soiltechnics

environmental and geotechnical consultants

Proposed redevelopment
Daedalus Park
Gosport
Hampshire

Ground Investigation Report

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GROUND INVESTIGATION REPORT

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RISQS RAILWAY INDUSTRY SUPPLIER QUALIFICATION SCHEME AUDITED

ACM Registered to: ISO 9001 ISO 14001 OHSAS 18001 UKAS MANAGEMENT SYSTEMS 245 OCCUPATIONAL HEALTH & SAFETY MANAGEMENT

Aerial photograph of site



Report status and format

Report section	Principal coverage	Report status	
		Revision	Comments
1	Executive summary		
2	Introduction		
3	Desk study information and site observations		
4	Fieldwork		
5	Ground conditions encountered		
6	Laboratory testing		
7	Engineering assessment		
8	Chemical contamination		
9	Gaseous contamination	1	Gas monitoring completed
10	Effects of ground conditions on building materials		
11	Classification of waste soils under the Waste Acceptance Criteria		
12	Further investigations		
13	Remediation statement		
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List of drawings

Drawing	Principal coverage	Status	
		Revision	Comments
01	Site location plan		
02	Plan showing existing site features and location of exploratory points		
03	Plot summarising insitu density testing		
04	Plot summarising results of pocket penetrometer determinations		
05	Section showing construction of combined water & gas monitoring standpipe installed in boreholes DTS01, DTS02, DTS03, DTS04 and DTS06.		

List of appendices

Appendix	Content
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B	Definitions of geo-environmental terms used in this report
C	Trial pit records
D	Borehole records (driven tube sampling)
E	Results of infiltration testing
F	Concrete core records
G	Copies of laboratory test result certificates – classification testing
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I	Analysis and summary of test data in relation to concentrations of chemical contaminants
J	Conceptual models for chemical contamination
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N	Landfill waste acceptance criteria – basic categorisation schedules
O	Copies of Statutory Undertakers replies
P	Copy of desk study information produced by Envirocheck

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 positioned on a flat coastal plain within the district of Lee-on-the-Solent, Gosport. At the time of the investigation, the site was disused and comprised two largely open grassed areas, albeit with some areas of hardstanding, divided north-south by a chain-link fence. An unoccupied single-storey building and associated bituminous bound car park was present to the south of the western site.

Inspection of historical maps indicate the site was agricultural fields until the 1940s, when it is recorded as part of the Royal Naval Air Station HMS Daedalus and a number of buildings are recorded across the site.

We understand the scheme will comprise the construction of commercial/industrial units with associated hardstandings.

Ground conditions encountered

Exploratory excavations encountered a similar profile of soils considered to be Topsoil/Made Ground overlying River Terrace deposits. The Made Ground extended to depths between 0.2m and in excess of 1.3m. The River Terrace deposits comprised low to medium strength clays overlying dense sand and gravel at depth. Groundwater was encountered between 2.2m and 3.2m.

Foundation solution

In our opinion the naturally deposited River Terrace will adequately support the proposed buildings on concrete strip/trench fill type foundations. Allowable bearing capacities for a range of foundation sizes are provided in Section 7. Near surface River Terrace comprise low and medium strength clays and therefore we recommend foundations extend through such deposits into the granular soils at depth.

Ground bearing floor slabs can be adopted at this site where buildings are remote from trees and where Made Ground and Topsoil deposits are fully removed within the footprint of the building.

The River Terrace deposits exhibit a degree of permeability and therefore infiltration systems could be adopted at the site. Further testing is however, recommended due to the variability in the test results obtained to date.

Chemical and gaseous contamination

Elevated concentrations of PAH have been encountered within the Made Ground/Topsoil which potentially pose a risk to end users and construction operatives. In addition, leachable concentrations of hydrocarbons have been measured within Made Ground soils that could potentially pose a risk to groundwater. Based on current development proposals, the majority of the site is likely to be covered in hardstanding and buildings, which will sever the pathway to human receptors and severely restrict the formation of leachates. Should any landscaped areas be incorporated into the development we recommend removal of Made Ground/Topsoil or introduction of a capping layer if these areas are significant is size additional investigation and assessment may prove more economical than capping or removal of Made Ground/Topsoil.

A number of landfill sites are recorded some 500m from the site and based on the permeability of the ground, there is a potential risk from landfill type gases. On this basis, we have undertaken a gas monitoring regime to determine whether any gas protection measures are considered necessary for the proposed building. The results of monitoring indicate the site can be classified as characteristic situation 1 and thus no gas protection measures are required for the proposed development.

Special precautions for Water Supply Pipes may be considered necessary due to measured concentrations of polycyclic aromatic hydrocarbons. We recommend provision of our report to the water supplier to determine their requirements based on the ground conditions explored at the site.

Landfill classification

Laboratory testing and our assessment indicate that Made Ground soils are classified as inert waste for off-site disposal. Natural River Terrace, unaffected by artificial contamination, can also be classified as inert waste for off-site disposal.

It should be noted that significant concentrations of PAH, above the acceptable concentrations for inert waste have been identified in some areas of the site. These concentrations of associated with significant ash concentrations within the Made Ground. We recommend any such soils be stockpiled separately and classified separately for off-site disposal.

2 Introduction

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

2.1 Objectives

2.1.1 This report describes a ground investigation carried out for a proposed redevelopment at Daedalus Park, Gosport, Hampshire.

2.1.2 The objective of the ground investigation was to establish ground conditions at the site, sufficient to identify possible foundation solutions for the development and provide parameters necessary for the design and construction of foundations.

2.1.3 The investigation included an evaluation of potential chemical and gaseous contamination of the site leading to the production of a risk assessment in relation to contamination.

2.1.4 The investigation has also been produced to support a planning application for the site by satisfying National Planning Policies Framework sections 120 and 121.

2.1.5 Our brief also included investigations and testing to allow classification of soils at the site to be disposed of to landfill.

2.2 Client instructions and confidentiality

2.2.1 The investigation was carried out in April 2015 and reported in May 2015 acting on instructions received from our client, Mildren Construction Limited.

2.2.2 This report has been prepared for the sole benefit of our above named instructing 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.

2.2.3 Our original investigation proposals were outlined in our letter to JPP Consulting Limited (Civil and Structural engineers) dated 18th February 2015 (ref. L-QM5282H-001). The investigation generally followed our original investigation proposals. The investigation process was also determined to maintain as far as possible the original investigation budget costs.

2.3 Site location and scheme proposals

2.3.1 The National Grid reference for the site is 456240, 101480. A plan showing the location of the site is presented on Drawing 01.

2.3.2 We understand the scheme will comprise the construction of commercial/industrial units with associated hardstandings. We understand the site will be developed in phases and that final layouts are not yet confirmed.

2.4 Report format and investigation standards

2.4.1 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, a risk assessment relating to construction materials likely to be in contact with the ground. Section 11 provides a classification of waste soils for off-site disposal under the waste acceptance criteria.

2.4.2 This investigation integrates both contamination and geotechnical aspects. The investigation was 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*'. The investigation process also followed the principles of BS10175: 2011 *'Investigation of potentially Contaminated Sites – Code of Practice'*. In view of the client's requirement for rapid implementation of the investigation, the following elements, defined in BS10175, have been completed and incorporated in this report.

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

2.4.3 The extent and result of the preliminary investigation (desk study) is reported in Section 3. Fieldwork combined the exploratory investigation and main investigation stages into one phase with the extent of these works described in Sections 4 and 6 of this report. Any supplementary investigations deemed necessary are identified in Section 12. Section 13 provides information on any remedial strategy and specification if required.

2.5 Status of this report

2.5.1 This report is final based on our current instructions.

2.5.2 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, 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 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
Waste recycling operators	For recycling or reducing hazardous properties

Table 2.6

3 Desk study information and site observations

3.1	General
3.2	Description of the site
3.3	Injurious and invasive weeds and asbestos
3.4	History of the site
3.5	Geology and geohydrology of the area
3.6	Environmental study
3.7	Landfill sites
3.8	Coal mining records
3.9	Radon
3.10	Flood risk
3.11	Shallow mining and natural subsidence hazards
3.12	Borehole records
3.13	Mining and dissolution hazards
3.14	Enquiries with statutory undertakers
3.15	Unexploded Ordnance risk assessment
3.16	Radiological risk assessment

3.1 General

3.1.1 We have carried out a desk study which was limited to a review of readily available information including:

a) Review of published Ordnance Survey maps dating back to 1866 at various published scales.

b) Inspection of geological maps produced by the British Geological Survey together with relevant geological memoirs.

c) Consultation with Statutory Undertakers.

d) Site reconnaissance.

e) Other relevant published documents.

3.1.2 We have obtained old Ordnance Survey maps using the Envirocheck database system. In addition to retrieval of historical and current Ordnance Survey data, Envirocheck provide information compiled from outside agencies including:

- Ordnance Survey
- Environment Agency
- Scottish Environment Protection Agency
- The Coal Authority
- British Geological Survey
- Centre for Ecology and Hydrology
- Countryside Council for Wales
- Scottish Natural Heritage
- Natural England
- Health Protection Agency

3.1.3 The study did not extend to research of meteorological information or consultation with other interested parties such as English Heritage (ancient monuments), Ordnance Survey (survey control points), Planning Authorities or Archaeological Units.

3.2 Description of the site

3.2.1 The site is positioned on a flat coastal plain within the district of Lee-on-the-Solent, Gosport, approximately 500m distant from The Solent (Coastline). Recent residential development borders the site to east and south-east while surrounding areas to the, west and south-west of the site comprise buildings associated with the former Royal Naval Air Station HMS Daedalus. The airfield is located to the immediate north of the site.

3.2.2 At the time of the investigation, the site was disused and comprised two largely open grassed areas divided north-south by a chain-link fence. The eastern half of the site was predominantly laid to grass with some areas of concrete hardstanding present and disused tennis courts to the north. The western half of the site was also surfaced in a mixture of grass and concrete. An unoccupied single-storey building and associated bituminous bound car park was present to the south.

3.2.3 Levels across the site were relatively flat and no significant trees or other major vegetation was observed onsite.

3.2.4 A plan showing observed site features and location of exploratory points is presented on Drawing 02.

3.3 Injurious and invasive weeds and asbestos

3.3.1 Injurious and invasive weeds

3.3.1.1 Under the Weeds Act 1959, the Secretary of State may serve an enforcement notice on the occupier of land on which injurious weeds are growing, requiring the occupier to take action to prevent the spread of injurious weeds. The Weeds Act specifies five injurious weeds: Common Ragwort, Spear Thistle, Creeping or Field Thistle, Broad leaved Dock and Curled Dock. The Wildlife and Countryside Act 1981 provides the primary controls on the release of non-native species into the wild in Great Britain. It is an offence under section 14(2) of the Act to *'plant or otherwise cause to grow in the wild*' any plants listed in schedule 9, part II. The full list of proscribed species is reviewed regularly by the Environment Agency. Guidance notes are published on their website at www.environment-agency.gov.uk, and also by DEFRA in their publication "*Guidance on section 14 of the Wildlife and Countryside Act, 1981*" available to download at www.defra.gov.uk. The presence of such weeds on site may have considerable effects on the cost/timescale in developing the site.

3.3.1.2 Our investigations exclude surveys to identify the presence of injurious and invasive weeds. Although it should be noted that during our site reconnaissance we did not observe any obvious evidence the above species, we recommend specialists in the identification and procedures to deal with injurious and invasive weeds are appointed prior to commencement of any works on site.

3.3.2 Asbestos

3.3.2.1 Our investigations exclude surveys to identify the presence or indeed absence of asbestos on site. It should be noted however, that where intrusive investigations were undertaken we did not observe any obvious evidence of potential asbestos containing materials. This information does not constitute a site specific risk assessment and we recommend specialists in the identification and control/disposal of asbestos are appointed prior to commencement of any works on site.

3.3.2.2 The presence of asbestos on site may have considerable effects on the cost/timescale in developing the site. There is good guidance in relation to asbestos available on the Health and Safety Executive (HSE) web site.

3.4 History of the site

3.4.1 An attempt to trace the history of the site has been carried out by obtaining copies of old Ordnance Survey maps provided by Envirocheck. The recent history of the site based on published Ordnance Survey maps is summarised on the following table:

Summary description of site history from Ordnance Survey maps

Date	Historical Usage	Comment
1866 to 1898	Agricultural fields. Milvill Lane runs north-south through the centre of the site.	Chark Lane borders the site to the north. Lee-on-the-Solent is located to the south of the site.
1909 to 1911	Suspected residential property "Kingslands" located within the north of the site to the east of Milvill Lane.	A gravel pit is recorded some 700m to the east of the site.
1931 to 1938	No significant change	The gravel pit has expanded but is recorded as rough ground and is likely disused.
1949 (aerial photograph)	A number of buildings are recorded in the eastern half of the site, associated with development on the adjacent site. Roads cross through the western half of the site.	Significant development has occurred to the west and east of the site, likely associated with the airfield now present to the immediate north.
1963	Buildings are no longer recorded although "Kingslands" remains to the north.	Majority of the buildings on the adjacent site to the east remain. A number of residential, commercial buildings and barracks are located to the south and west of the site.

Table 3.4.1 **Cont....**

Summary description of site history from Ordnance Survey maps		
Date	**Historical Usage**	**Comment**
1965 to 1978	Additional small buildings and tennis court are now located adjacent to "Kingslands". Additional buildings extend onto the site from the east and south. No buildings recorded on the western half of the site although roads are still present and a car park is recorded to the south.	The area to the east has been redeveloped with suspected commercial buildings associated with the adjacent airfield.
1983 to 1993	Additional buildings recorded to the east and two buildings recorded within the western half of the site.	The airfield, and area surrounding the site is recorded as HMS Daedalus.
2014	Buildings no longer recorded within the eastern half of the site although remain to the west.	Site to the east has been redeveloped as residential housing. Buildings to the south-east have been removed with the area now undeveloped.

Table 3.4.1

3.5 Geology and geohydrology of the area

3.5.1 Geology of the area

3.5.1.1 Envirocheck reproduce geological map extracts taken from the British Geological Survey (BGS) digital geological map of Great Britain at 1:50,000 scale (ref Appendix P). A summary of the recorded geological information for the site is presented in Table 3.5.1.below:

Summary of Geology and likely aquifer containing strata					
Strata	**Bedrock or drift**	**Approximate thickness**	**Typical soil type**	**Likely permeability**	**Likely aquifer designation**
River Terrace deposits	Drift	3m – 5m	Sand and gravel	Moderate	Secondary A
Eamley Sand Formation and Marsh Farm Formation	Bedrock	20m	Sand, silt and clay	Moderate	Secondary A
Wittering Formation	Bedrock	40m	Sand, silt and clay	Moderate	Secondary A

Table 3.5.1

3.5.1.2 It should be noted strata names in accordance with the BGS Lexicon of Named Rock Units have superseded commonly used local names for specific strata. Bedrock deposits are soils or rocks deposited prior to the glaciation, with drift deposited during or post glaciation. Soil types and assessments of permeability are based on geological memoirs, in combination with our experience of investigations in these soil types.

3.5.2 Geohydrology – aquifer designation and groundwater vulnerability

3.5.2.1 Envirocheck reports the River Terrace deposits (superficial), Earnley Sand Formation/Marsh Farm Formation and underlying Wittering Formation (bedrock) at the site are designated Secondary A aquifer.

3.5.2.2 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.

3.5.3 Geohydrology – water abstractions

3.5.3.1 Envirocheck report eight active groundwater abstraction points within 2000m of the site. There are no recorded surface water abstractions. The closest abstraction point lies 754m to the north-west of the site with water abstracted for general agriculture purposes.

3.5.4 Geohydrology – source protection zone

3.5.4.1 Envirocheck records the site is not located within a zone protecting a potable water supply abstracting from a principal aquifer (i.e. a source protection zone).

3.6 Environmental database

3.6.1 A copy of records produced by Envirocheck is presented in Appendix P. Envirocheck produce a wealth of factual database information. Although we can provide a discussion on each of the database topics, this would produce a very lengthy document, but some of these discussions would not be relevant to the aims of this report. As a consequence we have extracted some of the relevant geotechnical topics (including flood risk) and discussed them in this section of the report. Key environmental issues from the Envirocheck database are discussed in Section 8. Similarly landfilling is discussed in detail in Section 9.

3.7 Landfill sites

3.7.1 Envirocheck reports four historical/registered landfill sites within 1000m of the subject site. The sites are recorded between 530m and 830m to the east of the site and were licensed for wastes including inert, commercial, industrial and household waste. All of the licenses have now lapsed.

3.7.2 Envirocheck record one BGS recorded mineral site within 1000m of the site. The mineral site is located 698m to the east and is recorded as an open cast quarry extracting sand and gravel from the River Terrace deposits. Operations at the site have now ceased and we are aware that the site has been backfilled.

3.8 Coal mining records

3.8.1 Envirocheck refer to The Coal Authority to determine if the site is located within an area which has been affected by coal mining or brine extraction (within the Cheshire Brine Compensation District only).

3.8.2 The site is not recorded to be within an area affected by past or present coal mining, or minerals worked in association with coal or brine extraction (within the Cheshire Brine Compensation District).

3.9 Radon

3.9.1 With reference to the Building Research Establishment (BRE) publication "*Radon: guidance on protective measures for new buildings"* (2007), the site is located where no protection is considered necessary. In addition, Envirocheck use the British Geological Survey database to review reported radon levels in the area in which the site is located to establish recommended radon protection levels for new dwellings. The database confirms the BRE recommendations.

3.9.2 The Building Research Establishment publication applies to all new buildings, conversions and refurbishments whether they be for domestic or non-domestic use. For non-domestic buildings, the guidance supplements the requirements for radon protection at work specified in the Ionising Radiations Regulations 1999, legislation made under the Health and Safety at Work Act administered by the Health and Safety Executive (HSE). Further information is contained in the HSE/BRE guide "*Radon in the Workplace".*

3.9.3 It is noteworthy that the BRE and BGS/HPA information is based on statistical analysis of measurements made in dwellings in combination with geological units, which are known to emit radon. Therefore there is a risk for actual radon levels at the site to exceed the levels assessed by the BGS/HPA/BRE. Currently, the only true method of checking actual radon levels is by measurement within a building on the site over a period of several months. It should be noted that it is not currently a requirement of the Building Regulations to test new buildings for radon, however the BRE recommends testing on completion or occupation of all new buildings (domestic and non-domestic), extensions and conversions. Should you wish to undertake radon monitoring following completion of the development, we can provide proposals.

3.10 Flood risk

3.10.1 The Envirocheck report indicates the site is not located within a fluvial or tidal flood plain. It should be noted that this information does not constitute a site specific Flood Risk Assessment (FRA), and a full FRA may be required for the development to support a planning application or satisfy planning conditions.

3.11 Shallow mining and natural subsidence hazards

3.11.1 Envirocheck use the British Geological Survey database to establish hazard ratings for shallow minings and natural subsidence hazards. The database indicates the following ratings for the site.

