AQUIND Limited

AQUIND INTERCONNECTOR

Applicant's Response to the Examining Authority's Further Written Questions (ExQ2) – Appendix 3 A27 HDD Crossing Farlington, UK – CD622 Documentation for Highways England (MG2.1.1)

The Infrastructure Planning (Examination Procedure) Rules 2010, Rule 8(1)(b)

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DATE: 25 JANUARY 2021

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DOCUMENT

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Approved By	R. Yenn
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Aquind - A27 HDD Crossing

Geotechnical Design Organisation

Certificate Seq. No 62100616-351/001

HAGDMS No. 32227

GEOTECHNICAL CERTIFICATE

Aquind - A27 HDD Crossing CD622 Documentation

Report Reference: A27 HDD crossing, Farlington, UK, CD622 Documentation for Highways England, 62100616-351, HAGDMS No. 32227.

1. We certify that the document for the Geotechnical Activity listed below has been prepared by us with reasonable professional skill, care and diligence, and that in our opinion:
   i. Constitute an adequate and economic design for the project;
   ii. Solutions to all the reasonably foreseeable geotechnical risks have been incorporated;
   iii. The work intended is accurately represented and conforms to the Employer's requirements; and
   iv. With the exception of any item listed below or appended overleaf, the documentation has been repaired in accordance with the relevant standards from the Design Manual for Roads and Bridges and the Manual of Contract Documents for Highway Works.
2. LIST OF REPORTS, DESIGN DATA, DRAWINGS OR DOCUMENTS
   - A27 HDD crossing, Farlington, UK, CD622 Documentation for Highways England, 62100616-351, HAGDMS No. 32227.
3. DEPARTURES FROM STANDARDS

None

Signed:

[redacted]

Designer

Name: Roger Yenn MSc BSc(Hons) CEng MICE

Date: 12th January 2021

On behalf of: WSP

This certificate is:

Received* (see note)

Received with comments as follows:* (see note)

Returned marked "comments" as follows:* (see note)

Signed:

Overseeing Organisation

[redacted]

Digitally signed by Mark Shaw
Date: 2021.01.14 09:42:19 Z

Name:

Date:

Note:

'Received' = Submission accompanying certificate is accepted.

'Received with comments' = Submission accompanying certificate generally acceptable but require.

minor amendment which can be addressed in subsequent revisions.

'Returned marked comments' = Submission accompanying certificate unacceptable and should be revised and resubmitted.

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A27 HDD CROSSING, FARLINGTON, UK

CD622 Documentation for Highways England

HA GDMS Ref: 32227

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A27 HDD CROSSING, FARLINGTON, UK

CD622 Documentation for Highways England

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CONTENTS

APPENDICES

1 STATEMENT OF INTENT (SOI)

1.1 DETAILS OF THE SCHEME

The Aquind project is a UK – France interconnector comprising subsea and underground high voltage DC and AC cables, data transmission fibre-optic cables and supporting infrastructure.

WSP were commissioned by Aquind Ltd to provide a feasibility study and review of the ground investigation works undertaken along the potential cable routes, Horizontal Directional Drill (HDD) and associated route landfall. A ground investigations (GI) covered approximately 22km of potential cable routing from Lovedean, Waterlooville to Eastney, Portsmouth.

1.2 PROJECT NAME AND DETAILS OF THE PROJECT

This reporting focuses solely on the A27 HDD crossing at Farlington, herein known as UK-HDD3B, and is part of the section of the overall interconnector route (see Figure 1).

The UK-HDD3B is currently proposed to enter from Kendalls Wharf Aggregates Yard (NGR E467421, N103218) and exit in the Farlington Playing Fields (NGR E467901, N104830), a distance of 1.486km. The crossing point at the A27 is 1.235km into the bore, measured from the entry point.

A summary of the UK-HDD3B GI and extracts from the report in the proximity of the A27 crossing are presented, and reassurance given that the A27 asset will be protected throughout the proposed works.

The purpose of this combined CD622 Managing Geotechnical Risk report [Ref 1] is to ensure that any geotechnical risks are eliminated or mitigated and that all technical requirements required by Highways England to undertake the A27 HDD crossing are met. The primary geotechnical risk is that construction of the 4no bores causes adverse settlement and/or heave to the A27 carriageway. This has the potential to cause accidents and/or the closure of the A27 and/or increased maintenance costs.

For the UK-HDD3B route, see drawings 12731-WIE-ZZ-XX-DR-C-90102-A01 and 12731-WIE-ZZ-XX-DR-C-90302-A01 presented in Appendix A.

Figure 1: UK-HDD3B location plan (www.google.com)

1.3 OBJECTIVES

To satisfy the technical requirements of Highways England for permission to undertake the A27 HDD crossing, identify and mitigate/manage potential geotechnical risk.

1.4 EXISTING INFORMATION

Extensive and detailed desk studies and reporting has been undertaken along the route of UK-HDD3B, the relevant findings for the A27 crossing section are presented in Section 2 of this combined report.

1.5 PROPOSED STUDIES AND INVESTIGATIONS

GI and design work has been undertaken along the route of UK-HDD3B, the relevant findings for the A27 crossing section are presented in Sections 3 and 4 of this combined report.

Based on the geotechnical categories as defined in BS EN 1997 Eurocode 7; Part 1: Geotechnical Design, the A27 HDD crossing is categorised as a category 2, with no exceptional known risks.

1.6 CONSULTATION

A settlement analysis is presented in Section 5 of the report. Specialist consultation has been undertaken with the WSP tunnelling group and Stockton Ltd, an HDD specialist.

