REPORT N^{O} 70012378

WHITFIELD PHASE 1

GROUND INVESTIGATION REPORT

SUB-PHASE 1A

CONFIDENTIAL

DECEMBER 2016

WHITFIELD PHASE 1

GROUND INVESTIGATION REPORT

SUB-PHASE 1A

Halsbury Homes

Ground Investigation Report (V3.0)
Confidential

Project no: 70012378
Date: December 2016

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1 EXECUTIVE SUMMARY

WSP | Parsons Brinckerhoff (WSP) was instructed by Halsbury Homes (the Client) to undertake a Ground Investigation Report (GIR) for sub-phase 1A of Phase 1 of the proposed Light Hill development located near Whitfield, near Dover (the site).

WSP was subsequently instructed by Halsbury Homes to undertake a further 3 phases of plate bearing testing across the site.

OBJECTIVES	The principal aim of the investigation was to provide information to support the discharge of Planning Conditions 48 (part 1) and 52 from the Outline Planning Permission for the site (DOV/10/01010). Furthermore the investigation is to assess the nature and extent of any potential development constraints for the site, to mitigate risks in the design and cost modelling for development and to provide information appropriate to inform development design considerations. The investigation was also completed to provide geotechnical parameters to facilitate outline design of the proposed residential development and realignment of the A256 including the proposed roundabout.
GROUND INVESTIGATION	WSP supervised a ground investigation carried out by Geotechnical Engineering. The works undertaken across both the proposed residential development and A256 re-alignment areas included three dynamic sample boreholes, eleven window samples, twelve trial pits, fifteen infiltration tests and sixteen Californian Bearing Ratio (CBR) tests. Laboratory testing was conducted for geochemical analysis of soil samples. A groundwater level and ground gas monitoring programme has also been undertaken. A supplementary 3 phases of plate bearing testing were undertaken across the proposed residential development. These totalled thirty-one Plate Bearing tests (PBT), thirty-eight Hand Shear Vane (HSV) tests and one CBR test.
ENVIRONMENTAL CONCLUSIONS	Based on the findings of the GIR, WSP make the following conclusions with regards to identified contaminated land constraints and contaminant linkages which may pose a risk during the proposed residential development. → The risk to human health receptors is considered to be **VERY LOW**, on the basis that no exceedances of generic assessment criteria or soil guidance values occurred. → The risk to controlled water is considered to be **VERY LOW**. Although groundwater was not encountered during the

	investigation no sources of potential soil contamination were encountered that could impact deeper groundwater. → The risk to the built environment is considered to be **VERY LOW**, the site is classified as a Design Sulphate Class 1 (DS1) and an aggressive chemical environment for concrete class AC-1 is suitable for the site. → Due to no contamination of concern being encountered water supply pipes would not require barrier protection. → The site is situated within an area potentially affected by naturally occurring Radon gas. It is likely that 'Basic' Radon protection measures will be required in accordance with BRE Report BR211. → Following 3No. rounds of ground gas classification it was determined that the site is within Characteristic Situation 1 and protective measures are therefore not required. → The use of soakaways at the site would not increase the risk of pollution to groundwater due to no exceedances being identified within the soils and that regional groundwater is located at depth underlying the site.
GEOTECHNICAL CONCLUSIONS	Based on the findings of the GIR and additional plate bearing tests, WSP make the following conclusions with regards to identified geotechnical constraints which may pose a risk during the proposed residential development. → Based on the supplementary in-situ tests, WSP consider that shallow strip foundations would be suitable for all low rise residential properties in Phase 1. This is based on a line load of 60kN per meter run and a 600mm wide strip footing. This is also based on a foundation depth of at least 1m below either existing ground or finished floor level (whichever is deepest). → Suspended floor slabs are considered appropriate. Ground bearing slabs are considered appropriate if loaded with less than $10kNm^{-2}$ and founded at 0.4m bogl or more. → A CBR of 3% should be assumed for preliminary pavement design. → A minimum infiltration value of 7.0×10^{-5} m/s in the Head deposits and 1.0×10^{-5} m/s in the Seaford Chalk Formation should be assumed for design purposes. However caution should be considered due to the heterogeneous nature of the two deposits which may be found to be variable across the site. → WSP | Parsons Brinckerhoff recommend that during construction the formation of all foundations are tested in-situ with a hand shear vane, and a minimum of 60kN/m2 (average based on 3 tests per location) is achieved. Where a minimum of 60kN/m2 is not achieved WSP | Parsons Brinckerhoff should be notified to provide appropriate mitigation measures.

FURTHER WORKS	It is the opinion of WSP that planning conditions 48 (part 1) and 52 as set out by Dover District Council have been addressed as described by the works herein and that no further works are necessary within the Phase 1A area of the Phase 1 development.

2 INTRODUCTION AND OBJECTIVES

2.1 AUTHORISATION

WSP | Parsons Brinckerhoff (WSP) was instructed by Halsbury Homes (the Client), to undertake a Ground Investigation Report (GIR) for sub-phase 1A of Phase 1 of the proposed Light Hill development located near Whitfield, near Dover (the site). The site is located at approximately National Grid Reference (NGR) 631228, 145220 as shown on **Figure 1**.

The GIR has been undertaken in broad accordance with the scope agreed between WSP and the Client as set out in our proposal dated 18 January 2016 (Ref: 70012378).

A further scope of works was agreed on the 11 May 2016 for further phases of supplementary plate bearing testing, with a provision for 2 more phases of plate bearing testing if the results were favourable. The 3 phases of supplementary works were undertaken in accordance with the scope, and were completed by the 20 October 2016.

2.2 DEVELOPMENT PROPOSAL

The site is located to the east of Whitfield, south-east of Archers Court Road and to the west of the A256. Sub-phase 1A is situated in the central and eastern part of the Phase 1 development boundary and is approximately 9.3 hectares in area (see **Figure 2**).

The site can be considered as two separate areas; Area 1 comprises approximately 6ha of agricultural land to the west of the A256 Whitfield Bypass and Area 2 comprises approximately 3ha of the A256 extending north and south of the Great Pineham Farm Subway. Surrounding land use is predominantly agricultural with the residential areas of Whitfield located 380m to the west.

Current development plans comprise the construction of 94 new homes, predominantly semi-detached/detached with gardens, and a new at-grade roundabout on the A256. As part of the roundabout development the subway structure is proposed to be lengthened.

2.3 OBJECTIVES

The principal aim of the investigation will be to support the discharge of Planning Condition 48 (part 1) and 52 from the Outline Planning Permission for the site (DOV/10/01010). Planning condition 48 (part 1) states:

No development on a phase or sub-phase shall take place until, in accordance with section 7.4, and using information in the Phase 1 Ground condition report (Peter Brett Associates, July 2010, Reference: 23304 DTS/Rev2), for each phase or sub phase:

(1) An investigation and risk assessment shall be undertaken by competent persons. A written report of the findings shall be submitted to and approved in writing by the Local Planning Authority. The report shall include an assessment of the nature and extent of any contamination on the site, whether or not it originates on the site. The report shall also include the following:

(i) A survey of the extent, scale and nature of contamination;

(ii) An assessment of the potential risks to:

- *Human health;*
- *Property (existing or proposed) including buildings, crops, livestock, pets, woodland, and service line and pipes;*
- *Adjoining land;*
- *Ground and surface waters;*
- *Ecological systems; and*
- *Archaeological sites and ancient monuments.*

(iii) An appraisal of remedial options and identification of the preferred option(s).

All work pursuant to this condition shall be conducted in accordance with the DEFRA and Environment Agency document Model procedures for the Management of Land Contamination (Contamination report 11).

Planning condition 52 states:

No development other that the new A256 roundabout and the Primary Street of any phases or sub-phase shall take place until details of the results of ground investigation to assess the suitability of soakaways without increasing risk of pollution to groundwater and any mitigation measures for that phase or sub-phase have been submitted to an approved in writing by the Local Planning Authority. The development shall be fully implemented in accordance with the approved details prior to the first occupation of any unit within the particular phase or sub-phase to which the details relate.

The preliminary geotechnical design for the site provides an extension to a precast reinforced box subway, as well as associated changes to the surrounding slope in order to accommodate the increase in box length.

Furthermore the investigation is to assess the nature and extent of any potential development constraints, to mitigate risks in the design and cost modelling for redevelopment and to provide information appropriate to inform development design considerations.

2.4 SCOPE OF WORKS

To meet the objectives detailed in **Section 2.3**, the scope of works to be undertaken comprised the following in the residential area of the site (Area 1):

- 1 No. dynamic sample borehole advanced to a depth of 15.3m below ground level (bgl);
- 8 No. window samples advanced to a maximum depth of 5.45m bgl;
- Installation of 8 No. window samples and 1 No. dynamic sample borehole with groundwater monitoring standpipes;
- 12 No. trial pits advanced up to a maximum depth of 3.1m bgl;
- The logging of each exploratory hole in accordance with BS EN ISO 14688-1:2002;
- In-situ geotechnical Standard Penetration Tests (SPTs);
- Collection of U100 samples;
- Collection of soil samples for geotechnical and chemical laboratory analysis;
- Chemical testing of 27 soil samples for a suite of chemical analysis including metals, total petroleum hydrocarbons, poly-aromatic hydrocarbons, pH, asbestos and pesticides;

- Geotechnical testing comprised Atterberg Limits, consolidation (OED), particle size distribution, sulphate and pH, moisture content and saturated moisture content;
- 3 No. rounds of groundwater and ground gas monitoring;
- 9 No. infiltration tests undertaken in broad accordance with BRE digest 365; and,
- 6 No. CBR tests.

In the area of the A256 (Area 2) the following works were to be undertaken:

- 2 No. dynamic sample boreholes advanced to depths of 15.2m below ground level (m bgl) and installation of a deep groundwater monitoring standpipe in one of the boreholes;
- 4 No. window samples holes advanced to a maximum depth of 5.45m bgl;
- The logging of each exploratory hole in accordance with BS EN ISO 14688-1:2002;
- In-situ geotechnical Standard Penetration Tests (SPTs);
- Collection of U100 samples;
- Collection of soil samples for geotechnical and chemical laboratory analysis;
- Chemical testing of 10 soil samples for a suite of chemical analysis including metals, total petroleum hydrocarbons, poly-aromatic hydrocarbons, asbestos and pesticides;
- Geotechnical testing of 13 soil samples comprised sulphate and pH, consolidation (OED), Atterberg limits, moisture content and saturated moisture content;
- 3 No. rounds of groundwater and ground gas monitoring;
- 6 No. infiltration tests undertaken in broad accordance with BRE digest 365; and,
- 10 No. Californian Bearing Ratio (CBR) tests.

Three phases of supplementary works were to be undertaken in Area 1

- 4 No. Plate bearing tests and 8.No Hand Shear Vane Tests were to be undertaken at 1m bgl,
- 14No. Plate bearing tests and 14.No Hand Shear Vane Tests were to be undertaken at 1m bgl, and
- 14No. Plate bearing tests and 14.No Hand Shear Vane Tests were to be undertaken at 1m bgl.

2.5 PREVIOUS REPORTS AND REFERENCES

The following reports and information sources have been reviewed and summarised where appropriate in the preparation of this report and should be referred to for more detailed information relating to previous investigations undertaken at the site:

- **Southern Testing Investigation:** Overview Site Investigation Report, Whitfield, Dover, Southern Testing, Ref: J9733, January 2009;
- **PBA Phase 1:** Phase 1 Ground Condition Report, Land at Whitfield, Dover, Peter Brett Associates (PBA), Ref: 23304 DTS/Rev2, July 2010;
- **WSP PSSR:** Preliminary Sources Study Report, Whitfield 1256 Underpass, Dover, WSP | Parsons Brinckerhoff, Ref: 70012378, November 2015; and,
- **PBA Cavities Assessment:** Natural Cavities and Mining Cavities Database Search, Whitfield, Dover, Peter Brett Associates, Ref: 20013157, November 2015.

Information was also gathered from the:

- Environment Agency (EA);

- 'What's in your backyard?' website[1]

→ British Geological Survey (BGS)
  - Map No. 290 (Dover 1:50,000, 1990)
  - BGS Lexicon[2]
  - BGS Geology Viewer[3]

2.6 REGULATORY CONTEXT AND GUIDANCE

This GIR has been prepared with due regard to Contaminated Land Guidance documents issued by the Department for Environment, Food and Rural Affairs (and its predecessors) including Contaminated Land Report 11 (CLR 11), and in general accordance with the British Standard "Investigation of potentially contaminated sites - Code of practice" BS EN 10175. The methods used follow a risk-based approach, with the potential environmental risk assessed qualitatively using the 'source-pathway-receptor contaminant linkage' concept to assess risk as introduced in the Environmental Protection Act 1990 (EPA, 1990).

Legislation and guidance on the assessment of contaminated sites acknowledges the need for a tiered risk based approach. This assessment represents a Generic Quantitative Risk Assessment (GQRA) being a comparison of site contaminant levels against generic standards and compliance criteria including an assessment of risk using the source-pathway-receptor model.

This report forms a GIR as described in Part 2 of Eurocode 7 (BS EN 1997-2), however, it is not intended to fulfil the requirements of a Geotechnical Design Report as detailed in Part 2 of Eurocode 7 (BS EN 1997-2).

Further details relating to the WSP assessment approach are provided in **Appendix A**.

2.7 CONFIDENTIALITY STATEMENT AND LIMITATIONS

This report is addressed to and may be relied upon by the following party:

Halsbury Homes

This assessment has been prepared for the sole use and reliance of the above named party. This report has been prepared in line with the WSP proposal and associated notes. This report shall not be relied upon or transferred to any other parties without the express written authorisation of WSP. No responsibility will be accepted where this report is used, either in its entirety or in part, by any other party.

This report needs to be read and used in full.

General limitations of the assessment are included in **Appendix B**.

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[1] (Viewed 15/03/2016): http://maps.environment-gency.gov.uk/wiyby/wiybyController?ep=maptopics&lang=_e
[2] (Viewed 15/03/2016): http://www.bgs.ac.uk/Lexicon/
[3] (http://www.bgs.ac.uk/Lexicon/): http://mapapps.bgs.ac.uk/geologyofbritain/home.html

3 SITE INFORMATION

For full details of desk study sources of information and preliminary conceptual site model (CSM), refer to the PBA Phase 1, Southern Testing Investigation and WSP PSSR. A summary of the pertinent information is presented below.

3.1 SITE DETAILS

Table 3.1 Site Details

SITE ADDRESS	Whitfield, Dover (nearest postcode CT15 5HA)
NATIONAL GRID REFERENCE	631228, 145220
SITE AREA AREA 1 AREA 2	Approx. 9ha Approx. 6ha Approx. 3ha
SITE LOCATION	The site occupies an area on the west of the A256, adjacent to the Pineham Farm underpass and extends through the underpass and to the north and south of the A256.
CURRENT SITE USE	The site currently comprises farmland on the western section of the site and a farmer's underpass and dual carriageway and associated verges in the eastern section of the site.
TOPOGRAPHY	The topography at the site ranges from approximately 110m above ordnance datum (mAOD) in the north-west of the site to 100mAOD in the south-east of the site.
HISTORICAL SITE USE	The earliest available historical maps (1876/77) show the site comprised agricultural land. The 1898/99 map depicts chalk pits adjacent to the south-east of the field section of the site (**Figure 3**). In 1960/61 a cart track and footpath is shown to extend along the northern boundary of the field. The A256 is first displayed on the 2006 map.

3.2 ENVIRONMENTAL SETTING

GEOLOGY

The British Geological Survey (BGS) Map No. 290 (Dover 1:50,000 series, 1990) has been reviewed and the underlying geology and aquifer designations are presented in **Table 3.2**.

Table 3.2 Mapped Geology

Geological Unit	Location on Site	Typical Description	Aquifer Designation
Head[1]	Majority of site, apart from small strip at south of site.	Gravel, sand and clay.	Secondary (undifferentiated) Aquifer
Dry Valley and Nailbourne Deposits	North-east to south-west strip across centre of site.	Normally soft to firm consolidated, compressible silty clay, but may contain layers of silt, sand, peat and a basal gravel. A stronger, desiccated surface zone may be present. Formed within some at-present dry or intermittently wet valleys.	Secondary (A) Aquifer
Seaford Chalk Formation[2]	Entire site.	Firm white chalk with conspicuous semi-continuous nodular and tabular flint seams.	Principal Aquifer

[1]Map no. 290 referred to unit as Head Gravel, recommended nomenclature is now Head.

[2]Map no. 290 referred to unit as the Upper Chalk, the unit has now been subdivided. The BGS Geology]viewer indicated that the Chalk underlying the site is now named the Seaford Chalk Formation.

According to the geological mapping no superficial deposits are shown to be present in a thin strip of land parallel to the southern boundary of the site. The superficial geology is depicted on **Figure 3**.

A previous ground investigation carried out by Southern Testing, comprising twenty-five trial pits, was undertaken over the entire Phase 1 area (Southern Testing Investigation). TP06, TP09, TP15 and TP20 were located within the current site boundary; the locations are indicated on **Figure 3**. The strata encountered are summarised in **Table 3.3**, below. The borehole logs are presented in **Appendix C1**.

Table 3.3 Southern Testing Log Summary

TRIAL PIT NO.	STRATUM	DESCRIPTION	DEPTH TO TOP OF STRATUM (M BGL)	RECORDED THICKNESS (M)
TP06[1]	Topsoil	Brown sandy gravelly CLAY with frequent roots. Gravel is fine to coarse of flint.	GL[2]	0.25
	Clay	Very stiff friable light brown sandy gravelly CLAY with occasional brick fragments and ash. Gravel is fine to coarse subangular to angular of flint (20%).	0.25	0.45
	Chalk [Grade IV]	Off white weathered CHALK comprising frequent weak to moderately weak gravel size intact chalk fragments in a silty chalk matrix.	0.70	2.30
TP09	Made Ground[3]	Grey brown silty sandy gravelly CLAY with frequent rootlets and occasional brick fragments ashy clinker and roots. Gravel is fine to coarse of flint.	GL	0.30
	Made Ground	Off white and light brown weathered CHALK with frequent weak, fine to coarse chalk fragments in a silty chalk matrix with rare brick fragments and ashy clinker.	0.30	0.25
	Clay	Very stiff friable light brown silty sandy gravelly CLAY with occasional fine chalk fragments of fine chalk. Gravel is fine to coarse angular of flint.	0.55	0.85
	Chalk [Grade V]	Off white weathered CHALK comprising abundant weak gravel size intact chalk fragments in a silty chalk matrix with occasional flint cobbles.	1.40	1.60
TP15	Topsoil	Grey brown sandy gravelly CLAY with frequent rootlets. Gravel is fine to coarse of flint.	GL	0.20
	Made Ground[3]	Stiff to very stiff friable light brown silty sandy gravelly CLAY with occasional fine chalk fragments, ashy clinker and flint cobbles. Gravel is angular to subangular of flint.	0.20	1.20
	Chalk [Grade V]	Off white and light brown weathered CHALK comprising abundant weak to moderately weak gravel size intact chalk fragments in a silty chalk matrix with frequent flint cobbles.	1.40	1.60
TP20	Topsoil	Grey brown sandy gravelly CLAY with frequent rootlets. Gravel is fine to coarse flint gravel and occasional brick fragments.	GL	0.25

Trial Pit No.	Stratum	Description	Depth to top of stratum (m bgl)	Recorded thickness (m)
	Clay	Very stiff (very high strength) friable brown sandy gravelly CLAY with occasional fine chalk fragments and rootlets. Gravel is frequent fine to coarse angular to subangular flint (20%).	0.25	0.7
	Chalk [Grade III at 1.0m][Grade V from 1.8m]	White and light brown blocky CHALK comprising abundant weak to moderately weak gravel size intact chalk fragments in a silty chalk matrix with occasional subrounded flint gravel and chalk cobbles.	0.7	3.0

[1]**A BRE365 soakage test was carried out in trial pit TP06; results are reported in** Section 7.9

[2]**GL=Ground level**

[3]**Logged as topsoil and clay, however, due to the presence of clinker and/or brick fragments WSP have interpreted the strata as Made Ground**

Geological mapping suggests that the clay deposits could be classified as Head, and that the chalk forms the Seaford Chalk Formation. Geological mapping suggests that at locations TP20 and TP15, located towards the southern boundary of the site, superficial deposits would not be present; however, the logs indicated clay over chalk in both trial pits.

One BGS borehole record, TR34NW4, is available approximately 250m south-west of the site; the geology is summarised in **Table 3.4**. The borehole log is available in **Appendix C2**.

Table 3.4 BGS Borehole TR34NW4 Summary

Stratum Description	Strata Interpreted[1]	Depth to top of stratum (m bgl)	Depth to base of stratum (m bgl)	Recorded thickness (m)
Topsoil	Topsoil	GL	0.05	0.05
Flint Bed	Head	0.05	0.80	0.75
Brown clay		0.80	2.50	1.70
Brown flint bound sandy clay		2.50	3.00	0.50
Chalk and flints	Seaford Chalk Formation	3.00	17.0	14.0
Flint bed		17.0	18.0	1.00
Chalk and flints		18.0	105	87.0

[1]**Strata interpreted by WSP**

GROUNDWATER

The Environment Agency (EA) classifies the Head deposits as a Secondary (undifferentiated) Aquifer, the Dry Valley and Nailbourne Deposits as a Secondary (A) Aquifer and the Seaford

Chalk Formation as a Principal Aquifer. The site is located within a groundwater Source Protection Zone 3 (SPZ3), associated with abstractions approximately 3km to the north east and south west.

The previous Southern Testing Investigation (January, 2009) did not encounter groundwater within any of the trial pits, which extended to a maximum depth of 3m bgl. BGS borehole TR34NW4, located 250m south-west of the site, recorded a water strike at depths of 94.0m bgl in August 1982. Within the Southern Testing Investigation it was stated that the EA records show that groundwater in the area is likely to be at 10mAOD, so approximately 90m bgl given that the site is located at approximately 100mAOD. The Hydrogeological Map of the Chalk and Lower Greensand of Kent (1:126,720, 1970) indicates that the potentiometric surface of the Chalk is between 15mAOD and 30mAOD, indicating a water level of 70-85m bgl. Hence, available information would suggest that the water level in the vicinity of the site is likely to be between 70m bgl and 95m bgl, however, this has not been confirmed.

No groundwater abstractions are recorded with 1km of the site.

SURFACE WATER

The closest surface water feature to the site is a branch of the River Dour, located 2.4km to the south-west. No surface water abstractions are located within 1km of the site.

JAPANESE KNOTWEED

No Japanese Knotweed was observed during the site walkover. However, a Japanese Knotweed investigation has not been undertaken and would need to be undertaken by a specialist to confirm these conclusions.

