

3. FIELDWORK SUMMARY OF SCOPE AND RATIONALE

3.1. Rationale and Summary of Scope

Site investigation works were undertaken by Ridge on the 4th September 2017. The scope and rationale of the ground investigation undertaken are presented below.

- 5no. windowless sample boreholes (WS) to a maximum depth of 4.00mbgl
- 2no. cable percussive boreholes (BH) to a maximum depth of 10.00mbgl
- 5no. TRL probe locations for estimated CBR values
- Collection of representative samples to undergo chemical and geotechnical laboratory testing as detailed in later sections of this report.
- Installation of 7no. gas / water monitoring standpipes.

Table 3.1: Exploratory hole location rationale

Location	Rationale	Max Depth (mbgl)
BH201-BH202	2no. cable percussive boreholes positioned within the footprint of the proposed buildings across the site to confirm the nature and stratigraphy of the subsurface materials and allow collection of representative samples for chemical and geotechnical laboratory testing / analysis.	10.0
WS201-205	5no. windowless sample boreholes positioned across the site in areas not previously investigated and in the area of the former USTs to confirm the nature and stratigraphy of the subsurface materials and allow collection of representative samples for chemical and geotechnical laboratory testing / analysis.	4.00

The layout of the exploratory positions is presented in Figure 2.

3.2. Sampling

Soil sampling of the near surface materials was undertaken to assess the contamination risks to human health and controlled waters. Soil samples were also taken from various depths in the boreholes for geotechnical testing purposes.

3.3. Site Investigation Standards

Methods employed during the investigation were generally undertaken in accordance with BS10175, BS EN 1997-2 and BS5930.

4. GROUND CONDITIONS ENCOUNTERED

4.1. Soil Conditions

Ground conditions encountered during the recent ground investigation were broadly consistent with those identified in the published literature and in summary comprised a layer of Made Ground overlying superficial deposits of the Alluvium and River Terrace Deposits which in turn was underlain by the Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation (undifferentiated).

Variations in strata thicknesses are summarised in Table 4.1 below, engineering logs are presented in Appendix 2.

Table 4.1: Summary of encountered ground conditions

Location	Made Ground		Alluvium		River Terrace Deposits		Chalk	
	From (mbgl)	Thickness (m)	From (mbgl)	Thickness (m)	From (mbgl)	Thickness (m)	From (mbgl)	Thickness (m)
BH201	GL	1.30	N/E		1.30	3.70	5.00	>5.00
BH202	GL	1.70	N/E		1.70	6.30	8.00	>2.00
WS201	GL	0.90	N/E		0.90	>3.10	N/E	
WS202	GL	1.20	1.20	0.50	1.70	>2.30	N/E	
WS203	GL	1.40	N/E		1.40	>2.60	N/E	
WS204	GL	1.00	1.00	0.70	1.70	>2.30	N/E	
WS205	GL	1.80	N/E		1.80	>2.20	N/E	

N/E – Not Encountered

4.1.1. Surfacing

The site is predominantly unsurfaced with widespread vegetation and localised areas of residual asphalt surfacing, as encountered in WS204.

4.1.2. Made Ground

Made Ground was encountered beneath the surfacing or at ground level in all investigation locations. The total thickness of Made Ground (including the surfacing) varied between 0.90 and 1.80m. Although variable in nature the Made Ground generally comprised a granular fill of dark brown clayey sandy flint gravel with concrete, brick, chalk and asphalt fragments over reworked chalk with flints.

4.1.3. Alluvium

Alluvium was encountered beneath the Made Ground in WS202 and WS204 only. This stratum generally comprised soft dark grey silty gravelly clay. The Alluvium achieved a proven thickness of between 0.50m and 0.70m.

4.1.4. River Terrace Deposits

This stratum, interpreted as Brickearth and Coombe Deposits by RPS and Head gravels by SSL, was encountered beneath the Made Ground or Alluvium in all investigation locations and comprised silty and sandy flint gravel with occasional chalk gravel. This stratum achieved proven thicknesses of 3.70m to 6.30m and formed the basal stratum in all of the window sample boreholes.