Table summarising Envirocheck mining and subsidence hazards	
Hazard	**Envirocheck rating**
Shallow mining hazard rating	No hazard
Potential for collapsible ground stability hazard	Low
Potential for compressible ground stability hazard	No hazard
Potential for ground dissolution stability hazard	No hazard
Potential for landslide ground stability hazard	Very low
Potential for running sand ground stability hazard	Low
Potential for shrinking or swelling clay ground stability hazard	Low
Table 3.11	

3.12 Borehole records

3.12.1 The British Geological Survey (BGS) retain records of boreholes formed from ground investigations carried out on a nationwide basis. The location of boreholes with records held by the BGS is recorded on the borehole map contained in Appendix P. We do not normally obtain copies of these records but can do on further instructions. There is normally a charge made by the BGS for retrieving and copying these records.

3.13 Mining and dissolution hazards

3.13.1 Envirocheck's database indicates the subject site is not within a zone of conclusive rock mining based upon the findings of a report completed by Ove Arup and Partners in December 1991, commissioned by the Department of the Environment (DoE).

3.13.2 Envirocheck does not recorded any dissolution features or natural cavities within 2000m of the site.

3.14 Enquiries with statutory undertakers

3.14.1 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) Transco
c) Scotia Gas Network
d) Scottish and Southern Energy

3.14.2 Copies of responses received prior to publication of this report are presented in Appendix O. 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.

3.14.3 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 O.

3.14.4 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.

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

3.15 Unexploded Ordnance Risk Assessment

3.15.1 Based on the history of the site there is a potential risk of Unexploded Ordnance / Bombs (UXO/UXB) to be encountered on site. It is therefore recommended that:

- Stakeholders should be made aware of the risk and possible impact it may have on the project.
- UXO safety induction training, conducted by a qualified EOD engineer should be provided to everyone working or visiting the site.
- During intrusive excavations, UXO safety supervision and monitoring should be conducted by a qualified EOD Engineer using a specialist magnetometer to clear the ground ahead of the sampler.

3.16 Radiological Risk Assessment

3.16.1 During intrusive excavations, radiological safety supervision and monitoring was provided by a qualified health physicists using a specialist equipment to clear the ground ahead of works.

4 Fieldwork

4.1	General
4.2	Site restrictions
4.3	Exploratory trial pits
4.4	Driven tube sampling
4.5	Dynamic probing
4.6	Concrete coring
4.7	Measurement of landfill type gases in gas monitoring standpipes
4.8	Sampling strategy

4.1 General

4.1.1 Fieldwork was undertaken on 30th and 31st March 2015 and comprised the following activities:

- Excavation of twenty three exploratory trial pits formed using mechanical excavator
- Infiltration testing in five locations
- Excavation of seven exploratory boreholes formed using driven tube sampling equipment
- Dynamic cone penetration testing in five locations
- Diamond coring in two locations

4.1.2 A plan of the site showing observed/existing site features and position of exploratory points is presented on Drawing 02. The position of exploratory points shown on this plan is approximate only and confirmation of these positions is subject to dimensional surveys, which is considered outside our brief.

4.1.3 The extent of fieldwork activities and position of exploratory points were defined by Soiltechnics Limited and deemed sufficient for the proposals at the time.

4.1.4 Exploratory points were positioned to avoid known locations of underground services and to provide a reasonable coverage of the site. 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 BS EN ISO 14689 *'Identification and classification of rock'.*

4.2 Site restrictions

4.2.1 The site was generally accessible for investigations. However, based on the history of the site, all excavations were pre-checked by a qualified EOD Engineer using a magnetometer. In addition, a radiological report has previously been undertaken for the site, which indicates the presence of elevated radioactive readings in localised areas. On this basis, radiological protection support was also required during investigations.

4.3 Exploratory trial pits

4.3.1 Trial pits TP01 to TP20 were excavated to a maximum depth of 3.2 metres using a 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 Sampling and logging was carried out as trial pit excavations proceeded but trial pits were not entered at depths exceeding 1.2 metres, or where sides were deemed unstable. The density of granular soils encountered in excavations was gauged by the ease of excavation.

4.3.3 Soil samples for subsequent laboratory determination of concentration of chemical contaminants were taken from the sides of trial pits using clean stainless steel equipment and stored in new plastic containers, which were labelled and sealed. The stainless steel sampling equipment was cleaned with deionised water between sampling points 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.

4.3.4 Soil samples for subsequent 'classification' laboratory testing were taken from the side of trial pits or from bulk samples taken from the excavator bucket. The sample was placed in a plastic bag and subsequently sealed and labelled.

4.3.5 Soil samples were obtained to meet quality class 3 to 5 as described in BS EN I997-2:2007. Sample sizes were appropriate for the laboratory test being considered.

4.3.6 A pocket penetrometer was used in the cohesive soils encountered. This tool is deemed to measure the apparent ultimate bearing capacity of the soil under test. The pocket penetrometer is calibrated in kg/cm^2. 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 safety achieved otherwise testing was carried out on excavated intact clods. The results are reported in columns to the right of trial pit results. The pocket penetrometer is not covered by British Standards. This tool has the advantage that it can be used to determine the approximate insitu undrained shear strength of stony cohesive soils.

4.3.7 A summary of pocket penetrometer results obtained from the cohesive soils encountered in exploratory excavations are presented in graphical format on Drawing 05.

4.3.8 Soil infiltration tests were carried out in trial pits TP04a, TP06a, TP13a, TP17 and TP18 at depths of between 0.65 metres and 2.2 metres. Infiltration tests were carried out following the procedures described in the Building Research Establishment (BRE) Digest 365 (2007) "*Soakaway Design*" Records of test results and calculations to determine a soil infiltration rate are presented in Appendix E.

4.3.9 Trial pit records are presented in Appendix C.

4.4 Driven tube sampling

4.4.1 Boreholes DTS01 to DTS06 were formed using driven tube sampling equipment. Driven tube 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.

4.4.2 Samples for determination concentration of chemical contaminants are taken from samples obtained in the disposable tubes as sub-samples, using stainless steel sampling equipment, which is cleaned with de-ionised water.

4.4.3 The driven tube sampler obtains samples under category A allowing laboratory test quality classes 3 to 5 as described in BS EN ISO 22475-1:2006.

4.4.4 A pocket penetrometer was used in the cohesive soils retrieved from the borehole. This tool is deemed to measure the apparent ultimate bearing capacity of the soil under test. The pocket penetrometer is calibrated in kg/cm^2. The reading can be approximately converted to an equivalent undrained shear strength by multiplying the results by a factor of 50. The results are reported on borehole records. The pocket penetrometer is not covered by British Standards.

4.4.5 A summary of pocket penetrometer results obtained from the cohesive soils retrieved from the boreholes are presented in graphical format on Drawing 04.

4.4.6 Combined gas and groundwater monitoring standpipes were installed in boreholes DTS01, DTS02, DTS03, DTS04 and DTS-6. 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*'. Details of the standpipe installation are recorded on Drawing 05.

4.4.7 Water levels in the standpipes have been measured during a return visit to the site. 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. Water levels are measured from ground levels at the borehole position. Records of water levels are presented in Section 5.

4.4.9 Records of boreholes formed using driven tube sampling techniques are presented in Appendix D.

4.5 Dynamic cone penetration testing

4.5.1 Dynamic Cone Penetration (DCP) testing was carried out in five locations. Dynamic Cone Penetration testing consists of driving a 50mm diameter, 90° cone into the ground, via an anvil and extension rods with successive blows of a freefall hammer. The number of blows required to drive the cone each successive 100mm (N100) is recorded.

4.5.2 Dynamic Cone Penetration testing was carried out following BS EN ISO 22476-2:2005 and the apparatus used was categorised as 'super heavy' (DPSH-B) in accordance with the standard.

4.5.3 Dynamic cone penetration test data is presented in graphical format on Drawing 03.

4.6 Diamond coring

4.6.1 Diamond coring was undertaken through the existing concrete hardstanding to the north-west of the site in order to determine the thickness of slab. Coring was carried out using a 150mm diameter thin wall steel barrel with a diamond tipped cutting edge. The barrel is rotated using an electrically powered motor and when cutting, was lubricated with water and powered using a portable generator. Coreholes were reinstated with concrete on completion. Corehole records are presented in Appendix F.

4.7 Measurement of landfill type gases in gas monitoring standpipes

4.7.1 The concentrations of landfill type gases collected within gas monitoring standpipes installed in boreholes DTS01, DTS02, DTS03, DTS04 and DTS06 was measured using a portable infra-red gas analyser (model GA2000 plus, manufactured by Geotechnical Instruments). Initially the gas analyser was connected to the gas valve on the top of the standpipe to allow the flow rate to be measured. Essentially this is a measurement of gas pressure produced in the standpipe, which is compared with atmospheric pressure at the time of measurement to produce an equivalent gas 'flow' in l/hr. The equipment used is capable of measuring to an accuracy of 0.1l/hr; below this the gas analyser records zero flow. Following BS8485:2007 '*British Standard Code of Practice for the Characterisation and remediation from ground gas in affected developments'*,(clause 6.1), we assume flows of 0.1l/hr when the gas analyser reads zero, thus producing a pessimistic gas flow rate in our assessment of ground gases.

4.7.2 Following measurement of 'flow' the gas analyser pumps gases contained in the standpipe through the analyser for a period of not less than 180 seconds to allow a continuous measurement of landfill type gases. The analyser then measures 'peak' and 'steady' concentrations of the following gases.

- Methane (CH_4)
- Carbon dioxide (CO_2)
- Oxygen (O_2)

4.7.3 The ambient atmospheric temperature and barometric pressure was also recorded at the site. To determine if the atmospheric pressure is rising or falling we interrogate the internet on a daily basis.

4.7.4 Methane in concentrations of between 5 to 15% in air is potentially explosive. The 5% methane concentration in air is defined as the Lower Explosive Limited (LEL). The gas analyser measures a percentage of the LEL. For example, 10% LEL equates to 10% of 5%, i.e. 0.5% methane concentration in air.

4.7.5 Records of gas monitoring data are presented in Appendix J.

4.8 Sampling strategies

4.8.1 Geotechnical

4.8.1.1 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

4.8.2 Environmental

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

4.8.3 Sample retention

4.8.3.1 Samples are stored for a period of one month following issue of this report unless otherwise required.

5 Ground conditions encountered

5.1	Soils/rocks
5.2	Topsoil
5.3	Groundwater

5.1 Soils/Rocks

5.1.1 Each exploratory excavation encountered a similar profile of soils considered to be Topsoil/Made Ground overlying River Terrace deposits.

5.1.2 Topsoil was encountered in six locations as a brown clayey gravelly sand with the gravel comprising flint. The Topsoil extended to depths of 0.3m and 0.5m.

5.1.3 Made Ground was encountered the remaining excavations and generally consisted of low strength dark brown silty sandy gravelly clay or brown slightly clayey gravelly sand overlying medium dense brown slightly clayey sand and brown silty very gravelly clay or clayey gravel. The gravel comprised flint, brick, ash, charcoal and concrete. The Made Ground extended to depths between 0.2m and in excess of 1.3m. Deep Made Ground was generally encountered on the eastern half of the site to the south and eastern boundary and is likely associated with former buildings in these areas.

5.1.4 River Terrace deposits were encountered in each exploratory location and generally consisted of low to medium strength orange brown sandy gravelly clay to depths between 1m and 1.8m overlying medium dense becoming very dense slightly clayey sand and gravel. The gravel comprised flint and quartzite. The River Terrace extended beyond the termination depths of the exploratory excavations.

5.1.5 With the exception of Made Ground, the investigation generally confirmed published geological records.

5.2 Topsoil

5.2.1 As a practice we have adopted the following policy for description of Topsoil. If surface soils exhibit a visually significant organic content and darker colour than the soils it overlies (which are considered to be naturally deposited) then we will describe the soil as Topsoil. In some cases it is difficult to visually distinguish the interface between Topsoil and subsoils below, which may also exhibit an organic content, and in such cases we will adopt an estimate of the interface but may also use the terms ‘grading into’ with some defining depths.

5.2.2 If ‘Topsoil’ deposits include materials such as ash, brick and other man-made materials, or the Topsoil overlies Made Ground deposits we will term the material ‘Made Ground’, even though it may still be able to support vegetable growth, and potentially be reused as Topsoil.

5.2.3 Topsoil can be classified following a number of test procedures as described in BS3882: 2007 *'Specification for Topsoil and Requirements for use'*, to allow its uses to be determined. We do not carry out such testing unless specifically instructed to do so.

5.3 Groundwater

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

Table summarising groundwater observations

Exploratory point	Depth (m) below ground levels	Observations
TP02	2.6m	Rising to 2.4m after 5 minutes
TP03	2.4m	Minor inflow. Insufficient to measure depth on completion.
TP04	2.5m	Minor inflow. Insufficient to measure depth on completion.
TP06	2.6m	Minor inflow. Insufficient to measure depth on completion.
TP07	3.1m	Minor inflow. Insufficient to measure depth on completion.
TP08	2.9m	Minor inflow. Insufficient to measure depth on completion.
TP09	3.2m	Minor inflow. Insufficient to measure depth on completion.
TP10	2.4m	Minor inflow. Insufficient to measure depth on completion.
TP11	2.2m	Minor inflow. Insufficient to measure depth on completion.

Table 5.3.1

5.3.2 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 Laboratory testing

6.1	Classification testing
6.2	Chemical testing

6.1 Classification testing

6.1.1 Laboratory testing was carried out in accordance with BS1377: 1990 "*Methods of Test for Soils for Civil Engineering Purposes"* and limited to determination of:

i) the liquid limit (one point cone penetrometer method)(method 4.4)
ii) the plastic limit and plasticity index (method 5)
iii) Determination of particle size distribution – wet sieving (method 9.2)

6.1.2 Laboratory testing was carried out by an independent specialist testing house, which operates a quality assurance scheme. Copies of laboratory test result certificates are presented in Appendix G.

6.2 Chemical testing

6.2.1 Laboratory testing was carried out as deemed necessary and carried out using the following techniques:

- Using inductively coupled plasma mass spectrometry (ICP-MS), determination of concentration of metals, semi-metals and soluble sulphate.
- Using gas chromatography flame ionisation detection methods (GC–FID), determination of concentration of petroleum hydrocarbons (TPH).
- Using gas chromatography flame ionisation detection methods (GC–FID), determination of concentration of polycyclic aromatic hydrocarbons (PAH).
- Using gas chromatography mass spectrometry (GS–MS), determination of the concentration of

  i) Volatile organic compounds (VOC)
  ii) Semi-volatile organic compounds (sVOCs),
  iii) Glycols
  iv) Polychlorinated biphenyls (PCBs)

- Using electromagnetic measurement, determination of pH.
- Following methods described in the Environment Agency publication *'Guidance on sampling and testing of wastes to meet landfill waste acceptance procedures'* (April 2005) – suite of testing in accordance with Table 2.1**.**

6.2.2 Laboratory testing was carried out by an independent specialist testing house, which operates a quality assurance scheme. Copies of laboratory test result certificates are presented in Appendix H.

7 Engineering assessment

7.1	General description of the development
7.2	Building foundation design and construction
7.3	Influence of trees and hedges
7.4	Ground floor construction
7.5	Service trench excavations
7.6	Infiltration potential
7.7	Pavement foundations
7.8	Reuse of excavated soils from the site

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 The project will comprise the construction of commercial/industrial units with associated hardstandings.

7.2 Building foundation, design and construction

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

7.2.2 In our opinion naturally deposited River Terrace will adequately support proposed buildings on spread type foundations. Near surface River Terrace generally comprised low to medium strength cohesive soils to depths between 1m and 1.9m. Due to the variability in shear strength, we recommend foundations extend through these deposits into the underlying granular material by a minimum of 0.3m. As a precaution based on laboratory determination of plasticity of overlying cohesive River Terrace deposits and following National House Building Council (NHBC) Standards Chapter 4.2, we recommend foundations extend to a minimum depth of 0.9m below existing or proposed ground levels whichever gives the deeper founding level. In all cases we recommend foundation excavations fully penetrate any Made Ground deposits, cohesive River Terrace deposits and extend into the granular River Terrace subject to an overall minimum foundation depth of 0.9m.

7.2.3 Essentially, in our opinion, the granular River Terrace deposits will adequately support proposed buildings. Calculations based on an angle of shearing resistance of 32°, a foundation depth of 1.5m with ground water levels remote from founding levels indicate following bearing values for pad type foundations.

Table of bearing values Cohesionless River Terrace

Plan size of pad (m)	Ultimate bearing value kN/m²	Presumed bearing value kN/m²	Allowable bearing pressure kN/m²
1 x 1	995	350	220
1.5 x 1.5	1095	380	250
2 x 2	1190	415	280

Table 7.2.3

7.2.4 The presumed bearing value has been derived from the ultimate bearing value by applying a factor of safety of 3, and the allowable bearing pressure derived to limit total settlement.

7.2.5 It is difficult to accurately predict the amount of total and differential movement caused by consolidation of the foundations supporting subsoils, however, providing foundation stresses do not exceed allowable bearing pressures provided in the preceding paragraph, it is suggested that total settlement would be small and probably less than 25mm. Differential settlement is totally dependent upon the variation of foundation loads and consistency of the supporting ground. Assuming the foundation loads are reasonably uniform, we suggest that differential settlement is unlikely to exceed say 10mm between adjacent pads. Assuming a spacing of say 6m between frame/pad centres the angle of distortion in the building frame would be 10/6000 = 1/600 which is within normally acceptable limits. It is likely settlement will be fully achieved within say 5 years of construction.

7.2.6 The granular River Terrace deposits encountered in exploratory excavations at depth are consistent and will provide uniform support to foundations. In the unlikely event foundation excavations encounter a soft area, we recommend foundation excavations continue to locate stiffer soils or reinforcement introduced into foundation concrete to span the soft area.

7.2.7 Trench Stability

7.2.7.1 Based on groundwater observations in exploratory excavations, we consider it is unlikely that groundwater will be encountered in excavations extending to depths of up to 2.0m. Beyond this depth the risks of encountering inflows of groundwater increase, which may cause some instability of foundation excavations producing a wider than planned trench widths resulting in an increase in the quantity of foundation concrete to fill voids produced by instability of trench sides.

7.3 Influence of Trees and other major vegetation

7.3.1 Soil classification and new foundation design

7.3.1.1 The results of plastic and liquid limit determinations performed on samples of the River Terrace deposits indicate the cohesive deposits are soils of medium volume change potential when classified in accordance with National House Building Council (NHBC) Standards, Chapter 4.2. Particle size distribution testing indicate the River Terrace deposits at depth are granular and will not be influenced by any proposed vegetation at the site. We recommend all foundations penetrated near surface cohesive deposits and extend into the granular soils at depth. On this basis, foundations will not be influenced by any proposed trees or other major vegetation.