LANDFILL

No landfills were identified at or within 500m of the site.

GROUND HAZARDS

An Envirocheck report commissioned as part of the 2015 WSP PSSR identified the following ground hazards at the site.

Table 3.5 Ground Hazard Summary

Feature	Hazard/Potential
Radon Affected area	The property is in an intermediate probability radon area, as between 3 and 5% of homes are above the action level. Basic radon protective measures are necessary in the construction of new dwellings or extensions.
Landslide	Low
Compressibility of soils	Very Low/No Hazard

FEATURE	HAZARD/POTENTIAL
Collapsible Ground Stability Hazards	Low
Ground Dissolution Hazards	Low
Running Sand Ground Stability Hazards	Very Low
Shrinking or Swelling Clay Ground Stability Hazards	Low

WSP considered that due to the geology at the site, of superficial deposits over chalk, that the potential for ground dissolution hazards should be upgraded to moderate to high. Hence, a cavity assessment was commissioned (PBA Cavities Assessment).

3.3 PRELIMINARY CONCEPTUAL SITE MODEL (CSM)

The preliminary CSM from the PBA Phase 1 report has been reviewed, and the pertinent information for the current site is summarised below.

Potential sources of on-site contamination include:

- agricultural land use, which may give rise to fertiliser, pesticide and herbicide contamination
- the property is in an intermediate probability radon area, as between 3 and 5% of homes are above the action level

Off-site sources of contamination may include:

- a tank previously located at Great Pineham Farm, which may have been used to store hydrocarbons; and,
- the infilled chalk pits, four of which are located less than 400m from the site, the infilled chalk pits may generate ground gas, dependant on the infill material utilised.

The expected risk to current and future human health on-site and off-site is expected to be very low, with a very low to low risk to future human health on site. The risk to building services and ecological systems is expected to be very low.

Based on the preliminary CSM, PBA considered that the site represented a **VERY LOW** to **LOW** risk with respect to potential impacts to future site users and controlled waters, given the current site use and geo-environmental setting.

RECOMMENDATIONS

Based on the above conclusions PBA recommended that:

- A geotechnical and geo-environmental ground investigation is undertaken at the site to include;
  - Confirmation of the geological sequence and ground conditions across the site area;
  - Confirmation of the hydrogeological regime at the site;

- Assessment of the geochemical properties of soils and groundwater with particular focus on the potential sources of contamination identified in the preliminary CSM;
- Monitoring for the presence of soil gas/vapours where Made Ground is encountered;
- Collection of soil and groundwater samples for laboratory assessment in order to classify appropriate sulphate design classification;
- Assessment of the permeability of the deposits underlying the site in order to confirm appropriate site drainage measures for the site; and,
- Determination of the geotechnical properties of the deposits present, including confirmation of bearing capacity, volume change potential, CBR values, frost susceptibility, and compaction characteristics.

4 SITE INVESTIGATION AND ASSESSMENT RATIONALE

4.1 FIELDWORKS

An intrusive ground investigation was carried out by Geotechnical Engineering and supervised by WSP. The exploratory hole locations are provided on **Figure 4**.

In accordance with the requirements of the Health and Safety Plan each borehole and window sample location was hand pitted to 1.2m bgl as part of a service avoidance exercise.

A summary of the ground investigations undertaken in the proposed residential area (the field) is presented in **Table 4.1**, below.

Table 4.1 Fieldwork Summary in Area 1 (Residential)

METHOD	NUMBER	LOCATIONS	DEPTH (M BGL)
Dynamic Sample (Comacchio 305)	1	BH03	15.30
Window Sampler (Terrier Rig)	8	WS105, WS106, WS107, WS108, WS109, WS110, WS111, WS112	5.45
Trial Pits (Excavator 360)	12	TP101, TP102, TP103, TP104, TP105, TP106, TP107, TP108, TP109, TP110, TP111, TP112	3.10
Infiltration Tests (Excavator 360)	9	IN101, IN102, IN103, IN104, IN105, IN106, IN07, IN108, IN109	3.30
In-situ CBR tests	6	CBR104, CBR105, CBR106, CBR107, CBR108, CBR109	0.3

Eight of the window sample and one of the dynamic sample locations in the field area were installed with wells for monitoring and sampling of ground gas and groundwater. A summary of the monitoring wells installed in the field area is presented in **Table 4.2**. Details of ground and groundwater conditions, in-situ testing and well installation details are included in the exploratory hole records presented in **Appendix D**.

Table 4.2 Summary of monitoring wells installed in Area 1 (Residential)

EXPLORATORY HOLE	GROUND LEVEL (MAOD)	STANDPIPE / PIEZOMETER DIAMETER	SCREEN TOP AND BASE DEPTH (MBGL)	SCREEN TOP AND BASE ELEVATION (MAOD)	STRATA TARGETED
BH03	101.982	50mm	12.30 to 15.30	89.68 to 86.68	Seaford Chalk Formation
WS105	101.806	50mm	3.50 to 5.00	98.31 to 96.81	Seaford Chalk Formation
WS106	99.583	50mm	3.00 to 5.00	96.58 to 94.58	Seaford Chalk Formation
WS107	106.66	50mm	2.00 to 5.00	104.66 to 101.66	Seaford Chalk Formation
WS108	103.438	50mm	2.80 to 5.00	100.64 to 98.44	Seaford Chalk Formation
WS109	98.52	50mm	3.00 to 5.00	95.52 to 93.52	Head / Seaford Chalk Formation
WS110	104.397	50mm	2.00 to 5.00	102.40 to 99.40	Seaford Chalk Formation
WS111	101.702	50mm	1.50 to 5.00	100.20 to 96.70	Seaford Chalk Formation
WS112	99.306	50mm	1.50 to 5.00	97.81 to 94.31	Seaford Chalk Formation

[1]MAOD - metres above ordnance datum; MBGL – metres below ground level.

A summary of ground investigations undertaken in area 2 (the road) is presented in **Table 4.3**, below.

Table 4.3 Fieldwork Summary in Area 2 (The Road)

METHOD	NUMBER	LOCATIONS	DEPTH (M BGL)
Dynamic Sample (Comacchio 305)	2	BH01, BH02	15.20
Window Sampler (Terrier Rig)	3	WS01, WS03, WS04,	5.45
Infiltration Tests (Excavator 360)	6	IN01, IN02, IN03, IN04, IN05, IN06,	2.95
In-situ CBR tests[1]	10	CBR01, CBR02, CBR03, CBR04, CBR05, CBR06, CBR07, CBR08, CBR09, CBR10	0.3 (CBR10 to 2.0m bgl)

[1]The CBR test at location CBR10 was completed using the DCP technique due to access restrictions

One dynamic sample hole in the area of the road was installed with a well for monitoring and sampling of ground gas and groundwater. The detail of the installation is presented in **Table 4.4**. One window sample location (WS02) was too steep for the machine and was not undertaken.

Table 4.4 Monitoring well installations in the area of the A256

EXPLORATORY HOLE	GROUND LEVEL (MAOD)	STANDPIPE / PIEZOMETER DIAMETER	SCREEN TOP AND BASE DEPTH (MBGL)	SCREEN TOP AND BASE ELEVATION (MAOD)	STRATA TARGETED
BH01	95.187	50mm	12.30 to 15.20	82.89 to 79.99	Seaford Chalk Formation

4.2 IN-SITU AND FIELD SOIL TESTING

STANDARD PENETRATION TESTS (SPTS)

SPTs were performed within all boreholes and all window samples, the results are presented on the exploratory hole records (**Appendix D**).

A plot of all SPT 'N' values with depth in the road area is presented as **Figure 5A** and a plot of all SPT 'N' values with depth in the proposed residential area is presented as **Figure 5B**.

4.3 SAMPLING AND LABORATORY CHEMICAL ANALYSIS AND GEOTECHNICAL ANALYSIS

CHEMICAL ANALYSIS

All analysis was undertaken at the UKAS and MCERTS accredited laboratory of Alcontrol and field sampling was undertaken in accordance with industry guidance.

SOILS

The sampling strategy followed at the site aimed to achieve good spatial and vertical coverage.

Ten (10 No.) samples were tested in the area of the A256; four in the Made Ground, one in the Head and five in the Seaford Chalk Formation.

Twenty-seven (27 No.) samples were analysed from the area of the proposed residential area. Twenty-three samples were analysed from the Head; nine at less than 0.5m bgl, eleven at 1.0m bgl and three between 1.5 and 2.9m bgl. Four samples were analysed from the Seaford Chalk Formation between 2.5m bgl and 3.0m bgl.

Chemical laboratory analysis comprised metals, polycyclic aromatic hydrocarbons (PAH), soil organic matter (SOM), pH, asbestos, total petroleum hydrocarbons (TPH) and pesticides.

GROUNDWATER

No groundwater was encountered during the site investigation, therefore no sampling or testing was undertaken.

GEOTECHNICAL ANALYSIS

Geotechnical analysis has been carried out as part of this investigation. In the area of the A256 three samples (3 No.) within the Made Ground were analysed for moisture content, plasticity index, saturated moisture content and sulphate. Ten (10 No.) samples from the Seaford Chalk Formation were selectively analysed for moisture content, saturated moisture content, plasticity index, particle size distribution and sulphate.

In the proposed residential area six (6 No.) samples within the Head were selectively analysed for moisture content, plasticity index, particle size distribution, sulphate and undrained shear strength. Eight (8 No.) samples from within the Seaford Chalk Formation were selectively analysed for moisture content, saturated moisture content and plasticity index.

4.4 GROUNDWATER AND GAS MONITORING

Three monitoring visits were undertaken between the 17 February 2016 and the 3 March 2016.

Groundwater level monitoring together with ground gas monitoring were undertaken at WS105-WS112, BH02 and BH03 during all three visits with the results and analysis presented within **Section 9.3**.

4.5 SUPPLEMENTARY PLATE BEARING TESTING

Three phases of Plate Bearing Tests (PBT) and Hand Shear Vane (HSV) tests were undertaken in Area 1.

Phase 1 comprised the first four (4No.) PBT and eight (8No.) HSV tests, undertaken on 16 May in the centre of the site at 1m bgl. Phase 2 comprised thirteen (13No.) PBT tests and fourteen (14No.) HSV tests undertaken between the 19 July and the 21 July. Phase 3 comprised of fourteen (14No.) PBT and sixteen (16No.) HSV tests undertaken between the 18 October and the 20 October. The tests were undertaken in 3m by 5m trial pits using a 14 tonne machine as kentledge.

Note. One (1No.) of the scoped plate bearing tests was unable to be completed in phase 2. During phase 3, (2No.) extra HSV tests were undertaken in PBT113 due to the variability of the fill in that location.

The results of these tests are presented in table and in **Appendix J.**

The following geotechnical analyses and assessment have given more weight to the supplementary investigation results than the original investigation, due to the targeted nature of the supplementary exploratory holes and testing.

5 REVISED GROUND MODEL

5.1 GROUND CONDITIONS ENCOUNTERED

PROPOSED RESIDENTIAL AREA

Exploratory hole records are provided in **Appendix D** with a summary of the strata encountered in the field area presented in **Table 5.1**, below.

Table 5.1 Summary of strata encountered in the proposed residential area

STRATUM NAME	DEPTH TO BASE OF STRATA (MBGL)*	ELEVATION OF BASE OF STRATA (MAOD)*	THICKNESS (M)*	TYPICAL DESCRIPTION	LOCATIONS OBSERVED IN
Topsoil	0.05 to 0.60	108.7 to 97.6	0.05 to 0.60	Grass over soft brown silty and sandy slightly gravelly CLAY. Gravel is fine to coarse subangular to angular flint and medium chalk. Rare to frequent rootlets.	BH03, IN101-IN109, IN07, TP101-TP112, WS105-WS112
Head	1.0 to 3.50	104.7 to 95.4	0.90 to 3.45	**Firm to very stiff**[1] (Soft to firm [2]) orangish brown to light brown slightly sandy slightly gravelly silty CLAY. Gravel is angular and subangular fine to coarse flint.	BH03, IN07, IN101-IN106, IN108, IN109, TP101-TP112, WS105 – WS112
Seaford Chalk Formation	8.85	93.2	5.95	Recovered as structureless CHALK composed of white to light grey slightly sandy slightly gravelly SILT/ slightly silty subangular to subrounded fine to coarse GRAVEL. Clasts are weak with rare black spots, with occasional flints (CIRIA Grade Dm/Dc)	BH03, WS105-WS112, TP101, TP102, TP104, TP107-TP109, TP111, TP112, IN07, IN102, IN104, IN105, IN108, IN109
	Not proven to a max depth of 15.3	Not proven to a max depth of 86.7	Not proven	Very weak medium density white CHALK. Fractures are subhorizontal to 10deg, subvertical to 80deg and 70deg very closely and closely spaced undulating smooth. (CIRIA Grade B4).	BH03

[1] **Supplementary Investigation**
[2] **Original Investigation**

Due to the composition of the superficial deposits encountered during the investigation it was not possible to differentiate between the Head and Dry Valley Deposits, therefore, both deposits shall be referred to as Head in the remainder of this report.

The supplementary investigation presented an opportunity to analyse the properties of the Head deposits in situ. The Head deposits were described in situ as firm to very stiff at 0.2m to 1.0m bgl.

ROAD

Exploratory hole records are provided in **Appendix D** with a summary of the strata encountered in the road area presented in **Table 5.2**, below.

Table 5.2 Summary of strata encountered

Stratum Name	Depth to Base of Strata (mbgl)*	Elevation of Base of Strata (mAOD)*	Thickness (m)*	Typical Description	Locations observed in
Topsoil	0.05 to 0.35	109.1 to 97.2	0.05 to 0.35	Grass over soft brown silty and sandy slightly gravelly CLAY. Gravel is fine to coarse subangular to angular flint and medium chalk. Rare to frequent rootlets.	IN01-IN06, WS03, WS04
Made Ground Granular	0.50 to 1.00	94.2 to 92.6	0.50 to 1.00	CONCRETE and light brown to grey clayey sandy angular to subrounded fine to coarse flint, brick and chalk GRAVEL.	BH01, BH02
Made Ground Cohesive	Not proven to a max depth of 5.45	Not proven to a max depth of 94.1	Not proven	Soft brown silty CLAY and white locally stained yellow very gravelly SILT with a high angular flint content and a low subrounded chalk cobble content. Gravel is subangular and subrounded fine to coarse chalk.	WS01
Head	1.2	96.0	1.15	Soft occasionally firm[2] orangish brown to light brown sandy slightly gravelly CLAY. Gravel is angular and subangular fine to coarse flint.	IN02, WS04

STRATUM NAME	DEPTH TO BASE OF STRATA (MBGL)*	ELEVATION OF BASE OF STRATA (MAOD)*	THICKNESS (M)*	TYPICAL DESCRIPTION	LOCATIONS OBSERVED IN
Seaford Chalk Formation	7.2 to12.45	88.0 to 80.7	6.20 to11.95	Recovered as structureless CHALK composed of white to light grey slightly sandy slightly gravelly SILT/ slightly silty subangular to subrounded fine to coarse GRAVEL. Clasts are weak with rare black spots, with occasional flints (CIRIA Grade Dm/Dc)	BH01, BH02. WS03, WS04, IN01, IN03-IN06
	Not proven to a max depth of 15.20	Not proven to a max depth of 78.4	Not proven	Very weak medium density white CHALK. Fractures are subhorizontal to 10deg, subvertical to 80deg and 70deg very closely and closely spaced undulating smooth. (CIRIA Grade B4).	BH01, BH02

Due to the composition of the superficial deposits encountered during the investigation it was not possible to differentiate between the Head and Dry Valley Deposits, therefore, both deposits shall be referred to as Head in the remainder of this report.

5.2 GROUNDWATER CONDITIONS

Groundwater was not encountered during the site investigation or during subsequent monitoring visits.

5.3 OBSERVATIONS OF CONTAMINATION

No visual or olfactory contamination was noted during the site investigation.

6 GEOTECHNICAL RESULTS (MATERIAL PROPERTIES)

A factual summary of the results of geotechnical testing is presented below. For details of the methods and results refer to **Appendix E**.

Note. The supplementary investigation results will be given more weight than the original investigation, due to the targeted nature of the supplementary exploratory holes and testing.

6.1 AREA 1 (PROPOSED RESIDENTIAL AREA)

MADE GROUND

Made Ground was not encountered in this area of the site.

HEAD

Superficial deposits of Head were encountered over the entire area overlying the Seaford Chalk Formation. The depth of the Head varied laterally in a north - south direction over the site. **Figure 6** and **Figure 7** illustrate the depth of the Head over the site.

A summary of the geotechnical testing undertaken on samples from the Head are summarised in **Table 6.1**, below.

Table 6.1 Geotechnical and chemical testing on soil samples from the Head deposits (proposed residential area)

SOIL PARAMETER	RANGE	NO. OF TESTS
Moisture content (%)	22 - 26	4
Liquid Limit (%)	47 - 48	3
Plastic Limit (%)	20 - 24	3
Plasticity Index (%)	23 – 28	3
Plasticity term	Intermediate	3
Volume change potential	Medium	3

SOIL PARAMETER	RANGE	NO. OF TESTS
Consistency term	**Firm to very stiff**[1] Soft to firm[2]	3
Undrained shear strength (kN/m^2)	**65-100**[1] 30[2]	38 Hand Shear Vane Tests[1] 1 Single stage Triaxial test.[3]
Aqueous sulphate extract (g/L SO_4)	<0.01 – 0.02	2
pH	7.95	1

[1] **Supplementary Investigation**

[2] **Original Investigation**

[3] **Due to the lateral nature of the stratum only a single undisturbed sample was recovered from the Head as part of this investigation.**

Three samples of the Head were tested using particle size distribution analysis. The results are summarised in **Table 6.2**, below.

Table 6.2 Particle size distribution analysis on samples from the Head (proposed residential area)

LOCATION AND DEPTH (M BGL)	SILT AND CLAY (%)	SAND (%)	GRAVEL (%)	COBBLES (%)	DESCRIPTION
IN103 (2.0)	48	6	27	19	Brown slightly fine to coarse sandy slightly fine to coarse gravelly CLAY with cobbles.
IN106 (2.0)	96	4	0	0	Brown fine slightly sandy SILT/CLAY.
WS106 (1.0)	97	3	0	0	Brown fine slightly sandy CLAY.

A one dimensional consolidation test was undertaken on one sample from BH3, at 1.2-1.65m bgl. The result is summarised in **Table 6.3**.

Table 6.3 One dimensional consolidation test on sample BH3 1.2-1.65m bgl

PRESSURE RANGE (KPA)	MV (M^2/MN)	CV (M^2/YR)
0 – 20	0.47	11.49
20 – 50	0.30	14.16
50 – 100	0.20	17.27
100 – 150	0.15	12.59
150 – 200	0.13	4.75
200 - 250	0.11	1.60

SEAFORD CHALK FORMATION

The Seaford Chalk Formation was encountered beneath the entire area. The depth to chalk ranged from 1.0m bgl to 3.5m bgl.

Saturated moisture content and density results from the Seaford Chalk Formation samples are summarised in **Table 6.4**, below.

Table 6.4 Saturated moisture contents in the Seaford Chalk Formation (proposed residential area)

PARAMETER	RANGE	NO. OF TESTS
Moisture content (%)	27 - 32	10
Bulk density (mg/m^3)	1.5 – 1.95	8
Dry density (mg/m^3)	1.14 – 1.51	8
Saturated moisture content (%)	29 - 51	8

The above results would classify the chalk encountered during the investigation as a low density chalk. It should be noted that Geotechnical Engineering logged the deeper structured chalk as medium density, however, based on these laboratory results WSP consider it prudent to assume a low density chalk for the near surface chalk.

6.2 AREA 1 – SUPPLEMENTARY INVESTIGATION

Table 6.5 Supplementary investigation results undertaken between 0.9 and 1.3mbgl in the Head deposits

PARAMETER	RANGE	NO. OF TESTS
Settlement (Plate Bearing Test)	1.42 to 7.62mm	31
Hand Shear Vane Test	65-150kPa	38
CBR Test	4%	1

See **Appendix J** for Supplementary investigation testing locations, test results and logs.

6.3 AREA 2 – ROAD (A256)

MADE GROUND

Made Ground was encountered as granular deposits in BH1 and BH2, located in the Great Pineham Farm Subway, and as cohesive deposits in WS01, located on the verge of the A256. The granular deposits generally comprised flint, brick and chalk gravel. The Made Ground extended to a depth of 1.0m bgl in BH1 and a depth of 0.5m bgl in BH2. The cohesive deposits comprised a soft brown silty clay and a white locally stained yellow very gravelly silt with a high angular flint content and a low subrounded chalk cobble content. The Made Ground extended to a depth of 5.45m bgl in WS01, the base of the Made Ground was not proven.

A summary of the geotechnical testing on the granular Made Ground is presented in **Table 6.5**, below.

Table 6.6 Geotechnical summary of Made Ground samples (road)

SOIL PARAMETER	RANGE	NO. OF TESTS
Moisture content (%)	15 - 25	2
Plasticity index	NP[1]	2
Aqueous sulphate extract (g/L SO_4)	<0.01 – 0.01	2
pH	7.99	1
Saturated moisture content	40%	1

[1]Non plastic

HEAD

In the road area of the investigation only WS04 and IN02 encountered Head deposits. No geotechnical testing was undertaken on WS04 and IN02.

SEAFORD CHALK FORMATION

The Seaford Chalk Formation was encountered beneath the entire area. The depth to the top of the chalk ranged from 0.35m bgl to greater than 2.9m bgl.

Saturated moisture content and density results from the Seaford Chalk Formation samples are summarised in **Table 6.7**, below.

Table 6.7 Saturated moisture contents in the Seaford Chalk Formation (road)

PARAMETER	RANGE	NO. OF TESTS
Moisture content (%)	19 – 32	8
Bulk density (mg/m^3)	1.49 – 1.71	8
Dry density (mg/m^3)	1.25 – 1.32	8
Saturated moisture content (%)	39 - 43	8

The above results would classify the chalk encountered during the investigation as a low density chalk. It should be noted that Geotechnical Engineering logged the deeper structured chalk as medium density, however, based on these laboratory results WSP consider it prudent to assume a low density chalk for the near surface chalk.

Chemical results for the Seaford Chalk Formation are summarised in **Table 6.7**, below.

Table 6.8 Chemical results for the Seaford Chalk Formation (road)

PARAMETER	RANGE	NO. OF TESTS
Aqueous sulphate extract (g/L SO_4)	<0.01 – 0.02	6
pH	7.67	2

Plasticity testing was undertaken on three samples of the Seaford Chalk Formation, the results are summarised in **Table 6.8**, below.