1.7 PROGRAMME ESTIMATED

The remaining phases of the UK-HDD3B route are permissions, licences and construction, which at this time are still to be confirmed.

A Geotechnical Feedback Report (GFR) is proposed upon the completion of this HDD Section.

2 SUMMARY PRELIMINARY SOURCES STUDY REPORT DATA (PSSR)

2.1 INTRODUCTION

Presented are desk study findings to satisfy the technical requirements of Highways England for permission to undertake the UK-HDD3B A27 HDD crossing, identify and mitigate potential geotechnical risk.

The UK-HDD3B A27 HDD crossing will be 4No. reamed bore ducts to 711mm in diameter (28" inches) and lined with Weld HDPE SDR 9, see Figure 2. Ducts will be spaced approximately 5.5m apart, tapering slightly heading north-east under the A27, [Ref 11].

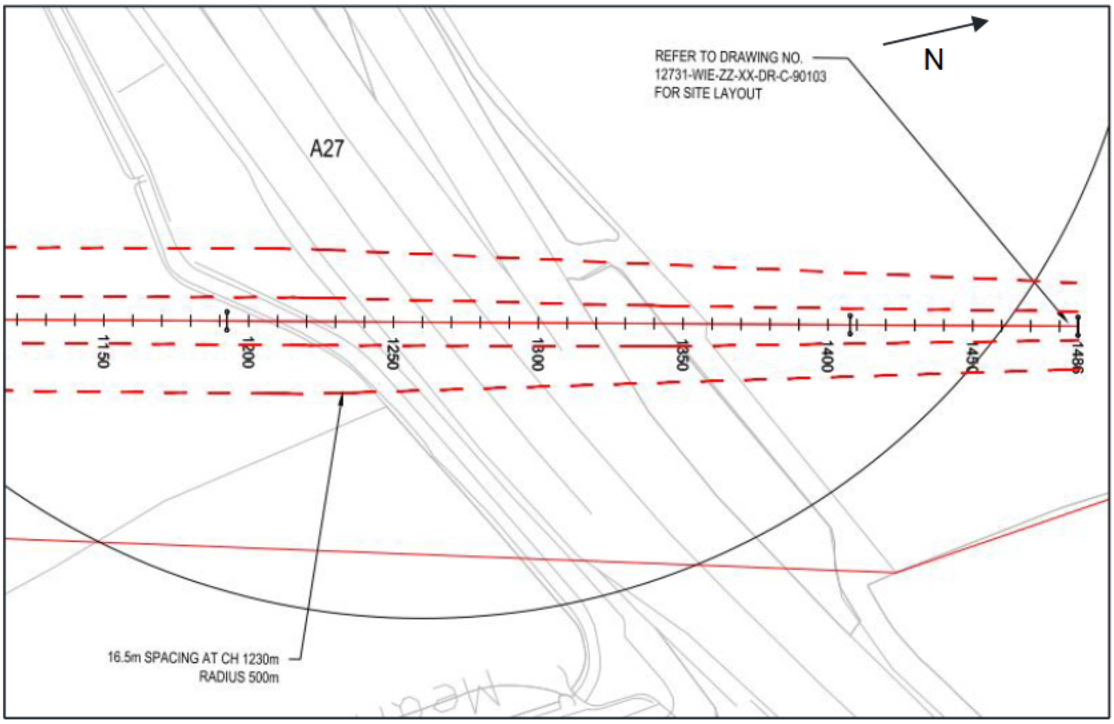


Figure 2: UK-HDD3B Bore location plan [12731-WIE-ZZ-XX-DR-C-90302-A01 presented in Appendix A]

2.2 SOURCES OF INFORMATION, DESK STUDY, SITE RECONNAISSANCE, SITE DESCRIPTION AND REVIEW OF FINDINGS

Data has been obtained from the following sources;

Initial desk study reviewing various cable routes, landfalls and Converter Station locations;

- REPORT No 20170202-TJM-AQUIND-UK CABLE ROUTE DESK STUDY REPORT – ISSUED V0, February 2017, [Ref 2].

Detailed desk study reviewing Route 3D including Converter Station locations, this report also details the proposed targeted ground investigation works;

- REPORT No 20170622-TJM-AQUIND-UK CABLE ROUTE DETAILED DESK STUDY-REPORT-ISSUED V0, June 2018, [Ref 3].

HDD Feasibility Report, HDD Execution Plan Report and associated drawings were used to build preliminary routing assumptions;

- Stockton and Waterman, Aquind UK-France HVDC Interconnector: HDD Feasibility Assessment, WIE12731-111-R-1-4-3, June 2019, [Ref 4];
- Stockton Ltd, Aquind Interconnector: Project Execution Plan for the UK Landfall, 100-694 PLA-01, June 2019, [Ref 5];
- UK-HDD-3B (Portsea Island to Mainland) Proposed Site Layout - 12731-WIE-ZZ-XX-DR-C-90102-A01, [Appendix A];
- UK-HDD-3B (Portsea Island to Mainland) Proposed HDD Plan & Section - 12731-WIE-ZZ-XX-DR-C-90302-A01, [Appendix A] and,
- Drawing 70019402-WSP-HGT-G-DR-GE-0117, [Appendix A].

Environmental influences due to the scheme proposal were reviewed within the Preliminary Environmental Information Report;

- Preliminary Environmental Information Report (PEIR), WSP, PINS Ref: EN020022, 2019, [Ref 6].