7.4 Ground Floor Construction

7.4.1 Ground bearing floor slabs can be adopted at this site where buildings are remote from trees and where Made Ground and Topsoil deposits are fully removed within the footprint of the building. We recommend a blanket of good quality compacted granular material be placed prior to construction of the floor slabs.

7.4.2 In areas close to existing major vegetation at the site, it may be possible to remove moisture depleted soils and replace them with non-shrinkable well graded well compacted (to an end point specification) granular fills thus allowing the adoption of a ground bearing floor slab unaffected by the influence of the vegetation. We will be pleased to advise further on this, in terms of providing material and compaction specification on further instructions.

7.4.3 Alternatively, in areas where deeper Made Ground is present, ground bearing floor slabs can be adopted at this site located on the Made Ground deposits, but some settlement could be expected (refer paragraph 7.4.5 below). Following completion of excavations to formation levels we recommend the formation is rolled using a heavy roller to identify any soft areas and indeed compact near surface soils which may have been disturbed by excavation processes. Any 'soft' areas will require excavation to locate more stable soils. We recommend a blanket of good quality compacted granular material be placed prior to construction of the floor slabs.

7.4.4 We understand the floor slabs are unlikely to support settlement sensitive equipment and will be constructed for general warehouse/retail usage. With reference to 'Concrete industrial ground floors' (Technical Report no. 34 – third edition) produced by the Concrete Society, the modulus of subgrade reaction (k) supporting the floor slab has only a minor effect on the slab design thickness for flexural stresses and does not therefore have to be estimated with great accuracy.

7.4.5 The modulus of subgrade reaction is a measure of the elastic properties of near surface soils. Plate bearing tests provide the most accurate measure of elastic modulus and we can carry this out on further instructions. California Bearing Ratio (CBR) test data be converted to an equivalent modulus of subgrade reaction (see Technical Report 34), but CBRs are not a direct measure of modulus. Again, we can carry out CBR testing on further instructions. Technical report 34, provides typical values of modulus of subgrade reaction based on soil descriptions, and using this guidance we estimate the modulus subgrade reaction in the range of 0.015 to 0.03 N/mm^3.

7.4.6 In addition to elastic deformation of soils (estimated from k values described above), some long-term settlement of the floor slab will occur under applied loads, particularly uniformly distributed loads. It is difficult to accurately predict levels of settlement, as the applied load pattern is not known. Assuming a constantly applied uniformly distributed load of say $40kN/m^2$, settlements in the order of 15mm could occur within 5 to 10 years. Some differential settlement will occur in the long term, if the floor slab is not uniformly loaded. Removal of the Made Ground and replacement with a well compacted (to an end point specification) well graded and durable granular fill would substantially reduce levels of possible settlement

7.5 Service Trench Excavations

7.5.1 Generally, the sides of trench excavations will remain stable in the short term. There is a possibility that locally, excavations may encounter more granular soils, which may include some water. In such cases we are of the opinion that water seepages/inflows could promote progressive instability in trench sides requiring continuous trench sheet shoring to maintain an open excavation. We anticipate water will be controlled with nominal pumping techniques.

7.5.2 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).

7.6 Infiltration Potential

7.6.1 Requirements for use of infiltration systems

7.6.1.1 It is a requirement under H3 (3) of the current building regulations to discharge stormwater collected by a development to soakaways as a priority (as opposed to water courses and sewers).

7.6.2 Contamination considerations

7.6.2.1 With reference to Environment Agency (EA) publication '*Groundwater protection: Policy and practice (GP3) Section G,* 2012, outside of SPZ1, the EA will support sustainable drainage systems for new discharges to ground. This is subject to an appropriate risk assessment to demonstrate that ground conditions are suitable and infiltration systems do not present an unacceptable risk of promoting mobilisation of contaminants or creating new pathways for contaminant migration.

7.6.2.2 The permeability of the near surface River Terrace in combination with the site located over a Secondary A aquifer suggests the site is sensitive to migration of contaminants. The site is not located within or close to a source protection zone. We have carried out leachate testing of a suite of contaminants with our assessment provided in Section 8. Essentially, leachable hydrocarbons have been identified in Made Ground and therefore we recommend all soil infiltration systems are sealed through Made Ground and allow water to drain into natural soils only. All discharges to groundwater are subject to compliance with the Water Framework Directive (2000/60/EC) and Groundwater Daughter Directive (2006/118/EC). We recommend advise and agreement is sought from the EA regarding the use of soakaways on site.

7.6.3 Infiltration measurements

7.6.3.1 The River Terrace deposits exhibit a degree of permeability. The permeability of these soils was measured in five trial pits following the procedures described in Building Research Establishment (BRE) Digest 365 (2007) "*Soakaway Design*". Records of testing and calculations are presented in Appendix E.

7.6.3.2 Infiltration testing was undertaken in TP04a between depths of 1.53m and 2.01m, TP06a between depths of 1.19m and 1.47m, TP13a between depths of 0.65m and 0.9m and TP18 between depths of 0.51m and 1.79m. The majority of the soils in these excavations comprised cohesive River Terrace with up to 300mm of granular soils at the base. Some infiltration was recorded in these locations but was insufficient to calculate a soil infiltration rate.

7.6.3.3 Infiltration testing was also undertaken in TP17 between depths of 1.68m and 2.2m. The majority of the soils between these depths were granular River Terrace and infiltration rates of 1.54×10^{-5}m/s and 3.85×10^{-6}m/s were calculated in two test cycles.

7.6.3.4 Based on the above, the granular River Terrace deposits at depth exhibit a degree of permeability. However, it should be noted that groundwater was encountered in a number of locations below 2m depth (although generally around 2.5m).

7.6.4 Design of infiltration systems

7.6.4.1 Testing completed to date indicates the granular River Terrace exhibit a degree of permeability. However, limited testing could be undertaken within the timeframe and therefore we recommend further testing be undertaken across the site, potentially over a number of days to allow three test cycles to be undertaken in a number of locations in accordance with BRE Digest 365 (2007). Such testing will allow the detailed design of infiltration systems to be progressed.

7.6.4.2 If infiltration systems are adopted as a means of stormwater disposal (including permeable pavement construction), we recommend approval for the use of soakaways is sought from the Environment Agency. It should be noted that the Groundwater Regulations 1998 require that list 1 substances (e.g. hydrocarbons) are to be prevented from entering groundwater receptors and list 2 substances (e.g. metals) are also restricted. Typically, the Environment Agency will require details of the proposed soakaway systems, showing pollution prevention measures. They will also require geological and geo-hydrological information, (contained in this report) as well as the risks of chemical contaminants in the ground affecting water resources. It is also typical requirement that there is an 'unsaturated zone' between the base of the soakaway system and the groundwater table (saturated zone) providing attenuation capacity.

7.7 Pavement Foundations

7.7.1 It is anticipated that the proposed access road and associated hardstanding areas will be located at or about existing ground levels with formation located on Made Ground and River Terrace soils.

7.7.2 Equilibrium CBR (California Bearing Ratio) values (with reference to Transport and Road Research Laboratory (TRRL) Report LR1132 '*Structural design of Bituminous Roads'*) are derived from knowledge of soil classification data (plasticity index for soils exhibiting cohesion (clay type) and particle size distribution for granular soils), the location of the water table pavement thickness, and weather conditions at the time of construction. It is anticipated that excavations to formation levels will encounter a mixture of both granular and cohesive soils. Granular soils will provide numerically high CBR values, but cohesive soils will typically provide significantly lower values. Assuming an average plasticity index of say 15 for cohesive soils, a low water table, a 'thin' pavement the following equilibrium CBR values are derived for varying construction conditions

Equilibrium CBR values for differing construction conditions		
Poor	**Average**	**Good**
CBR = 2.5%	CBR = 4.5%	CBR = 6%

Table 7.7.2

7.7.3 It is possible to derive the 'insitu' CBR value at formation from undrained shear strength data by applying a conversion factor of 23 (refer TRRL laboratory report LR889). Thus adopting pessimistic undrained shear strength of say 40kN/m^2 at formation level (based on insitu shear strength measurements) then an equivalent CBR value can be obtained i.e.

$$\text{Insitu CBR} = \text{undrained shear strength } {}^{C}\!/_{23} = 1.7\%$$

7.7.4 The 'insitu' CBR derived above, is susceptible to change dependent upon weather conditions during construction. The equilibrium CBR value derived in paragraph 7.7.2 above is an estimate of the CBR value, which will predominate during the life of the pavement. We recommend the insitu CBR of 1.7% derived from shear strength data be utilised for design purposes and reassessed during construction. The fact that the clay subgrade soils are likely to be deemed frost susceptible will probably be the overriding criteria for pavement foundation design purposes. It should also be noted that the thickness of the pavement foundation also relates to the amount and loading from construction traffic, which is discussed in detail in the Transport and Road Research Laboratory (TRRL) Report LR1132 '*Structural design of Bituminous Roads'.*

7.7.5 Once formation levels have been established it is recommended that the formation be trimmed and rolled following current requirements of the Highways Agency Specification for Highways Works (clause 616) (refer www.dft.gov.uk/ha/standards/mchw/vol1). Such a process will identify any soft areas, which we recommend be either excavated out and backfilled with a suitable well compacted material similar to those exposed in the sides of the resulting excavation, or large cobbles of a good quality stone rolled into the formation to stabilise the 'soft' area.

7.7.6 The silty nature of the Made Ground and River Terrace will render them moisture susceptible with small increases in moisture content giving rise to a rapid loss of support to construction plant. We therefore recommend, as soon as formation is trimmed and rolled, that sub-base is laid in order to avoid deterioration of the subgrade in wet or frosty conditions.

7.8 Reuse of excavated soils from the site

7.8.1 Generally soils excavated from the site could be reused as bulk filling, if reused at their natural moisture content. We recommend soils be classified and compacted in accordance with the current Highways Agency '*Specification for Highway Works'* (600 series) – table 6/1 (refer www.dft.gov.uk/ha/standards/mchw/vol1).

8 Chemical contamination

8.1	Contaminated land, regulations and liabilities
8.2	Objectives and procedures
8.3	Development characterisation and identified receptors
8.4	Identification of pathways
8.5	Assessment of sources of contamination
8.6	Initial conceptual model
8.7	Laboratory testing
8.8	Updated conceptual model
8.9	Remedial action
8.10	Risk assessment in relation to infiltration systems
8.11	Risk assessment summary and recommendations
8.12	Statement with respect to National Planning Policy Framework
8.13	On site monitoring

8.1 Contaminated land, regulation and liabilities

8.1.1 Statute

8.1.1.1 Part IIA of the Environment Protection Act 1990 became statute in April 2000. The principal feature of this legislation is that the hazards associated with contaminated land should be evaluated in the context of a site-specific risk based framework. More specifically contaminated land is defined as:

> *"any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reasons of substances in, on or under the land, that:*
>
> *a) Significant harm is being caused or there is a significant possibility of such harm being caused; or*
> *b) Pollution of controlled waters is being or is likely to be caused".*

8.1.1.2 Central to the investigation of contaminated land and the assessment of risks posed by this land is that:

i) There must be contaminant(s) at concentrations capable of causing health effects (*Sources).*
ii) There must be a human or environmental receptor present, or one which makes use of the site periodically *(Receptor)*; and
iii) There must be an exposure pathway by which the receptor comes into contact with the environmental contaminant *(Pathway).*

8.1.1.3 In most cases the Act is regulated by Borough or District Councils and their role is as follows:

i) Inspect their area to identify contaminated land
ii) Establish responsibilities for remediation of the land
iii) See that appropriate remediation takes place through agreement with those responsible, or if not possible:
- by serving a remediation notice, or
- in certain cases carrying out the works themselves, or
- in certain cases by other powers

iv) keep a public register detailing the regulatory action which they have taken

8.1.1.4 For "special" sites the Environment Agency will take over from the Council as regulator. Special sites typically include:

- Contaminated land which affects controlled water and their quality
- Oil refineries
- Nuclear sites
- Waste management sites

8.1.2 Liabilities under the Act

8.1.2.1 Liability for remediation of contaminated land would be assigned to persons, organisations or businesses if they caused, or knowingly permitted contamination, or if they own or occupy contaminated land in a case where no polluter can be found.

8.1.3 Relevance to predevelopment conditions

8.1.3.1 For current use, Part IIA of the Environmental Protection Act 1990 provides the regulatory regime. The presence of harmful chemicals could provide a 'source' in a 'pollutant linkage' allowing the regulator (Local Authority or Environment Agency) to determine if there is a significant possibility of harm being caused to humans, buildings or the environment. Under such circumstances the regulator would determine the land as 'contaminated' under the provision of the Act requiring the remediation process to be implemented.

8.1.4 Relevance to planned development

8.1.4.1 The developer is responsible for determining whether land is suitable for a particular development or can be made so by remedial action. In particular, the developer should carry out an adequate investigation to inform a risk assessment to determine:

a) Whether the land in question is already affected by contamination through source – pathway – receptor pollutant linkages and how those linkages are represented in a conceptual model

b) Whether the development proposed will create new linkages e.g. new pathways by which existing contaminants might reach existing or proposed receptors and whether it will introduce new vulnerable receptors, and

c) What action is needed to break those linkages and avoid new ones, deal with any unacceptable risks and enable safe development and future occupancy of the site and neighbouring land?

8.1.4.2 Building control bodies enforce compliance with the Building Regulations. Practical guidance is provided in Approved documents, one of which is Part C, '*Site preparation and resistance to contaminants and moisture'* which seeks to protect the health, safety and welfare of people in and around buildings, and includes requirements for protection against harm from chemical contaminants.

8.1.5 Pollution of controlled waters

8.1.5.1 Part IIA of the Environment Protection Act 1990, defines pollution of controlled waters as:

'The entry into controlled waters of any poisonous, noxious or polluting matter or any solid waste matter'

8.1.5.2 Paragraphs A36 and A39 of statutory guidance (DETR 2000) further define the basis on which land may be determined to be contaminated land on the basis of pollution of controlled waters.

'Before determining that pollution of controlled waters is being, or likely to be, caused, the Local Authority should be satisfied that a substance is continuing to enter controlled waters, or is likely to enter controlled waters. For this purpose, the local authority should regard something as being likely when they judge it more likely than not to occur'

'Land should not be designated as contaminated land where:

a) A substance is already present in controlled waters:
b) Entry into controlled waters of that substance from the land has ceased, and
c) It is not likely that further entry will take place.

Substances should be regarded as having entered controlled waters where:

a) They are dissolved or suspended in those waters; or
b) If they are immiscible with water, they have direct contact with those waters, or beneath the surface of the waters'

8.1.5.3 Controlled waters are defined in statute to be:

> *'territorial waters which extend seawards for 3 miles, coastal waters, inland freshwaters, that is to say, the waters in any relevant lake or pond or of so much of any relevant river or watercourse as is above the freshwater limit, and groundwaters, that is to say, any waters contained in underground strata.'*

8.1.6 Further information

8.1.6.1 The above provides a brief outline as regards current statute and planning controls. Further information can be obtained from the Department for the Environment, Food and Rural Affairs (DEFRA) and their website www.defra.gov.uk.

8.2 Objectives and procedures

8.2.1 Objectives

8.2.1.1 This report section discusses investigations carried out with respect to chemical contamination issues relating to the site. The investigations were carried out to determine if there are any liabilities with respect to Part IIA of the Environment Protection Act. As stated in Section 2.4.2, the investigation process followed the principles of BS10175: 2011 *'Investigation of potentially contaminated sites – Code of Practice',* with the investigation combining a desk study (preliminary investigation) together with the exploratory and main investigations (refer BS10175: 2011 for an explanation).

8.2.1.2 This section of the report produces *'Conceptual models'* based on investigatory data obtained to date. The conceptual model is constructed by identification of *contaminants* and establishment of feasible *pathways* and *receptors.* The conceptual model allows a *risk assessment* to be derived. Depending upon the outcome of the risk assessment it may be necessary to carry out remediation and/or further investigations with a view to eliminating, reducing or refining the risk of harm being caused to identified receptors. If appropriate, our report will provide recommendations in this respect.

8.2.1.3 Definition of terms used in the preceding paragraph and subsequent parts of this section of the report are presented in Appendix B.

8.2.2 Procedure to assess risks of chemical contamination

8.2.2.1 For the purposes of presenting this section of this report, we have adopted the following sequence in assessing risks associated with chemical contamination.

Table outlining sequence to assess risk associated with chemical contamination

Conceptual model element	Contributory information	Outcome
Receptor	Development categorisation	Identification of receptors at risk of being harmed Method of analysing test data Criteria for risk assessment modelling
Pathways	Geology and ground conditions Development proposals	Identification of critical pathways from source to receptor
Source	Previous site history Desk study information Site reconnaissance Fieldwork observations	Testing regime Identification of a chemical source Analysis of test data and other evidence

Table 8.2.2

8.2.2.2 We have adopted, in general, the procedures described in CIRIA C552 *'Contaminated land risk assessment - a guide to good practice'* in deriving a risk assessment. Initially we have carried out a 'phase 1 assessment' based on desk study information and site reconnaissance, to produce an initial conceptual model and thus a preliminary risk assessment. This model/assessment is then used to target fieldwork activities and laboratory testing, with the results of this part of the investigation used to allow a phase 2 assessment to be produced by updating the conceptual model and refining the risk assessment.

8.3 Development characterisation and identified receptors

8.3.1 Site characterisation

8.3.1.1 The nature of the site has a significant influence the likely exposure pathways between potentially contaminated soils and potential receptors. The following table summarises elements which characterise the site based on site observations and desk study information.

Summary of site characteristics		
Element	**Source/criteria**	**Characteristic**
Current land use	Observations	Currently disused and secure against public access.
Future land use	Advice	Commercial/light industrial development.
Site history	Desk study	Agricultural fields until 1940s when site was redeveloped as part of the Royal Naval Air Station HMS Daedalus.
Geology	Desk study/Site investigation	Made Ground/Topsoil overlying River Terrace deposits to depths in excess of 3.0m. Underlying soils at depth recorded as Eamley Sand Formation and Marsh Farm Formation.
Ground water	Aquifer potential	Secondary A aquifer within the River Terrace and Earnley Sand Formation and Marsh Farm Formation.
	Abstractions	Closest abstraction point located 754m to the north-west with water abstracted for general agriculture.
	Source protection zone	Site not located within a source protection zone.
Surface waters	Location	No significant watercourses within 1000m. Coastline recorded 500m to the west.
	Abstractions	None within 2000m of the site.

Table 8.3.1

8.3.2 Identified receptors

8.3.2.1 The principal receptors subject to harm caused by any contamination of the proposed development site are as follows.

Principle Receptor	Detail
Humans	Users of the current site
	End user of the developed site
	Construction operatives and other site investigators
Vegetation	Plants and trees, both before and after development
Controlled waters	Surface waters (Rivers, streams, ponds and above ground reservoirs)
	Ground waters (used for abstraction or feeding rivers / streams etc)
Building materials	Materials in contact with the ground

Table 8.3.2

8.3.2.2 This section of the report assesses those receptors listed above. Section 10 provides a risk assessment in relation to building materials.