Table 6.9 Plasticity testing within the Seaford Chalk Formation (road)

Sample	Description	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Plasticity Term
BH2 1.2-1.65m bgl	Structureless CHALK composed of white slightly sandy silty angular and subangular fine to coarse GRAVEL. Clasts are weak low density white with rare yellow staining, rarely angular fine to coarse flint. Matrix is white. (Probable CIRIA Grade Dc).			Non plastic	
IN03 2.0m bgl	Structureless CHALK composed of white and light grey slightly gravelly SILT. Gravel is subrounded and subangular fine and medium very weak low density white with rare angular coarse flint. (CIRIA Grade Dm)			Non plastic	
WS3 1.0m bgl	Structureless CHALK composed of white slightly gravelly SILT with a high angular flint cobble content. Gravel is angular to subrounded fine to coarse very weak and weak low density white with rare black specks (up to 1mm) chalk. (probable CIRIA Grade Dm)	55	26	29	High

Particle size distribution analysis was carried out on one sample from the Seaford Chalk Formation, however, the results may not be indicative as chalk fragments are likely to alter size during the test process.

Table 6.10 Particle size distribution analysis in the Seaford Chalk Formation (road)

Location and depth (m bgl)	Silt and clay (%)	Sand (%)	Gravel (%)	Cobbles (%)	Description
IN03 2.0m bgl	13	3	84	0	Silty/clayey slightly sandy GRAVEL (chalk).

7 GEOTECHNICAL ASSESSMENT

7.1 PROPOSED WORKS

Current development plans comprise the construction of 94 new homes, predominantly semi-detached/detached with gardens, and a new at-grade roundabout on the A256. As part of the roundabout development the subway structure is proposed to be lengthened. This report is not intended to meet the requirements of a Eurocode 7 Geotechnical Design Report (GDR).

In relation to the widening of the road for the roundabout, to provide access to the proposed development, an Approval in Principle (AIP Form C) and GDR have been submitted under separate cover.

7.2 GEOTECHNICAL CONSTRAINTS

A summary of geotechnical constraints is provided in **Table 7.1**, below.

Table 7.1 Geotechnical constraints

GEOTECHNICAL CONSTRAINTS	
Made Ground	Granular Made Ground was encountered in BH1 and BH2 (1.0m and 0.5m in thickness respectively), located in and adjacent to the Great Pineham Farm Subway. Cohesive Made Ground was encountered in WS01 (to 5.45m bgl), located on the verge of the A256. Made Ground was not encountered across the field area of the site.
Obstructions	No below ground obstructions were encountered during the site investigation.
Groundwater	No groundwater was encountered during the site investigation or during subsequent monitoring visits. It is considered to be present at depth, approximately 70 – 95m bgl.
Lateral changes in geology	The geology at the site consists of Head over the Seaford Chalk Formation. The depth to the Chalk varies across the site, **Figure 6** and **Figure 7** illustrates the contours of depth to chalk across the site.
Compressible soils	Head is present over the majority of the site, extending to a maximum depth of 3.5m bgl. The Head deposits, were encountered as a firm to very stiff clay, of medium volume change potential and have the potential to be compressible.
Frost susceptibility	Where the chalk is present within 500mm of the ground level, pavements should be designed to ensure protection against frost damage.

GEOTECHNICAL CONSTRAINTS	
Excavation instability	During the site investigation a minor sidewall failure occurred in IN02. However, no structural failures were recorded in the remaining trial pits/soakaways. Refer to CIRIA 97 for guidance on trench stability.

7.3 PRELIMINARY FOUNDATION APPRAISAL

Table 7.2 provides an appraisal of a selection of different foundation options and their respective appropriateness for the proposed development for the residential development of Area 1.

Table 7.2 Foundation options appraisal

FOUNDATION OPTION	SUITABILITY	JUSTIFICATION
Shallow spread foundations	Suitable	It is likely that the shallow deposits on site will provide a suitable bearing capacity for the proposed development. The Head deposits overlying the majority of the residential site are typically firm to very stiff, with a corresponding medium to high shear strength. Plate bearing tests also indicate an anticipated acceptable long term settlement.
Rafts	Suitable	It is likely that the shallow deposits on site will provide a suitable bearing capacity for the proposed development. The Head deposits overlying the majority of the residential site are typically firm to very stiff, with a corresponding medium to high shear strength. Plate bearing tests also indicate an anticipated acceptable long term settlement.
Ground Improvement – vibro stone / concrete columns	Suitable	Vibro improvement could be considered to improve the shallow soils.
Piles – bored	Suitable	Sufficient bearing capacity can be achieved from piles bored into the chalk.
Piles – driven	Suitable	Sufficient bearing capacity can be achieved from piles driven into the chalk.

The above appraisal is a preliminary assessment based on a number of generalising assumptions relating to the development.

Based on a low rise residential development, it is considered that strip foundations are most likely to be the most appropriate at this stage, as the maximum long term resultant settlement is anticipated to be within service limits. This is based on a line load of 60kN per meter run and a 600mm wide strip footing (as specified by the Structural Engineer). This is also based on a foundation depth of at least 1m below either existing ground or finished floor level (whichever is deepest).

WSP recommend that during construction the formation of all foundations is tested in-situ with a hand shear vane, and a minimum of 60kN/m^2 (average based on 3 tests per location) is achieved. Where a minimum of 60kN/m^2 is not achieved WSP should be notified to provide appropriate mitigation measures.

7.4 FLOOR SLABS

WSP consider a beam and block floor will most likely be incorporated into the design, which is a form of suspended slab. If ground bearing floor slabs are preferred, WSP consider a ground bearing floor slab would be acceptable for lightly loaded slabs, no greater than 10kN/m^2 at an embedment depth of at least 0.4 metres below original ground level.

7.5 PAVEMENT DESIGN

Sixteen CBR tests were undertaken across the site, at a depth of 0.3m bgl. The CBR value ranged from 1.3 to 5.8%.

A single DCP test was completed at the location of CBR10, due to access restrictions. Assuming the proposed road will mimic the existing vertical alignment, the CBR values reported in location CBR10 between 0.2 and 0.3m bgl ranged from 1.6 – 9.1%.

Typically the Head deposits were encountered at 0.3m bgl, which was typically a firm clay. Based on HD25/94 Subgrade Design, a CBR of 3% is considered appropriate to facilitate preliminary pavement design.

Following excavation to formation level, the subgrade should be proof rolled with a heavy roller, inspected by an engineer and any soft spots removed and replaced with well compacted granular fill. Any sub structure remains should be “grubbed out” to a minimum depth of 500mm below the underside of the formation to prevent hard spots from forming. Voids, or low areas should be backfilled with granular fill and appropriately benched to ensure a gradual transition between the fill and the adjacent ground.

Where the chalk is encountered at shallow depths the pavement design should ensure protection from frost. A minimum construction thickness of 450mm should be adopted.

The CBR and DCP results are attached in **Appendix F**.

7.6 EXCAVATIONS AND DEWATERING

No groundwater was encountered during the site investigation and subsequent monitoring visits, hence, it is unlikely that dewatering will be required. During the site investigation a minor sidewall failure occurred in IN02. However, no structural failures were recorded in the remaining trial pits/soakaways.

It is recommended that CIRIA 97, Trenching Practice is referred to.

7.7 EARTHWORKS

Based on existing site levels, it is anticipated that some form of earth movements will take place to provide a level development platform, for the purposes of the above assessment it has been considered that this will be limited to excavations for foundations and service infrastructure. If significant earth movements are required an Earthworks Strategy and Specification will be required and the above recommendations will need to be reviewed.

7.8 CHEMICAL ATTACK ON BURIED CONCRETE

Soil samples over the entire site were analysed for water soluble sulphate concentration, including samples in the Made Ground, the Head, and from the Seaford Chalk Formation.

The highest sulphate concentration from a solid sample in the Made Ground is 10mg/l, and the lowest pH is 7.99.

The highest sulphate concentration from a solid sample in the Head is 20mg/l SO_4 corresponding to a pH of 7.95.

The average of the two highest sulphate concentrations from a solid sample of the Seaford Chalk Formation is 20mg/l SO_4 and the minimum pH for a solid sample of the Seaford Chalk Formation is 7.67.

Using the methods identified in BRE Special Digest 1:2005 3rd edition both the Made Ground and natural soils at the site are classified as Design Sulphate Class 1 (DS1). Assuming the pH of the soil is representative of the pH of the groundwater, an aggressive chemical environment for concrete class AC-1 is suitable for the site.

7.9 INFILTRATION TESTING (SOAKAWAYS)

Soakaway results are attached as **Appendix G**.

METHODOLOGY

During the site investigation fifteen (15 No.) trial pits were excavated specifically for infiltration purposes. The soakaways were undertaken within these pits from the 8 to the 12 of February 2016. The number, location and depth of the pits were specified by WSP | Parsons Brinckerhoff drainage engineers. The locations are presented on **Figure 4**.

The soakaways were conducted in broad accordance with BRE Digest 365 ‘Soakaway Design’. In some of the pits only two of the standard three tests were completed due to time constraints in the field.

Bulk samples were collected from the horizon where a soakaway was conducted for laboratory analysis. Selected samples of the Head deposits underwent particle size distribution analysis, and those within the Seaford Chalk Formation were selectively analysed for saturated moisture content.

RESULTS

Table 7.3, below, presents the lowest infiltration rate achieved dependant on the geology and location on site.

Table 7.3 Infiltration rates

STRATA	SOAKAWAY	INFILTRATION RATE (M/S)	
		Minimum	No. of tests
Residential area			
Head	IN101	n/a	1
	IN103	**1.2×10^{-4}**	3
	IN106	**7.0×10^{-5}**	3
Seaford Chalk Formation	IN102	**7.5×10^{-5}**	3
	IN104	n/a	1
	IN105	**2.9×10^{-5}**	3
	IN07	**5.8×10^{-5}**	3
	IN108	n/a	1
	IN109	n/a	2
Road			
Head	IN02	n/a	1
Seaford Chalk Formation	IN01	8.5×10^{-5}	2
	IN03	n/a	2
	IN04	n/a	2
	IN05	4.0×10^{-5}	2
	IN06	**1.0×10^{-5}**	3

n/a indicates insufficient infiltration to generate a representative infiltration rate.

Bold results are indicative of BRE 365 compliant infiltration rates.

Particle size distributions for the samples undertaken in the Head are provided in **Table 7.4**, below.

Table 7.4 Particle size distribution of infiltration samples within the Head.

LOCATION AND DEPTH (M BGL)	SILT AND CLAY (%)	SAND (%)	GRAVEL (%)	COBBLES (%)	DESCRIPTION
IN103 2.0m	48	6	27	19	Brown slightly fine to coarse sandy slightly fine to coarse gravelly CLAY with cobbles.
IN106 2.0m	96	4	0	0	Brown fine slightly sandy SILT/CLAY.

Dry density and saturated moisture contents for the infiltration tests undertaken in the Seaford Chalk Formation are presented in **Table 7.5**, below.

Table 7.5 Saturated moisture content data of infiltration samples within the Seaford Chalk Formation.

LOCATION	DRY DENSITY (MG/M^3)	SATURATED MOISTURE CONTENT (%)	DENSITY
Residential area			
IN102	1.27	42	Low
IN104	1.29	41	Low
IN105	1.32	39	Low
IN07	1.51	29	Low
IN108	1.33	38	Low
IN109	1.25	43	Low
Road			
IN01	1.3	40	Low
IN04	1.32	39	Low
IN05	1.32	39	Low
IN06	1.25	43	Low

The Southern Testing investigation completed a soakaway test in TP06, located in the north east of the site. An infiltration rate of $7.5x10^{-5}$ m/s was reported from two tests. This is considered comparable to the results encountered during the current WSP investigation.

INFILTRATION TESTING SUMMARY

The results obtained from the soakaway tests indicate a minimum infiltration value of $7.0 x10^{-5}$ m/s in the Head deposits and $1.0 x10^{-5}$ m/s in the Seaford Chalk Formation. The failure of two soakaway tests in the Head deposits (50% of the test locations) and five in the Seaford Chalk Formation (45%) suggests heterogeneity of permeability across the site.

It should be noted that only those highlighted in bold in Table 7.3 above are fully in compliance with BRE 365 (i.e. 3 tests were completed in each location). Therefore WSP recommend that the remaining results are only used for preliminary design purposes and are treated with care / appropriately factored.

Given the low density of the Seaford Chalk Formation samples CIRIA C574 Engineering in Chalk recommends that soakways should be sited at least 10m away from any foundations.

8 ENVIRONMENTAL RESULTS AND RISK ASSESSMENT

8.1 OVERVIEW

The presence of contaminated materials on a site is generally only of concern if an actual or potentially unacceptable risk exists. Part 2A of the Environmental Protection Act (EPA), its accompanying regulations and Statutory Guidance contained in DEFRA Circular 01/2012 present the statutory definition of "contaminated land". For the purposes of Part 2A, 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 reason of substances in, on, or under the land that:

- Significant harm is being caused or there is a significant possibility of such harm being caused;
- Contamination of controlled waters is being, or is likely to be caused.

The Part 2A regime was designed and intended to encourage voluntary remediation rather than regulatory action and to work with the established role of planning and building control in those cases where the land is suitable for or scheduled for redevelopment.

DEFRA Circular 01/2012 makes clear that, where new development is taking place, it is the responsibility of the developer to ensure that redevelopment is safe and suitable for use for the purpose for which it is intended and thus to carry out any necessary remediation. In most cases the enforcement of remediation requirements is therefore through planning conditions and building control rather than through a Remediation Notice under Part 2A. The National Planning Policy Framework (NPPF) Section 121, states that *'After remediation, as a minimum, land should not be capable of being determined as contaminated land under Part 2A of the EPA 1990'*.

A developer will need to satisfy the local authority that unacceptable risk from contamination will be successfully addressed through remediation without undue environmental impact during and following the development.

The term contaminant linkage has been described in the Preliminary Conceptual site Model as an assessment of Sources, Pathways and Receptors. Each of these three elements can exist independently, but they create a risk only where they are linked together, so that a particular contaminant affects a particular receptor through a particular pathway. Without a contaminant linkage, there is not a risk – even if a contaminant is present. Even where there is a contaminant linkage and therefore some measure of risk, the question still needs to be asked as to whether the level of risk justifies remediation. In the context of land contamination, 'risk' is a combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

8.2 FRAMEWORK

Our approach is consistent with that established in the publication Model Procedures for the Management of Land Contamination (CLR11) (Environment Agency 2004a). This establishes a tiered approach including:

- Stage 1 – Preliminary Risk Assessment (e.g. the establishment of potential contaminant linkages);

- Stage 2 – Generic Quantitative Risk Assessment (GQRA) (e.g. the comparison of contaminant concentrations against Soil Guideline Values (SGV) or other Generic Assessment Criteria (GAC)); and
- Stage 3 – Detailed Quantitative Risk Assessment (DQRA) (e.g. the comparison of contaminant concentrations against site specific assessment criteria).

Stage 1 (Preliminary Risk Assessment) has been completed for the wider site, and has been reviewed, summarised and focussed in **Section 3** of this report. A ground investigation has been completed and soil laboratory analysis results are available. Therefore the assessment can proceed to Stage 2 (Generic Quantitative Risk Assessment). As part of this exercise, the results are compared to generic screening criteria for the protection of human health receptors. If exceedances of these generic criteria are identified then the assessment proceeds to the next, and more detailed, level of assessment (Stage 3, Detailed Quantitative Risk Assessment). This detailed level of assessment uses modelling algorithms and site specific data to assess the significance of the potential contaminant linkages. If, after the detailed modelling, a potential significant risk is still identified then some form of further action may be required – and could comprise mitigation or some form of further assessment or remediation.

9 GENERIC QUANTITATIVE RISK ASSESSMENT

9.1 HUMAN HEALTH GQRA

In order to undertake a GQRA (Stage 2), contaminant concentrations need to be compared to appropriate generic assessment criteria. Current UK industry practice is to use, as first preference, UK SGVs which are generic assessment criteria published by the Environment Agency and derived using the Contaminated Land Exposure Assessment model (CLEA). Where these are not available and in order to provide a consistent methodology for the assessment of various contaminants, a series of Generic Assessment Criteria (GAC) screening values have been calculated by WSP using CLEA V1.071, a computer modelling tool designed to assess human health related risks posed by contaminated soil.

The contaminant concentrations have also been screened against Category 4 Screening Levels (C4SL) as outlined by Defra. The C4SLs provide a less conservative toxicological/exposure assumption. The impact assessment was agreed during the revision of the Part 2A Statutory Guidance and was developed on the basis that C4SLs could be used under the planning regime as well as within Part 2A.

COMPLIANCE CRITERIA

The future use of the site is proposed to be residential properties with private gardens. Therefore, soil contaminant concentrations detected have been compared against SGV/GAC values for a residential with plant uptake land use scenario. Sixteen samples were tested for soil organic matter (SOM). The SOM content for all the samples tested ranged between <0.35% to 1.32%. Based on this distribution the samples from the site have been compared to the GAC values relating to a SOM of 1%.

SOIL SAMPLE ANALYSIS

Thirty-seven soil samples were submitted for chemical analysis at a UKAS and MCERTS accredited laboratory and were analysed for a range of inorganic and organic determinands as detailed in **Section 4.3**. Four samples were taken in the Made Ground, twenty-four samples were taken in the Head and nine samples were taken in the Seaford Chalk Formation.

An asbestos soil screen was undertaken in the Made Ground (BH01, BH02, WS01 at 0.4-0.5m bgl and 1.0m bgl). Laboratory results are attached in **Appendix H.**

ASBESTOS

Three samples were screened for the presence of asbestos. Asbestos was not detected within any samples.

ENVIRONMENTAL ANALYSIS

No exceedances of SGVs/GAC have been identified within the soil samples at the site.

9.2 CONTROLLED WATERS GQRA

No groundwater was encountered at the site, therefore, no analysis have been undertaken.

9.3 GROUND GAS ASSESSMENT

Following completion of the intrusive investigation three ground gas monitoring visits were undertaken between the 17 February 2016 and the 3 March 2016.

Results of the gas monitoring are presented in **Appendix I**, and are summarised in **Table 9.1**, below.

Table 9.1 Gas monitoring results

Monitoring Point	Methane (%v/v)		Carbon Dioxide (%v/v)		Oxygen (%v/v)		Flow (l/hr)	
	Min	Max	Min	Max	Min	Max	Min	Max
BH01	0.0	0.0	0.0	0.3	18.5	19.8	-0.3	2.7
BH03	0.0	0.0	0.0	2.1	17.1	20.1	-1.0	1.6
WS105	0.0	0.0	0.8	2.1	17.4	19.4	-0.6	0.9
WS106	0.0	0.0	0.9	1.6	18.4	19.2	-0.1	0.7
WS107	0.0	0.0	0.0	0.7	18.9	20.0	0.1	1.5
WS108	0.0	0.0	0.0	2.3	18.1	20.1	-0.1	1.0
WS109	0.0	0.0	0.0	1.1	18.9	20.0	-1.2	1.8
WS110	0.0	0.0	0.0	2.0	18.1	20.1	0.0	1.0
WS111	0.0	0.0	0.0	2.0	18.1	20.1	-0.1	2.7
WS112	0.0	0.0	0.0	1.3	18.8	19.9	-0.9	1.8

Methane was not detected in any of the monitoring wells, and has therefore been excluded from **Table 9.2**, which summarises the representative gas screening values. The maximum flow detected was 2.7 l/hr in WS111.

Table 9.2 Gas screening values

	CARBON DIOXIDE
GSV Max Per Hole[1] (l/hr)	0.054
GSV based on Max Values[2] (l/hr)	0.062
Max values (%v/v)	2.3

[1]The maximum calculated GSV using data specific to each borehole over the monitoring period.

[2]A worst case estimate of the GSV using Maximum Concentration and Maximum Flow for the whole data set.

Based on the gas monitoring results described above and the proposed residential with plant uptake end use, the site would be classified in terms of ground gas risk as described in **Table 9.3**, below.

Table 9.3 Ground gas risk assessment

GROUND GAS RISK ASSESSMENT SCHEME	SITE CLASSIFICATION
CIRIA	Characteristic Situation 1 (CS1)
NHBC	Green

Atmospheric pressure during the monitoring varied between 993mB and 1016mB. The maximum range of atmospheric pressures during the monitoring visits was a fall of 2mB in visit 1.

9.4 SUMMARY OF CONTAMINATION ASSESSMENT

No exceedances against residential with plant uptake screening criteria were detected and no asbestos was identified.

No groundwater was encountered at the site.

Ground gas classification determined that the site fell within CS1 and protective measures are therefore not required.

10 REVISED CONCEPTUAL SITE MODEL

As a result of the GQRA the preliminary CSM (**Section 3.3**) has been revised in the context of risks to Human Health (assuming a residential with plant uptake end use) and controlled waters.

The preliminary CSM identified the potential on-site contamination sources due to the agricultural land use, and off-site contaminant sources comprising the tank previously located at Great Pineham Farm and the infilled chalk pits.

No contamination was identified during the site investigation. All samples analysed returned concentrations below the relevant SGV/GAC.

No groundwater was encountered during the investigation or subsequent monitoring visits. Therefore, any potential impact to groundwater is considered to be negligible.

Elevated levels of ground gas were not detected within the monitoring wells. Ground gas classification determined that the site fell within CS1 and protective measures are not required.

Given the extremely low levels of contaminants detected on the site there are no plausible contaminant pathways.

However, the site is situated within an area potentially affected by naturally occurring Radon gas. It is likely that 'Basic' Radon protection measures will be required in accordance with BRE Report BR211.

11 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the assessment and the limitations provided in **Appendix B** the following conclusions and recommendations are made.

11.1 CONTAMINATION CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the GIR, WSP make the following conclusions with regards to identified contaminated land constraints and contaminant linkages which may pose a risk during the proposed residential development.

- The risk to human health receptors is considered to be **VERY LOW**, on the basis that no exceedances of generic assessment criteria or soil guidance values occurred.
- The risk to controlled water is considered to be **VERY LOW**. Although groundwater was not encountered during the investigation no sources of potential soil contamination were encountered that could impact deeper groundwater.
- The risk to the built environment is considered to be **VERY LOW**, the site is classified as a Design Sulphate Class 1 (DS1) and an aggressive chemical environment for concrete class AC-1 is suitable for the site.
- The site is situated within an area potentially affected by naturally occurring Radon gas. It is likely that 'Basic' Radon protection measures will be required in accordance with BRE Report BR211.
- Due to no contamination of concern being encountered water supply pipes would not require barrier protection.
- Following 3No. rounds of ground gas classification it was determined that the site is within Characteristic Situation 1 and protective measures are therefore not required.
- The use of soakaways at the site would not increase the risk of pollution to groundwater due to no exceedances being identified within the soils and that regional groundwater is located at depth underlying the site.

