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Proposed residential development

HMRC Government Office

Barrington Road

Goring-by-Sea

Worthing

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**Proposed residential development
HMRC Government Offices
Barrington Road
Goring-by-Sea
Worthing
BN12 4XH**

GROUND INVESTIGATION REPORT

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Aerial photograph of site



The approximate site boundaries are highlighted in red.

Report status and format

Report section	Principal coverage	Report status	
		Revision	Comments
1	Executive summary		
2	Introduction		
3	Summary of desk study and site observations		
4	Fieldwork		
5	Laboratory testing		
6	Ground conditions encountered		
7	Geotechnical Appraisal		
8	Chemical contamination		
9	Gaseous contamination		
10	Effects of ground conditions on building materials		
11	Landfill issues		
12	Further investigations		

List of drawings

Drawing	Principal coverage	Status	
		Revision	Comments
01	Site location plan		
02	Exploratory hole plan (current layout)		
03	Plot summarising SPT N Values		
04	Section showing construction of standpipes installed in boreholes BH04, WS201 and WS202		

List of appendices

Appendix	Content	Status	
		Revision	Comments
A	Definitions of geotechnical terms used in this report		
B	Definitions of geo-environmental terms used in this report		
C1	Insitu testing in boreholes / trial pits	Details of standard penetration tests (SPT)	
C2		Details of insitu shear strength determinations	
D1	Trial pits	Machine excavated	
D2		Hand excavated	
E1	Borehole / probing records	Cable and tool percussion drilling	
E2		Windowless sampling	
F1	Copies of laboratory test result certificates (Soil Engineering)	Soil classification testing	
F2		Triaxial testing	
G	Copies of laboratory test result certificates (Chemical).		
H	Analysis and summary of chemical test data		
I	Conceptual models for chemical contamination		
J	Copies of statutory undertakers’ replies		
K	Copy of UXO preliminary risk report produced by MACC International		
L	Copy of CPT report produced by Lankelma Limited		
M	Gas monitoring results		

Bookmarking

As a PDF version this document is bookmarked. If you click on the bookmark icon  on a PDF viewer then the main contents listing is shown and by clicking on the bookmark you can navigate through the report.

1 Executive summary

General

We recommend the following executive summary is not read in isolation to the main report which follows.

Site description, history and development proposals

The site is situated in a predominantly residential area of Goring-by-Sea, west Worthing with access granted off Barrington Road. Essentially, the site comprises a vacant office complex with an area of undeveloped scrubland to the south west.

Based on historical Ordnance Survey maps, the site was a brickworks until it was redeveloped into Inland Revenue Offices by 1953. A chimney and tanks were recorded in the centre of the site from 1967-68. The western most buildings were demolished by 2002 to make way for the existing car park.

We understand development proposals are for a mixed-use development of houses, flats, retirement apartments and a new care home, including areas of soft landscaping and private gardens.

Ground conditions encountered

Each exploratory excavation encountered a similar profile of soils considered to be Made Ground or Topsoil overlying River Terrace Deposits, which extended to 5-7m depth and subsequently White Chalk Subgroup. The River Terrace comprised a mixture of sands and clays and was of variable strength/density.

Groundwater was encountered at depths between 5.2m and 8.5m.

Foundation solution

Based on the variable nature of the River Terrace Deposits, taking the site as a whole, strip foundations will not be suitable without ground improvement (vibrotreatment) for the proposed low rise housing. However, the lower strength soils are not consistent across the site and in some cases are either limited to shallow soils or those at depth below the zone of influence of likely foundations. On this basis, it is considered possible that subject to additional ground investigation, the site could be zoned, with some areas being suitable for the adoption of strip foundations. Alternatively, a raft or piled foundation solution could be adopted. A piled foundation solution should be adopted for larger buildings (apartment buildings, care home etc.).

The results of plastic and liquid limit determinations performed on samples of the River Terrace Deposits indicate these deposits are soils of medium volume change potential when classified in accordance with National House Building Council (NHBC) Standards, Chapter 4.2.

We understand there are existing soakaways on site. We recommend these should be measured and taken as a guide to the future design principal. Infiltration testing could be undertaken within the existing soakaways to provide infiltration rates.

A DS-1 Design Sulfate Class and an AC-1s ACEC classification may be assumed for the design of concrete in contact with the ground.

Chemical and gaseous contamination

Based on testing undertaken to date, no significant contamination has been identified although low levels of PAH have been identified in near surface Made Ground and localised asbestos fibres and elevated arsenic and lead are present. We would recommend a capping layer be incorporated into all future gardens and soft landscaping. This should be 600mm in potentially productive residential gardens, potentially reducing the 300mm within non-productive gardens. The capping layer can incorporate site won, clean natural soils (River Terrace).

Further investigations and testing are still required following removal of tanks, substations and the existing facilities maintenance building to determine if there is any localised soil or ground water contamination in these areas. A standpipe installation for groundwater sampling in the west will also be required once the site has been cleared and is accessible to equipment.

Based on gas monitoring undertaken to date, the site can be classified as characteristic situation 1 and traffic light colour 'Green'. On two occasional concentrations of CO₂ marginally exceeded 5% but concentrations were lower on subsequent visits. Overall, they are not considered typical of the site and therefore are insufficient to raise the characteristic gas situation. On this basis, gas protection measures are not considered necessary.

Unexploded Ordnance

We have obtained a preliminary risk review from a UXO specialist to assess the risk and identify any precautionary measures necessary for our intrusive investigations. The review identified a medium risk. It is recommended that a Detailed UXO Risk Assessment Report is obtained for the site to determine the risk for the construction phase. UXO specialist attendance may be required during the construction phase.

2 Introduction

2.1	Objectives
2.2	Status of this report
2.3	Client instructions and confidentiality
2.4	Site location and scheme proposals
2.5	Report format and investigation standards
2.6	Report distribution
2.7	Soiltechnics liability

2.1 Objectives

- 2.1.1 This report describes a ground investigation carried out for a proposed housing redevelopment at the HMRC Government Offices, Barrington Road, Goring-by-Sea, Worthing, BN12 4XH.
- 2.1.2 A previous investigation has been undertaken at the site by Ashdown Ground Investigation Limited and is reported in the document referenced R18-13236 dated 6th December 2018. This report comprised both a phase 1 and phase 2 ground investigation report.
- 2.1.3 The objective of this investigation was to undertake supplementary works to address outstanding geotechnical and contamination concerns at the site. This report provides an updated assessment of possible foundation solutions for the development and parameters necessary for the design and construction of foundations. It also provides a refined assessment of the potential chemical and gaseous contamination leading to the production of an updated phase 2 risk assessment.
- 2.1.4 The investigation has also been produced to support a planning application for the site by satisfying National Planning Policy Framework (2019) section 178.

2.2 Status of this report

- 2.2.1 This report is final based on our current instructions.

2.3 Client instructions and confidentiality

- 2.3.1 The investigation was carried out in January 2021 and reported in April 2021 acting on instructions received from our client, Cannon Capital Developments Limited.
- 2.3.2 This report has been prepared for the sole benefit of our above-named client, but this report, and its contents, remains the property of Soiltechnics Limited until payment in full of our invoices in connection with production of this report.

- 2.3.3 Our original investigation proposals were outlined in our correspondence with Morph Structures Limited (reference QS10536 Rev100, dated 9th November 2020). The investigation generally followed our original investigation proposals.

2.4 Site location and scheme proposals

- 2.4.1 The National Grid reference for the site is 511875,103085. A plan showing the location of the site is presented on Drawing 01.
- 2.4.2 We understand proposals are for the demolition of the existing buildings and construction of a mixed-use development of houses, flats, retirement apartments and a new care home.

2.5 Report format and investigation standards

- 2.5.1 Sections 2 to 6 of this report describe the factual aspects of the investigation with Section 7 presenting an engineering assessment of the investigatory data. Section 8 provides a risk assessment of chemical contamination based on readily available historic records, inspection of the soils and laboratory testing. Section 9 provides a similar risk assessment in relation to gaseous contamination with Section 10 providing a risk assessment relating to construction materials likely to be in contact with the ground. Section 11 discusses issues relating to classification of waste soils for disposal and reuse.

2.5.2 Geotechnical aspects

- 2.5.2.1 Geotechnical investigations were carried out generally, and where practical following the recommendations of BS EN 1997:2 2007 '*Eurocode 7 – Geotechnical Design – Part 2: Ground Investigation and Testing*'. From a geotechnical viewpoint this is deemed to be a Ground Investigation Report (GIR) as set out in BS EN 1997:2. This report does not constitute a Geotechnical Design Report as defined in section 2.8 of BS EN 1997-1:2004+A1:2013 '*Eurocode 7 – Geotechnical Design – Part 1: General Rules*' and in particular will exclude assessment of lifetime actions to buildings from geotechnical influences.

2.5.3 Geo-environmental aspects

- 2.5.3.1 The investigation process also followed the principles of BS 10175:2011+A2:2017 '*Investigation of potentially Contaminated Sites – Code of Practice*'. The following elements, defined in BS 10175, have been completed and incorporated in the report by Ashdowns.

- | | | |
|----|----------|--|
| a) | Phase I | Preliminary investigation (desk study and site reconnaissance) |
| b) | Phase II | Exploratory and detailed (intrusive) investigations |

- 2.5.3.2 We have relied on information within the Ashdown report it for our assessments. However, we recommend the Ashdown report is read in conjunction with this report.

2.5.3.3 A summary of the salient points of the desk study produced by Ashdowns is reported in Section 3. Details of the supplementary exploratory investigations are described in Sections 4 and 6 of this report. Any supplementary investigations deemed necessary are identified in Section 12.

2.5.3.4 This investigation has been carried out and reported based on our understanding of best practice. Improved practices, technology, new information and changes in legislation may necessitate an alteration to the report in whole or part after publication. Hence, should the development commence after expiry of one year from the publication date of this report then we would recommend the report be referred back to Soiltechnics for reassessment. Equally, if the nature of the development changes, Soiltechnics should be advised, and a reassessment carried out if considered appropriate.

2.6 Report distribution

2.6.1 This report has been prepared to assist in the design and planning process of the development and normally will require distribution to the following parties, subject to Soiltechnics liabilities defined below, although this list may not be exhaustive:

Table summarising parties likely to require information contained in this report

Party	Reason
Client	For information/reference and cost planning
Developer/Contractor/project manager	To ensure procedures are implemented, programmed and costed
Planning department	Potentially to discharge planning conditions
Environment Agency	If ground controlled waters are affected and obtain approvals to any remediation strategies
Independent inspectors such as NHBC/Building Control	To ensure procedures are implemented and compliance with building regulations
Project design team	To progress the design
Principal Designer (PD)	To advise in construction risk identification and management under the Construction (Design and Management) regulations

Table 2.6.1

2.7 Soiltechnics liability

2.7.1 Soiltechnics disclaims any responsibility to our Client and others in respect of any matters outside the scope of this report. This report has been prepared with reasonable skill, care and diligence in accordance with the terms of our contract, taking account of the manpower, resources, investigations and testing devoted to it by agreement with our Client. This report is confidential to our Client and Soiltechnics accepts no responsibility of whatsoever nature to third parties to whom this report or any part thereof is made known. Any such party relies upon the report at their own risk.

3 Summary of desk study and site observations

3.1	General
3.2	Description of the site
3.3	History of the site
3.4	Geology and geohydrology of the area
3.5	Landfill and infilled ground
3.6	Enquiries with statutory undertakers
3.7	Unexploded Ordnance (UXO) Risk

3.1 General

3.1.1 A full desk study has been undertaken for the site by Ashdown Site Investigation Limited and is presented in the report referenced R18-13236. We have reviewed this information and this section provides a summary of the salient points. In addition, we have also undertaken the following, which is reported in this section:

- a) Consultation with Statutory Undertakers
- b) Consultation with UXO specialists
- c) Site reconnaissance

3.2 Description of the site

3.2.1 The site is situated in a predominantly residential area of Goring-by-Sea, west Worthing with access granted off Barrington Road in the south-eastern corner of the site. Local topography is relatively flat with the coastline located some 1.1km south of the site. There are no significant water features within 1000m of the site.

3.2.2 The site is bound by a railway line to the north, and Barrington Road to the south, beyond which lies residential housing. A commercial building and car park border the site to the east and residential housing and undeveloped land border the site to the west.

3.2.3 A full site description is provided in the report by Ashdown and there was no obvious change at the time of our site reconnaissance. A summary of the site is presented below but for full details, the Ashdown report should be consulted.

- 3.2.4 Essentially, the site comprises a partially occupied office complex with an area of undeveloped scrubland to the south west. An access road surfaced in asphalt runs from Barrington Road, part way up the eastern boundary and subsequently in a westerly direction, through the centre of the site, terminating in a large asphalt surfaced car park. To the north of the road were a number of single and multi-storey buildings, including a maintenance area containing a chimney, fuel/chemical store, above ground and underground tanks and boilers. To the south of the access road was a single storey office building orientated east-west with many wings leading off in a north-south orientation. Areas of grass were present between each wing.
- 3.2.4 The area of scrubland is a small rectangular area located to the south west of the main car park. It was heavily overgrown at the time of our site reconnaissance. An area of land off site to the north west formerly housed a gas holder however it is understood that the structure is no longer present. It is understood that the land is still owned and managed by the gas company and was therefore inaccessible.
- 3.2.5 Trees were present along site boundaries and located sporadically within soft landscaping areas.
- 3.2.6 A plan showing observed site features and location of exploratory points is presented on Drawing 02. Photographic records of the site at the time of our site reconnaissance are presented below.



Photograph 01 - View of the large car park in the western section of the site. View looking north.



Photograph 02 - View of the centre of the site looking east and showing the single storey building to the south of the access road.



Photograph 03- View of the maintenance area showing oil tank, typical building and chimney on site. View looking north-west.



Photograph 04 - View of part of the main complex to the north of the site. View looking south



Photograph 05 - View of the scrubland area to the west of the main site. View looking south east.

3.3 History of the site

- 3.3.2 The main site comprised open fields until 1909 when a brick works was recorded, which included a wind pump and kilns. In 1932, the brick works was no longer recorded. The main site was subsequently developed into Inland Revenue Offices by 1953 which included a number of buildings across the site, some of which are still present. A chimney and tanks were recorded in the centre of the site from 1967-68. The western most buildings were demolished by 2002 to make way for the existing car park.
- 3.3.3 Land to the north and south of the main building was undeveloped (with the exception of the railway line) until existing residential housing was constructed. Land to the east was also undeveloped before a car park was recorded in the 1970s. The existing commercial building was present by 2002.
- 3.3.3 The existing area of scrubland to the west of the site has never been developed. The land to the north of this area was recorded as a gas works and contained a gas holder and number of small buildings from 1932 until around 2010. Land to the west was recorded as a sewage works from around 1969 to late 1990s/early 2000s.

3.4 Geology and geohydrology of the area

- 3.4.1 The expected geology on site is River Terrace Deposits (approximately 6-8m thick) overlying the White Chalk Subgroup. The River Terrace Deposits and Chalk are both likely to be permeable and are recorded as a secondary A aquifer and principal aquifer respectively.
- 3.4.2 Secondary A aquifers are predominantly permeable layers capable of supporting water supplies at a local rather than strategic scale. In some cases, Secondary A aquifers can form an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.
- 3.4.3 Principal aquifers are defined as deposits exhibiting high permeability capable of high levels of groundwater storage. Such deposits are able to support water supply and river base flows on a strategic scale.
- 3.4.4 The site is not located within a source protection zone and there are no recorded abstraction points within 1000m of the site.

3.5 Landfill and infilled ground

- 3.5.1 The Ashdown report states that there are no recorded or historical landfill sites which pose a significant risk to the site. It does note that there was a brick works previously present on site and desk study information identifies cuttings and workings on site. There is likely to have been some infilling works on the site.
- 3.5.2 The Groundsure report within the Ashdown report also identifies “unspecified heaps” and “sewage works” on land to the west of the site.

3.6 Radon

- 3.6.1 The Ashdown report indicates the site is in an area where between 1-3% of properties are above the action level. The report also notes that the Groundsure data suggests no radon protective measures are required.
- 3.6.2 On this basis, it is likely that the site will not require radon gas protection measures. However, this should be confirmed with building control and a site-specific radon report may be required.

3.7 Enquiries with statutory undertakers

- 3.7.1 We have contacted the following Statutory Undertakers (SUs) to obtain copies of their records in order to avoid damaging their apparatus during our fieldwork activities:
- a) BT Openreach Ltd
 - b) Scotia Gas Networks
 - c) ESP Utilities Group Ltd
 - d) Southern Water Services Ltd
 - e) UK Power Networks
- 3.7.2 Copies of responses received prior to publication of this report are presented in Appendix J. These records have been obtained solely for the purposes described above. Some of these records have been obtained from the Internet and from our database without contacting the statutory undertaker direct. Occasionally, SU information is recorded on drawings larger than A3, and thus cannot be easily presented in this report. In such cases we will copy the correspondence but not incorporate the drawing in this report and maintain the records on our office file.
- 3.7.3 In addition, we have visited the Linesearch web site (www.linesearch.org) which provides a report on national grid networks (National Gas and Electricity Transmission Networks). Again, a copy of their report is presented in Appendix J.
- 3.7.4 Normally Statutory Undertakers drawings record the approximate location of their services. We recommend further on-site investigations be undertaken to confirm the position of the apparatus and thus establish the effect on the proposed development and the necessity or otherwise for the permanent or temporary diversion of the service to allow the construction of the development to safely and successfully proceed.
- 3.7.5 It should be noted that Scotia Gas Networks identify low and medium pressure gas pipes running north along the western boundary of the large car park in the west of the main HMRC site. BT Openreach also record multiple cables across the site and UK Power Networks identify an electricity cable running south though the far western section of the site as well as north from Barrington Road, into the existing substation in the south eastern corner of the site. We are not aware that the supply to such services have been capped off and as such, they should be treated as live until further information indicates otherwise.