4.1.5. Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation (undifferentiated)

The Chalk Formation was encountered only in the cable percussive boreholes (BH201-BH202) and was recovered as white putty with Chalk clasts (CIRIA Grade D_c). The Chalk formed the basal unit in the cable percussive boreholes, terminating at a maximum depth of 10.00mbgl.

4.2. Obstructions

Obstructions were not encountered within any of the investigation locations.

4.3. Groundwater Conditions

Groundwater was encountered within the River Terrace Deposits at 1.80mbgl in BH201 and BH202 during the investigation.

4.4. Visual/Olfactory Evidence of Contamination

Table 4.2: Evidence of Contamination

Location	Evidence	Depth (mbgl)
WS202	Hydrocarbon odour and staining	1.30-1.70

5. GENERIC RISK ASSESSMENT

5.1. Contamination Assessment Methodology

In order to assess the human health and environmental risks posed by potential contaminants within the underlying soils and groundwater, Ridge undertook an initial screen of the laboratory results from both the recent investigation and the historical locations associated with the study site (as far as was practical from the abridged report versions provided) using generic assessment criteria. Generic assessment criteria (GAC) are conservative contaminant concentration values used for comparison purposes to assess the risk associated with contaminant concentrations found on site and are derived using non-site-specific information.

5.1.1. Soils

In order to assess the soil analyses results with regard to potential human health risks, Ridge has adopted the LQM/CIEH Suitable 4 Use Levels (S4ULs), generic assessment criteria (GACs) derived in accordance with the UK framework set out in the most recent CLR (Contaminated Land Report) documents using the Contaminated Land Exposure Assessment (CLEA) Model.

S4ULs have been published for an extensive suite of contaminants, with assessment criteria derived for each contaminant for four different land use scenarios namely:

- Residential with homegrown produce;
- Residential without homegrown produce
- Allotments; and
- Commercial and industrial.

A full list of the GACs together with an indication of the method used for their derivation is provided in Appendix 3. GACs applicable to commercial/industrial end use have been used for the assessment of the site. Contaminant concentrations below the GACs are considered not to warrant further risk assessment. However, concentrations of contaminants above the GACs may require further consideration through statistical analysis, if appropriate, or further detailed assessment using site specific data.

This document does not constitute a Site Assessment Report (SAR) as outlined in the UKWIR Guidance for the Selection of Water Supply Pipes to be Used in Brownfield Sites (Ref: 10/WM/03/21, 2010). As such, the full generic suite of testing recommended in the UKWIR guidance may not have been undertaken for this site and may be required by some water companies. However, consideration has been given to the 'threshold' concentrations presented in Table 3.1 of the UKWIR guidance, where they are applicable to the analysis undertaken, to provide an indication of the potential risks to buried water supply pipes.

5.1.2. Assessment framework

In regards to human health, the CLEA model states that, ‘the contamination is assumed to be at or within 1m of the surface’ (CLR10 pg10). It is considered that at depths greater than 1m, the probability of human exposure via the direct contact pathways are significantly reduced, leaving inhalation of volatile compounds as the dominant pathway with regard to human health risks. Typically, volatile compounds only significantly affect the indoor inhalation pathway. Therefore, for the purposes of statistical analysis, data from the top 1.0 to 1.5m is used for assessment of risks to human health via direct contact pathways in accordance with the CLEA model, dependant on proposed future site levels.

5.1.3. Groundwater

Groundwater analyses, where undertaken, shall be assessed by direct comparison with the freshwater Environmental Quality Standards (EQS), or, in the absence of EQSs, UK or WHO Drinking Water Standards or other appropriate guidance values. For certain compounds, the EQS is quoted as a range of values based on the alkalinity of the water, where the measured concentration lies within this range, the results are interpreted qualitatively. The guideline values selected as appropriate GACs for each contaminant are presented in Appendix 3.

5.1.4. Leachate

Leachate analyses, where undertaken, shall be assessed in the same manner as the groundwater samples. The guideline values selected as appropriate GACs for each contaminant are presented in Appendix 3.