11.2 GEOTECHNICAL CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the GIR, WSP make the following conclusions with regards to identified geotechnical constraints which may pose a risk during the proposed residential development.

Update as per results.

- WSP | Parsons Brinckerhoff consider that shallow strip foundations would be suitable for the properties within Phase 1. This is based on a line load of 60kN per meter run and a 600mm wide strip footing. This is also based on a foundation depth of at least 1m below either existing ground or finished floor level (whichever is deepest).
- WSP | Parsons Brinckerhoff recommend that during construction the formation of all foundations are tested in-situ with a hand shear vane, and a minimum of 60kN/m2 (average based on 3 tests per location) is achieved. Where a minimum of 60kN/m2 is not achieved WSP | Parsons Brinckerhoff should be notified to provide appropriate mitigation measures.
- Suspended floor slabs are considered most appropriate. However, for lightly loaded slabs, ground bearing floor slabs would be acceptable if embedded at least 0.4mbogl.

- A CBR of 3% should be assumed for preliminary pavement design.
- A minimum infiltration value of 7.0 $x10^{-5}$ m/s in the Head deposits and 1.0 $x10^{-5}$ m/s in the Seaford Chalk Formation should be assumed for design purposes. However caution should be considered due to the heterogeneous nature of the two deposits which may found to be variable across the site.

11.3 FURTHER WORK RECOMMENDATIONS

It is the opinion of WSP that planning conditions 48 (part 1) and 52 as set out by Dover District Council have been addressed as described by the works herein and that no further works are necessary within the Phase 1A area of the Phase 1 development.

File: Z:\#Projects\Z:\#Projects\70010000\70012378 - Whitfield, Dover\(8) Report\GIR\Figures\Figure 1 - SLP.pdf   Drawn By: UKAJA912   Date Modified: March 2016

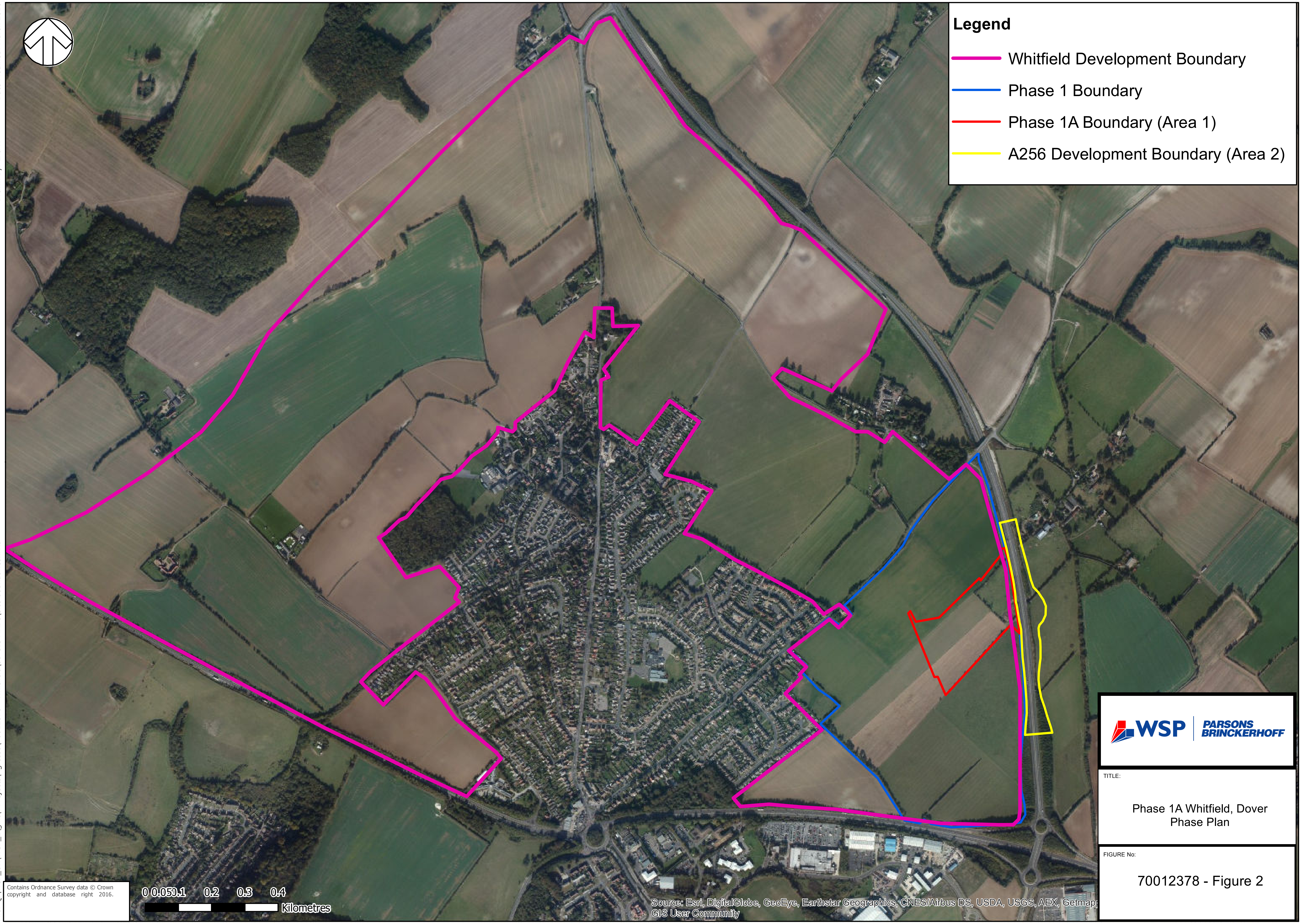
WSP | PARSONS BRINCKERHOFF

TITLE:

Whitfield, Dover
Site Location Plan

FIGURE No:

70012378 - Figure 1



Date Modified: March 2016

Drawn By: Ella N

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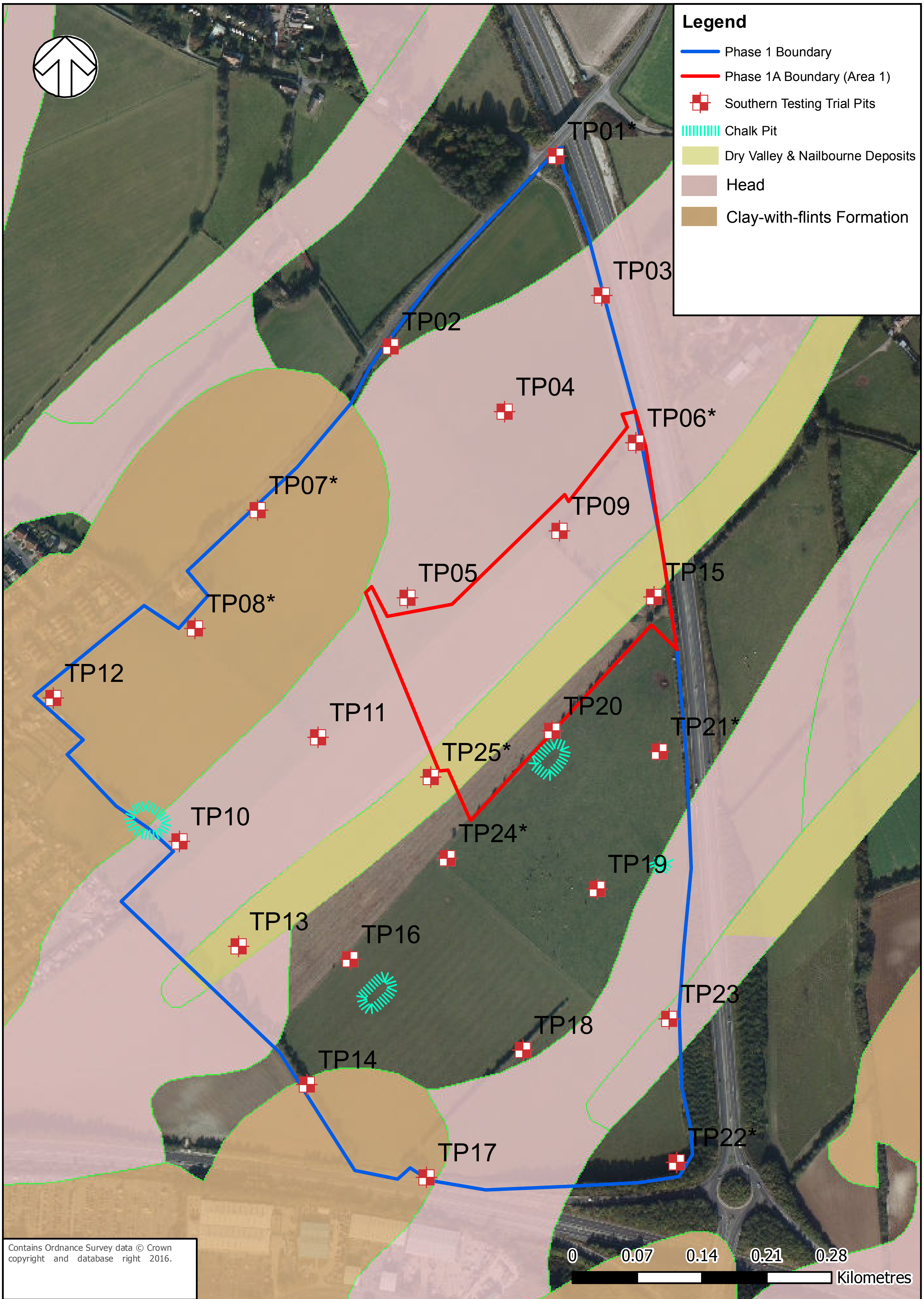

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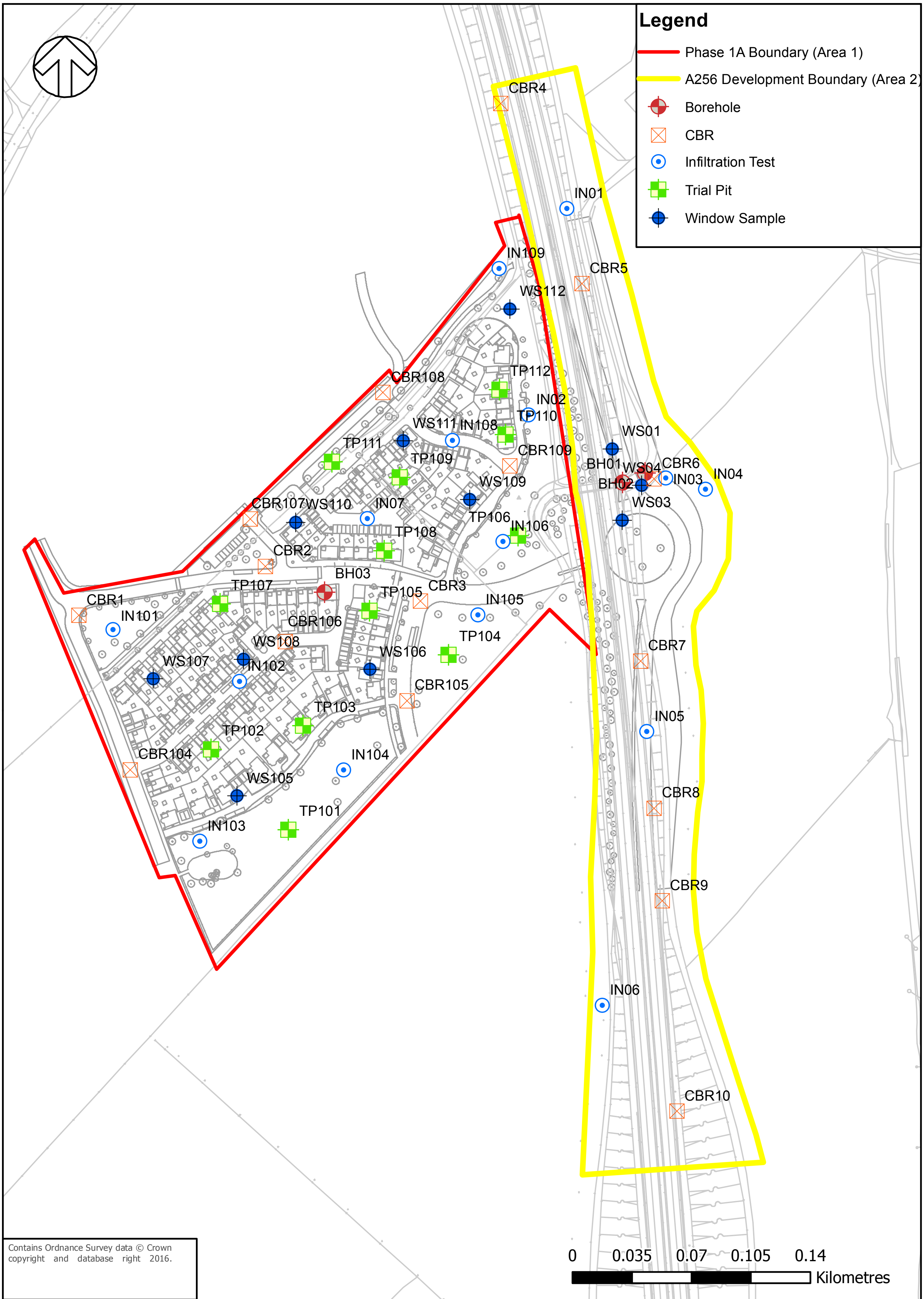
Drawn By: Andrea A/Ella N Date Modified: March 2016

WSP | PARSONS BRINCKERHOFF

TITLE:
PHASE 1A WHITFIELD, DOVER
SOUTHERN TESTING LOCATIONS, SUPERFICIAL GEOLOGY AND CHALK PIT LOCATIONS

FIGURE No:
70012378 - FIGURE 3



WSP | PARSONS BRINCKERHOFF

TITLE:

PHASE 1A, WHITFIELD, DOVER
EXPLORATORY HOLE PLAN

FIGURE No:

70012378 - FIGURE 4

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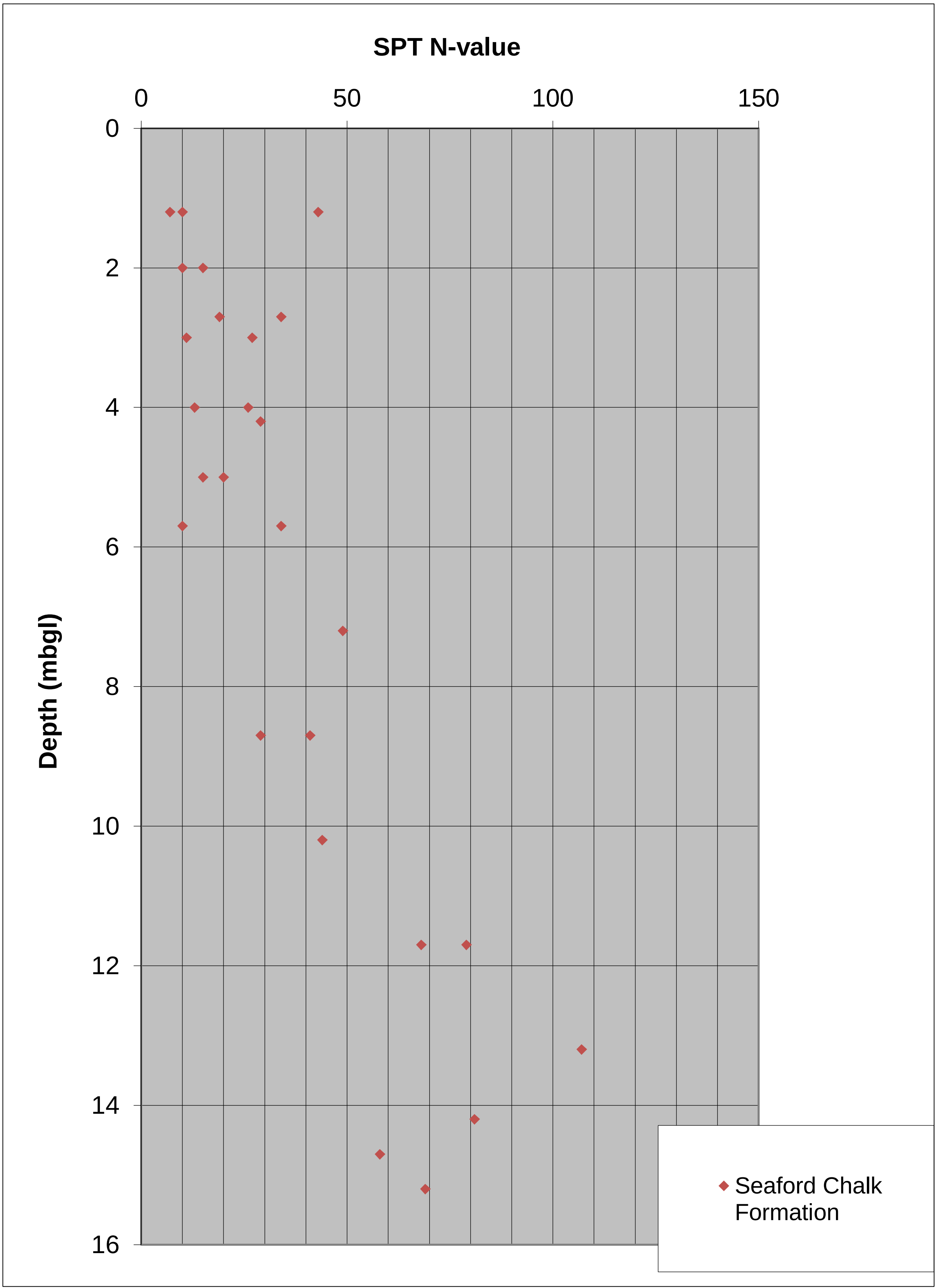
Drawn By: Andrea A/ Ella N   Date Modified: March 2016



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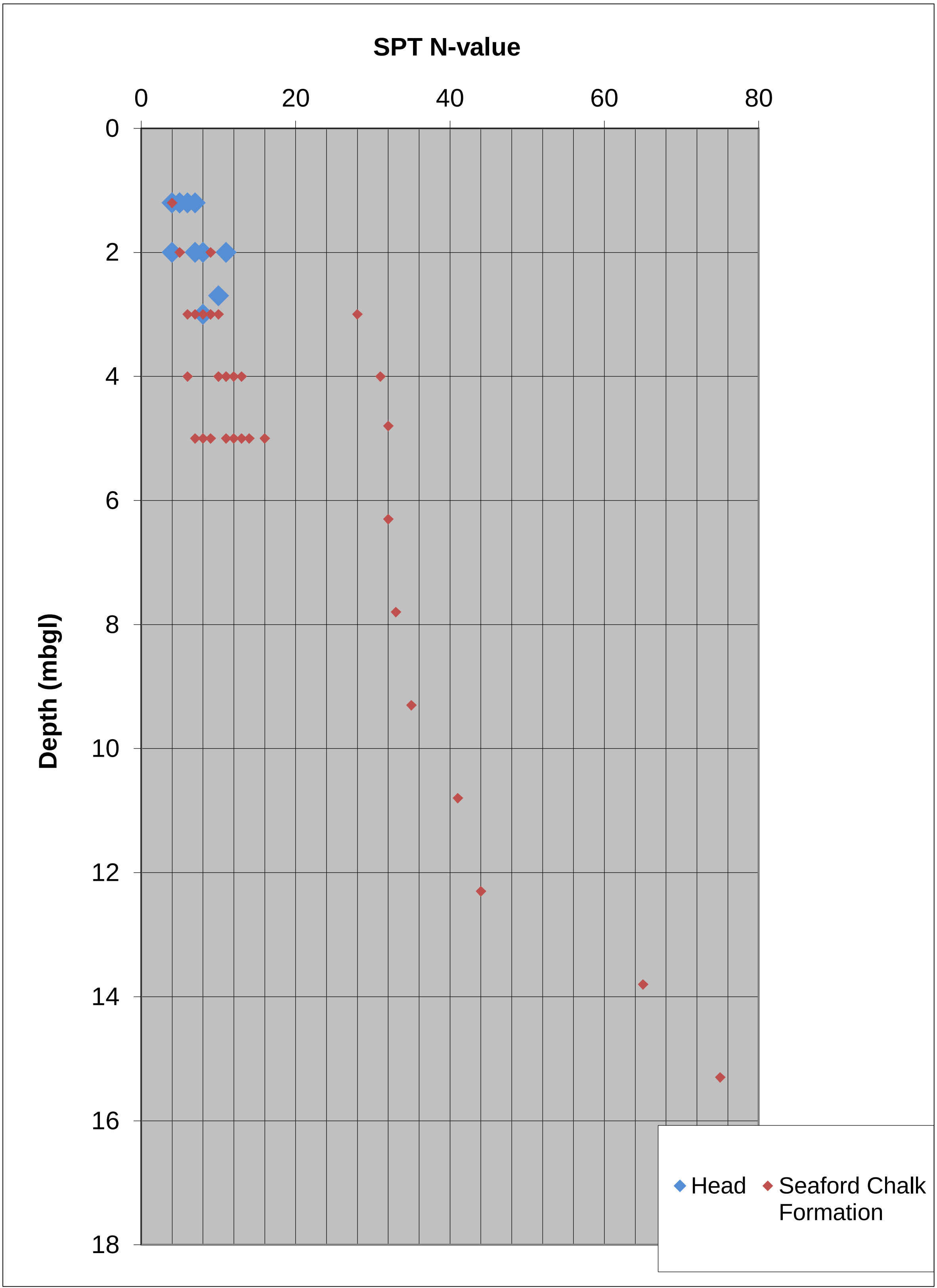
Chk.	**AJB**	**Scale:**	**NTS**		Dover
App.	**AJB**	**Date**	**Mar-16**	**Title:**	Plot of SPT 'N' versus Depth
WSP				**Figure**	**5A**



Made By:	ECN	Job:	70012378	Site:	Phase 1 Whitfield (residential area)
Chk.	AJB	Scale:	NTS		Dover
App.	AJB	Date	Mar-16	Title:	Plot of SPT 'N' versus Depth
WSP				Figure	5B

Date Modified: March 2016
Drawn By: Ella N
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WSP | PARSONS BRINCKERHOFF

TITLE:

Phase 1A Whitfield, Dover
Map of the top of the Seaford Chalk Formation (mAOD)

FIGURE No:

70012378 - Figure 6

Legend

Holes with SEAFORD CHALK FORMATION - Depth of strata top

Phase 1A Boundary - Current Site

metres

- 1.01 to 1.77
- 1.77 to 2.14
- 2.14 to 2.44
- 2.44 to 2.7
- 2.7 to 3.48

WSP | PARSONS BRINCKERHOFF

TITLE:

Phase 1A Whitfield, Dover
Depth to the top of the Seaford Chalk Formation (m bgl)

FIGURE No:

70012378 - Figure 7

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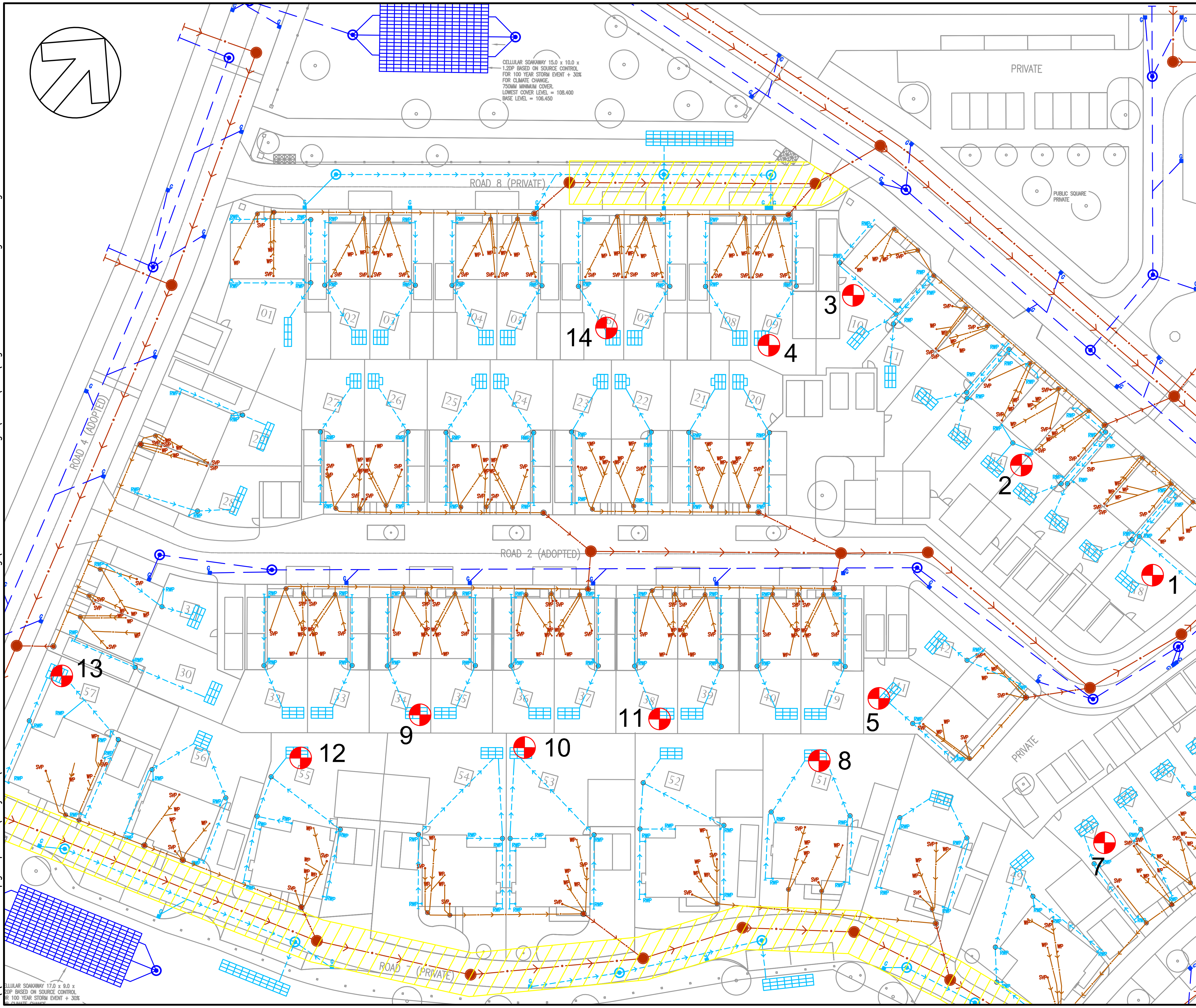
Drawn By: Ella N

Date Modified: March 2016



Key

Plate Bearing Test

WSP | PARSONS BRINCKERHOFF

TITLE:

Whitfield, Phase 1 Housing

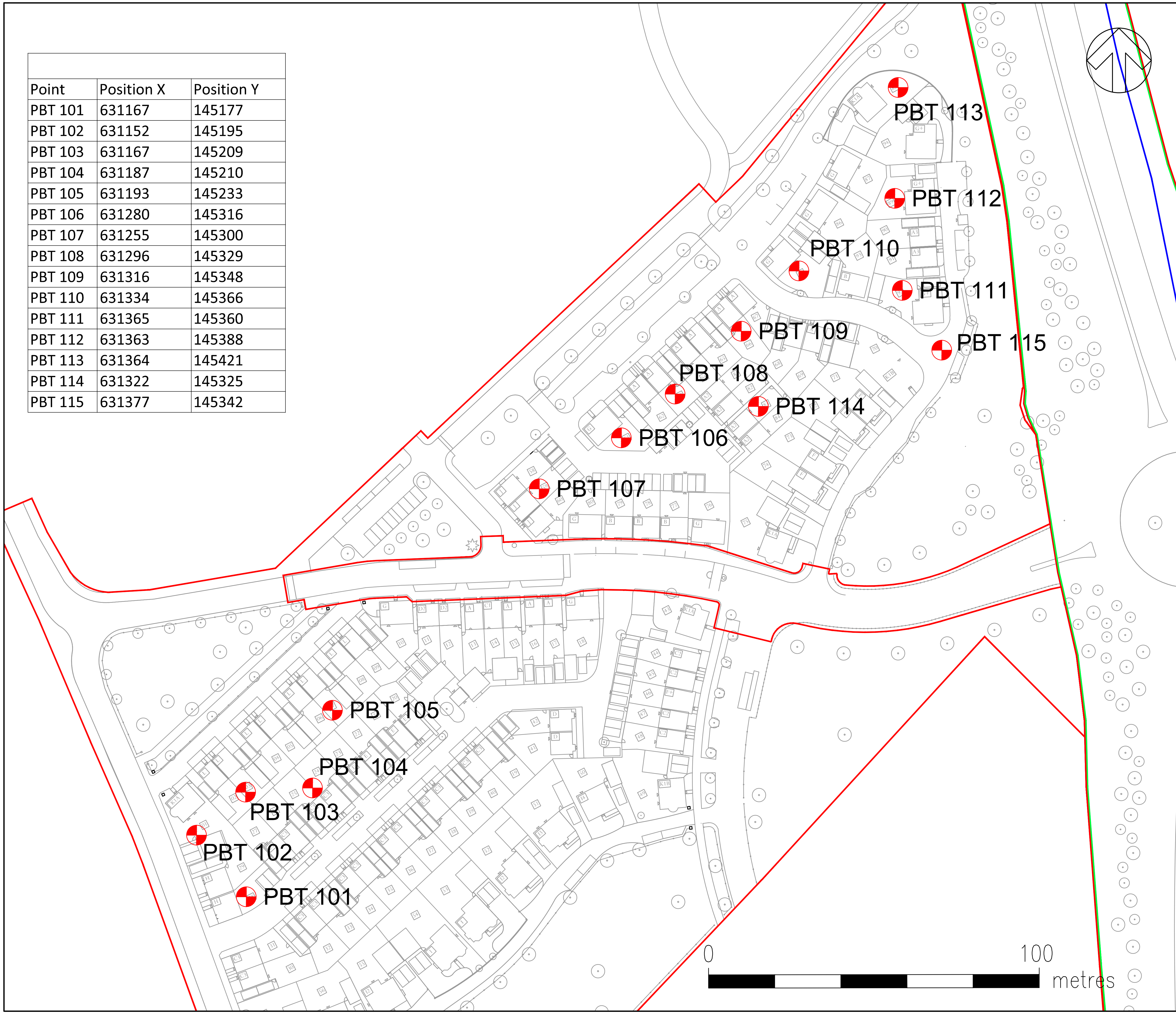
Plate Bearing Test Locations

FIGURE No:

70013822 - Figure 8

\\ser01cam1uk.uk.wspgroup.com\Projects\70013822 - Whitfield Phase 1 Housing\E Models and Drawings\Civils\WIP\Figure - Plate Bearing Test.dwg

Point	Position X	Position Y
PBT 101	631167	145177
PBT 102	631152	145195
PBT 103	631167	145209
PBT 104	631187	145210
PBT 105	631193	145233
PBT 106	631280	145316
PBT 107	631255	145300
PBT 108	631296	145329
PBT 109	631316	145348
PBT 110	631334	145366
PBT 111	631365	145360
PBT 112	631363	145388
PBT 113	631364	145421
PBT 114	631322	145325
PBT 115	631377	145342



DO NOT SCALE

KEY:

PBT 1xx Trial Pit Location

REV	DATE	BY	DESCRIPTION	CHK	APD
A	NOT ISSUED	XXX	ISSUED	@	@

DRAWING STATUS: FOR INFORMATION ONLY

WSP | PARSONS BRINCKERHOFF

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CLIENT: Halisbury Homes

ARCHITECT: Adam Architecture

PROJECT: Whitfield Plate Bearing Tests - Phase 3 Dover

TITLE: Trial Pit Test Plan

SCALE @ A2: 1:2000	CHECKED: AB	APPROVED: MW
CAD FILE: Plate Bearing Test Location Plan	DESIGN-DRAWN: DGL	DATE: 31 October 16
PROJECT No: 70012378	DRAWING No: Figure 9	REV: A

Appendix A

WSP ASSESSMENT APPROACH

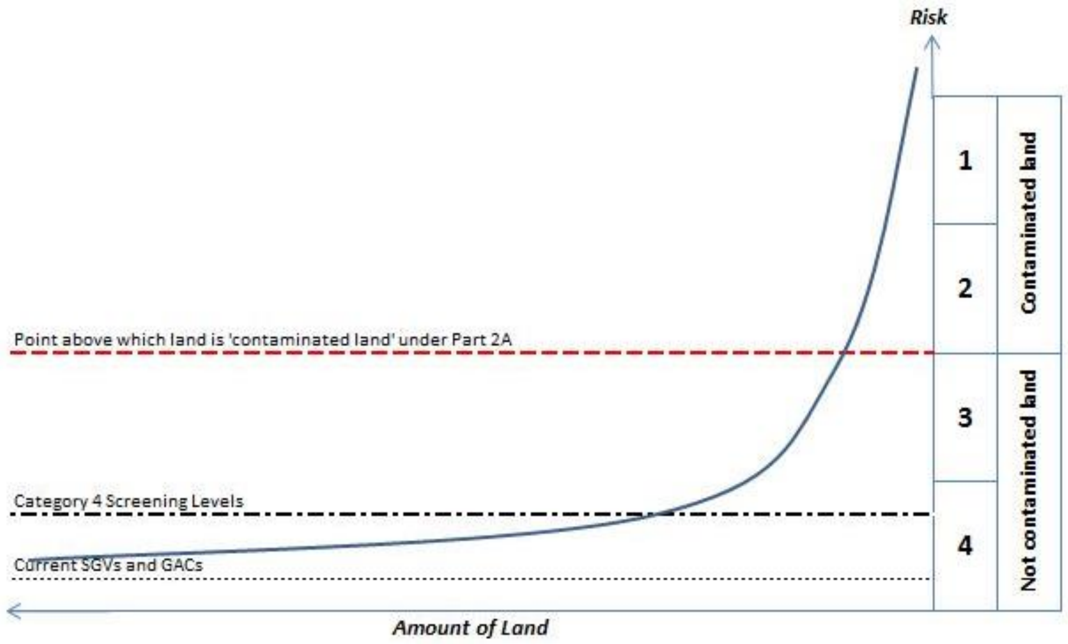
UK APPROACH

In the UK, the potential risks to human health from contamination in the ground are usually evaluated through a generic quantitative risk assessment (GQRA) approach. This allows generic and conservative exposure assumptions to be readily applied to risk assessments and can be a useful tool for rapidly screening data and to identify those contaminants or scenarios that could benefit from further investigation and/or site-specific detailed quantitative risk assessment (DQRA).

Current industry good practice is to use the approach presented in the Environment Agency (EA) publications SR2[1] and SR3[2]. This approach allows the derivation of Generic Assessment Criteria (GACs), primarily for chronic exposure. The Environment Agency's published Soil Guideline Values (SGVs) follow the same approach, but are limited to a small number of substances.

In April 2012, the Department of Environment, Food and Rural Affairs (Defra) published updated statutory guidance[3] which introduced a four category approach to determining whether land in England and Wales is contaminated or not on the grounds of significant possibility of significant harm (SPOSH). **Figure 1** presents a graphical representation of the categories.

Figure 1: Four Categories for Determining if Land Represent a SPOSH



Cases classified as Category 1 are considered to be SPOSH based on actual evidence or an unacceptably high probability of harm existing. Category 4 cases are those where there is no risk, or a low risk of SPOSH.

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[1] Environment Agency '*Human Health Toxicological Assessment of Contaminants in Soil',* Report SC050021/SR2. January 2009.

[2] Environment Agency '*Updated Technical Background to the CLEA Model*,' Report SC050021/SR3. January 2009.

[3] Defra '*Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance'.* April 2012.

GACs and SGVs represent a minimal risk level, well within Category 4. A 2014 publication by Contaminated Land: Applicatons in Real Environments (CL:AIRE),SP1010[4] and endorsed by Defra[5] provided an approach to determine Category 4 Screening Levels (C4SLs) which are higher than the GACs whilst being "more pragmatic but still strongly precautionary". It also provided C4SLs for six contaminants of concern.

Although the C4SLs were designed to support Part 2A assessments to determine 'contaminated land' they are specifically mentioned, along with reference to the Part 2A statutory guidance, by the Department for Communities and Local Government (DCLG) for use in a planning context[6].

The SGVs were derived using the Contaminated Land Exposure Assessment (CLEA) Workbook v1.06. An updated version (v1.071) was released by the EA in September 2015 to take into account the publication of SP1010. The updates comprised: additional toxicity data for the six chemicals for which C4SLs were derived; two new public open space land use scenarios; updated exposure parameters; options to run the model using C4SL exposure assumptions; and increased functionality. There were no changes to algorithms, so it is still possible to replicate the SGVs using the input parameters held within v1.071.

It should be noted that the four category approach has not been adopted in Scotland either under Part 2A or the planning regime. The Part 2A statutory guidance applicable in Scotland (Paper SE/2006/44 dated May 2006) does not reflect the changes introduced by Defra in April 2012 which allow for the use of C4SLs within Part 2A risk assessments. Additionally, it is considered that the principal of 'minimal risk' should still apply under planning in Scotland, based on current guidance.

WSP | PARSONS BRINCKERHOFF APPROACH

In the absence of a comprehensive set of SGVs it is down to individual practitioners to derive their own GACs. WSP | Parsons Brinckerhoff has used the approach provided within SR2, SR3, SP1010, CLEA Workbook v1.071and SR4[7] to produce a set of minimal risk GACs. The chemical-specific data within two key publications were considered during their production: CL:AIRE 2010[8] and LQM 2015[9]. Both documents provide comprehensive sets of GACs for different contaminants of concern.

The LQM Suitable For Use Levels (S4ULs) have selected exposure parameters someway between those of the SR3 land uses and the C4SL exposure scenarios. This approach was rejected by WSP | Parsons Brinckerhoff as not representing minimal risk, however, the LQM S4UL document was critically reviewed and the approach and chemical input parameters were utilised where considered to be appropriate.

A C4SL Working Group is planning to derive a larger set of C4SLs during 2016, and it is understood that this will include a critical review of the chemical input data for all selected substances. This may lead to further amendments to the chemical input data used in the WSP | Parsons Brinckerhoff in-

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[4] CL:AIRE *'Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination'* SP1010, Final Project Report (Revision 2). September 2014.

[5] Defra 'SP1010: *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document'*. December 2014.

[6] DCLG Planning Practice Guidance '*Land Affected by Contamination'*, particularly Paragraphs 001 and 007. Ref IDs: 33-001-20140306 & 33-007-20140612.

[7] Environment Agency '*CLEA Software (Version 1.05) Handbook (and Software)',* Report SC050021/SR4. September 2009.

[8] CL:AIRE 'The EIC/AGS/CL:AIRE *Soil Generic Assessment Criteria for Human Health Risk Assessment'.* ISBN 978-1-05046-20-1. January 2010.

[9] Nathanail et al '*The LQM/CIEH S4ULs for Human Health Risk Assessment'*, Land Quality Press, ISBN 978-0-9931084-0-2. 2015.

house screening values. It is considered likely that the contaminant list will crossover with the current CL:AIRE GACs. As such, this document was not critically reviewed by WSP | Parsons Brinckerhoff.

WSP | Parsons Brinckerhoff's current approach to the assessment of risks to human health is to continue to evaluate minimal risk through the use of SGVs and in-house derived GACs, and to use the published C4SLs as a secondary tier of assessment until such time as additional suitable C4SLs are published and/or in-house values are derived.

EXPOSURE MODELS

LAND USES

WSP | Parsons Brinckerhoff has largely adopted the exposure assumptions of the generic land use scenarios included within SR3 with two additional public open space scenarios included within SP1010:

- Residential with homegrown produce consumption
- Residential without homegrown produce consumption
- Allotments
- Commercial
- Public open space near residential housing (POS_{resi})
- Public park (POS_{park})

Exceptions are described in the following Sections.

SOIL PROPERTIES

SR3 assumes a sandy loam soil with a pH of 7 and Soil Organic Matter (SOM) content of 6% for its generic land uses, based on the geographical spread of topsoils in the UK. WSP | Parsons Brinckerhoff has adopted these default values. In addition, GACs based on SOM of 1% and 2.5% have also been derived based on common experience of the nature of Made Ground and lack of topsoil on many brownfield sites.

RECEPTOR CHARACTERISTICS AND BEHAVIOURS

SP1010 provides some updated exposure parameters for long-term inhalation rates[10] and the consumption rates for homegrown produce[11] compared to those provided in SR3. This data was used to derived WSP | Parsons Brinckerhoff's GACs. The changes in inhalation rates do not apply to the allotment generic land use scenario. These are based on the breathing rates for short-term exposure of light to moderate intensity activity which were derived from a study that was not updated in USEPA 2011, so the SR3 rates were retained.

CHEMICAL DATA

PHYSICO-CHEMICAL PARAMETERS

Physico-chemical properties for the contaminants for which GACs have been derived have been obtained following critical review of the following hierarchy of data sources:

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[10] USEPA, National Centre for Environmental Assessment '*Exposure Factors Handbook: 2011 Edition*' EPA/600/R-09/052F. September 2011.

[11] National Diet and Nutrition Survey 2008/2009 to 2010/2011.

1. Environment Agency/Defra SGV reports where available.
2. Environment Agency '*Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values*', Report SC050021/SR7, November 2008.
3. Published fate and transport reviews within Nathanail et. al 2015 and CL:AIRE 2010.

Where appropriate, and where sufficient data is available, values were adjusted to reflect a UK soil temperature of 10ºC (e.g. K_{aw}).

TOXICOLOGICAL DATA

Toxicological data for the derivation of minimal risk Health Criteria Values (HCV) for each contaminant was selected with due regard to the approach presented in SR2. Where appropriate, the following hierarchy of data sources was used:

1. UK toxicity reviews published by authoritative bodies including:
   - EA
   - Public Health England (PHE)
   - Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT)
   - Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC)
2. Authoritative European sources such as European Food Standards Agency (EFSA)

3. International organisations including:
   - World Health Organisation (WHO)
   - Joint FAO/WHO Expert Committee on Food Additives (JECFA)

4. Authoritative country-specific sources including:
   - United States Environmental Protection Agency (USEPA)
   - US Agency for Toxic Substances and Disease Registry (ATSDR)
   - US Integrated Risk Information System (IRIS)
   - Netherlands National Institute for Public Health and the Environment (RIVM)

Factors such as the applicability of the data to human health (e.g. epidemiological vs. animal studies), the quality of the data, the level of uncertainty in the results and the age of the data were also taken into account in the final selection. Details for specific substances are available on request.

MEAN DAILY INTAKES

Estimations of background exposure for each threshold substance have been updated. In line with the SR2 approach, the exposure from non-threshold substances in the soil does not take into account exposure from other sources, and as such GACs were derived without consideration of the Mean Daily Intakes (MDI) for those substances.

The data published by the EA in its series of TOX reports between 2002 and 2009 was evaluated to determine whether the values were considered to remain valid today. Values from these current UK published sources were not amended unless they were considered to be significantly different so that the GACs remained as comparable as possible with the still commonly used SGVs.

ORAL MEAN DAILY INTAKES

Oral MDI were generally estimated as the sum of exposure via the ingestion of food and drinking water using the default adult physiological parameters presented in Table 3.3 of SR2.

Data on the exposure of substances from food ingestion was generally obtained from UK Total Diet Studies (TDS) published by the Food Standards Agency (FSA) and its predecessor the Ministry of Agriculture, Fisheries and Food (MAFF) and from studies commissioned by COT. Where no UK-specific data was available, MDI were derived from the European Food Safety Authority (EFSA), Health Canada and US sources. This was a rare occurrence, and in these instances, the data was evaluated to determine its applicability to the UK.

Data on the concentrations of substances in tap water was obtained from a variety of sources. UK data was used where available, with preference given to Drinking Water Inspectorate (DWI) 2014 data from water company tap water testing (LOD, 1st and 99th percentile data is available). Where the substance was not included in tap water testing, other UK sources of information were considered including:

- DWI data from water company tap water testing from previous years;
- COT; and
- FSA.

Where UK data was not available, a number of other data sources were considered, largely WHO International Programme on Chemical Safety (IPCS) Concise International Chemical Assessment Documents (CICADs) and background documents for the development of Guidelines for Drinking Water Quality, using professional judgement on the relevance of the data to the UK. The final decision on the MDI from drinking water was made using professional judgement on the balance of relevance and probability, taking into account the detection limit where not detected, Koc and solubility, reduction in use of the substance, banned substances, tight controls (e.g. on explosives) and with due consideration to the SR2 instruction that “if no data or information in background exposure are available, background exposure should be assumed to be negligible and the MDI set to zero….”.

Data from other countries was generally not used because it was considered that the hydrogeology of these countries along with industrial practices were unlikely to be reflective of the UK.

