptor model for the site, reproduced from the Desk Study [1].

Table 3. Potential Source=Pathway-Receptor Linkages

Source	Receptor	Pathways
Inorganic and organic chemical impact within the made ground (if present) and superficial deposits	Future Site Users (users of the residential houses and the road)	Inhalation of volatile organic vapours/ground-gas.
	Construction Workers	Direct contact (ingestion, dermal contact, inhalation of dusts) with contaminated soils. Inhalation of volatile organic vapours/ground-gas.
	Site Neighbors (Residential)	Inhalation of contaminated soil dusts during construction works.
	Groundwater on-site (Secondary A Aquifer)	Leaching and downward vertical migration of contaminants from the made ground into the underlying groundwater (if present) within the Alluvium and Horsham Stone Member.
	Surface water (River Adur)	Leaching and downward vertical migration of contaminants from the made ground into the underlying groundwater (if present) and potentially subsequent lateral migration and discharge into surface water. Surface water runoff off-site.
Inorganic and organic chemical impact within shallow groundwater (if present)	Future Site Users (users of the residential houses and the road)	Inhalation of volatile organic vapours
	Construction Workers	Dermal contact with contaminated groundwater and inhalation of volatile vapours from contaminated groundwater.
Ground gases – primarily methane and carbon dioxide	Construction and Maintenance Workers	Ingress into confined spaces, such as excavations during construction, or utility manhole chambers following development, causing hazardous atmospheres

See section 3.7 for a summary of the 2017 WYG site investigation at the land of Maple Drive.

3.11 Other Relevant Information

3.11.1 Hydrogeology

The Envirocheck report presented in the WYG Environmental Desk Study Report prepared on behalf of Rydon Homes (Ref. A078699-1, dated September 2016), identifies that the Alluvium deposits located along the western boundary along the course of the River Adur are classed as a Secondary A Aquifer. This aquifer is characterised by permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

The Weald Clay Formation and clay-ironstone bands are classified as Unproductive Strata, and the Horsham Stone Member bands are classified as a Secondary A Aquifer. The Weald Clay Formation is likely to act as an aquitard that will protect the underlying Tunbridge Wells Sand Secondary A aquifer.

The site is not located within a source protection zone (SPZ). There are no licensed groundwater abstractions within 1km of the site according to the Envirocheck report obtained by WYG in 2016. WYG did not contact the Local Authority regarding potential unlicensed abstractions.

3.11.2 Hydrology

Worlds End Stream, a tertiary river, cuts across the narrow centre of the site and runs in a westerly direction along the southwestern boundary of the northern part of the site. The stream appears to be partially fed by a spring located approximately 380m east of the site and is culverted beneath Freek's Lane. Worlds End Stream flows into the River Adur, a primary river which runs adjacent to the western and northern site boundaries and flows in a south-westerly direction.

The River Adur has been rated on chemical quality as Good and for ecological quality as Poor (based on 2016 data, reported by the Environment Agency). There are no known surface water abstractions within 1km of the site boundary-based data in the Envirocheck report obtained by WYG in September 2016.

3.11.3 Unexploded Ordnance (UXO)

A review of Zetica's online unexploded ordnance risk maps [13] indicates that the Site is within a 'low risk' area for presence of sub-surface unexploded ordnance.

The West Sussex County Council Library Service website indicates that Burgess Hill experienced a number of high explosive bombs in the residential area during the 1939 – 1945 air raids.

The Site is (and was) mainly agricultural land where bomb strikes may go unnoticed and be poorly mapped out. Therefore, the presence of unmapped UXO on-site cannot be completely discounted.

4. Field and Laboratory Studies

4.1 Walkover Survey

During GI works the site was described as predominantly agricultural land with areas of woodland and agricultural development in the centre of the site, around Freek's Farm house. A vast range of waste, vehicles and agricultural machinery were spread around Freek's Farm house and to the north (this area has been named fly tipping area). Some derelict vehicles were also present along the western side of Freek's Lane and a pile of household waste (which included human excrements – nappies and asbestos corrugated roof sheets) was noted near a dry pond in the northern field.

The River Adur forms the north-western boundary of the site; with a tributary stream (Worlds End Stream) crossing east-west through the centre of the site. Freek's Lane marks the eastern boundary of the site. Residential development was present at the other side of Freek's Lane at the centre of the site and to the south east of the site.

The topography is gently undulating in the northern and central area of the site with higher levels to the north of the fly tipping area, falling towards River Adur at the northern boundary and towards Worlds End Stream. The southern area of the site is generally flat slowly falling to the south. Relatively steep slopes were noted closer to the watercourses with slight bank erosion in the north western area of the site.

An extremely clayey and boggy area was encountered at the fly tipping area and to the north due to machinery movements.

The south-eastern part of the site (referred as "Land off Maple Drive or Maple Drive Link Road") is a public grassed area (historical landfill capping material) and included a number of footpaths and a children's playground at its southernmost extent. Residential dwellings were present to the south of the site.

4.2 Geomorphological/ Geological Mapping

During the ground investigation geomorphological mapping was undertaken to assess the topographic profile of the site with emphasis on the areas adjacent to River Adur, and Worlds End Stream which bounds the site to the south, west and north. Due to the density of vegetation some areas could not be accessed. Low slope angles are consistent within the centre of the site and most southerly fields with the slopes increasing in gradient closer to perimeter watercourses. Table 4 summarises the topographic conditions of the site. A figure showing the zones in the table can be found in Appendix B – BURG-ACM-XX-XX-DR-GT-00006. The proposed development has been taken as that shown on the Indicative Drainage Strategy drawing no. 186400-002 dated November 2018 as presented in Appendix B. This assessment will need to be reviewed when details of the development are finalised.

Table 4. Topographic Conditions on Site

Zone	Slope gradient	Proximity to development	Site observation	Geology	Risk to Development
A	Typically 1:5 or shallower	The majority of the proposed developments indicated on the drainage surface are on relatively shallow gradients	No evidence of solifluction or periglacial features associated with shallow slopes.	Weald Clay Formation (mudstone and siltstone). Horsham Stone Member (ironstone, sandstone).	No risk.
B	1:3 to 1:2	Residential dwellings, land raising and Basin A to be developed near the crest of an existing slope with a foul water rising main also to be installed approximately 10m further south	Low/nil risk of erosion. Watercourse located approximately 5m from existing toe of slope	Weald Clay Formation (mudstone and siltstone). Horsham Stone Member (ironstone, sandstone).	Medium-Surcharge (housing) and removal of weight near the toe of the slope (service trench) could induce failure.

Zone	Slope gradient	Proximity to development	Site observation	Geology	Risk to Development
C	1:1.5	Limited development in area- Type 3 pumping station proposed serving dwellings in catchment A and B (531200, 120680). Land raising. Basin B in close proximity	-Low/nil risk of erosion. Watercourse located approximately 10m from existing toe of slope	Weald Clay Formation (mudstone and siltstone). Horsham Stone Member (ironstone, sandstone).	Medium-Surcharge (housing) and removal of weight near the toe of the slope (service trench) could induce failure.
D	1:1.5 locally 1:1	Basin A & B and residential development proposed in south west section of site. Potentially 2-3m of soil to be removed from basin and replaced with water.	-Low/nil risk of erosion. Watercourse located approximately 5m from existing toe of slope	Alluvium (soft compressible clay and silt). Weald Clay Formation (mudstone and siltstone). Horsham Stone Member (ironstone, sandstone).	Low/ Medium
E	1:1.5 to 1:1 locally >1:1	No proposed developments	High risk of erosion. Evidence of watercourse undercutting existing slopes.	Alluvium (soft compressible clay and silt). Weald Clay Formation (mudstone and siltstone). Horsham Stone Member (ironstone, sandstone).	Low/ Medium

The assessment given above is preliminary and the risk to the development and the stability of the slopes will need to be further analysed when all relevant data is available ie topographic mapping, development details and ground conditions local to the slope under construction.

4.3 Ground Investigations

4.3.1 Description of Fieldwork

A ground investigation was carried out at the site in general accordance with BS EN 1997-2:2007 [9], BS 5930:2015, BS10175:2011+A:2017 and BS EN ISO 22475-1. The ground investigation described herein was specified by the Designer, AECOM, in line with the ICE UK Specification for Ground Investigation, Second Edition. Structural Soil Ltd (SSL) was appointed as the CDM Principal Contractor.

The fieldwork was undertaken between the 7th April and 3rd May 2019.

The fieldwork comprised the following:

- 9 No. rotary cored / cable percussion boreholes (BH101, BH102, BH103, BH104, BH105, BH106, CP101-CP103) to depths between 5.18 and 20.20m.
 - Combined ground gas and groundwater standpipe was installed at the boreholes BH101, CP101, CP102 and CP103, while two separate pipes comprising a ground gas pipe and a groundwater pipe were installed in the boreholes BH102, BH103, BH104, BH105 and BH106.
 - Boreholes CP101-CP103 are located in the Maple Drive area and borehole BH105 is located in the fly tipping area.
- 21 No. mechanically excavated trial pits (TP101-TP116 TPM101-TPM104 and TP201) to depths between 1.55m and 4.20m.
 - Trial pits TPM101-TPM104 are located in the Maple Drive Area and trial pits TP106-TP108 are located in the fly tipping area, with the remaining spread across the site.
 - Trial TP201 is located near the River Adur at the proposed bridge crossing.
- 4 No. near surface samples up to 0.7m bgl in the Maple Drive area (NSS101-NSS104).
- 18 No. percussive window sampling (WS101, WS103-WS108, WS110-WS114, WS116-WS121) to depths between 1.60m and 3.25m.

- Ground gas pipe was installed in the window samplings WS101, WS105, WS112, WS114, WS116, WS117, WS118, WS121.
- Window samples WS107, WS113 and WS114 are located in the fly tipping area.

Drawing BURG-ACM-XX-XX-DR-GT-00005 included in Appendix B shows the as built locations of all exploratory holes for the ground investigation. The drawing includes also exploratory holes completed for the adjacent A273 Isaac's Lane junction and bridge to Freek's Farm.

Originally proposed locations within the south western corner of the site (BH101, WS102, TP101 and TP102) had to be relocated/cancelled due to potential services (sewers).

4.3.2 Factual Report

A copy of the factual SSL factual report can be found in Appendix A.

4.3.3 Results of In Situ Tests

The following in-situ testing was carried out during the site investigation:

- Standard Penetration Tests (SPT)
- Hand Shear Vane Tests
- TRL Dynamic Cone Penetrometer (DCP) tests
- Photo-Ionisation Detector (PID) measurements of volatile hydrocarbons
- Soakaway infiltration testing.

The in-situ test results are provided on the exploratory hole logs in Appendix A and discussed in Section 6.0.

4.4 Drainage Studies

No drainage studies were carried out for this Ground Investigation Report.

4.5 Geophysical Survey

No specific geophysical survey was carried out for this Ground Investigation Report.

4.6 Pile Tests

No pile tests have been carried out in the preparation of this Ground Investigation Report.

4.7 Other Fieldwork

4.7.1 Groundwater, Surface Water and Ground Gas Monitoring

Following the intrusive site investigation and the groundwater well development works carried out by SSL, AECOM carried out the following scope of work:

- 1No. round of groundwater sampling following the well development completed by SSL.
- 1No. round of surface water sampling up gradient and downgradient of the proposed development.
- 3No. rounds of groundwater level monitoring.
- 4No. rounds of ground-gas monitoring and one round of groundwater sampling;

Groundwater level gauging was undertaken on the 14th, 31st May and 7th June 2019. Following the first groundwater level gauging round, groundwater samples were collected using a slow flow technique. Prior to sampling, groundwater was purged using a peristaltic pump and field parameters (temperature, pH, electrical conductivity, redox potential and dissolved oxygen) were measured, to ensure that groundwater parameters had stabilized, indicating the presence of formation water in the sampling points. Groundwater levels and field parameters are presented in Table 1 and 2 of Appendix D.

Four rounds of ground-gas monitoring were undertaken by AECOM on the 14th, 23rd, 31st May and 7th July 2019 using a GFM436 portable gas analyser. Wells were monitored for the presence of methane, carbon dioxide and

oxygen concentrations together with atmospheric pressure and flow rates. Ground-gas monitoring results are included in Table 3 of Appendix D.

Surface water samples were collected from upstream locations in River Adur and Worlds End Stream and from downstream location where the Worlds End Stream meets the River Adur. A sample was also collected from the small pond located in the south western corner of the site. The pond located in the northern fields was found dry. Samples were collected using a peristaltic pump on the 14th May. Sampling locations are indicated in drawing Drawing BURG-ACM-XX-XX-DR-GT-00005 included in Appendix B.

4.8 Laboratory Investigation

4.8.1 Geotechnical Tests

Geotechnical laboratory testing was undertaken by SSL on selected soil and rock samples as requested by AECOM. All the geotechnical soil testing work was carried out in accordance with the procedures stipulated in the various sections of BS 1377:1990 "Methods of test for soils for civil engineering purposes" and to UKAS accreditation where applicable. Rock testing was carried out in accordance with ISRM standards where applicable. Table 5 details the geotechnical tests undertaken.

Table 5. Geotechnical Tests Undertaken

Type of Test	Standard	Number of Tests
Soil		
Moisture content	BS1377:1990 Part 2	64
4 Point liquid limit and plastic limit	BS1377:1990 Part 2	64
Particle Size Distribution by Wet Sieve	BS1377:1990 Part 2	36
Particle Size Distribution: Sedimentation by pipette	BS1377:1990 Part 2	22
UU Triaxial without PWP measurement	BS1377:1990 Part 7	3
One Dimensional Consolidation	BS1377:1990 Part 5	6
Dry Density/ moisture content relationship	BS1377:1990 Part 4	3
Moisture Condition Value	BS1377:1990 Part 4	3
Rock		
Rock: Point Load Test	ISRM	88
Rock: Unconfined Compressive strength	ISRM	25
Chemical		
pH, Soluble Sulphate + Total Sulphur	BS1377:1990 Part 3 BRE SD1	48
Organic Matter Content	BS1377:1990 Part 3	2

The geotechnical laboratory test results are provided in Appendix E of the factual SSL report [4] (included in Appendix A).

4.8.2 Geo-environmental Tests

Soil, groundwater and surface water samples were placed in appropriate sample containers provided by the laboratory (Exova Jones / Element). The sample containers were placed in cool boxes which were collected on site by a courier and transported under chain of custody documentation to Exova Jones Environmental for chemical analysis. Exova holds UKAS accreditation and undertakes most standard soil and groundwater testing to MCERTS standards. Table 6 and Table 7 details the testing carried out.

Table 6. Geo-environmental Testing Undertaken – Freek's Farm

Analyses	Soils	Groundwater	Surface Water
VOC/SVOC/PAH			
Volatile Organic Compounds (VOCs)	12	3	4
Semi Volatile Organic Compounds (SVOCs)	12	3	4
PAH-16	26	6	4
Petroleum Hydrocarbons / Fuel			
Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG)	29	6	4
Extractable Petroleum Hydrocarbons (EPH)	9		
Pesticides			
Combined Pesticide Suite	14	-	-
Metals			
Metals (inc. As, B, Ba, Be, Cd, Cr, Cr(III), Cr(VI), Cu, Hg, Ni, Pb, Se, V, WSB, Zn)	36	6	4
Water Soluble Boron	36	-	-
Hexavalent Chromium	36	6	4
General Inorganics			
Moisture	39	-	-
pH	36	6	4
BOD	-	-	4
COD	-	-	4
TOC	15	6	4
TDS	-	-	4
TSS	-	-	4
Ammoniacal Nitrogen	36	6	4
Free Cyanide	11	-	-
Total Cyanide	11	-	-
Nitrate	36	6	4
Orthophosphate	36	6	4
Sulphide	12	2	-
Total Sulphate	11	6	4
Asbestos			
Asbestos	33	-	-

Table 7. Geo-environmental Testing Undertaken – Maple Drive Link Road

Analyses	Soils	Groundwater	Surface Water
VOC/SVOC/PAH			
Volatile Organic Compounds (VOCs)	7	3	-
Semi Volatile Organic Compounds (SVOCs)	7	2	-
PAH-16	7	3	-
Petroleum Hydrocarbons / Fuel			

Analyses	Soils	Groundwater	Surface Water
Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG)	7	3	-
Extractable Petroleum Hydrocarbons (EPH)	7	3	-
Pesticides			
Combined Pesticide Suite	7	-	-
Metals			
Metals (inc. As, B, Ba, Be, Cd, Cr, Cr(III), Cr(VI), Cu, Hg, Ni, Pb, Se, V, WSB, Zn)	7	3	-
Water Soluble Boron	7	-	-
Hexavalent Chromium	7	3	-
General Inorganics			
Moisture	7	-	-
pH	7	3	-
BOD	-	-	-
COD	-	-	-
TOC	7	3	-
TDS	-	-	-
TSS	-	-	-
Ammoniacal Nitrogen	7	3	-
Free Cyanide	7	-	-
Total Cyanide	7	-	-
Nitrate	7	3	-
Orthophosphate	7	3	-
Sulphide	7	3	-
Total Sulphate	7	3	-
Asbestos			
Asbestos	11	-	-
Asbestos Quantification	4	-	-

5. Ground Summary

5.1 General

An interpretation of the existing information and the results from field and laboratory studies has been carried out, upon which the following ground summary is presented.

5.2 Ground Model

Based on the results of the ground investigation and the available existing information, including the WYG report, a general ground model has been derived for the site. The ground model is shown in Table 8.

Table 8. Ground Model

Strata	Freek's Farm		Maple Drive	
	Top level (m AOD)	Thickness (m)	Top level (m AOD)	Thickness (m)
Topsoil	Surface	0.15 – 1.30	Surface	0.30 – 0.50
Made Ground - Landfill Cover	-	-	Surface to 30.66	0.25 – 3.00
Made Ground - Landfill	-	-	29.78 – 30.63	1.70 – 2.35
Alluvium	19.81	0.60	-	-
Residual Soil -Weald Clay	22.37 – 34.88	0.40 – 3.45	27.09 – 29.89	0.90 – 2.20
Weathered – Weald Clay	16.92 – 34.08	1.65 – 7.70	22.09 – 29.46	Not proven
Unweathered – Weald Clay	13.57 - 27.08	Not proven	-	-

5.3 Topsoil

Topsoil was encountered in all exploratory holes. The thickness varies from 0.15m in TP108 to 1.3m in TP201. The average thickness was 0.35m.

The nature of the Topsoil is generally described as grass/vegetation over brown/orange slightly sandy clay/silt with frequent rootlets.

5.4 Made Ground

Made Ground was encountered in all exploratory locations associated with Maple Drive (CP101 – CP103, TPM101 - TPM104 and NSS101 – NSS104). The locations were all carried out within the historically mapped landfill and as such the Made Ground encountered is associated with the landfill cap. The landfill capping material generally comprised of soft to firm greyish brown slightly gravelly slightly sandy silt clay. The thickness of the capping was fully penetrated in five of the locations and was found to vary in thickness between 0.25m (NS103) and 3.0m (TPM104).

Underlying the landfill cap, material considered to represent landfill waste was encountered in five of the locations with the base proven in all of them. The top of the landfill material was encountered between 0.35m bgl (TPM101) and 1m bgl (CP102) and with a thickness of between 1.70m (TPM102) and 2.35m (CP102). The maximum depth of the base of the landfill material was encountered in CP102 – 4.3m bgl. 30 – 95% volume of the landfill material was found to comprise of a slightly sandy gravelly clay. The remaining part of the landfill material comprised of a

large variety of manmade materials including wood, clothes, glass, plastic, metal and rubber. Due to the nature of the landfill the material and composition encountered varied significantly. No landfill material was encountered at TMP104 and CP103 located in the western area of the land off Maple Drive.

In CP103 and TPM104 the encountered Made Ground is likely to be a deep pocket of capping material as no landfill material was encountered.

5.5 Alluvium

Alluvium was only reported in TP201 between 1.3 and 1.9m bgl. Alluvium was reported as very soft to soft yellowish brown slightly sandy silty clay with frequent pockets (<5mm x 3mm) of organic material.

According to BGS geological maps, Alluvium is present along the flooding plain of River Adur East. The Alluvium indicated on TPM101 and TPM104 is probably Weald Clay Formation weathered to Residual Soil.

5.6 Weald Clay Formation

The Weald Clay Formation was encountered in differing weathering stages. These have been separated into Residual Soil, weathered and unweathered.

The Residual Soil was encountered in most exploratory holes, with the exception of some of the locations on Maple Drive. Some of the Residual Soil within BH104, TP210 and WS119 was very soft to soft. These locations are at the base of the slope close to the watercourse and are possibly related to reworked colluvium or landslip material.

The Residual Soil is logged as completely weathered or partially weathered Weald Clay on the investigation logs. The surface of the Residual Soil was encountered between 0.15m bgl (34.88m AOD in TP108) and 1.2m bgl (31.08m AOD in BH105 and 29.68m OAD in BH106) with a thickness ranging from 0.5m (TP107) to 3.45m (BH104). Residual Soil was recorded to the full depth within TP201 and appears to increase in thickness towards the river.

The Residual Soil is typically described as firm to stiff, locally soft, yellow brown slightly sandy slightly gravelly clayey silt becoming more granular with depth with the gravel composed of mudstone.

Weathered Weald Clay Formation was encountered within all exploratory positions apart from TP201, TPM101, TPM102 and NSS101-104. The Weathered Weald Clay is logged as partially weathered and slightly weathered Weald Clay/ The surface of the weathered material was encountered between 0.7m bgl and 3.65m bgl (16.92m AOD to 34.08m AOD) with a thickness, where proven, of between 1.65m and 7.7m. The Weathered Weald Clay is typically described as extremely weak to very weak yellow brown and grey thinly laminated mudstone. Discontinuities are subhorizontal very closely to closely spaced, planar smooth with rare infill and staining.

Unweathered Weald Clay Formation was proven only within the deep rotary boreholes (BH101 to BH106). surface of the Unweathered Weald Clay was encountered at between 3.80m bgl (23.31m AOD) and 9.9m bgl (16.43m AOD) and progressed to the full depth of the investigation. The unweathered material is typically described as weak grey thinly laminated mudstone. Discontinuities are subhorizontal, closely to medium spaced, planar smooth, clean. Within the Weald Clay some subordinate siltstone and occasional sandstone bands were encountered.

5.7 Hydrogeology

Groundwater strikes and seepages were encountered in nine exploratory holes during the ground investigation as summarised in Table 9.

Table 9. Groundwater Strike Summary

Exploratory hole	Strike depth (m bgl)	Strike level (m AOD)	Strike geology	Max. rise (m bgl)	Max. rise (m AOD)
BH104 shallow	1.15	19.42	Weald Clay	Not recorded	Not recorded
BH104 deeper	12.5 – 17	8.07 – 3.57	Weald Clay	3.5m above ground level	24.07
WS119	2.0	19.07	Weald Clay	2.0	19.07

Exploratory hole	Strike depth (m bgl)	Strike level (m AOD)	Strike geology	Max. rise (m bgl)	Max. rise (m AOD)
CP101	3.80	27.39	Weald Clay	3.20	27.99
TPM101	2.20	28.44	Landfill	Seepage	-
TPM103	1.95	29.83	Landfill	Seepage	-
TP105	2.39	26.03	Weald Clay	2.20	26.22
TP201	1.70	19.41	Alluvium	Seepage	-

It should be noted that the water was encountered within BH101 (3.80m bgl), BH103 (4.49m bgl) and BH105 (1.18m bgl) may be related to flush used as opposed to groundwater as it was encountered when dipping the boreholes during drilling.