5.1.5. Ground Gas

The criteria used to assess the ground gas monitoring results, where monitored, have been taken from the following guidance documents:

- Assessing risks posed by ground gases to buildings, CIRIA Report C665, 2007
- Code of practice for the characterisation and remediation from ground gas in affected developments, British Standard BS 8576, 2013
- A Pragmatic Approach to Ground Gas Risk Assessment, CL:AIRE Research Bulletin RB17, 2012

The frequency and period of monitoring is assessed based on the gas generation potential of the source material and the sensitivity of the development, in accordance with Figure 6 of BS8576 and Table 5.5 of CIRIA C665. As BS8576 promotes a risk based approach to ground gas assessment, it recognises that ground gas monitoring might not be necessary if a viable pollutant linkages is not present, e.g. if a ‘credible’ source with significant ground gas generation potential and/or a ‘credible’ migration pathway are not present.

The Characteristic Situation for a monitoring location is determined using the worst case gas screening value for methane or carbon dioxide from all of the monitoring rounds at that location. Following the precautionary principal, the most stringent of the Characteristic Situations for the monitoring locations within the Site is generally used to classify the site as a whole.

5.2. Soil Assessment

5.2.1. General

A total of 11no. soil samples collected during the site investigation from depths and locations likely to be subject to human exposure during the proposed development works were submitted to a UKAS accredited laboratory for analysis for a suite of heavy metals, phenols, speciated polycyclic aromatic hydrocarbons (PAHs), fractionated total petroleum hydrocarbons (TPH), BTEX compounds and several inorganic parameters. The results of the laboratory analyses are summarised in Appendix 4, in which they are compared to the relevant generic assessment criteria. A full set of all the laboratory test certificates is presented as Appendix 5.

The range of potentially hazardous contaminants present on the site can be wide and varied and the suite has been chosen to reflect both commonly found contaminants and others indicated by research to have a significant risk of being present. It is, however, possible that others may exist for which analyses have not been carried out or which were outside the scope of completed exploratory holes.

The decision to recommend acceptability or a requirement for remediation is based on the evaluation of a number of factors which when combined present a statutory or non-statutory risk that may require remedial action.

5.2.2. Heavy metals

The heavy metals included in the analysis of the samples from the site were identified at concentrations below the relevant GACs in all of the samples across the site. Therefore, heavy metals in the soils across the site are not considered to present a significant source of contamination with regard to human health. This is consistent with the findings of the previous assessments of the study site and wider former depot.

5.2.3. Petroleum hydrocarbons

Total petroleum hydrocarbon (TPH) concentrations were recorded to be well below GACs in the soil samples across the site and predominantly below the laboratory detection limits. Evidence of minor hydrocarbon contamination was identified both during the investigation and in the analysis results (WS202) in the vicinity of the former underground fuel storage tanks, as had been identified in previous investigations. Therefore, the identified TPH concentrations are not considered to represent a significant source of contamination with regard to human health across the site and are consistent with the results of the previous investigations.

Concentrations of TPH C11-C40 fractions were recorded to slightly exceed the UKWIR 'threshold' values for mineral oil at several locations. TPH is therefore considered to represent a potentially significant source of contamination to proposed PE water supply pipes, as also identified in the SSL reports. However, the designers of the water supply pipes for this site should review the data in this report to inform their decision making process.

5.2.4. Polyaromatic hydrocarbons (PAHs)

Polyaromatic hydrocarbons (PAH) compound concentrations were recorded to be well below the relevant GACs in the soil samples across the site. Therefore, PAHs are not considered to represent a significant source of contamination with regard to human health.

5.2.5. BTEX compounds and MTBE

BTEX compounds and MTBE were not identified at concentrations in excess of the laboratory detection limits and were well below the relevant GACs in all of the samples from across the site. Therefore, BTEX compounds and MTBE are not considered to represent a significant source of contamination with regard to human health.

Concentrations of BTEX and MTBE were not recorded to exceed the UKWIR 'threshold' values. BTEX and MTBE are therefore not considered to represent a significant source of contamination to proposed water supply pipes.