8.3.3 Human receptors

8.3.3.1 The Contaminated Land Exposure Assessment (CLEA) model can be used to derive guideline values, against which land quality data can be compared to allow an assessment of the likely impacts of soil contamination on humans. The parameters used within the model can be chosen to allow guideline values to be derived for a variety of land uses and exposure pathways. For example, a construction worker is likely to be exposed in different ways and for different durations than an adult in a residential setting.

8.3.3.2 The site is currently disused and inaccessible to the general public. On this basis, we have not considered current site users further. Following completion of the proposed commercial/industrial development the critical site user (receptor) is considered to be an adult. This criterion has been used in the conceptual model for the future site use. Our assessment also considers construction operatives as adult receptors.

8.3.4 Vegetation receptors

8.3.4.1 Soil contaminants can have an adverse effect on plants if they are present at sufficient concentrations. The effects of phytotoxic contaminations include growth inhibition, interference with natural processes within the plant and nutrient deficiencies.

8.3.4.2 No major vegetation is currently present on site. There is a possibility of some landscaped areas being incorporated into the development, which may include trees.

8.3.5 Water receptors

8.3.5.1 The site lies in an area designated as seconday A aquifer probably contained in the River Terrace deposits. On this basis, groundwater is considered to be a potentially viable receptor.

8.3.5.2 The nearest surface water receptor is The Solent located 500m to the west and due to its distance from the site, is not considered to be a potentially viable receptor. No significant watercourses are recorded within 1000m of the subject site.

8.3.6 Summary of identified receptors

8.3.6.1 Based on the above assessments, the following table summarises identified and critical receptors.

Table summarising identified (viable) receptors				
Principle Receptor	**Detail**	**Viable and critical receptors**		
		Viability and justification		**Critical receptor**
Humans	Users of the current site	No	Site disused and secure against public access	N/A
	End user of the developed site	Yes	Commercial/ industrial development	Adult
	Construction operatives and other site investigators	Yes		Adult
Vegetation	Current site	No	No significant vegetation	Vegetation
	Developed site	Yes	Possibility of some landscaping	Vegetation
Controlled waters	Surface waters (Rivers, streams, ponds and above ground reservoirs)	No	Nearest water receptor 500m from site	Surface waters
	Ground waters (used for abstraction or feeding rivers / streams etc)	Yes	Site over a secondary A aquifer	Groundwater
Building materials	Materials in contact with the ground	Yes	Assessed in report section 10	Building materials
Table 8.3.6				

8.4 Identification of pathways

8.4.1 Pathways to human receptors

8.4.1.1 Guidance published by the Environment Agency in Science Report SC050021/SR3 *'Updated technical background to the CLEA model'* provides a detailed assessment of pathways and assessment and human exposure rates to source contaminants. In summary, there are three principal pathway groups for a human receptor:

Table summarising likely pathways	
Principal pathways	**Detail**
Ingestion through the mouth	Ingestion of air-borne dusts
	Ingestion of soil
	Ingestion of soil attached to vegetables
	Ingestion of home grown vegetables
Inhalation through the nose and mouth.	Inhalation of air-borne dusts
	Inhalation of vapours
Absorption through the skin.	Dermal contact with dust
	Dermal contact with soil
Table 8.4	

8.4.1.2 The site will be redeveloped for commercial/industrial use and will be predominantly surfaced in buildings/hardstandings, which will severely restrict pathways from potentially contaminated soils to human receptors. Pathways associated with the consumption of vegetables will not be viable.

8.4.1.3 All of the above pathways are considered potentially viable for construction operatives with the exception of those associated with the consumption of vegetables.

8.4.1.4 A summary of our pathway assessment is presented in Section 8.4.4.

8.4.2 Pathways to vegetation

8.4.2.1 Guidance published by the Environment Agency in Science Report SC050021/SR (Evaluation of models for predicting plant uptake of chemicals from soil) provides a detailed assessment of plant uptake pathways. In summary, plants are exposed to contaminants in soils by the following pathways:

- Passive and active uptake by roots.
- Gaseous and particulate deposition to above ground shoots.
- Direct contact between soils and plant tissue.

8.4.2.2 All of the above routes of exposure are considered to be present for vegetation.

8.4.3 Pathways to controlled waters

8.4.3.1 A number of pathways exist for the transport of soil contamination to controlled waters. A summary of these pathways is presented below:

- Percolation of water through contaminated soils.
- Near-surface water run-off through contaminated soils.
- Saturation of contaminated soils by flood waters.

8.4.3.2 Near surface soils comprised both granular and cohesive deposits and are therefore likely to exhibit variable permeability. On this basis, both percolation and near surface water run-off through contaminated soils are considered to be potentially viable pathways. However, no surface water receptors have been identified and therefore we have not considered the run-off pathway further.

8.4.3.3 Envirocheck reports that the site is not located within a flood zone and therefore saturation of contaminated soils by flood waters is not considered to be a potentially viable pathway.

8.4.4 Summary of identified likely pathways

8.4.4.1 Based on the above assessments, the following table summarises likely pathways of potential chemical contaminants at the site to identified receptors.

Table of likely pathways

Receptor group	Critical receptor	Pathway
Proposed site users and construction operatives	Adult	Ingestion of air-borne dusts
		Ingestion of soil
		Inhalation of air-borne dusts
		Inhalation of vapours
		Dermal contact with dust
		Dermal contact with soil
Vegetation		Root uptake, deposition to shoots and foliage contact.
Controlled waters	Groundwater	Percolation of water through contaminated soils

Table 8.4.4

8.5 Assessment of sources of chemical contamination

8.5.1 Introduction

8.5.1.1 Initially, potential sources of contamination are assessed using the following elements of the investigation process.

- History of the site
- Desk study information
- Site reconnaissance
- Geology
- Fieldwork

8.5.1.2 These elements will dictate a relevant soil/water testing regime to quantify possible risks of any identified contaminative sources which may harm identified receptors.

8.5.2 Source assessment – History of the site

8.5.2.1 The history of the site and its immediate surroundings based on published Ordnance Survey maps is described in Section 3.

8.5.2.2 Based on published historical maps the site formed part of the former Royal Naval Air Station HMS Daedalus from the 1930s, which also extended onto adjacent sites. The airfield was recorded on the adjacent site to the north.

8.5.2.3 This former site usage is included in 'Industry Profiles' *Airports* published by the Department of the Environment, which provides an indication of the type of chemical contaminants likely to be used by the industry. It suggests that hydrocarbons, solvents, polychlorinated biphenyls and glycols are common contaminants associated with this industry. Clearly, the possibility of potential soil contamination from this former land use would be dependent upon the management of the potential contaminants within this former industry. At this stage we have assumed there is a risk of each of the potential contaminants impacting soils at the site, and thus posing a potential risk to on site receptors.

8.5.3 Source assessment – Desk study information

8.5.3.1 Envirocheck presents a detailed database of environmental information in relation to the site including;

- Pollution incidents
- Landfill sites
- Trading activities

8.5.3.2 Envirocheck record one pollution incident within 1000m of the subject site. The incident is located 426m to the east and comprised oils impacting a pond. The incident is recorded as a category 3 – minor incident. Based on the nature of the incident and the distance from the site, in our opinion, there is unlikely to be a significant risk of contamination migrating to the subject site.

8.5.3.3 Envirocheck reports four historical/registered landfill sites within 1000m of the subject site. The sites are recorded between 530m and 830m to the east of the site and were licensed for wastes including inert, commercial, industrial and household waste. All of the licenses have now lapsed. Although such wastes have the potential be sources of contamination due to the distance from the site, it is considered unlikely any contamination would feasibly migrate to the subject site.

8.5.3.4 Envirocheck record a number of trading activities within 50m of the subject site. It is considered unlikely any significant contamination would migrate to the subject site from activities in excess of 50m. An airport, car body repairs, tyre dealers and pallet suppliers are all located some 8m from the subject site. The airport and car body repairs are considered to be potential sources of contamination. A blast cleaners is also recorded 27m to the south-west of the site. Such a source is considered unlikely to produce significant contamination capable of migrating to the subject site.

8.5.4 Source assessment – Site reconnaissance

8.5.4.1 A full description of the site and observed adjacent land uses is provided in Section 3 of this report. A plan summarising observations made on site during our site reconnaissance visit is presented on Drawing 02.

8.5.4.2 We did not observe any obvious evidence of any current or recent activities on site or adjacent sites, which provide a potential source of chemical contamination.

8.5.5 Source assessment – Geology

8.5.5.1 The geological map of the area indicates the topography local to the site is formed in deposits of River Terrace. Typically, and in our experience, the River Terrace do not exhibit any abnormal concentrations of naturally occurring chemical contaminants.

8.5.6 Source assessment - Fieldwork observations

8.5.6.1 Made Ground was encountered in a number of locations and included anthropogenic material such as concrete, brick and ash. Such materials can be potential sources of contamination and therefore we obtained samples of the potentially chemically impacted soils for subsequent laboratory testing.

8.5.7 Source assessment - summary

8.5.7.1 Based on the paragraphs above, we have identified the following potential sources of contamination:

Table summarising results of source assessment

Source	Origin of information	Possible contaminant	Probability of risk occurring	Likely extent of contamination
On site				
Historical site use – part of HMS Daedalus	Historical maps	Inorganics and organics Solvents (SVOC and VOCs) Glycols Polychlorinated biphenyls (PCBs) Hydrocarbons (TPH & BTEX)	Likely	Potentially site wide
Made Ground	Fieldwork	Inorganics and organics	Likely	Potentially site wide
Adjacent sites				
Adjacent airfield and other buildings associated with HMS Daedalus	Desk study information and site reconnaissance	Inorganics and organics Solvents (SVOC and VOCs) Glycols Polychlorinated biphenyls (PCBs) Hydrocarbons (TPH)	Likely	Local to site boundaries.

Table reference 8.5.7

8.6 Initial Conceptual Model

8.6.1 Based on our assessment of potential contaminative sources, identified receptors and viable pathways to receptors described in preceding paragraphs, we have produced an initial conceptual model in the form of a table which is presented in Appendix J.

8.6.2 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 refine the risk assessment.

8.7 Laboratory testing

8.7.1 Testing regime – Human receptors

8.7.1.1 Based on our source assessment (and our initial conceptual model) there are potential sources of chemical contamination at the site and on adjacent sites therefore laboratory testing is considered necessary.

8.7.1.2 Eight samples were submitted for measurement of organic and inorganic contaminants. In addition, the past use of the site is included in '*Airports'* produced by the Department of the Environment (now DEFRA) as part of the Industrial Profiles series. The industrial profile suggest that asbestos, hydrocarbons, glycols, SVOCs, VOCs and PCBs are commonly occurring contaminants on sites that have been used as an airport and associated buildings. Clearly, the possibility of potential soil contamination from this industry would be dependent upon past management of the potential contaminants. At this stage we have assumed there is a risk of each of the potential contaminants impacting soils at the site, and thus there is a potential (and thus a risk) of this chemical source to migrate to the subject site.

8.7.1.4 Again twelve samples were scheduled to determine the presence/absence of asbestos and three samples were scheduled to measure the concentration of each of the above remaining contaminants.

8.7.2 Testing regime – Vegetation

8.7.2.1 As described in 8.7.1 above we have scheduled testing for a suite of inorganic and organic contaminants. With reference to '*BPG Note 5 - Best Practice Guidance for Land Regeneration*' testing will include copper and zinc.

8.7.3 Testing regime – Water receptors

8.7.3.1 We have selected three soil samples for measurement of the leachable concentrations of potential contaminants. Based on our conceptual model, it is considered unlikely that naturally deposited soils at the site have been affected by artificial contamination thus we have selected three samples of Made Ground. The testing included commonly occurring inorganic and organic contaminants where they are considered a risk to water resources. In addition, based on the historic use of the site, we have also scheduled three samples to determine the concentrations of leachable TPH, VOCs, SVOCs and glycols.

8.7.3.2 It should be noted that we have only scheduled three samples for laboratory determination of leachable concentrations of contaminants described above. This in our opinion is an absolute minimum to assist in the risk assessment. Further laboratory testing would increase the accuracy of the risk assessment.

8.7.4 Scheduled testing

8.7.4.1 The following table summarises the scheduled testing, in relation to soil types and identified receptors under consideration of the conceptual model.

Sample origin	Sample type	Strata	Non targeted sampling	Scheduled testing	Critical receptor
TP02 (0.2m)	Soil	Topsoil	✓	Inorganic & organics Asbestos	All human receptors and vegetation
TP09 (0.3m)	Soil	Made Ground	✓		
TP10 (0.4m)	Soil	River Terrace	✓		
TP14 (0.2m)	Soil	Made Ground	✓		
TP18 (0.2m)	Soil	Topsoil	✓		
TP20 (0.3m)	Soil	Made Ground	✓		
TP01 (0.2m)	Soil	Made Ground	✓	Asbestos	All human receptors
TP11 (0.4m)	Soil	Made Ground	✓		
TP15 (0.1m)	Soil	Made Ground	✓		
TP17 (0.1m)	Soil	Made Ground	✓		
TP12 (0.3m)	Soil	Made Ground	✓	Inorganics and organics Glycols, PCBs, SVOCs & VOCs TPH & BTEX	All human receptors and vegetation
TP06 (0.3tm)	Soil	Made Ground	✓	Inorganics and organics Asbestos Leachable inorganics & organics Leachable: Glycols, PCBs SVOCs & VOCs TPH & BTEX	All human receptors, vegetation and water receptors.
TP11 (0.3m)	Soil	Topsoil	✓	Leachable inorganics & organics Leachable: Glycols, PCBs SVOCs & VOCs TPH & BTEX	Water receptors
TP15 (0.4m)	Soil	Made Ground	✓		
CH01 (0.2m) TP19 (0.2m)	Soil	Made Ground	✓	Glycols, PCBs SVOCs & VOCs TPH & BTEX	All human receptors and vegetation

Table reference 8.7.4

8.7.4.2 The results of laboratory determination of concentration of chemical contaminants are presented in Appendix H.

8.7.5 Criteria for assessment of test data – Human receptors

8.7.5.1 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.

8.7.5.2 Soil guideline values (SGVs) are used as a screening tool to assess the risks posed to health of humans from exposure to soil contamination in relation to land uses. Where published SGVs are not available, we have adopted Generic Assessment Criteria (GAC) and Soil Screening Values (SSV) derived by Soiltechnics and by Atkins (SSV^{ATK}). GACs have been derived by Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) and presented in *'Generic Assessment Criteria for Human Health Risk Assessment'*. GACs have been prepared for a number of metals and polycyclic aromatic hydrocarbons (PAH) and are used in preference to values produced by Soiltechnics and Atkins. The CLEA model has been used with toxicology data presented by the EA, LQM/CIEH and Atkins (in that order of preference) to derive SSVs by Soiltechnics. SSVs produced by Atkins are presented on their $ATRISK^{SOIL}$ website.

8.7.5.3 SGVs, GACs, 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 soil 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 SGV/GAC has not been exceeded.

8.7.5.4 For evaluation of test data in relation to polycyclic aromatic hydrocarbon (PAH) contamination, we have compared measured concentrations with corresponding GACs. The GAC fractions are dependent on the Soil Organic Matter (SOM) content of the soils. We have adopted the lowest GAC as an initial screening value.

8.7.5.5 For evaluation of total petroleum hydrocarbon (TPH) and BTEX contamination we have compared measured concentrations directly to the relevant SGV or GAC. For evaluation of SVOCs, VOCs, PCBs and glycols we have either directly compared concentrations to the GAC if available or we have assumed a risk of contamination should concentrations be above detectable limits.

8.7.5.6 We have followed procedures outlined by the CIEH to compare measured concentrations of inorganics, metals and PAH contaminants against 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.

8.7.5.7 We have adopted an industrial/commercial land use for proposed end users of the site.

8.7.6 Criteria for assessment of test data – Construction operatives

8.7.6.1 In the absence of guidelines we have adopted industrial guideline values for assessment of construction operatives.

8.7.7 Criteria for assessment of test data – Vegetation

8.7.7.1 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.

8.7.7.2 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.

8.7.8 Criteria for assessment of test data – Controlled waters

8.7.8.1 For interpretation of test data in relation to water receptors we have directly compared measured values with the Environmental Quality Standards (EQS) and UK Drinking Water Standards (UKDWS). In the absence of EQS or UKDWS we have adopted World Health Organisation Drinking Water Guidelines (WHODWG). Where values are not available for a contaminant, we have assumed a potential risk if concentrations are above detectable limits.

8.7.8.2 EQS values are published by the Environment Agency in their publication, "*Environment Agency technical advice to third parties on Pollution of Controlled Waters for Part 11A of the Environmental Protection Act 1990*". EQS values for most inorganic contaminants in freshwater are dictated by the hardness of the receiving watercourse. The hardness of water is a measure of the concentration of calcium carbonate in the water. Although we have not sampled water from nearby watercourses, we have reviewed the Portsmouth Water website who record the hardness for the area is approximately 308mg/l.

8.7.8.3 Using this information for List II substances (DOE Circular 7/89) we have compared the measured values with the EQS values relative to the hardness of the receiving watercourse assuming a worst case scenario of the watercourse supporting 'sensitive' aquatic life.

8.7.8.4 UKDWS are presented in the Water Supply (Water Quality) Regulations.

8.7.8.5 Following our receptor assessment (outlined in Section 8.3.5), we have adopted EQS values in preference to alternative guidelines where possible.

8.7.7 Evaluation of test data – Human receptors

8.7.7.1 Tables summarising and analysing test data are presented in Appendix I. The following table summarises the outcome of the analyses.

Table Summarising assessment of test data for Human receptors

Analysis tables	Receptor group	Critical receptor	CLEA model	Inorganic contaminants	Organic contaminants (PAH)	Organic contaminants (TPH)
1 and 2	Future site users and construction operatives	Adult	Industrial/ commercial	No exceedances	Elevated benzo(a)pyrene and dibenzo(a,h)an-thracene.	No exceedances

Table 8.7.7.1

8.7.7.2 Inorganics and Polycyclic Aromatic Hydrocarbons (PAH)

8.7.7.2.1 With reference to tables 1 and 2 in Appendix I, analysis of chemical test data with respect to critical (adult) receptors for future site uses, indicates all measured concentrations of selected contaminants and 95 percentile upper confidence limits (UCL) are below relevant adopted guideline values with the exception of benzo(a)pyrene and dibenzo(a,h)anthracene.

8.7.7.2.2 The UCL for benzo(a)pyrene was calculated as 43.7mg/kg compared to a GAC of 14mg/kg. Test results ranged from 0.1mg/kg to 57mg/kg, with two of the eight test results above the guideline value.

8.7.7.2.3 The UCL for dibenzo(a,h)anthracene was calculated as 30.6mg/kg compared to a GAC of 13mg/kg. Test results ranged from 0.1mg/kg to 40mg/kg, with two of the eight test results above the guideline value.