The results of the ground investigation for the UK-HDD3B alignment is presented in the following Factual Report;

- Geotechnics Ltd, 2019, UK - France HVDC Interconnector Onshore Work Package 2, PE181481, [Ref 7].

The engineering properties for the strata encountered in the ground investigation undertaken for the proposed cable route, HDD and landfall as discussed in the GIDDR (cable route, HDD and landfall), see Section 3.1;

- Cable route, HDD and Landfall Geotechnical Interpretative Design Development Report, WSP, 70019402-GIDDR2, 2019, [Ref 8].

The Highways England Geotechnical Data Management System (HAGDMS), [Ref 9].

2.3 SUMMARY

The UK-HDD3B Entry point will be positioned at a car park at Kendalls Wharf, east of the A2030 Eastern Road at approximate NGR E467421, N103218. The alignment of the HDD bores will be from the southwest to the northeast, crossing below the Broom Channel (approximately -1mOD), with the Exit Pit located within a playing field north of the A27 at approximate NGR E467901, N104830. The HDD crossing below the A27 will be at approximately -12mOD.

The Entry Pit is proposed to be located within the car park immediately east of the A2030 Eastern Road. The Ordnance Survey (O.S.) Explorer Map: Meon Valley Portsmouth, Gosport & Fareham (OL3, scale 1: 25,000), indicates the proposed Entry Pit Site to lie approximately at 3mOD.

The area of the car park in which the entry point is located covers approximately 0.75 hectares. Vegetation and trees located at the boundary with the A2030 will likely have to be removed to provide sufficient space for the HDD compound and Car Park.

The exit area is proposed to be located within playing fields immediately north of the A27. The Ordnance Survey (O.S.) Explorer Map: Meon Valley Portsmouth, Gosport & Fareham (OL3, scale 1: 25,000), indicates the proposed exit site to lie at approximately 2mOD. The area of playing field covers approximately 14 hectares, however the area identified for the HDD operations is in the northeast portion of the playing field and covers approximately 4.8 hectares. The total bore is a distance of 1.486km. The crossing point at the A27 is 1.235km into the bore measured from the entry point.

A review of the HDD specialist reports has been completed to ensure relevant details are presented in Table 1.

The review of the suitability of techniques to various ground conditions is based on CIRIA Special Publication 147, [REF 10]. In terms of suitability, the CIRIA Report identifies three categories;

- Generally Suitable: by experienced Contractor with suitable equipment.
- Difficulties May Occur: some modification of equipment and/or operating procedures may be needed.
- Substantial Problems: generally unsuitable or not intended for this application.

HDD	Notable HDD Constraints and Consideration				
	Suitability of techniques to various ground conditions(1)	Potentially Difficult ground and/or groundwater conditions	Spatial restrictions(2)	Environmental / Ecological Designations	Preliminary Potential Contamination (Contamination review within the PEIR [Ref 6]
UK-HDD3B	Beach & Tidal Flat Deposits: Difficulties May Occur Raised Marine Deposits: Generally Suitable River Terrace Deposits (Granular): Generally Suitable River Terrace Deposits (Cohesive): Generally Suitable Structureless and Structured Cha k: Difficulties May Occur	Beach and Tidal flats containing Peat or soft compressible organics. High groundwater and tidally influenced. Shallow Chalk bedrock. The abrasivity tests were all classified as low abrasivity and only conducted on Chalk, it is considered flint bands could be of medium to very high abrasivity if encountered. Potential for hard flint bands within the Chalk bedrock.	Working within the aggregates yard could be a restrained site. The influence and depth of the sea defences each side of Langstone Harbour and Broom Channel. The piles supporting the A27/A2030 Eastern Road bridge and the road network foundation depth and locations require confirmation. The Eastney to Budds Farm Transfer Tunnel could potential restrain HDD movement to the east.	Broom Channel is identified as a Site of Special Scientific Interest and a Ramsar Site.	Potential asbestos and/or contamination within the Made Ground. Hydrocarbons noted within the Made Ground and Superficial Deposits at Kendalls Wharf Aggregates Yard.

(1) The suitability of techniques to various ground conditions has been reviewed against 'Table 1 - Suitability of techniques to various Ground Conditions' in CIRIA Special Publication 147 [Ref 10]
(2) Services and structures constraints are broadly summarised in Section 2.5

Table 1: UK-HDD3B Considerations.

The piles supporting the A27/A2030 Eastern Road bridge and the road network foundation depth and locations are considered in Section 2.6.

2.4 SITE RECONNAISSANCE

No specific walkover survey has been undertaken for this combined report. At the location of the proposed HDD crossing the A27 is a dual carriageway, elevated on a small section of embankment.

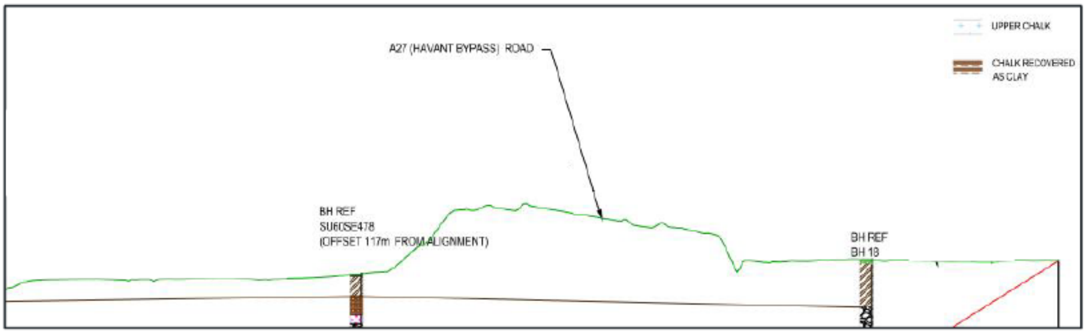


Figure 3: Section Extracted from Location Plan Drawing [12731-WIE-ZZ-XX-DR-C-90302-A01 presented in Appendix A]

2.5 GROUND CONDITIONS

2.5.1. Geology

Assessment of the site geology has been based on the BGS Fareham Solid and Drift Geology Map Sheet 316 scale 1: 50,000 (1998) and Portsmouth Solid and Drift Geology Map Sheet 331, scale 1: 50,000 (1994) and supplemented by GI information provided by WSP, [Ref 8].