In BH104, 3.5m high artesian groundwater was encountered while drilling open hole (casing at 5mbgl) on Friday 5th May. Water was contained by raising the casing above ground level. By Monday morning pressure had reduced to approximately 0.5m above ground level and casing was installed down to the base of the BH to attempt to reduce the pressure further. The water, however, found its way through and started coming out at surface level from between the casing and the ground. A decision was taken to terminate the BH and grout it up with a dense mix of cement and bentonite.

BH104 is located in a lower ground area of the site, approximately 14m lower than highest point of Freek's farm.

From the drilling observations, lower topographical level at BH104 and the geological knowledge of the Site it is considered the artesian water encountered in BH104 may be due to fractured mudstone encountered between 12m and 17m bgl being connected to the higher topographical areas to the east and therefore with higher hydrostatic pressure. It is also possible that the Horsham Sandstone Member was encountered at the base of the borehole and this is an aquifer.

Standpipe piezometers were installed in all rotary (Freek's Farm) and cable percussion (Maple Drive) exploratory holes in order to monitor the groundwater conditions. Table 10 shows a summary of the installation details.

Table 10. Groundwater Monitoring Installation Details

Exploratory hole	Installation	Response zone (m bgl)	Response zone (m AOD)	Response zone geology
BH101	Piezometer	3.0 to 9.0	26.82 to 20.82	Weald Clay
BH102	Piezometer	3.0 to 9.0	24.11 to 18.11	Weald Clay
BH103	Piezometer	3.0 to 9.0	23.33 to 17.33	Weald Clay
BH104p	Piezometer	2.0 to 8.0	18.84 to 12.84	Weald Clay
BH105	Piezometer	3.0 to 9.0	29.28 to 23.28	Weald Clay
BH106	Piezometer	3.0 to 9.0	27.88 to 21.88	Weald Clay
CP101	Piezometer	1.0 to 3.0	30.19 to 28.19	Landfill
CP102	Piezometer	2.0 to 4.0	30.23 to 28.23	Landfill
CP103	Piezometer	1.0 to 2.3	31.59 to 30.29	Landfill Cover

A total of three groundwater levelling rounds were completed between May 2019 and June 2019 following the intrusive works. The data is presented in Table 11.

Table 11. Groundwater Elevation May 2019 – June 2019

Exploratory hole	14 May 2019 (m AOD)	31 May 2019 (m AOD)	07 June 2019 (m AOD)
BH101	27.36	27.48	27.35
BH102	24.08	23.89	23.81
BH103	21.10	21.04	21.10

Exploratory hole	14 May 2019 (m AOD)	31 May 2019 (m AOD)	07 June 2019 (m AOD)
BH104p	20.38	20.05	20.03
BH105	28.66	28.56	28.59
BH106	26.79	26.83	26.91
CP101	28.75	28.73	28.74
CP102	29.63	29.60	29.60
CP103	30.23	30.49	30.59

Groundwater levels ranged between 0.46-5.29m bgl (20.026-30.568m AOD). A groundwater contour plot has been generated and is presented in Appendix B. The contour plots confirm the expected inferred groundwater flow towards the west / River Adur, showing a potential direct connectivity with the river. Inferred groundwater within the landfill material are anomalous and/or towards the south east, which is likely to indicate perched water above the Weald Clay.

5.8 Ground Gas

Installations were constructed in some of the locations to monitor ground gas as summarised in Table 12.

Table 12. Ground Gas Monitoring Installation Details

Exploratory hole	Response zone (m bgl)	Response zone (m AOD)	Response zone geology
BH101	3.0 to 9.0	26.82 to 20.82	Weald Clay
BH102	1.0 to 2.5	26.11 to 24.61	Weald Clay
BH103	1.0 to 2.5	25.33 to 23.83	Weald Clay
BH104	1.0 to 2.0	19.84 to 18.84	Weald Clay
BH105	1.0 to 2.5	31.28 to 29.78	Topsoil/ Weald Clay
BH106	0.5 to 1.5	30.38 to 29.38	Topsoil/ Weald Clay
WS101	0.5 to 1.5	28.71 to 27.71	Weald Clay
WS105	1.0 to 2.0	27.77 to 26.77	Weald Clay
WS112	0.5 to 1.5	29.13 to 28.13	Weald Clay
WS114	1.0 to 2.0	33.20 to 32.20	Weald Clay
WS116	1.0 to 2.0	33.07 to 32.07	Weald Clay
WS117	0.9 to 1.9	27.80 to 26.80	Weald Clay
WS118	1.0 to 2.8	27.42 to 25.62	Weald Clay
WS121	1.0 to 1.5	26.71 to 26.21	Weald Clay
CP101	1.0 to 3.0	30.19 to 28.19	Landfill
CP102	2.0 to 4.0	30.23 to 28.23	Landfill
CP103	1.0 to 2.3	31.59 to 30.29	Landfill Cover

6. Ground Conditions and Material Properties

6.1 Topsoil

Topsoil was encountered in most of the exploratory holes on the site. Due to limited depths encountered within the test locations, no laboratory testing was undertaken on the topsoil.

It is recommended that Topsoil material is stripped from the footprints of earthworks and structures prior to construction and stockpiled on site for re-use. As a result, in-situ Topsoil material will not be considered in the stability analyses of earthworks and structures. Consequently, no geotechnical parameters have been derived for the in-situ material.

Site won Topsoil may be suitable for re-use as Class 5A Topsoil material. Depending on the scheme's landscaping proposals, specific testing may be required to determine if the Topsoil is suitable for use as a planting medium.

6.2 Made Ground – Landfill Cover

Landfill Cover was encountered in 10 of the locations carried out at Maple Drive.

The following tests were undertaken on the landfill cover:

- 2 No. Standard Penetration Tests (SPT)
- 5 No. Natural moisture content determination
- 5 No. Atterberg limits
- 5 No. Particle Size Distribution (PSD)
- Hand Shear Vane (HSV)
- 1 No. Dry Density/ Moisture Content Relationship
- 1 No. Moisture Condition Value

6.2.1 Classification Tests

Natural moisture content and Atterberg limits tests results are shown in Figure 4. The natural moisture content is lower than the plastic limit in all locations. Based on the Casagrande A-line plot in Figure 5 the Landfill Cover is a high plasticity clay. The modified plasticity index IP' has been calculated between 21.9% and 36.1% in accordance with NHBC guidelines. This indicates that the material has a medium volume change potential.

Figure 6 shows the results of the 6 PSD tests. The results show that between 69% and 88% of the samples tested comprised of fine grained soil (silt and clay), with between 7% and 16% sand, and between 1% and 11% gravel.

One dry density/ moisture content relationship test was completed within the Made Ground - Landfill cover, returning a moisture content at optimum of 22% and a maximum dry density of 1.55 Mg/m^3 . The initial moisture content and optimum moisture contents are the same. At the optimum moisture content the moisture condition value (MCV) is 12.6.

A bulk unit weight of 14 kN/m^3 to 20 kN/m^3 is recommended for the Landfill Cover based on the soil descriptions and typical values for similar soils presented in BS8002. Based on this it is suggested that a bulk unit weight of 17 kN/m^3 is adopted for the landfill capping for design purposes.

Figure 4. Landfill Cover. Moisture Content and Atterberg Limits

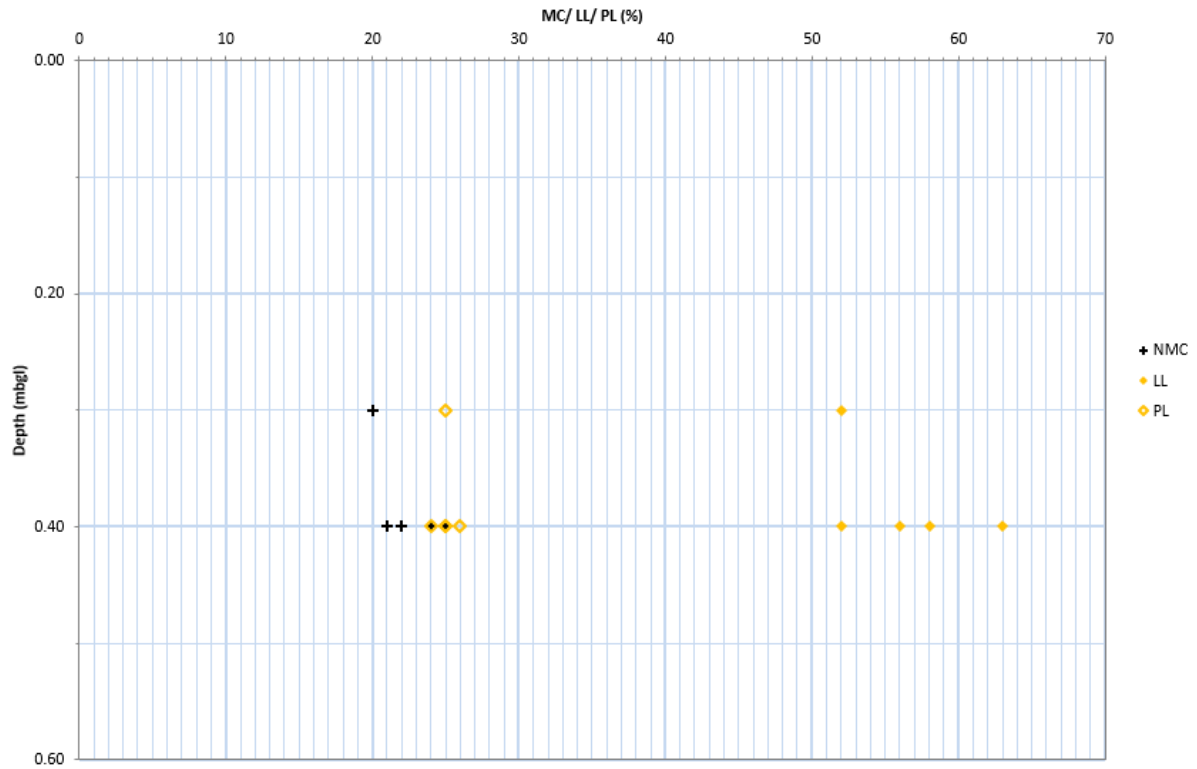


Figure 5. Landfill Cover. Casegrande A-Line Plot

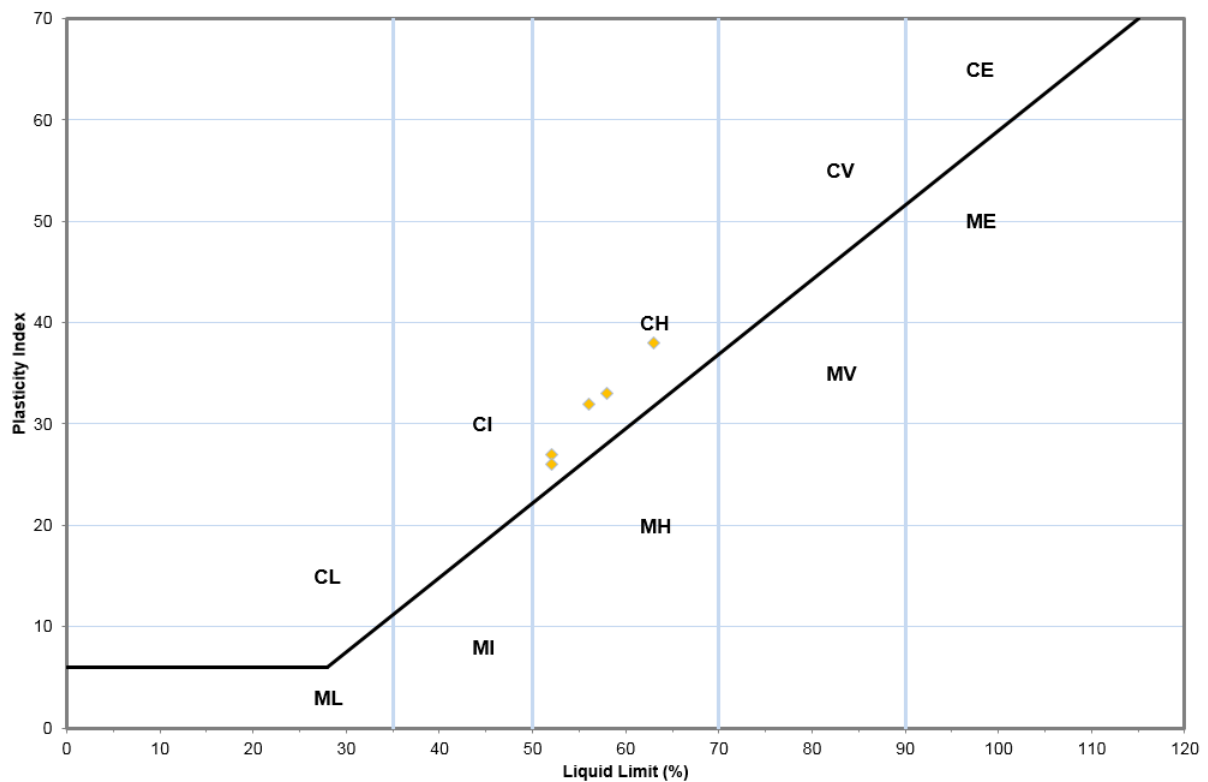
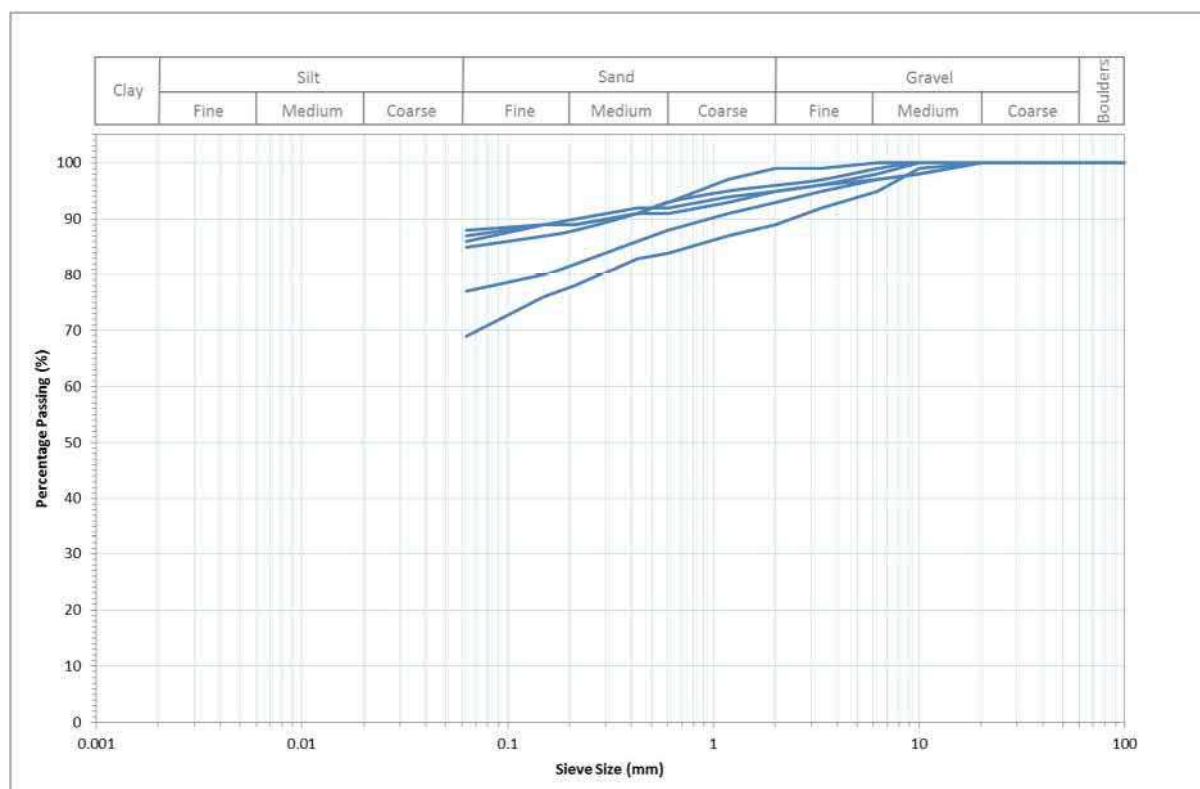


Figure 6. Landfill Cover. Particle Size Distribution

6.2.2 California Bearing Ratio

Equilibrium CBR for the Made Ground- Landfill Cover has been estimated from the plasticity index range of 26% to 37% and material composition in accordance with Interim Advice Note 73/06, 2009 'Design Guidance For Road Pavement Foundations' (Draft HD25). A CBR value of 3% can be adopted based on a thin layered construction and a PI of 30%.

The CBR value assumes a high water table and that the foundations may be wetted by ground water during their life.

In selecting the Design CBR value for the subgrade, consideration must be given to the likely moisture conditions applying during construction.

6.2.3 Standard Penetration Test

Two Standard Penetration Tests were undertaken in the Landfill Cover in CP102 and CP103. The N values recorded are 3 and 21 with an N_{60} value of 4 and 26.

6.2.4 Strength

Undrained shear strength

Based on the SPT results, and using the Stroud correlation [12] ($f_1=4.6$ for Plasticity Index of 31%), undrained shear strength values of 17kPa and 120kPa. The hand shear vane results range between 58 to 72 and the material is described as soft to firm. As such, it is recommended that a characteristic shear strength of 50kPa is used for this material but the designer should bear in mind that the strength of this material is likely to be variable. This relates to a firm material.

Drained shear strength

In absence of reliable laboratory data, a conservative estimate has been made following guidance in BS 8004:2015 [10]. For a plasticity index of 31%, a characteristic constant volume angle of shearing resistance of ϕ'_{cv} of 24° may be adopted. Contribution from dilatancy is assumed to be zero, hence a peak angle of shearing resistance ϕ'_{pk} of 24° may be adopted.

6.2.5 Stiffness

Undrained stiffness

A cautious estimate of undrained stiffness has been made following guidance in CIRIA C143 [12]. Assuming a shear strength of 50kPa and the conservative relation $E_u = 220c_u$ [12], an undrained Young modulus E_u of 11MPa may be adopted.

A one dimensional consolidation tests were undertaken in the Made Ground- Landfill Cover. The samples were loaded to a level beyond their in-situ stress conditions, after which an unloading-reloading cycle was applied, followed by another stress increment. The coefficient of volume compressibility, M_v , measured during oedometer testing is presented in Table 13.

Table 13. Consolidation Test Results

Hole ID	Summary Description	Test Depth	Stress (kPa)	Void Ratio	Volume Compressibility Coefficient (M_v) (m^2/MN)
CP103		1.50	20	0.455	0.31
			40	0.451	0.16
			60	0.446	0.16
			80	0.441	0.18
			100	0.438	0.11
			20	0.444	NA
			40	0.443	0.063

The test carried out on a sample from CP103 were undertaken on the very soft to soft material used as capping for an historical landfill.

Where applied pressures ranged from 20 to 100kPa the oedometer M_v results range from 0.11 to 0.31 m^2/MN indicating medium compressibility (Tomlinson, 2001).

6.3 Made Ground – Landfill Material

The landfill material was encountered along Maple Drive only. The landfill was only encountered in CP101, CP102, TPM101, TPM102 and TPM103. The landfill material generally comprised on very soft to firm sandy silty clay or slightly sandy gravelly clay. Within the land fill a large variety of material was encountered including plastic, ceramic, glass, metal, wood and rubber.

The following tests were undertaken on the landfill material:

- 4 No. Standard Penetration Tests (SPT)
- 12 No. Natural moisture content determination
- 10 No. Atterberg limits
- 6 No. Particle Size Distribution (PSD)
- Hand Shear Vane Tests (HSV)
- 2 No. Dry Density/ Moisture Content Relationship
- 2 No. Moisture Condition Value

6.3.1 Classification Tests

Natural moisture content and Atterberg limits tests results are shown in Figure 7. The natural moisture content is higher than the plastic limit in all but one location. This shows that the material is plastic in its in-situ moisture condition at the time of testing. Between 45% and 100% of the material passed the 425 μ m sieve. Based on the Casagrande A-line plot in Figure 8 the Landfill Material ranges from intermediate to very high plasticity clay. The

modified plasticity index IP' has been calculated between 17.1% and 42.0% in accordance with NHBC guidelines. This indicates that the material has a low to high volume change potential.

Figure 9 shows the results of the 6 PSD tests. The landfill material can be separated into two materials. There is a predominantly cohesive material with sand and gravel located close to surface (blue) beneath which is an organic rich silty clay with rare granular material (red).

Two dry density/ moisture content relationship tests were completed within the Made Ground - Landfill Material. Both tests returned a moisture content at optimum of 23% and 24% and maximum dry density results of 1.62Mg/m^3 and 1.59Mg/m^3 . The MCV testing has been carried out at 24% and 25% moisture with the results being 9.5 and 10.1 respectively.

A bulk unit weight of 14kN/m^3 to 20kN/m^3 is recommended for the Landfill material based on the soil descriptions and typical values for similar soils presented in BS8002. Based on this it is suggested that a bulk unit weight of 17kN/m^3 is adopted for the landfill material for design purposes.