- 3.7.6 It should be noted that statutory undertakers' records normally exclude private services.

3.8 Unexploded Ordnance (UXO) Risk

- 3.8.1 We have obtained a preliminary risk review from a UXO specialist to assess the risk and identify any precautionary measures necessary for our intrusive investigations. A copy of which is presented in Appendix K. This should not be referred to or relied upon for other purposes. This risk assessment has not been carried out fully in accordance with CIRIA report C681 '*Unexploded Ordnance (UXO) A guide for the construction Industry*'. According to their response, Worthing was subject to a moderate level of bombing during WWII and at least one highly explosive bomb strike was recorded on land to the west of the site. A UXO specialist attended site during intrusive investigations. A magnetometer was suspended down the boreholes at regular intervals as it advanced to detect metallic objects. If a metallic object is detected, then drilling is stopped. At this site, no metallic objects were detected in any of the excavation locations. It is recommended that a Detailed UXO Risk Assessment Report is obtained for the site to determine the risk for the construction phase. UXO specialist attendance may be required during the construction phase.

4 Fieldwork

4.1	General
4.2	Site restrictions
4.3	Exploratory trial pits
4.4	Light cable percussion boring
4.5	Windowless sampling boreholes
4.6	Standpipe installation
4.7	Insitu testing
4.8	Cone Penetration Testing
4.9	Sampling strategies

4.1 General

4.1.1 Fieldwork was undertaken between the dates of 18th and 22nd January and comprised the following activities:

- Excavation of two exploratory machine excavated trial pits to 3m depth.
- Excavation of four exploratory boreholes using cable and tool percussion drilling techniques to depths of between 9.4m and 20m.
- Excavation of three exploratory boreholes formed using windowless sampling equipment to depths of up to 6m.
- Cone penetration testing in six positions to depths of between 5.02m and 3.6m.

4.1.2 A plan of the site showing observed/existing site features, position of exploratory points completed by Soiltechnics and position of exploratory points completed by Ashdown Site Investigation Limited is presented on Drawing 02. The position of exploratory points shown on these plans is approximate only.

4.1.3 The extent of fieldwork activities and position of exploratory points were determined by Soiltechnics

4.1.4 Exploratory points were positioned to avoid known locations of underground services and, where possible, to target areas where further information was required based on the Ashdown report. Prior to commencement of exploratory excavations an electronic cable locating tool was used to scan the area of the excavation. If we received a response to this equipment, then the excavation would be relocated.

4.1.5 All soils exposed in excavations were described in accordance with BS EN ISO 14688 '*Identification and Classification of soil*' and CIRIA C574 '*Engineering in chalk*'.

4.2 Site restrictions

- 4.2.1 The site was predominantly vacant at the time of the investigation and therefore was generally accessible to fieldwork. Excavations were all undertaken externally and were positioned to avoid obvious service runs.
- 4.2.2 The area of scrubland to the west of the main HMRC site was very heavily overgrown and as such, only a very thin path provided access into the centre of the area. On this basis, excavation positions were severely limited. In addition, there was a pipe observed at surface running across the entrance. Whether the pipe was an active service is not known. It was therefore not possible to get an excavator onto the site as the weight would likely damage the pipe.

4.3 Exploratory trial pits

4.3.1 Trial pits excavated using handheld tools

- 4.3.1.1 Service avoidance trial pits to 1.2m depth were excavated for each borehole and CPT location. An electrically powered breaker was used to loosen surface bituminous bound materials prior to excavation of CPT01, CPT03, CPT05 and CPT06. The remaining locations were positioned in grassed areas.
- 4.3.1.2 The trial pit excavations were backfilled with excavated material, which was compacted using handheld ramming tools. The surface was reinstated to match the original surroundings. A Geotechnical Engineer supervised the excavations.
- 4.3.1.3 The trial pit excavations for all boreholes are included within the appropriate borehole log. The logs of the service pits for CPT01-06 are presented in Appendix D1.

4.3.2 Trial pits formed using a mechanical excavator

- 4.3.2.1 Trial pits TP201 and TP202 were excavated to a depth of 3.0m using a 360° tracked excavator. The excavations were backfilled with excavated material compacted using the back of the excavator bucket. Whilst we attempted to reinstate the excavation to its original condition the soils could not be fully compacted into the trial pit and thus the soils were left proud of the ground surrounding the pit to allow for short-term settlement of the backfill. A Geotechnical Engineer supervised the excavations.
- 4.3.2.2 Sampling and logging was carried out as trial pit excavations proceeded but trial pits were not entered at depths exceeding 1.2m, or where sides were deemed unstable. The density of granular soils encountered in excavations was gauged by the ease of excavation.

- 4.3.2.3 Soil samples for subsequent laboratory determination of concentration of chemical contaminants were taken from the sides of trial pits using clean equipment and stored in new plastic containers, which were labelled and sealed. Samples from below access depth into trial pits were taken as a sub sample from soil contained in the excavator bucket, discarding any soil, which may have been in contact with the bucket. If as a consequence of visual or olfactory evidence, a sample was suspected to be contaminated by organic material, the sample was stored in an amber glass jar with a PTFE sealing washer.
- 4.3.2.4 Soil samples for subsequent laboratory 'classification' testing were taken from the side of trial pits or from bulk samples taken from the excavator bucket. The sample was immediately placed in a plastic bag and subsequently sealed and labelled. Samples for determination of water content were placed in sealable tubs and appropriately labelled. Soil samples were obtained to meet Category A and quality class 3 to 5 as described in BS EN 1997-2:2007 (table 3.1) sufficient for laboratory testing being considered. Sample sizes were also appropriate for the laboratory test being considered (refer BS EN 1997-2:2007 annex L).
- 4.3.2.5 Trial pit records are presented in Appendix D2.

4.4 Light cable and tool percussion boreholes

- 4.4.1 Boreholes BH01 to BH04 were excavated using light cable percussion boring techniques as described in EN ISO 22475-1:2006 forming 150mm diameter holes. Temporary casing was advanced within the borehole excavation to maintain the stability of the hole. When groundwater was encountered the excavation was temporarily halted to allow for groundwater observations to be made. Following groundwater observations the casing was advanced within the hole and the location/locations of the water strikes recorded. The casing was subsequently advanced to maintain the stability of the borehole and seal off the water to prevent further ingress. Additional records were taken when (and if) the casing produced a seal against water ingress and at the commencement and completion of a days drilling operations. When obstructions were encountered a chisel was employed to break through the obstruction. Time taken to progress the excavation using the chisel is recorded on the borehole logs.
- 4.4.2 Soil samples for subsequent laboratory determination of concentration of chemical contaminants were taken from 'intact' bulk disturbed samples obtained in the cutting shoe of the drilling rig. A sub sample was obtained discarding soil, which would have been in contact with the drilling rig cutting shoe with the subsamples taken using clean equipment. In all cases samples were stored in new plastic containers, which were labelled and sealed. If as a consequence of visual or olfactory evidence, a sample was suspected to be contaminated by organic material, the sample was stored in an amber glass jar with a PTFE sealing washer.
- 4.4.3 Water samples collected for laboratory determination of concentration of chemical contaminants was taken from the borehole using new proprietary plastic bailing equipment. The samples were placed in a new amber jar, quickly sealed with a screw cap with a PTFE washer and subsequently labelled.

- 4.4.4 Bulk soil samples for identification or subsequent 'classification' laboratory testing were taken from borehole cutting equipment. The sample were placed in a plastic bag and subsequently sealed and labelled. Soil samples were obtained where possible to meet category B quality classes 3 to 5 as described in BS EN 1997-2:2007 (table 3.1).
- 4.4.5 'Undisturbed' 100mm diameter samples were taken in cohesive soils when considered appropriate using a general-purpose open tube thin-walled sampler. These samples were obtained with a view to achieve category A sampling methods to meet quality class 1 as described in BS EN ISO 22475-1: 2006 (table 3). The undisturbed sample was obtained in a steel or aluminium liner and sealed with wax prior to labelling. The number of blows of the standard driving hammer required to obtain the sample is recorded on borehole records.
- 4.4.6 The borehole excavations were formed by drillers who are NVQ Level 2 qualified in Land Drilling under the Construction Awards Alliance CAA with samples relogged by an experienced Geotechnical Engineer. On completion of excavations the boreholes were backfilled with excavated soils compacted using drilling tools or installed with a monitoring standpipe.
- 4.4.7 Records of boreholes formed by light cable and tool percussion drilling techniques are presented in Appendix E1.

4.5 Windowless sampling boreholes

- 4.5.1 Boreholes WS201 to WS202 were formed using windowless sampling equipment. Windowless sampling comprises driving 1m long steel sample tubes which are screw coupled together or coupled to extension rods and fitted with a screw on cutting edge. The sample tubes are of various diameters, generally commencing with 100mm and reducing, with depth, to 50mm and include a disposable plastic liner which is changed between sampling locations in order to limit the risk of cross contamination. On completion of excavation the liner containing the sample is cut open and the soil sample logged by a geo-environmental engineer. The sample tubes are considered thick walled with reference to BS EN ISO 22475-1:2006 clause 3.3.11.
- 4.5.2 Samples for determination concentration of chemical contaminants are taken from samples obtained in the disposable tubes as sub-samples.
- 4.5.3 Soil samples for subsequent laboratory 'classification' testing were taken from samples obtained in the disposable tubes. The sample was placed in a plastic bag and subsequently sealed and labelled. Samples for determination of water content were placed in sealable tubs and appropriately labelled. These samples were obtained with a view to achieve category B sampling methods to meet quality class 3 (for fine grained soils only) as described in BS EN ISO 22475-1: 2006 (table 3). Sample sizes were appropriate for the laboratory test being considered.
- 4.5.4 In WS203, surface asphalt was broken out prior to excavation of the borehole. The asphalt was reinstated on completion. WS201 and WS202 were completed in grassed areas.

- 4.5.5 Records of boreholes formed using driven tube sampling techniques are presented in Appendix E2.

4.6 Standpipe installations

- 4.6.1 Combined gas and groundwater monitoring standpipes were installed in boreholes BH04, WS201 and WS202. The standpipes were installed following the recommendations of BS EN ISO 22475-1:2006 '*Geotechnical Investigation and Testing – Sampling methods and groundwater measurements – Part 1: Technical Principles for execution*' (figure 6) and BS8576:2013 '*Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs)*' (figure 7). Details of the standpipe installations are recorded on Drawing 04.
- 4.6.2 Water levels in the standpipes were measured the day after installation. The water level was measured using a measuring tape calibrated in 1mm intervals with an electronic end piece, which emits an alarm sound in contact with water. The water level was measured from ground levels at the borehole position. A record of water levels on site is presented in Section 6.

4.7 Insitu testing

- 4.7.1 A pocket penetrometer was used in the cohesive (fine-grained) soils encountered in all trial pits and boreholes. This tool is deemed to measure the apparent ultimate bearing capacity of the soil under test. The pocket penetrometer is calibrated in kg/cm². The reading can be approximately converted to equivalent undrained shear strength by multiplying the results by a factor of 50. Tests were carried out in the sides of trial pits when access can be safely achieved otherwise testing was carried out on excavated intact clods. Details of pocket penetrometer determinations are tabulated in Appendix C2. An average of measurements taken at a specific depth are recorded on trial pit records. The pocket penetrometer is not covered by British Standards.
- 4.7.2 Standard Penetration Testing (SPT) was carried out at regular frequencies in all boreholes. The tests were carried out in accordance with BS EN ISO 22476-3:2005. Key details of the test, as required by BS EN ISO 22476-3 are recorded in Appendix C1.
- 4.7.3 Within the cable tool percussion boreholes, the drive rods were type AW up to 20m depth and type BW for depths in excess of 20m. Samples taken from the open sampler (SPT) were placed in a plastic bag, sealed and labelled. In coarse granular soils, a solid 60° cone may have been used to replace the SPT cutting shoe. This test is reported as SPT(C). Summary of standard penetration testing is recorded on borehole logs.
- 4.7.4 Within the windowless sampler boreholes, SPTs were carried out using a solid 60° cone. This test is reported as SPT(C). Summary of standard penetration testing is recorded on borehole logs.
- 4.7.5 A graphical summary of undrained shear strength from insitu testing is presented in graphical format on Drawing 03.

4.8 Cone Penetration Testing

- 4.8.1 Cone penetration testing (CPT) was undertaken by a specialist company, Lankelma, and comprised pushing a cone tip, fitted with electronic sensor equipment, into the ground using hydraulic pressure at a regular speed. The CPT unit was an 18-tonne truck-mounted vehicle 8.6 x 2.6m in size. The cone is pushed through a hole in the base of the truck and all test equipment is contained within the vehicle.
- 4.8.2 A combination CPT/magnetometer was used due to the potential risk of UXO at the site. If a signal was produced from the magnetometer then the test was terminated.
- 4.8.3 A copy of the CPT testing report is provided in Appendix L.

4.9 Sampling strategies

4.9.1 Geotechnical

- 4.9.1.1 In general we adopted a judgemental sampling strategy in relation to geotechnical aspects of the investigation. The location and frequency of sampling was carried out in consideration of the following:

- i) Topography
- ii) Geology (including Made Ground)
- iii) Nature of development proposals

4.9.2 Environmental

- 4.9.2.1 Details of sampling with respect to contamination issues are described in Section 8.

4.9.3 Sample retention

- 4.9.3.1 Samples are stored for a period of one month following issue of this report, unless otherwise requested.

5 Laboratory testing

5.1	Classification testing
5.2	Chemical testing

5.1 Classification testing

5.1.1 Laboratory testing was carried out on samples retrieved from site. The method of testing is recorded on the laboratory test certificate. The following table summarises the classification testing scheduled;

Table summarising classification testing			
Location	Depth (m)	Soil type	Testing scheduled (determination of)
BH01	1.2-1.65	River Terrace Deposits	Plasticity index, plastic limit and liquid limit Moisture content
BH03	1.0		
BH04	1.0		
BH04	5.0-5.95		
TP201	1.0		
TP202	1.2		
WS202	1.2		
BH01	3.0-3.45	River Terrace Deposits	Plasticity index, plastic limit and liquid limit Moisture content Single stage triaxial
BH02	4.0-4.45		
BH03	5.5-5.95		
BH02	2.0-2.5	River Terrace Deposits	Particle size distribution
BH03	3.5-3.95		
BH04	2.5-2.95		
TP201	2.4		
TP202	2.0		
WS201	2.5-4.5		
BH01	18.5	Chalk	Intact dry density and saturation moisture content
BH02	6.0-6.45		
BH03	13.0		
BH04	7.0-7.45		
	11.5-11.95		
	14.5-14.95		

Table 5.1.1

5.1.2 Laboratory test certificates are presented in Appendix F1, F2 and F3.

5.2 Chemical testing

5.2.1 Chemical testing was carried out based on ground conditions and with reference to the contamination Initial Conceptual Model as presented in Section 8. The test methods are recorded on the chemical test certificates. The following table summarises the chemical testing scheduled;

Table summarising chemical testing			
Location	Depth (m)	Soil type	Testing scheduled (Refer to Appendix B for details).
WS203	0.3	Made Ground	Suite 1, suite 4 and asbestos screening
WS203	0.6		
TP201	0.5	Made Ground	Suite 1 and asbestos screening
CPT01	0.3		
CPT06	0.3		
WS201	0.3	River Terrace Deposits	Suite 8
BH02	1.2-1.7	Made Ground	
BH01	2.0-2.45	River Terrace Deposits	
BH04	3.0		
BH02	6.5	Chalk	Suite 9 and Suite 17 (water)
BH04	5.22	Groundwater	
BH04	5.13		Suite 6
Table 5.2.1			

5.2.2 Laboratory test certificates for chemical testing are presented in Appendix G.

6 Ground conditions encountered

6.1	Soils/rocks
6.2	Geotechnical parameters
6.3	Groundwater
6.4	Evidence of contamination
6.5	Obstructions and instability

6.1 Soils

6.1.1 Each exploratory excavation encountered a similar profile of soils considered to be Made Ground or Topsoil overlying River Terrace Deposits and subsequently White Chalk Subgroup. With the exception of Made Ground, the investigation generally confirmed published geological records.

6.1.2 Topsoil

6.1.2.1 Topsoil was encountered in BH02, TP201, TP202 and WS202 to depths of between 0.2-0.4m. The material generally comprised brown and dark brown slightly gravelly very sandy clay with gravels of flint.

6.1.2.2 Topsoil was also encountered in CPT04A-04C and WS201 to depths of up to 0.5m but these soils contained some anthropogenic materials such as brick, pottery and clinker. They have therefore been designated Topsoil-Made Ground.

6.1.3 Made Ground

6.1.3.1 Made Ground was encountered in all locations with the exception of WS201 and WS202, undertaken in the scrubland to the west. The Made Ground extended to depths between 0.3-1.8m. Although Made Ground was not encountered in CPT04A, CPT04B, it should be noted these were terminated at shallow depth within the Topsoil due to the presence of a brick wall. Made Ground in this area is therefore anticipated.

6.1.3.2 Where shallow Made Ground (<0.5m) was present, it generally comprised asphalt surfacing and concrete over reddish brown, dark brown and black sands and gravels, considered to be a sub-base. Gravels were variable and included clinker, flint, brick, ash, bituminous coated materials and granite.

6.1.3.3 Where deeper Made Ground was encountered, it was variable but generally comprised reddish grey brown, orangish brown or brown gravelly to very gravelly sand and dark brown to brown slightly sandy gravelly clay. Gravels included flint, brick, bituminous coated material, concrete, ash, clinker, slag, slate, wood and pottery.

6.1.3.4 TP202 encountered Made Ground as a brown and orangish brown gravelly very clayey sand with some cobbles of brickwork and pieces of plastic, wire and carpet. The gravels were flint, brick, concrete and chalk. A possible former strip footing was identified at 0.65m depth which was 1.3m wide and extended across the entire pit.