INHALATION MEAN DAILY INTAKES

Inhalation MDIs were based on estimates of average daily exposure by the inhalation pathway and calculated using the default adult physiological parameters presented in Table 3.3 of SR2.

The inhalation MDIs were generally estimated using background exposure data from the UK, derived from Defra's UK-AIR: Air Information Resource[12], which provides ambient air quality data from a number of sites forming a UK-wide monitoring network. The MDIs for heavy metals were based on rolling annual average metal mass concentration data from Defra's UK Heavy Metals Monitoring Network from the period October 2009 to September 2010[13].

Information for some substances was obtained from UK sources including Environment Agency TOX reports and data from the UK Expert Panel on Air Quality Standards (EPAQS). Where recent UK data was not available, data was sourced from the International Programme on Chemical Safety (IPCS), the World Health Organisation (WHO), the Agency for Toxic Substances and Diseases Registry (ATSDR), Health Canada, and various other peer-reviewed sources summarised by LQM/CIEH[14].

For other substances, where no data or information on background exposure was available, background exposure was assumed to be negligible and the MDI set at 0.5*TDI in accordance with guidance in SR2.

PLANT UPTAKE

Soil to plant concentration factors are available in CLEA v1.071 for arsenic, cadmium, hexavalent chromium, lead, mercury, nickel and selenium. For all remaining inorganic chemicals, concentration factors were obtained using the PRISM model. Substance-specific correction factors have been selected in accordance with the guidance established within SR3. This is consistent to the approach utilised in the derivation of the LQM S4UL values and the EIC/AGS/CL:AIRE GAC.

Where there is a lack of appropriate data to enable the derivation of specific soil to plant concentrations factors for organic chemicals, plant uptake was modelled within CLEA v1.071 using the generic equations recommended within SR3, as follows:

- Green Vegetables – Ryan et al. (1988);
- Root Vegetables – Trapp (2002);
- Tuber Vegetables – Trapp et al. (2007); and
- Tree Fruit – Trapp et al. (2003).

There are no suitable models available for modelling uptake for herbaceous fruit or shrub fruit. Exposure is considered negligible.

SOIL SATURATION LIMITS

GACs are not limited to their theoretical soil saturation within CLEA, although where either the aqueous or the vapour-based saturation is exceeded, this is highlighted within the Workbook (compared with the lower of the two values). This affects pathways which depend on partitioning calculations so in reality this only affects the vapour pathways and is relevant to organic substances and other substances, such as elemental mercury, that have a significant volatile component. However, the Workbook highlights saturation for direct contact pathways to indicate to the user where further qualitative consideration of free phase contamination at surface may be required.

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[12] Crown 2016 copyright Defra via uk-air.defra.gov.uk, licenced under the Open Government Licence (OGL).
[13] Defra, 20143 Spreadsheet of historic data for multiple years for the Metals network. Available online at: http://uk-air.defra.gov.uk/data/metals-data. [Accessed 13/03/2016].
[14] LQM/CIEH, 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment.

Where the lower of the two saturation limits is exceeded and the vapour pathway is the only exposure route being considered, the chronic risks to human health are likely to be negligible. Further evaluation could be undertaken using an alternative model suitable for evaluating non-aqueous phase liquids (NAPLs), such as the Johnson & Ettinger (J&E) approach described in USEPA 2003. However, WSP | Parsons Brinckerhoff considers that if NAPLs are suspected, given the known limitations and over-simplifications of J&E, soil vapour monitoring is a more accurate way of assessing potential risks.

Where the lower saturation limit is exceeded for the vapour pathway and a number of exposure routes are being considered, then the contribution from the NAPL via vapour inhalation to the overall exposure can be evaluated using the procedure provided in SR4. WSP | Parsons Brinckerhoff would evaluate this as part of a DQRA process or through soil vapour monitoring on-site to determine site-specific soil vapour concentrations.

CHEMICAL SPECIFIC ASSUMPTIONS

CYANIDES

Cyanide has high acute toxicity, and short term exposure is an important consideration when assessing the risks from soils contaminated with cyanide. The primary risk to human receptors from free cyanide in soils is an acute risk.

There is no current UK guidance available for calculating acute risks from free cyanide. Consequently, GAC for acute exposure were derived using the algorithms presented in MADEP 1992[15] and assuming a one-off ingestion of 10g of soil (this conservative value has been taken as an upper bound estimate for pica amongst children). Receptor body weights have been selected according to the critical receptor for each exposure scenario.

The lowest of the chronic and acute GAC for each land use scenario were adopted by WSP | Parsons Brinckerhoff.

LEAD

The SGV for lead was withdrawn by the EA in 2009, and in 2011 the EA withdrew their published TOX report in light of new scientific evidence. The C4SL for lead was derived using the latest scientific evidence from a large human dataset. As such, no chemical-specific margin was applied in the derivation of the C4SL for lead. It may be possible for WSP | Parsons Brinckerhoff to derive a GAC for lead using the same dataset and applying a chemical-specific margin, but the value is likely to be lower than UK natural background concentrations. Therefore, WSP | Parsons Brinckerhoff has adopted the toxicological data used to derive the C4SLs in deriving the GAC for lead until such time as alternative GACs are published by an authoritative body. The relative bioavailability was set at 100% in line with the approach taken for other GACs, whereas the C4SL assumes 60% for soil and 64% for airborne dust. Thus, the WSP | Parsons Brinckerhoff GAC are lower than the C4SLs.

POLYCYCLIC AROMATIC HYDROCARBONS

WSP | Parsons Brinckerhoff's approach to the assessment of polycyclic aromatic hydrocarbons (PAHs) uses the surrogate marker approach. BaP was used as a surrogate marker for all genotoxic PAHs in line with the Health Protection Agency 2010[16] recommendations and SP1010. This assumes that the PAH profile of the data is similar to that of the coal tars used in the Culp *et al* oral carcinogenicity study from which the toxicity data for BaP was produced. In reality, this profile has

[15] MADEP '*Background Documentation for the Development of an "Available Cyanide" Benchmark Concentration'* 1992. http://www.mass.gov/dep/toxics/cn_soil.htm

[16] HPA Contaminated Land Information Sheet '*Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)* 2010

been shown by HPA to be applicable on the majority of contaminated sites based on assessment of sites across the country.

The alternative is the Toxic Equivalency Factor (TEF) approach which uses a reference compound and assigns TEFs for other compounds based on estimates of potency. Key uncertainties with this approach include the assumption that all compounds have the same toxic mechanism of action within the body and that no compounds with a greater potency than the reference compound are present. It is considered by the HPA that the TEF approach is likely to under predict the true carcinogenicity of PAHs and therefore favours the surrogate marker approach.

For these reasons, WSP | Parsons Brinckerhoff considers that the adoption of BaP as a surrogate marker for genotoxic PAHs as opposed to the TEF approach is reasonable, even in cases where the PAH profile may differ from that of the Culp *et al* study. In addition, WSP | Parsons Brinckerhoff has derived a GAC for naphthalene, which is commonly a risk driver due to its high volatility, relative to other PAH compounds, as an indicator compound for threshold PAHs.

CHEMICAL GROUPS

For a number of chemical groups, the available toxicity data is for combinations of chemicals. Given that the physico-chemical parameters may differ between the chemicals, the GACs for the chemicals within the groups has been calculated and then the lowest GAC selected to represent the entire group. This was the approach taken by the EA for m-, o- and p-xylenes, and has also been adopted by WSP | Parsons Brinckerhoff for:

- 2-chlorophenol, 2,4-dichlorophenol, 2,4,6-trichlorophenol and 2,3,4,6-tetrachlorophenol;
- 2-, 3- and 4-methylphenol (total cresols);
- aldrin and dieldrin; and
- α- and β-endosulphan.

EXPOSURE TO VAPOURS

INHALATION OF MEASURED VAPOURS

WSP | Parsons Brinckerhoff has derived a set of soil vapour GACs (GAC_{sv}) that allow for the assessment of measured site soil vapour concentrations, using J&E, in order to establish potential risks via indoor inhalation of vapours. This methodology enables a more robust assessment of exposure via the inhalation of soil vapours indoors than using CLEA-derived soil GAC, as it is based upon measured soil vapour concentrations beneath the site. It also allows for the assessment of vapours from all source terms (i.e. groundwater, soil or NAPL). Outdoor inhalation was not included. WSP | Parsons Brinckerhoff considers that the indoor inhalation pathway is the significantly dominant risk-driver.

The generic land use scenarios within CLEA (residential and commercial) that were used to derive the soil GAC were used to define the receptor and building characteristics for the soil vapour GAC. Only residential and commercial generic land use scenarios include the indoor inhalation of vapours pathway.

The GAC_{sv} were derived for three different soil types; sand, sandy loam and clay, reflecting the importance of this parameter within the J&E model. A depth to contamination of 0.85m below the base of the building foundation was assumed (i.e. 1m below ground level). This differs from the depth assumed for the soil GAC (0.5m bgl), but was selected by WSP | Parsons Brinckerhoff as a reasonable worst case scenario. It is acknowledged that the J&E commonly over-predicts indoor vapour concentrations. In particular, it will significantly over-predict vapour concentrations for suspended floor slabs, which many new builds are constructed with, it does not take into account lateral migration and assumes an infinite source of contamination at steady state conditions. In addition, it is common for soil gas/vapour wells to be installed with at least 1m of plain riser at the surface and this equates to a total depth of 0.85m below the building foundation plus a 0.15m thick foundation, and so is more representative of te depth that samples will taken from.

The TDSIs and IDs for each substance were converted from $\mu gkg^{-1}bwday^{-1}$ to μgm^{-3} using the standard conversions quoted in Table 3.3 of SR2, thereby replacing the need to model C_{air} in the equation:

$$C_{air} = \alpha . C_{vap} . 1{,}000{,}000 cm^3 m^{-3}$$

Where:

C_{air} is the concentration of vapours within the building, mg^{-3}
α is the steady state attenuation coefficient between soil and indoor air, dimensionless
C_{vap} is the soil vapour concentration, $mgcm^{-3}$

The target concentrations within indoor air for each substance (C_{air}) are a function of receptor inhalation rates and occupancy periods, as defined by the site conceptual exposure model (assuming standard CLEA occupancy periods and receptors).

The attenuation factor was calculated using J&E (Equation 10.4 in SR3) and the resulting C_{vap} is equivalent to the GAC_{sv} for the modelled exposure scenario.

Where the calculated GAC_{sv} for a substance exceeds the vapour saturation limit, no GAC_{sv} has been proposed.

INHALATION OF GROUNDWATER-DERIVED VAPOURS

The CLEA model does not have the capacity to derive GACs to assess vapours derived from dissolved phase contamination. WSP | Parsons Brinckerhoff has derived a set of groundwater GACs (GAC_{gw}) to evaluate the potential risks through the indoor inhalation of groundwater-derived vapous by first applying the approach described above for the derivation of the WSP | Parsons Brinckerhoff GAC_{sv} to determine the acceptable concentration in soil vapour directly above the water table.

The depth to groundwater was assumed to be 1m bgl (i.e. 0.85m below the base of the building foundation). This depth was considered to be more representative of commonly encountered groundwater conditions than the 0.5m below the base of the building foundation (i.e. 0.65m bgl) that is used by CLEA for an unsaturated source present in the overlying soil.

The GAC_{gw} was then back-calculated from the GAC_{sv} using the air-water partition coefficient (K_{aw}) for each substance.

Where the calculated GAC_{gw} for a substance exceeds the solubility limit, no GAC_{gw} has been proposed.

Appendix B

GENERAL LIMITATIONS

LIMITATIONS FOR WSP LAND RESTORATION AND GROUND ENGINEERING DIVISION

General

WSP has prepared this report solely for the use of the Client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed and outlined in the body of the report. Unless explicitly agreed otherwise, in writing, this report has been prepared under WSP standard Terms and Conditions, as included within our proposal to the Client.

Project specific appointment documents may be agreed on a project by project basis, at our discretion. A charge may be levied for both the time to review and finalise appointments documents and also for associated changes to the appointment terms. WSP reserve the right to amend the fee should any changes to the appointment terms create an increase risk to WSP

The report needs to be considered in the light of the WSP proposal and associated limitations of scope. The report needs to be read in full and isolated sections cannot be used without full reference to other elements of the report. The report is only valid for its originally intended purpose as set out in either our report or the proposal.

Phase 1 Geo Environmental and Preliminary Risk Assessments

The works undertaken to prepare this report comprised a study of available and easily documented information from a variety of sources (including the Client), together with (where appropriate) a brief walk over inspection of the Site and correspondence with relevant authorities and other interested parties. Due to the short timescales associated with these projects responses may not have been received from all parties. It is not standard, due to the timescales, to visit archives and local libraries as part of these works. WSP cannot be held responsible for any disclosures that are provided post production of our report and will not automatically update our report.

The opinions given in this report have been dictated by the finite data on which they are based and are relevant only for the purpose for which the report was commissioned. The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data pertaining to site conditions. Should additional information become available which may affect the opinions expressed in this report, WSP reserves the right to review such information and, if warranted, to modify the opinions accordingly.

It should be noted that any risks identified in this report are perceived risks based on the information reviewed. Actual risks can only be assessed following intrusive investigations of the Site.

WSP does not warrant work / data undertaken / provided by others.

This section covers reports with the following titles or combination of titles: phase 1; Desk top study; geo environmental assessment; development appraisal; preliminary environmental risk assessment; constraints report; due diligence report; geotechnical development review; environmental statement; environmental chapter; geotechnical development risk register or baseline environmental assessment. The limitations associated with preliminary works apply when they are reported within an intrusive investigation report.

Intrusive Investigation Reports

The investigation has been undertaken to provide information concerning the type and degree of contamination present at the Site in order to allow a generic risk assessment to be undertaken or identification of the soil properties to allow for geotechnical development constraints to be identified.

The objectives of the investigation are limited to establishing the risks associated with potential contamination sources with the potential to cause harm to human health, building materials, the environment (including adjacent land), or controlled waters. For Geotechnical investigations the purpose is to broadly identify the development constraints associated with the physical property of the soils underlying the site.

The amount of exploratory work, soil property and chemical testing undertaken has necessarily been restricted by various factors which may include accessibility, the presence of services; existing buildings; current site usage or short timescales. The exploratory holes completed assess only a small percentage of the area in relation to the overall size of the Site, and as such can only provide a general indication of conditions. The number of sampling points and the methods of sampling and testing do not preclude the possible existence of localised "hotspots" of contamination where concentrations may be significantly higher than those actually encountered or ground conditions that vary from those identified. In addition, there may be exceptional ground conditions elsewhere on the site which have not been disclosed by this investigation and which have therefore not been taken into account in this report. For example these include spatial variations in soil properties; the varying thickness and physical nature of the strata identified and changes in groundwater levels or flow rates.

The inspection; testing and monitoring records relate specifically to the investigation points and the timeframe that the works were undertaken. They will also be limited by the techniques employed. WSP has interpreted between these points based upon assumptions to develop our interpretation and conclusions. The assumption made in forming our conclusions is that the ground and groundwater conditions (both chemically and physically) are the same as have been encountered during the works undertaken at the specific points of investigation.

On 1st April 2010, BS EN 1997-1:2004 (Eurocode 7: Geotechnical Design – Part 1) became the mandatory baseline standard for geotechnical ground investigations.

In terms of geotechnical design for foundations, slopes, retaining walls and earthworks, EC7 sets guidance on design procedures including specific guidance on the numbers and spacings of boreholes for geotechnical design, there are limits to methods of ground investigation and the quality of data obtained and there are also prescriptive methods of assessing soil strengths and methods of design. Unless otherwise explicitly stated, the work has not been undertaken in accordance with EC7. A standard geotechnical interpretative report will not meet the requirements of the Geotechnical Design Report (GDR) under Eurocode 7. A GDR can strictly only be prepared following confirmation of all structural loads and serviceability requirements. The design process requires close co-operation between the geotechnical engineer and the structural engineer and is iterative. Where a GDR is prepared using preliminary or assumed loadings and/or serviceability limits it should only be considered as an interim report and should not be relied upon for the procurement or construction of the works it describes.

During any build programme WSP should be consulted if alternative ground conditions are encountered. It assumes during any site works that the contractor will use their best endeavours to manage and control groundwater and other unforeseen ground conditions. WSP will not be liable for actions taken prior to consultation.

The scope of the investigation was selected on the basis of the specific development and land use scenario proposed by the Client and may be inappropriate to another form of development or scheme. If the development layout was not known at the time of the investigation the report findings may need revisiting once the development layout is confirmed.

The risk assessment and opinions provided are based on currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values. Specific assumptions associated with the WSP risk assessment process have been outlined within the body or associated appendix of the report.

Additional investigations may be required in order to satisfy relevant planning conditions or to resolve any engineering and environmental issues.

If costs have been included in relation to additional site works, and / or site remediation works these must be considered as indicative only and must, be confirmed by a qualified quantity surveyor.

The following report titles (or combination) may cover this category of work: geo environmental site investigation; geotechnical assessment; GIR (Ground Investigation reports); preliminary environmental and geotechnical risk assessment; geotechnical risk register.

Detailed Quantitative Risk Assessments and Remedial Strategy Reports

These reports either use primary data or build upon previous report versions and associated notes. The scope of the investigation; further testing and monitoring and associated risk assessments were selected on the basis of the specific development and land use scenario proposed by the Client and may not be appropriate to another form of development or scheme layout. The risk assessment and opinions provided are based on currently available approaches in the generation of Site Specific Assessment Criteria relating to contamination concentrations and are not considered to represent a risk in a specific land use scenario to a specific receptor. No liability can be accepted for the retrospective effects of any future changes or amendments to these values, associated models or associated guidance.

The outputs of the Detailed Quantitative Risk Assessments are based upon WSP manipulation of standard risk assessment models. Models are simulations based on the available data set and should not be used as predictions.

Where a remediation strategy is proposed, this is based on our interpretation of the risk assessment criteria and is specific to a particular location and a particular intended land use and configuration / layout. Prior to adoption they will need discussing and agreeing with the Regulatory Authorities prior to adoption on site. The regulatory discussion and engagement process may result in an alternative interpretation being determined and agreed. The process and timescales associated with the Regulatory Authority engagement are not within the control of WSP. All costs and programmes presented as a result of this process should be validated by a quantity surveyor and should be presumed to be indicative.

Geotechnical Design Report (GDR)

A GDR can strictly only be prepared following confirmation of all structural loads and serviceability requirements. The design process requires close co-operation between the geotechnical engineer and the structural engineer and is iterative. Where a GDR is prepared using preliminary or assumed loadings and/or serviceability limits it should only be considered as an interim report and should not be relied upon for the procurement or construction of the works it describes. A GDR will be a standalone specifically entitled report.

Monitoring (including Remediation Monitoring reports)

These reports are factual in nature and comprise monitoring, normally groundwater and ground gas and data provided by contractors as part of an earthworks or remedial works.

The data is presented and will be compared with assessment criteria.

Asbestos in soils

Unless explicitly included for in our proposal, our investigation does not include for a formal asbestos assessment. The inspection for asbestos, either as asbestos containing materials (ACMs) lying on the surface or as ACMs and/or as loose asbestos fibres within made ground / stockpiles are excluded. Our report will include for the factual reporting of any soil screens that are collected. These results should be treated cautiously and should not be relied upon to provide detailed and representative information on the delineation, type and extent of bulk ACMs and/or trace loose asbestos fibres within the soil matrix at the site.

Where we indicate in our proposal that we will consider asbestos we will undertake screening of representative soil samples for the presences / absence of loose asbestos fibres. If these are found a further and more detailed specific investigation into asbestos in soils, will need to be undertaken which will include asbestos quantification testing. These investigations are associated with more rigorous monitoring of asbestos and health and safety provisions.

Appendix C

PREVIOUS EXPLORATORY HOLE LOGS

APPENDIX C-1

2009 SOUTHERN TESTING LOGS

Southern Testing
Environmental & Geotechnical

TEST HOLE LOG

National Grid Reference		TR 312 457	
Job No	J9733	Date	30/10/2008
Logged by	WF	Engineer	CL

Site : **Whitfield, Dover**

Client : **Phillip Jeans Homes Limited**

Excavation Method : 5 Tonne Excavator

Hole No TP01

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type	Test Type & Value
200	D	
600	D	
1.0	D	▽ 42
2.5	D	

Depth (Thickness)	Key	Soil Description
(500) 500	MADE GROUND	MADE GROUND composed of brown, sandy CLAY, with frequent roots, rootlets, fine to coarse flint gravel, ash, brick fragments and occasional chalk fragments.
650	MADE GROUND	MADE GROUND composed of white, weathered CHALK, with frequent weak chalk fragments, fine to coarse flint gravel and brick fragments. [Layer of black and grey, ashy clinker and brick fragments at 0.5-0.65m.]
(2.4) 3.0	CHALK	White, blocky CHALK, comprising abundant weak to moderately weak gravel and cobble size intact fragments in a silty chalk matrix, with occasional fine to coarse, angular flint gravel. [Grade I] [No flint gravel from 0.9m. Moderately weak from 0.9m. Slow progress from 1.2m.]

BRE365 soakage test carried out

Hole No TP02

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type	Test Type & Value
200	D	
600	D	
1.0		▽ 24
2.0	D	▽ 26

Depth (Thickness)	Key	Soil Description
(350) 350	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootlets, chalk fragments and occasional organic matter.
(2.7) 3.0	CHALK	White and light brown blocky CHALK, comprising abundant weak to moderately weak, gravel size intact fragments in a silty chalk matrix. [Grade III at 1.0m] [Grade II from 2.0m] [Occasional coarse, sub-rounded, flint gravel and cobbles from 1.1m.]

Hole No TP03

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type	Test Type & Value
150	D	
500	D	⊥ 250
1.0		⊥ 230
1.2	D	⊥ 250
1.8		⊥ 240; ▽ 14
2.0	D	
2.7		▽ 20
3.0	D	

Depth (Thickness)	Key	Soil Description
(300) 300	TOPSOIL	Grey brown, sandy, clay TOPSOIL, with frequent rootlets, occasional fine to coarse flint gravel and brick fragments.
(1.8) 2.1	CLAY	Stiff (high strength), friable, brown, silty, sandy CLAY, with occasional fine to coarse, angular to sub-rounded flint gravel (5-10%) and occasional chalk fragments.
(900) 3.0	CHALK	Off-white and light brown, weathered CHALK, comprising abundant weak, gravel size intact chalk fragments in a silty chalk matrix. [Grade IV-III] [Becoming moderately weak with occasional flint cobbles from 2.6m.]