Figure 7. Landfill Material. Moisture Content and Atterberg Limits

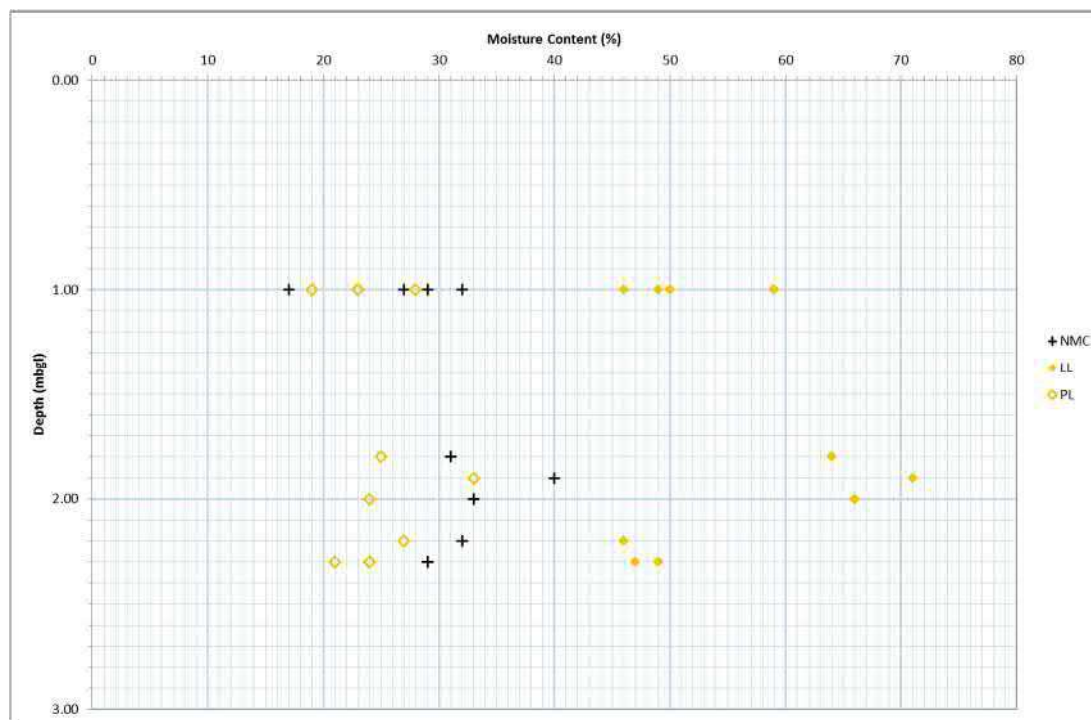


Figure 8. Landfill Material. Casagrande A-Line Plot

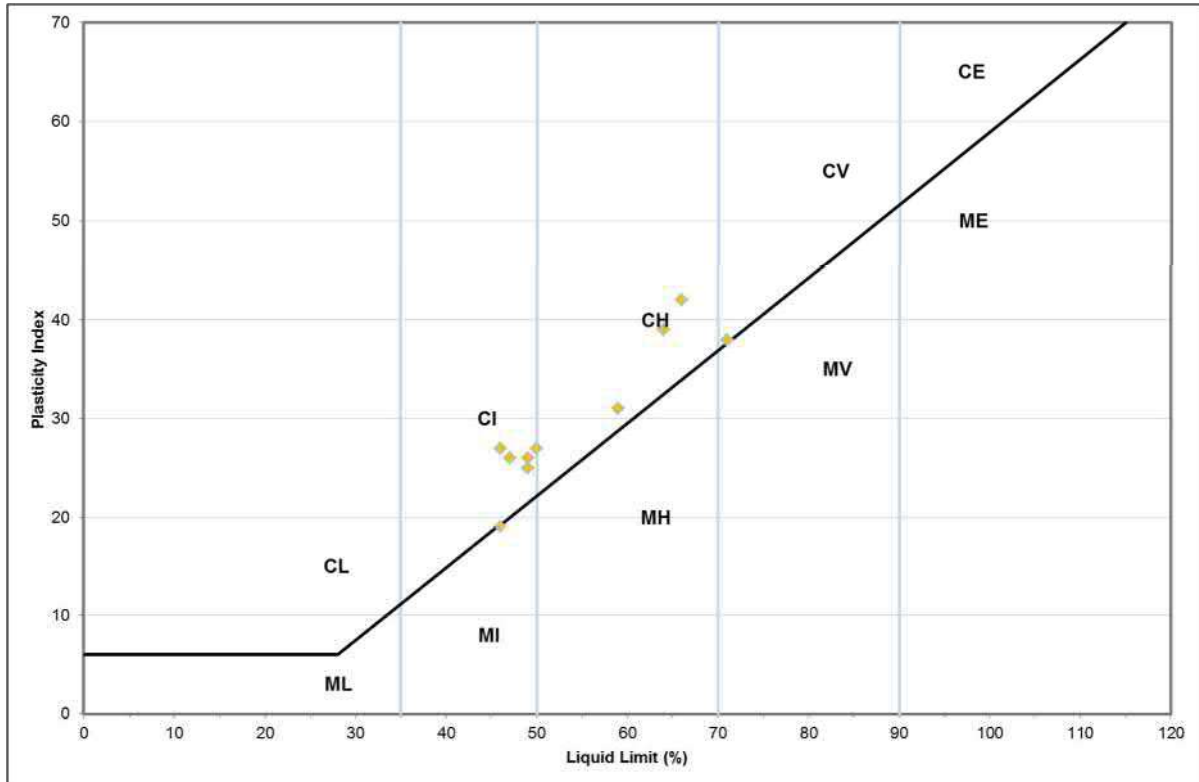
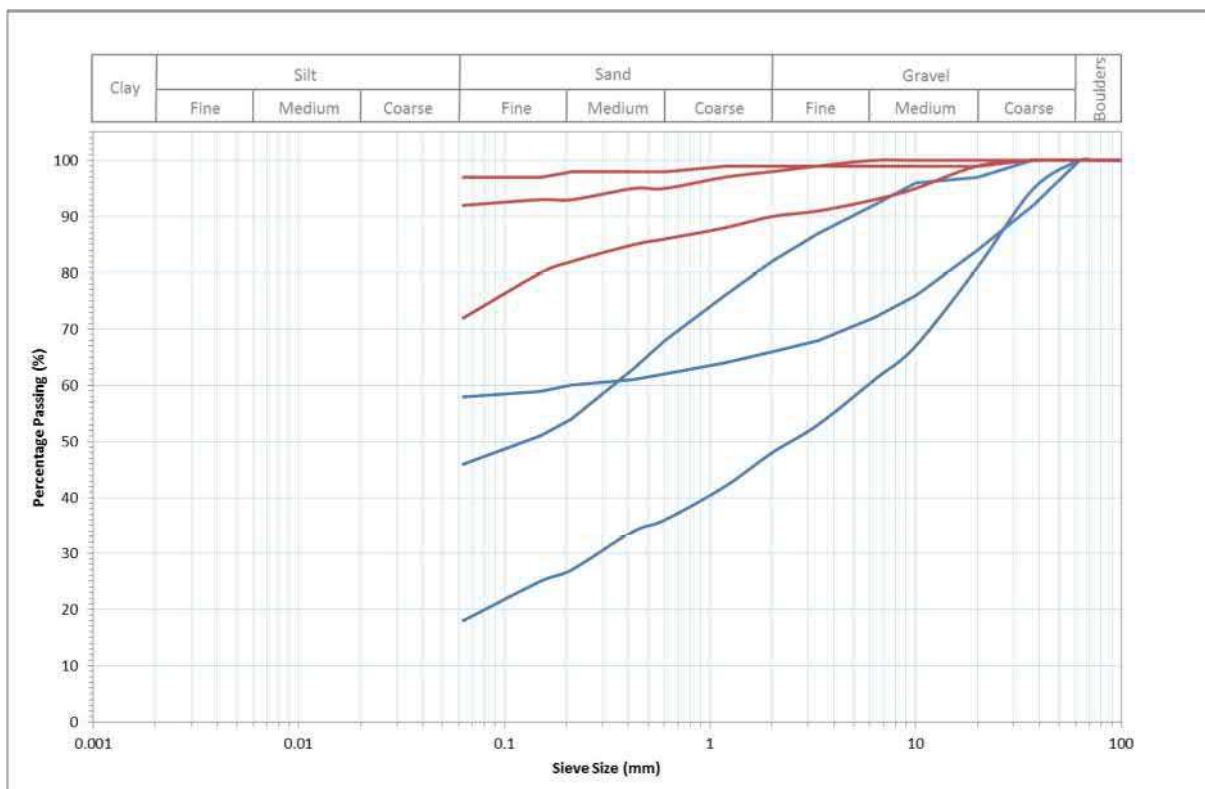


Figure 9. Landfill Material. Particle Size Distribution



6.3.2 California Bearing Ratio

Equilibrium CBR for the Made Ground- Landfill Material has been estimated from the above PI information and composition in accordance with Interim Advice Note 73/06, 2009 'Design Guidance For Road Pavement Foundations' (Draft HD25). A CBR value has been estimated for the two materials identified within the Landfill (Blue and Red curves presented on Figure 9):

- Slightly sandy silty CLAY (red)- CBR value of 2% based on a thin layered construction and PI of 40%
- Sandy gravelly silty CLAY (blue)- CBR value of 3% based on a thin layered construction and a PI of 30%.

These CBR values assume a high water table and that the foundations may be wetted by ground water during their life.

In selecting the Design CBR value for the subgrade, consideration must be given to the likely moisture conditions applying during construction.

6.3.3 Standard Penetration Test

Four Standard Penetration Tests were undertaken in the Landfill Material in CP101 and CP102. The test carried out at 1.5m in CP101 refused early and as such it is not considered further as it is likely that it encountered a large fragment within the landfill. The N values recorded range between 1 and 23 with an N_{60} value of between 1 and 29.

6.3.4 Strength

Undrained shear strength

Based on the SPT results, and using the Stroud correlation [12] ($f_1=4.6$ for Plasticity Index of 32%), undrained shear strength values can be derived of between 6kPa and 131kPa with an average of 49kPa. Due to the high variation in strength observed in the exploratory holes it is recommended that the designer adopts a characteristic shear strength appropriate to the conditions local to the structure they are designing.

Drained shear strength

In absence of reliable laboratory data, a conservative estimate has been made following guidance in BS 8004:2015 [10]. For a plasticity index of 32%, a characteristic constant volume angle of shearing resistance of ϕ'_{cv} of 24° may be adopted. Contribution from dilatancy is assumed to be zero, hence a peak angle of shearing resistance ϕ'_{pk} of 24° may be adopted.

6.4 Alluvium

Soil descriptions indicate the Alluvium to be very soft to soft.

6.5 Residual Soil – Weald Clay

Residual soil was encountered across the entire site, with the exception of some of the locations on Maple Drive where landfill was encountered. In general the material was described as firm to stiff, locally soft, yellow brown slightly sandy slightly gravelly clayey silt becoming more granular with depth.

The following tests were undertaken in the Residual Soil:

- 27 No. Standard Penetration Tests (SPT)
- 49 No. Natural moisture content determination
- 49 No. Atterberg limits
- 24 No. Particle Size Distribution (PSD)
- 3 No. Undrained Unconsolidated Triaxial
- 4 No. One-dimensional Consolidated test
- 2 No. Organic Matter Content
- Hand shear vane tests (HSV).
- 16 No. Dynamic Cone Penetrometer Tests adjacent to Trial Pits.

6.5.1 Classification Tests

Natural moisture content and Atterberg limits tests results are shown in Figure 10. Liquid limit and plasticity index values are plotted together with the Casagrande A-line in Figure 11. The data indicates that the Residual Soil is

generally a low to high plasticity clay, with a value lying in the very high plasticity range. The modified plasticity index IP' has been calculated between 7% and 50% in accordance with NHBC guidelines. This indicates that the material has a low to high volume change potential.

Figure 12 shows the results from the PSD tests carried out in the Residual Soil. The testing shows that three of the tested samples show more granular material within the silty clay with the descriptions being a gravelly clayey silt. These results can be seen on Figure 12.

For the slight sandy clayey silt / silty clay the content of fines generally ranges between 67% and 100%, with a clay content generally between 12% and 58%. The samples which are tested as being gravelly clayey silt had a fines content ranging between 27% and 50% with a clay content generally between 4% and 21%.

Seven bulk density tests were carried out on the Residual Soil as a part of the odometer tests and undrained triaxial tests and values ranged from 2.03Mg/m^3 to 2.11Mg/m^3 . Based on these results a unit weight of 20kN/m^3 is suggested for this material.

2 organic matter content tests were carried out on this material with the results being 0.6% in both tests.

Figure 10. Residual Soil. Moisture Content and Atterberg Limits

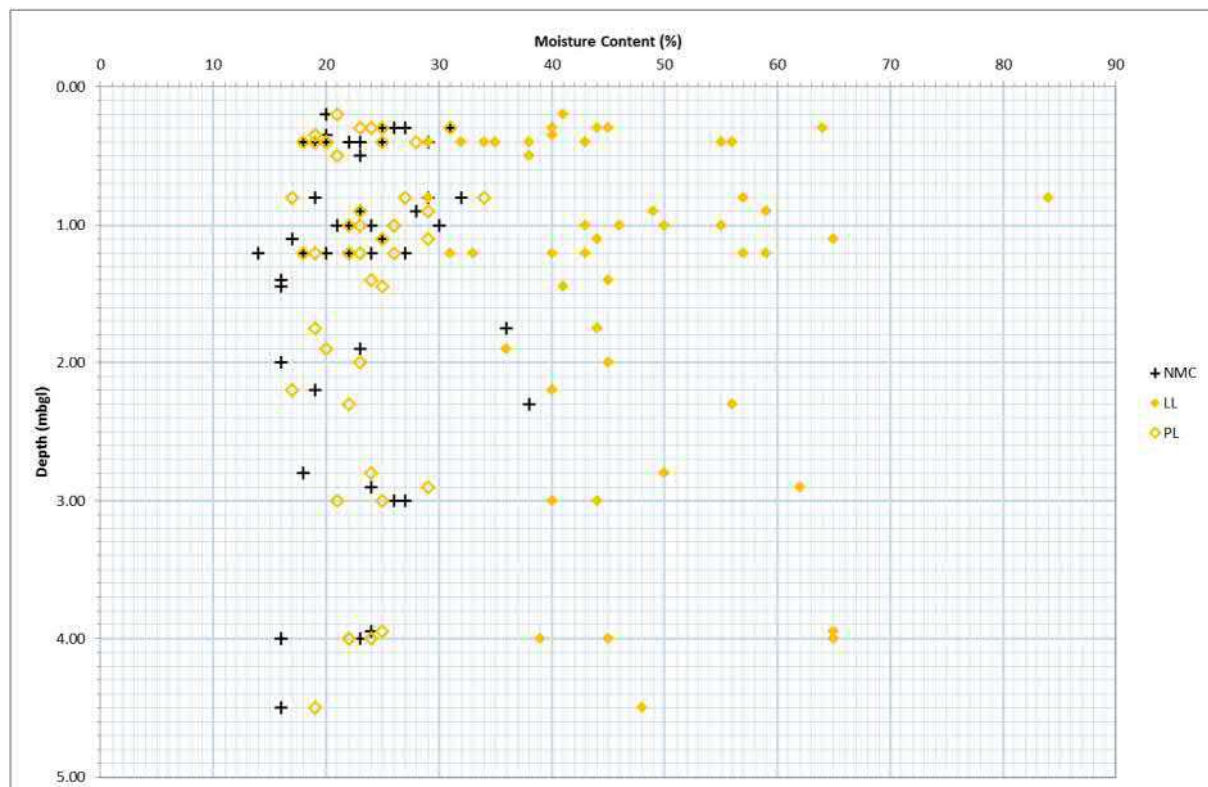


Figure 11. Residual Soil. Casagrande A-Line Plot

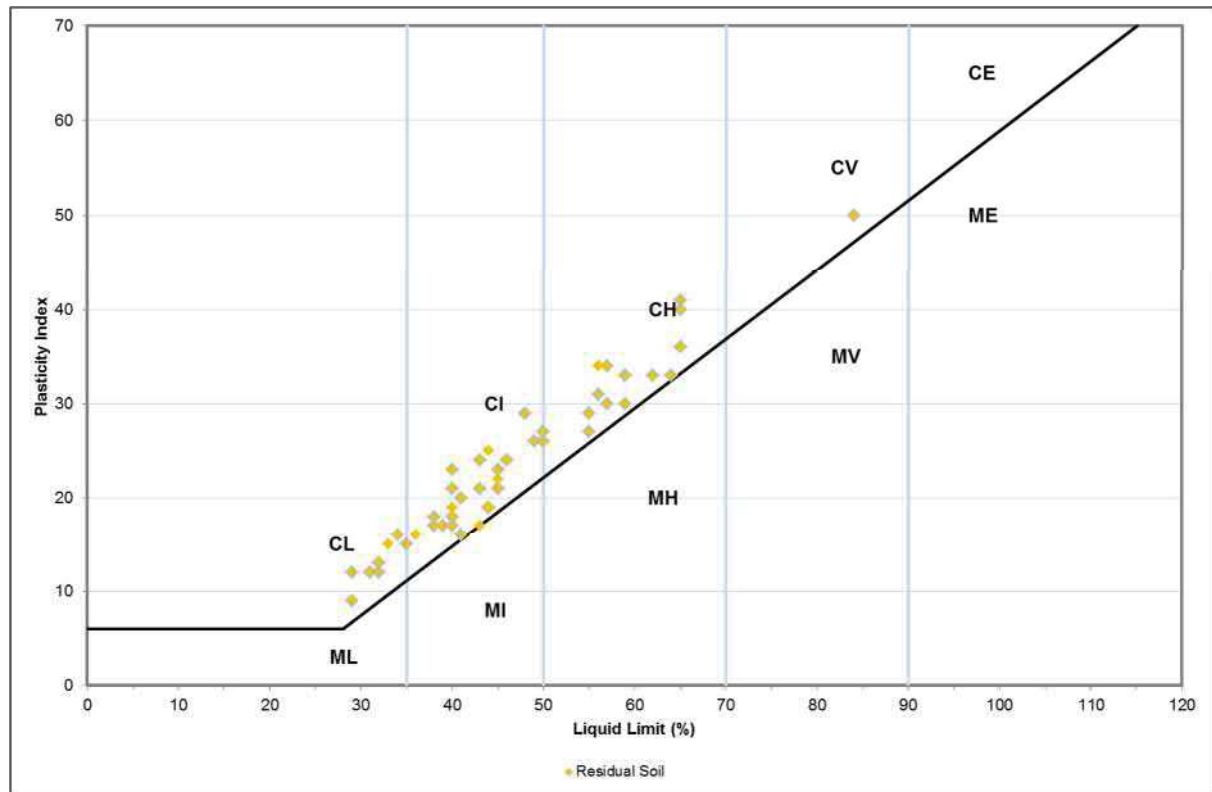
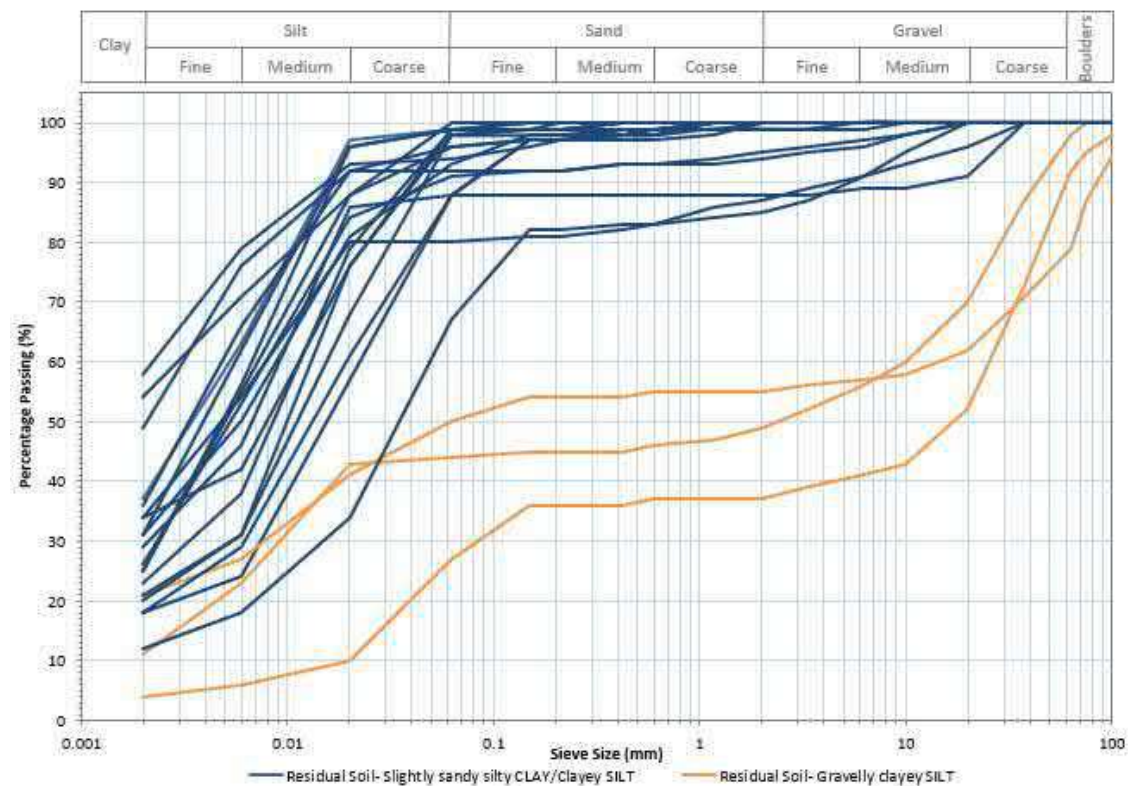


Figure 12. Residual Soil. Particle Size Distribution

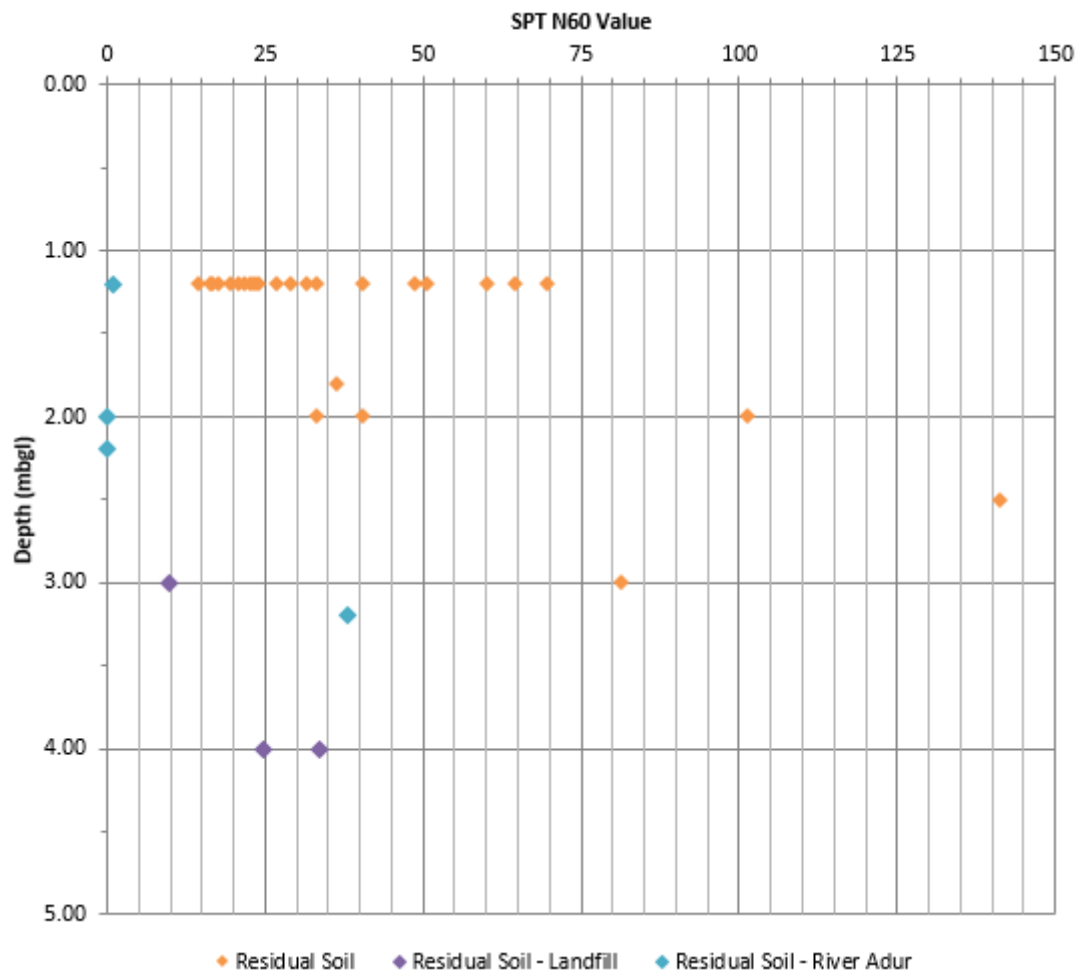


6.5.2 Standard Penetration Test

Twenty-seven Standard Penetration Tests (SPT) were undertaken in the Residual Soil in twenty-one exploratory holes. For the non extrapolated results the N value ranges between 0 and 45. Where refusal occurred within the SPT, the results have been extrapolated to provide an N value with the results of this ranging from 15 to 65. All the results have been corrected using the energy ratio of the SPT hammer to give an N_{60} value. The results of

the tests plotted against depth can be seen in Figure 13. The N_{60} values range between 0 and 141 with the average being 22 and the lower quartile being 19. It should be noted that some of the low values and deeper results are associated with locations adjacent to the River Adur or underlying the landfill material. These have been marked in Figure 13. The results associated with the River Adur range between 0 and 38 with an average of 10. In general, it should be noted that the SPT N_{60} value increases with depth.