6.1.4 River Terrace Deposits

6.1.4.1 The River Terrace Deposits were encountered in all locations where Made Ground was penetrated. The material extended to depths of between 5.0-7.0m and was only penetrated in the cable percussive boreholes, BH01 to BH04. The material comprised both fine-grained and coarse-grained soils.

6.1.4.2 Fine-grained soils generally comprised firm (occasionally soft) orangish brown becoming light grey slightly gravelly sandy clay with gravels of flint and chalk and some cobbles of flint.

6.1.4.3 Coarse-grained soils generally comprised medium dense pale orangish brown and light grey gravelly sand with gravels and some cobbles of flint.

6.1.5 White Chalk Subgroup

6.1.5.1 The Chalk was encountered in BH01 to BH04 only and extended beyond 20m depth. The material was generally excavated as off-white clayey gravels with frequent cobbles. The gravels were weak to moderately strong, high density, and off-white. Flint gravels and cobbles were present throughout. Due to the method of excavation, it is not possible to determine if the chalk is structured although high SPT results suggest it is likely to be at depth.

6.2 Geotechnical parameters

6.1.2.2 The following table summarises test data in the cohesive River Terrace Deposits.

Table summarising soil testing and derived geotechnical parameters					
Geotechnical parameter	Method	Value range	Characteristic value	Comments	Notes
Weight density (above water table)	Soil descriptions	16-22	18	Derived from BS 8004 figure 1. Most onerous value to be used in structural design	
Plasticity index	Laboratory testing by Ashdown	8-29%	30%	Report as worst-case scenario	3
	Laboratory testing by Soiltechnics	13-25%	25%		1
Undrained Shear strength (kN/m ²)	Triaxial testing	19-94	-	-	1,2
	In situ testing	25-250	-	-	2
	Combined	-	30	Based on all test data	2

Table 6.1.2.2

1. Laboratory testing presented in Appendices F1 and F2
2. Presented on Drawing 03.
3. Refer to Ashdown Site Investigation's report

6.1.2.2 With regard to the Chalk Formation, it has an intact dry density between 1.74Mg/m³ and 1.96Mg/m³ indicating the Chalk is high density.

6.3 Groundwater

6.3.1 Groundwater inflows were observed in some of the exploratory excavations. A summary of our observations is tabulated below:

Table summarising groundwater observations			
Location	Date of observation	Depth (m) below ground levels	Observations
BH01	18.01.21	5.4m	Groundwater strike at 5.4m rising to 4.5m in 20 minutes.
BH02	19.01.21	5.5m	Groundwater strike at 5.5m rising to 4.7m in 20 minutes.
BH03	21.01.21	8.5m	Groundwater strike at 8.5m rising to 6.6m in 20 minutes.
BH04	19.01.21	8.0m	Groundwater strike at 8.0m rising to 6.1m in 20 minutes.
	21.01.21	5.22m	Groundwater recorded at 5.22m depth the day after completion.
	26.02.21	4.77	Monitoring visit
CPT05	19.01.21	0.2-0.35m	Seepages observed from 0.2-0.35m depth, filling trial pit by 5cm in 10 minutes.

Table 6.3.1

6.3.2 It should be noted that water levels will vary depending generally on recent weather conditions and only long-term monitoring of levels in standpipes will provide a measure of seasonal variations in groundwater levels.

6.4 Evidence of contamination

6.4.1 During excavation of our exploratory points, no evidence of significant contamination was noted.

6.5 Obstructions and instability

6.5.1 The following table summarises obstructions and instability encountered during our exploratory excavations.

Table summarising obstructions and instability observations		
Location	Depth of obstruction	Description of obstruction
BH02	9.4m	Borehole terminated due to the competency of chalk deposits
CPT01	12.90m	Cone penetration testing terminated due to density of chalk
CPT02	10.52m	Cone penetration testing terminated due to density of chalk
CPT03	9.32m	Cone penetration testing terminated due to density of chalk
CPT04C	13.60m	Cone penetration testing terminated due to density of chalk
CPT05	5.02m	Cone penetration testing terminated due to density of River Terrace
CPT06	9.16m	Cone penetration testing terminated due to density of chalk
WS201	5.5m	Borehole collapsed from 6.0m to 5.5m depth upon completion.
TP201	2.0-3.0m	Trial pit sides collapsed from between 2.0-3.0m depth, widening trial pit sides by approximately 0.15m each side.
TP202	2.1-3.0m	Trial pit sides collapsed from between 2.1-3.0m depth, widening trial pit sides by approximately 0.1m each side.

Table 6.5.1

7 Geotechnical Appraisal

7.1	General description of the development
7.2	Building regulations and this report section
7.3	The geological model
7.4	Building foundation solution
7.5	Vibrotreatment
7.6	Raft
7.7	Piled foundations
7.8	Influence of trees and other major vegetation
7.9	Ground Floor Construction
7.10	Effect of existing development on new foundations
7.11	Trench stability
7.12	Infiltration Potential
7.13	Dissolution Features
7.14	Pavement Foundations

7.1 General description of the development

- 7.1.1 The following assessments are made on the investigatory data presented in the preceding sections of this report and are made with reference to specific nature of the development. Should scheme proposals change then it may be necessary to review the investigation and report.
- 7.1.2 This report has been produced to give some preliminary design information for the site. We have been provided with layout options for the site and understand it will include standard two-storey residential housing and some larger multi-storey buildings (apartments) and a care home.

7.2 Building regulations and this report section

7.2.1 Building Regulations

- 7.2.1.1 Current Approved Document A of the building Regulations references Eurocodes and their UK National Annexes as practical guidance in meeting part A requirements. Approved document A advises there may be alternative ways of achieving compliance with requirements where it can be demonstrated that the use of withdrawn standards no longer maintained by the British Standards Institution continues to meet Part A requirements.

7.2.2 This report section

- 7.2.2.1 This chapter of the report provides both a foundation strategy for the proposed development and geotechnical design parameters to comply with Eurocode 7 (BSEN1997-1:2004 '*Geotechnical Design – part 1 General Rules*' and the corresponding UK National Annex).

7.2.3 Geotechnical terms

7.2.3.1 Definitions of geotechnical terms used in the following paragraphs are provided in Appendix A.

7.2.4 This report

7.2.4.1 This report is a ground investigation report (GIR) and does not constitute a Geotechnical Design Report as defined in section 2.8 of BS EN 1997-1:2004 '*Eurocode 7 – Geotechnical Design – Part 1: General Rules*' and in particular will exclude assessment of lifetime actions to buildings from geotechnical influences.

7.3 The geological model

7.3.1 Four boreholes formed at the site to depths of up to 20m each encountered a reasonably consistent profile of soils which are summarised in the following table:

Summary of ground conditions encountered at the site					
Strata	Summary soil type	Depth to base of strata		Groundwater	
		Range	Model	Range	Model
Made Ground	Mixture of gravelly sand and sandy, gravelly clay	0.3-1.8m	1.5	None	-
River Terrace Deposits	Medium dense brown sand and gravel.	5.0-7.0m	7.0m	4.77-8.5m	6.0m
Chalk	Off-white clayey gravels of high density chalk.	Unknown	>20m	None	-

Table 7.3.1

7.3.2 Groundwater

7.3.2.1 Groundwater has not been encountered in any of the shallow exploratory boreholes but has been recorded at between 4.77m and 8.0m in the cable percussive boreholes. On this basis, it is considered unlikely groundwater would influence shallow foundations. However, its presence should be considered if a piled foundation solution is adopted.

7.4 Building foundation solution

7.4.1 The Ashdown report suggests that naturally deposited River Terrace Deposits will adequately support proposed buildings on concrete strip/trench fill foundations and gives a bearing capacity of 100kN/m². Review of the test data indicates this is based on hand vane and pocket penetrometer results which give insitu shear strengths generally in the range of 50kN/m² to >250kN/m². This suggests the River Terrace Deposits are variable in strength as well as in composition: comprising both clays and sands. Ashdowns also completed dynamic probing adjacent to each borehole location. Several of these record blow counts of 0,1 and 2 to depths of around 2.5. Similarly low blow counts were identified in a number of locations at around 3.5-4.0m. Such blow counts are suggestive of soft to firm soils rather than the firm to stiff clays indicated by the borehole descriptions.

7.4.2 We have undertaken additional insitu testing including SPTs, pocket penetrometer tests and CPT. Inspection of the results suggests that while generally the shear strengths are in the range identified by Ashdown's, there are areas of lower strength, around 20-30kN/m², both near surface and at depths of 3-4m. This is particularly noticeable in the CPT results where the continuous shear strength is shown to vary significantly within the near surface River Terrace.

7.4.3 Based on the above, we suggest that, the River Terrace are not generally not suitable for spread foundations. However, subject to further investigation and insitu testing, it may be possible to zone the site to identify plots that could adopt strip foundations.

7.4.4 Alternatively, a raft or piled foundation could be adopted. It may also be possible to use ground improvement techniques, such as vibrotreatment to allow for strip foundations to be adopted.

7.5 Vibrotreatment

7.5.1 Vibrotreatment could be used to increase the density of the River Terrace Deposits. By increasing the density of the the River Terrace, settlement levels can be substantially reduced and allow the adoption of traditional concrete pad/strip foundations.

7.5.2 Should this option be considered further we recommend the contents of this report be provided to a specialist vibrotreatment contractor to obtain their opinion as to the ability of the River Terrace to be effectively treated to allow the adoption of traditional spread foundations located at shallow depths. It is important that the vibrotreatment specialist takes into account any boulder-sized materials or other obstructions as encountered in the exploratory excavations, which may affect penetration of the vibratory poker.

7.5.3 Typically, following treatment the following foundation design criteria are appropriate but require confirmation by the designer / specifier of the vibrotreatment.

- Spread foundations would be located 1m below existing or finished ground levels, whichever produces the deeper foundation (in the absence of trees if the soils are plastic, or foundation depths will have to be greater than 1m in plastic soils close to trees).
- Concrete strip foundations require reinforcement to stiffen the foundations to resist localised differential movement.
- Treated soils will be able to provide an allowable bearing pressure of 120kN/m² at a depth of 1m. The designer / specifier of the vibrotreatment will need to advise on likely levels of settlement / differential settlement which will occur to loaded foundations constructed on treated ground to allow the building designer to determine if this is acceptable for the building under consideration at the site.

7.5.4 It is noteworthy that vibrotreatment does generate vibrations which could damage nearby buildings and any nearby vibration sensitive equipment including services. the designer/specifier of the vibrotreatment should be able to advise further on this.

7.5.5 NHBC Standards, Chapter 4.6 provides good guidance on the use of vibrotreatment of soils to support residential buildings. The NHBC require a vibrotreatment to be designed and specified by an Engineer experienced in ground improvement techniques who is independent of a contractor responsible for the vibratory ground improvement operations. NHBC require the use of suspended ground floors combination with concrete strip/ trench fill foundations supported on vibrotreated soils.

7.6 Raft

7.6.1 Raft foundations could potentially be adopted for low-rise buildings. Raft foundations have the ability to spread super structural loads over the footprint of the building thus substantially reducing stresses imparted to the ground compared with spread foundations transferring more concentrated loads to the ground. It is normal practice to limit plan lengths to a maximum of 1:2.

7.6.2 For ground conditions investigated at this site, we are of the opinion that the raft will need to accommodate a local loss of support. The following table provides guidance on the likely diameter of loss of support below a raft, and is taken from “*Structural Foundation Designers’ Manual*” – by Curtins Consulting Engineers.

Assessment of local loss of support to a raft		
Soil conditions	Typical soil type	Assessed diameter of loos of support (m)
Type A Consistent (firm)	Only one of clay, sand, gravel, sandy clay, clayey sand	1 to 1.5
Type B Consistent, but variable density	Only one of clay, sand, gravel, sandy clay, clayey sand	1.5 to 2
Type C Variable soil type, but firm	Two or more of clay, sand, gravel, sandy clay, clayey sand	2 to 2.5
Type D Variable soil type and variable density	Two or more of clay, sand, gravel, sandy clay, clayey sand	2.5 to 3.5

Table 7.2.1

7.6.3 Based on ground conditions explored at the site, and the results of insitu density testing (refer Drawing 03) and inconsideration of the above table, it is our opinion, the raft be designed to accommodate a loss of ground support of say 2.5m diameter below any part of the raft.

7.6.4 The serviceability limit state for the raft requires consideration. It is impossible to accurately determine likely levels of settlement of a loaded raft foundation although assuming typical loads for a two-storey house, settlement is not likely to be significantly high. We can comment further on proposed likely settlements if raft foundation solutions are considered and proposed loadings can be provided.

7.7 Piled foundations

7.7.1 A piled foundation solution is likely to be required for proposed multistorey buildings and could also be adopted for standard two-storey residential properties as an alternative to the above options.

7.7.2 Piles will obtain shaft adhesion support from the River Terrace Deposits and underlying Chalk deposits, and end bearing support in the Chalk.

7.7.3 Pile design and installation

7.7.3.1 We recommend the design and installation of the piles are determined by a specialist piling contractor who has experience in pile installation in these or similar ground conditions, and may be able to interpret the observed ground conditions in a different and potentially more beneficial manner. We recommend the specialist piling contractor assumes responsibility for the choice, design and installation of the piles, with design carried out to current nationally recognised standards.

7.7.3.2 We recommend piling be carried out following the current version of "*Specification for Piling and Embedded Retaining Walls*" produced by the Institution of Civil Engineers.

7.7.4 Piling constraints

7.7.4.1 It should be noted that these piles will penetrate the ground water table likely to be located at a level of between 5-8m which will affect piling operations.

7.7.4.2 In ground obstructions should be considered within the main development area. Concrete was encountered in WS08 at 1m and further obstructions may be present, although significant number of obstructions are unlikely.

7.7.5 Piling mat

7.7.5.1 It is likely that a 'piling mat' will have to be constructed in advance of piling operations. This will be designed following the Building Research Establishment publication '*Working Platforms for tracked plant: good practice guide to the design, installation, maintenance and repair of ground supported working platforms*'. We will be pleased to assist in the design and specification of such a platform on further instructions.

7.8 Influence of trees and other major vegetation

7.8.1 Soil classification and new foundation design

7.8.1.1 The results of plastic and liquid limit determinations performed on samples of the River Terrace Deposits indicate these deposits are soils of medium volume change potential when classified in accordance with National House Building Council (NHBC) Standards, Chapter 4.2. Foundations taken down onto a depth of 0.9m will penetrate the zone of shrinkage and swelling caused by seasonal wetting and drying. Trees and other major vegetation extend this zone and will require deeper foundations. A good guide to this subject is provided in NHBC Standards, Chapter 4.2.

7.8.2 Tree species identification

7.8.2.1 There are a number of trees and other major vegetation at the site (and adjacent sites). On this basis it will be necessary to appoint a qualified Arboriculturist (listed in the Arboricultural Association Directory of Consultants – www.trees.org.uk) to determine the location, height (and mature height) and water demand of all trees/major hedgerows at and close to the site, information, which will be necessary to design foundations in accordance with NHBC Standards, Chapter 4.2.

7.8.3 New planting

7.8.3.1 Any planting schemes should also take into account the effect that new trees could have on foundations when they reach maturity. Again, a good guide to this subject is provided in NHBC Standards, Chapter 4.2.

7.9 Ground Floor Construction

7.9.1 The type of ground floor slab adopted will be dependent on the foundation solution adopted for the proposed development.

7.10 Effect of existing development on new foundations

7.10.1 Clearly demolition of the existing building and removal of existing foundations will disturb near surface soils requiring new foundations to extend into soils which have not been disturbed.

7.11 Trench stability

7.11.1 Based on our observations of the stability of the sides of trial pit excavations we consider there is a possibility of some instability in the granular River Terrace Deposits which may result in a wider than planned trench width. Continuous trench sheet shoring may be required to maintain an open excavation.

7.11.2 Based on groundwater observations in exploratory excavations, we consider it is unlikely that groundwater will be encountered in shallow excavations (<5m depth).

7.11.3 We recommend any trench excavation requiring human entry is shored as necessary to conform with current best practice, and accepted by the Health and safety Executive (HSE) and in particular, following guidance provided in the HSE publication '*Health and Safety in Construction (HSG 150)*' (www.hse.gov.uk).

7.12 Infiltration Potential

7.12.1 Falling head tests were undertaken and reported in the previous Ashdown report and demonstrated that the River Terrace deposits are permeable. However, a number of the tests were undertaken in soils described as clay and within uncased granular soils. This would affect the reliability of the results.

7.12.2 The River Terrace deposits are variable and it is considered likely soakway systems will be feasible. There are no comments on the existing drainage provision, in the Ashdown report. However, we understand a review of existing drainage has been undertaken and soakaways are present. We recommend these should be measured and taken as a guide to the future design principal. The ideal option would be then to undertake tests within the soakaways.

7.13 Dissolution Features

7.13.1 Chalk is typically rich in Calcium Carbonate. CIRIA report PR11 (and C574) states 'The presence of dissolution features should be expected on all calcium carbonate rich chalk sites'. Dissolution features in general comprise the following:

- Sinkhole, formed by dissolution of near surface chalks reducing their volume and creating a surface depression.
- Dissolution pipe, a cone or pipe like cavity typically in filled with chalk which has subsided into the cavity, with the infill chalk much weaker than the surrounding chalk.
- Swallow holes, a surface feature where a void in the chalk continuously or intermittently 'swallows' wholly or partially a surface stream.

7.13.2 Assessment of the risk to foundations posed by dissolution features

7.13.2.1 Dissolution features pose a hazard to foundations because of the presence of one or more of the following:

1. Large variations in intact chalk horizon
2. Loose chalk or superficial deposits infilling pipes
3. Cavities or caves within the chalk
4. Dissolution widened discontinuities in the chalk affecting its load carrying capacity

7.13.2.2 These features are generally located above the groundwater table level.

7.13.2.3 Clearly the risk that these hazards present to a building relates to its vulnerability, which in turn relates to the foundation type. A building on shallow spread type foundations and ground bearing floors is more vulnerable than piled foundations extending through the base of these features supporting a suspended ground floor slab.