2.5.2. Drift Geology

The BGS geological maps indicate that at the entry location Made Ground overlying Alluvium (soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and gravel) are present at the surface.

At the Exit Pit location, Alluvium and Aeolian Deposits (wind-blown Sand) are recorded.

2.5.3. Solid Geology (Tarrant Chalk)

At the entry location, the Upper Chalk (Tarrant Chalk) underlies the Made Ground and Alluvium, described as white Chalk with beds of flint, nodular Chalks, hardgrounds and marl seams. The thickness of this deposit ranges from 60m to 300m. There are no faults noted within 1km on the BGS Portsmouth Solid and Drift Geology Map Sheet 331 (1994).

At the Exit Pit location, the Upper Chalk is indicated to be underlying the Alluvium and Aeolian Deposits. As the solid geology comprises of Upper Chalk, there is a potential risk of karst and dissolution features which are associated with soluble rocks. However, no evidence of Karst appears to have been encountered within the GI undertaken by WSP, [Ref 7].

2.5.4. A27 Crossing Conceptual Ground Model

The conceptual ground model at the A27 crossing point (as shown on drawing 70019402-WSP-HGT-G-DR-GE-0117, presented in Appendix A), of the A27 crossing is interpreted from the historical BGS borehole SU60SE1 and borehole BH18 and BH19 (presented in Appendix B), undertaken by Geotechnics on behalf of Aquind Limited in 2018, [Ref 7], drilled to a maximum depth 38.05mbgl.

Stratum	Depth (mbgl)	Description
Topsoil	0.00 – 0.30	Dark brown topsoil described as slightly sandy gravelly Silt with frequent rootlets.
Alluvium/Gravels	0.30 to 4.00	Light brown to yellowish brown, slightly silty sandy Gravel. Gravel is subangular to subrounded fine to coarse flint, chert and sandstone. Firm to very stiff, orange brown to light grey, gravelly silty Clay to clayey Silt with occasional cobbles of flint
Upper Chalk	4.00 to 18.45 (base of stratum not proven)	Soft to very stiff white sandy, gravelly, Silt and as a white grey slightly clayey to silty sandy, angular to subangular fine to coarse Gravel. From 8.25m bgl recovered as weak to medium strong, medium density white Chalk.
Groundwater	At the entry location, groundwater was encountered in BH-35 at 1.2m bgl, 2.5m bgl and 22.0m bgl. At the Exit Pit location, groundwater was recorded in BH-18 at 3.20m bgl and 8.25m bgl.	

Table 2: UK-HDD3B Conceptual Ground Model at A27 Crossing.

2.6 PRELIMINARY ENGINEERING ASSESSMENT

The UK-HDD3B bore path was chosen to avoid the piled foundations associated with the A27/A2030 Eastern Road bridge (the original HDD-3A alignment was further west).

There are no as-built records of the A27 available or recorded on HAGDMS, [Ref 9]. Upon consultation with Highways England (November 2020) the road construction is highly unlikely to be piled. This is also supported by the age and construction techniques at that time (C.1960's). Since the A27 embankment is constructed over Alluvial deposits there may have been ground improvement carried out within the compressible Alluvial deposits. This could have taken the form of stone columns or wick drains to accelerate consolidation. Any such ground improvement will be significantly above the elevation of the HDD and therefore not constitute an obstruction. However, this may have stiffened the Alluvium which could reduce any predicted settlement/heave arising from the HDD construction.

It is understood the pavement construction is likely to be Pavement Quality Concrete (PQC) and the subgrade may have been improved with lime or lime/cement stabilisation. The alignment of the Eastney to Budds Farm Tunnel, a Southern Water rising main with a 1.4m

Diameter, is located southeast of the UK-HDD-3B entry point but is not considered to present a constraint at this location.

The exit pit is located at Kendalls Wharf Aggregates Yard. There are some small structures associated with the aggregates yard within 50m but none are anticipated to have deep foundations.

The current exit pit location and alignment does not pass under or near the A27/A2030 Eastern Road bridge on the A27.

2.7 COMPARISON OF PROJECT OPTIONS AND RISKS

A comparison of options is presented in the following document; Stockton and Waterman, Aquind UK-France HVDC Interconnector: HDD Feasibility Assessment, WIE12731-111-R-1-4-3, June 2019, [Ref 4].

From this study an HDD option was selected based on its risk profile and minimal disruption to the highway network.

2.8 DRAWINGS

For the UK-HDD3B route, see drawings 12731-WIE-ZZ-XX-DR-C-90102-A01, 12731-WIE-ZZ-XX-DR-C-90302-A01 and drawing 70019402-WSP-HGT-G-DR-GE-0117 presented in Appendix A.