Figure 13. SPT N_{60} Values v Depth of Residual Soil



6.5.3 California Bearing Ratio

16 no dynamic cone penetrometer (DCP) tests were carried out to TRL standards. The locations were adjacent to the trial pit locations to ascertain the CBR value of the near surface soils. The tests show a scatter. This may be due to the variable nature of the material. The results range from 3% to 100%.

Equilibrium CBR for the Residual Soil has also been estimated from the above PI information and composition in accordance with Interim Advice Note 73/06, 2009 'Design Guidance For Road Pavement Foundations' (Draft HD25). A CBR value of 4% has been estimated based on a thin layered construction and PI of 25%

This CBR value assumes a high water table and that the foundations may be wetted by groundwater during their life.

Based on these results it is suggested that a CBR value of 3% be used if the road is to be constructed within the top 0.6m of the ground profile and 4% if it is below this depth.

In selecting the Design CBR value for the subgrade, consideration must be given to the likely moisture conditions applying during construction.

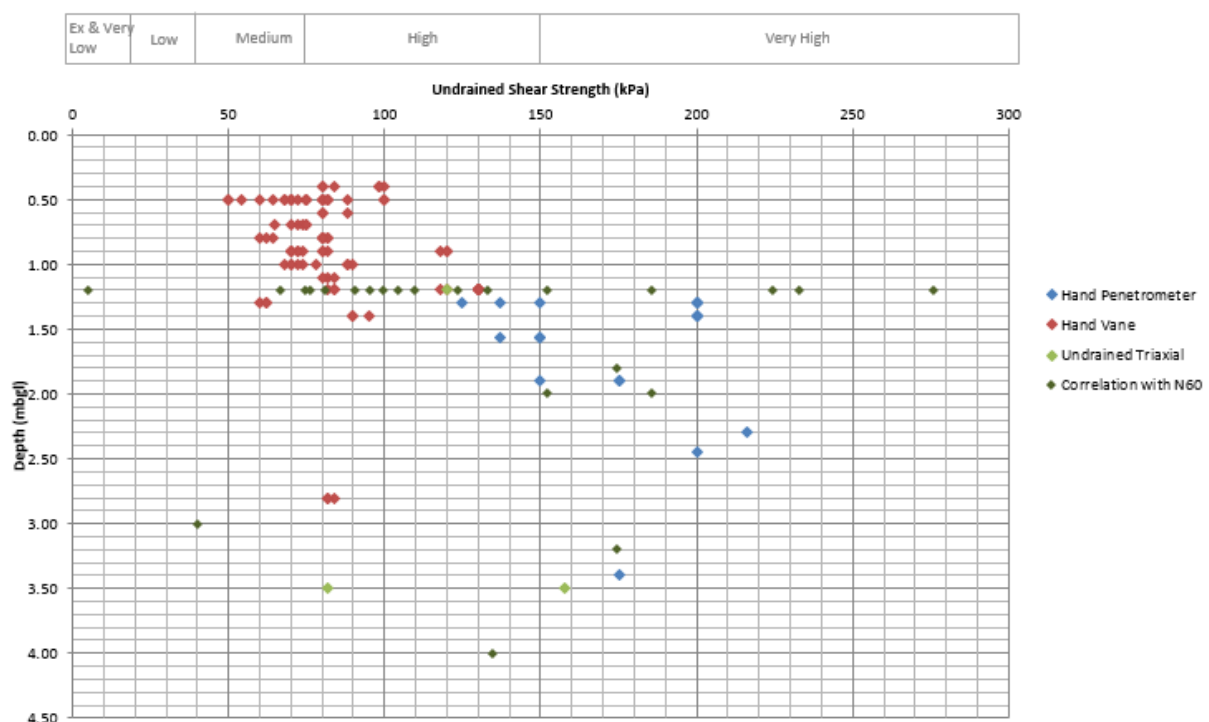
6.5.4 Strength

Undrained Shear Strength

Based on the SPT results, and using the Stroud correlation [12] ($f_1=4.6$ for Plasticity Index of 23%), undrained shear strength values have been derived of between 0kPa and 648kPa with an average of 188kPa. It should be noted that six of the results are greater than 300kPa and are not presented on Figure 14. Undrained shear strengths were recorded on site using hand shear vanes and hand penetrometers and three undrained triaxial was carried out in the laboratory to obtain a shear strength. Three undrained triaxials were carried out on the Residual Soil with the results ranging between 82kPa and 158kPa. The range of the results from all the testing is between 50kPa and 648kPa. Most of the results are presented on Figure 14.

The undrained shear strength across the majority of the site increased from around 50kPa at 0.5m to around 200kPa at 2.5m. Below 2.5m the undrained shear strength varies between 40kPa and 175kPa. These tests have been carried out within the very soft area adjacent to the watercourse, and also underlying the landfill. The low values (<50kPa) above 2.5m are associated with the area adjacent to the River Adur where soft ground was encountered. The designed should select an undrained shear strength profile appropriate to the structure being designed and based on the ground investigation local to the structure.

Figure 14. Residual Soil. Undrained Shear Strength



Drained shear strength

PI values range from 9% to 50% with an average of 23% and a upper quartile value of 29%. The PI – ϕ' correlation Santamarina & Diaz-Rodriguez (2003) yields a ϕ' range between 23° and 27° with an average of 25° and lower quartile of 24°.

In absence of reliable laboratory data, a conservative estimate has been made following guidance in BS 8004:2015 [10]. For a plasticity index of 23%, a characteristic constant volume angle of shearing resistance ϕ'_{cv} of 25° may be adopted. Contribution from dilatancy is assumed to be zero, therefore the peak angle of shearing resistance ϕ'_{pk} is assumed to be 25°.

6.5.5 Stiffness

Four one dimensional consolidation tests were undertaken in the Residual Soil (3no. Freek's Farm 1no. Maple Drive). The samples were loaded to a level beyond their in-situ stress conditions, after which an unloading-reloading cycle was applied, followed by another stress increment. The coefficient of volume compressibility, M_v , measured during oedometer testing is presented in Table 14.

Table 14. Consolidation Test Results

Hole ID	Summary Description	Test Depth	Stress (kPa)	Void Ratio	Volume Compressibility Coefficient (Mv) (m ² /MN)
WS119	Soft to firm orangish brown mottled grey brown slightly gravelly slightly sandy silty clay	1.2	80	0.54	0.450
			120	0.53	0.130
			240	0.51	0.120
			480	0.48	0.078
			80	0.49	Unloading
			120	0.49	0.024
WS119	Very soft to soft brownish grey clay with rare pockets of mudstone	3.0	80	0.63	0.650
			120	0.62	0.230
			240	0.58	0.180
			480	0.54	0.110
			80	0.56	Unloading
			120	0.56	0.082
BH103	Stiff orangish brown to greyish brown slightly sandy slightly gravelly clay.	1.2	80	0.53	0.066
			120	0.52	0.11
			240	0.51	0.091
			480	0.48	0.070
			80	0.51	Unloading
			120	0.50	0.053
CP101	Stiff orangish brown to greyish brown slightly sandy slightly gravelly clay.	3.5	160	0.59	0.000
			40	0.55	-
			80	0.55	0.042
			120	0.54	0.062
			160	0.54	0.066
			200	0.53	0.088
			240	0.53	0.084
			40	0.55	-
			80	0.54	0.050

The tests carried out on WS119 were undertaken on the very soft material adjacent to the river bank, in an area with a potential for flooding. As such these results indicate low stiffness potentially due to the saturation and softening of the soil.

At the current insitu stress state the Residual Soil in close proximity to the water course has medium and high compressibility characteristics (Tomlinson, 2001). The results from BH103 and CP101 suggest low compressibility characteristic in locations away from water courses.

The depth of any foundation will also be dependent on achieving the minimum required undrained shear strength to provide adequate bearing resistance and settlement performance.

6.6 Weathered Weald Clay

The Weathered Weald Clay was encountered in all the test locations with the exception of TP112. The following tests were undertaken on the weathered material:

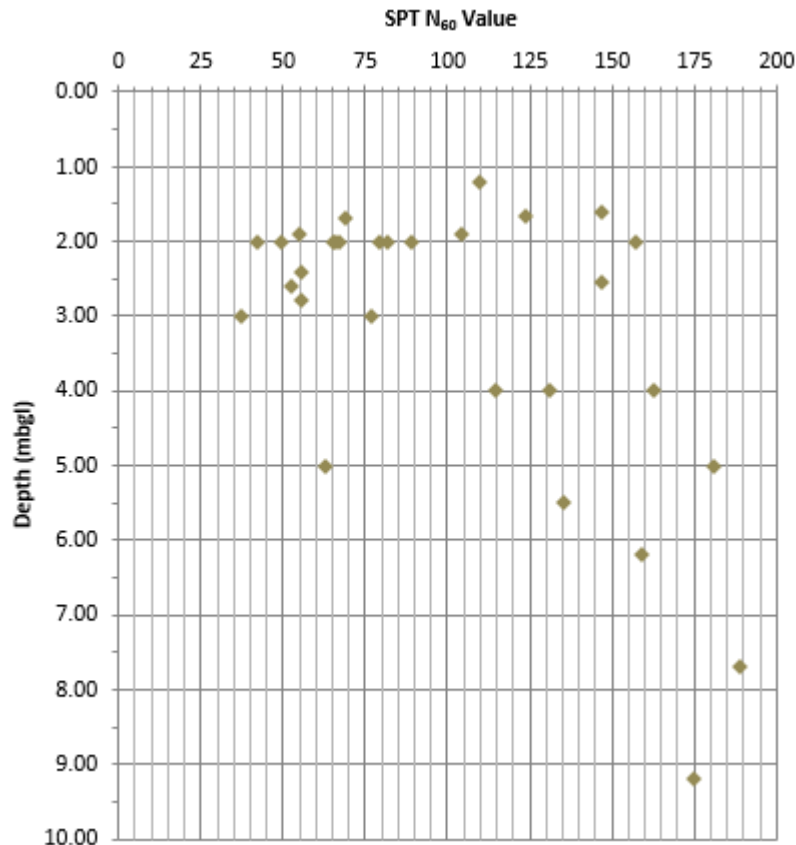
- 31 No. Standard Penetration Tests (SPT)
- 2 No. Uniaxial Compressive Strength Tests (UCS)

- 16 No. Point Load Index Tests (PLI)

6.6.1 Standard Penetration Test

Thirty-one Standard Penetration Tests (SPT) were undertaken in the Weathered material. For the non extrapolated results the N value ranges between 36 and 86. Where refusal occurred within the SPT, the results have been extrapolated to provide an N value with the results ranging from 61 to 183. The results have been corrected using the energy ratio of the SPT hammer to give an N_{60} value. The results of the tests plotted against depth can be seen in Figure 15. The N_{60} values range between 37 and 189 with the average being 41 and the lower quartile being 61.

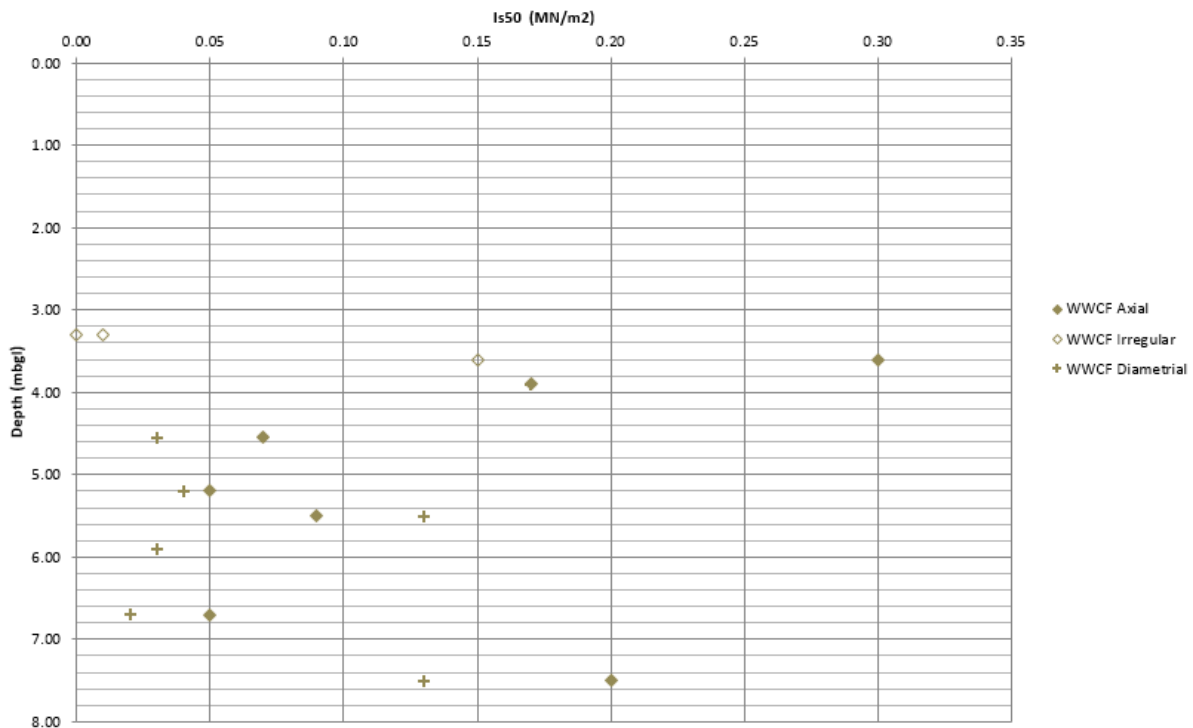
Figure 15. Weathered Weald Clay Extrapolated SPT N_{60} Values v Depth



6.6.2 Material Properties

A bulk unit weight of 20N/m^3 to 23KN/m^3 is recommended for the Weathered Weald Clay based on the rock descriptions and typical values obtained from UCS laboratory testing. Based on the above, it is proposed that a bulk unit weight of 21KN/m^3 is adopted for this material for design purposes.

A total of 19 tests were carried out on samples taken from the Weathered Weald Clay to determine the Point Load Index, reported as I_{s50} . Of these tests, eight were completed on axial samples, 3 on irregular samples and seven on diametral samples. The results of the testing ranged from 0.00 to 0.30MN/m^2 with the average results being 0.09MN/m^2 and the lower quartile of 0.03MN/m^2 . The results of this testing are presented in Figure 16.

Figure 16. Weathered Weald Clay I_{S50} Results

Two uniaxial compressive strength tests (UCS) were carried out on the Weathered Weald Clay. The results of these tests are 0.5MPa and 1.5MPa.

The values obtained from the testing support the strength descriptors of extremely weak to very weak given in the exploratory hole logs. The designer should select an unconfined compressive strength profile appropriate to the structure being designed and based on both the borehole descriptions and the test data local to the structure.

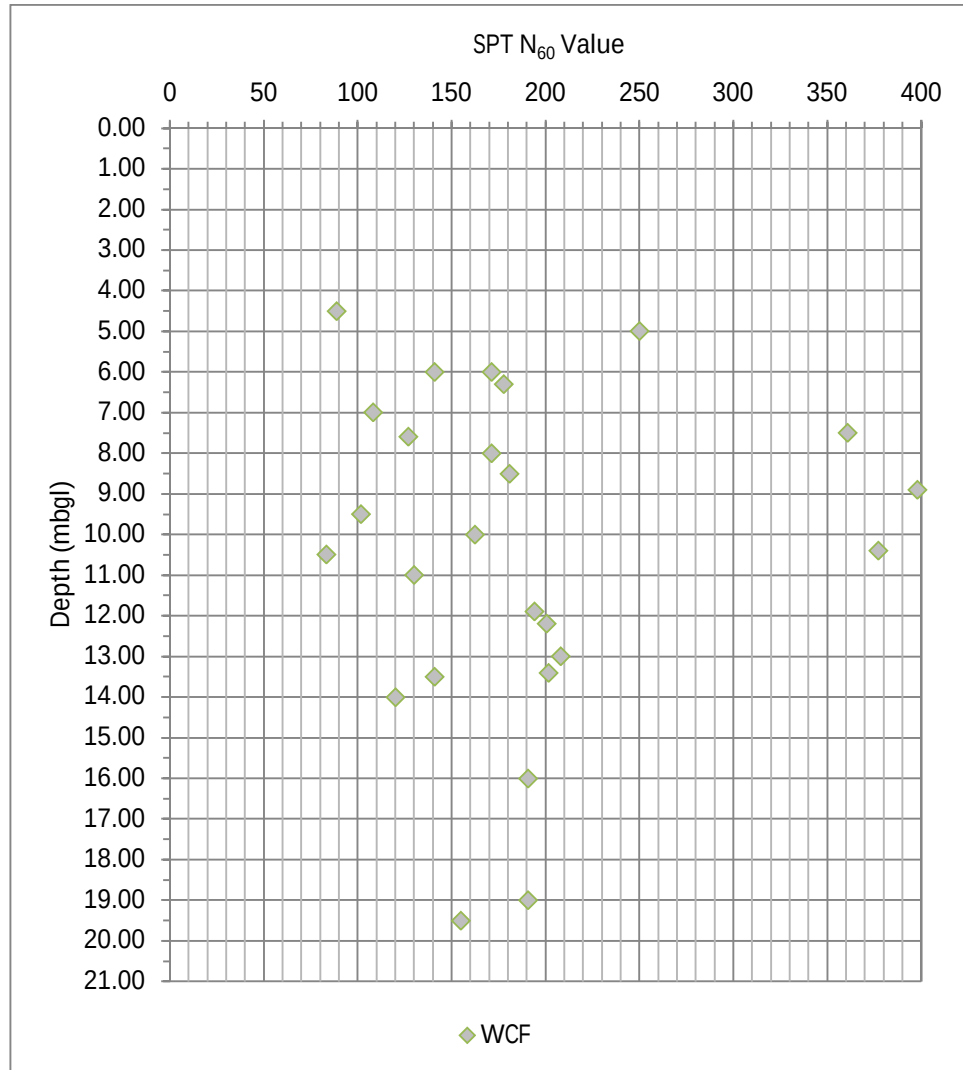
6.7 Unweathered Weald Clay

The Unweathered Weald Clay was only encountered in the deep boreholes carried out on the site (BH101 to BH104). The following tests were undertaken within this unit:

- 27 No. Standard Penetration Tests (SPT)
- 21 No. Uniaxial Compressive Strength Tests (UCS)
- 58 No. Point Load Index Tests (PLT)

6.7.1 Standard Penetration Tests

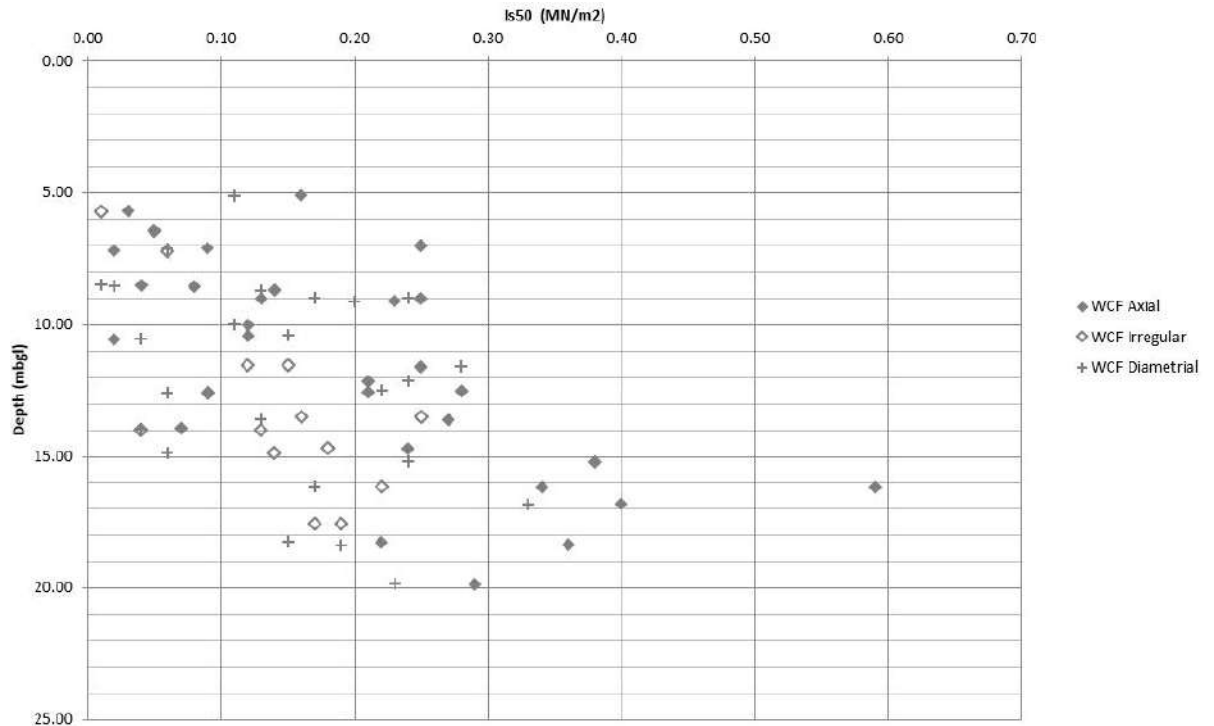
Figure 17 shows the SPT results undertaken in the Unweathered Weald Clay. Only one of these tests achieved the required depth of test prior to refusal and obtained an N value of 82. For all the tests the N_{60} results vary between 83 and 398, with an average of 58 and a lower quartile value of 129. The results of the testing are presented in Figure 17.