7.13.2.4 Research described in CIRIA report C574 concludes that the majority of recent ground subsidence occurring on the chalk outcrop was induced by man. The most common activities triggering subsidence are as follows

- Dynamic and static loading
- Leaking drains
- Leaking water supply pipes
- Water flows from soakaways
- Overzealous garden watering in dry weather

7.13.3 Risk assessment and mitigation

7.13.3.1 Unfortunately in many cases it is not possible to confidently discount the presence of dissolution features, but we have assessed the risk based on the following:

Item	Observation / enquiry	Assessed risk
Surface features	No obvious evidence of any surface depressions in topography local to the site	Low
Variation in density of near surface soils	No significant variation in density of near surface soils	Low
Variation in intact chalk horizon	No significant variation in intact chalk horizon	Low
Adverse movement in nearby buildings	No adverse movement in neighbouring properties close to the site (viewed from public roads / footways only)	Low
Envirocheck data base	Provided in Ashdown's report	Very low
Table 7.13.3.1		

7.13.3.2 Based on the above, the risk of the site being subject to dissolution features is considered low. Although the risk is considered low, clearly there is a residual risk that dissolution features could be encountered in the construction phase, identified by voiding or locally loose soil, in which case Soiltechnics shall be advised to determine a solution.

7.13.4 Risk mitigation measures

7.13.4.1 As infiltration systems are likely to be utilised at the site we recommend water is not concentrated in isolated locations but evenly distributed in say level trench type soakaways to minimise the risk of promoting the formation of dissolution features. Again, such soakaways need to be positioned remote from buildings and remote from settlement sensitive features.

7.13.4.2 Water supply pipes need to be watertight and flexible to minimise risks of leaks. Heavy vibration from compaction plant shall not be used.

7.14 Pavement Foundations

7.14.1 Insitu cone penetrometer tests were undertaken as part of the investigations by Ashdown's recommendations with regard to CBR are fully detailed in their report. We have not identified any significantly different ground conditions and therefore we have not undertaken any additional assessment.

8 Chemical contamination

8.1	Objectives
8.2	Laboratory testing
8.3	Updated conceptual model
8.4	Additional testing or remedial action
8.5	Risk assessment summary and recommendations
8.6	Final conceptual model
8.7	Statement with respect to National Planning Policy Framework
8.8	On site monitoring

8.1 Objectives

8.1.1 The previous ground investigation report by Ashdown Site Investigation Limited included a phase II contamination assessment. Our investigations are considered supplementary and target areas where previous works were recommended. This Section also reviews previous assessments together with the findings of this investigation to refine the recommendations in the previous report.

8.1.2 Identified contamination sources

8.1.2 The potential contamination sources which were identified in the Ashdown report include.

- The electrical substation in the south eastern corner of the site.
- Made Ground across the site from demolition works and historic ground working associated with brick field.
- Tanks, chimney and electricity substation in the facilities maintenance area of the site.
- Interceptor in the south eastern corner of the car park.
- Backfilled filter beds to the west of the site.
- Historical gas holder to the north west of the site.

8.1.3 Summary of findings

8.1.3.1 Generally, the Ashdown report identified elevated concentrations of metals and PAH within the Made Ground, which could pose a risk to end users of the site. Asbestos fibres were also identified in one area, likely due to a relict structure. The investigation did not identify any significant hydrocarbon or volatile compound contamination but acknowledged that some localised contamination may be present, particularly in the area of the facilities maintenance buildings. There were also concentrations of cyanide recorded in close proximity to the former adjacent gas works.

8.1.3.2 Based on the above, the potential sources of contamination identified and specific hotspots of possible contamination, the Ashdown report details specific areas that require further works to refine the assessment. The following table provides a summary of these areas and where Soiltechnics have completed further works.

The following table should be read in conjunction with Drawing 02 which details existing site features and location of exploratory points undertaken by both Ashdown Site Investigations and Soiltechnics.

Summary of conclusions made in Ashdown Ltd report and further works completed by Soiltechnics Ltd	
Conclusion made in Ashdown report	Further works completed by Soiltechnics
Made Ground	
Made Ground from WS8 identified asbestos fibres and bound fragment of chrysotile and amosite asbestos.	Additional five asbestos screening tests from Made Ground across the site.
Arsenic, lead and PAH compounds within the Made Ground in the main part of the site may pose a risk to proposed end users where soils remain in areas of proposed soft landscaping. There is not however considered to be a risk of these compounds to controlled waters.	Additional five samples of Made Ground across the site tested for presence of metals and PAHs.
Interceptor in south eastern corner of car park	
No samples tested from WS10 (adjacent to interceptor tank) identified elevated TPH or BTEX concentrations. It is recommended however that the soils are inspected during the removal of the interceptor to confirm that no visual or olfactory evidence of contamination is present beneath.	No further action required until interceptor tank is removed.
Electrical substation in south eastern corner of the site	
No PCBs were identified in WS01 adjacent to the substation in the south east of the site. Again, it is recommended that the soils are inspected should this substation be removed.	No further action required until substation is removed.
Maintenance facilities area (chimney, tanks and substation)	
No elevated concentrations of TPHs, BTEX, VOCs or PCBs were identified in WS8 and WS9 adjacent to the chimney and tanks in the centre of the site. Although WS7 and WS8 were terminated at shallow depth due to obstructions. It is recommended that further works are undertaken in this area following removal to confirm that there is no significant contamination beneath these structures.	WS203 located adjacent to the large fuel tank. No visual or olfactory evidence of contamination was identified. Testing undertaken to confirm. Further action limited until these areas are removed.
Historical gas holder to the north west of the site	
Elevated cyanide was identified in Topsoil and Made Ground in WS105, considered to be associated with gas holder. It is recommended that a detailed quantitative risk assessment (DQRA) and further works is completed in this area to determine the potential risk to groundwaters from the gas holder onsite.	Concentrations of cyanide tested in near surface sample from WS201. Water sample tested from BH04 to determine whether any significant groundwater contamination is present.
Shallow soils in south west of the site	
There is considered to be a PAH hotspot around WS105, and additional works are recommended. It is not however considered to pose a risk to groundwaters.	PAHs tested in near surface sample from WS201. Limited locations for boreholes available due to overgrown vegetation.
Table 8.1.3	

8.2 Laboratory testing

8.2.1 Testing regime

8.2.1.1 With reference to the above, the following table summarises the chemical testing scheduled as well as a rationale for the testing.

Table summarising scheduled testing					
Location	Depth (m)	Strata	Targeted sampling?	Scheduled testing (refer to Appendix B)	Rationale
WS203	0.3	Made Ground	Y	Suite 1	Targeting fuel tank and chimney
	0.6		Y	Suite 4 Asbestos screening	
TP201	0.5	River Terrace Deposits	N	Suite 1	General site coverage
CPT01	0.3		N	Asbestos screening	
CPT06	0.3		N		
WS201	0.3	River Terrace Deposits	Y	Suite 1 Asbestos screening	Near surface soils near gas holder
BH04	5.22	Groundwater	Y	Suite 17 (water)	Groundwater sample close to gas holder
BH04	5.13		Y	Suite 6	General assessment of groundwater

Table 8.2.1.1

8.2.1.2 Obviously, additional testing (quantity and types) would allow a more accurate risk assessment to be made. The results of laboratory determination of concentration of chemical contaminants are presented in Appendix G.

8.2.2 Criteria for assessment of test data – Human receptors

8.2.2.1 Assessment of laboratory test data has been carried out with reference to current nationally recognised documents listed in the final page of Appendix B. Due to changes in guidance on contaminated land, items 6-8 and item 10 in the document listing above have been withdrawn. In the absence of alternative guidance however we have used these documents. Where new guidance is available, this has been followed in preference to superseded guidance.

8.2.2.2 The Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) have derived Suitable for Use Levels (S4ULs) which are presented in 'The LQM/CIEH S4ULs for Human Health Risk Assessment' (2015). S4ULs have been used as a screening tool to assess the risks posed to the health of humans from exposure to soil contamination in relation to appropriate land uses. Where published S4ULs are not available, we have adopted C4SLs (Category 4 Screening Levels) produced by DEFRA or SGVs (Soil Guideline Values) as appropriate. In the absence of any of these criteria we have adopted Soil Screening Values (SSV) derived by Soiltechnics and by Atkins (SSV^{ATK}). The CLEA model used to derive SSVs has been used with toxicology data presented by the EA, LQM/CIEH and Atkins (in that order of preference). SSVs produced by Atkins are presented on their ATRISK^{SOIL} website.

8.2.2.3 S4ULs, C4SLs, SGVs, SSVs and SSV^{ATK}s represent ‘intervention values’; indications to an assessor that soil concentrations above these levels might present an unacceptable risk to the health of site users. These guideline values have been produced using conceptual exposure models, which use assumptions and are applied to differing end uses of land. If the values are exceeded, it does not necessarily imply there is an actual risk to health and site-specific circumstances should be taken into account. Conversely, where a critical pathway or chemical form of the contaminant has not been evaluated, a risk may be present even if the adopted guideline value has not been exceeded.

8.2.2.4 For evaluation of test data in relation to polycyclic aromatic hydrocarbon (PAH), phenols and total petroleum hydrocarbon (TPH) contamination, we have compared measured concentrations with corresponding S4ULs. The S4UL fractions are dependent on the Soil Organic Matter (SOM) content of the soils. We have adopted the relevant guideline values based on SOM testing.

8.2.2.5 We have followed procedures outlined by the CIEH to compare measured concentrations of metals and PAH contaminants against guideline values. TPH contamination results are compared directly with the relevant guideline values. The guidance presents an approach to data analysis and includes the examination of data for potential outliers, assessment of the normality of the test data and the calculation of a 95% Upper Confidence Limit (UCL). The UCL provides an estimate of the population mean, based on test data, with a 95% confidence that the actual mean does not exceed this value. The UCL is compared to the guideline value for the site.

8.2.2.6 We have adopted a commercial/industrial land use for current site users and a residential land use for proposed end users of the site. In the absence of guidelines we have adopted industrial guideline values for assessment of construction operatives.

8.2.3 Criteria for assessment of test data – Vegetation

8.2.3.1 Guidance published by Forest Research in “BPG Note 5 - Best Practice Guidance for Land Regeneration” suggests that a residential without plant uptake or industrial/commercial CLEA model should be adopted for this receptor although specific guideline values are provided for copper and zinc at 130mg/kg and 300mg/kg respectively. As a practice we have adopted the industrial/commercial CLEA model for assessment of test data for vegetation.

8.2.4 Criteria for assessment of test data – Controlled waters

8.2.5.1 For interpretation of test data in relation to water receptors we have directly compared measured values with relevant screening values. Details of the source data and adopted threshold values are outlined on the summary tables in Appendix H.

8.2.5.2 Following our receptor assessment (outlined above), and in consideration of the pathways and migration potential for contaminants on site, the critical receptor for the site is considered to be the underlying aquifers, secondary A in the River Terrace Deposits and principal in the chalk. We have therefore adopted drinking waters as the critical receptor, and this has been utilised within our assessment model in Appendix H.

8.2.6 Evaluation of test data – Human receptors

8.2.6.1 We have undertaken an evaluation of all test data obtained to date, combining the results presented in the Ashdown report with our supplementary testing. In line with the Ashdown report, we have separated the main, developed site from the undeveloped site to the west. We have also undertaken our analysis in terms of each previously identified area of concern, as detailed in Table 8.1.3.

8.2.6.1.1 *Made Ground - asbestos*

8.2.6.1.1.1 The Ashdown report identified asbestos fibres in a sample taken from WS08 and the source was considered to potentially be an adjacent relict structure as asbestos had not been identified elsewhere on the site. Asbestos screening was undertaken on a further nine samples but no asbestos was identified.

8.2.6.1.1.2 As part of these supplementary works, asbestos screening was undertaken on a further six samples. Asbestos (identified as a bundle of amosite fibres) was identified in one sample (WS203 at 0.6m depth). This location was located adjacent to the facilities maintenance building (to the south). WS08 was located to the north of this building. It is therefore considered possible that asbestos contamination is generally located towards the centre of the site around the facilities maintenance building. However, given the heterogenous nature of the Made Ground, its presence elsewhere cannot be discounted.

8.2.6.1.2 *Made Ground – metals and PAH*

8.2.6.1.2.1 With reference to Tables 1 and 3 in Appendix H, analysis of chemical test data with respect to critical (adult) receptors for current site users and construction operatives indicates all measured concentrations of selected contaminants and 95 percentile upper confidence limits (UCL) are below relevant adopted guideline values.

8.2.6.1.2.2 With reference to Tables 2 and 4 in Appendix H, analysis of chemical test data with respect to critical (child) receptors for future site users indicates elevated measured concentrations of arsenic, beryllium, lead and PAH compounds. The Ashdown report identified arsenic, lead and PAH as potentially posing a risk to end users.

- 8.2.6.1.2.3 With regard to arsenic (Table 2), an elevated concentration was measured in one of the 19 samples tested from the main site. The mean concentration is calculated as 16.2mg/kg, which is well below the guideline value of 37mg/kg. However, the UCL is 38.7mg/kg, which marginally exceeds the guideline value. A review of the test data shows the single elevated concentration of 107mg/kg is in WS04 at 0.2m. All other concentrations are significantly below this concentrations (between 5-25mg/kg). On this basis, we suggest that this concentration of arsenic is not representative of the site as a whole and can be considered an isolated hotspot. Excluding this outlier, the UCL of arsenic is 15.9mg/kg.
- 8.2.6.1.2.4 With reference to Table 2, beryllium was measured above the guideline value in one of six samples, WS203 at 0.6m depth. The concentration was recorded as 2.1mg/kg compared to a guideline value of 1.7mg/kg.
- 8.2.6.1.2.5 The existing guideline value for beryllium is based on research into the impact of **industrial** exposure, where the inhalation exposure route poses the most significant risk to end users. Indeed, the overwhelming majority of the existing literature strongly indicates that intake of beryllium orally through dermal contact has no ill health effects on humans and there is no evidence to suggest that naturally occurring beryllium poses a risk to end users.
- 8.2.6.1.2.6 As the site has not been subject to past industrial activities which are likely to have handled beryllium, concentrations recorded on site are likely to be naturally occurring. The average concentration of natural beryllium in the earth's crust is approximately 2-5mg/kg which notably exceeds the residential guideline value of 1.7mg/kg, derived by research into industrial exposure. On site, the concentrations of beryllium within soils were recorded at 0.5mg/kg-2.1mg/kg, which reflect natural, background concentrations. On this basis, the recorded concentrations of beryllium are not considered to present a risk to human receptors.
- 8.2.6.1.2.7 With regard to lead (refer to Table 2), an elevated concentration was measured in one of the 19 samples tested from the main site. The mean concentration is calculated as 62.1mg/kg and the UCL was calculated as 175.5mg/kg, both of which are well below the guideline value of 210mg/kg. A review of the test data shows the single elevated concentration of 504mg/kg is in WS09 at 0.3m. All other concentrations are significantly below this concentration (between 7-159mg/kg). On this basis, we suggest that the concentrations of lead at the site do not pose a significant risk to end users and that the single elevated concentration is potentially a hotspot that may require further consideration.
- 8.2.6.1.2.8 The PAH compounds benzo(b)fluoranthene and benzo(a)pyrene were elevated in one and two of the nineteen samples respectively. However, with reference to Table 4 in Appendix H, the mean concentrations and UCL values fall below guideline values for end use. On this basis, they are not considered to pose a risk to end users. Dibenzo(a,h)anthracene was elevated in four of the 19 samples and the UCL was calculated as 0.5mg/kg, which exceeds the guideline value of 0.24mg/kg. These are similar to the findings of the Ashdown report with respect to PAH.

8.2.6.1.3 *Maintenance facilities area*

8.2.6.1.3.1 Although access was not possible to this area during either investigation, Ashdowns placed three boreholes to the north, west and east of the buildings/tanks. Two were terminated at shallow depth due to obstructions but the testing undertaken did not identify any elevated concentrations of organic contaminants. We have undertaken a further borehole to the immediate south of the area and tested a sample for TPH and BTEX. None of the concentrations exceeded the guideline values for residential end use.

8.2.6.1.3.2 On this basis, results support the findings of the Ashdown's report. Localised contamination may be present immediately below the existing infrastructure although there is no evidence of significant migration through near surface soils.

8.2.6.1.3 *Adjacent historical gas holders*

8.2.6.1.3.1 Elevated cyanide was identified in WS105, located in the undeveloped western part of the site close to the northern boundary. Due to the overgrown nature of the site, locations for supplementary boreholes were limited. However, concentrations of cyanide and phenol within a near surface sample from WS201 were below detectable limits.

8.2.6.1.3.2 On this basis, there is a potential for localised cyanide contamination near the site boundary, potentially near WS105 but further testing would be required to confirm this. It is considered unlikely the contamination has migrated a significant distance across the site based on testing to date.

8.2.6.1.4 *Undeveloped land to the west*

8.2.6.1.4.1 Ashdown's tested eleven samples of soil from this area. Two of the nine samples contained elevated dibenzo(a,h)anthracene and the UCL exceeded the guideline value. The samples were from WS105, in the north-east corner and a sample of River Terrace deposits from WS107, although the concentration in these deposits was only marginally elevated. On this basis, there was considered to be a risk of PAH contamination within near surface soils.

8.2.6.1.4.2 We have tested one further sample of River Terrace deposits from this area (WS201). Concentrations were below detectable limits.

8.2.6.1.4.3 A review of the Ashdown logs shows that near surface soils in WS105 are described as Made Ground and extend to a depth of 0.6m. It includes clinker-like material, which could be a potential source of the PAH. Remaining near surface soils in this area are described as Topsoil, with some anthropogenic fragments such as brick.