3 GROUND INVESTIGATION REPORT (GIR)

3.1 EXISTING INFORMATION

The data presented in Tables 3 through 7 has been extracted from the following report; Cable route, HDD and Landfall Geotechnical Interpretative Design Development Report, WSP, 70019402-GIDDR2, 2019, [Ref 8].

3.2 EXISTING INFORMATION & FIELD AND LABORATORY STUDIES (UNDERTAKEN)

Specific GI works were undertaken from April to November 2019 [Ref 7] along the potential cable route and HDDs. This phase of GI for the, HDD and landfall comprised the following:

- 11 boreholes; 5 at Converter Station South and 6 at Converter Station West;
- 15 trial pits; 4 at each potential Converter Station, 7 for the potential HVAC route and access track;
- 9 In-situ CBR/Plate Load Tests targeting the potential access track and parking areas;
- In-situ Electrical Resistivity Tests;
- Geophysical survey to locate the 132kV SSE Cable;
- Geophysical karstic feature survey (conductivity and resistivity) of both potential Converter Station sites; and
- Laboratory testing of samples for geotechnical and contamination purposes.

The nearest Converter Station is approximately 9km from the UK-HDD-3B route.

The ground investigation for the proposed UK-HDD3B alignment comprised four boreholes BH18, BH19, BH36 and BH35.

The nearest boreholes to the HDD crossing of the A27 are BH18 and BH19 to the north and south of the A27 respectively, see Figure 4 and drawing 70019402-WSP-HGT-G-DR-GE-0117 presented in Appendix A.

Figure 4: Borehole location plan [70019402-WSP-HGT-G-DR-GE-0117 presented in Appendix A]

3.3 GROUND SUMMARY & SUMMARY OF FINDINGS

The descriptions in Table 3 are extracted from the Cable route, HDD and Landfall Geotechnical Interpretative Design Development Report, WSP, 70019402-GIDDR2, 2019, [Ref 8].

Geology	Code	Description
Topsoil	TS	Soft dark brown slightly sandy slightly gravelly clay. Gravel is angular to subrounded fine to coarse of various lithologies including flint.
Made Ground	GMG, GMG_CMG, CMG.	Variable composition – summarised in infographic table notes.
Beach and Tidal Flat Deposits	B&TF	Soft to firm brownish orangish grey slightly gravelly Clay. Gravel is angular to subrounded fine to coarse chert.
River Terrace Deposits (Granular)	RTD-G	Dense yellowish brown very sandy Gravel. Gravel is rounded to angular fine to coarse chert.
River Terrace Deposits (Cohesive)	RTD-C	Soft to firm light brown grey silty slightly sandy very gravelly Clay.
Structureless (Grade Dm) Chalk	Chalk-Dm	Structureless or remoulded mélange, Soft to firm cream and white slightly sandy slightly gravelly SILT.
Structureless (Grade Dc) Chalk	Chalk-Dc	Structureless or remoulded mélange, gravels and cobbles in a white brown matrix.
Structured Chalk	Chalk-Str	Structured with typical discontinuity apertures of 3 mm or less. Generally comprising very weak (Grade C) to moderately strong (Grade A) low to medium density Structured Chalk

Table 3: Ground Models Geological Key and Description

The exploratory hole ground model for UK-HDD3B is presented in Table 4 below, the corresponding geological cross-section is available in Appendix A and the boreholes for BH18 and BH19 in Appendix B.

Geology	BH18 (Exit Pit) North	The A27 HDD Crossing	BH19	BH36	BH35 (Entry Pit) South
Topsoil	0.00 to 0.30mbgl 1.74 to 1.44mOD		0.00 to 0.15mbgl 1.71 to 1.56mOD	0.00 to 0.10mbgl 2.41 to 2.31mOD	-
Made Ground	-		0.15 to 0.80mbgl 1.56 to 0.91mOD	0.10 to 0.80m 2.31 to 1.61mOD	0.00 to 2.20mbgl 3.07 to 0.87mOD
Beach and Tidal Flats	-		-	-	2.20 to 4.70mbgl 0.87 to -1.63mOD
River Terrace Deposits (Granular)	0.30 to 1.20mbgl 1.44 to 0.54mOD		-	-	-
River Terrace Deposits (Cohesive)	1.20 to 4.00mbgl 0.54 to -2.26mOD		0.80 to 4.00mbgl 0.91 to -2.29mOD	0.80 to 5.10mbgl 1.61 to -2.69mOD	-
Structureless Chalk	4.00 to 14.56mbgl -2.26 to -12.82mOD		4.00 to 16.55mbgl -2.29 to -14.84mOD	5.10 to 15.00mbgl -2.69 to -12.59mOD	4.70 to 18.00mbgl -1.63 to -14.93mOD
Structured Chalk	14.56 to 18.50*mbgl -12.82 to -16.76*mOD *Depth not proven		16.55 to 38.05*mbgl -14.84 to -36.34*mOD *Depth not proven	15.00 to 30.00*mbgl -12.59 to -27.59*mOD *Depth not proven	18.00 to 35.00*mbgl -14.93 to -31.93*mOD *Depth not proven
Groundwater	3.20 & 8.25mbgl -2.54 & -6.51mOD		1.80 & 5.40mbgl -0.09 & -3.69mOD	1.90m bgl 0.51mOD	2.00 & 2.50mbgl 1.07 & 0.57mOD

Table 4: UK-HDD3B Ground Model

The shallow (5mbgl (below ground level)) geology is identified in Table 5 and the groundwater monitoring summary is presented in Table 6.