Figure 17. Unweathered Weald Clay. Extrapolated N_{60} Standard Penetration Test Values

6.7.2 Material Properties

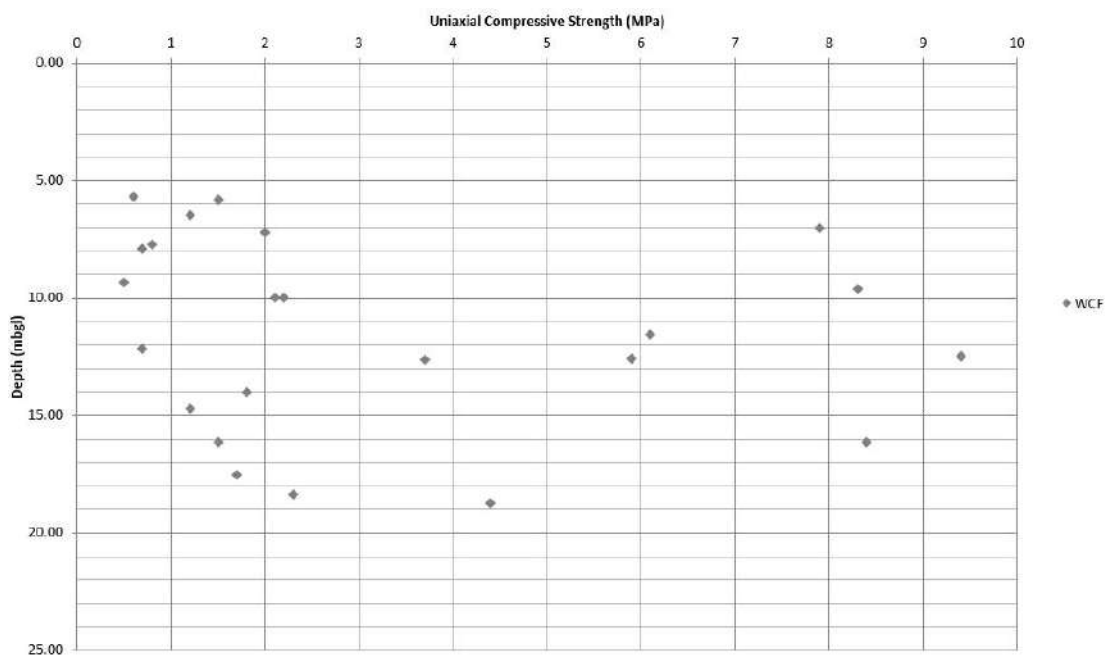
A bulk unit weight of 19kN/m^3 to 21kN/m^3 is recommended for the Unweathered Weald Clay based on the rock descriptions and typical values obtained from UCS laboratory testing. Based on the above, it is proposed that a bulk unit weight of 20kN/m^3 is adopted for this material for design purposes.

A total of 70 tests were carried out on samples taken from the Unweathered Weald Clay to determine the Point Load Index, reported as I_{s50} . Of these tests, 30 were completed on axial samples, 15 on irregular samples and 25 on diametral samples. The results of the testing ranged from 0.01 to 0.59MN/m^2 with the average results being 0.17MN/m^2 and the lower quartile of 0.08MN/m^2 . The results of this testing are presented in Figure 18. It can be seen that in general the strength of the material increases with depth and that there is no obvious difference in the results depending on the orientation tested.

Figure 18. Unweathered Weald Clay I_{s50} Results

23 uniaxial compressive strength (UCS) tests were carried out on the Unweathered Weald Clay. The results varied between 0.5MPa and 9.4MPa with an average of 3.3MPa and a lower quartile of 1.2MPa. The results of the testing can be seen in Figure 19. It can be seen that in general that the strength profile increases with depth.

The values obtained from the testing support the strength descriptors of very weak to weak given in the exploratory hole logs. The designer should select an unconfined compressive strength profile appropriate to the structure being designed and based on both the borehole descriptions and the test data local to the structure.

Figure 19. Unweathered Weald Clay UCS

7. Design Considerations

7.1 Design of Buried Concrete

The pH and sulphate results have been used to determine the Aggressive Chemical Environment for Concrete (ACEC) and Design Sulphate Classes (DS) in accordance with BRE Special Digest 1:2005 3rd Edition, Section C5.1.2. The results are presented in Table 15.

Table 15. Summary of BRE SD1 Assessment

Stratum	No. Of Tests	Characteristic Values			Design Sulphate (DS) Class	ACEC Class
		Water Soluble Sulphate mg/l	Total Potential Sulphate (SO ₄) %	pH		
Made Ground – Landfill Cover	1	48	0.06	7.47	DS-1	AC-1
Made Ground - Landfill	5	537.5	0.24	7.50	DS-2	AC-2
Residual Soil	26	28.4	0.07	4.94	DS-1	AC-2z
Weathered Weald Clay Formation	10	87.5	0.33	4.84	DS-2	AC-3z
Unweathered Weald Clay Formation	6	115	0.86	6.06	DS-3	AC-3

Assessment of the results of pH and sulphate testing indicates that concrete in contact with the soils will need to be designed for Design Sulphate Class of DS-3 and an ACEC class of AC-3. An assessment has been made using mobile groundwater due to the potential presence of the Horsham Sandstone Member.

7.2 Soakaway

Three soakaway tests were carried out in accordance with BRE Digest 364 “Soakaway Design”, 2016. Tests were carried out within the Weald Clay in TP101, TP105 and TP116. Whilst the digest requires the testing to be carried out three times in each location, due to slow soakage the testing was only carried out once in each location. The results of all of the infiltration testing indicated that the ground conditions are not suitable for shallow infiltration as due to limited infiltration the soil infiltration rate could not be calculated.

7.3 Foundations

Information on the final design and loadings of structures has not been provided. For typical house construction of 2-3 storeys, with low magnitude loads, shallow foundations are likely to be suitable. For more heavily loaded developments piles may be required. The depth to groundwater will need to be considered in the foundation design.

The depth of the foundations in shrinkable soils is dependent on the shrinkage potential of the soil and the presence of any existing, recently removed or proposed vegetation. Based on the classification testing the Residual Soil at the site is indicated to be of high volume change potential for which a minimum foundation depth of 1.0m is recommended in the NHBC standards outside the zone of vegetation influence. Where foundations will be within the zone of influence of vegetation the founding depth will need to be increased in accordance with published standards (e.g. NHBC)

8. Phase II Environmental Quality Risk Assessment (EQRA)

8.1 Introduction and General Observations

The following Generic Quantitative Risk Assessment has been carried out based on the preliminary desk studies using the knowledge and data collected as part of the intrusive site investigation and in accordance with the CLR11 guidance to assist on the discharge of the associated contaminated land planning conditions.

Although care has been taken to investigate all the potential sources, it should be noted that the ground investigation works were carried out before the waste clearance was completed from the fly tipping area, Freek's lane and northern field dry ponds. A photo log and associated map have been produced to record as much as reasonable possible on the visual condition of waste at the time of the ground investigation works. Due to the amount of waste spread in this area, the ground investigation was limited in that ground conditions beneath the waste heaps could not be assessed. Consequently, there is the potential for unidentified hotspots to be present beneath the waste heaps which were not identified during the ground investigation. Photos taken at the time of the site investigation are included in Appendix C.

The originally proposed boreholes and trial pits within the southwestern corner of the Site had to be cancelled / relocated due to potential services in the area (sewers). These boreholes were designed to investigate a potential infilled area shown in historical drawings from 1910 and 1956. This is an area currently occupied by trees and dense vegetation and a small pond (which has been sampled as part of the current works)

During preparation of this report (following completion of the ground investigation) anecdotal evidence was received from an adjacent landowner suggesting the presence of a potential buried container of blue asbestos near one of the barns and animal carcasses and vehicles across the site. This information was received too late to be assessed during the ground investigation, but the potential risks have been added to the revised CSM included in section 7.10.

8.2 Selection of Generic Assessment Criteria (GAC)

The purpose of the Generic Quantitative Risk Assessment (GQRA) as defined in CLR11 is to establish where Generic Assessment Criteria (GAC) and assumptions about a site are appropriate for assessing risks and, if so, to apply them to site data in order to establish whether there are actual or potentially unacceptable risks.

The GQRA also determines whether further detailed assessment is required. In doing so, it confirms whether the contaminant linkages identified in the preliminary risk assessment are of concern or not.

For this GQRA, laboratory test results have been compared against a range of GAC published by authoritative national or international bodies or developed in accordance with methodologies set out by these bodies.

The GAC selected for this assessment are based on the preliminary CSM and identified linkages. The key aspects of the CSM relevant to GAC selection include:

- The future proposed development (Freek's Farm and Maple Drive). A future residential land-use scenario with plant uptake has been considered for the Freek's Farm area, and a future residential public open space scenario has been considered for the Maple Drive area.
- The classification of groundwater underlying the Site as a Secondary-A aquifer with nearby surface water course (River Adur East). Although the identified underlying geology (Weald Clay Formation) is classified as unproductive strata, it is noticed that a groundwater table has been measured across the site (with groundwater flowing to the west) and available BGS data indicate potential small outcrops of the Horsham Stone member (Secondary A aquifer) in the central of the site.

All the environmental samples were sent to Exova Jones Environmental, a UKAS accredited laboratory. The chemical test certificates are presented in Appendix F.

8.2.1 Human Health Screening Criteria – Freek's Farm

In Freek's Farm area, the GACs have been taken from the following sources, in order of preference, with the residential land-use scenario (with plant uptake) considered. According to the Environment Agency, a typical residential property is a two-storey house built on a ground-bearing slab with a private garden. It is assumed that parents with young children, who make regular use of the garden, are occupants of the house. In this scenario, the

critical receptor is a young female child aged between zero and six years old, with direct soil and indoor dust ingestion, consumption of homegrown produce, consumption of soil adhering to homegrown produce, skin contact with soils and indoor dust, and inhalation of indoor and outdoor dust and vapours being the exposure pathways; lastly, it is considered an exposure period of six years. Moreover, in this pathway, it is assumed the potential transfer of chemicals in soil to fruit and vegetables grown in contaminated ground via different pathways (e.g. root uptake) [17].

- LQM/CIEH Suitable 4 Use Levels, 2014 – Residential with Homegrown Produce.
- Defra SP1010, 2014 – Development of Category 4 Screening Levels for Assessment of Land Contamination - Policy Companion Document, December 2014. Resi with produce;
- EIC/AGS/CL:AIRE GAC. Residential, Sandy Loam, Plant Uptake;
- AECOM GAC, modified EIC. Residential, Sandy Loam, Plant Uptake;
- Dutch Soil Remediation Circular 2009 - Soil Intervention Values;
- Dutch Soil Remediation Circular 2009 - Soil - Serious Contamination; and
- United States Environmental Protection Agency (USEPA), 2019 – Regional Screening Levels, May 2019. Residential (no vapours).

GAC are available for two soil types – sand and sandy loam – and three total organic carbon contents (TOC) – 0.58-1.45%, 1.45-3.48% and >3.48%. Based on the encountered geology and using the average TOC concentration for shallow soils (0-1m bgl) at the Site, GAC have been selected for a sandy loam soil type with TOC in the range of 0.58-1.45%.

8.2.2 Human Health Screening Criteria – Maple Drive

For the Maple Drive area, the GAC have been taken from the following source considering a land use scenario of residential public open space:

- LQM/CIEH Suitable 4 Use Levels (2014). Public Open Space (residential).

According to Defra C4SL guidance, a public open space in close proximity to residential housing includes the predominantly grassed areas adjacent to high density housing and the central green area around which houses are located. It is considered to generally be a predominantly grassed area of up to 500 m² (0.05 ha) and a considerable proportion of this (up to 50%) may be bare soil.

GAC are available for two soil types – sand and sandy loam – and three total organic carbon contents (TOC) – 0.58-1.45%, 1.45-3.48% and >3.48%. Based on the encountered geology and using the average TOC concentration for shallow soils (0-1m bgl) at the Site, GAC have been selected for a sandy loam soil type with TOC in the range of 0.58-1.45%.

The paved children's playground area present at the southern area of the Site (at the junction between the proposed link road and Maple Drive) has not been further assessed as the area was previously investigated by WYG, the landfill was not identified in this area and no exceedances were reported by WYG (residential public open space scenario considered).

8.2.3 Controlled Water Screening Criteria

For the assessment of linkages associated with potential adverse effects to controlled waters and taking into account the information presented above, GAC have been selected to be protective of groundwater as a drinking water resource and to be protective of surface water bodies that might be affected by lateral migration from affected groundwater. The GACs used for the screening of groundwater and surface water results have been taken from the following sources:

- AECOM Drinking Water Guidance (adopting WHO methodology);
- EU REACH – Freshwater Predicted No Effect Concentration (PNEC);
- SEPA - Supporting Guidance (WAT-SG-53) Environmental Quality Standards for Discharges to Surface Waters. v6. Dec 2015. Fresh EQS – AA;
- SEPA - Supporting Guidance (WAT-SG-53) Environmental Quality Standards for Discharges to Surface Waters. v6. Dec 2015. Fresh EQS – MAC;

- UK Drinking Water Standards (DWS), 2016 – The Water Supply (Water Quality) Regulations 2016;
- United States Environmental Protection Agency (USEPA), 2019 – Regional Screening Levels, May 2019. Tapwater;
- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 - AA-EQS Inland;
- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 - MAC-EQS Inland;
- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 - Freshwater Standards;
- The Water Environment (River Basin Management Planning etc.) (Miscellaneous Amendments) (Scotland) Regulations 2015. Scottish SI 2015 No. 211. AA-EQS Inland;
- World Health Organisation (WHO), 2008 – Petroleum Products in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality; and
- World Health Organisation (WHO), 2017 – Guidelines for Drinking-water Quality (4th Edition inc. the First Addendum).

Where groundwater data is not available and in order to evaluate a potential risk from reported soil concentrations to controlled waters, soil GAC were calculated as the theoretical soil concentrations that would partition at equilibrium to give a concentration in soil pore water equal to the water GACs. A sandy soil type with a TOC content of 0.2% was assumed. It is noted that this approach is highly conservative; however, the methodology is consistent with the Environment Agency's preferred approach as outlined within the Remedial Target Methodology (RTM) guidance document¹.

8.3 Soil Laboratory Results – Freek's Farm

The Chemical analyses have been performed on a total 42No. soil samples from 6No. deep rotary drilled boreholes, 14No. trial pits and 18No. shallow window sampling boreholes across the site.

The screened data is presented in Appendix E and the exceedances are summarised as follows:

Table 16. Summary of Soil Exceedances Against Human Health GAC – Residential Land Use Scenario – Freek's Farm

Determinant	HH GAC, POS (mg/kg)	Number of Exceedances	Maximum Concentration (mg/kg)
Metals			
Lead	200	1	370 (WS120)

Table 17. Summary of Soil Exceedances Against Controlled Water GAC – DWS, Freek's Farm

Determinant	CW GAC, DWS (mg/kg)	Number of Exceedances	Maximum Concentration (mg/kg)
Metals			
Arsenic	5	36	19.2 (WS118)
Barium	53.3	31	154 (TP113)
Lead	26.9	24	370 (WS120)
Nickel	10	31	34 (TP103)
Selenium	5.0E-01	23	2 (TP113)
Vanadium	1.09	34	61 (WS118)
Organochlorine Pesticides			
Endrin	6.78E-03	1	0.014 (TP107)

¹ Environment Agency, 2006. Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination

Determinant	CW GAC, DWS (mg/kg)	Number of Exceedances	Maximum Concentration (mg/kg)
PAHs			
Benzo(a)pyrene	2.58E-03	6	0.24 (WS119)
Fluoranthene	1.46E-01	3	0.34 (WS119)
Phenanthrene	4.41E-02	3	0.1 (WS119)
Dibenz(a,h)anthracene	2.61 E-02	1	0.06 (WS119)

In addition to the above, a sample for asbestos identification was collected from a pile of household waste and corrugated roof sheets located in the northern area of the site. Laboratory results confirmed these are asbestos containing materials (ACM). Other piles of potential corrugated cemented asbestos roof sheets were located in the southern area of the fly tipping area. Also an animal shed next to Freek's Farm house (and potential other associated buildings) was reported by the land owner to have corrugated cemented asbestos roof sheets. Photos are included in Appendix C which includes a map indicating the locations of the photos.

Table 18. Summary of Soil Exceedances against Controlled Water GAC – EQS Freshwater, Freek's Farm

Determinant	CW GAC, EQS Freshwater (mg/kg)	Number of Exceedances	Maximum Concentration (mg/kg)
Metals			
Cadmium	8.00E-03	17	0.3 (BH105, TP105 and TP1133)
Chromium Trivalent	22.6	34	54.4 (WS118)
Copper	1.0E-01	34	58 (WS107)
Lead	3.23	34	114 (WS101)
Nickel	2	34	24.90 (TP113)
Vanadium	2.53E-01	34	61 (WS118)
Zinc	4.15E-01	34	137 (BH105)
PAHs			
Benzo(a)pyrene	4.38E-05	6	0.24 (WS119)
Benzo(b)fluoranthene	3.56E-03	6	0.36 (WS119)
Benzo(g,h,i)perylene	6.84E-03	4	0.2 (WS119)
Benzo(k)fluoranthene	5.03E-03	6	0.14 (WS119)
Fluoranthene	2.30E-04	18	0.34 (WS119)
Pesticides			
Aldrin + Dieldrin + Endrin + Isodrin	2.52E-04	1	0.034 (TP107)

8.4 Soil Laboratory Results – Maple Drive

A total 11No. soil samples were collected across the Maple Drive area within the clean cover of the landfill, between depth ranging 0.1 and 0.7m bgl to complement the previous assessments carried out by WYG in 2017. Soil data has not screened against controlled water receptors as soil data samples were only collected from cover layer and groundwater data is available from installed groundwater monitoring wells.

Human Health exceedances have not been reported in soil samples collected within the clean cover overlaying the landfill material.

One (NSS101) of the 11 soil samples collected in the clean cover and tested for asbestos reported asbestos fibres (Chrysotile) at concentrations < 0.001%. This is a near surface sample collected at 0 – 0.1 m bg that was aimed to further investigate/delineate the asbestos insulating board debris previously identified by WYG in WS02.

The screened soil data is presented in Appendix E.

8.5 Groundwater Laboratory Results – Freek's Farm

Chemical analyses have been performed on a total No. 6 groundwater samples from No. 6 exploratory boreholes across Freek's Farm.

The screened data is presented in Appendix E and the exceedances are summarised as follows:

Table 19. Summary of Groundwater Exceedances Against Controlled Water GAC – DWS, Freek's Farm

Determinant	CW GAC, DWS (µg/l)	Number of Exceedances	Maximum Concentration (µg/l)
Metals			
Chromium (III+VI)	50	1	65.3 (BH101)
Boron	1000	1	1042 (BH104)
PAHs			
Benzo(a)pyrene	1 E-02	1	0.028 (BH104)

Table 20. Summary of Groundwater Exceedances Against Controlled Water GAC – EQS Freshwater, Freek's Farm

Determinant	CW GAC, EQS Freshwater (µg/l)	Number of Exceedances	Maximum Concentration (µg/l)
Metals			
Chromium Trivalent	4.7	1	65 (BH101)
Copper	1	1	8 (BH101)
Nickel	4	3	12 (BH102 and BH105)
Vanadium	20	1	70.80 (BH101)
Zinc	10.9	1	44 (BH105)
PAHs			
Fluoranthene	6.3 E-03	1	0.06 (BH104)
Benzo(a) pyrene	1.7 E-04	1	0.028 (BH104)
Benzo(g,h,i)perylene	8.2 E-03	1	0.019 (BH104)
Benzo(b)fluoranthene	1.7 E-02	1	0.03 (BH104)

8.6 Groundwater Laboratory Results – Maple Drive

Chemical analyses have been performed on a total No. 3 groundwater samples from No. 3 exploratory boreholes across the Maple Drive area.

The screened data is presented in Appendix E and the exceedances are summarised as follows:

Table 21. Summary of Groundwater Exceedances Against Controlled Water GAC – Drinking Water Quality, Maple Drive

Determinant	CW GAC, DWS (µg/l)	Number of Exceedances	Maximum Concentration (µg/l)
BTEXs			
Benzene	1	1	2 (CP102)

Determinant	CW GAC, DWS (µg/l)	Number of Exceedances	Maximum Concentration (µg/l)
Metals			
Boron	1000	2	1375 (CP101)
PAHs			
Benzo(a)pyrene	1.0E-02	2	0.252 (CP102)
Naphthalene	6	1	14 (CP102)
Phenanthrene	4	1	4.473 (CP102)
PAHs (sum of 4)	1.0E-01	2	0.613 (CP102)
TPHs			
>EC10-EC12 Aromatics	90	1	123 (CP102)
>EC12-EC16 Aromatics	90	1	110 (CP102)
>EC16-EC21 Aromatics	90	1	130 (CP102)

Table 22. Summary of Groundwater Exceedances Against Controlled Water GAC – EQS Freshwater, Maple Drive

Determinant	CW GAC, EQS Freshwater (µg/l)	Number of Exceedances	Maximum Concentration (µg/l)
Metals			
Copper	1	1	11 (CP102)
Nickel	4	2	19 (CP101)
Zinc	1	1	11 (CP103)
PAHs			
Anthracene	1.0E-01	1	1.021 (CP102)
Benzo(a)pyrene	1.7E-04	2	0.252 (CP102)
Benzo(b)fluoranthene	1.7E-02	2	0.29 (CP102)
Benzo(g,h,i)perylene	8.2E-03	2	0.099 (CP102)
Benzo(k)fluoranthene	1.7E-02	2	0.11 (CP102)
Fluoranthene	6.3E-03	3	1.653 (CP102)
Naphthalene	2	1	14 (CP102)

8.7 Surface Water Laboratory Results – Freek's Farm

Chemical analyses have been performed on a total No. 3 surface water samples collected along River Adur East and the tributary stream (Worlds End Stream). A fourth sample was collected from a small pond located in the SW corner of the Site.

The screened data is presented in Appendix E and the exceedances are summarised as follows:

Table 23. Summary of Surface Water Exceedances Against Controlled Water GAC – EQS Freshwater, Freek's Farm

Determinant	CW GAC, EQS Freshwater (µg/l)	Number of Exceedances	Maximum Concentration (µg/l)
Metals			
Copper	1	1	37 (SW4)
Lead	1.2	1	77 (SW4)

Determinant	CW GAC, EQS Freshwater (µg/l)	Number of Exceedances	Maximum Concentration (µg/l)
Nickel	4	1	28 (SW4)
Zinc	10.9	2	37 (SW4)
PAHs			
Benzo(a) pyrene	1.7E-04	2	0.049 (SW2)
Benzo(b)fluoranthene	1.7E-02	3	0.060 (SW2)
Benzo(g,h,i)perylene	8.2E-03	2	0.032 (SW2)
Benzo(k)fluoranthene	1.7E-02	1	0.020 (SW2)
Fluoranthene	6.3E-03	3	0.064 (SW2)

8.8 Ground Gas Risk Assessment

A quantitative ground gas risk assessment has been undertaken and calculated based on the classification system set out in the CIRIA C6652 and BS8485:2015 + A1:2019. The risk assessment methodology uses both the gas concentrations and borehole flow rates to define a characteristic situation for a Site based on the limiting gas volume flow for methane and carbon dioxide. The Gas Screening Value (GSV) is calculated using the maximum gas concentration as a fraction multiplied by the maximum recorded steady flow.

Field data collected during the four ground gas monitoring visits are provided in Table 3 of Appendix D.