8.2.6.1.4.4 Given these soils are different to those encountered elsewhere across the site, the elevated concentration is considered to be an outlier. Removing this outlier from the data set produces a UCL below guideline values suggesting the remaining soils do not pose a risk to end users. This is shown on Table 10.

8.2.6.1.5 *Summary*

- 8.2.6.1.5.1 Generally, the results of the supplementary investigation support the findings of the Ashdown investigation.
- 8.2.6.1.5.2 Within the main site, the near surface Made Ground exhibits some low-level PAH contamination that could pose a risk to future site users in a residential setting. However, it should be noted that concentrations do not exceed guideline values for public open space in a residential area.
- 8.2.6.1.5.3 There is a hotspot of lead contamination adjacent to the existing facilities maintenance shed and asbestos fibres have also been identified in this location. A hotspot of arsenic appears to be present around WS04.
- 8.2.6.1.5.4 With regard to the land to the west, the soils generally do not exhibit contamination that would pose a risk to end users. A hotspot of contamination has been identified within the vicinity of WS05.
- 8.2.6.1.5.5 Recommendations with regard to dealing with the identified contamination are discussed in Section 8.4.

8.2.7 *Evaluation of test data – Vegetation*

- 8.2.7.1 Comparison of test data with guideline values is presented on Tables 3, 5 and 10 in Appendix H. None of the calculated mean values of 95% UCL values were recorded above the guideline values. As such, there is not considered to be a significant risk of contamination on site affecting vegetation.
- 8.2.7.2 It is difficult to quantify the phytotoxicity of a contaminant as large variations exist between plant tolerances, soil effects and synergistic/antagonistic reactions between chemicals. Due to the complexities of the effects of soil contamination on different plant species, we recommend that the test results presented in this report are passed to a landscape architect for the selection of suitable planting.

8.2.8 *Evaluation of test data – Controlled waters*

- 8.2.8.1 Groundwater was not encountered during the original investigation by Ashdown. We have therefore undertaken a suite of testing on two samples of groundwater obtained from BH04. The results of the screening are presented on Table 8 in Appendix H.

8.2.8.2 *Inorganic contaminants*

- 8.2.8.2.1 None of the measured concentrations of inorganic contaminants exceed the relevant guideline outlined above.

8.2.8.3 *Organic contaminants (polycyclic aromatic hydrocarbons)*

8.2.8.3.1 For the analysis of PAH contamination, the sum of the following contaminants has been compared to a UKDWS.

- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(ghi)perylene
- Indeno(1,2,3-cd)pyrene

8.2.8.3.2 The summed concentration of the PAH 'suite' does not exceed the UKDWS. In addition, the leachable concentration of benzo(a)pyrene and naphthalene, do not exceed their respective guideline values.

8.2.8.4 *Organic contaminants (total petroleum hydrocarbons)*

8.2.8.4.1 The measured values of TPH contaminants fall below the relevant guideline value with the exception of Aliphatic EC>21-EC35. This fraction was recorded as 107µg/l compared to a guideline value of 10µg/l in BH04 at 5.22m depth. It should be noted that the guideline value adopted is highly conservative given the site is not located in a source protection zone and there are no abstraction points within 1km of the site. In addition, despite this elevated concentration, the overall total concentration of TPH is below detectable limits.

8.2.8.4.2 This water sample was taken shortly after excavation and it is possible that disturbance during drilling has resulted in soils entering groundwater and producing a slight exceedance. As a precaution, we have undertaken additional sampling and testing of groundwater from this location at 5.13m depth. This testing did not identify any concentrations of TPH exceeding detectable limits, which confirms the assumption that the original exceedance is not characteristic of the groundwater.

8.3 Updated conceptual model

8.3.1 Following the additional ground investigation and laboratory testing undertaken by Soiltechnics, an updated conceptual model has been produced which is presented in Appendix I. This is based on the original quantitative conceptual model produced by Ashdown's and revised based on the additional testing undertaken.

8.3.2 Based on the conceptual model there are risks which exceed the low category which in our opinion are unacceptable and require either remedial action or further investigation by laboratory testing of soil/water samples to further refine the risk assessment.

8.4 Additional investigation and remedial action

8.4.1 Based on the above assessment, further testing pre-construction or remedial action is considered necessary to make this site safe and suitable for proposed end uses. A summary of the recommended works are detailed below;

8.4.2 Undeveloped land to the west

- 8.4.2.1 Based on investigation works, no evidence of significant contamination has been identified in this area. An area of Made Ground, exhibiting elevated concentrations of cyanide and dibenzo(a,h)anthracene was noted in WS105.
- 8.4.2.2 On this basis, significant remediation is considered unlikely to be required in this area. Further testing and sampling of soils around WS105 should be undertaken to determine the extent of the contamination, with excavation and removal of Made Ground soils in this area recommended.
- 8.4.2.3 The area is adjacent to a former gas holder, which would have potentially posed a risk to groundwater. Due to dense vegetation across this area of the site, a deep borehole could not be undertaken and groundwater has not been identified, in the shallow excavations. We recommend a further deep borehole is undertaken in this area following clearance to allow for groundwater sampling and testing.

8.4.3 Main site

- 8.4.3.1 Overall, no significant contamination has been identified in this area. The near surface Made Ground exhibits some low-level PAH contamination that could pose a risk to future site users and we would recommend a capping layer be incorporated into all future gardens and areas of soft landscaping. The thickness of the capping will be dependent on the end use but is likely to be 600mm in potentially productive gardens and 300mm in soft landscaping and communal areas of open space. Site won, chemically clean natural soils (River Terrace) could be utilised as part of the capping layer and overlain by imported Topsoil for use as a growth medium.
- 8.4.3.2 A hotspot of arsenic appears to be present around WS04. If this area is covered in buildings/hardstandings pathways to end users will be severed and no further action is likely to be required. A capping layer would also sever the pathway to end users, however, consideration may want to be given to further sampling and testing, and possible excavation of this hotspot should it be in a sensitive location such as a private back garden.
- 8.4.3.3 There is a hotspot of lead contamination adjacent to the existing facilities maintenance shed and asbestos fibres have also been identified in this location. Further localised contamination, particularly fuels may be present beneath the buildings/tanks and further investigations and testing are recommended once this area has been decommissioned and tanks/buildings removed. No fuel/oil contamination was encountered within WS09 or WS203 so significant migration of any contamination is considered unlikely. However, we cannot rule out contamination of groundwater as it has not been encountered in this area. A deep borehole into groundwater is also recommended in this area. It should be anticipated that some excavation and removal of soils will be necessary in this area.

8.4.3.4 In addition to the above, a watching brief should also be kept during removal of the interceptor tanks, the maintenance facility and sub-stations with some additional testing undertaken to confirm or otherwise the absence of associated contamination.

8.4.3.5 Adequate hygiene precautions should also be adopted for construction operatives.

8.4.4 Groundwater

8.4.4.1 As stated above, there are potential sources of contamination which could impact groundwater. At this stage, limited groundwater testing has been undertaken which did not identify significant contamination. However, we would recommend additional sampling and testing of groundwater be undertaken within existing standpipes (if groundwater is present) to refine the assessment. In addition, further deep boreholes are recommended within the area to the west and adjacent to the facilities maintenance area to determine if there is any associated groundwater contamination.

8.5 Risk assessment summary and recommendations

8.5.1 Based on our assessments described above, we can provide the following summary and recommendations for each identified receptor.

8.5.2 Current site users

8.5.2.1 As no elevated concentrations of chemical contamination have been identified on site with regards to the current site users, we are of the opinion that the site represents a low risk of causing harm to health.

8.5.3 End users

8.5.3.1 PAH contamination has been identified across the main site which may pose a risk to proposed site users. As such, capping has been recommended in all areas of soft landscaping. There are also a number of hotspots of contamination which will require further investigation and potential removal in order to reduce the risk to end users. The extent of such works is dependent on the development proposals for the site (residential house, apartments, commercial).

8.5.4 Construction operatives and other site investigators

8.5.4.1 The risk of damage to health of construction operatives and other site investigators is, in our opinion, low. As a precautionary approach, however, we recommend adequate hygiene precautions are adopted on site. Such precautions would be:

- Wearing protective clothing particularly gloves to minimise ingestion from soil contaminated hands.
- Avoiding dust by dampening the soils during the works.
- Wearing masks if processing produce dust.

8.5.4.2 Guidance on safe working practices can be obtained from the following documents

- The Health and Safety Executive Publication *“Protection of Workers and the General Public during the Development of Contaminated Land”* (HMSO) and
- *“A Guide to Safer Working on Contaminated Sites”* (CIRIA Report 132).

8.5.4.3 In addition, reference should be made to the Health and Safety Executive. In all cases work shall be undertaken following the requirements of the Health and Safety at Work Act 1974 and regulations made under the Act including the COSHH regulations.

8.5.4.4 If during the course of excavations hydrocarbon type odours become evident, we recommend works are halted, and the air quality measured to determine if the excavation can be safely entered. If the air quality is unacceptable then appropriate personal protective equipment, will be required for human entry into the excavation. If elevated concentrations of airborne hydrocarbons / vapours are detected on site, we recommend Soiltechnics are advised to determine an appropriate course of action with respect to building construction.

8.5.5 Controlled waters

8.5.5.1 Limited testing has been undertaken on groundwater which has not identified any significant contamination. However, further groundwater sampling and testing is recommended to refine the risk. This will require an additional deep borehole in the western half of the site once the site has been cleared and potentially further boreholes on the main site.

8.5.6 Vegetation

8.5.6.1 No elevated concentrations of chemical contaminants have been identified on site, which pose a risk to vegetation. On this basis, we are of the opinion that the site represents a low risk of causing harm to vegetation.

8.6 Statement with respect to National Planning Policy Framework

8.6.1 Providing the recommendations described above are satisfactorily completed, we are of the opinion the proposed development will be safe and suitable for use for the purpose for which it is intended, thus meeting the requirements of the National Planning Policy Framework section 178, and compliant with the Building Regulations Part C, *‘Site preparation and resistance to contaminants and moisture’*.

8.7 On Site Monitoring

8.7.1 We have attempted to identify the potential for chemical contamination on the site, however, areas, which have not been investigated at this stage, may exhibit higher levels of contamination. If such areas are exposed at any time during construction we will be pleased to re-attend site to assess what action is required to allow the development to safely proceed.

9 Gaseous contamination

9.1	Overview of previous landfill risk assessment
9.2	Sources of landfill gas - summary of Soiltechnics investigation
9.3	Review of test data in the Ashdown report
9.4	Additional monitoring data
9.5	Gas protective measures – new buildings
9.6	Statement with respect to National Planning Policy Framework

9.1 Overview of previous landfill risk assessment

- 9.1.1 A landfill gas risk assessment is provided in the Ashdown report referenced R18-13236. Essentially, potential sources of landfill type gas were identified on site by virtue of Made Ground associated with former demolition of buildings and historical brickworks on site. Possible backfill of adjacent sewage filter beds to the west of the site was also identified as a possible source. As such, gas monitoring standpipes were installed across both the main site and the western site. Six monitoring visits were completed in the main site and three monitoring visits completed in the overgrown area in the west.
- 9.1.2 The text of the report suggests that both areas have been classified as traffic light colour 'Green' in accordance with Table 8.7 of the CIRIA document and as characteristic situation 1 and that providing a well-ventilated sub floor void is installed, no other specific gas protection measures are necessary.
- 9.1.3 However, with reference to BS 8485:2015+A1:2019 '*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*' and CIRIA Report C665 '*Assessing risks posed by hazardous ground gases to buildings*' (2007) CS1 and traffic light 'Green' sites do not require any protective measures.
- 9.1.4 We have therefore undertaken a review of the gas risk at the site based on Ashdown's assessment, the findings of our supplementary investigation and an additional round of gas monitoring.

9.2 Sources of landfill gas - summary of Soiltechnics investigation

- 9.2.1 During the ground investigation completed by Soiltechnics in January 2021, no additional deep Made Ground deposits were identified which could be considered a significant landfill type gas on site. The maximum depth of Made Ground was 1.8m in BH02. This Made Ground contained anthropogenic materials such as brick, ash and clinker but no easily degradable material such as paper, textile or waste food. One fragment of wood was observed however this was considered to be a one-off instance and not likely to be widespread throughout the Made Ground in this area.
- 9.2.2 As such, we have not identified any additional risk to the that already identified in the Ashdown report.

9.3 Review of test data in the Ashdown report

9.3.1 A review of test data shows all concentrations of methane were below detectable limits in all locations during each monitoring visit. Concentrations of carbon dioxide were generally between 0.6% and 4.6% in all locations with the exception of WS11. On the first two visits, concentrations were measured at 7.1% and 6.0%, before reducing below 5% on the final three visits (during falling pressure). Concentrations in WS105 (some 20m to the south-west) and WS13 (some 70m to the north) did not exceed 5%.

9.3.2 No flow was detected during any of the monitoring visits.

9.3.2 With reference to Table 4 of BS 8485:2015+A1:2019, the site would be classified as characteristic situation 1 although it recommends consideration is given to increasing the classification where CO₂ concentrations exceed 5%. In our opinion, based on test data, the two exceedances are not typical of the site as a whole or the borehole as lower concentrations were recorded during times of falling pressure (considered worst-case).

9.4 Additional monitoring data

9.4.1 We have undertaken a supplementary gas monitoring visit and measured gas concentrations within BH04. An attempt was made to locate and monitor the Ashdown boreholes, however, the covers had seized up and it was not possible to access them on this occasion.

9.4.2 Results of the gas monitoring visit are presented in Appendix M. The measurements of landfill type gases were obtained at an atmospheric condition of 1039mb and a temperature of 12°C. Essentially, we did not detect any concentrations of methane and carbon dioxide was measured at 0.2%. No flow was detected.

9.4.3 Although further gas monitoring is limited, it has not identified an exceedance of the 5% for carbon dioxide concentrations. BH04 is located some 50m south of borehole WS11 and supports the findings of the other surrounding boreholes.

9.4.4 Clearly further monitoring will increase the accuracy of this risk assessment, however in our opinion current best practice has been followed with respect to investigations completed to date, the monitoring regime and analysis of data, and again in our opinion, the data categories used in the analysis is considered to be *'representative and comprehensive'* as defined in section 6.3.7 of BS 8485:2015+A1:2019.

9.5 Gas protective measures – new buildings

9.5.1 Based on monitoring observations to date, development categorisation, the site characteristic gas situation, and with reference to Table 4 of BS 8485:2015+A1:2019, the development does not require any gas protective measures.

- 9.5.2 With the site being classified as green, then following NHBC report No 10627-R01(04) gas protection measures are not considered necessary.

9.6 Statement with respect to National Planning Policy Framework

- 9.6.1 Based on investigations completed to date with respect to gaseous contamination, we are of the opinion the proposed development will be safe and suitable for use for the purpose for which it is intended (without the need for any remedial action) thus meeting the requirements of the National Planning Policy Framework section 178, and compliant with the Building Regulations Part C, *'Site preparation and resistance to contaminants and moisture'*.

10 Effects of ground conditions on building materials

10.1	General
10.2	Concrete – sulphate attack
10.3	Concrete – chloride attack
10.4	Concrete – acid attack
10.5	Concrete – magnesium attack
10.6	Concrete – ammonium attack
10.7	Plastic pipes

10.1 General

10.1.1 Building materials are often subjected to aggressive environments which cause them to undergo chemical or physical changes. These changes may result in loss of strength or other properties that may put at risk their structural integrity or ability to perform to design requirements. Aggressive conditions include:

- Severe climates
- Coastal conditions
- Polluted atmospheres
- Aggressive ground conditions

10.1.2 This report section only considers aggressive ground conditions in relation to buried concrete and water pipes. Ground conditions may affect other materials but have not been considered here.

10.2 Concrete - Sulphate attack

10.2.1 Hazard

10.2.1.1 Sulphate attack on concrete is characterised by expansion, leading to loss of strength, cracking, spalling and eventual disintegration. There are three principal forms of sulphate attack, as follows:-

- Formation of gypsum through reaction of calcium hydroxide and sulphate ions.
- Ettringite formation through reaction of tricalcium aluminate and sulphite ions.
- Thaumasite formation as a result of reactions between calcium silicate hydrates, carbonate ions (from aggregates) and sulphate ions.

10.2.2 Assessment

10.2.2.1 The hazard of sulphide attack is addressed by reference to procedures described in Building Research Establishment (BRE) Special Digest 1: 2005 '*Concrete in Aggressive Ground*' to establish a design sulphate class (DS) and the '*Aggressive Chemical Environment for Concrete*' (ACEC). These procedures have been followed during our investigation and are described in the following paragraphs.

10.2.3 Desk Study Information

10.2.3.1 The first step in the procedure is to consider specific elements of the desk study. These are tabulated below.

Summary of desk study information			
Element	Interrogation	Outcome	SD1: 2005 reference
Geology	Likelihood of soils containing pyrites	Unlikely	Box C6
Past industrial uses	Brownfield site?	Yes	C2.1.2
Table 10.2.3.1			

10.2.3.2 A brownfield site is defined in SD1: 2005 as a site, or part of a site which has been subject to industrial development, storage of chemicals (including for agricultural use) or deposition of waste, and which may contain aggressive chemicals in residual surface materials, or in ground penetrated by leachates. Where the history of the site is not known, it should be treated as brownfield until there is evidence to classify it as natural.

10.2.3.3 Based on the above it is necessary to follow the procedures described in figure C6 ('locations on brownfield sites except where soils may contain pyrite').