Hole No TP04

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type	Test Type & Value
200	D	
500	D	⊥ 160
1.0	D	⊥ 600; ▽ 5; ▽ 8
1.8		▽ 26
2.3	D	

Depth (Thickness)	Key	Soil Description
(300) 300	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootlets, fine to coarse flint gravel and occasional organic matter.
(500) 800	CLAY	Firm to stiff (medium to high strength), friable, brown, silty, sandy CLAY, with occasional fine to coarse, angular to sub-angular flint gravel (5%).
(300) 1.1	SILT	Loose, light brown, slightly sandy, clayey SILT, with frequent fine to coarse, angular to sub-angular flint gravel (15%).
(1.9) 3.0	CHALK	Off white and light brown, weathered CHALK, comprising abundant weak gravel size intact chalk fragments, occasional sub-rounded flint cobbles and brown staining. [Grade VI at 1.0m.] [Grade II from 1.8m] [Becoming blocky and moderately weak intact fragments, with less brown staining from 1.5m.]

*▽ : Perth Penetration Test, 'N' value; ▼: Standard Penetration Test, 'N' values; ⊥: Unconfined Compression Strength by hand penetrometer, kN/m2; V : Shear Vane test, kN/m2; X: CBR by Mexe cone penetrometer, %; D: Disturbed sample; U: Undisturbed sample; B: Bulk sample; W: Water sample

Southern Testing
Environmental & Geotechnical

TEST HOLE LOG

National Grid Reference	TR 312 457		
Job No	J9733	Date	30/10/2008
Logged by	WF	Engineer	CL

Site : **Whitfield, Dover**

Client : **Phillip Jeans Homes Limited**

Excavation Method : 5 Tonne Excavator

Hole No TP05

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type	Test Type & Value
200	D	
500		⊥ 250
900	D	
1.0		⊥ 260
1.4	D	
1.5		⊥ 320
1.8		▽ 10
		▽ 22
2.5	D	

Depth (Thickness)	Key	Soil Description
(300) 300	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootlets, fine to coarse, angular to sub-angular flint gravel and occasional glazed pipe fragments.
(1.3) 1.6	CLAY	Stiff (high strength), friable, orange brown, sandy CLAY, with occasional fine to coarse, angular to aub-angular flint gravel (5%). [Colour change to dark brown at 1.4-1.6m.]
(1.3) 2.9	CHALK	White and light brown, blocky CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with occasional fine to coarse, angular to sub-rounded flint gravel. [Grade III

Hole No TP06

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type	Test Type & Value
150	D	
400	D	
500		⊥ 400
1.0		▽ 20
1.2	D	
		▽ 6
1.8		▽ 14
		▽ 17
2.7	D	

Depth (Thickness)	Key	Soil Description
250	TOPSOIL	Brown, sandy, clay TOPSOIL, with frequent roots and fine to coarse flint gravel.
(450) 700	CLAY	Very stiff (very high strength), friable, light brown, sandy CLAY, with occasional fine to coarse, sub-angular to angular flint gravel (20%), brick fragments and ash (possibly ploughed in?). [Frequent flint gravel from 0.5m.]
(2.3) 3.0	CHALK	Off white, weathered CHALK, comprising frequent weak to moderately weak gravel size intact chalk fragments in a silty chalk matrix. [Grade IV] [Abundant fine to coarse, angular to rounded flint gravel and frequent cobbles from 0.7-1.3m. Becoming blocky and moderately weak from 1.3m. Slow progress from 1.3m.]

BRE365 soakage test carried out

Hole No TP07

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type	Test Type & Value
150	D	
500		⊥ 190
800	D	⊥ 170
1.0		▽ 15
		▽ 21
2.7		▽ 25
2.9	D	

Depth (Thickness)	Key	Soil Description
250	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootletsm, fine to coarse flint gravel, occasional brick fragments and ashy clinker.
(650) 900	CLAY	Stiff (high strength), friable, brown, sandy CLAY, with frequent fine to coarse, angular to sub-angular flint gravel (15%) and occasional rootlets to 0.5m.
(2.0) 2.9	CHALK	White and light brown, blocky CHALK, comprising abundant moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with frequent brown and dark brown, silty, sandy clay lenses to 1.3m. [Grade IV-III at 1.0m] [Grade III-II from 2.9m]

BRE365 soakage test carried out

Hole No TP08

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type	Test Type & Value
200	D	
500		⊥ 230
900	D	
1.0		⊥ 230
1.5		⊥ 270
1.8	D	▽ 21
2.0		⊥ 290
2.7		▽ 20
2.8	D	

Depth (Thickness)	Key	Soil Description
(450) 450	TOPSOIL	Dark grey brown, sandy clay TOPSOIL, with frequent rootlets, fine to coarse flint gravel, occasional brick fragments and ashy clinker.
(1.4) 1.8	CLAY	Stiff (high strength), friable, light brown patched grey, sandy CLAY, with occasional fine to medium, angular to rounded flint gravel. [Occasional flint cobbles from 1.1m. Becoming silty from 1.4m.]
1.9	CLAY/ SILT	Stiff (high strength), light brown, patched light grey, silty CLAY/ clayey SILT, with occasional flint cobbles.
(1.1) 2.9	CHALK	White blocky CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with frequent lenses of stiff (high strength), brown, grey and dark brown silty clay to 2.3m. [Grade III]

BRE365 soakage test carried out

*▽: Perth Penetration Test, 'N' value; ▼: Standard Penetration Test, 'N' values; ⊥: Unconfined Compression Strength by hand penetrometer, kN/m2;
V: Shear Vane test, kN/m2; X: CBR by Mexe cone penetrometer, %; D: Disturbed sample; U: Undisturbed sample; B: Bulk sample; W: Water sample

Southern Testing
Environmental & Geotechnical

TEST HOLE LOG

National Grid Reference		TR 312 457	
Job No	J9733	Date	30/10/2008
Logged by	WF	Engineer	CL

Site : **Whitfield, Dover**

Client : **Phillip Jeans Homes Limited**

Excavation Method : 5 Tonne Excavator

Hole No TP09

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
150	D	(300)	TOPSOIL	Grey brown, silty, sandy clay TOPSOIL, with frequent rootlets, fine to coarse flint gravel, occasional brick fragments, ashy clinker and roots.
400	D	300	MADE GROUND	MADE GROUND composed of off white and light brown, weathered CHALK, with frequent weak, fine to coarse chalk fragments in a silty chalk matrix, with very occasional brick bragments and ashy clinker.
600	⊥ 600	550	CLAY	Very stiff (very high strength), friable, light brown, silty, sandy CLAY, with frequent fine to coarse, angular flint gravel (20%) and occasional fine chalk fragments.
900	D	(850)		
1.0	⊥ 600			
1.5	▽ 11	1.4	CHALK	Off white weathered CHALK, comprising abundant weak, gravel size intact chalk fragments, in a silty chalk matrix, with occasional flint cobbles. [Grade V]
1.9	D ▽ 7	(1.6)		[Colour change to white, becoming blocky and moderately weak from 2.0m.]
		3.0		

Hole No TP10

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
200	D	(350)	TOPSOIL	Dark grey brown, sandy clay TOPSOIL, with frequent roots, rootlets, fine to coarse flint gravel, occasional ashy clinker, brick and ceramic tile fragments.
500	⊥ 600	350	CLAY	Very stiff (very high strength), desiccated, light brown, sandy CLAY, with occasional roots and fine to coarse, angular to sub-rounded flint gravel (5%).
600	D	(350)		
650	⊥ 450	700	CHALK	White and light brown blocky CHALK, comprising abundant moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with occasional sub-rounded flint cobbles. [Grade II at 1.0m] [Grade IV from 2.5m]
1.0	▽ 31	(1.8)		[Frequent rootlets to 1.3m. Hard dig from 2.1m.]
1.8	▽ 32			
1.9	D			
2.5	▽ 19	2.5		

Hole No TP11

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
200	D	(400)	TOPSOIL	Dark grey brown, sandy clay TOPSOIL, with frequent rootlets, fine to coarse, angular to sub-rounded flint gravel, occasional brick fragments and ashy clinker.
500	⊥ 260	400	CLAY	Stiff (high strength), friable, light brown, sandy CLAY, with frequent fine to coarse, angular to sub-angular flint gravel (25%) and occasional flint cobbles.
700	D	(1.0)		[Becoming silty from 1.4m and colour change to light brown, with occasional fine to coarse, angular to sub-angular flint gravel and black iron staining.]
1.0	⊥ 290			
1.5	D ⊥ 260	1.4	CLAY	Stiff (high strength), friable, light brown, silty CLAY, with occasional fine to coarse, angular to sub-angular flint gravel (5%), occasional black iron staining and frequent silt lenses.
2.5	⊥ 270	(2.2)		
3.0	D ⊥ 270			
3.5	⊥ 260	3.6		

Hole No TP12

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
200	D	(350)	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootlets, fine to coarse flint gravel, occasional brick fragments, ashy clinker and roots.
1.0	▽ 18	350	CHALK	White and light brown blocky CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with occasional sub-rounded flint cobbles. [Grade IV]
1.2	D	(2.6)		[Occasional dark brown staining along fissures to 1.5m.]
2.0	▽ 18			
2.6	D	2.9		

*▽: Perth Penetration Test, 'N' value; ▼: Standard Penetration Test, 'N' values; ⊥: Unconfined Compression Strength by hand penetrometer, kN/m2; V: Shear Vane test, kN/m2; X: CBR by Mexe cone penetrometer, %; D: Disturbed sample; U: Undisturbed sample; B: Bulk sample; W: Water sample

TEST HOLE LOG

Southern Testing
Environmental & Geotechnical

National Grid Reference		TR 312 457	
Job No	J9733	Date	30/10/2008
Logged by	WF	Engineer	CL

Site : **Whitfield, Dover**

Client : **Phillip Jeans Homes Limited**

Excavation Method : 5 Tonne Excavator

Hole No TP13

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
200	D	(300) 300	TOPSOIL	Dark grey, friable, brown, sandy clay TOPSOIL, with frequent rootlets and occasional fine to coarse flint gravel.
500	⊥ 150		CLAY	Firm to stiff (medium to high strength), brown, sandy, silty CLAY, with occasional fine to medium chalk fragments, and fine to coarse, angular to sub-angular flint gravel (5%).
700	D			
1.0	⊥ 170			
1.5	⊥ 180	(3.1)		[Frequent fine to coarse, angular to sub-angular flint gravel from 1.9m (25%). Colour change to light brown and becoming silty from 2.6m.]
2.0	D ⊥ 110			
2.5	⊥ 170			
3.1	D	3.4		

Hole No TP14

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
150	D	200	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootlets, fine to medium flint gravel and occasional brick fragments.
500	D ⊥ 200	(400) 600	CLAY	Stiff (high strength), friable, brown, sandy CLAY, with frequent roots, occasional fine to medium, angular to sub-rounded flint gravel (5%) and very occasional brick fragments.
1.0	▽ 8		CHALK	Off white and brown, weathered CHALK, comprising abundant weak, gravel size intact chalk fragments in a silty chalk matrix. [Grade V at 1.0m] [Grade IV from 1.7m]
1.7	▽ 11, ▽ 16	(2.5)		[Colour change to white and light brown, becoming blocky and moderately weak, with frequent sub-angular to sub-rounded flint cobbles from 1.8m.]
3.0	D			
3.1	D	3.1		

Hole No TP15

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
100	D	200	TOPSOIL	Grey brown, sandy, clay TOPSOIL, with frequent rootlets and fine to coarse flint gravel.
500	⊥ 320	(1.2)	CLAY	Stiff to very stiff (high to very high strength), friable, light brown, silty, sandy CLAY, with frequent fine to coarse, angular to sub-angular flint gravel and cobbles (20%), occasional fine chalk fragments and ashy clinker (possibly ploughed in?).
750	D			
1.0	⊥ 300	1.4		
1.5	▽ 14		CHALK	Off white and light brown, weathered CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with frequent flint cobbles. [Grade V]
1.5	D, ▽ 7	(1.6)		[Becoming blocky and moderately weak from 2.0m.]
2.5	D	3.0		

Hole No TP16

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
150	D	200	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootlets.
400	D ⊥ 220	450	CLAY	Stiff (high strength), friable, brown, sandy CLAY, with frequent rootlets, fine to coarse, angular to sub-angular flint gravel (15%), fine to coarse chalk fragments and occasional brick fragments (possibly ploughed in?).
1.0	▽ 17		CHALK	Off white and light brown, blocky CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with occasional fine to coarse angular to sub-rounded flint gravel and cobbles. [Grade IV]
1.5	D	(2.4)		
1.8	▽ 18			[Hard dig from 2.7m - flint cobble band.]
2.8	D	2.8		

*▽: Perth Penetration Test, 'N' value; ▼: Standard Penetration Test, 'N' values; ⊥: Unconfined Compression Strength by hand penetrometer, kN/m2;
V: Shear Vane test, kN/m2; X: CBR by Mexe cone penetrometer, %; D: Disturbed sample; U: Undisturbed sample; B: Bulk sample; W: Water sample

Southern Testing
Environmental & Geotechnical

TEST HOLE LOG

National Grid Reference	TR 312 457		
Job No	J9733	Date	30/10/2008
Logged by	WF	Engineer	CL

Site : **Whitfield, Dover**

Client : **Phillip Jeans Homes Limited**

Excavation Method : 5 Tonne Excavator

Hole No TP17

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
150	D	200	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootlets and fine to coarse flint gravel.
500	D	(500) 700	MADE GROUND	MADE GROUND composed of friable, brown, sandy CLAY, with frequent fine to coarse, angular to sub-angular flint gravel (15%), brick fragments and ash.
1.0	D ⊥ 300	(2.7) 3.4	CLAY	Stiff to very stiff (high to very high strength), friable, brown and grey, silty, sandy CLAY. [Frequent sub-rounded flint cobbles from 3.2m.]
1.5	⊥ 280			
2.0	D ⊥ 270			
2.5	⊥ 300			
3.0	D ⊥ 320			

Hole No TP18

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
200	D	200	TOPSOIL	Dark grey brown, sandy clay TOPSOIL, with frequent rootlets, fine to coarse flint gravel, fine to medium chalk fragments and occasional roots.
600	D	(900) 1.1	CLAY	Brown, friable, sandy CLAY, with abundant fine to coarse chalk fragments (40%), frequent fine to coarse, angular to sub-angular flint gravel (20%), occasional roots and rootlets to 0.5m.
1.0	▽ 30	(1.9) 3.0	CHALK	White and light brown, blocky CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments. [Grade II] [Frequent sub-angular to sub-rounded chalk cobbles from 2.0m.]
1.4	D			
1.7	▽ 30			
3.0	D			

Hole No TP19

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
150	D	(300) 300	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootlets, fine to coarse flint gravel and chalk fragments.
500	D	(600) 900	CLAY	Friable, brown, silty, sandy CLAY, with abundant fine to coarse chalk fragments (40%) and frequent fine to coarse, angular flint gravel (20%).
1.0	▽ 21	(700) 1.6	CHALK	White and light brown, blocky CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with occasional flint cobbles. [Grade III]
1.5	▽ 29	(1.9) 3.5	CHALK	Grey white, blocky CHALK, comprising abundant weak, gravel size intact chalk fragments, frequent fine to coarse, angular flint gravel and occasional flint and chalk cobbles. [Grade II] [Frequent pockets of stiff (high strength), friable, brown, silty, sandy clay.]
2.0	D	3.6	CHALK	White blocky CHALK, comprising abundant moderately weak, gravel size intact chalk fragments, in a silty chalk matrix.
2.6	⊥ 230			

Hole No TP20

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
150	D	250	TOPSOIL	Grey brown, sandy, clay TOPSOIL, with frequent rootlets, fine to coarse flint gravel and occasional brick fragnments.
500	D ⊥ 320	(450) 700	CLAY	Very stiff (very high strength), friable, brown, sandy CLAY, with frequent fine to coarse, angular to sub-angular flint gravel (20%), occasional fine chalk fragments and rootlets.
700	⊥ 350	(2.3) 3.0	CHALK	White and light brown, blocky CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with occasional sub-rounded flint gravel and chalk cobbles. [Grade III at 1.0m] [Grade V from 1.8m] [Colour change to white and becoming moderately weak from 2.5m]
1.0	▽ 21			
1.8	▽ 14			
2.0	D			
3.0	D			

*▽ : Perth Penetration Test, 'N' value; ▼: Standard Penetration Test, 'N' values; ⊥: Unconfined Compression Strength by hand penetrometer, kN/m2; V : Shear Vane test, kN/m2; X: CBR by Mexe cone penetrometer, %; D: Disturbed sample; U: Undisturbed sample; B: Bulk sample; W: Water sample

Southern Testing
Environmental & Geotechnical

TEST HOLE LOG

National Grid Reference		TR 312 457	
Job No	J9733	Date	30/10/2008
Logged by	WF	Engineer	CL

Site : **Whitfield, Dover**

Client : **Phillip Jeans Homes Limited**

Excavation Method : 5 Tonne Excavator

Hole No TP21

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
100	D	250	TOPSOIL	Grey brown, sandy, clay TOPSOIL, with frequent rootlets and fine to coarse flint gravel.
500	D ⊥ 600	350	MADE GROUND	MADE GROUND composed of white, weathered CHALK, with frequent weak, fine to coarse chalk fragments, fine to coarse flint gravel and ashy clinker.
1.0	⊥ 600; ▽ 30	(1.1) 1.4	CLAY	Very stiff (very high strength), friable, brown, silty, sandy CLAY, with frequent fine to coarse, angular to sub-angular flint gravel (25%) and fine to coarse chalk fragments. [Hard dig from 0.35m-1.2m. Becoming less friable from 1.2m.]
1.2	D ⊥ 400			
2.0	D	(1.6) 3.0	CHALK	White, blocky CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments and cobbles in a silty chalk matrix. [Grade II] [Becoming moderately weak from 2.0m.]
2.4	▽ 35			

BRE365 soakage test carried out

Hole No TP22

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
200	D	250	TOPSOIL	Dark grey brown, silty, sandy, clay TOPSOIL, with frequent rootlets, occasional fine to coarse flint gravel and chalk fragments.
500	⊥ 170	(750) 1.0	CLAY	Stiff (high strength), friable, brown, silty, sandy CLAY, with occasional fine to coarse, angular flint gravel (5%) and rootlets to 0.5m.
700	D			
1.0	⊥ 190	(2.0) 3.0	CHALK	White and light brown, partly weathered CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments in a silty chalk matrix. [Grade V at 1.1m] [Grade IV from 2.1m] [Becoming blocky and less weathered from 1.5m.]
1.1	▽ 5; ▽ 9			
2.0	D			
2.1	▽ 18			

BRE365 soakage test carried out

Hole No TP23

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
50	D	100	TOPSOIL	Dark grey brown, sandy, clay TOPSOIL, with frequent rootlets, fine to coarse flint gravel and fine chalk fragments.
500	⊥ 450	(2.9) 3.0	CLAY	Very stiff (very high strenth), friable, brown, sandy CLAY, with frequent fine to medium chalk fragments, occasional fine to coarse, angular to sub-rounded flint gravel (10%) and roots to 0.5m. [Firm to stiff (medium to high strength) from 1.5m. Frequent flint gravel (20%) from 2.1m. Colour change to light brown and becoming silty from 2.6m.]
750	D			
1.0	⊥ 470			
1.5	⊥ 150			
2.0	D ⊥ 140			
2.5	⊥ 150			
3.1	D	(300) 3.3	CHALK	White and light brown, blocky CHALK, comprising abundant weak to moderately weak, gravel size intact chalk fragments in a silty chalk matrix, with frequent fine to coarse, angular to sub-angular flint gravel.

Hole No TP24

Water strikes: **None**
Water level: **N/A**
Pit sides: **Stable in short-term**

Depth m/mm	Sample Type or Test Type & Value	Depth (Thickness)	Key	Soil Description
150	D	(300) 300	TOPSOIL	Dark brown, sandy, clay TOPSOIL, with frequent rootlets and fine to coarse flint gravel.
500	D ⊥ 350	(400) 700	CLAY	Very stiff (very high strength), friable, brown, silty, sandy CLAY, with frequent fine to coarse, angular to sub-rounded flint gravel (10%), occasional fine chalk fragments, rootlets and brick fragments (possibly ploughed in?).
1.0	▽ 23	(2.3) 3.0	CHALK	White and light brown, blocky CHALK, comprising abundant weak, gravel size intact chalk fragments in a silty chalk matrix. [Grade III] [Becoming moderately weak with frequent flint cobbles from 1.4m.]
1.5	D; ▽ 10 for 150 mm			
2.9	D			

BRE365 soakage test carried out

*▽: Perth Penetration Test, 'N' value; ▼: Standard Penetration Test, 'N' values; ⊥: Unconfined Compression Strength by hand penetrometer, kN/m2; V: Shear Vane test, kN/m2; X: CBR by Mexe cone penetrometer, %; D: Disturbed sample; U: Undisturbed sample; B: Bulk sample; W: Water sample

APPENDIX C-2

BRITISH GEOLOGICAL SOCIETY (BGS) LOG

TR 34 NW/4
3160 4507

...titute use only

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA *If measurements start below ground surface, state how far.*	Thickness Feet	Thickness Inches	Thickness Metres	Depth Feet	Depth Inches	Depth Metres
	TOP SOIL			0.05			0.05
HEAD	FLINT BED			0.75			0.80
	BROWN CLAY			1.70			2.50
	BROWN FLINT BOUND SAND CLAY			0.50			3.00
UPPER CHALK	CHALK AND FLINTS			14.00			17.00
	FLINT BED			1.00			18.00
	CHALK AND FLINTS			87.00			105.00

Appendix D

EXPLORATORY HOLE LOGS

Geotechnical Engineering Limited

KEY TO EXPLORATORY HOLE LOGS

Sample type

D Small disturbed	U Undisturbed	X/L Dynamic	D*/ES Environmental - soil	Cs Core subsample (prepared)
B Bulk disturbed	UT Undisturbed thin wall	C Core	EW Environmental - water	Xs/Ls Dynamic subsample (prepared)
LB Large bulk disturbed	P Piston	W Water		

Test type

S SPT - Split spoon sampler followed by uncorrected SPT 'N' Value
C SPT - Solid cone followed by uncorrected SPT 'N' Value
(*250 - Where full test drive not completed, linearly extrapolated 'N' value reported, ** - Denotes no effective penetration)
H Hand vane - direct reading in kPa - not corrected for BS1377 (1990). Re* denotes refusal
M Mackintosh probe - number of blows to achieve 100mm penetration
PP Pocket penetrometer - direct reading in kg/sq.cm
Vo Headspace vapour reading, uncorrected peak values in ppm, using a PID (calibrated with Isobutylene, using a 10.6eV bulb)

Sample/core range/I_f

Dynamic sample

Undisturbed sample - open drive including thin wall. Symbol length reflects recovery

x x = Total Core Recovery (TCR) as percentage of core run

y y = Solid Core Recovery (SCR) as percentage of core run. Assessment of core is based on full diameter.

z z = Rock Quality Designation (RQD). The amount of solid core greater than 100mm expressed as percentage of core run.