8.7.7.2.4 In our experience, elevated concentrations of benzo(a)pyrene and dibenzo(a,h)anthracene are commonly found in Made Ground, particularly within industrial/commercial settings.

8.7.7.3 Petroleum hydrocarbons (TPH) and semi-volatile and volatile organic contaminants (SVOCs and VOCs)

8.7.7.3.1 None of the concentrations of TPH fractions exceed industrial/commercial guideline values. In addition, none of the concentrations of VOCs and SVOCs exceed either the relevant guideline value, or, in the absence of a guideline value, detectable limits.

8.7.7.4 Glycols and polychlorinated biphenyls (PCBs)

8.7.7.4.1 All measured concentrations of glycols and PCBs are below detectable limits.

8.7.7.4 Asbestos containing material (ACM)

8.7.7.4.1 ACM was not detected in any of the samples screened.

8.7.7.5 Summary

8.7.7.5.1 Based on the above, near surface soils (Made Ground and Topsoil) exhibit a degree of PAH contamination capable of posing a risk to end users and construction operatives. Our recommendations are presented in Section 8.9.

8.7.8 Evaluation of test data – Vegetation

8.7.8.1 Comparison of test data with guideline values is presented on Tables 2 and 3 in Appendix I. None of the measured concentrations exceed the adopted guideline values with the exception of the PAHs detailed in 8.7.7.2.

8.7.8.2 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.

8.7.9 Evaluation of test data – Controlled waters

8.7.9.1 Inorganic contaminants

8.7.9.1.1 With reference to table 5 in Appendix I, none of the measured concentrations of inorganic contaminants exceed the relevant guideline outlined in Section 8.7.8.

8.7.9.2 Organic contaminants (polycyclic aromatic hydrocarbons)

8.7.9.2.1 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

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

8.7.9.3 Organic contaminants (total petroleum hydrocarbons)

8.7.9.3.1 All of the measured concentrations of TPH exceed the relevant guideline value. None of the measured concentrations of BTEX exceed the relevant guideline values.

8.7.9.3.2 Concentrations of TPH were measured at concentrations of 32µg/l, 46µg/l and 190µg/l, which exceed the UKDWS guideline value of 10µg/l. It should be noted that this is an extremely conservative guideline value based on drinking water standards. However, the site is not located in a source protection zone or in close proximity to any groundwater abstraction points.

8.7.9.4 Organic contaminants (SVOCs, VOCs and glycols)

8.7.9.4.1 None of the measured concentrations of SVOCs, VOCs and glycols exceed detectable limits or relevant guideline values.

8.7.9.5 Summary

8.7.9.5.1 Based on the above evaluation, we are of the opinion that the near surface soils exhibit a degree of hydrocarbon contamination capable of being a risk to groundwater.

8.8 Updated conceptual model

8.8.1 Having now completed analysis of laboratory testing, we can now update our conceptual model which is presented in Appendix J.

8.8.2 Based on the conceptual model there are risks which exceed the low category which in our opinion are unacceptable, and require remedial action which is discussed below.

8.9 Remedial action

8.9.1 Based on the above elevated concentrations of PAH and leachable TPH have been identified within near surface Made Ground/Topsoil deposits. The concentrations potentially pose a risk to end users, construction operatives and groundwater.

8.9.2 The majority of the site will be surfaced in buildings/hardstandings, which will sever the pathway between end users and contaminated soils. In addition, hard surfacing across the site will prevent infiltration of rainwater, which will prevent the percolation of rainwater into the ground and the formation of leachates.

8.9.3 Should any landscaped areas be proposed within the development, we recommend either introduction of a 600mm capping layer comprising 450mm impermeable soils or removal of all Made Ground/Topsoil in these areas. In areas of extensive landscaping it will likely be more economically viable to undertake additional testing and assessment of the soils to minimise disposal.

8.9.4 With regard to construction operatives, we recommend the adoption of adequate hygiene precautions.

8.10 Risk assessment in relation to use of infiltration systems

8.10.1 With reference to Environment Agency publication '*Groundwater protection: Policy and practice (GP3)* 2012, outside of SPZ1, the EA will support sustainable drainage systems for new discharges to ground. This is subject to an appropriate risk assessment to demonstrate that ground conditions are suitable and infiltration systems do not present an unacceptable risk of promoting mobilisation of contaminants or creating new pathways for contaminant migration.

8.10.2 As leachable hydrocarbons have been identified in Made Ground, we recommend all soil infiltration systems are sealed through Made Ground and allow water to drain into natural soils only. All discharges to groundwater are subject to compliance with the Water Framework Directive (2000/60/EC) and Groundwater Daughter Directive (2006/118/EC). We recommend advise and agreement is sought from the EA regarding the use of soakaways on site.

8.11 Risk assessment summary and recommendations

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

8.11.2 End users

8.11.2.1 Providing the site is completely surfaced in buildings/hardstanding in our opinion, there is unlikely to be a significant risk to end users. Should landscaped areas be proposed, we recommend either removal of Made Ground or introduction of a capping layer to sever the pathway between end users and Made Ground soils. In areas of extensive landscaping it will likely be more economically viable to undertake additional testing and assessment of the soils to minimise disposal.

8.11.3 Construction operatives and other site investigators

8.11.3.1 The risk of damage to health of construction operatives and other site investigators is, in our opinion, moderate and would be minimised by taking adequate hygiene precautions 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.

8.11.3.2 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).

8.11.3.3 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.

8.11.3.4 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.

8.11.4 Controlled waters

8.11.4.1 The presence of buildings/hardstanding across the site will severely restrict leachate formation at the site. Should any landscaped areas be proposed, we recommend either removal of Made Ground or introduction of an impermeable capping layer to prevent infiltration of rainwater and therefore leachate formation.

8.11.5 Vegetation

8.11.5.1 Elevated concentrations of PAH have been identified within Made Ground soils. We recommend that the test results presented in this report are passed to a landscape architect for the selection of suitable planting.

8.12 Statement with respect to National Planning Policy Framework

8.12.1 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 121, and compliant with the Building Regulations Part C, '*Site preparation and resistance to contaminants and moisture*'

8.13 On Site Monitoring

8.13.1 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 of safely proceed.

9 Gaseous contamination

9.1	Legislative framework
9.2	General
9.3	Assessment of source of gases
9.4	Gas migration
9.5	Conceptual model
9.6	Development categorisation
9.7	Monitoring observations
9.8	Classification of site characteristic gas situation
9.9	Gas protective measures – new buildings
9.10	Statement with respect to National Planning Policy Framework

9.1 Legislative framework

9.1.1 There is currently a complex mix of documentation relating to legislative and regulatory procedures on the issue of contamination, and it is not considered a purpose of this report to discuss the detail of these regulations. Essentially, Government Policy is based on *'suitable for use approach',* which is relevant to both the current and proposed future use of land. For current use Part IIA of the Environmental Protection Act 1990 provides the regulatory regime (see Section 8.1). The presence of harmful soil gases could provide a 'source' in a 'pollutant linkage' allowing the regulator (Local Authority) to determine if there is a significant possibility of harm being caused to humans, buildings or the environment. Under such circumstances the regulator would determine the land as 'contaminated' under the provision of the Act requiring the remediation process to be implemented with the Environment Agency responsible for enforcement.

9.1.2 The Town and Country Planning (General Development Procedure) Order 1995, requires the planning authority to consult with the Environment Agency before granting planning permission for development on land within 250 metres of land which is being used for deposit of waste, (or has been at any time in the last 30 years) or has been notified to the planning authority for the purposes of that provision.

9.1.3 Building control bodies enforce compliance with the Building Regulations. Practical guidance is provided in Approved documents, one of which is Part C, '*Site preparation and resistance to contaminants and moisture'* which seeks to protect the health, safety and welfare of people in and around buildings, and includes requirements for protection against harm from soil gas.

9.2 General

9.2.1 The following assessment relates to the potential for, and the effects of, gases generated by biodegradable matter. A separate, but related class of problem involves migration of vapour phase of hydrocarbons resulting from spillages of petroleum and solvents, but this is addressed under organic contamination in Section 8. The potential for the development to be affected by radon gas is considered in Section 3. The principal ground gases are carbon dioxide (CO_2) and methane (CH_4). The following table provides a summary of the effects of these gases when mixed with air.

Significant gas concentrations in air		
Gas	**Concentration by volume**	**Consequence**
Methane	0.25%	Ventilation required in confined spaces
	5%	Potentially explosive when mixed with air
	30%	Asphyxiation
Carbon Dioxide	0.5%	8 hour long term exposure limit (LTEL) (HSE workplace limit)
	1.5%	15 min short term exposure limit (STEL) (HSE workplace limit)
	>3%	Breathing difficulties
	>5%	Death can occur

Table 9.2.1

9.2.2 Following the current Building Regulations Approved Document C1, Section 2 *'Resistance to Contaminants'* (2004 incorporating 2010 and 2013 amendments) a risk assessment approach is required in relation to gaseous contamination based on the source-pathway-receptor conceptual model procedure. We have adopted procedures described in the following reference documents for investigation and assessments of risk of the development being affected by landfill type gases (permanent gases) and if appropriate the identification of mitigation measures.

- BS10175:2011 *'Investigation of potentially contaminated sites- Code of Practice'.*
- BS8576: 2013 '*Guidance on investigations for ground gas –Permanent gases and Volatile Organic Compounds (VOCs)'*
- BS8485: 2007 '*British Standard Code of practice for the characterisation and remediation from ground gas in affected developments'*
- CIRIA Report C665 '*Assessing risks posed by hazardous ground gases to buildings'* (2007)**.**
- NHBC report No 10627-R01(04) '*Guidance on development proposals on sites where methane and carbon dioxide are present'* (January 2007)

9.2.3 An assessment of the risk of the site being affected by ground gases is based on the following aspects.

a) Source of the gas
b) Investigation information
c) Migration feasibility
d) Sensitivity of the development and its location relative to the source

9.3 Assessment of source of gases

9.3.1 General sources

9.3.1.1 The following table summarises the source of gases and parameters for producing gases.

Source and control of gases	
Type	**Parameters affecting the rate of gassing**
Landfills	Portion of biodegradable material, rate reduces with time.
Mine workings	Flooding reduces rate of gassing
Dock silt	Portion of organic matter
Carbonate deposits	Ground/rainwater (acidic) reacts with some carbonates to produce carbon dioxide.
Soils/rocks	Portion of organic matter

Table 9.3.1

9.3.1.2 The rate of decomposition in gas production is also related to atmospheric conditions, pH, temperature, and water content/infiltration.

9.3.1.3 As the site is not within a dockland environment or an area affected by mineworkings, and near surface soils do not exhibit high carbonate content, then potential gas sources are limited to landfills and/or soils with a high proportion of organic matter.

9.3.2 Landfill sources

9.3.2.1 Waste Management Paper 27 (1991) produced by the Department of the Environment '*Control of Landfill Gases*' contains the recommendation to avoid building within 50m of a landfill site actively producing large quantities of landfill type gases and to carry out site investigations within a zone 250m beyond the boundary of a landfill site. No distinction is made between sites of differing ground conditions, but the paper does not advocate the site is safe beyond the 250m zone, dependent, of course, upon the type of landfill and potential for migration of landfill gases.

9.3.2.2 Envirocheck reports four historical/registered landfill sites within 1000m of the subject site. The sites are recorded between 530m and 830m to the east of the site and were licensed for wastes including inert, commercial, industrial and household waste. All of the licenses have now lapsed. Such materials have the potential to produce significant concentration of landfill type gases and on this basis, there is a potential risk to the site from this potential source.

9.3.3 Soil conditions

9.3.3.1 None of the soils observed in exploratory excavations, in our opinion, exhibit significant concentrations of organic matter which are likely to produce elevated quantities of carbon dioxide and/or methane gas.

9.3.3.2 Based on an assessment of 'deep' geological conditions we are of the opinion that it is unlikely that the subject site would be affected by significant quantities of carbon dioxide and methane generated by soils/rocks at depth.

9.3.4 Source assessment summary

9.3.4.1 The following table summarises the possibility of a source of landfill type gases.

Source assessment summary		
Potential source origin	**Viability of source**	**Evidence**
Landfills	Possible	Desk study information Landfill recorded 530m to the east.
Mineworkings	Unlikely	Desk Study information Geological conditions not amenable
Dock silt	Unlikely	Site remote from dockland environment
Carbonate deposits	Unlikely	Recorded and observed soil conditions do not indicate high concentrations of carbonates
Soils / rocks	Unlikely	Soils exposed in exploratory excavations do not exhibit high concentrations of organic matter

Table 9.3.4

9.3.4.2 Based on the above it there is a possibility of a source of potential landfill gases which may affect the subject site. On this basis, it is considered necessary to consider possible pathways for migration of ground gases, from this potential source to the site.

9.4 Gas migration

9.4.1 Exploratory excavations encountered a reasonably consistent deposit of River Terrace to depths of in excess of 3m, which in our opinion are relatively permeable and would provide little resistance to both lateral and vertical migration of landfill type gases. In addition, based on published geological records the River Terrace extend between the subject site and the landfilll sites. On this basis it is considered possible that landfill gases could feasibly migrate to the subject site from this potential source.

9.5 Conceptual model

9.5.1 Based on the above, there is a potential source of landfill type gases, and a feasible migration pathway to the site via potentially permeable River Terrace. Our conceptual model is tabled below. On this evidence we are of the opinion that the site is at risk of being affected by ground gases (carbon dioxide/methane) sufficient to potentially cause harm to human end users of the site, construction operatives or indeed buildings. On this basis, we have installed monitoring standpipes in boreholes, and implemented a monitoring regime, generally following procedures described in CIRIA report C665, to quantify the risk, and if appropriate, identify mitigation measures.

Conceptual model		
Potential source origin	**Potential pathway**	**Receptors at risk**
Landfills Restored opencast quarry 250m from site – source of backfill not known.	Via sands and gravels	End users Construction operatives Buildings
Table 9.5.1		

9.6 Development categorisation

9.6.1 With reference to BS 8485:2007 (table 2), the proposed development would be classified as *'Commercial buildings'.*

9.7 Monitoring observations.

9.7.1 Five standpipes have been installed at the site to depths between 1.9m and 2.0m (refer Drawing 05). Following CIRIA Report C665 (tables 5.5a, and 5.5b) we have assessed the site as moderate risk of generation potential of source ideally requiring three monitoring visits over a one month period. We have initially proposed two monitoring visits be undertaken at the site, with additional visits to be undertaken should it be considered necessary.

9.7.2 Only one borehole could be monitoring during our first site visit due to access issues. We subsequently returned on two further occasions to obtain readings from each standpipe. The measurements of landfill type gases were recorded at atmospheric conditions in the range of 1016 to 1025mb and temperatures in the range of 15°C to 17°C. Our observations/measurements are recorded in Appendix K. Essentially concentrations of methane were below detectable levels and concentrations of carbon dioxide were measured in the range of 1.4% to 3.5%. If flows were detected during our monitoring visits then these are recorded, but where no flow is detected then, following BS8485:2007, we have assumed flow at the detection limit of the monitoring equipment at 0.1l/s.

9.7.3 Gas monitoring results reported in appendix K can be summarised as follows in respect to steady concentrations of carbon dioxide and methane.

Test point	Methane			Carbon dioxide		
	Maximum concentration, C_{hg}, (%)	Maximum flow, q (l/hr)	Maximum gas flow rate, Q_{hg}(l/hr)	Maximum concentration, C_{hg}, (%)	Maximum flow, q (l/hr)	Maximum gas flow rate, Q_{hg}(l/hr)
DTS01	0.0	0.1	0.0	2.8	0.1	$2.8x10^{-3}$
DTS02	0.0	0.1	0.0	3.4	0.1	$3.4x10^{-3}$
DTS03	0.0	0.1	0.0	3.1	0.1	$3.1x10^{-3}$
DTS04	0.0	0.1	0.0	3.3	0.1	$3.3x10^{-3}$
DTS06	0.0	0.1	0.0	2.7	0.1	$2.7x10^{-3}$
All points	0.0	0.1	0.0	3.4	0.1	$3.4x10^{-3}$
Table 9.7.3						

9.8 Classification of site characteristic gas situation.

9.8.1 Using test data and with reference to table 1 of BS8485:2007, the site would be classified as characteristic gas situation 1.

9.8.2 Clearly further monitoring will increase the accuracy of this risk assessment, however in our opinion we have followed current best practice 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 at least '*adequate*', and more likely '*comprehensive*' as defined in section 5.5 of BS8485:2007.

9.8.3 In addition we have assessed the sufficiency of data in accordance with annex F of BS8576:2013. The following table summarises our assessment.

Action	Result
From current results (concentration, flow rates and pressure) estimate likely risk associated with ground gas (note steady state flow results are to be used, not peak values that only last a few seconds on opening the gas tap)	Current estimate of risk GSV = gas concentration x borehole flow rate. CSV = 3.4/100 x0.1 = 0.0034l/hr Characteristic situation CS1 (maximum limit is 0.7l/hr
What increase in gas concentration is required to increase the estimated risk and level of gas protection to be provided?	Estimate increase in gas concentration Keeping the flow rate constant, the gas concentration would need to exceed 100% to move into the next band. This is not feasible.
What increase in flow rate is required to increase the estimated risk and level of gas protection to be provided?	Estimate increase in flow rate: Keeping the concentration constant, the flow rate would need to exceed 20.50l/hr to move into the next risk band, i.e needs to increase 200 times. From current data and knowledge of the gas source and generation potential, this is not considered feasible.
Is the increase in gas concentration feasible given the known source of the gas?	No It is not possible for the methane or carbon dioxide concentration to exceed 100%.
Is the increase in flow rate feasible when compared to gas generation and migration model results, the collected gas monitoring data and the conceptual site model?	No Source of possible landfill type gases comprises landfills located in excess of 500m from the subject site. Due to the distance from the site it is considered unlikely such significant increases in gas concentration is likely to occur at the subject site. In addition, ground water variations are likely to be the main variable affecting flow rate. No groundwater was encountered in any of the monitoring standpipes and thus it is considered unlikely such a significant increase in flow would occur at the site.
Decide whether further monitoring is required.	Based on the above analysis, further gas monitoring is not required.

Table 9.8.3

9.9 Gas protective measures – new buildings.

9.9.1 Based on monitoring, development categorisation (section 9.6 above), and the site characteristic gas situation (section 9.8 above) and with reference to table 2 of BS8485:2007, the development does not require any gas protective measures.

9.10 Statement with respect to National Planning Policy Framework

9.10.1 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 121, 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	Reference documents
10.3	Hazard identification and assessment
10.4	Provision of test data to specifiers/manufacturers/installers
10.5	Risk assessments for individual building materials
10.6	Concrete – general mechanisms of attack
10.7	Concrete – sulphate attack
10.8	Concrete – chloride attack
10.9	Concrete – acid attack
10.10	Concrete – magnesium attack
10.11	Concrete – ammonium attack
10.12	Concrete blocks
10.13	Clay bricks/pipes
10.14	Mortar
10.15	Metals – general
10.16	Metals – cast iron
10.17	Metals – steel piles
10.18	Metals – stainless steel
10.19	Metals – galvanised steel
10.20	Metals – copper
10.21	Metals – lead
10.22	Plastics – general
10.23	Plastic membranes and geotextiles
10.24	Plastic pipes
10.25	Electrical cables
10.26	Rubbers

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, with other items considered outside our brief and scope of investigations.