8.8.1 Maple Drive Link Road/ Landfill Area

The following CSM has been produced to assess a potential gas migration from the landfill to the new proposed development:

Source: The landfill operated between 1970 and 1986 and authorized waste types included inert, commercial and household waste. This is in general accordance with the material encountered during the current and previous site investigation. No potential gassing landfill material has been encountered which explains why no flow has been measured in the ground gas wells installed within the landfill material.

Pathway: The completed site investigations indicate the landfill material does not extend up to Freek's Lane and is at least 50m away from proposed residential development in Freeks Farm based on CP103 and WS04 (WYG borehole). No granular made ground deposits were identified which could facilitate the sub-surface migration of gases. The impermeable nature of the underlying weathered Weald Clay Formation would act as a barrier for potential gas migration.

Receptors: Residential dwellings constructed in the 90's are located approximately 30m away from the landfill material and topographically downhill (where any escaping CO₂ is likely to migrate). AECOM is not aware of any gas intrusion issues to the existing properties. Proposed residential development in Freeks Farm is located at least 50 m away from the landfill material, also topographically downhill to the landfill.

Maximum concentrations of 68% methane and 25.7% carbon dioxide have been measured within wells installed in the landfill material. No flow was however measured during the four monitoring visits completed and at least one visit was carried out during a low barometric pressure event (995mb) during which a flow would have been expected if the material was gassing. It is noted barometric pressure was stable or rising during monitoring when the monitoring was carried out in the Maple drive area. No methane and a maximum of 2.1% of carbon dioxide have been measured in CP103, located approximately 30m away from CP102 (well installed in the landfill material and with highest concentrations) and 30m away from Freek's lane / future residential development. Equally null / low concentrations (and no flow) have been recorded in ground gas wells installed within the southern part of the Freek's Farm future development.

A ground gas risk due to migration of gases from the landfill material is therefore considered unlikely based on the above arguments and monitoring carried out within the landfill material and surroundings. No ground gas protection measures are considered necessary. It is however recommended that any drainages/services that may be installed

² CIRIA document C665: Assessing Risks Posed by Hazardous Ground Gases to Buildings (2007);

³ BS8576:2013 Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs) and BS 8485:2015 Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings.

through the proposed Maple Drive road and to the future development are sealed to avoid opening a potential future pathway.

8.8.2 Freek's Farm

No Methane and a maximum of 4.7% carbon dioxide (BH102) have been measured across the Freek's Farm site over four monitoring visits and a total of 15 ground gas installations. No flow was measured in any of the locations and methane and carbon dioxide was not measured above the threshold defined by the guidance's (1% methane and 5% carbon dioxide) above which a ground gas risk may exist. Ground gas risk is therefore considered unlikely and no ground gas mitigation measures are recommended.

It should however be noted that due to the cancellation / relocation of boreholes in the southern area of the site (due to potential sewers) the closest ground gas monitoring point to the potentially infilled area in the south western boundary of the site (identified from historical drawings and currently heavily vegetated with a small pond) is located at approximately 75m (WS101). An EA historical landfill site and a waste transfer/treatment site were also reported by the Envirocheck report to the west of the southern area of the site. The existing subsoil (Weald Clay) is considered to act as a barrier for gas migration across the site, however, the potential presence of granular made ground associated with the sewers/utilities crossing the site in the south western area of the site could potentially act as a preferential pathway connecting a potentially infilled area to the west and the future development. Although the risk for the south western boundary of the site to be infilled with active gassing waste is considered unlikely it may be prudent to further investigate this area when services in the area are removed.

8.9 Risk Evaluation

8.9.1 Human Health

8.9.1.1 Freek's Farm

No obvious visual or olfactory evidence of potential contamination or elevated PID readings indicative of impact were reported.

Soil laboratory data reported lead concentrations exceeding the respective Human Health GACs (residential with plant uptake scenario) in 1 of the 41 samples collected across the future proposed residential development in Freek's Farm. The minor exceedance for lead (370 mg/kg versus GAC of 200 mg/kg) is not considered to pose a risk for future site residents.

It should however be noted that the ground investigation works were carried out before the waste clearance was completed and did not assess soils directly underlying waste/vehicles. It is therefore possible that residual contamination hotspots may be present beneath and around the waste, however, these are likely to be localised due to the anticipated low permeability of the cohesive superficial deposits and the lack of widespread impacts encountered in soils and groundwater during the GI works. Validation sampling works are recommended once all waste is removed and the top surface layer is stripped out in the fly tipping area and other areas containing waste

8.9.1.2 Maple Drive Link Road

No obvious visual or olfactory evidence of potential contamination or elevated PID readings indicative of impact were reported within the clean cover material protecting the landfill waste.

Soils exceedances over the Human Health GACs (Residential public open space scenario) have not been reported in any of the 7 samples analyzed within the clean cover material covering the landfill material and therefore a HH risk to future site users is considered unlikely assuming the clean cover is maintained to avoid direct a potential direct contact with the landfill material. Previous assessments completed by WYG in 2017 similarly did not identify a Human Health risk from the clean cover material.

Asbestos insulating debris was reported by WYG in WS02 at 0.5m bgl. This was further investigated during the current ground investigation, collecting 4 near surface samples around WS02 (and testing for asbestos as well in the other 7 samples collected across the clean cover material). One of the near surface samples next to WS02 reported asbestos fibres (Chrysotile) at concentrations < 0.001%. Consideration of control measures to minimise airborne fibres during ground disturbance is recommended.

Care should be taken if the clean cover is temporally removed during future works to avoid spreading landfill material at surface level. As a minimum, any existing clean cover should be reinstated (unless hardstanding) with a minimum thickness of 1 metre of clean subsoil.

8.9.2 Ground Gas

In Maple Drive link road, relatively high methane and carbon dioxide concentrations (and no flow) have been measured within monitoring points installed in the landfill material. A detailed conceptual site model has been developed in section 7.8.2 to assess a potential risk for these gases to migrate to the new proposed residential development. The collected data indicates the landfill material is not actively gassing (based on the identified material and the lack of flow measured), the lack of pathway (due to clayey natural ground and absence of made ground between the landfill material and the proposed residential development), the monitoring data collected in Maple Drive and Freek's Farm and the distance of the proposed residential development to the landfill material (>50m). Also, AECOM understand that current residential properties built in the 90's and located next to the landfill (within 30m) have not experienced any gas intrusion issues.

Ground gas migration and risk to future residents is considered unlikely based on the data collected and the developed ground gas conceptual site model. Therefore mitigation measures (gas membranes) are not considered required for the proposed residential development in Freek's Farm and/or in the proposed Maple Drive link road. It is however recommended that any drainages/services that may be installed through the proposed Maple Drive road and to the future development are sealed to avoid opening a potential future pathway.

A data gap exists for a potential relatively small area in the south western boundary (currently heavily vegetated) of the site to be infilled. It is recommended this area is further investigated during future earthworks in the area.

8.9.3 Controlled Water

Metals, PAHs and Endrin (a pesticide) concentrations in soil samples have been reported to exceed the CW GACs in Freek's Farm. It should however be noted that GACs used are highly conservative and therefore should be only considered in locations where groundwater data is not available. Metal exceedances have been reported at all locations of Freek's Farm at similar levels and therefore concentrations are considered to be background levels. In Freek's Farm, soils PAHs exceedances to the CW GACs were reported in 18 of a total of 34 locations, with highest concentrations located, with highest exceedances reported for benzo(a)pyrene which exceeded in 6 locations. Exceedances were reported only in shallow soils and no PAH exceedances were recorded in samples collected >0.5m bgl. Benzo(a) pyrene National Background Concentrations³ (NBC) in topsoil samples across England have been reported to be between 3.6 mg/kg in urban areas and 0.5mg/kg in other non-urban areas. Maximum benzo(a)pyrene concentrations have been recorded at 0.24 mg/kg and therefore much lower than the NBC average for rural areas. Endrin (pesticide) in soils was reported above the laboratory method detection limit and above CW GAC in one location (fly tipping area). No other pesticides were detected above the laboratory method detection limit within the other 13 soil samples tested and Endrin reported in one sample has a very low aqueous solubility which significantly limits a potential migration. Reported soils exceedances are therefore not considered to oppose a risk to the identified CW receptors.

Groundwater data across Freek's Farm has reported some metals to exceed DWS and EQS GAC's by a maximum factor of 4 (Zinc). Four PAHs compounds (benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene and fluoranthene) were also reported to exceed the CW GACs in BH104. Highest PAHs exceedance was for benzo(a)pyrene which exceeded the DWS by a factor of 2.8 and the EQS by 2 orders of magnitude. These concentrations are considered minor and unlikely to represent a risk to the Aquifer or River Adur East located approximately 20m away.

A petroleum hydrocarbon fraction (>EC10-EC21 aromatics), benzene, nine PAH compounds and four metals were reported to exceed CW GACs in wells installed within the landfill material. Only marginal fluoranthene and zinc exceedances were reported in potentially downgradient well CP103, located 30m away from the landfill material. No exceedances were reported in BH101 and BH102 located further downgradient within Freek's Farm. These exceedances are not considered to pose a risk to the identified controlled water receptors.

Five PAHs and zinc exceedances have been reported in all three samples collected from River Adur East and Worlds End Stream which crosses Freek's Farm and merges River Adur East in the south western corner of Freek's Farm. The highest reported exceedances are for benzo(a)pyrene which exceeded the EQS GAC by two orders of magnitude. The highest PAH and zinc concentrations were recorded at SW2, located in the subsidiary brook, immediately upstream of the Freek's Farm and in close proximity to the northern boundary of the Maple drive landfill. Metal concentrations have been reported at SW4, which is a pond located downstream of Freek's Farm. It is therefore considered unlikely that contaminants detected on site are adversely impacting the brook. Zinc, lead

³ BGS Commissioned Report CR/12/035. Normal Background Concentrations (NBCs) of contaminants in English soil

and arsenic minor exceedances have been reported in a water sample collected from the very small and almost dry pond located in the southwestern corner of the site. Exceedances may reflect metallic debris (e.g. a supermarket trolley) in the pond.

8.10 Data Gaps And Recommendations

The following data gaps have been identified which should be considered / investigated during future earthworks.

- A potential infilled area was identified during the initial desk studies in the south western boundary of the site (as shown in historical drawings) which is currently occupied with dense vegetation / trees and the small pond (sampled as part of the current works). Exploratory locations within this area had to be relocated / cancelled due to potential services (sewers) and therefore the area was not possible to be investigated. It is recommended this area is further investigated during earthworks and service removal works to discount a potential ground gas risk from a infilled material and potential soil and groundwater impacts associated with possible leaks from the sewers.
- The ground investigation works were carried out before the clearance of fly tipped waste was undertaken and no investigation of the soils beneath the fly tipped waste/vehicles was undertaken. It is therefore possible that residual contamination hotspots may be present beneath and around the waste, however, these are likely to be localised due to the anticipated low permeability of the cohesive superficial deposits. Validation sampling works are recommended once all waste is removed and the top surface layer is stripped out in the fly tipping area and any other areas with waste.
- Anecdotal evidence of a potential buried container of blue asbestos and vehicles at the Freeks Farm site were received after the ground investigation was completed. While no direct evidence of these burials was encountered during the ground investigation, it is noted that the investigations in the fly tipping area were limited by the presence of above ground waste deposits. It is recommended further detail on these potential burials is collected in the first instance, coupled with a geophysical survey of the identified areas of concern to assess the presence of possible ground disturbance and metallic anomalies which could support these claims. Potential animal carcass burning activities and subsequent spreading / burial of ash has been also reported which, dependent on the nature of the carcasses involved and the relative timing of the incineration and disposal activities, may require further investigation (e.g. additional analysis of soils for potential viruses and toxins). It is recommended that this could be incorporated into future soil validation sampling and testing in the vicinity of the former fly tipping area.
- The following risk and possible mitigation measures should be considered for the final design and construction of the proposed Maple Drive link road and during future construction works:
 - Gas monitoring: high methane and CO₂ concentrations measured within landfill waste can accumulate in excavations and future manhole chambers. Monitoring of ground gases and explosive risks is recommended during construction works in the vicinity of the former landfill.
 - Gas migration: Drainages/services that may be installed through the proposed Maple Drive road and to the future development should be sealed to avoid opening a future potential pathway.
 - The selection and construction of future water pipes / services and road foundations should consider potential direct contact with contaminated material.
 - Any excavated landfill material is likely to be classified as waste and may require off-site disposal.
 - If disturbed, the landfill capping layer should be fully reinstated on a like for like basis (e.g. a minimum thickness of 1 m of clean cover placed in engineered lifts etc.).
 - Mitigation measures (dust suppression and asbestos monitoring) may be required to minimise risks to construction workers and the general public if the landfill capping layer is disturbed during construction works.

8.11 Updated Conceptual Site Model

The Preliminary Conceptual Site Model has been updated to incorporate the results of the GQRA and additional risk identified:

Table 24. Updated CSM following GQRA – Freek's Farm

Source	Potential linkage	Risk / Comments
Inorganic and organic chemical impact in soils, groundwater and surface water		Unlikely based on GQRA findings.
	Direct contact (ingestion, dermal contact, inhalation of dusts) and/or inhalation of volatile compounds by future Freek's Farm residents / users	It is however possible that unidentified residual hotspots exist in fly tipping area (area to be validated following waste clearance and strip of top surface layer)
	Direct contact (ingestion, dermal contact, inhalation of dusts) and/or inhalation of volatile compounds by construction workers	Good practices and adoption of appropriate mitigation (e.g. appropriate PPE) assumed during waste clearance and construction works
	Inhalation of contaminated soil dusts during construction works by site neighbours (residents).	Good practices assumed during waste clearance and construction works to minimize dust (e.g. damping down).
	Leaching and downward vertical migration of contaminants to underlying groundwater (Horsham Stone Member Secondary A Aquifer).	Unlikely based on GQRA findings
	Leaching and downward vertical migration of contaminants into the underlying groundwater and potentially subsequent lateral migration and discharge into surface water (River Adur East and Worlds End Stream).	Unlikely based on GQRA findings
	Surface water runoff off-site.	
Ground gases – primarily methane and carbon dioxide		Unlikely based on ground gas risk assessment.
	Migration and ingress of ground gases (including from the registered landfill to the east and potential infilled area to the south west of the site) into future residential properties	It is however recommended: - The southern western area of the site is investigated during future earthworks to discount gas risk associated with infill material and a potential impacts associated with possible leaks from the sewers. - Any drainages/services that may be installed through the proposed Maple Drive road and to the future development are sealed to avoid creating a future potential preferential pathway
Anecdotal evidence of a potential buried container of blue asbestos and vehicles were reported at the time of writing this report. It is recommended further details/clarifications are collected, and a potential geophysical survey to the identified areas of concern be undertaken. Potential animal burning activities and potential buried residues (ash/animal carcasses) have been reported which may merit further investigation, and potential analysis of toxins and viruses during validation works on the fly tipping area following removal of the wastes.		

Table 25. Updated CSM Following GQRA – Maple Drive Link Road

Source	Potential linkage	Comments
Identified inorganic and organic chemical impact in soils and groundwater	Direct contact (ingestion, dermal contact, inhalation of dusts) and/or inhalation of volatile compounds by future Maple Drive link road users	Unlikely based on GQRA, assessment of the landfill capping material and assuming no disturbance of the capping layer and underlying landfill waste.
	Direct contact with landfill material (ingestion, dermal contact, inhalation of dusts) and/or inhalation of volatile compounds by construction workers	Good practices assumed during construction works, including appropriate mitigation measures (e.g. dust suppression and PPE).
	Inhalation of contaminated soil dusts during construction works by site neighbours (residents).	Suitable mitigation measures will be required if the clean cover is temporarily removed during future works to avoid spreading contaminants (including asbestos)
	Leaching and downward vertical migration of contaminants to underlying groundwater (Horsham Stone Member Secondary A Aquifer).	Unlikely based on GQRA findings.
	Leaching and downward vertical migration of contaminants into the underlying groundwater and potentially subsequent lateral migration and discharge into surface water (River Adur East and Worlds End Stream).	Unlikely based on GQRA findings.
	Permeation - Migration of contaminants through potable water supply pipes running through the landfill material.	To be considered at the design stage for future services along Maple Drive.
Ground and landfill gases – primarily methane and carbon dioxide	Ingress into confined spaces, such as excavations during construction, or utility manhole chambers following development, causing hazardous atmospheres for future construction and Maintenance workers	Consideration should be taken at the design stage for a potential ingress of vapours into confined spaces in the landfill area.
		Drainages/services that may be installed through the proposed Maple Drive road and to the future development should be sealed to avoid opening a future potential pathway

9. Geotechnical Risk Register

It is noted that Geotechnical Category Classifications are determined on the basis of the geotechnical works and risk implications

The following geotechnical risks are anticipated:

- Unforeseen ground conditions might lead to construction delays and redesign (site specific risks are detailed below);
- Variability of Made Ground and presence of voids or obstructions;
- Variability of natural strata – soft pockets of ground may cause instability of slopes, foundations or working platforms;
- Localised weak/ compressible soils might lead to differential settlement and increased maintenance liability;
- Differential settlement within foundations;
- Shrinkage or swelling of soils with volume change potential especially where trees are planted or removed;
- River bank erosion in close proximity to the proposed development;
- Variability of natural strata – presence of Horsham Stone Member and clay ironstone bands in Weald Clay Formation causing obstructions to foundations and excavations and potential for higher permeability leading to groundwater ingress;
- Unforeseen groundwater levels; high groundwater levels may lead to poor drainage and construction problems; artesian water leading to construction problems especially if cast in-situ bored piling is to be used, and flooding;
- Encountering unexploded ordnance might cause delays or endanger life;
- Encountering existing services. Cost and programme delays for reinstatement/ diversion of existing services, loss of life if gas/ electrical mains are hit.
- Excavations causing slope instability, leading to traffic and construction programme disruption;
- Excavations causing ground movements leading to undermining services or the subgrade of the neighbouring infrastructure;
- Contaminated ground might cause health and safety issues and have cost and programme implications (if encountered on site);
- Ground gases from organic deposits or potential sources of contamination (if encountered on site);
- Chemical attack on buried concrete which may result in maintenance problems;

More details regarding geotechnical risks can be found in the Geotechnical Risk Register below. The Geotechnical Risk Register is a live document and will be further developed and updated in the following reports with more recent information.

includes an assessment of risk based on the perceived likelihood of the hazard and the potential consequence both before and after the proposed design control measures using the following scales.

<u>Likelihood (L)</u>	<u>Consequence (C)</u>
5 – Frequent	5 – Catastrophic
4 – Probable	4 – Critical
3 – Occasional	3 – Major
2 – Remote	2 – Moderate
1 – Improbable	1 – Minor

Risk Rating $R = L \times C$

1 to 4 = Low	
5 to 9 = Medium	
10 to 25 = High	

A more detailed explanation of the Risk Rating (R) is given below:

Low: The risk is tolerable and can be managed by experienced designers, contractors and clients.

Medium: The risk is significant and cannot be ignored. Risk should be further addressed during the design and/or construction.

High: The risk is unacceptable and needs to be further mitigated during design.

Table 26. Geotechnical Risk Register

ID	Hazard	Consequence	Before Mitigation			Design Control Measures	After Mitigation		
			L	C	R		L	C	R
GEO1	Unforeseen ground conditions.	Construction delays and redesign.	4	3	12	Undertake comprehensive desk study and project specific intrusive ground investigation to develop a robust ground model.	3	2	6
GEO2	Localised weak/compressible soils, e.g. silt	Instability, total and differential settlement and increased maintenance.	4	3	12	Appropriate ground investigation, design, excavation and replacement where required. Further ground investigation may need to be carried out to delineate areas of soft ground associated with watercourses.	3	2	6
GEO3	High groundwater levels.	Poor drainage and construction difficulties.	3	3	9	Assess groundwater conditions prior to construction and design appropriate groundwater control and temporary support to excavations.	2	2	4
GEO4	Artesian groundwater	Construction difficulties especially where bored cast in-situ piling used	3	3	9	Ground investigation has identified the presence of artesian groundwater. Design should account for this when selecting foundation types and depths.	2	2	4
GEO5	Poor drainage.	Construction difficulties leading to redesign, cost increase and project delay.	3	3	9	Assess drainage conditions prior to construction and design appropriate drainage measures.	2	2	4
GEO6	Excavations causing slope instability.	Slope failure. Possible impact on site safety. Increased cost and delay.	3	2	6	Fully supported trenches, limited open length to that which can be completed in one shift.	1	2	2
GEO7	Encountering unexploded ordnance.	Delays caused by clearance works or initiation endangering life.	2	5	10	Adopt appropriate mitigation measures.	1	5	5
GEO8	Encountering services.	Cost and programme delays for reinstatement/diversion of existing services. Loss of life if gas/electrical mains are hit.	4	5	20	Undertake thorough services searches. All excavations/intrusive works to be checked for services prior to works.	2	2	4
GEO9	Buried obstructions associated with previous structures.	Difficulty during construction, increased cost, time delays.	5	3	15	Study historical site information and vigilance during site surveys. Contractors to manage risk of buried obstructions during construction.	2	2	4

ID	Hazard	Consequence	Before Mitigation			Design Control Measures	After Mitigation		
			L	C	R		L	C	R
GEO10	Influence on new works to existing infrastructure (e.g. settlement of highway and/or infrastructure).	The new works might interfere with existing structures and movement of these (new structures) might damage/ make existing infrastructure non-operational. The availability and maintenance of existing structures might be influenced.	3	4	12	Design to account for differential movement between new and existing structures. Accurate surveys to establish extent and condition of existing structures are recommended. Monitoring of the existing infrastructure during construction works.	1	3	3
GEO11	Shrink swell of soils especially in vicinity of trees	Damage to structures particularly with moisture content changes	3	3	9	High volume change soils have been identified on the site. Adequate design considerations should be taken in areas of existing or proposed trees and other vegetation.	1	2	2
GEO12	Failure of new earthworks during construction.	Slope failure during construction leading to delays in construction.	3	3	9	Design embankments and areas of land raising to appropriate standards. Assess stability of earthworks during construction and provide appropriate temporary works.	2	2	4
GEO13	Contaminated ground and groundwater.	Health and safety of construction workers or site users or groundwater/surface water resources. Cost/programme implications if additional protection measures are required or there are special requirements for disposal of site won material.	3	3	9	Assess risk of contamination and implement appropriate mitigation and remedial measures.	2	2	4
GEO14	Ground gases.	Migration of gases into confined spaces may lead to accumulations of dangerous concentrations of gases capable of asphyxiation and potentially explosion in the case of methane.	2	3	6	Assess risk of ground gas and implement appropriate mitigation measures.	2	2	4
GEO15	Chemical attack on buried concrete.	Reduced durability of concrete.	2	4	8	Determine ground chemistry and use appropriate concrete class.	1	1	1
GEO16	River Bank Erosion	Erosion of river bank in close proximity to proposed development	2	3	6	Design bank protection where required.	2	2	4
GEO17	Variability of Natural Strata	Construction delays and higher permeability of Horsham Sandstone Member if encountered	4	3	12	Carry out design specific ground investigation to develop a robust ground model	3	2	6

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Appendix A – Factual GIR



HE Northern Arc, Burgess Hill - Freeks Farm Ground Investigation

Factual Report on Ground Investigation

Report No: 562943 – Freeks Farm

Client: Homes England

JUNE 2019

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1 INTRODUCTION

This investigation was carried out by Structural Soils Ltd (SSL) on the instructions of AECOM (the Engineer) on behalf of Homes England (the Client) at the site of HE Northern Arc, Freeks Farm & Link Road, in Burgess Hill, West Sussex.