10.2.4 Laboratory testing

10.2.4.1 The following table summarises ground conditions and laboratory testing.

Item	Soil type	Outcome
Soil		
Number of samples	Made Ground	1
	River Terrace	2
	Chalk	1
Characteristic w/s sulphate	Made Ground	14mg/l
	River Terrace	43mg/l
	Chalk	21mg/l
Characteristic pH	Made Ground	7.7
	River Terrace	8.1
	Chalk	8.1
Characteristic total acid soluble sulphate	Made Ground	0.02%
	River Terrace	0.03%
	Chalk	0.05%
TPS	Made Ground	0.02 %SO ⁴
	River Terrace	0.04 %SO ⁴
	Chalk	0.02 %SO ⁴
OS	Made Ground	0.01 %SO ⁴ . Pyrite is probably not present
	River Terrace	0.02 %SO ⁴ . Pyrite is probably not present
	Chalk	0.00 %SO ⁴ . Pyrite is probably not present
Groundwater		
Number of samples	-	1
Characteristic sulphate	-	58mg/l
Mobility	-	Mobile
Table 10.2.4.1		

10.2.5 Disturbed ground

10.2.5.1 As potentially pyritic ground has not been identified at the site, disturbed ground is not considered in the following assessment.

10.2.6 Assessment of design sulphate class (DC) and aggressive chemical environment for concrete (ACEC)

10.2.6.1 Based on the design sulphate class, characteristic value of pH and assessment of groundwater mobility, and with reference to table C2 of SDI: 2005, the ACEC class for each soil type is presented in Table 10.2.6.

Summary of concrete classification				
Soil type	Disturbed ground?	Consider TPS?	DS class	ACEC class
Made Ground	Y	N	DS-1	AC-1
River Terrace	N	N	DS-1	AC-1
Chalk	N	N	DS-1	AC-1
Groundwater samples	N	N	DS-1	AC-1
Table 10.2.6.1				

10.2.6.2 It should be noted that the Ashdown report determined soils to be DS-1 and AC1s based on the assumption that concrete would not be in contact with groundwater. As groundwater was encountered during this investigation and as soils are relatively permeable, it is considered possible that concrete could be in contact with groundwater. This is particularly likely if piled foundations are adopted. On this basis, we recommend the above classifications are adopted in preference to the DS-1/AC1s class given in the Ashdown report.

10.3 Concrete - Chloride attack

10.3.1 Hazards

10.3.1.1 There are a number of ways in which chlorides can react with hydrated cement compounds in concrete. These are as follows:

- Chlorides react with calcium hydroxide in the cement binder to form soluble calcium chloride. This reaction increases the permeability of the concrete reducing its durability.
- Calcium and magnesium chlorides can react with calcium aluminate hydrates to form chloroaluminates which result in low to medium expansion of the concrete.
- If concrete is subject to wetting and drying cycles caused by groundwater fluctuations, salt crystallisation can form in concrete pores. If pressure produced by crystal growth is greater than the tensile strength of the concrete, the concrete will crack and eventually disintegrate.

10.3.2 Risk assessment

10.3.2.1 Chlorides of sodium, potassium, and calcium are generally regarded as being non-aggressive towards mass concrete; indeed, brine containers used in salt mines have been known to be serviceable after 20 years service. Depending upon the type of concrete, and the cement used up to 0.4% chloride is allowed in BS8110: Part 1.

10.3.2.2 In view of the past use of the site we consider the likelihood of elevated concentrations of chlorides in the ground to be low and on this basis have not specifically measured concentrations of chlorides.

10.4 Concrete - Acid attack

10.4.1 Hazards

10.4.1.1 Concrete being an alkaline material is vulnerable to attack by acids. Prolonged exposure of concrete structures to acidic solutions can result in complete disintegration.

10.4.2 Risk assessment

10.4.2.1 The rate of acid attack on concrete depends upon the following:

- The type of acid
- The acid concentration (pH)
- The composition of the concrete (cement/aggregate)
- The soil permeability
- Groundwater movement

10.4.2.2 British Standard BS8110: Part 1 classifies extreme environment as one where concrete is exposed to flowing groundwater that has a pH<4.5. The standard also warns that Portland Cement is not suitable for acidic conditions with a pH of 5.5 or lower.

10.4.2.3 The pH of the soil/groundwater was measured exceeding 5.5 and on this basis the risk of concrete being affected by acidic conditions is considered low.

10.5 Concrete - Magnesium attack

10.5.1 Hazards

10.5.1.1 Magnesium salts (excepting magnesium hydrogen carbonate) are destructive to concrete. Corrosion of concrete occurs from cation exchange reactions where calcium in the cement paste hydrates and is replaced with magnesium. The cement loses binding power and eventually the concrete disintegrates.

10.5.2 Risk assessment

- 10.5.2.1 In practise 'high' concentrations of magnesium will be found in the UK only in ground having industrial residues. Following BRE Special Digest 1:2005, measurement of the concentration of magnesium is recommended if sulphate concentrations in water extract or groundwater exceed 3000mg/l. Once measured the concentration of magnesium is considered further in BRE Special Digest in establishing the concrete mix to resist chemical attack.
- 10.5.2.2 We are not aware the site has been subject to any manufacturing processes which would have included magnesium containing compounds, and in addition sulphate concentrations did not exceed 3000mg/l. On this basis we have not measured the concentration of magnesium in soils at the site and would consider the risk of soils at the site promoting attack on concrete is considered low.
- 10.5.2.3 BS EN 206-1:2000 '*Concrete - Part 1: Specification, performance, production and conformity*' does, however, provide exposure classes for concrete in contact with water, with varying concentrations of magnesium for the design/specification for concrete mixes. As there is a possibility that concrete for the building may be in contact with groundwater during its life, then we have measured the concentration of magnesium in groundwater samples.
- 10.5.2.4 We have measured the concentration of magnesium in groundwater samples at the site which produced a result of 26.3mg/l. This result is less than 300mg/l and thus magnesium in groundwater is not considered to present a risk to buried concrete.

10.6 Concrete - Ammonium attack

10.6.1 Hazards

- 10.6.1.1 Ammonium salts, like magnesium salts act as weak acids and attack hardened concrete paste resulting in softening and gradual decrease in strength of the concrete.

10.6.2 Risk assessment

- 10.6.2.1 UK guidance is not available on the concentration of ammonium which may affect concrete. BS EN 206-1: 2000 '*Concrete - Part 1: Specification, performance, production and conformity*' does, however, provide exposure classes for concrete in contact with water with varying concentrations of ammonia for the design/specification for concrete mixes.
- 10.6.2.2 We have measured the concentration of ammonia in a groundwater sample at the site, and there is a potential possibility that concrete for the building may be in contact with groundwater during its life. The concentration of ammonia was 0.193mg/l. This result is below 15mg/l and thus ammonia in groundwater is unlikely to present a risk to buried concrete.

10.7 Plastic Pipes

10.7.1 Hazards

10.7.1.1 Plastic pipes are predominantly manufactured from PVC and PE but other materials can be used. In general, they perform well but it is known that chemical attack and permeation of contaminants through the pipes can result from use in contaminated land. A published review on plastic pipes reports the following:

- Polyethylene (PE) - good resistance to solvents, acids and alkalis
- Poly vinyl chloride (PVC) - most common form of pipe. Good general resistance to chemical attack but can be attacked by solvents such as ketones, chlorinated hydrocarbons and aromatics.
- Polypropylene (PP) - chemically resistant to acids, alkalis and organic solvents but not recommended for use with strong oxidising acids, chlorinated hydrocarbons and aromatics.
- Poly vinylidene fluoride (PVDF) - inert to most solvents, acids and alkalis as well as chlorine, bromine and other halogens
- Polytetrafluoroethylene (PTFE) - one of the most inert thermoplastics available. PTFE has good chemical resistance to solvents, acids and alkalis

10.7.1.2 A survey carried out by the Water Research Centre (WRC) on reported incidents of permeation (more than 25), only two involved PVC with these incidents relating to spillages of fuel.

10.7.2 Assessment

10.7.2.1 A survey carried out by the Water Research Centre (WRC) on reported incidents of permeation (more than 25), only two involved PVC with these incidents relating to spillages of fuel.

10.7.2.2 The UK Water Industry research (UKWIR) have published a document entitled 'Guidance for the selection of Water supply pipes to be used in Brownfield sites'. The publication defines brownfield sites as

'Land or premises that have been used or developed. They may also be vacant, or derelict. However, they are not necessarily contaminated'

10.7.2.3 The subject site has previously been developed and on this basis could potentially be considered brownfield in accordance with the UKWIR document.

- 10.7.2.4 Whilst we have not carried out a full investigation set out in guidance in the UKWIR document, the subject site does exhibit a degree of localised hydrocarbon (PAH) contamination. The UKWIR document advises a trigger concentration of 0.125mg/kg for their 'extended VOC (Volatile Organic Carbons) suite' which includes the PAH suite which we have results for. The measured concentration of individual contaminants forming part of the PAH suite exceeds the trigger value of 0.125mg/kg and, on this basis, it is considered likely that barrier pipes will have to be installed at this site where they are in contact with Made Ground. There is also a possibility of some localised hydrocarbon contamination beneath the existing facilities maintenance area, which may need further consideration. We recommend Southern Water Services is consulted on this to gain their opinion and requirements.

11 Landfill issues

- 11.1.1 An assessment of the landfill classification of materials on site has been undertaken by Ashdown Site Investigation Limited in their report referenced R18-13236.
- 11.1.2 Further assessment is considered outside of our brief. However, it should be noted that we have identified a further sample that contains asbestos fibres. Depending on the quantity of asbestos fibres present, soils containing asbestos can be considered hazardous waste (if fibre concentrations are >0.1%).
- 11.1.3 Asbestos does not seem to be prevalent across the site, with only two samples identified as containing fibres. Both of these are located close to the existing facilities maintenance building and therefore it is likely contamination is localised. Soils in this area may require separating from soils elsewhere and additional asbestos testing and quantification undertaken to refine the classification.
- 11.1.4 In addition, any hydrocarbon impacted soils identified following demolition of the facilities maintenance compound will require a separate classification.

12 Further investigations

12.1 Further investigations

12.1 We have provided a comprehensive investigation to supplement the previous investigation by Ashdowns. We recommend the following further investigations are carried out prior to construction commencing:

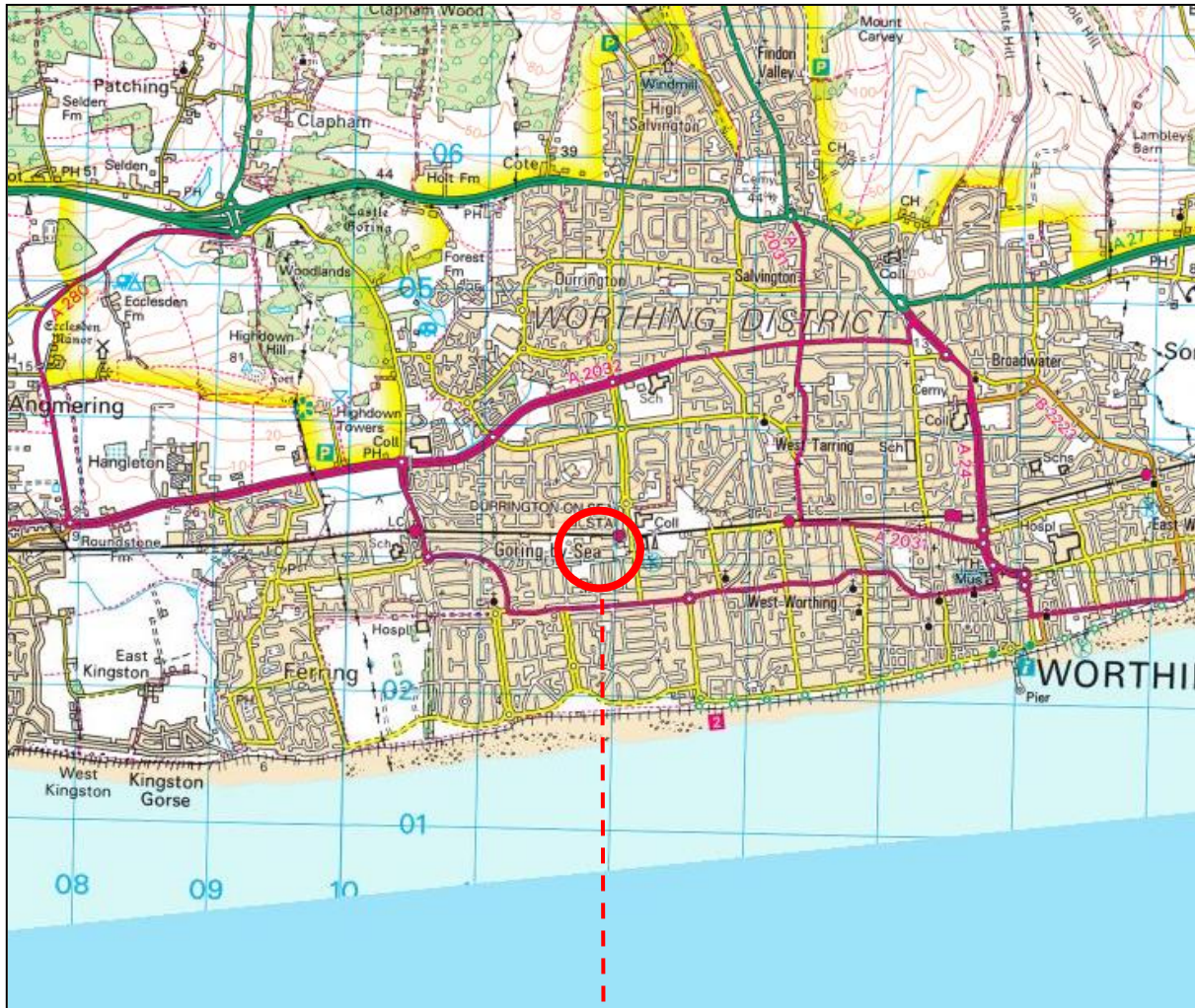
1. Following demolition and removal of existing buildings, further investigations, sampling and testing are recommended within the area of the facilities maintenance area (including beneath tanks) to determine whether any localised contamination is present. Investigations should be deep enough to allow for groundwater samples to be collected for testing.
2. A watching brief should also be kept during removal of the interceptor tanks, the maintenance facility and sub-stations with some additional testing undertaken to confirm or otherwise the absence of associated contamination.
3. Further testing may be required around WS04 (hotspot of arsenic) once the proposed layout is confirmed if this area is to be located within a particularly sensitive location such as a private garden.
4. Further testing and sampling of soils around WS105 should be undertaken to determine the extent of the contamination, with excavation and removal of Made Ground soils in this area recommended.
5. Further deep borehole excavated following clearance of the western part of the site to allow for groundwater sampling to be undertaken to confirm or otherwise the absence of contamination associated with the former gas holder.
6. Laboratory testing and validation of capping material and thickness will be required during the construction phase. As previously stated, this could comprise a subsoil of site won natural (River Terrace) soils underlying a covering of imported Topsoil. Further validation may be required if localised contamination is identified that needs either removal or treatment.

12.2 We would be pleased to carry out any of the supplementary investigations described above and provide proposals with costings on further instructions.