10.1.3 In aggressive ground conditions, the potential for contaminant attack depends on the following:

- The presence of water as a carrier of chemical contaminants, (except free phase organic contamination).
- The availability of the contaminant in terms of solubility, concentration and replenishment rate.
- Contact between the contaminant and the building material.
- The nature of the building materials and its capability of being attacked by contaminants.

10.1.4 In general the thicker the building material the less likelihood there is for contaminant attack to cause damage to the integrity of the structure.

10.2 Reference documents

10.2.1 Following the Environment Agency publication *'Model Procedures for the Management of Land Contamination'* (Contaminated Land Report 11) the following documents have been referred to in production of the following report paragraphs.

- *'Performance of Building Materials in Contaminated Land'* report BR255 (Building Research Establishment 1994).
- *'Risks of Contaminated Land to Buildings, Building Materials and Services. A Literature Review'* - Technical Report P331 (Environment Agency 2000).
- *'Guidance on assessing and managing risks to buildings from land contamination'* - Technical Report P5 035/TR/01).
- Building Regulations Approved document C - site preparation and resistance to contaminants and moisture (Office of the Deputy Prime Minister, 2004).
- *'Concrete in aggressive ground'* Special Digest 1: 2005 (Building Research Establishment).

10.3 Hazard identification and assessment

10.3.1 The identification of hazards is based on the findings of this investigation primarily relating to former land uses (potential for chemical contamination, and likely type of contamination) and laboratory determination of concentration of chemical contaminants. Clearly, the scope of laboratory testing is determined with respect to former land uses, contaminants which may cause harm to human health and water resources.

10.3.2 Based on the above, the scope of our testing regime is described in Sections 8. We have utilised this test data in production of the following risk assessments in relation to building materials, in conjunction with test data targeting the effects of chemical attack on concrete in contact with the ground, as described in BRE Special Digest 1.

10.3.3 The identification of hazards from contamination and subsequent assessment of risks is based on the following:

- The contaminants present on site.
- The nature of the contaminant (i.e. calcium sulphate is much less soluble than sodium or magnesium sulphate and is, therefore, less of a concern with regards sulphate attack).
- The concentration of contaminants - in general the higher the concentration the greater the hazard.
- The solubility of the contaminants - contaminants which are not soluble will not generally react with materials.
- The permeability of the soils - i.e. ease by which fluids can transport contaminants to the building.

10.3.4 The process of risk assessment for building materials is concerned with identification of the hazard (contaminants at the site - a source) and subsequently how the contaminants can reach the building (pathway) and how they can react with the building (receptor). Thus the risk assessment is produced based on the source - pathway - receptor model.

10.4 Provision of test data to specifiers/manufacturer/installer

10.4.1 The following risk assessments are based on current published data. We strongly recommend, however, that information gained from this investigation are provided to specifiers/manufacturers/installers of building materials/service ducts/apparatus who may have more up to date research to confirm the ability of the product to resist the effects of chemical contaminants at the site for the desired lifespan of the product.

10.5 Risks assessments for individual building materials

10.5.1 The following/typical sections contain risk assessments for various building materials likely to be incorporated in developments. Other materials which we are not aware of may also be used in developments and in contact with the ground and, therefore, recommend the suppliers are consulted with respect to ground conditions at this site and their opinion sought as to the ability of the product to resist chemical conditions determined at the site.

10.6 Concrete - General mechanisms of attack

10.6.1 There are a number of mechanisms by which contaminants attack concrete including the following:

- Hydrolysis of the hardened concrete.
- Degradation as a result of exchange reactions between calcium in calcium hydroxide (free lime hydrate) and ions in aggressive solutions.
- Expansive reactions as a result of chemical reaction or salt crystallisation.

10.7 Concrete - Sulphate attack

10.7.1 Hazard

10.7.1.1 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 alluminate and sulphite ions.
- Thaumasite formation as a result of reactions between calcium silicate hydrates, carbonate ions (from aggregates) and sulphate ions.

10.7.2 Assessment

10.7.2.1 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.

10.7.3 Desk Study Information

10.7.3.1 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 10.7			

10.7.3.2 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.

10.7.3.3 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*').

10.7.4 Assessment of Design Sulphate Class

10.7.4.1 The sulphate concentration in a 2:1 water/soil extract was measured in one composite sample of Made Ground and three samples of River Terrace**.** The highest test result has been used as the characteristic value (refer to table 10.7.7). The measured values are not considered to be significantly variable.

10.7.4.2 The concentration of sulphate was measured at less than 3000mg/l and thus the concentration of magnesium was not measured.

10.7.5 Assessment of groundwater mobility

10.7.5.1 With reference to SD1: 2005, Section C3.2, we are of the opinion that ground and site characteristics suggest 'mobile groundwater' conditions.

10.7.6 Assessment of pH

10.7.5.1 Following SD1: 2005, Section C5.1.1 (step 4) only a 'small number' of samples have been tested and thus the characteristic value for pH within Made Ground and River Terrace equates to the lowest measured values of 6.8 and 7.8 respectively.

10.7.6.2 None of the measured pH values were below 5.5, thus the concentration of chlorides and nitrates was not measured.

10.7.7 Assessment of aggressive chemical environment for concrete (ACEC)

10.7.7.1 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 10.7.2 below.

Summary of concrete classification

Soil type	No. of samples	Characteristic pH	Groundwater mobility	Characteristic TPS	Characteristic sulphate (mg/l)	DS class	ACEC class
Made Ground	1	6.8	Mobile	N/A	<10	DS-1	AC-1
River Terrace	3	7.3	Mobile	N/A	<10	DS-1	AC-1

Table reference 10.7.7

10.8 Concrete - Chloride attack

10.8.1 Hazards

10.8.1.1 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.

10.8.2 Risk assessment

10.8.2.1 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.

10.8.2.2 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.

10.9 Concrete - Acid attack

10.9.1 Hazards

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

10.9.2 Risk assessment

10.9.2.1 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

10.9.2.2 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.

10.9.2.3 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.

10.10 Concrete - Magnesium attack

10.10.1 Hazards

10.10.1.1 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.

10.10.2 Risk assessment

10.10.2.1 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.

10.10.2.2 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.

10.11 Concrete - Ammonium attack

10.11.1 Hazards

10.11.1.1 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.

10.11.2 Risk assessment

10.11.2.1 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.

10.11.2.2 As the site has no history which provides evidence of the uses of ammonia on site, in our opinion the risk of concrete being affected by ammonia is considered low.

10.12 Concrete blocks

10.12.1 Hazards

10.12.1.1 Precast aggregate concrete blocks and autoclaved aerated concrete blocks are commonly used in the construction of shallow foundations. Concrete blocks are potentially attacked by the same contaminants and ground conditions which affect dense concrete.

10.12.2 Risk Assessment

10.12.2.1 In general, the mechanism of attack on concrete blocks is the same for hardened concrete. We recommend parameters for ground conditions for concrete described in the preceding paragraphs for concrete blockwork in contact with the ground/groundwater and the blockwork manufacturers confirmation sought for applicability of their product.

10.13 Clay Bricks/Pipes

10.13.1 Clay Bricks are highly durable materials which have been used in buildings for many centuries. Fire clay pipe material can also be considered similarly resistant to contaminants.

10.13.2 Hazards

10.13.2.1 Dissolution of clay brick is a potentially serious cause of deterioration. The extent of dissolution depends upon the solubility of the glassy material (produced by firing of the clay) contained in the brick. The acidic nature of the glass phase will produce low solubility in a neutral and acidic environment, but can be soluble in a basic environment.

10.13.2.2 A potentially more serious hazard for brickwork is the crystallisation of soluble salts within the brick pore structure. Salts are transported by water to the interior of the brick originating from the external environment or by rehydration, however, are only likely to occur when there is a gradient from a wet interior to a drying surface. The potential, therefore, for salt crystallisation in the ground is, therefore, low.

10.13.3 Risk Assessment

10.13.3.1 There seems to be little published information as regards the resistance to clay bricks/pipes in aggressive ground conditions, however, clay bricks are generally considered very durable. We recommend manufacturers' advices are sought with respect to their resistance to ground conditions encountered at this site.

10.13.3.2 Some basic guidance is provided in BS5628-3: 2005 '*Code of Practice for the Use of Masonry - Part 3: Materials and components, design and workmanship'* with regards to resistance of masonry to resist the effects of sulphate attack.

10.14 Mortar

10.14.1 Mortars are based on building sands mixed with cement and/or lime as a binder. In the UK Portland cements and masonry cement are commonly used. Masonry cements are a mixture of Portland Cements and fine mineral filler (i.e. limestone) with an air entraining agent.

10.14.2 Hazards

10.14.2.1 Mortar is subject to the same agents for deterioration as concrete with the major cause of deterioration being sulphate attack.

10.14.3 Risk assessment

10.14.3.1 Sulphates can originate from soils/groundwater or from the bricks themselves. Calcium, magnesium, sodium and potassium sulphates are present in almost all fired-clay bricks. Water can dissolve a fraction of these sulphates and transport them to the mortar.

10.14.3.2 Currently, we are not aware of any guidance on the resistance of mortars to sulphate attack. The Building Research Establishment report that the sulphate resistance of mortar was improved by the use of sulphate resisting Portland cements and lime. Some guidance is also provided in BS5628-3: 2005 *'Code of Practice for the use of Masonry - Part 3: Materials and components, design and workmanship'.*

10.14.3.3 Based on ground conditions determined at the site the risk of significant sulphate attack on mortars (Based on testing/analysis of sulphates in relation to concrete - refer Section 10.7) is considered low.

10.15 Metals - general

10.15.1 There are a number of metals which are used in buildings either as piles, services, non-structural and, indeed, structural components. The most common metals used in buildings are steel, stainless steel, copper, lead, zinc, aluminium and cast iron. All these metals can deteriorate through the corrosion process. Corrosion can affect metals in a variety of ways depending upon the nature of the metal and the environment to which it is subjected. In most common forms of corrosion are:

- Electrochemical - the most common form of corrosion in an aqueous solution.
- Chemical corrosion - occurs when there is a direct charge transfer between the metal and the attacking medium (examples are oxidation, attack by acids, alkalis and organic solvents).
- Microbial induced corrosion.

10.16 Metals - Cast iron

10.16.1 Cast iron is a term to describe ferrous metals containing more than 1.7% carbon and is used extensively in the manufacture of pipes.

10.16.2 Hazards

10.16.2.1 Generally, cast iron has a good resistance to corrosion by soils, however, corrosion can occur due to the following mechanisms:

1) Generation of large scale galvanic cells caused by differences in salt concentrations, oxygen availability or presence of stray electrical currents.

2) Hydrochloric acid will cause corrosion at any concentration and temperature. Dilute sulphuric, nitric and phosphoric acids are also aggressive as also are well aerated organic acids.

10.16.3 Risk assessment

10.16.3.1 Testing can be carried out on site to measure the resistivity and redox potential of soils which can assist in deriving recommendations for protection of cast iron components using coatings, burial trenches, or isolation techniques. Currently, however, there is no specific guidance and we recommend advice is sought from manufacturers.

10.16.3.2 Guidelines produced by the Water Research Centre (WRc) on the use of ductile iron pipes, state that highly acidic soils (pH <5) are corrosive to cast iron pipe even when protected by a zinc coating or polythene sleeving. WRc also indicate that groundwater containing >300ppm chloride may corrode even protected cast iron pipes.

10.16.3.3 On the basis that the pH of soils at the site are not less than 5, and groundwater is unlikely to be in contact with cast iron elements, then the risk of ductile cast iron pipes being affected by acid/chloride attack is considered low. We have not carried out any redox/resistivity testing (considered outside our brief) and thus we cannot comment further with regards to the risks of galvanic action.

10.17 Metals - Steel piles

10.17.1 Hazards

10.17.1.1 The corrosion of steel requires the presence of both oxygen and water. In undisturbed natural soils the amount of corrosion of driven steel piles is generally small. In disturbed soils (Made Ground) however, corrosion rates can be high and normally twice as high as those for undisturbed natural soils.

10.17.2 Risk Assessment

10.17.2.1 Guidance on the use of steel piles in different environments is provided in British Steel's piling handbook which includes calculating the effective life of steel piles. There is no specific guidance, however, for contaminated soils in this publication. Coatings can be provided to the pile surface but experience has shown that some coatings can be damaged during driving, particularly in ground which can contain hard materials such as brick/concrete/stone.

10.18 Metals - Stainless steel

10.18.1 Hazards

10.18.1.1 Stainless steel is used in a number of building components including services, pipework, reinforcement bars and wall ties. There is little knowledge, however, of the performance of stainless steel in aggressive environments.

10.18.2 Risk assessment

10.18.2.1 Stainless steel can withstand pH of 6.5 to 8.5, but the chlorine content of a soil increases the risk of corrosion. At concentrations of 200mg/l type 304 stainless steel can be used, but for concentrations of 200 to 1000mg/l type 316 should be used in preference to type 304, but for concentrations greater than 1000mg/l type 316 should always be used.

10.18.2.2 At this site the pH of the soils was near neutral (within the range of 6.5 to 8.5) and it is considered unlikely that groundwater will be in contact with stainless steel components (unless we are advised otherwise) thus the risk of ground conditions at the site affecting stainless steel is considered low.

10.19 Metals - Galvanised steel

10.19.1 Hazards

10.19.1.1 Galvanising steel is a means of protecting steel from aggressive environments; however, zinc galvanising can be corroded by salts and acids.

10.19.2 Risk assessment/remedial action

10.19.2.1 There is no current specific guidance on the effects of aggressive ground conditions on galvanised steel, however, some research indicates zinc alloys are generally more resistant than pure zinc coatings in aggressive conditions.

10.20 Metals - Copper

10.20.1 Hazards

10.20.1.1 Copper is commonly used for gas and water supplies. Copper is generally resistant to corrosion in most natural environments, but in contaminated ground copper can be subject to corrosion by acids, sulphates, chlorides and ground containing cinders/ash. Wet peat (pH 4.6) and acid clays (pH 4.2) are considered aggressive conditions to promote corrosion to copper.

10.20.2 Risk assessment

10.20.2.1 There is no specific published guidance on what constitutes aggressive conditions to copper except very acid/peaty conditions.

10.20.2.2 Although there are no significantly acidic or peaty conditions at the site, there are significant concentrations of ash/cinders which may lead to the risk of corrosion. We recommend manufacturers are consulted possibly to provide a coating to the pipe or possibly installation of the pipe in a trench with clean backfill.

10.21 Metals - Lead

10.21.1 Hazards

10.21.1.1 Lead is used in tanking, flashings, damp proof courses, etc. Lead is a durable material which is resistant to corrosion in most environments. Lead damp proof courses can be subject to attack from the lime released by Portland Cement based mortar and concrete. In the presence of moisture, a slow corrosive attack is initiated on lead sheet. In such cases a thick coat of bitumen should be used to protect the lead damp proof course.

10.21.2 Risk assessment

10.21.2.1 There is no current guidance on the performance of lead in contact with contaminated soils, however, acids and alkalis (lime) could be aggressive towards lead.

10.21.2.2 At the site pH conditions are not considered significantly extreme and thus it is considered unlikely that ground conditions at the site would significantly affect lead.

10.22 Plastics - General

10.22.1 The range of plastics in construction is wide and increasing. The deterioration of plastics varies with the individual material and the environment to which it is exposed. In general, plastics deteriorate through degradation of their polymer constituent, but loss of plasticizer and other additives can render plastics ultimately unserviceable.

10.23 Plastic membranes and geotextiles

10.23.1 Plastic membranes and textiles are used in the construction industry as damp proof courses, gas resistant membranes, cover systems and liners. They are typically used to restrict the movement of gas or water into buildings, building materials or components or to separate differing soil types. Typically materials used for membranes are polyethylene (PE) and poly vinyl chloride (PVC).

10.23.2 Hazards

10.23.2.1 Membranes of PE and PVC are attacked by a variety of acids and solvents. PE has a poor corrosion resistance to oxidising acids (nitric and sulphuric) at high concentrations. Hydrochloric acid (HCl) does not chemically attack PE but can have a detrimental effect on its mechanical properties. Alkalis, basic salts, ammonia solutions and bleaching chemicals such as chlorine will cause deterioration of PE. PE is resistant to non-oxidising salt solutions.

10.23.2.2 PVC is degraded by the action of oxidising acids. Nitric acid is particularly aggressive towards PVC. PVC does not deteriorate under the action of neutral or alkaline solutions.

10.23.3 Risk assessment

10.23.3.1 There is no published guidance on quantitative assessment of the risks to PE or PVC although there is a lot of advice on how contaminants react with these plastics. In general, the more concentrated the contamination the greater the risk to plastic membranes/geotextiles.

10.23.3.2 Based on the investigatory data obtained to date, and in consideration of the hazards described above, there is no evidence of significant concentrations of acids or alkalis, indicating the risks of ground conditions at the site affecting PE and PVC materials are considered low.

10.24 Plastic Pipes

10.24.1 Hazards

10.24.1.1 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 storing oxidising acids, chlorinated hydrocarbons and aromatics.
- Poly vinylidene fluoride (PVDF) - inert to most solvents, acids and alkalis as well as chlorine, bromide and other halogens.
- Polytetrafluoroethylene (PTFE) - one of the most inert thermoplastics available. PTFE has good chemical resistance to solvents, acids and alkalis.

10.24.1.2 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.

10.24.2 Assessment

10.24.2.1 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.

10.24.2.2 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'

10.24.2.3 The subject site has previously been developed and on this basis could potentially be considered brownfield in accordance with the UKWIR document. Following the preliminary risk assessment procedures described in the UKWIR document however, (paragraph 2.4.2) there is no evidence to indicate that chemicals have ever been used or stored on site.

10.24.2.4 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 within the Made Ground and on this basis it is considered likely that barrier pipes will have to be installed at this site where located within Made Ground. Barrier pipes are unlikely to be required where they are laid within River Terrace deposits. However, we recommend Portsmouth Water is consulted on this to gain their opinion and requirements.

10.25 Electrical cables

10.25.1 Hazards

10.25.1.1 Electrical cables are generally protected by plastic sleeves. These sleeves are potentially subject to chemical and permeation in similar modes as plastic pipes. Medium and low voltage cables are often laid directly into the ground and are thus at risk of attack by contaminants. High voltage cables tend to be laid in trenches backfilled with 'clean' materials.

10.25.2 Risk assessment/remedial action

10.25.2.1 The selection of appropriate sheathing material is important to provide resistance to ground conditions at the site and recommend manufacturers' advices are sought.