The purpose of the work was to obtain geotechnical information for a proposed residential development. This is planned to comprise up to 460 residential units.

The intrusive works included:

- Two rotary core boreholes to a depth of 20m below ground level (m bgl);
- Three rotary cored boreholes to an estimated depth of 15m bgl;
- One rotary cored borehole to an estimated depth of 35m bgl;
- Sixteen machine excavated trial pits (TP) to an estimated depth of 3.00m bgl;
- Seventeen percussive windowless sample (WS) boreholes to approximately 5.00m bgl;
- Installation of ground gas monitoring wells in ten of the windowless samples' boreholes and installation of groundwater monitoring wells and ground gas monitoring wells in the five rotary cored boreholes;
- TRL DCPs (Transport Research Laboratory Dynamic Cone Penetrometer) Tests to be undertaken adjacent to TP locations.
- Infiltration / soakaway tests to be undertaken in selected TPs.
- Factual reporting of investigation findings.

This report contains a description of the site and the works carried out, the exploratory hole logs, in-situ and laboratory testing results.

The ground investigation has been carried out in accordance with the contract specification, and the general requirements of BS 5930:2015, BS 10175:2011+A2:2017, BS EN 1997-2 (2007), BS EN ISO 22475-1 (2006) and other relevant standards as identified below.

This report presents the factual records of the fieldwork carried out and laboratory testing. Whilst every attempt is made to record full details of the strata encountered in the exploratory holes, techniques of hole formation and sampling will inevitably lead to disturbance, mixing or loss of material in some soils and rocks. All information given in this report is based on the ground conditions encountered during the site work, and on the results of laboratory and field tests performed during the investigation. However, there may be conditions at the site that have not been considered, such as unpredictable soil strata, contaminant concentrations, and water conditions between or below exploratory holes.

This report was prepared by SSL for the sole and exclusive use of AECOM / Homes England in response to particular instructions. Any other parties using the information

contained in this report do so at their own risk and any duty of care to those parties is excluded. No liability will be accepted after a period of 6 years from the date of the report.

2 SITE DESCRIPTION

2.1 Location and Topography

The site is located approximately 1.5 km north of Burgess Hill town centre in West Sussex (see Site Location Map in Appendix A). The British National Grid Reference (NGR) of the main Freeks Farm site is TQ314206.

The site consists of a series of undeveloped pastoral farm fields and can be split into two distinct sections. Two fields form the southern end of the site, with maximum dimensions of 300 m from north to south and 100m from east to west. The northern section of the site consists of three fields, is roughly rectangular, with maximum dimensions of approximate 525m from north to south and 350m east to west.

The site is accessed from the south via Freeks Lane, which leads north from Maple Drive. Freeks Lane is an unmade road, consisting of compacted gravel. This is a public right of way footpath, which also gives vehicular access to Freeks Farm (and adjacent Lowlands Farm) itself.

At the time of investigation, the site was predominantly grass surfaced, with a number of mature deciduous trees in the north western section of the site and along Freeks Lane.

There are also several small ponds, water courses and drainage ditches across the site.

The site is gently undulating with approximate levels ranging between 20 m and 28 m Above Ordnance Datum (AOD).

The field towards the centre of the site, just north of the farm house, has been used as a storage area for farming equipment, cars and general farming related scrap.

The site boundaries were generally defined by mature hedgerows, containing a mixture of large shrubs and deciduous trees. The River Adur forms parts of the northern and western site boundaries.

The immediate surrounding area generally consists of pastoral farmland to the north, east and west. To the south west of the site a former sewage treatment works is currently being redeveloped. Slightly further to the south west there is a small industrial estate. Residential properties at the northern end of Burgess Hill are located to the south of the site, with associated green spaces, a BMX track and public footpaths.

For the site area, please see Exploratory Hole Location Plan in Appendix A.

2.2 Geology

Information on the geology of the site was obtained from the following sources published by the British Geological Survey (BGS):

- BGS map (sheet 318 / 333 scale 1:50,000, published 2006).
- The BGS digital geology map, which utilises the most up to date names for geological units (www.bgs.ac.uk/data).
- The BGS Lexicon of Named Rock Units, which provides typical descriptions for most geological units (www.bgs.ac.uk/lexicon).

The site is shown to be underlain by the following descending sequence of strata:

TABLE 1 : SUMMARY OF EXPECTED SITE GEOLOGY	
Geological Unit Name	Description
ANTHROPOGENIC GROUND	
Artificial Ground	No artificial ground is shown on the map
SUPERFICIAL / DRIFT DEPOSITS	
Alluvium	Clays, Silts, Sands & Gravels locally deposited in environments dominated by Rivers. Quaternary in age (up to 2 million years ago) This includes the Northern extent of the site around the River Adur
SOLID GEOLOGY	
Weald Clay Formation	Mudstone – Sedimentary Bedrock, formed in Cretaceous Period (126 to 134 million years ago). Local environment previously dominated by swamps estuaries and deltas. “Dark grey thinly bedded mudstones (shales) and mudstone with subordinate siltstones, fine to medium grained sandstones, including calcareous sandstone, shelly limestones and clay ironstones.”
Weald Clay Formation (bands up to 75m wide to North & South of site)	Clay – Ironstone, formed in Cretaceous Period (126 to 134 million years ago). Local environment previously dominated by swamps estuaries and deltas.
Horsham Stone Member (bands up to 150m wide to Northern extent of site)	Sandstone formed in Cretaceous (131 to 134 million years ago). Local environment previously dominated by swamps estuaries and deltas. “Sandstone, calcareous, generally fine grained, micaceous, locally well laminated, pale grey to greenish / olive grey. Contains clayey partings and lignite fragments and rootlet traces. Frequently shows internal slumping and deformation.”

Note: Information obtained from BGS digital records © NERC.

The site is predominantly underlain by the Weald Clay Formation comprising weathered mudstone and mudstone, with bands of clay – ironstone of the Weald Clay and bands of sandstone of the Horsham Stone Member crossing site from east to west. The Weald Clay, Weald Clay Ironstone and Horsham Stone Member are all Cretaceous in age.

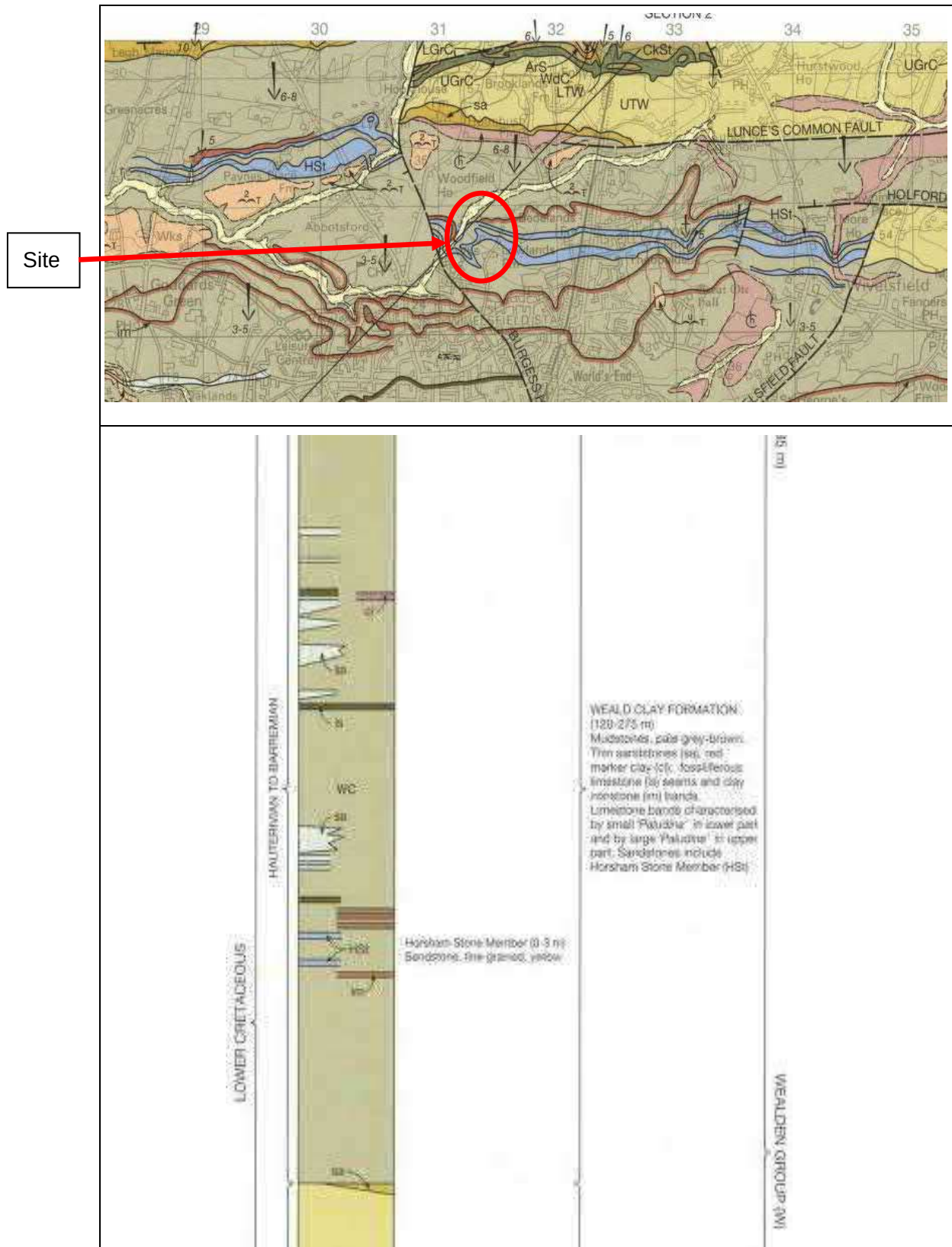
It is noted from the geological map, that the Burgess Hill Fault runs south east to north west (down the downthrow to the south west) at the south eastern side of the site. The bands of ironstone and sandstone are shown to be offset by ~250 m.

Quaternary age superficial deposits of alluvium are shown to follow the line of the River Adur to the west and north of the site. These are indicated to comprise clay, silts, sand and gravel.

There is no anthropogenic ground shown on the map, although the Specification states that:

“...re-worked topsoil is expected to be present, with Made Ground likely present in the vicinity of the farm buildings in the central eastern part of the site.”

The BGS online maps portal provides access to scans of almost all maps produced by the BGS since 1932. An extract of the most recent available scanned map for the site is included below:



Note: Above images contain British Geological Survey materials ©NERC [2018].

AECOM

HE Northern Arc – Freeks Farm

562943 – 1 (00)

3 FIELDWORK

3.1 General

The ground investigation was carried out by SSL between 3 April and 25th April 2019. The investigation was supervised by an engineer from SSL. The scope of works and positions were selected by AECOM, set out by SSL and adjusted where necessary to take account of buried or overhead services, or other restrictions. The exploratory hole and in-situ test locations are shown on the Exploratory Hole Location Plan presented in Appendix A.

3.2 Exploratory Holes

The exploratory holes completed are listed in the following table.

TABLE 2 : SCOPE OF INTRUSIVE WORKS			
Quantity	Exploratory Hole Type	Maximum depth (m)	Hole / Test Numbers
5	Rotary Dynamic Sample / Cored Boreholes.	20.00	BH101, BH102, BH103, BH105, BH106.
16	Machine Excavated Trial Pits.	2.90	TP101 – TP116 inclusive
17	Percussive Windowless Sample Boreholes	3.80	WS101, WS103 - WS108, WS110 – WS114, WS116 – WS118, WS120 - WS121

The exploratory hole logs are presented in Appendix B. These provide information including the equipment and methods used, samples taken, tests carried out, water observations and descriptions of the strata encountered. Explanation of the terms and abbreviations used on the logs is given in the Key to Exploratory Hole Records in Appendix B, together with other explanatory information.

The holes were logged by an engineer in general accordance with the recommendations of BS 5930:2015 (which incorporates the requirements of BS EN ISO 14688-1, 14688-2 and 14689-1), Detailed descriptions, together with relevant comments, are given on the logs. Photographs of the rotary drilled core, trial pits and window samples are presented in Appendix B, alongside the exploratory hole logs.

Prior to the commencement of any exploratory hole or intrusive test all positions were checked for buried services by a specialist utility surveyor using a cable avoidance tool (CAT), signal generator ('genny'), and ground penetrating radar (GPR). Inspection pits were hand dug at exploratory locations where noted on the relevant

exploratory hole logs.

On completion of the works, a survey of the exploratory hole locations was undertaken using specialist Global Positioning System (GPS) equipment. The coordinates of each exploratory hole were measured relative to British National Grid, and the level relative to Ordnance Datum. These are shown on the exploratory hole logs contained in Appendix B which have been printed with a reduced level column.

3.3 Backfill and Instrumentation

On completion 50mm diameter groundwater and 19m gas monitoring wells were installed in all rotary boreholes and selected window sample holes, the design having been instructed by AECOM.

The installation details are shown on the exploratory hole logs and on a summary table presented within Appendix B.

All remaining exploratory holes were backfilled with bentonite pellets. The trial pits were backfilled with arisings, compacted in layers by the excavator bucket.

3.4 In-situ Testing

The in-situ tests are listed in the following table. The test methods used are detailed on the test result sheets included in Appendix C, unless otherwise noted. All test results shown on exploratory hole logs where appropriate.

TABLE 3 : SCOPE OF IN-SITU TESTING		
Quantity	In-situ Test	Remarks
28	Standard Penetration Tests (SPT)	Carried out in boreholes
39	Standard Penetration Tests (SPT)	Carried out in windowless sample boreholes
34	Hand Vane (HV) *Empirical Vane	Carried in suitable material where possible
16	TRL Dynamic Cone Penetrometer (DCP)	Carried out adjacent to all trial pit locations
3	Soakaway Infiltration Tests in trial pits	Carried out in TP101, TP105 & TP116
115	Photo-Ionisation Detector (PID) measurement of volatile hydrocarbons.	Carried out on all environmental samples where appropriate.

*All hand vane tests were completed using a hand vane tester which report an empirical measure of undrained shear strength. A correction factor may be applied to the test results to give a direct measurement of undrained shear strength based on the mathematical relationship between the applied torque and the cross-sectional area of the soil surface sheared. No correction factor has been applied to the results quoted.

3.5 Post Field Work Well Development

The wells installed in the rotary boreholes were purged of three well volumes of groundwater as requested by AECOM. This was carried out post intrusive fieldworks on 29 April to 1 May 2019. Results are included within Appendix E. No further monitoring or sampling was required of SSL as part of this contract.

4 LABORATORY TESTING

Samples for potential geotechnical testing were returned to one of the Company's UKAS accredited laboratories. Those samples taken for potential geo-environmental testing were sent to the AECOM selected Exova Jones Laboratory.

Laboratory tests were scheduled by AECOM. Tests carried out in accordance with MCERTS/UKAS standards where noted on the results sheets.

4.1 Geotechnical Laboratory Testing

Geotechnical laboratory testing was generally carried out in accordance with the relevant part of BS1377: 1990, *Methods of Test for Soils for Civil Engineering Purposes*, or, where superseded, by the relevant part of BS EN ISO 17892:2014+ *Geotechnical investigation and testing – Laboratory Testing of Soil*.

The number of tests completed, and the test methods used are summarised below. Where non-standard procedures have been undertaken, this is recorded on the report sheet. The results are reported in tabular and/or graphical form and included as Appendix D of this report.

TABLE 4 : SUMMARY OF GEOTECHNICAL TESTING		
Number of tests scheduled	Test	Remarks
Classification Tests		
62	Moisture content.	
38	Liquid and plastic (Atterberg) limits (4 point).	
10	Particle size distribution by sieving.	
23	Particle size distribution by sedimentation.	
Compressibility, Permeability and Durability Tests		
1	One-dimensional consolidation test.	
Shear Strength - Total Stress		
1	Single stage unconsolidated undrained triaxial compression tests without the measurement of pore pressure.	
Rock Tests		
24	Uniaxial compressive strength tests.	
37	Point Load Index.	The natural ('as received') moisture content of the samples was determined.
Chemical Tests: Soil*		
41	Water soluble sulphate, total (acid soluble) sulphate and total sulphur contents and pH value – Pyritic Geology	
2	Organic Matter Content	

Note: * Test(s) carried out to method approved in BRE Special Digest 1.

4.2 Geoenvironmental Laboratory Testing

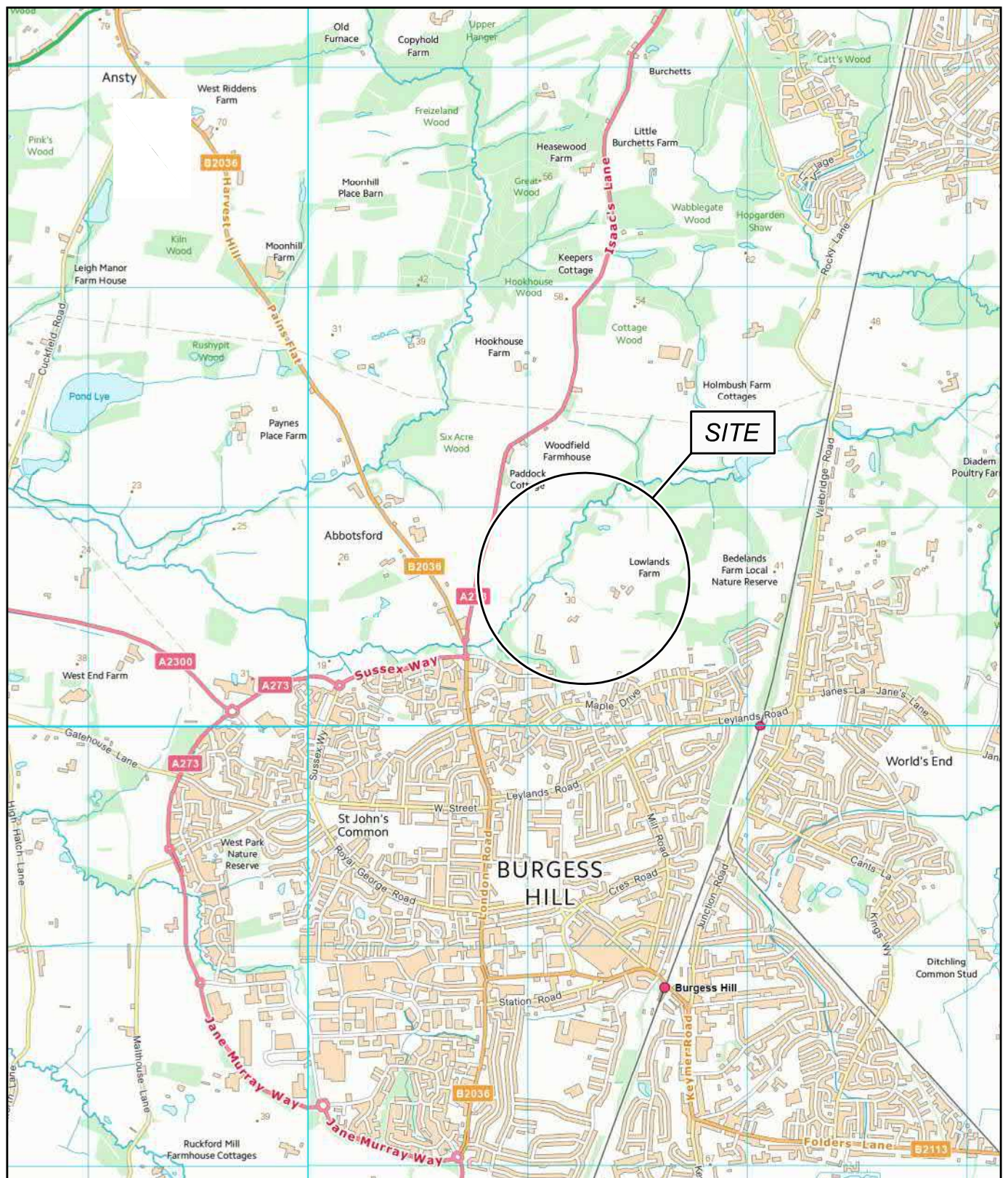
All Geoenvironmental testing was scheduled by AECOM and undertaken by Exova Jones. The results have been sent directly to AECOM and do not form part of this report.

5 REFERENCES

- 5.1 BS 5930:2015 *Code of practice for ground investigations*
- 5.2 BS EN 1997-1:2004 *Eurocode 7 — Geotechnical Design Part 1 - General Rules* incorporating corrigendum Feb 2009 and Amendment A1 2013
- 5.3 BS EN 1997-2:2007 *Eurocode 7 — Geotechnical design Part 2: Ground Investigation and testing*
- 5.4 BS 10175:2011 *Investigation of potentially contaminated sites: Code of practice*, including amendment A2 2017
- 5.5 British Geological Survey sheet 318 & 333 scale 1:50,000, published 2006
- 5.6 British Geological Survey online digital geological map, www.bgs.ac.uk/data
- 5.7 British Geological Survey Lexicon of Named Rock Units, www.bgs.ac.uk/lexicon
- 5.8 BS EN ISO 14688-1:2002 *Geotechnical investigation and testing – Identification and classification of soil: Part 1: Identification and description*, including Amendment A1 2013
- 5.9 BS EN ISO 14688-2:2004 *Geotechnical investigation and testing – Identification and classification of soil: Part 2: Principles for a classification*, including Amendment A1 2013
- 5.10 BS EN ISO 14689-1:2003 *Geotechnical investigation and testing – Identification and classification of rock: Part 1: Identification and description*
- 5.11 BS EN ISO 22475-1:2006 *Geotechnical Investigation and Testing – Sampling methods and groundwater measurements, Part 1 Technical principals for execution*
- 5.12 BS EN ISO 22476-3:2005 (updated February 2007) *Geotechnical Investigation and Testing – Field Testing Part 3: Standard Penetration Test*, including Amendment A1 (2011)
- 5.13 CIRIA Report R143 (1995) *The Standard Penetration Test (SPT) - Methods and Use*
- 5.14 BS 1377:1990 *Method of Test for Soils for Civil Engineering Purposes*
- 5.15 BS EN ISO 17892:2014 *Geotechnical investigation and testing – Laboratory Testing of Soil*

APPENDIX A - PLANS AND DRAWINGS

- (i) Site Location Plan
- (ii) Exploratory Hole Location Plan



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STRUCTURAL SOILS

18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

Tel: 01442 416 660
ask@soils.co.uk
www.soils.co.uk

CLIENT

Homes England

PROJECT

Freeks Farm

TITLE

SITE LOCATION MAP

00	30.05.2019	-	NP	AH	-	TITLE						
						SITE LOCATION MAP						
REV.	DATE	DESCRIPTION	BY	CHD.	APR.	JOB NO		GRID REF	SCALE BAR		ORIGIN SIZE	FIGURE
DIMENSION		SCALE	DRAWING STATUS			562943	TQ 313 207	</				



LEGEND

- Trial Pit Location
- Borehole Location
- Window Sample Location

00	30.05.2019	-	NP	AH	-
REV	DATE	DESCRIPTION	BY	CHD	APR
DIMENSION		SCALE	ORIGIN SIZE		
m		1:2500	A3		



STRUCTURAL SOILS

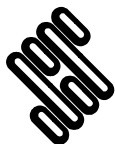
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

Tel: 01442 416 660
ask@soils.co.uk
www.soils.co.uk

CLIENT	
Homes England	
PROJECT	
Freeks Farm	
TITLE	
EXPLORATORY HOLE LOCATION PLAN	
JOB NO	FIGURE
562943	2A
DRAWING STATUS	REV
-	00
SCALE BAR	
	

APPENDIX B - EXPLORATORY HOLE RECORDS

- (i) Key to Exploratory Hole Logs
- (ii) Borehole Logs
- (iii) Trial Pit Logs
- (iv) Window Sample Logs
- (v) Standpipe Summary Table



KEY TO EXPLORATORY HOLE LOGS - SUMMARY OF ABBREVIATIONS

SAMPLING

Sample type codes

B	=	Bulk disturbed sample.
C	=	Core sample.
D	=	Small disturbed sample.
DSPT	=	Small disturbed sample originating from SPT test.
ES	=	Soil sample for environmental testing.
UT	=	Undisturbed thin wall sample.