A27

Exploratory Locations	BH16	BH18	Estuary	BH19	BH36	BH35
Ground Level m AOD	0.74	1.74		1.71	2.41	3.07
Depth (m bgl)						
0.25	1	TS		TS	3	4
0.50	1	RTD-G		3	3	4
0.75	1			3	3	4
1.00	1			RTD-C	RTD-C	4
1.25	2					4
1.50	2	RTD-C				4*
1.75	2					4*
2.00	Chalk - Dc					4*
2.25						4*
2.50						B&TF *
2.75	Chalk - Dm					*
3.00						*
3.25						*
3.50						*
3.75						*
4.00		Chalk - Dc				*
4.25				Chalk - Dm		*
4.50						*
4.75						*
5.00						Chalk - Dc

1 -Made Ground - Firm grey brown orangish slightly sandy slightly gravelly silty clay. Gravel subangular to subrounded fine to coarse chert, Chalk and occasional flint and brick cobbles.
2- Made Ground - Similar lithological description to '1' with increased organic content.
3- Made Ground - Stiff grey brown slightly sandy slightly gravelly silty clay. Gravel subangular to subrounded fine to coarse chert, Cha k and occasional fragments of metal, glass, pottery, plastic, flint and brick cobbles.
4- Made Ground - Loose slightly sandy very clayey angular to subrounded fine to coarse gravel. Gravel is chert, brick and concrete. With frequent pieces of pottery, glass, plastic and metal. (*) Odour of hydrocarbons.

Table 5: UK-HDD3B shallow 5mbgl geology

Groundwater Monitoring	Exploratory Hole Encounter	Data Logger/ Installation Depth and Response Zone (metres bgl)	Other Relevant Information
BH18 and BH19, were installed for groundwater monitoring. BH18: Groundwater fluctuated between 0.3m bgl and 1.65m bgl, generally lowering towards summer. Temperature remained relatively stable approximately between 10-13C°. BH19: Groundwater fluctuated approximately between 0.2m bgl and 1.2m bgl, generally lowering towards summer. The groundwater appears to have daily fluctuations potentially suggesting it is in-part tidally controlled. Temperature remained relatively stable approximately between 11-13C°.	Upper groundwater strikes: 3.2m bgl (BH18) and 1.8m bgl (BH19), Lower groundwater strikes: 8.25m bgl (BH18) and 5.4m bgl (BH19 .	3 / 4.5 / 1.0 to 4.5 4 / 5.0 / 1.0 to 5.0	Broom Channel lies within UK-HDD3B forming the land separation between Portsea Island and the mainland. The likelihood of tidal influence to the groundwater table is considered probable.

Table 6: Groundwater Monitoring Findings

The specific ground model for the A27 HDD crossing is presented in Table 7. It is likely that the A27 embankment was built using some form of Engineered Fill. For the purposes of this combined report this material shall be assumed and modelled as Superficial Deposits, which represents a worst case scenario in terms of the prediction of any settlement/heave induced by the bores.

Geology	BH18	The A27 HDD Crossing	BH19
A27 Embankment	N/A		N/A
Topsoil	0.00 to 0.30mbgl 1.74 to 1.44mOD		0.00 to 0.15mbgl 1.71 to 1.56mOD
Made Ground	-		0.15 to 0.80mbgl 1.56 to 0.91mOD
Superficial Deposits River Terrace Deposits (Granular)	0.30 to 1.20mbgl 1.44 to 0.54mOD		-
Superficial Deposits River Terrace Deposits (Cohesive)	1.20 to 4.00mbgl 0.54 to -2.26mOD		0.80 to 4.00mbgl 0.91 to -2.29mOD
Structureless Chalk	4.00 to 14.56mbgl -2.26 to -12.82mOD		4.00 to 16.55mbgl -2.29 to -14.84mOD
Structured Chalk	14.56 to 18.50*mbgl -12.82 to -16.76*mOD Depth not proven		16.55 to 38.05*mbgl -14.84 to -36.34*mOD Depth not proven
Groundwater	3.20 & 8.25mbgl -2.54 & -6.51mOD		1.80 & 5.40mbgl -0.09 & -3.69mOD

Table 7: UK-HDD3B A27 HDD Crossing Ground Model

3.4 CONCLUSION

The GI found that UK-HDD3B entrance pit at Kendalls Wharf Aggregates Yard is likely to encounter Made Ground, Tidal Flat and Beach Deposits and River Terrace Deposits within approximately 5.0m of ground surface. Underlying the Superficial Deposits Chalk bedrock described as Structureless Chalk for approximately 10.0-15.0m after which it transitions to Structured Chalk.

The geology at the exit pit within Farlington Playing Fields is anticipated to be similar with the main differences within the Superficial deposits. The GI at this location did not encounter Made Ground or Beach deposit, with only Tidal Flat Deposits encountered during the ground investigation. Groundwater is anticipated between 0.0-5.0mbgl at the entry and exit pits of UK-HDD3B.

A prediction of the settlement/heave induced by the construction of the 4No. bores beneath the A27 is presented in Section 4. Made Ground presents a potential risk of contaminants and other hazardous substances (e.g. asbestos), therefore areas of proven Made Ground will require suitable mitigation measures to protect site personnel and any other site users. The Chalk bedrock potentially contains harder bands or flint. Chalk bedrock could potentially host karstic features/voids however the GI indicated these are unlikely in the vicinity of UK-HDD3B and the vicinity of the A27 HDD crossing.

The presence of the Budds Farm to Eastney Transfer Tunnel to the east does not influence the proposed alignment. The A27/A2030 Eastern Road bridge is currently west of the alignment, therefore will not be influenced by the A27 HDD crossing.