Barrington Road, Worthing
ST5226

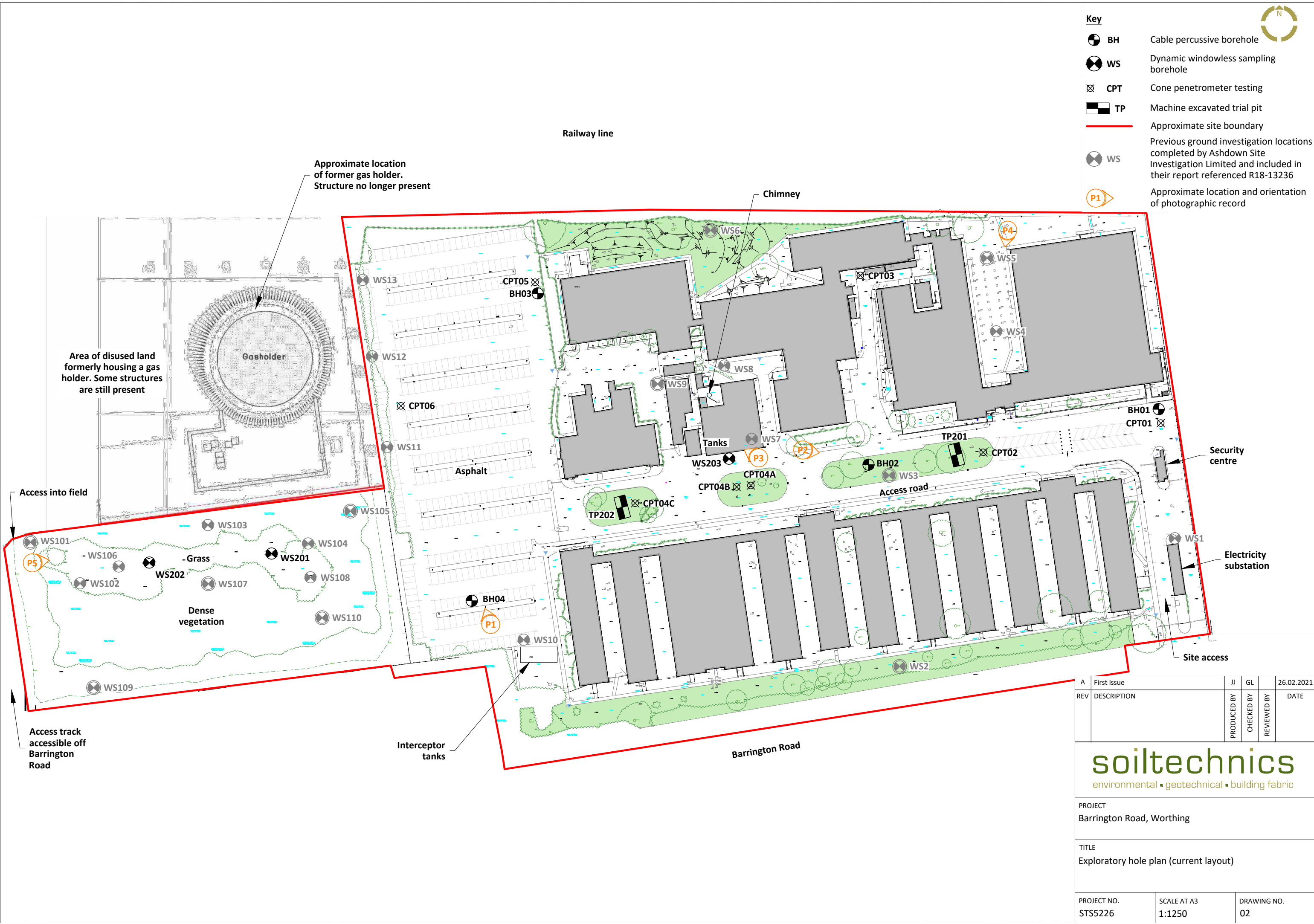
soiltechnics

environmental • geotechnical • building fabric

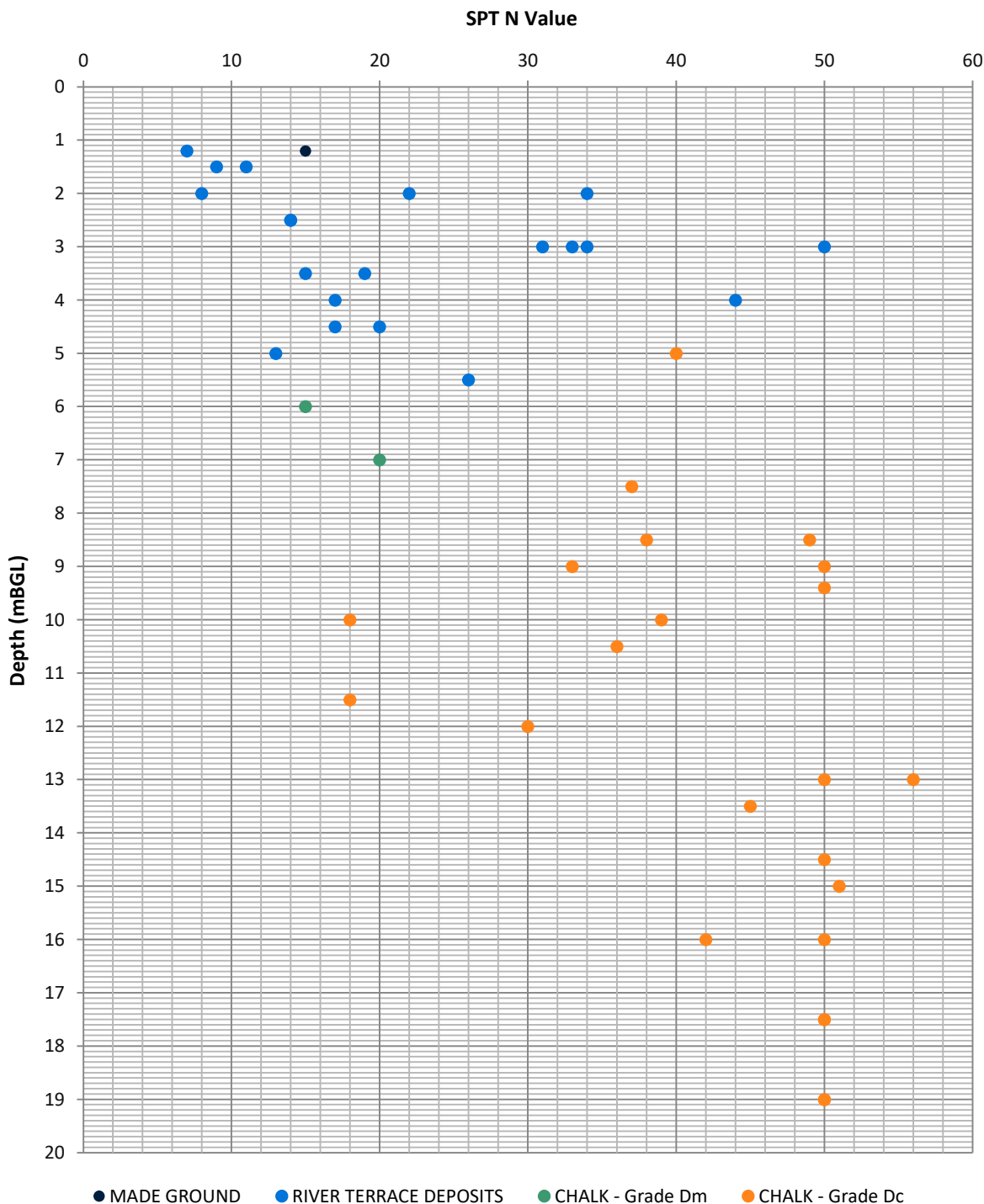


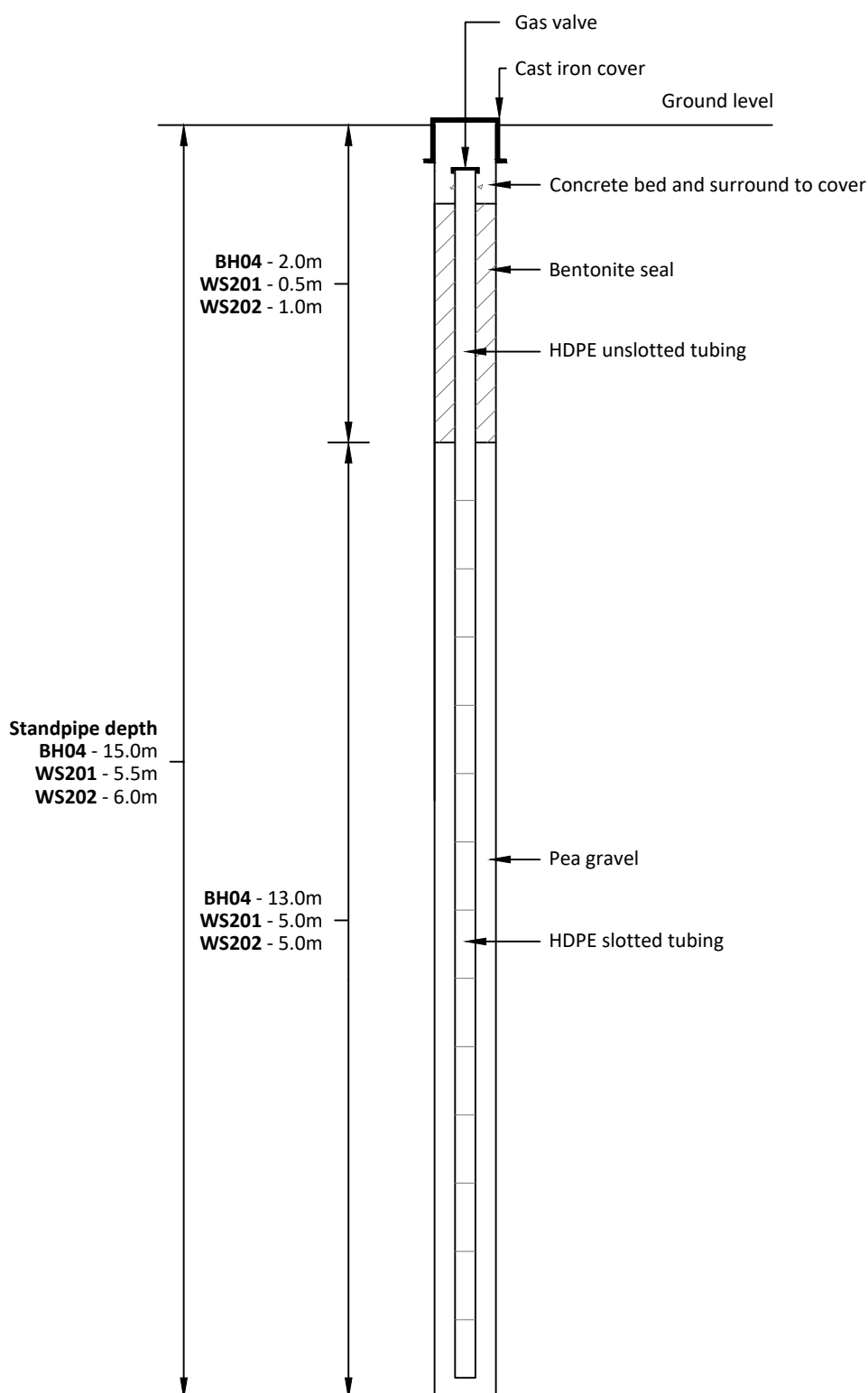
Site location

Title	Scale	Drawing number
Site location plan	Not to scale	01



Plot summarising Standard Penetration Test (SPT) results versus depth filtered by geology





Title

Section showing construction of combined water & gas monitoring standpipes installed in boreholes WS201, WS202 and BH04

Scale

Not to scale

Drawing number

04

Definition of geotechnical terms used in this report - foundations

Strip foundations.

A foundation providing a continuous longitudinal ground bearing.

Trench fill concrete foundation.

A trench filled with mass concrete providing continuous longitudinal ground bearing.

Pad foundation.

An isolated foundation to spread a concentrated load.

Raft foundation.

A foundation continuous in two directions, usually covering an area equal to or greater than the base area of the structure.

Substructure.

That part of any structure (including building, road, runway or earthwork) which is below natural or artificial ground level. In a bridge this includes piers and abutments (and wing walls), whether below ground level or not, which support the superstructure.

Piled foundations and end bearing piles. A pile driven or formed in the ground for transmitting the weight of a structure to the soil by the resistance developed at the pile point or base and the friction along its surface. If the pile supports the load mainly by the resistance developed at its point or base, it is referred to as an end-bearing pile; if mainly by friction along its surface, as a friction pile.

Bored cast in place pile.

A pile formed with or without a casing by excavating or boring a hole in the ground and subsequently filling it with plain or reinforced concrete.

Driven pile.

A pile driven into the ground by the blows of a hammer or a vibrator.

Precast pile.

A reinforced or pre-stressed concrete pile cast before driving.

Driven cast in place pile.

A pile installed by driving a permanent or temporary casing, and filling the hole so formed with plain or reinforced concrete.

Displacement piles.

Piled formed by displacement of the soil or ground through which they are driven.

Skin friction.

The frictional resistance of the surrounding soil on the surface of cofferdam or caisson walls, and pile shafts.

Downdrag or negative skin friction. A downwards frictional force applied to the shaft of a pile caused by the consolidation of compressible strata, e.g. under recently placed fill. Downdrag has the effect of adding load to the pile and reducing the factor of safety.

Definition of geotechnical terms used in this report – bearing values

To Eurocode 7

Formal definitions of Eurocode terms are provided in BS EN 1990:2002 '*Eurocode – Basis of Structural Design*'. The following are considered informal definitions relating to the context of the geotechnical design report.

Bearing resistance

Calculated ability of a foundation to resist applied actions considered for ultimate and serviceability limit states.

Ultimate limit state (ULS) considerations

Partial factors applied to soil parameters, and actions (applied loads) in bearing resistance calculations to avoid risk of failure of the foundation in bearing.

Serviceability limit state (SLS) considerations

Calculations to determine bearing resistance of a foundation which will generate acceptable levels of settlement under applied actions

Characteristic geotechnical parameters

These are based on results and derived values from laboratory field tests, complemented by well-established experience.

Pre-Eurocode 7 methods.

Ultimate bearing capacity.

The value of the gross loading intensity for a particular foundation at which the resistance of the soil to displacement of the foundation is fully mobilised.

Presumed bearing value.

The net loading intensity considered appropriate to the particular type of ground for preliminary design purposes. The particular value is based on calculation from shear strength tests or other field tests incorporating a factor of safety against shear failure.

Allowable bearing pressure.

The maximum allowable net loading intensity at the base of the foundation, taking into account the ultimate bearing capacity, the amount and kind of settlement expected and our estimate of ability of the structure to accommodate this settlement.

Factor of safety.

The ratio of the ultimate bearing capacity to the intensity of the applied bearing pressure or the ratio of the ultimate load to the applied load.

Definition of geotechnical terms used in this report – road pavements

The following definitions are based on Transport and Road Research Laboratory (TRRL) Report LR1132.

Equilibrium CBR values.

A prediction of the CBR value, which will be attained at formation level under the completed pavement.

Thin pavement.

A thin pavement (which includes both bound and unbound pavement construction materials) is 300mm thick (very lightly trafficked road) and a thick pavement is 1200mm thick (typical of motorway construction).

Definition of geo-environmental terms used in this report

Conceptual model

Textual and/or schematic hypothesis of the nature and sources of contamination, potential migration pathways (including description of the ground and groundwater) and potential receptors, developed on the basis of the information obtained from the investigatory process.

Contamination

Presence of a substance which is in, on or under land, and which has the potential to cause harm or to cause pollution of controlled water.

Controlled water

Inland freshwater (any lake, pond or watercourse above the freshwater limit), water contained in underground strata and any coastal water between the limit of highest tide or the freshwater line to the three mile limit of territorial waters.

Harm

Adverse effect on the health of living organisms, or other interference with ecological systems of which they form part, and, in the case of humans, including property.

Pathway

Mechanism or route by which a contaminant comes into contact with, or otherwise affects, a receptor.

Receptor

Persons, living organisms, ecological systems, controlled waters, atmosphere, structures and utilities that could be adversely affected by the contaminant(s).

Risk

Probability of the occurrence of, and magnitude of the consequences of, an unwanted adverse effect on a receptor.

Risk assessment

Process of establishing, to the extent possible, the existence, nature and significance of risk.

Definition of environmental risk/hazard terms used in this report

Based on CIRIA report C552 '*Contaminated land risk assessment – A guide to good practice*'.

Potential hazard severity definition

Category	Definition
Severe	Acute risks to human health, catastrophic damage to buildings/property, major pollution of controlled waters
Medium	Chronic risk to human health, pollution of sensitive controlled waters, significant effects on sensitive ecosystems or species, significant damage to buildings or structures
Mild	Pollution of non-sensitive waters, minor damage to buildings or structures
Minor	Requirement for protective equipment during site works to mitigate health effects, damage to non-sensitive ecosystems or species

Probability of risk definition

Category	Definition
High likelihood	Pollutant linkage may be present, and risk is almost certain to occur in long term, or there is evidence of harm to the receptor
Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term
Low likelihood	Pollutant linkage may be present, and there is a possibility of the risk occurring, although there is no certainty that it will do so
Unlikely	Pollutant linkage may be present, but the circumstances under which harm would occur are improbable

Level of risk for potential hazard definition

Probability of risk	Potential severity			
	Severe	Medium	Mild	Minor
High likelihood	Very high	High	Moderate	Low/Moderate
Likely	High	Moderate	Low/Moderate	Low
Low likelihood	Moderate	Low/Moderate	Low	Very low
Unlikely	Low/Moderate	Low	Very low	Very low

See below for definitions of 'very high' to 'very low'

Definition of environmental risk/hazard terms used in this report

Based on CIRIA report C552 '*Contaminated land risk assessment – A guide to good practice*'.

Risk classifications and likely action required:

Very high risk

High probability that severe harm could arise to a designated receptor from an identified hazard OR there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised is likely to result in substantial liability. Urgent investigation and remediation are likely to be required.

High risk

Harm is likely to arise to a designated receptor from an identified hazard. This risk, if realised, is likely to result in substantial liability. Urgent investigation is required and remedial works may be necessary in the short term and are likely over the long term.

Moderate risk

It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is likely that the harm would be relatively mild. Investigation is normally required to clarify risks and to determine potential liability. Some remedial works may be required in the long term.

Low risk

It is possible that harm could arise to a designated receptor from an identified hazard but it is likely that this harm, if realised, would at worst normally be mild.

Very low risk

It is a low possibility that harm could arise to a designated receptor. On the event of such harm being realised it is not likely to be severe.