5.2.6. Inorganics

The concentrations of free cyanide fell below laboratory detection limits in all of the soil samples analysed.

The pH of the soil samples analysed was generally slightly alkali with one Made Ground sample falling slightly outside the 7-9 range with a maximum recorded pH of 10.29. It is considered that this recorded pH values is likely to be associated with the chalk generally present in Made Ground across the site.

No asbestos containing materials were identified in any of the 11no samples analysed. While this indicates that asbestos is unlikely to represent a significant source of contamination on the site, the potential remains for residual asbestos containing material or loose fibres to be present as a result of the former use of the site.

5.3. Groundwater Assessment

The risks to controlled water from the area of the former underground fuel tanks in the east of the site was the subject of extensive assessment and discussion within the SSL reports reviewed, particularly the Remedial Method Statement (January 2014) and Supplementary Investigation report (May 2014). Ridge

concurs with the SSL assessment that the identified impacts on site do not represent a significant risk to controlled waters due to the low risk hydrocarbon fractions identified and absence of notable migration towards the controlled waters noted during the previous investigation works.

Ridge further notes that the Ridge investigation confirmed the absence of notable evidence of hydrocarbon contamination in the smear zone down hydraulic gradient of the former fuel tanks or between the former fuel tanks and the stream to the north of the site. Furthermore, risk driver indicator compounds (such as naphthalene and benzene) were not identified in association with the impact and the assessment criteria for TPH to be considered a risk to controlled waters it would need to: form a visible film on the surface of the water or form coatings on the beds of watercourses and lakes; impart a detectable 'hydrocarbon' taste to fish; produce harmful effects in fish, none of which have been noted in association with the stream to the north of the site.

It was therefore not considered necessary to replicate the low flow groundwater sampling and analysis undertaken by SSL for the purpose of this assessment and the impacts on site are not considered to represent a significant risk to controlled waters.

5.4. Statistical Analysis

Statistical analysis was not considered to be appropriate on the presented analysis results.

5.5. Ground Gas Assessment

The SSL Remedial Method Statement report presents the monitoring results for 11no ground gas monitoring wells within and surrounding the site undertaken over 5no monitoring rounds in July, August and September 2013. Of these 11no wells, 5no (BH10, WS3, WS4, WS5 and WS7) were located within the study site and a further 2no (WS2 and BH7) were located adjacent to the study site boundary. The data from these locations has been reassessed for the purpose of this assessment, with particular consideration to the study site rather than the wider depot site discussed in the SSL reports.

Concentrations of flammable gas as methane were recorded at a maximum of 0.1% by volume and carbon dioxide concentrations were recorded at a maximum of 15.3% by volume with steady state flow rates of up to 0.5l/hr. These concentrations and the resultant gas screening values indicate a ground gas regime classification of Characteristic Situation 1, requiring no gas protection measures for proposed buildings, for all but one of the monitoring wells within and adjacent to the study site. The highest carbon dioxide concentration was identified in WS4 in the southwest corner of the site and is indicative of a Characteristic Situation 2 gas regime, requiring gas protection measures.

Although the WS4 is not located in an area of the site where buildings are currently proposed, the potential for ground gas migration to take place beneath the proposed buildings is considered to be sufficient to warrant a conservative assessment of the site as Characteristic Situation 2, requiring ground gas protection measures. This assessment is consistent with the SSL assessment for the wider former depot site.

The details of the ground gas protection measures required will be dependent on the design of the proposed buildings, in line with the guidance in BS8485.