10.26 Rubbers

10.26.1 Hazards

10.26.1.1 Rubbers are cross-linked polymeric materials containing a number of additives such as carbon black, fillers, antioxidant and vulcanising agents. The corrosion resistance of rubber is dependent upon the polymeric constituent. The mechanisms by which rubbers deteriorate when placed in aggressive chemical environments are similar to those described for plastics. Oxidation is the principal form of degradation. Whilst rubbers are resistant to strong acids and alkalis, they are rapidly attacked by oxidising agents such as nitric acid and oxidising salts such as copper, manganese and iron.

10.26.1.2 Rubber is also susceptible to attack by certain hydrocarbons and oils. The absorption of these liquids causes the rubber to smell.

10.26.2 Risk assessment/remedial action

10.26.2.1 Information on the effect of a range of chemicals on the physical properties of various rubbers has been produced by the Rubber and Plastics Research Association. This was based on observations carried out following immersion tests using undiluted chemicals, but this has limitations such as the effects of combined chemicals and the effects of dilution.

10.26.2.2 We recommend manufacturers of the rubber materials likely to be in contact with the ground at the site are consulted to confirm, or otherwise, the applicability of their product.

11 Classification of waste soils under the Waste Acceptance Criteria

11.1	The Landfill Directive
11.2	Classification of soil types
11.3	Waste Acceptance Criteria (WAC)
11.4	Primary Classification
11.5	Secondary Classification
11.6	Naturally deposited soils not affected by artificial contaminants
11.7	Basic Categorisation
11.8	Treatment of waste
11.9	Reuse of soils - Materials Management Plans

11.1 The Landfill Directive

11.1.1 The Landfill Directive represents an important change in the way we dispose of waste. It encourages waste minimisation by promoting increased levels of recycling and recovery. The Landfill Directive became law in 1999 and was transcribed into the Landfill (England and Wales) Regulations which came into force in 2002. These Regulations were amended in 2005 by introducing criteria to classify soils for disposal to landfill. It is the duty of the waste producer (the client) to classify the soils for this purpose.

11.2 Classification of soil types

11.2.1 Our investigations consider two soil types which may be generated as wastes as part of construction operations, potentially contaminated soil and uncontaminated soil. A full hazard assessment and subsequent testing for waste acceptance criteria is undertaken on soils which are not considered to be naturally deposited or are likely to be affected by artificial contamination. For soils that are unlikely to be affected by artificial contamination (such as natural soils), specific testing in relation to the classification process is not necessary.

11.3 Waste acceptance criteria (WAC)

11.3.1 The Environment Agency publication, *'Framework for the classification of contaminated soils as hazardous wastes'* (July 2004), provides an appropriate procedure for establishing if the soils are hazardous or non-hazardous and applies to soils that are identified as potentially contaminated. Uncontaminated, natural soils are considered separately (see Section 11.6).

11.3.2 Primary classification

11.3.2.1 The first stage in classifying a potentially 'contaminated' soil for disposal to landfill is to establish its chemical status by first identifying potential sources/types of chemical contamination (desk study) followed by intrusive site investigations to obtain samples for undefined testing of soil samples to measure concentrations of chemical contaminants. Such data provides information to partly complete the basic characteristic checklist.

11.3.2.2 Laboratory test data is then compared with the Environment Agency publication '*hazardous waste – Interpretation of the definition and classification of hazardous waste (second edition, version 2.1)'.* Where the waste is suspected to contain oil, we have referred to the Environment Agency draft consultation paper *'How to Find Out if Waste Oil and Wastes that Contain Oil are Hazardous'* (Draft Version 2.5 – October 2006). With reference to these documents a hazard assessment has been carried out to enable categorisation of the material as hazardous or non-hazardous and to subsequently establish the European Waste Catalogue (EWC) code (ref Section 11.3.4).

11.3.3 Secondary classification

11.3.3.1 If the soil is deemed hazardous then measurement of organic contaminants and leachable inorganic contaminants is necessary for comparison with values listed in the Environment Agency publication '*Guidance on sampling and testing of wastes to meet landfill waste acceptance procedures'* (April 2005) Table 5.1. Similarly should the soil be deemed as non-hazardous then such testing may also be undertaken to determine if it is potentially inert. This document also provides guidance on sampling materials and frequency as well as test procedures and quality assurance of testing.

11.3.3.2 The above procedures are described with respect to the subject site in the following sections Section 11.4 (primary) and 11.5 (secondary), leading to basic characterisation of soils for disposal. Subject to the results of the categorisation and anticipated development methodology, consideration should be given by the developer to reduce volumes of disposal or treatment to allow reclassification.

11.3.4 European waste catalogue (EWC) coding

11.3.4.1 The EWC 2002 is a catalogue of all wastes, grouped according to generic industry, process or waste type. It is divided into twenty main chapters, each with a two digit code between 01 and 20. Following the EWC, in our opinion, soils considered as part of this investigation would be categorised within 'Group 17' of the EWC catalogue, which comprises 'Construction and Demolition Wastes (including excavated soils from contaminated sites)'.

11.3.4.2 The Catalogue further categorises the waste, such that soils considered as part of this investigation would be classified as either 17 05 04 defined as *'soil and stones (other than those mentioned in 17 05 03)';* or 17 05 03* defined as soil or stones containing dangerous substances (where hazardous wastes are described by entries followed by an asterisk).

11.4 Primary classification

11.4.1 Soil types

11.4.1.1 Based on soils exposed in exploratory excavations, in combination with anticipated construction works, we assume soils requiring off-site disposal will comprise Topsoil, Made Ground and River Terrace derived from general site clearance, foundation and service trench excavation and potentially remediation.

11.4.2 Classification as hazardous or non-hazardous waste

11.4.2.1 The Environment Agency publication '*Framework for the classification of contaminated soils as hazardous wastes'* (July 2004) provides the following procedure for establishing if the soils are hazardous or non-hazardous. The first stage in classifying a potentially 'contaminated' soil for disposal is to establish its chemical status by first identifying potential sources/types of chemical contamination (desk study) followed by intrusive site investigations to obtain samples for laboratory testing of soil samples to measure concentrations of chemical contaminants.

11.4.2.2 An assessment of potential source of contamination is presented in Section 8 of this report. Laboratory testing has been set as deemed appropriate to our source assessment.

11.4.2.3 We have carried out an analysis of test data for each chemical contaminant considered in this investigation. A conservative approach has been adopted for the analysis whereby the maximum test value for each contaminant has been adopted as a preliminary screening process to determine if the soils are hazardous or non-hazardous. Should the analysis indicate potentially hazardous properties then a process of zoning by further analysing the site history, geological conditions and analytical data may be undertaken.

11.4.2.4 Laboratory test data measures the concentration of anions, which are unlikely to exist in the pure metallic form in the soil, but probably exist as a compound. Following guidance provided in the Environment Agency Technical Guidance WM2 *'Interpretation of the definition and classification of hazardous waste,* we have reviewed a variety of compounds for each of the metallic and semi metallic elements we have tested.

11.4.2.5 To determine the hazardous waste properties for each element, we have reviewed chemical compounds listed in Table 3.2 of Annex VI of the European Regulation (1272/2008) for Classification, Labelling and Packaging (CLP) of chemicals which has now superseded the Approved Supply List (Published by the Health and Safety Executive) for the classification of hazardous chemicals in the UK. In order to provide a 'worst case' scenario, initially we adopt the most severe hazardous properties (risk phrases) associated with the various compounds for each element under review. If measured concentrations produce a hazardous outcome then the element or elements are reassessed on a site specific basis. For review of organic contamination, we have directly adopted the threshold concentrations for the appropriate organic compounds listed in Table 3.2.

11.4.2.6 The compound or compounds adopted for each element is used to convert the measured metallic concentration to the substance concentration using their respective molecular weights. This derived conversion factor is then used in the threshold concentration spreadsheet (refer paragraph 11.4.2.8).

11.4.2.7 Our assessment of each of the chemical substances is maintained on our files and is available for confidential review/audit by the Environment Agency.

11.4.2.8 A spreadsheet detailing the hazard assessment following the procedures described in *'framework for the classification of contaminated soils as hazardous wastes'* is presented in Appendix L.

11.4.2.9 The spreadsheet indicates the soils are **non-hazardous.**

11.5 Secondary assessment

11.5.1 Following '*Guidance on sampling and testing of wastes to meet landfill waste acceptance procedures'* produced by the Environment Agency (Version 1, April 2005) we have scheduled testing of one sample to measure the parameters listed in table 5.1 (landfill waste acceptance criteria) included in the above publication. A copy of the test result certificate is presented in Appendix H. The source of the composite sample is detailed below:

Composition of soil samples for classification testing

Strata	Source	Soil Type
Made Ground	TP03 (0.2m) TP05 90.1m) TP10 (0.4m) TP11 (0.1m) TP12 (0.3m) TP14 (0.4m)	Dark brown and brown silty sandy gravelly clay, brown slightly clayey gravelly sand. The gravel comprised flint, brick, ash, charcoal and concrete.

Table 11.5.1

11.5.2 The sample was deemed representative of Made Ground soils as described in Section 5. The sample was formed by combining individual samples taken from exploratory excavations within the Made Ground. The combined sample was then quartered in the laboratory to produce a representative sample for subsequent testing.

11.5.3 Laboratory test data has been compared with the landfill waste acceptable criteria (table 5.1) to allow the secondary assessment to be completed. A copy of table 5.1 is presented in Appendix M with test result data added for ease of comparison.

11.5.4 Comparison of test data with landfill waste acceptance criteria indicates that Made Ground soils are suitable for disposal as **inert waste**.

11.5.5 It should be noted that significant concentrations of PAH, above the acceptable concentrations for inert waste have been identified in some areas of the site. These concentrations of associated with significant ash concentrations within the Made Ground. We recommend any such soils be stockpiled separately and classified separately for off-site disposal

11.6 Naturally deposited soils not affected by artificial contaminants

11.6.1 With reference to the European Waste Catalogue and table 5.1 of the Environment Agency publication *'a better place – guidance for waste destined for disposal in landfills – version 2 June 2006'*, naturally occurring soils not likely to be affected by contamination can be classified as inert waste, with a EWC code of 17 05 04. Should any of the naturally deposited soils be suspected to contain contamination (by virtue of visual of olfactory evidence) upon excavation, then such soils should be stockpiled appropriately and additional testing carried out as considered necessary. Based on evidence obtained during our investigations, we are of the opinion that the River Terrace at the site is not likely to be affected by chemical contamination and thus can be classified as **inert waste.**

11.7 Basic categorisation

11.7.1 Based on the preceding assessment, we have produced two basic categorisation schedules relating to the Made Ground and River Terrace deposits, which are presented in Appendix N. These schedules should be provided together with a copy of this report to an appropriately licensed landfill facility to demonstrate the material can be deposited at this facility.

11.7.2 We understand that some landfill sites have licences which have restrictions on concentrations of chemical contaminants and thus we recommend this report is provided to the selected landfill facility to confirm (or otherwise) it can accept the waste. Please be aware that landfill sites are obligated to undertake in house quality assurance tests and thus may require further WAC testing for any soils encountered as part of this investigation. There is no obligation on any landfill operator to accept waste if they choose not to and waste operators may require additional testing of untested waste soils prior to acceptance at landfill in accordance with the landfill regulations.

11.8 Treatment of waste

11.8.1 Treatment of wastes is now a requirement of the landfill directive applied by the Landfill (England and Wales) Regulations 2002. Landfill cannot accept untreated waste (be it hazardous or non-hazardous), thus waste producers have the choice of treating it themselves on site or treating it elsewhere prior to disposal to landfill. The regulations require:

> *'10 – (1) The operator of a landfill shall ensure that the landfill is only used for landfilling waste which is subject to prior treatment unless:*
>
> *a) It is inert waste for which treatment is not technically feasible; or*
>
> *b) It is waste other than inert waste and treatment would not reduce its quantity or the hazards which it poses to human health or the environment.'*

11.8.2 Regulation 2 defines treatment as: *'physical, thermal, chemical or biological processes (including sorting) that change the characteristics of waste in order to reduce its volume or hazardous nature, facilitate its handling or enhance recovery.'*

11.8.3 A treatment option must comply with the definition of treatment. This involves a 'three point test' against which treatment is assessed i.e.

1. It must be a physical, thermal, chemical or biological process including sorting
2. It must change the characteristics of the waste: and
3. It must do so in order to:
    a) Reduce its volume: or
    b) Reduce its hazardous nature: or
    c) Facilitate its handling: or
    d) Enhance its recovery.

11.8.4 Treatment of inert wastes

11.8.4.1 Inert waste does not need to be treated if it is not technically feasible however treatment should reduce the amount of waste which goes to landfill and enhance its recovery (by re-use or recycling). Inert wastes are often suitable for recycling, for example as an aggregate or an engineering fill material. A fact sheet on treatment of inert wastes is available on the following website www.environment-agency.gov.uk

11.8.4.2 Clearly, excavations in the River Terrace (not affected by artificial contamination) will generate inert wastes which could be reused on site or off site for bulk filling, subject of course to maintenance of an acceptable water content and provided that it is fit for its intended purpose.

11.8.5 Treatment of non-hazardous waste

11.8.5.1 Guidance and indeed examples of treatment is provided in the Environment Agency publication '*Treatment of non-hazardous wastes for landfill – your waste – your responsibility,'* again available on the EA website.

11.8.6 Landfill operators

11.8.6.1 It is a requirement of the landfill operator to check if the waste soils taken to the facility have been treated.

11.9 Reuse of Soils - Materials Management Plans

11.9.1 Where soils are to be moved and reused onsite, or are to be imported to the site, a Waste Exemption or an Environmental Permit is required.

11.9.2 An alternative is the use of a Materials Management Plan (MMP) to determine where soils are and are not considered to be a waste. By following *'The Definition of Waste: Development Industry Code of Practice'* published by CL:AIRE (produced in 2008 and revised in March 2011), soils that are suitable for reuse without the need for remediation (either chemical or geotechnical) and have a certainty of use, are not considered to be waste and therefore do not fall under waste regulations. In addition, following this guidance may present an opportunity to transfer suitable material between sites, without the need for Waste Exemptions or Environmental Permits.

11.9.3 MMPs offering numerous benefits, including maximising the use of soils onsite, minimising soils going to landfill and reducing costs and time involved in liaising with waste regulators.

11.9.4 We can provide further advice on this and provide fees for producing a Materials Management Plan on further instructions.

12 Further investigations

12.1 Further investigations

12.1 At this stage we do not consider further investigations to be necessary. Should infiltration systems be considered as a drainage option for the site, we recommend further testing be undertaken to confirm likely infiltration rates.

12.2 Should landscaped areas be proposed in the development, validation of removal of Made Ground or introduction of a capping layer will be required.

13 Remediation strategy

13.1 Providing the site is fully surfaced in buildings/hardstandings, no remediation is considered necessary at the site. Should landscaped areas be proposed, we recommend either removal of Made Ground or introduction of a capping layer to sever the pathway between end users and Made Ground soils. . In areas of extensive landscaping it will likely be more economically viable to undertake additional testing and assessment of the soils to minimise disposal.

13.2 Gas monitoring is required at the site and a remediation strategy may also be required depending on the results of this monitoring.

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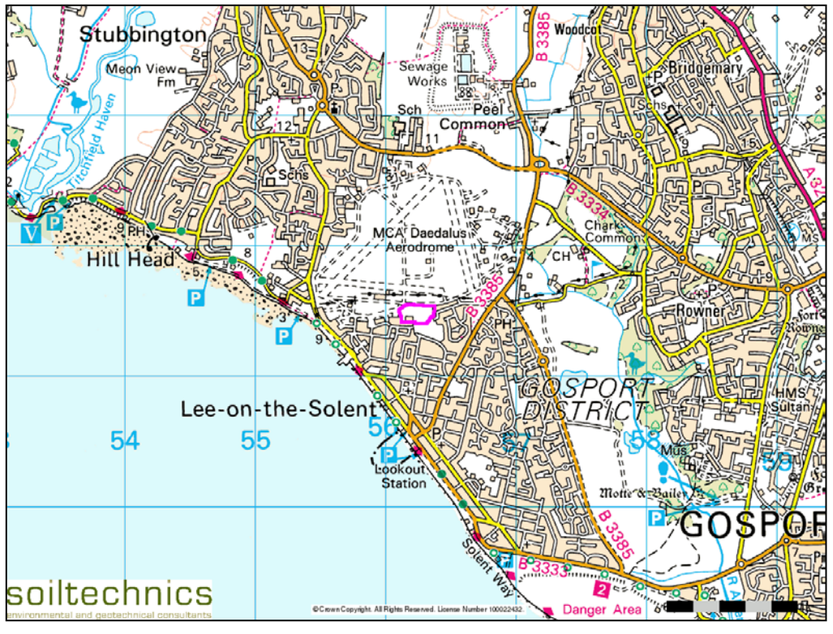
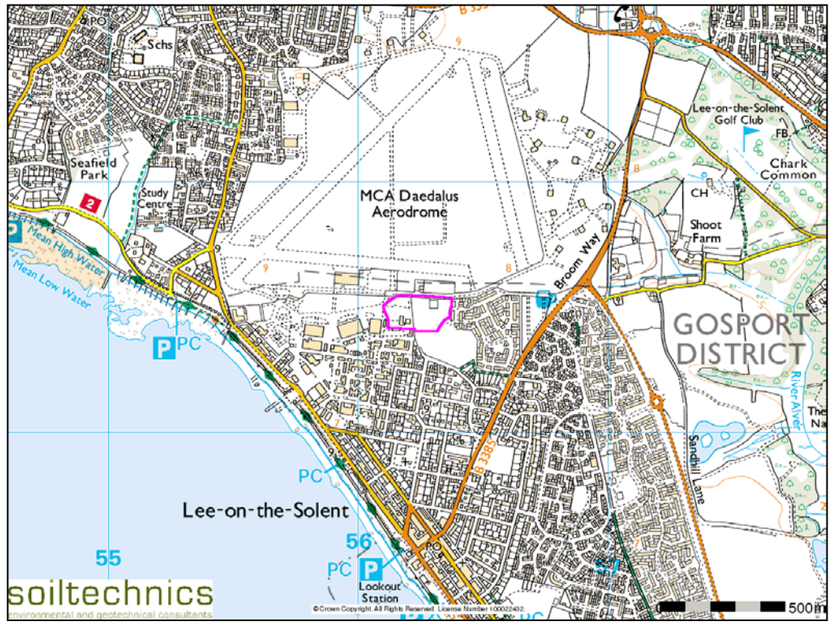
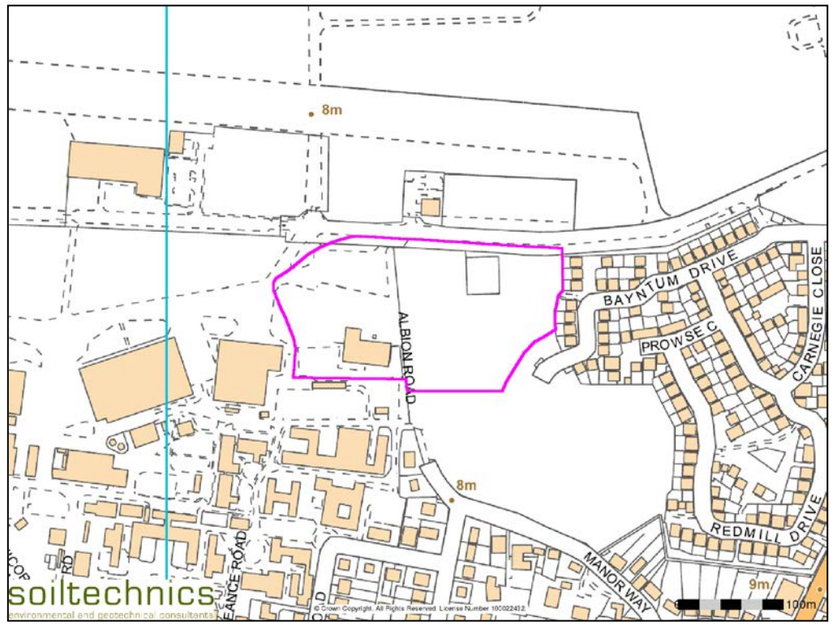