Where SPT has been carried out at beginning of core run, disturbed section of core excluded from SCR and RQD assessment.

I_f - fracture spacing - the modal fracture spacing (mm) over the indicated length of core. Where spacing varies signficantly, the minimum, mode and maximum values are given. NI = non-intact core NA = not applicable

Instrumentation

Porous tip | Perforated standpipe | Granular response zone | Bentonite seal | Cement/ bentonite grout | Soil Backfill | Concrete

Stratum boundaries

Estimated boundary | Grading boundary

Logging

The logging of soils and rocks has been carried out in general accordance with BS 5930:2015.

Chalk is logged in general accordance with Lord et al (2002) CIRIA C574. Where possible, dynamic samples in chalk have been logged in accordance with CIRIA C574; descriptions and gradings (if presented) should be treated with caution given the potential for sample disturbance.

For rocks the term fracture has been used to identify a mechanical break within the core. Where possible incipient and drilling induced fractures have been excluded from the assessment of fracture state. Where doubt exists, a note has been made in the descriptions. All fractures are considered to be continuous unless otherwise reported.

Made Ground is readily identifiable when, within the material make up, man made constituents are evident. Where Made Ground appears to be reworked natural material the differentiation between in situ natural deposits and Made Ground is much more difficult to ascertain. The interpretation of Made Ground within the logs should therefore be treated with caution.

The descriptors "topsoil" and "tarmacadam" are used as generic terms and do not imply conformation to any particular standard or composition.

Rootlets are defined as being less than 2mm in diameter, roots are defined as in excess of 2mm diameter.

General Comments

The process of drilling and sampling will inevitably lead to disturbance, mixing or loss of material in some soil and rocks.

Indicated water levels are those recorded during the process of drilling or excavating exploratory holes and may not represent standing water levels.

Legends are drawn in accordance with BS 5930:1999 incorporating Amendment 2.

All depths are measured along the axis of the borehole and are related to ground level at the point of entry. All inclinations are measured normal to the axis of the core.

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT WSP GROUP

BH01

SITE WHITFIELD

Sheet 1 of 4

Start Date 10 February 2016

Scale 1 : 25

End Date 11 February 2016

Depth 15.20 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	If	instru -ment	description	depth (m)	reduced level (m)	legend
10/02/16 0800hrs	1C	0.00 - 0.20			100			Light grey CONCRETE. (MADE GROUND)	0.20		
	1ES 2B 3D 4B 2ES 5D	0.30 - 0.40 0.20 - 0.50 0.30 - 0.40 0.50 - 0.80 0.50 - 0.70 0.50 - 0.70						Light brown mottled dark grey clayey sandy angular to subrounded fine to coarse flint, crystalline and brick GRAVEL. (MADE GROUND)	0.50		
	6B 3ES 7D	1.00 - 1.20 1.00 - 1.20 1.00 - 1.20						Grey silty angular to subrounded fine to coarse chalk and flint GRAVEL. (MADE GROUND)	1.00		
	8UT 10L 9D 4ES 11D 12D 13L 5ES 14D	1.20 - 1.65 1.20 - 2.70 1.65 - 1.70 2.00 2.00 2.70 - 3.15 2.70 - 4.20 3.00 3.00	Nil Nil	 S 19				Structureless CHALK composed of slightly sandy silty angular and subangular fine to coarse GRAVEL. Clasts are very weak low density white with rare yellow staining, rarely angular fine to coarse flint. Matrix is white. (Probable CIRIA Grade Dc).	3.80		
								Structureless CHALK composed of slightly silty angular and subangular fine to coarse GRAVEL. Clasts are weak			
								Continued Next Page	{4.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.20m. Dynamic sampled (128mm) 1.20-7.20m. Waterflush rotary core drilled (146mm) 7.20-15.20m.

CASING: 160mm diam to 4.20m.

BACKFILL: On completion, a slotted standpipe (50mm) was installed from 15.20 to 12.20m, granular response zone 15.20-12.20m, bentonite seal 12.20-0.50m, concrete and stopcock cover 0.50-0.00m.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	31634	CT

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT	WSP GROUP		**BH01**
SITE	WHITFIELD	Sheet	2 of 4
Start Date	10 February 2016	Scale	1 : 25
End Date	11 February 2016	Depth	15.20 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
	6ES 15D	4.00 4.00						low density white with rare yellow staining, rarely angular fine to coarse flint. Matrix is white. (Probable CIRIA Grade Dc).			
	16UT 18L	4.20 - 4.65 4.20 - 5.70	Nil 4.20								
	17D	4.65 - 4.70									
	7ES 19D	5.00 5.00									
	20D 21L	5.70 - 6.15 5.70 - 7.20	4.20	S 10							
	22D	6.00									
	23D	7.00									
	24UT 26C	7.20 - 7.65 7.20 - 8.70	4.20		66 13 6	NI 60 300		Very weak medium density white CHALK. Fractures are subhorizontal to 10° and subvertical to 80° and 70° very closely and closely locally medium spaced undulating smooth. (CIRIA Grade B4).	7.20		
	25D	7.65 - 7.70									
	27D	8.00									
	28D 29C	8.70 - 9.15 8.70 - 10.20	4.20	S 29	64 20 20						
								Continued Next Page	{9.00}		

water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	**31634**	**CT**

AGS

Geotechnical Engineering Limited

BOREHOLE LOG

BH01

CLIENT WSP GROUP

SITE WHITFIELD

Start Date 10 February 2016

End Date 11 February 2016

Scale 1 : 25

Depth 15.20 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
	30D	9.00									
								9.40 - 9.50m: Flint.			
	31D	10.00									
	32UT	10.20 - 10.65	4.20		73 18 13						
	34C	10.20 - 11.70									
	33D	10.65 - 10.70									
	35D	11.00									
	36C	11.70 - 12.04	4.20	C*79	50 5 0						
		11.70 - 13.20									
	37D	12.00									
						NI NI 90					
	38D	13.00									
	39C	13.20 - 14.20			98 18 0						
								13.40m: 80° planar smooth fracture.			
								13.50m: 80° planar smooth fracture.			
								Continued Next Page	{14.00}		

water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks
				Groundwater not encountered prior to use of water flush.

AGS

CONTRACT **31634**

CHECKED **CT**

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT	WSP GROUP		**BH01**
SITE	WHITFIELD	Sheet	4 of 4
Start Date	10 February 2016	Scale	1 : 25
End Date	11 February 2016	Depth	15.20 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
10/02/16 1800hrs 2.97m	40D	14.00									
		14.20 - 14.54	4.20	C*81							
11/02/16 0800hrs 12.20m	41C	14.20 - 15.20			66 7 0						
11/02/16 1150hrs 8.90m	42D	15.00									
									15.20		
		15.20 - 15.53	4.20	C*69				Borehole completed at 15.20m.			
									{19.00}		

water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	**31634**	**CT**

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT WSP GROUP

BH02

SITE WHITFIELD

Sheet 1 of 4

Start Date 8 February 2016

Scale 1 : 25

End Date 9 February 2016

Depth 14.70 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
08/02/16 1400hrs	1B 1ES 2D 3B 2ES 4D	0.20 - 0.50 0.20 - 0.50 0.20 - 0.50 0.50 - 0.80 0.50 - 0.80 0.50 - 0.80						Light brown mottled dark grey clayey sandy angular to subrounded fine to coarse flint, brick, chalk and crystalline GRAVEL. (MADE GROUND)	0.50		
	5B 3ES 6D	1.00 - 1.20 1.00 - 1.20 1.00 - 1.20						Structureless CHALK composed of slightly sandy silty angular and subangular fine to coarse GRAVEL. Clasts are very weak low density white with rare yellow staining, rarely angular fine to coarse flint. Matrix is white. (Probable CIRIA Grade Dc).			
	 7C	1.20 1.20 - 2.70	Nil	C 43	20	NA		1.20 - 2.70m: Limited recovery.			
	 8L	2.70 2.70 - 4.20	1.20	C 34							
	4ES 9D	3.00 3.00							3.20		
								Structureless CHALK composed of slightly silty angular and subangular fine to coarse GRAVEL. Clasts are very weak low density white, rarely angular fine to coarse flint. Matrix is white locally mottled yellow . (Probable CIRIA Grade Dc).			
	5ES	4.00									

Continued Next Page {4.00}

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.20m. Dynamic sampled (113mm) 2.70-5.70m. Waterflush rotary core drilled (140mm) 1.20-2.70m and (116mm) 5.70-14.70m.

CASING: 140mm diam to 5.70m.

BACKFILL: On completion, hole backfilled with bentonite pellets.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	**31634**	**CT**

Geotechnical Engineering Limited

BOREHOLE LOG

BH02

CLIENT	WSP GROUP		
SITE	WHITFIELD	Sheet	2 of 4
Start Date	8 February 2016	Scale	1 : 25
End Date	9 February 2016	Depth	14.70 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
08/02/16 1715hrs 3.10m	10D	4.00									
		4.20 - 4.65	1.20	C 29							
09/02/16 0800hrs Dry	11L	4.20 - 5.70									
	5ES	5.00									
	12D	5.00									
		5.70 - 6.15	1.20	C 34					5.70		
	13C	5.70 - 7.20	5.70		30 0 0	NA		Structureless CHALK composed of slightly silty angular and subangular fine to coarse GRAVEL. Clasts are very weak low density white, rarely angular fine to coarse flint. Matrix is white locally mottled yellow. (CIRIA Grade Dc). 6.00m: Angular flint cobble.			
		7.20 - 7.65	5.70	C 49							
	14C	7.20 - 8.70			80 0 0						
	15D	7.20									
	16D	8.00									
	17D	8.70 - 9.15	5.70	S 41							
	18C	8.70 - 10.20			53 0 0				8.90		
								Continued Next Page	{9.00}		

water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	31634	CT

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT WSP GROUP

SITE WHITFIELD

Start Date 8 February 2016

End Date 9 February 2016

BH02

Scale 1 : 25

Depth 14.70 m

progress date/time water depth	sample no & type	depth (m) from - to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
	19D	9.00						Structureless CHALK composed of slightly silty angular and subangular fine to coarse GRAVEL. Clasts are weak medium density white, rarely angular fine to coarse flint. Matrix is white. (CIRIA Grade Dc).			
	20D	10.00									
		10.20 - 10.65	5.70	C 44							
	21C	10.20 - 11.70			54 0 0			10.30m: Angular flint cobble.			
	22D	11.00									
		11.70 - 12.07	5.70	C*68							
	23C	11.70 - 13.20			33 3 0	NI 120 170					
	24D	12.00									
								Very weak medium density white CHALK. Fractures are subhorizontal to 10° and subvertical to 80° very closely and closely spaced undulating smooth. (CIRIA Grade B4).	12.45		
	25D	13.00									
		13.20 - 13.49	5.70	C*107							
	26C	13.20 - 14.70			92 41 38						
								Continued Next Page	{14.00}		

water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks
				Groundwater not encountered prior to use of water flush.

AGS

CONTRACT **31634**

CHECKED **CT**

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT WSP GROUP

SITE WHITFIELD

Start Date 8 February 2016

End Date 9 February 2016

BH02

Sheet 4 of 4

Scale 1 : 25

Depth 14.70 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
09/02/16 1800hrs 10.00m											
		14.70 - 15.11	5.70	C*58							
								Borehole completed at 14.70m.	15.11		
									{19.00}		

water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	**31634**	**CT**

AGS

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT	WSP GROUP						**BH03**
SITE	WHITFIELD					Sheet	1 of 4
Start Date	11 February 2016	Easting	631266.4			Scale	1 : 25
End Date	12 February 2016	Northing	145265.4	Ground level	102.00mOD	Depth	15.30 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
11/02/16 1150hrs	1B 2D 1ES	0.10 - 0.30 0.10 - 0.30 0.10 - 0.30						Soft brown slightly sandy CLAY. Frequent rootlets.	0.50	101.50	
	2ES 3B 4D	0.90 - 1.10 0.90 - 1.10 0.90 - 1.10						Soft light brown slightly sandy CLAY. Rare rootlets.			
	5UT 7L	1.20 - 1.65 1.20 - 2.70	Nil					1.20m: Firm from 1.20-1.60m.	1.60	100.40	
	6D	1.65 - 1.70						Firm brown slightly sandy slightly gravelly CLAY. Gravel is angular to subrounded fine to coarse flint.			
	3ES 8D	2.00 2.00									
	 9L	2.70 - 3.15 2.70 - 4.20	Nil	C 10					2.90	99.10	
	4ES 10D	3.00 3.00						Structureless CHALK composed of slightly silty angular and subangular fine to coarse GRAVEL. Clasts are weak medium density white rarely mottled yellow, rarely angular fine to coarse flint. Matrix is white. (Probable CIRIA Grade Dc).			
								Continued Next Page	{4.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.20m. Dynamic sampled (128mm) 1.20-4.80m and 12.30-13.80m. Waterflush rotary core drilled (146mm) 4.80-12.30m and 13.80-15.30m.

CASING: 160mm diam to 4.20m.

BACKFILL: On completion, hole backfilled with bentonite pellets.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	**31634**	**CT**

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT WSP GROUP **BH03**

SITE WHITFIELD Sheet 2 of 4

Start Date 11 February 2016 Easting 631266.4 Scale 1 : 25

End Date 12 February 2016 Northing 145265.4 Ground level 102.00mOD Depth 15.30 m

progress date/time water depth	sample no & type	depth (m) from - to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
	5ES	4.00									
	11D	4.00									
	12UT	4.20 - 4.52	4.20								
	14L	4.20 - 4.80									
	13D	4.52 - 4.57									
		4.80 - 5.25	4.20	C 32	100	NA		Structureless CHALK composed of slightly silty angular and subangular fine to coarse GRAVEL. Clasts are weak medium density white rarely mottled yellow, rarely angular fine to coarse flint. Matrix is white. (CIRIA Grade Dc).	4.80	97.20	
	15C	4.80 - 6.30									
	6ES	5.00									
	16D	5.00									
	17D	6.00									
		6.30 - 6.75	4.20	C 32	82						
	18C	6.30 - 7.80									
	19D	7.00									
		7.80 - 8.25	4.20	C 33	53						
	20C	7.80 - 9.30									
	21D	8.00									
						NI 50			8.85	93.15	

Continued Next Page {9.00}

water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	31634	CT

AGS

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT	WSP GROUP				BH03
SITE	WHITFIELD			Sheet	3 of 4
Start Date	11 February 2016	Easting	631266.4	Scale	1 : 25
End Date	12 February 2016	Northing	145265.4 Ground level 102.00mOD	Depth	15.30 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
	22D	9.00				200		Very weak medium density white CHALK. Fractures are subhorizontal to 10°, subvertical to 80° and 70° very closely and closely spaced undulating smooth. (CIRIA Grade B4).			
		9.30 - 9.75	4.20	C 35							
	23C	9.30 - 10.80			96 0 0						
	24D	10.00									
		10.80 - 11.25	4.20	C 41							
	25C	10.80 - 12.30			80 16 13						
	26D	11.00									
11/02/16 1730hrs 8.68m	27D	12.00									
		12.30 - 12.75	4.20	C 44							
12/02/16 0800hrs 11.90m	28L	12.30 - 13.80			25 0 0						
	29D	13.00									
		13.80 - 14.18	4.20	C*65							
	30C	13.80 - 15.30			67 14 0						
								Continued Next Page	{14.00}		

water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	31634	CT

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT	WSP GROUP				BH03
SITE	WHITFIELD			Sheet	4 of 4
Start Date	11 February 2016	Easting	631266.4	Scale	1 : 25
End Date	12 February 2016	Northing	145265.4 Ground level 102.00mOD	Depth	15.30 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
12/02/16 1310hrs 7.65m	31D	15.00							15.30	86.70	
		15.30 - 15.65	4.20	C*75				Borehole completed at 15.30m.			
									{19.00}		

water strike (m)	casing (m)	rose to (m)	time to rise (m)	remarks	CONTRACT	CHECKED
				Groundwater not encountered prior to use of water flush.	**31634**	**CT**

Geotechnical Engineering Limited

BOREHOLE LOG

WS01

CLIENT	WSP GROUP				
SITE	WHITFIELD			Sheet	1 of 1
Start Date	10 February 2016	Easting	631435.6	Scale	1 : 50
End Date	10 February 2016	Northing	145349.7 Ground level 99.50mOD	Depth	5.45 m

progress date/time water depth	sample no & type	depth (m) from - to	casing depth (m)	test type & value	samp./core range	instrument
10/02/16 1030hrs						
	1B	0.40 - 0.50				
	1ES	0.40 - 0.50				
	2B	1.00 - 1.10				
	2ES	1.00 - 1.10				
	3D	1.20 - 1.65	Nil	S 4		
	4L	1.20 - 2.00	1.20			
	3ES	1.90 - 2.00				
	5D	2.00 - 2.45	2.00	S 1		
	6L	2.00 - 3.00				
	4ES	2.90 - 3.00				
	7D	3.00 - 3.45	2.00	S 6		
	8L	3.00 - 4.00				
	5ES	3.90 - 4.00				
	9D	4.00 - 4.45	2.00	S 1		
	10L	4.00 - 5.00				
	6ES	4.90 - 5.00				
10/02/16 1200hrs Dry	11D	5.00 - 5.45	2.00	S 6		

description	depth (m)	reduced level (m)
Grass over soft brown silty CLAY. Frequent roots (up to 5mm diam) and rootlets. (MADE GROUND)	0.40	99.10
White locally stained yellow very gravelly SILT with a high angular flint cobble content and a low subrounded chalk cobble content. Gravel is subangular and subrounded fine to coarse chalk. (MADE GROUND) 1.20 - 1.65m: Loose. 1.90m: Subrounded chalk cobble.	1.90	97.60
Very loose becoming loose white silty angular to subrounded fine to coarse chalk GRAVEL. (MADE GROUND) 1.95 - 2.00m: Stained orange. 2.70 - 2.80m: Locally stained orange. 2.80 - 2.90m: Subrounded chalk cobble.	3.40	96.10
Soft brown slightly gravelly silty CLAY. Gravel is angular medium and coarse flint. (MADE GROUND) 4.00 - 5.00m: Limited recovery. 4.60m: Red angular medium sandstone gravel. 4.60 - 4.70m: Frequent pockets (up to 50mm) of green silt. Mottled dark brown.	5.45	94.05
Borehole completed at 5.45m.		

{8.00}

EQUIPMENT: Geotechnical Terrier 2000 rig.
METHOD: Hand dug inspection pit 0.00-1.20m. Dynamic sampled (98mm) 1.20-2.00m, (84mm) 2.00-3.00, (74mm) 3.00-4.00m and (64mm) 4.00-5.00m.
CASING: 113mm diam to 2.00m.
BACKFILL: On completion, hole backfilled with bentonite pellets 5.00-0.50m and arisings 0.50-0.00m.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks	CONTRACT	CHECKED
				Groundwater not encountered.	31634	CT

Geotechnical Engineering Limited

BOREHOLE LOG

CLIENT	WSP GROUP						**WS03**
SITE	WHITFIELD					Sheet	1 of 1
Start Date	10 February 2016	Easting	631441.5			Scale	1 : 50
End Date	10 February 2016	Northing	145307.9	Ground level	100.55mOD	Depth	5.45 m

progress date/time water depth	sample no & type	depth (m) from - to	casing depth (m)	test type & value
10/02/16 1200hrs				
	1B	0.40 - 0.50		
	1ES	0.40 - 0.50		
	2B	1.00 - 1.10		
	2ES	1.00 - 1.10		
	3D	1.20 - 1.65	Nil	S 7
	4L	1.20 - 2.00	1.20	
	3ES	1.90 - 2.00		
	5D	2.00 - 2.45	2.00	S 10
	6L	2.00 - 3.00		
	4ES	2.90 - 3.00		
	7D	3.00 - 3.45	2.00	S 11
	8L	3.00 - 4.00		
	5ES	3.90 - 4.00		
	9D	4.00 - 4.45	2.00	S 13
	10L	4.00 - 5.00		
	6ES	4.90 - 5.00		
10/02/16 1330hrs Dry	11D	5.00 - 5.45	2.00	S 15

description	depth (m)	reduced level (m)
Grass over soft brown silty CLAY. Frequent rootlets and rare roots (up to 5mm diam).	0.35	100.20
Structureless CHALK composed of white slightly gravelly SILT with a high angular flint cobble content. Gravel is angular to subrounded fine to coarse very weak and weak low density white with rare black specks (up to 1mm) chalk. (Probable CIRIA Grade Dm)	1.70	98.85
Structureless CHALK composed of silty subangular and subrounded fine to coarse GRAVEL. Clasts are weak medium density white locally stained yellow with rare black specks (up to 1mm) chalk. Matrix is white. (Probable CIRIA Grade Dc) 1.90 - 1.95m: Stained yellow. 2.50m: Flint cobble, recovered non intact. 2.70m: Flint cobble, recovered non intact. 2.90m: Subangular chalk cobble. 3.30m: Flint cobble. 3.40 - 3.50m: Locally stained yellow. 3.50 - 3.60m: Rare subrounded medium flint gravel. 3.60 - 3.90m: Frequent pockets (up to 5mm) of brown clay. 3.90m: Flint cobble, recovered non intact.	3.90	96.65
Structureless CHALK composed of silty subangular and subrounded fine and medium GRAVEL. Clasts are very weak and weak white with frequent black specks (up to 2mm) chalk. Matrix is white. (Probable CIRIA Grade Dc) 4.40m: Rinded flint cobble, recovered non intact.	5.45	95.10
Borehole completed at 5.45m.		
	{8.00}	

EQUIPMENT: Geotechnical Terrier 2000 rig.

METHOD: Hand dug inspection pit 0.00-1.20m. Dynamic sampled (113mm) 1.20-2.00m, (98mm) 2.00-3.00, (84mm) 3.00-4.00m and (74mm) 4.00-5.00m.

CASING: 128mm diam to 2.00m.

BACKFILL: On completion, hole backfilled with bentonite pellets 5.45-0.50m and arisings 0.50-0.00m.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks
				Groundwater not encountered.

AGS

CONTRACT	CHECKED
31634	**CT**