6. CONCEPTUAL SITE MODEL

6.1. Sources

The conceptual model, based on information obtained as part of the intrusive investigation and screening of the chemical analysis results, identified the following contaminant sources:

6.1.1. On-site – Historic and Current

- Ground gas from Made Ground and natural strata
- Potential for asbestos containing materials to be encountered during development
- Minor residual hydrocarbon contamination in Made Ground

6.1.2. Off-site – Historic and Current

- Potential migration of ground gas from off site landfills

6.2. Pathways

The key environmental pathways and exposure routes by which potentially toxic substances can reach the identified potential receptors are considered to be:

6.2.1. Indirect

- Lateral and vertical migration of gas leading to accumulation in enclosed spaces

6.2.2. Direct

- Inhalation of contaminated dust.
- Inhalation of gas/vapours
- Direct contact

6.3. Receptors

Receptors that may be affected by the potential contamination are:

6.3.1. Human

- Future site users
- Construction workers
- Adjacent occupiers

6.3.2. Environmental

- Proposed water supply pipes

7. RISK ASSESSMENT

7.1. Risk Assessment Procedure

By considering the sources, pathways and receptors (pollutant linkages), an assessment of the human health/ environmental risks is made with reference to the significance and degree of the risk. This assessment is based on consideration of whether the source contamination can reach a receptor and hence whether it is of major or minor significance.

The risk assessment has been undertaken with reference to BS 10175:2011+A1:2013 and CIRIA Document C552: Contaminated Land Risk assessment 'A Guide to Good Practice'. The risk assessment has been carried out by assessing the severity of the potential consequence, taking into account both the potential magnitude of the hazard and the sensitivity of the target, based on the categories given overleaf.

Table 7.1: Sensitivity of receptor

Category	Examples
High	Residential with gardens/Groundwater Source Protection Zone
Medium	Residential without gardens/Principal (Major) Aquifer/sensitive watercourse
Low	Commercial and industrial use/Secondary (Minor) Aquifer
Very Low	Construction and maintenance workers/non-sensitive watercourse

Table 7.2: Magnitude of impact

Category	Examples
Gross Impact	Heavily contaminated gasworks or industrial Site, hazardous waste landfill
Moderate Impact	Major leaks and spills from fuel infrastructure (e.g. petrol stations), domestic waste landfills
Slight Impact	Minor leaks and spills from fuel infrastructure, 'inert' waste landfills

Table 7.3: Level of severity of potential hazard

Magnitude of impact	Sensitivity of receptor			
	High	Medium	Low	Very Low
Gross Impact	Severe	Medium	Mild	Minor
Moderate Impact	Medium	Mild	Minor	Minor
Slight Impact	Mild	Minor	Minor	Minor

The likelihood of an event (probability) takes into account both the presence of the hazard and target and the integrity of the pathway and has been assessed based on the categories given below.

Table 7.4: Probability of risk definition

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

The potential severity of the risk and the probability of the risk occurring have been combined in accordance with the following matrix in order to give a level of risk for each potential hazard.

Table 7.5: Level of risk for potential hazard definition

Probability of risk	Sensitivity of receptor			
	Severe	Medium	Mild	Minor
High likelihood	Very High	High	Moderate	Low/Moderate
Likely	High	Moderate	Low/Moderate	Low
Low likelihood	Moderate	Low/Moderate	Low	Very Low
Unlikely	Low/Moderate	Low	Very Low	Very Low

The assessment is discussed below in terms of plausible pollutant linkages. A complete assessment of the pollutant linkages is presented in Table 7.6.

A description of these risk classifications and likely action required are given in CIRIA 552 as:

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

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

Moderate risk – It is possible that harm could arise to a designated receptor from an identified hazard.

However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild. Investigation is normally required to clarify risks and to determine potential liability. Some remedial works may be required in the long term.

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

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

7.2. Pollutant Linkage Assessment

Table 7.6: Pollutant linkage assessment

Source	Pathway	Receptor	Severity	Likelihood	Risk Level
Potential asbestos containing material in soil	Inhalation	Future Site users	Medium	Unlikely	Low
		Construction workers	Medium	Low Likelihood	Low/ Moderate
		Adjacent occupiers	Medium	Unlikely	Low
Residual hydrocarbon impacts in Made Ground	Direct contact	Proposed water supply pipes	Minor	Likely	Low
Ground gas from Made Ground, natural soils and off site landfills	Lateral and vertical migration leading to accumulation in enclosed spaces and inhalation	Future Site users	Mild	Low Likelihood	Low

7.2.1. Asbestos in Made Ground

Asbestos containing material or fibres have not been identified in the soils on site during the Ridge or previous investigations. However, due to the age of the former buildings on site, the discrete nature of asbestos contamination in soil and the variable character of the Made Ground across the site, asbestos should be considered to potentially be present in all of the Made Ground across the site. It is therefore recommended that the contractor remains vigilant throughout the development works for asbestos containing materials in soil. If suspected asbestos containing material are encountered, the risks posed by these materials should be assessed by a specialist.