IN-SITU TESTING

SPT _(c)	=	Standard Penetration Test using a solid 60 degree cone.
SPT	=	Standard Penetration Test using split spoon sampler. _(NR) indicates 'No Sample Recovery'.
	=	* denotes extrapolated N value. NP denotes 'No Penetration'.
HP	=	Hand Penetrometer Test. Value given as shear strength c_u , in kPa.
V	=	Field Vane Test. Peak value (c_u) & Residual value (c_r), given as shear strength in kPa.
PID	=	Photo Ionisation Detector Results, in ppm.

ROTARY DRILLING INFORMATION

W	=	Water flush returns (%)
TCR	=	Total core recovery (%)
SCR	=	Solid core recovery (%)
RQD	=	Rock quality designations (%)
If	=	Fracture spacing (mm).
		In fracture column (i) denotes discontinuity is infilled (refer to Fracture Table for details).
		Where variable the minimum - mode - maximum spacing may be quoted.
		'NI' denotes non-intact core. 'NA' denotes not applicable.

All lengths used to determine rock core mechanical properties taken along the centre line of the core.

Obvious induced fractures have been ignored.

The assessment of solid core is based on lengths that show a full diameter and not necessarily a full circumference.

AZCL = Assessed zone of core loss.

ADDITIONAL NOTES

1. All soil and rock descriptions and legends in general accordance with BS EN ISO 14688-1, 14688-2, 14689-1, and BS5930:2015.
2. Material types divided by a broken line (- - -) indicates an unclear boundary.
3. The data on any sheet within the report showing the AGS icon is available in the AGS format.



KEY TO EXPLORATORY HOLE LOGS - SUMMARY OF GRAPHIC SYMBOLS

WATER COLUMN SYMBOLS

	First water strike, second water strike etc.
	Standing water level following first strike, standing water level following second strike etc.
	Seepage.
	Standing water level recorded at documented date.

MATERIAL GRAPHIC LEGENDS

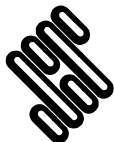
	CLAY		Gravelly CLAY		Gravelly SILT		Mudstone
	Sandstone		Sandy CLAY		Sandy silty CLAY		Sandy gravelly CLAY
	Sandy gravelly silty CLAY		Silty sandy gravelly CLAY		Sandy gravelly clayey SILT		Sandy gravelly SILT
	Siltstone		Sandy clayey SILT		Sandy SILT		Topsoil
	SILT		Clayey SILT		Silty CLAY		

INSTRUMENTATION SYMBOLS

	Backfill		Bentonite cement grout		Bentonite seal		Concrete
	Gravel filter		Flush cover		Upstanding cover		
	Plain pipe		Slotted pipe				



Drilling Progress and Water Observations						General Remarks 1. Service clearance undertaken by DDS Ltd 2. Inspection pit hand dug to 1.20m depth. 3. Standing groundwater noted at 1.90m on 24.04.19 (hole depth 4.50m), 3.80m on 24.04.19 (hole depth 16.0m) and 3.80m on 25.04.19 (hole depth 20.0m). 4. Weathering classifications applied using BS EN ISO 14689:2018 (approach 4). 5. 50mm diameter HDPE groundwater monitoring pipe installed to 9.0m depth		
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth			
18/04/19	17:30	7.00	4.50	121	Dry			
23/04/19	09:00	7.00	4.50	121	1.90			
24/04/19	17:00	16.00	4.50	121	3.80			
25/04/19	13:00	20.00	4.50	121	3.80			
All dimensions in metres					Scale: 1:50			
Method Used:	Inspection pit + Rotary coring		Plant Used:	Comacchio GEO 205	Drilled By: Rhymal Ricketts	Logged By: DPellatt	Checked By:	 AGS

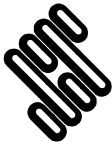


Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH101
Contract Ref: 562943	Start: 18.04.19 End: 23.04.19	Ground Level (m AOD): 29.82	National Grid Co-ordinate: E:531374.8 N:120276.6	Sheet: 2 of 7

Mechanical Log					Flush Returns & Details	Samples & Testing			Backfill & Instrumentation	Water	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)		No	Type	Results					
9.10-9.30	81	80	47		1	C	17,8/30,20 for 25mm			Very weak to weak thinly laminated grey MUDSTONE with 3 discontinuity sets. 1 (bedding) subhorizontal very closely to medium spaced planar smooth probably partly open and low. 2 & 3 (Opposing Dip direction) 60° medium to widely spaced planar smooth probably partly open and clean. (Unweathered WEALD CLAY FORMATION) (stratum copied from 6.90m from previous sheet)	(4.50)		
10.00-11.50 10.00-10.25 10.00-10.18	↕	↕	↕		2 7	C SPT							
10.40-10.67	97	87	72		3	C							

Drilling Progress and Water Observations						General Remarks	
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth		
						on completion (reponse zone 3.0m-9.0m) with concreted flush cover. 6. SPT hammer CJA.8-2018 ($E_r = 65.00\%$) used.	
						All dimensions in metres	Scale: 1:50
Method Used: Inspection pit + Rotary coring	Plant Used: Comacchio GEO 205		Drilled By: Rhymal Ricketts		Logged By: DPellatt	Checked By: AGS	

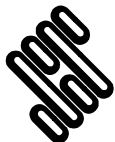
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Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH101
Contract Ref: 562943	Start: 18.04.19 End: 23.04.19	Ground Level (m AOD): 29.82	National Grid Co-ordinate: E:531374.8 N:120276.6	Sheet: 3 of 7

Mechanical Log					Flush Returns & Details	Samples & Testing			Backfill & Instrumentation	Water	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)		No	Type	Results					
18.35-18.70	90	90	55		100% return	6	C				Very weak becoming weak thinly laminated blueish grey MUDSTONE with 3 discontinuity sets. 1 (bedding) subhorizontal very closely to medium spaced planar smooth probably partly open and low. 2 & 3 (Opposing Dip direction) 60° medium to widely spaced planar smooth probably partly open and clean. (Unweathered WEALD CLAY FORMATION) (stratum copied from 11.40m from previous sheet) . . . from 19.25m to 19.40m recovered non-intact. Borehole terminated at 20.20 m depth.		
19.00-20.20				NI 161		11	SPT	21,4/36,14 for 10mm					
19.00-19.16				NI 460		14	D						
19.00-19.20	100	88	43		100% return	15	D						
19.85-20.10													

Drilling Progress and Water Observations						General Remarks	
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth		



Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH101
Contract Ref: 562943	Start: 18.04.19 End: 23.04.19	Ground Level (m AOD): 29.82	National Grid Co-ordinate: E:531374.8 N:120276.6	Sheet: 4 of 7

Additional Remarks

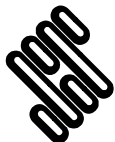
BH101 1.20m-4.00m

18/04/2019:



BH101 4.00m-7.00m

Method Used:	Inspection pit + Rotary coring	Plant Used:	Comacchio GEO 205	Drilled By:	Rhymal Ricketts	Logged By:	DPellatt	Checked By:	AGS
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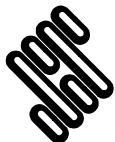
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Contract Ref: 562943	Start: 18.04.19 End: 23.04.19	Ground Level (m AOD): 29.82	National Grid Co-ordinate: E:531374.8 N:120276.6	Sheet: 5 of 7

BH101 7.00m-10.00m



BH101 10.00m-13.00m

Method Used:	Inspection pit + Rotary coring	Plant Used:	Comacchio GEO 205	Drilled By:	Rhymal Ricketts	Logged By:	DPellatt	Checked By:	AGS
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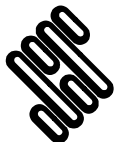
Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH101
Contract Ref: 562943	Start: 18.04.19 End: 23.04.19	Ground Level (m AOD): 29.82	National Grid Co-ordinate: E:531374.8 N:120276.6	Sheet: 6 of 7

BH101 13.00m-16.00m



BH101 16.00m-19.00m

Method Used: Inspection pit + Rotary coring	Plant Used: Comacchio GEO 205	Drilled By: Rhymal Ricketts	Logged By: DPellatt	Checked By:	
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Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH101
Contract Ref: 562943	Start: 18.04.19 End: 23.04.19	Ground Level (m AOD): 29.82	National Grid Co-ordinate: E:531374.8 N:120276.6	Sheet: 7 of 7

BH101 19.00m-20.00m



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| 11/06/19 - 10:41 | SG8 |

Method Used: Inspection pit + Rotary coring	Plant Used: Comacchio GEO 205	Drilled By: Rhymal Ricketts	Logged By: DPellatt	Checked By:	
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Drilling Progress and Water Observations						General Remarks 1. Service clearance undertaken by DDS Ltd 2. Inspection pit hand dug to 1.20m depth. 3. No water strikes observed due to water flush being used. 4. Weathering classifications applied using BS EN ISO 14689:2018 (approach 4). 5. 50mm diameter HDPE groundwater monitoring pipe installed to 9.0m depth (reponse zone 3.0m-9.0m) and 19mm HDPE gas monitoirng pipe installed to All dimensions in metres Scale: 1:50			
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth				
15/04/19	08:00	0.00	-	121	-				
15/04/19	18:00	7.50	1.50	121	-				
16/04/19	18:00	15.00	4.50	121	-				
17/04/19	15:30	19.68	4.50	121	-				
Method Used:		Inspection pit + Rotary coring		Plant Used: Comacchio GEO 205		Drilled By: Rhymal Ricketts	Logged By: DPellatt	Checked By:	AGS

GINT_LIE | 11/06/1



STRUCTURAL SOILS

BOREHOLE LOG

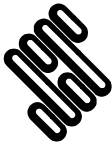
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Contract Ref: 562943	Start: 15.04.19 End: 19.04.19	Ground Level (m AOD): 27.11	National Grid Co-ordinate: E:531351.9 N:120488.7	Sheet: 2 of 7

Mechanical Log					Flush Returns & Details			Samples & Testing			Backfill & Instrumentation	Water	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)	No	Type	Results	No	Type	Results					
9.00-10.50	↑	↑	↑	↑	5	C	19,6/50 for 15mm						Very weak grey fine grained SANDSTONE. Discontinuities are subhorizontal very closely to closely spaced planar undulating probably open and clean. (Unweathered WEALD CLAY FORMATION)	(1.20)	
9.00-9.20	↑	↑	↑	↑	6	SPT									
9.00-9.10	↑	↑	↑	↑	7	D	100% return							10.20	
9.60-9.90	↑	↑	↑	↑	7	D									
10.50-12.00	↑	↑	↑	↑	7	SPT	14,11/18,22,10 for 45mm						Extremely weak to weak thinly laminated grey MUDSTONE. Discontinuities are subhorizontal very closely to widely spaced planar undulating probably open and clean. (Unweathered WEALD CLAY FORMATION)	(2.30)	
10.50-10.85	↑	↑	↑	↑	8	D									
10.50-10.80	↑	↑	↑	↑	9	D	100% return						. . . between 11.50 and 11.65 m approx. 70° discontinuity.		
11.30-11.50	↑	↑	↑	↑	9	D									
12.00-13.50	↑	↑	↑	↑	6	C	100% return						Very weak to weak thinly laminated blueish grey MUDSTONE. Discontinuities are subhorizontal very closely to widely spaced planar undulating probably partially open and clean. (Unweathered WEALD CLAY FORMATION)	12.50	
12.50-12.85	↑	↑	↑	↑	8	SPT									
13.50-15.00	↑	↑	↑	↑	7	C	21,4/27,23 for 40mm							(3.50)	
13.50-13.69	↑	↑	↑	↑	9	D									
14.00-14.30	↑	↑	↑	↑	9	D	100% return						. . . between 15.30 and 15.50 m recovered as soft clay with frequent mudstone lithorelicts up to 20 mm.	16.00	
15.00-16.50	↑	↑	↑	↑	8	C									
15.15-15.25	↑	↑	↑	↑	9	SPT	25/50 for 30mm						Description on next sheet		
16.15-16.30	↑	↑	↑	↑	9	C									
16.50-18.00	↑	↑	↑	↑	9	SPT	100% return								
16.50-16.54	↑	↑	↑	↑	9	C									
16.80-17.15	↑	↑	↑	↑	9	C	100% return						Description on next sheet	(3.68)	
	↑	↑	↑	↑											

Drilling Progress and Water Observations						General Remarks				
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth					
						2.50m depth (response zone 1.0m-2.50m) on completion with concreted flush cover. 6. SPT hammer CJA.8-2018 (E_r = 65.00%) used.				
						All dimensions in metres	Scale:	1:50		
Method Used:	Inspection pit + Rotary coring			Plant Used:	Comacchio GEO 205		Drilled By: Rhymal Ricketts	Logged By: DPellatt	Checked By:	

GINT_LIBRARY_V8_07.GLB LibVersion: v8_07_001 PrjVersion: v8_07 | Log ROTARY CORED LOG - A4P | 562943_HE_NORTH_ARC_BURGESS_HILL_FREES_FARM&LINK_ROAD_GI.GPJ - v8_07.
| 11/06/19 - 10:42 | SG8 |

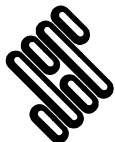




Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH102
Contract Ref: 562943	Start: 15.04.19	Ground Level (m AOD): 27.11	National Grid Co-ordinate: E:531351.9 N:120488.7	Sheet: 3 of 7
End: 19.04.19				

Mechanical Log				Flush Returns & Details	Samples & Testing			Backfill & Instrumentation	Water	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	TCR (%)	SCR (%)	RQD (%)		No	Type	Results					
18.00-19.50	↑	↑	↑	↑						. . . between 17.80 and 18.00 Sandstone laminations more dominant		
18.25-18.50	↑	↑	↑	↑	10	C				Very weak to weak thinly laminated blueish grey MUDSTONE		
18.75-19.10	85	83	47	100% return	11	C				interlaminated with weak grey fine grained SANDSTONE. Discontinuities are subhorizontal very closely to widely spaced planar undulating probably partially open and clean. Sandstone contains occasional laminations of black lignite.		
19.50-19.68	↓	↓	↓	↓	10	SPT	19,6/29,21 for 30mm			(Unweathered WEALD CLAY FORMATION) (stratum copied from 16.00m from previous sheet) Borehole terminated at 19.68m depth.	19.68	

Drilling Progress and Water Observations						General Remarks	
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth		
						All dimensions in metres	Scale: 1:50
Method Used: Inspection pit + Rotary coring	Plant Used: Comacchio GEO 205		Drilled By: Rhymal Ricketts		Logged By: DPellatt	Checked By:	AGS



Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH102
Contract Ref: 562943	Start: 15.04.19 End: 19.04.19	Ground Level (m AOD): 27.11	National Grid Co-ordinate: E:531351.9 N:120488.7	Sheet: 4 of 7

Additional Remarks

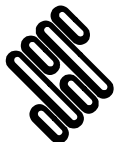
BH102 1.20m-3.00m

15/04/2019:



BH102 3.00m-6.00m

Method Used: Inspection pit + Rotary coring	Plant Used: Comacchio GEO 205	Drilled By: Rhymal Ricketts	Logged By: DPellatt	Checked By:	
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Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH102
Contract Ref: 562943	Start: 15.04.19 End: 19.04.19	Ground Level (m AOD): 27.11	National Grid Co-ordinate: E:531351.9 N:120488.7	Sheet: 5 of 7

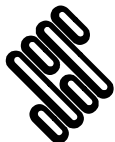
BH102 6.00m-9.00m



BH102 9.00m-12.00m

Method Used:	Inspection pit + Rotary coring	Plant Used:	Comacchio GEO 205	Drilled By:	Rhymal Ricketts	Logged By:	DPellatt	Checked By:	
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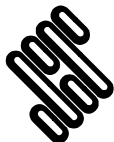
Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH102
Contract Ref: 562943	Start: 15.04.19 End: 19.04.19	Ground Level (m AOD): 27.11	National Grid Co-ordinate: E:531351.9 N:120488.7	Sheet: 6 of 7

BH102 12.00m-15.00m



BH102 15.00m-18.00m

Method Used: Inspection pit + Rotary coring	Plant Used: Comacchio GEO 205	Drilled By: Rhymal Ricketts	Logged By: DPellatt	Checked By:	
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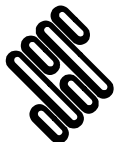


Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH102
Contract Ref: 562943	Start: 15.04.19 End: 19.04.19	Ground Level (m AOD): 27.11	National Grid Co-ordinate: E:531351.9 N:120488.7	Sheet: 7 of 7

BH102 18.00m-19.50m



Method Used: Inspection pit + Rotary coring	Plant Used: Comacchio GEO 205	Drilled By: Rhymal Ricketts	Logged By: DPellatt	Checked By:	
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STRUCTURAL SOILS

BOREHOLE LOG

Contract: HE Northern Arc, Burgess Hill - Freeks Farm & Link Road GI		Client: Homes England		Borehole: BH103
Contract Ref: 562943	Start: 15.04.19 End: 17.04.19	Ground Level (m AOD): 26.33	National Grid Co-ordinate: E:531153.7 N:120700.4	Sheet: 1 of 6

Mechanical Log					Flush Returns & Details	Samples & Testing			Backfill & Instrumentation	Water	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	TCR (%)	SCR (%)	RQD (%)	If (mm)		No	Type	Results					
0.10-0.25					1	B					Grass over soft to firm light brown to yellowish brown slightly sandy clayey SILT with many rootlets. Sand is fine. (TOPSOIL)	0.25	
0.20					2	B						0.60	
0.30-0.50						B							
0.40						D							
0.50						ES		$c_u=60/64/70$			Firm orangish brown slightly sandy slightly gravelly CLAY. Sand is fine. Gravel is angular to subrounded fine to medium of mudstone. (Residual soil WEALD CLAY FORMATION)	(1.20)	
0.50						V							
0.70						D							
0.80-1.00					3	B							
1.00						ES		$c_u=74/78/68$					
1.00						V							
1.20-1.65					4	UT	100% recovery				Stiff locally very stiff orangish brown to greyish brown slightly sandy slightly gravelly CLAY. Sand is fine. Gravel is angular to subrounded fine to coarse of mudstone. (Residual soil WEALD CLAY FORMATION)	1.80	
1.65-1.80					5	ES							
1.80-2.20													
1.80-2.25	50												
1.80-2.20					6	SPT	N=35					2.20	
2.20-3.00					201	D							
2.30						HP	$c_u=216$						
2.45	125					HP	$c_u=200$					(0.72)	
2.75-2.90						C							
3.00-4.00					202						Very stiff thinly laminated orangish brown mottled grey slightly sandy CLAY with occasional lithorelicts of mudstone. Sand is fine. (Residual soil WEALD CLAY FORMATION)	2.92	
3.00-3.45												3.00	
3.30-3.35					8	SPT	N=36						
3.30-3.35					203	D						3.40	
3.40-3.68	100	68	68	200	204	C							
3.40				300		HP	$c_u=175$					(0.85)	
				400									
4.00-5.00											Extremely weak thinly laminated orange brown MUDSTONE with very closely to closely spaced thinly to medium bedded very stiff orange brown clay (Weathered Mudstone). Discontinuities are sub horizontal closely to medium spaced undulating rough partly open to open infilled with orange clay or black staining. (Destructured WEALD CLAY FORMATION)	4.25	
4.00-4.24					9	SPT	13,12/34,16 for 43mm						
4.55-4.75				140	205	C						(1.05)	
				200									
				350									
5.00-6.20													
5.00-5.39					10	SPT(c)	10,12/14,13,16,7 for 17mm					5.30	
	100	100	100										
5.80-6.20					206	C					. . . at 2.26m thinly laminated brown siltstone up to 5mm thick.		
											Very weak thinly laminated orange brown fine grained SANDSTONE. Bedding is sub horizontal. (Distinctly weathered WEALD CLAY FORMATION)	(2.20)	
6.20-7.70				60									
6.20-6.39				300	11	SPT(c)	16,9/32,18 for 22mm						
				400							Very stiff thinly laminated orange brown CLAY. (Residual soil WEALD CLAY FORMATION)		
	100	97	93										
7.50-7.60					207	C					Extremely weak thinly laminated orange brown MUDSTONE with rare thin beds of orange brown siltstone. (Partially weathered WEALD CLAY FORMATION)	7.50	
7.70-9.20													
7.70-7.87					12	SPT(c)	19,6/44,6 for 7mm				. . . between 3.90 and 4.00m, thin bed of very weak orange brown siltstone with dark brown staining on incipient fractures.	(2.40)	
	100	97	93	180									
				270									
				400									
											Description on next sheet		

Drilling Progress and Water Observations						General Remarks	
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth		
15/04/19	17:45	5.00	1.70	120	1.54	1. Service clearance undertaken by DDS Ltd 2. Inspection pit hand dug to 1.20m depth. 3. Standing water noted at 1.54m depth on 15.04.19 (hole depth 5.0m), 1.54m depth on 16.04.19 (hole depth 13.70m) and 4.49m depth on 17.04.19 (hole depth 13.70m). 4. Weathering classifications applied using BS EN ISO 14689:2018 (approach 4).	
16/04/19	08:00	5.00	1.70	120	1.54		
16/04/19	17:50	13.70	1.70	120	1.54		
17/04/19	08:15	13.70	1.70	120	4.49		
17/04/19	17:00	15.20	1.70	120	-		
All dimensions in metres						Scale:	1:50
Method Used:	Inspection pit + Rotary coring		Plant Used:	Comacchio GEO 205		Drilled By:	G Haddock
						Logged By:	BSaimen
						Checked By:	
						AGS	