3.5 GEOTECHNICAL RISK REGISTER

See Section 7

3.6 ENGINEERING ASSESSMENT

See Section 4

4 GEOTECHNICAL DESIGN REPORT (GDR)

4.1 EXISTING INFORMATION

- Stockton Ltd, Aquind Interconnector: Project Execution Plan for the UK Landfall, 100-694 PLA-01, June 2019, [Ref 5];
- The data presented in Tables 8 through 12 have been extracted from the following report; Cable route, HDD and Landfall Geotechnical Interpretative Design Development Report, WSP, 70019402-GIDDR2, 2019, [Ref 8].

4.2 CD622 - SECTION 7 REQUIREMENTS

The previous sections of this combined report confirm the following;

- Contamination is considered extremely unlikely to affect the A27 HDD crossing;
- The location and types of materials anticipated at the A27 HDD crossing are presented in Section 3 and are Chalk at the depth of the bores;
- The likely groundwater conditions at the A27 HDD crossing are presented in Section 3;
- The risk of damage to existing services at the A27 HDD crossing is extremely unlikely based on the depth of the HDD (min. 12.23mbgl) and no services in the proximity;
- The risk of encountering previous trenchless crossings is extremely unlikely based on the depth of the A27 HDD crossing and no trenchless crossings in the proximity;
- The short-term and long-term stability of the launch and reception pits and support methodology will have no influence on the highway due to their location remote from the A27 HDD crossing;
- Groundwater control (including pumping or well pointing) will not be required under the A27 HDD crossing; and
- Spoil handling and disposal will not affect the A27 crossing based on the entry and exit pit locations.

This section of the combined report shall address the following;

- Confirmation of the engineering properties of the ground;

- The HDD methodology proposed in relation to ground conditions;
- Predicted ground movements caused by the proposed crossing, settlement and heave mitigation;
- Monitoring of the ground surface on the alignment of the HDD where it passes under the A27 shall be undertaken before, during and after the works with a set frequency, if requested by Highways England.
- Emergency procedures for adverse settlement or heave;
- The horizontal and vertical profiles of the works following completion shall be recorded in a GFR; and
- Specific risks and requirements associated with the A27 HDD crossing.

4.3 THE ENGINEERING PROPERTIES OF THE GROUND

The following presents the characteristic parameters for the strata associated with the A27 HDD Crossing.

SUPERFICIAL DEPOSIT - RIVER TERRACE DEPOSITS (GRANULAR)

River Terrace Deposits are described as 'sand and gravel, locally with lenses of silt, clay or peat'. During the GI River Terrace Deposits were described as a stratum comprising dense yellowish brown very sandy rounded to angular fine to coarse flint Gravel.

The characteristic parameters from the GI, laboratory testing and empirical correlations are summarised in Table 8 [Ref 8].

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
SPT N SPT N(60)	N N(60)	7 to 58 7 to 58 (22)	-
Angle of Shearing Resistance BS 8004:2015	φ	32 to 45 35	°
Bulk Density	γ_b	1.8 to 2.2	Mg/m^3

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
BS1377, Derived from unit weight.		2.0	
Drained Deformation (Youngs) Modulus	E_d	10.0-98.9 35.0	MPa
Dry Density BS1377	γ_d	1.87-2.06 1.97	Mg/m^3
Natural Moisture Content (BS1377)	mc	1.8-26.2 17.6 (15)	%
Moisture Condition Value BS1377	MCV	-	-
Optimum Moisture Content BS1377	OMC	9.8-11.0 10.4 (10)	%
Particle Size Distribution BS1377, Ref	%	Cobbles: 0.0-0.0 Gravel: 0.0-73.1 Sand: 12.9-81.4 Silt: 4.8-35.2 Clay: 5.1-28.3 (14, 2 followed on by pipette)	% passing
Liquid Limit BS5930:2015	^{w}L	21-85 37 (13)	%
Plastic Limit BS5930:2015	^{p}L	16-33 * 22.5 (13, 9 of which were NP)	%
Plasticity Index (Low to high plasticity clays) BS5930:2015	I_p	10-52 * 22.8 (13, 9 of which were NP)	-
Poisson's Ratio BS EN 1997-2	v	0.3	(Ratio)
Thermal Conductivity	W/(m.k)	0.091-2.779	Watts per metre-Kelvin

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
ASTM D 5334-08		1.456 (6)	
Specific Gravity BS EN 1997-2	G_s	2.55-2.65 2.63 (10)	-
Unit Weight BS EN 8004	γ	18.0 to 22.0 20.0	kN/m^3
pH BRE SD1	pH	6.9 6.9 (1)	pH Units
SO_4 BRE SD1	SO_4	12 12 (1)	mg/kg
Earth pressure co-efficient (engineering judgment) (see Section 4.4)	**k**	0.4 to 0.5 **0.4**	**-**

* Range corresponds to the clay pockets and/or layers within the granular River Terrace Deposits, 9 of 13 samples were not plastic (NP).

Table 8: River Terrace Deposits (Granular) Preliminary Parameter Ranges

SUPERFICIAL DEPOSIT - RIVER TERRACE DEPOSITS (COHESIVE)

River Terrace Deposits are described as 'sand and gravel, locally with lenses of silt, clay or peat'. During the ground investigation River Terrace Deposits (Cohesive) were described as a stratum comprising soft to firm light brown grey silty slightly sandy very gravelly Clay.

The characteristic parameters from the GI, laboratory testing and empirical correlations are summarised in Table 9 [Ref 8].