7.2.2. Residual TPH in Made Ground

TPH has been identified in near surface Made Ground samples at concentrations that may present a risk to proposed PE water supply pipes. It is therefore recommended that the chemical analysis results from this investigation and the previous investigations are provided to the designer of these pipes so an appropriate material can be selected for the pipes.

7.2.3. Ground Gas from Made Ground

The site has been assessed as having a Characteristic Situation 2 ground gas regime, requiring ground gas protection measures. The details of the ground gas protection measures required will be dependent on the design of the proposed buildings, in line with the guidance in BS8485.

8. GEOTECHNICAL ASSESSMENT

8.1. Introduction

This geotechnical assessment and the subsequent foundation design recommendations will use the findings of the ground investigation and the results of the in-situ and laboratory geotechnical testing carried out in the boreholes and on representative samples of the materials encountered across the site. In addition, this Report will make reference to the previous ground investigations where appropriate.

8.2. Geotechnical Tests

A programme of geotechnical laboratory testing was carried out on representative samples collected from the strata encountered during the ground investigation. Details of the specific procedure used in each case are shown below in Table 8.1 and the geotechnical test certificates are presented in Appendix 6.

Table 8.1: Summary of Geotechnical Testing

Test	Standard (BS1377:1990) unless otherwise indicated	No.	Previous GIs
Classification Tests			
Atterberg Limits	Part 2, Clauses 4.3, 5.3 & 5.4	-	9
Particle Size Distribution – Wet Sieve	Part 2, Clause 9.2	6	7
Particle Size Distribution - Sedimentation	Part 2, Clause 9.4	3	-
Intact Dry Density	Part 2, Clause 7.3	-	6
Chemical Tests			
Sulphate Content 2:1 soil water extract	Part 3, Clause 5.3	7	6
pH value	Part 3, Clause 9.0	7	6

8.3. Geotechnical and Geological Parameters

This section discusses the key geotechnical characteristics of each encountered stratum as determined from field observations, in-situ and laboratory geotechnical testing. The stratigraphy revealed during the ground investigation comprised Made Ground over Alluvium in turn overlying River Terrace Deposits with the Undifferentiated Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation, henceforth termed the Undifferentiated White Chalk (UWC), forming the basal unit of the ground investigation.

Each of the above strata will be discussed separately in the following Sections.

8.3.1. Made Ground

Made Ground was encountered in all exploratory holes and attained thicknesses of 0.90 to 1.80m in WS201 and WS 205 respectively. The Made Ground generally consisted of a brown clayey silty fine to coarse angular to subrounded flint gravel with some brick fragments; overlying a basal layer of reworked chalk. These descriptions are consistent with a previously placed engineered fill.

No geotechnical laboratory testing was undertaken on samples of the Made Ground as all foundations should be constructed beneath them.

8.3.2. Alluvium

Alluvium was encountered immediately below the Made Ground in two of the seven exploratory holes undertaken during the recent ground investigation. The Alluvium comprised between 0.50 and 0.70m of soft grey brown silty gravelly Clay. In the previous ground investigation this fine-grained deposit has been described as intermittent or discontinuous with thicknesses of up to 1.00m being recorded.

Due to its limited thickness and absence from most of the current boreholes no in-situ or geotechnical laboratory testing has been carried out during the current ground investigation. However, one Atterberg limits test was undertaken during the RPS investigation and returned a plasticity index of 21%.