List of documents used in assessment of chemical contamination

No.	Title	Publication reference / publisher
1	Human health toxicological assessment of contaminants in soil	EA Science Report – SC050021/SR2
2	Updated technical background to the CLEA model	EA Science Report – SC050021/SR3
3	CLEA Software (Version 1.03 beta) Handbook	EA Science Report - SC050021/SR4
4	Guidance on comparing Soil Contamination Data with a Critical Concentration	CIEH
5	The LQM/CIEH S4ULs for Human Health Risk Assessment (2015)	LQM/CIEH
6	Assessment of Risks to Human Health from Land Contamination: An overview of the development of soil guideline values and related research	R&D Publication, Contaminated Land Report CLR 7
7	Contaminants of Soil: Collation of Toxicological Data and Intake Values for Humans	R&D Publication, Contaminated Land Report CLR 9
8	The Contaminated Land Exposure Assessment Model (CLEA): Technical Basis and Algorithms	R&D Publication, Contaminated Land Report CLR 10
9	Model Procedures for the Management of Land Contamination	R&D Publication, Contaminated Land Report CLR 11
10	Contaminants in Soil: Collection of Toxicological Data and Intake Values for Human Values	R&D Publications, Tox. 6
11	Soil Guideline Values for Contamination (2002)	R&D Publications, SGV 10
12	Soil Guideline Values (2009)	EA Science Reports – SC050021
13	Atkins ATRISK ^{SOIL} (2011)	http://www.atrisksoil.co.uk
14	Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination (September 2014)	CL:AIRE

CIEH	Chartered institute of Environmental Health
LQM	Land Quality Management
EA	Environment Agency
CL:AIRE	Contaminated Land: Applications in Real Environments

Testing suite summary

Table summarising testing suites		
Suite	Parameters	Medium
Suite 1	Arsenic, beryllium, boron, cadmium, chromium (total and VI), copper, lead, mercury, nickel, selenium, vanadium zinc, cyanide (free, total and complex), organic matter content, PAH (16 speciated), pH, phenol (total), TOC	Soil
Suite 2	Arsenic, boron (water soluble), beryllium, cadmium, chromium (total), copper, lead, mercury, nickel, selenium, vanadium, zinc, cyanide (free, total and complex, PAH (16 speciated), pH, phenol (total), sulfate (water soluble), sulfide, nitrate	Leachate
Suite 3	Arsenic, boron (water soluble), beryllium, cadmium, chromium (total), copper, lead, mercury, nickel, selenium, vanadium, zinc, cyanide (free, total and complex, PAH (16 speciated), pH, phenol (total), sulfate (water soluble), sulfide, nitrate	Water
Suite 4	TPH Texas Banding Aliphatic/Aromatic Split, BTEX, MTBE, PAH (16 speciated), organic matter	Soil
Suite 5	TPH Texas Banding Aliphatic/Aromatic Split, BTEX, MTBE, PAH (16 speciated)	Leachate
Suite 6	TPH Texas Banding Aliphatic/Aromatic Split, BTEX, MTBE, PAH (16 speciated)	Water
Suite 7	TPH Texas Banding Aliphatic/Aromatic Split, BTEX, TOC, organic matter	Soil
Suite 8	Sulphur (total), sulphate (water and acid soluble), pH	Soil
Suite 9	Sulphate, ammoniacal nitrogen, dissolved magnesium, pH	Water
Suite 10	VOC, SVOC, TOC, organic matter	Soil
Suite 11	VOC, SVOC	Leachate
Suite 12	VOC, SVOC	Water
Suite 13	Organotins dibutyltin/ tributyl-tin/tetrabutyltin/triphenyl-tin, tetraethyl-lead/tetramethyl-lead	Soil
Suite 14	Organotin	Leachate
Suite 15	Organotin	Water
Suite 16	TPH Texas Banding Aliphatic/Aromatic Split, BTEX, VOC, SVOC	Soil, water, leachate
Suite 17	TPH Texas Banding Aliphatic/Aromatic Split, BTEX, SVOC, VOC, arsenic, boron (water soluble), beryllium, cadmium, chromium (total), copper, lead, mercury, nickel, selenium, vanadium, zinc, cyanide (free, total and complex, pH, phenol (total), sulfate (water soluble), sulfide, nitrate	Soil, water, leachate
Concrete BRE suite	pH, sulphate (water and acid soluble), magnesium (water soluble), ammonia (water soluble), chloride, nitrate	Soil

Table summarising Standard Penetration Test (SPT) results

Location	Start Depth (m)	Penetration (mm)					
		Seating 1-2	Main 1-4	Total Seating	Total Main	Total Seating	Total Main
BH01	1.20	1/1	1/2/2/2	2	7	150	300
BH01	2.00	1/1	2/2/2/2	2	8	150	300
BH01	4.00	2/3	3/4/4/6	5	17	150	300
BH01	5.00	2/3	4/5/3/1	5	13	150	300
BH01	6.00	2/2	2/4/6/3	4	15	150	300
BH01	8.50	3/5	8/11/10/9	8	38	150	300
BH01	10.00	3/5	5/5/4/4	8	18	150	300
BH01	11.50	3/3	3/3/5/7	6	18	150	300
BH01	13.00	5/8	12/17/16/5	13	50	150	240
BH01	14.50	7/14	19/16/15/0	21	50	150	225
BH01	16.00	4/21	50	25	50	150	0
BH01	17.50	5/20	50	25	50	135	0
BH01	19.00	8/17	50	25	50	125	65
BH02	1.20	1/2	4/4/3/4	3	15	150	300
BH02	2.00	2/4	5/7/10/12	6	34	150	300
BH02	3.00	1/0	2/7/10/14	1	33	150	300
BH02	5.00	7/8	8/10/11/11	15	40	150	300
BH02	7.50	7/11	10/9/9/9	18	37	150	300
BH02	9.00	5/15	23/17/10	20	50	150	180
BH02	9.40	25/25	50	50	50	25	0
BH03	1.50	1/2	2/3/3/3	3	11	150	300
BH03	2.50	2/2	3/3/4/4	4	14	150	300
BH03	3.50	2/3	4/4/5/6	5	19	150	300
BH03	4.50	3/4	4/5/5/6	7	20	150	300
BH03	7.00	4/5	5/5/5/5	9	20	150	300
BH03	9.00	4/5	6/8/9/10	9	33	150	300
BH03	10.50	4/7	8/8/10/10	11	36	150	300
BH03	12.00	3/3	5/5/9/11	6	30	150	300
BH03	13.50	5/7	8/11/12/14	12	45	150	300
BH03	15.00	5/8	16/17/18	13	51	150	225
BH04	1.50	1/1	2/2/2/3	2	9	150	300
BH04	2.50	2/2	3/4/3/4	4	14	150	300
BH04	3.50	1/2	3/4/4/4	3	15	150	300
BH04	4.50	2/2	3/4/4/6	4	17	150	300
BH04	5.50	3/4	5/6/7/8	7	26	150	300
BH04	8.50	4/7	9/10/14/16	11	49	150	300
BH04	10.00	4/5	7/8/10/14	9	39	150	300
BH04	13.00	5/6	7/14/16/19	11	56	150	300

Table summarising Standard Penetration Test (SPT) results

Location	Start Depth (m)	Penetration (mm)					
		Seating 1-2	Main 1-4	Total Seating	Total Main	Total Seating	Total Main
BH04	16.00	3/8	9/10/11/12	11	42	150	300
BH04	17.50	6/19	41/9	25	50	150	90
BH04	19.00	8/17	50	25	50	120	70
WS201	2.00	4/4	5/6/5/6	8	22	150	300
WS201	3.00	6/6	7/7/9/11	12	34	150	300
WS202	3.00	5/10	8/7/6/10	15	31	150	300
WS202	4.00	8/10	10/12/11/11	18	44	150	300
WS203	3.00	10/13	17/25/8	23	50	150	160

Table summarising Pocket Penetrometer results

* Signifies that instrument limit reached.

Location	Start Depth (m)	Results 1-3	Average	Undrained Shear Strength (kN/m ²)
BH01	0.80	1.5/1.5/1.5	1.50	75
BH01	1.20	1.5/1.25/2	1.58	79
BH01	3.50	1.25/1.25/1.25	1.25	63
BH02	4.00	0.5/0.5/0.5	0.50	25
BH02	4.50	1.5/1.25/1.5	1.42	71
BH03	1.50	1/1.25/1.25	1.17	58
BH03	2.50	1.25/1.25/1.25	1.25	63
BH03	3.50	0.5/0.5/0.5	0.50	25
BH03	5.00	0.75/1/1	0.92	46
BH03	6.00	1.5/1.5/1.5	1.50	75
BH04	0.40	1.25/1/1.25	1.17	58
BH04	1.00	1.5/2/1.5	1.67	83
CPT05	0.50	2.5/2.5/2	2.33	117
CPT05	0.80	2.25/2.25/2.25	2.25	113
TP201	1.00	2.25/2.25/2.5	2.33	117
TP201	1.60	2/1.5/1.5	1.67	83
TP202	1.20	1.25/1.25/1.5	1.33	67
TP202	1.60	0.75/0.75/0.75	0.75	38
WS202	1.30	2/2/1.5	1.83	92
WS202	1.50	1.25/1.25/1.25	1.25	63
WS202	1.70	1/1/1.5	1.17	58
WS202	1.90	1.25/1.25/1	1.17	58
WS202	2.10	1/1/0.75	0.92	46
WS202	2.30	1/1/1	1.00	50
WS202	2.50	1.75/1.5/1.5	1.58	79
WS202	2.70	1.25/1.25/1.25	1.25	63
WS202	5.40	2.5/2.5/2.25	2.42	121
WS202	5.60	2.5/2.5/2.75	2.58	129
WS203	1.20	1.25/2/1.25	1.50	75

Key to legends

Composite materials, soils and lithology					
	Topsoil		Made Ground		Boulders
	Clay		Coal		Cobbles
	Gravel		Limestone		Mudstone
	Sand		Sandstone		Silt
					Siltstone
					Peat
					Concrete
					Chalk

Note: Composite soil types are signified by combined symbols.

Key to 'test results' and 'sampling' columns

Test result		Sampling	
Depth	Records depth that the test was carried out (i.e.: at 2.10m or between 2.10m and 2.55m)	From (m) To (m)	Records depth of sampling
	PP – Pocket penetrometer result reported as an equivalent undrained shear strength (kN/m ²) by applying a factor of 50.		D Disturbed sample
			B Bulk disturbed sample
			ES Environmental sample
Result	SV – Hand held shear vane result reported as an undrained shear strength (kN/m ²). Where multiple readings are taken at the same level the average value is shown on the log. * Signifies that instrument limit reached.	Type	W Water sample
			U Undisturbed thick-walled sample 100mm diameter sampler
			UT Undisturbed thin walled sample 100mm diameter sampler
			UTF Failed undisturbed sample

Water observations

Described at foot of log and shown in the 'water strike' column.

▼ Water level observed after specified delay in drilling

∇ Water strike

Density

Density recorded in brackets determined by qualitative field assessment or inferred from density testing and soil descriptions from across the site (i.e.: [Medium dense]).

STRATA				WATER STRIKES	IN SITU TESTING		SAMPLING		
DESCRIPTION	DEPTH (m)	REDUCED LVL (m OD)	LEGEND		TYPE / DEPTH (m)	RESULT	FROM (m)	TO (m)	TYPE
Grass onto dark brown slightly gravelly very sandy CLAY with some cobbles of flint and frequent rootlets and roots to 20mm in diameter. Gravel of subrounded to subangular flint. (TOPSOIL)									
Medium dense orangish brown gravelly fine to coarse SAND. Gravel of subangular to subrounded flint and brick. (MADE GROUND)	0.25						0.20		ES
...at 0.35m depth, material membrane and concrete edge (possibly former footing) on north western corner of trial pit.	0.35						0.30		ES
Firm brown slightly sandy slightly gravelly CLAY with some roots to 30mm in diameter. Gravel of bitumonous coated material, brick, flint, clay pipe, chalk, ash and clinker. (MADE GROUND)							0.50		ES
Firm to stiff orangish brown and pale yellow brown friable slightly gravelly sandy CLAY. Gravel of rounded to angular flint and chalk. (RIVER TERRACE DEPOSITS)	0.95				PP 1.00	PP=117	1.00		D
...between 1.5m and 1.8m depth, cobble and boulder sized pockets of pale orangish brown sand.					PP 1.60	PP=83			
Medium dense pale orangish brown slightly gravelly fine to medium SAND with occasional cobble of subrounded flint. Gravel of subangular to subrounded flint. (RIVER TERRACE DEPOSITS)	1.80						1.90		D
...from 2m depth, becoming pale grey and cream in colour.							2.40		D
TRIAL PIT TERMINATED AT 3.00m	3.00								

Notes Collapse of trial pit sides from 2m to 3m depth widening trial pit by 0.15m each side. UXO Specialist in attendance.	Title Trial pit record	Dimensions (w x l) 0.40m x 2.20m	Date(s) 21/01/2021
	Method Machine excavator	Logged by GL	Sheet number Sheet 1 of 1
Groundwater observations No groundwater encountered.	Level (m OD) -	Compiled by GL	Revision
	Co-ordinates -	Checked by KB	TP201

STRATA				WATER STRIKES	IN SITU TESTING		SAMPLING		
DESCRIPTION	DEPTH (m)	REDUCED LVL (m OD)	LEGEND		TYPE / DEPTH (m)	RESULT	FROM (m)	TO (m)	TYPE
Grass onto dark brown slightly gravelly very sandy CLAY with some cobbles of flint and frequent rootlets and roots to 20mm in diameter. Gravel of subrounded to subangular flint. (TOPSOIL)	0.25						0.10		ES
Medium dense brown and orangish brown gravelly very clayey fine to coarse SAND with some cobbles of brick and pieces of plastic, wire and carpet. Gravel of flint, brick, concrete and chalk. (MADE GROUND)							0.40		ES
...at 0.65m depth, concrete strip (possible former footing) 1.3m wide on southern half of pit. Trial pit moved north to avoid.									
...at 0.9m depth, boulder sized pocket of dark grey gravels of bituminous coated material.									
Firm orangish brown slightly gravelly CLAY. Gravel of subrounded to subangular flint. (RIVER TERRACE DEPOSITS)	1.20				PP 1.20	PP=67	1.20		D
...from 1.5m depth, becoming sandy.					PP 1.60	PP=38			
Greyish brown and creamish grey gravelly clayey fine to coarse SAND with some cobbles of subrounded to subangular flint. Gravel of flint. (RIVER TERRACE DEPOSITS)	1.95						2.00		D
...from 2.7m depth, becoming pale grey and cream in colour.									
TRIAL PIT TERMINATED AT 3.00m	3.00						2.90		D

Notes Collapse of trial pit sides from 2.1m to 3m depth widening trial pit by 0.1m each side. UXO Specialist in attendance.	Title Trial pit record	Dimensions (w x l) 0.40m x 4.00m	Date(s) 21/01/2021
	Method Machine excavator	Logged by GL	Sheet number Sheet 1 of 1
Groundwater observations No groundwater encountered.	Level (m OD) -	Compiled by GL	Revision
	Co-ordinates -	Checked by KB	TP202

STRATA				WATER STRIKES	IN SITU TESTING		SAMPLING		
DESCRIPTION	DEPTH (m)	REDUCED LVL (m OD)	LEGEND		TYPE / DEPTH (m)	RESULT	FROM (m)	TO (m)	TYPE
ASPHALT (MADE GROUND)	0.10						0.30		ES
Light grey reinforced CONCRETE with aggregates of flint up to 20mm in size. Reinforcement bar at 0.2m depth. (CONCRETE)	0.25								
Medium dense greyish brown gravelly slightly clayey fine to coarse SAND. Gravel of subangular to angular flint, brick, bituminous coated material and concrete. (MADE GROUND)	0.45								
Firm dark grey slightly sandy gravelly CLAY. Gravel of subangular to angular flint, ash, bituminous coated material and concrete. (MADE GROUND)	0.65								
Firm orangish brown slightly sandy CLAY. (RIVER TERRACE DEPOSITS)	0.75								
TRIAL PIT TERMINATED AT 0.75m									

STRATA				WATER STRIKES	IN SITU TESTING		SAMPLING		
DESCRIPTION	DEPTH (m)	REDUCED LVL (m OD)	LEGEND		TYPE / DEPTH (m)	RESULT	FROM (m)	TO (m)	TYPE
Grass onto firm dark brown slightly gravelly CLAY with some rootlets. Gravel of flint, brick, chalk and occasional clinker. (MADE GROUND)	0.25 0.35						0.10		ES
Medium dense orangish brown slightly gravelly fine to coarse SAND. Gravel of sandstone, flint and chalk. (MADE GROUND)									
Firm brown slightly sandy slightly gravelly CLAY. Gravel of chalk, flint, brick and occasioal clinker and ash. (MADE GROUND)									
...at 0.8m depth, clay pipe on eastern side of pit. Approximately 100mm in diameter.									
Medium dense orangish brown gravelly very clayey fine to coarse SAND. Gravel of subrounded to subangular flint. (RIVER TERRACE DEPOSITS)	0.95						1.00	1.10	D
TRIAL PIT TERMINATED AT 1.20m	1.20								

Notes Trial pit sides remained upright and stable upon completion. UXO Specialist in attendance.	Title Trial pit record	Dimensions (w x l) 0.30m x 0.30m	Date(s) 18/01/2021
	Method Hand tools	Logged by GL	Sheet number Sheet 1 of 1
Groundwater observations No groundwater encountered.	Level (m OD) -	Compiled by GL	Revision
	Co-ordinates -	Checked by KB	CPT02

STRATA				WATER STRIKES	IN SITU TESTING		SAMPLING		
DESCRIPTION	DEPTH (m)	REDUCED LVL (m OD)	LEGEND		TYPE / DEPTH (m)	RESULT	FROM (m)	TO (m)	TYPE
ASPHALT (MADE GROUND)	0.15						0.20		ES
Medium dense light grey gravelly fine to coarse SAND. Gravel of subangular to angular flint, brick, igneous rock, bituminous coated material and slate. (MADE GROUND)									
...from 0.5m depth, becoming grey in colour.	0.60						0.55		ES
Medium dense to dense orangish brown gravelly fine to coarse SAND. Gravel of sandstone, brick, flint and bituminous coated material. (MADE GROUND)									
TRIAL PIT TERMINATED AT 1.20m	1.20								

Notes Trial pit sides remained upright and stable upon completion. UXO Specialist in attendance.	Title Trial pit record	Dimensions (w x l) 0.30m x 0.30m	Date(s) 18/01/2021
	Method Hand tools	Logged by GL	Sheet number Sheet 1 of 1
Groundwater observations No groundwater encountered.	Level (m OD) -	Compiled by GL	Revision
	Co-ordinates -	Checked by KB	CPT03

STRATA				WATER STRIKES	IN SITU TESTING		SAMPLING		
DESCRIPTION	DEPTH (m)	REDUCED LVL (m OD)	LEGEND		TYPE / DEPTH (m)	RESULT	FROM (m)	TO (m)	TYPE
Grass onto firm brown slightly sandy slightly gravelly CLAY. Gravel of flint, brick, pottery and clinker. (TOPSOIL - MADE GROUND) <i>...from 0.1m depth, becoming orangish brown in colour.</i>	0.50						0.10		D
TRIAL PIT TERMINATED AT 0.50m									

Notes Trial pit sides remained upright and stable upon completion. UXO Specialist in attendance. Terminated due to brickwork obstruction at 0.5m depth.	Title Trial pit record	Dimensions (w x l) 0.30m x 0.30m	Date(s) 18/01/2021
	Method Hand tools	Logged by GL	Sheet number Sheet 1 of 1
Groundwater observations No groundwater encountered.	Level (m OD) -	Compiled by GL	Revision
	Co-ordinates -	Checked by KB	CPT04A