Neighbourhood extract from Ordnance Survey map



Town extract from Ordnance Survey map



Detail extract from Ordnance Survey map

Title	Scale	Drawing number
Site location plan	Not to scale	01

Proposed redevelopment,
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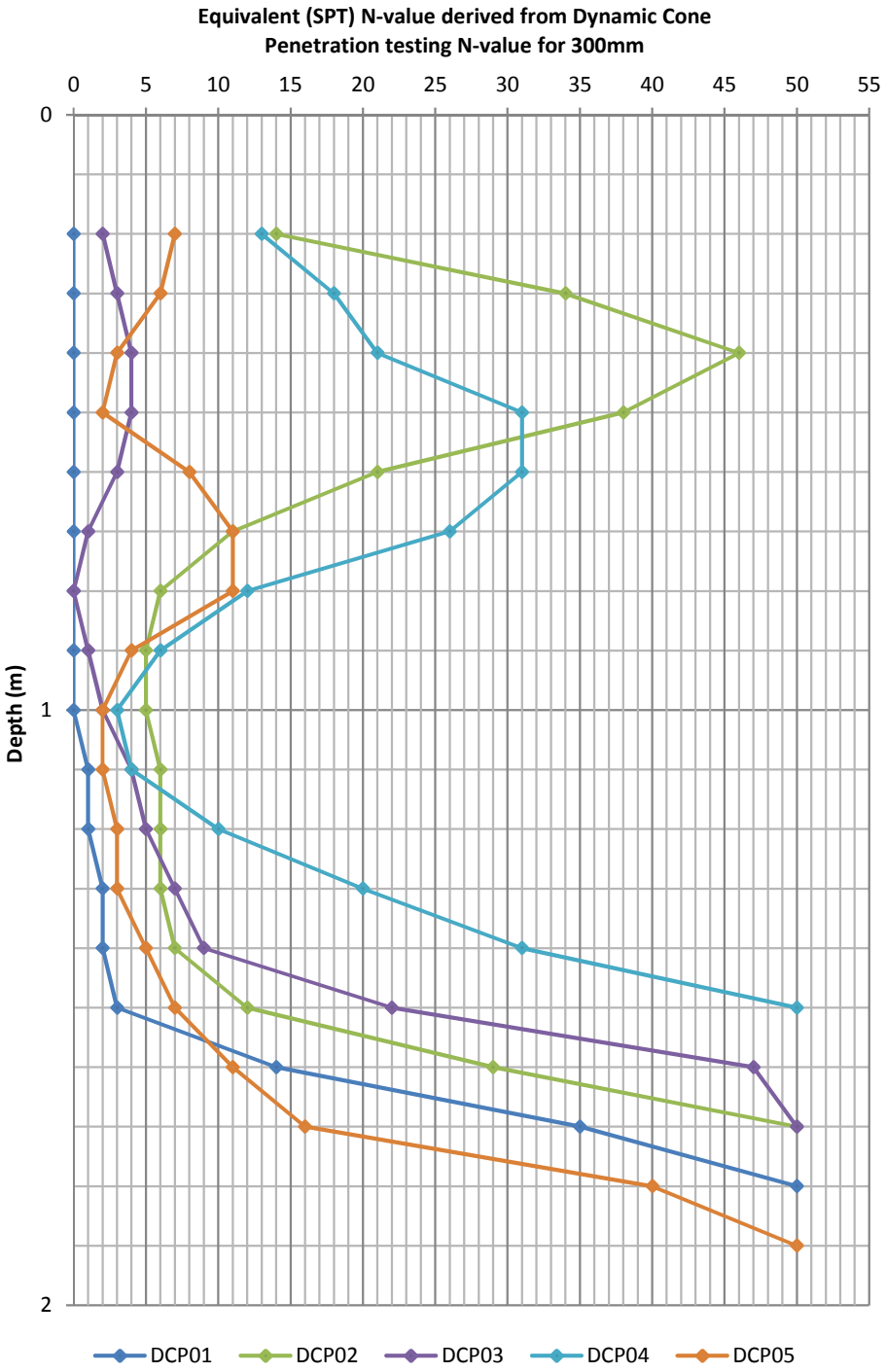
Key

TP	Approximate location of trial pit excavation
DTS	Approximate location of borehole formed by Driven Tube Sampling techniques
DCP	Approximate location of Dynamic Cone Penetration testing
CH	Approximate location of corehole

Notes

Base drawing provided by Campbell Reith Consulting Engineers

Title	Scale	Drawing number
Plan showing existing site features and location of exploratory positions	1:1000 @ *A3*	02



Notes

1) Density descriptions obtained from EN ISO 14688-2:2004

Density terms

0 - 4	Very loose
4 -10	Loose
10 - 30	Medium dense
30 - 50	Dense
50+	Very dense

Title

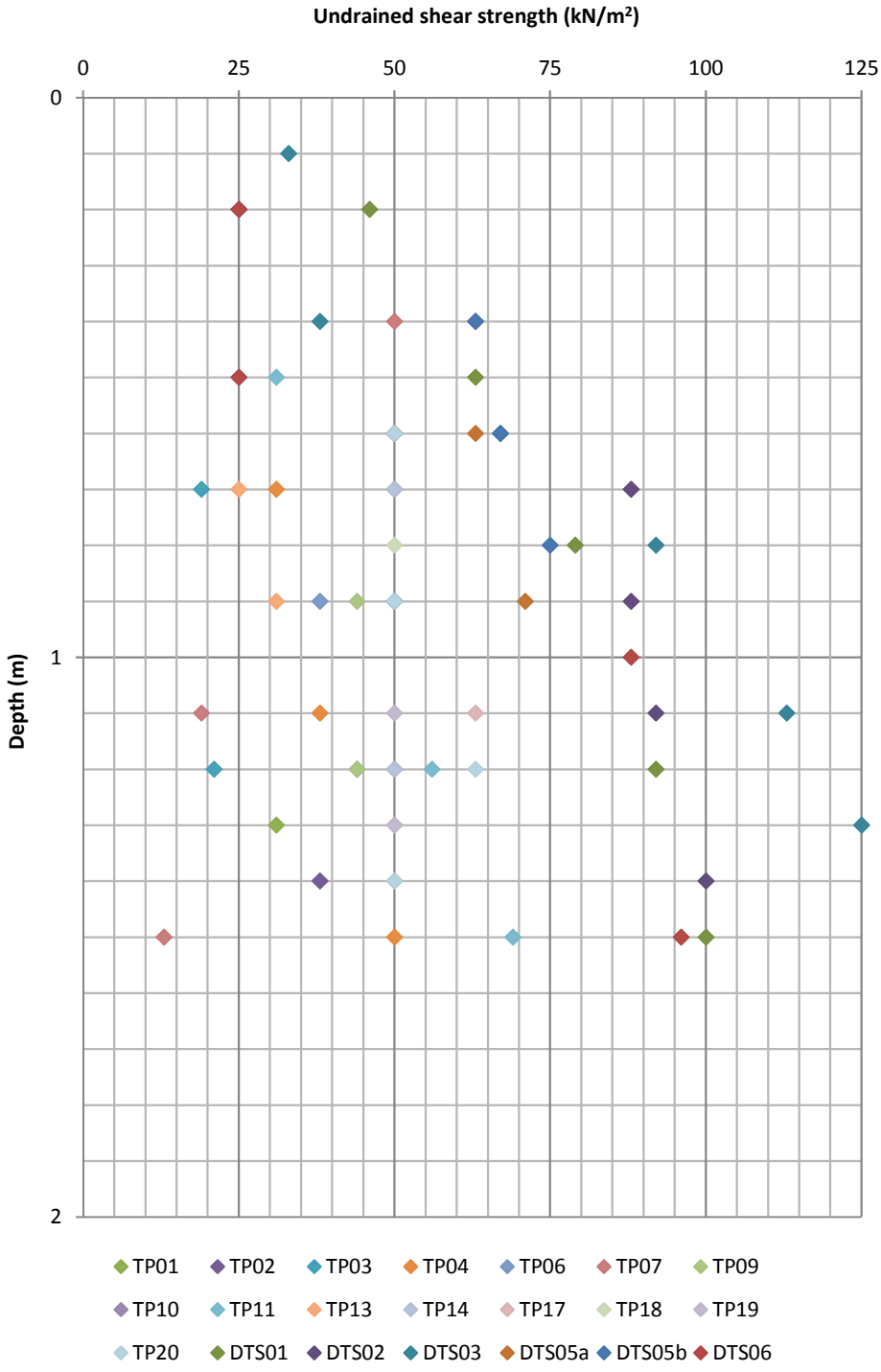
Plot summarising insitu density testing utilising dynamic cone penetration (DCP) techniques

Scale

As shown

Drawing number

03



Notes

1) Strength terms obtained from EN ISO 14688-2:2004

2) Equivalent undrained shear strength derived by multiplying Pocket Penetrometer (PP) results by 50

Strength terms

0 - 20	Very low strength
20 -40	Low strength
40 - 75	Medium strength
75 - 150	High strength
150 - 300	Very high strength
300+	Extremely high strength

Title

Plot summarising results of pocket penetrometer determinations by location

Scale

As shown

Drawing number

04

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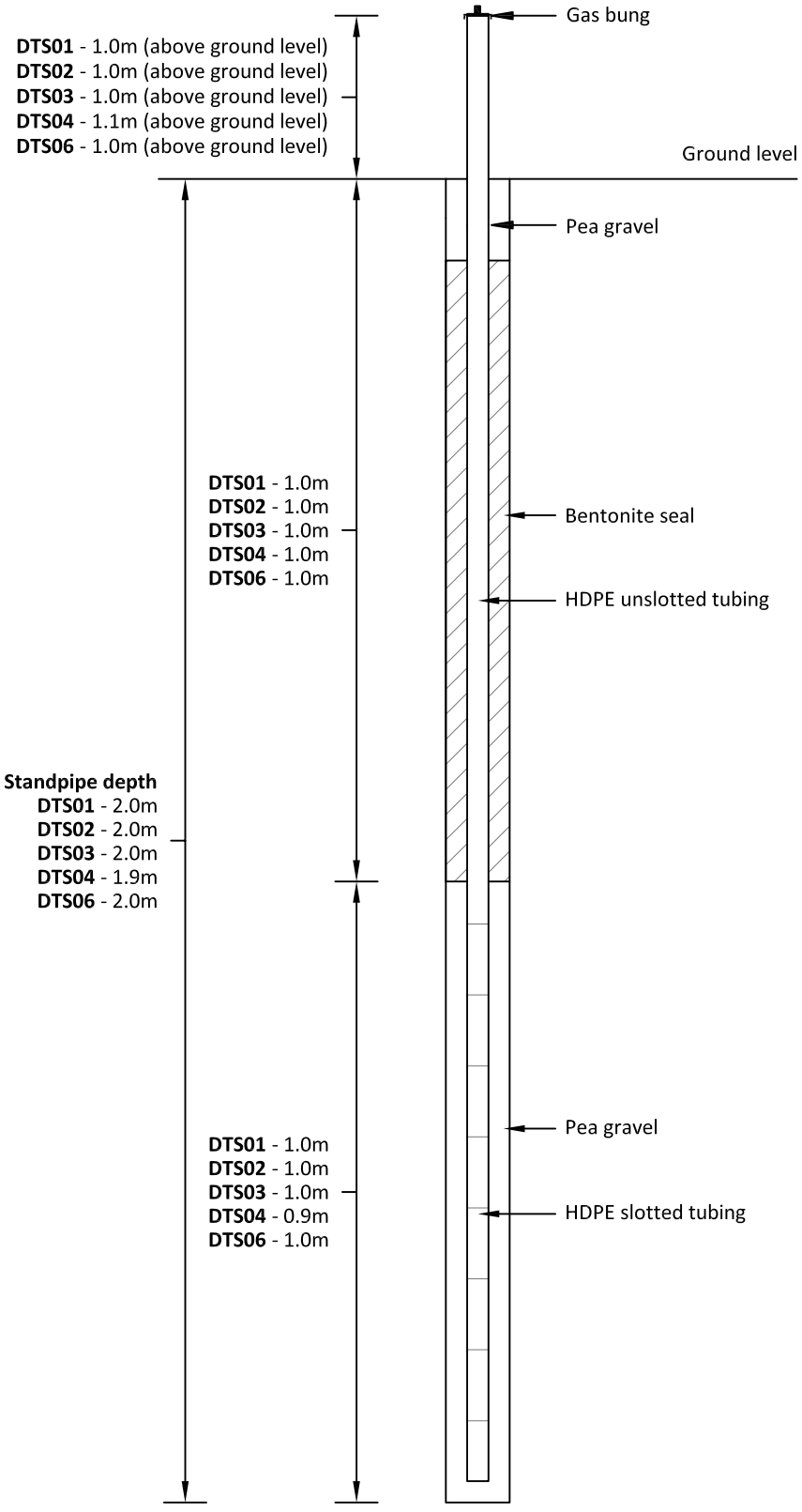

Title	Scale	Drawing number
Section showing construction of gas monitoring standpipes installed in boreholes DTS01, DTS02, DTS03, DTS04 and DTS06	Not to scale	05

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 prestressed 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 plan 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

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 under the completed pavement.

***Thin pavement*.**
A thin pavement (which includes both bound and unbound pavement construction materials 1 in 300mm thick 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

Refer sheet 2 for definitions of 'very high' to '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.

Gaseous contamination -
Extract copy of table 3 of BS8485:2007 Solutions scores

PROTECTION ELEMENT/SYSTEM		SCORE	COMMENTS
a) Venting/dilution (see Annex A of BS8485)			
Passive sub-floor ventilation (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc) [A)]	Very good performance	2.5	*Ventilation performance in accordance with Annex A of BS8485.*
	Good performance	1	*If passive ventilation is poor this is generally unacceptable and some form of active system will be required.*
Subfloor ventilation with active abstraction/pressurization (venting layers can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc)A)		2.5	*There have to be robust management systems in place to ensure the continued maintenance of any ventilation system.* *Active ventilation can always be designed to meet good performance.* *Mechanically assisted systems come in two main forms: extraction and positive pressurization*
Ventilated car park (basement or undercroft)		4	*Assume car park is vented to deal with car exhaust fumes, designed to Building Regulations Document F and IStructE guidance.*
b) Barriers			
Floor Slabs			*It is good practice to install ventilation in all foundation systems to effect pressure relief as a minimum.*
Block and beam floor slab		0	
Reinforced concrete ground bearing floor slab		0.5	
Reinforced concrete ground bearing foundation raft with limited service penetrations that are cast into slab		1.5	*Breaches in floor slabs such as joints have to be effectively sealed against gas ingress in order to maintain these performances.*
Reinforced concrete cast in situ suspended slab with minimal service penetrations and water bars around all slab penetrations and at joints		1.5	
Fully tanked basement		2	
c) Membranes			
Taped and sealed membrane to reasonable levels of workmanship/in line with current good practice with validation [B), C)]		0.5	*The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installations, and the integrity of joints.*
Proprietary gas resistant membrane to reasonable levels of workmanship/in line with current good practice under independent inspection (CQA) [B), C)]		1	
Proprietary gas resistant membrane installed to reasonable levels of workmanship/in line with current good practice under CQA with integrity testing and independent validation.		2	
d) Monitoring and detection (not applicable to non-managed property, or in isolation)			
Intermittent monitoring using hand held equipment		0.5	Where fitted, permanent monitoring system ought to be installed in the underfloor venting/dilution system in the first instance but can also be provided within the occupied space as a fail safe.
Permanent monitoring and alarm system [A)]	Installed in the underfloor venting/dilution system	2	
	Installed in the building	1	
e) Pathway Intervention			
Pathway intervention		-	*This can consist of site protection measures for off-site or on-site sources (see Annex A of BS8485)*

NOTE In practice the choice of materials might well rely on factors such as construction method and the risk of damage after installation. It is important to ensure that the chosen combination gives an appropriate level of protection.

[A)] It is possible to test ventilation systems by installing monitoring probes for post installation validation.

[B)] If a 200g DPM material is to function as a gas barrier it should be installed according to BRE 212)/BRE 414), being taped and sealed to all penetrations.

[C)] Polymeric Materials > 1 200g can be used to improve confidence in the barrier. Remember that their gas resistance is little more than the standard 1 200g (proportional to thickness) but their physical properties mean that they are more robust and resistant to site damage.

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	Generic Assessment Criteria for Human Health Risk Assessment	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

CIEH Chartered institute of Environmental Health
LQM Land Quality Management
EA Environment Agency

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Key to legends

Composite materials, Soils and Lithology

Topsoil	Made Ground	Boulders
Chalk	Clay	Coal
Cobbles	Cobbles & Boulders	Concrete
Gravel	Limestone	Mudstone
Peat	Sand	Sand and Gravel
Sandstone	Silt	Silt / Clay
Siltstone		

Note: Composite soil types are signified by combined symbols.

Key to 'test result' and 'sampling' columns

Test result	
Depth	Records depth that the test was carried out (ie at 2.1m or between 2.1 and 2.55m) [1]
Result	PP – Pocket penetrometer result (kN/m^2) HVP – Hand held shear vane result (kN/m^2) *PP result converted to an equivalent undrained shear strength by applying a factor of 50. Where at least 3 results obtained at same depth then an average value may be reported.*

Sampling		
From (m) To (m)	Records depth of sampling	
Type	D	Disturbed sample
	B	Bulk disturbed sample
	J	Disturbed sample placed in sealed amber jar
	W	Water sample
	CBR	Undisturbed sample in mould (California Bearing Ratio)

Note [1]: Carried out on undisturbed samples or in sides/base of trial pit.

Water observations

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

▼ = water level observed after specified delay in drilling

▽ = water strike