8.3.3. River Terrace Deposits

River Terrace Deposits (RTD) were identified in beneath the Made Ground / Alluvium in all investigative positions. During the current ground investigation the RTD attained proven thicknesses of 3.30 to 6.30m during the Structural Soils ground investigation the RTD attained a maximum thickness of 11.00m in BH9 whilst in the earlier RPS investigation RTD thicknesses were reported between 1.90m and 7.50m in BH4 and BH1 respectively

The RTD comprised brown grey sandy subangular to subrounded flint Gravel.

In – Situ Testing

Standard Penetration testing (SPT) was carried out throughout the RTD. The distribution of SPT N-Values is shown in Table 8.2 and graphically presented in Figure 3.

Table 8.2: Distribution of SPT N Values in the River Terrace Deposits

BH No.	Depth (mbgl)	SPT N Value	Main Constituent	BH No.	Depth (mbgl)	SPT N Value	Main Constituent		
BH201	2.10	22	Fine to Coarse Gravel	WS201	2.00	20	Fine to Medium Gravel		
	3.00	17			3.00	21			
	4.00	16			4.00	20			
BH202	2.10	11	Fine to Coarse Gravel	WS202	2.00	10	Fine to Medium Gravel		
	3.00	17			3.00	12			
	4.00	39			4.00	24			
	5.00	32		WS203	2.00	21	Fine to Medium Gravel		
	6.50	24			3.00	11			
				WS204	4.00	17	Fine to Medium Gravel		
					WS205	2.00		13	Fine to Medium Gravel
						3.00		10	
				4.00		40			
				WS205	2.00	18	Fine to Medium Gravel		
					3.00	9			
					4.00	40			

Careful inspection of the SPT results indicates an increase in N-value with depth from 10 at 2.00mbgl to 25 at 6.00mbgl. However, for the determination of shear strength a single characteristic N-value of 15 is considered appropriate for all the RTD.

Classification Testing

Particle Size Distribution

Six representative samples of the RTD underwent particle size distribution testing; subsequently three of these samples underwent follow on sedimentation analyses to determine their fine-grained content. The results of these analyses are presented in Table 8.3 whilst the laboratory test certificates and grading envelopes are located in Appendix 6.

Table 8.3: Results of the Particle Size Distribution – River Terrace Deposits

Location	Depth (mbgl)	Granulometric Composition (%)					Uniformity Coefficient	Curvature Coefficient
		Clay	Silt	Sand	Gravel	V Coarse		
BH201	2.10	1.1	2.2	15.9	80.8	0	23	2
	3.00	2.4		6.0	91.6	0	9.1	2
	4.00	4.6		8.9	86.6	0	22	4.7
BH103	2.10	1.4		6.7	91.9	0	8.5	1.2
	4.00	0.3	3.8	14.8	73.8	7.3	26	1.4
	6.50	2.4	4.7	12.0	74.8	6.1	70	3.4

The results of the particle size distribution analyses confirm the engineering description of the RTD as a coarse-grained material with a fine-grained content (<0.063mm) of between 1.4 and 7.1%. Careful inspection of the grading envelopes along with the calculated values of the uniformity and curvature coefficients indicate the RTD to be medium to multi-graded.

Shear Strength

The shear strength of the RTD has been determined following the procedure recommended in BS8002 (2015); where

$$\phi_{pk,k} = \phi'_{cv,k} + \phi'_{dil}$$

and

$$\phi_{cv,k} = 30 + \phi'_{ang} + \phi'_{psd}$$

Where ϕ'_{ang} = contribution to $\phi'_{cv,k}$ from the angularity of the particles
 ϕ'_{psd} = contribution to $\phi'_{cv,k}$ from soil's particle size distribution
 ϕ'_{dil} = contribution to $\phi'_{pk,k}$ from soil's dilatancy.

Based on the results of the above determination a critical angle of shearing resistance of 36° is considered appropriate for the RTD.

8.3.4. Undifferentiated White Chalk

The Undifferentiated White Chalk (UWC) was encountered in the two cable percussive boreholes (BH201 & 202) where it formed the basal unit. The UWC was generally recovered as a CIRIA Grade Dc Chalk. However, it is possible that structured Chalk was present within the boreholes but the percussive nature of the drilling method making identification of structure not possible.