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
SPT N SPT N(60)	N N(60)	1 to 35 1 to 37 (44)	-
Angle of Shearing Resistance BS 8004:2015	φ	19 to 27 22	°
Bulk Density BS1377 *Carried out as part of total stress triaxial test. **Derived from unit weight.	γ_b	1.97-2.10* 1.7 to 2.3** 2.0 (4)	Mg/m^3
Coefficient of Volume Compressibility Tomlinson Lankelma	m_v	0.066 – 1.46 0.62 (Correlation from 44 SPTs)	m^2/MN
Undrained Deformation (Youngs) Modulus	E_u	1.1-45.0 12.5	MPa
Dry Density BS1377	γ_d	1.27-1.74 1.55 (32)	Mg/m^3
Natural Moisture Content BS1377	mc	5.6-37.9 21.2 (21)	%
Moisture Condition Value BS1377	MCV	1.0-20.7 11.2 (91)	-
Optimum Moisture Content BS1377	OMC	16.0 to 23.0 18.3 (32)	%
Particle Size Distribution BS1377	%	Cobbles: 0.0-0.0 Gravel: 0.0-50.8 Sand: 1.4-40.1 Silt: 21.5-61.9 Clay: 10.5-53.0 (23, 12 followed on by pipette)	% passing

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
Liquid Limit (BS5930:2015, Ref **(16)**)	w_L	27-73 45.6 (32)	%
Plastic Limit BS5930:2015	p_L	15-30 21.2 (32 , 3 of which were NP)	%
Plasticity Index (Intermediate to high plasticity clays) BS5930:2015	I_p	11-50 26.2 (32 , 3 of which were NP)	-
Poisson's Ratio BS EN 1997-2	v	0.25	(Ratio)
Thermal Conductivity ASTM D 5334-08	W/(m.k)	0.966-2.227 1.576 (22)	Watts per metre-Kelvin
Undrained Shear Strength BS EN 1377- CIRIA 143	c_u	5.4-145.8 35.0 (Correlation from 44 SPTs) (4 triaxial total stress)	kPa
Specific Gravity BS EN 1997-2	G_s	2.55-2.65 2.63 (32)	-
Unit Weight BS EN 8004	γ	17.0 to 23.0 1.9	kN/m^3
pH BRE SD1	pH	6.9-8.1 6.9 (4)	pH Units
SO_4 BRE SD1	SO_4	9.4-110 110 (4)	mg/kg
Earth pressure co-efficient (engineering judgment) (see Section 4.4)	**k**	0.4 to 0.5 **0.4**	**-**

* Not plastic (NP).

Table 9: River Terrace Deposits (cohesive) Preliminary Parameter Ranges

CHALK GRADE DM (STRUCTURELESS)

Structureless Grade Dm Chalk is described as structureless or remoulded mélange. The ground investigation generally encountered Grade Dm Chalk as a soft to firm cream and white slightly sandy slightly gravelly SILT.

No pH or water-soluble sulphate tests were carried out in this stratum. If buried concrete is proposed in this stratum, due consideration should be given to the requirement for assessment of the aggressivity of this stratum to concrete. However, HDPE is proposed as the bore liner.

The characteristic parameters from the GI, laboratory testing and empirical correlations are summarised in Table 10 [Ref 8].

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
SPT N SPT N(60)	N N(60)	2-49 2-51 (26)	-
Angle of Shearing Resistance CIRIA C574	φ	18-22	°
Bulk Density BS1377	γ_b	1.7-2.0 1.8	Mg/m^3
Cerchar Abrasivity	CA	0.1 (1)	CA Index
Chalk Crushing Value CIRIA C574	CCV	2.9 (1)-4.4 (CIRIA C574) 2.9	-
Coefficient of Volume Compressibility Tomlinson Lankelma	m_v	0.02-0.07 0.07 Values taken from CPT results	m^2/MN
Drained Deformation (Youngs) Modulus	E_d	8.5-100.0	MPa

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
		35 (2)	
Dry Density CIRIA C574	γ_d	1.29-2.46 1.6 (2)	Mg/m^3
Natural Moisture Content BS1377, Ref	mc	17.6-28.8 23.3 (10)	%
Moisture Condition Value	MCV	-	-
Optimum Moisture Content	OMC	-	%
Particle Size Distribution BS1377	%	Cobbles: 0.0-0.0 Gravel: 0.0-34.0 Sand: 8.8-17.5 Silt: 35.0-75.1 Clay: 9.6-18.7 (4, 2 followed on by pipette)	% passing
Point Load Index	$I_{s(50)}$	0.3-0.4 0.35 (2)	MPa
Liquid Limit BS5930:2015	w_L	27.0-33.0 29.9 (7)	%
Plastic Limit BS5930:2015	p_L	21-23 21 (7, 4 of which were NP)	%
Plasticity Index BS5930:2015	I_p	8-12 10 (7, 4 of which were NP)	%
Poisson's Ratio CIRIA C574	v	0.18-0.27 0.26	(Ratio)
Thermal Conductivity	W/(m.k)	0.216-1.861	Watts per metre-Kelvin

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
ASTM D 5334-08		1.170 (11)	
Undrained Shear Strength BS EN 1377-7 CIRIA 143	c_u	11.5-210.5 35 (Correlation from 26 SPTs)	kPa
Specific Gravity CIRIA C574	G_s	2.63-2.71 2.67 (2)	-
Unit Weight CIRIA C574	γ	17-20 18	kN/m^3
Earth pressure co-efficient (engineering judgment) (see Section 4.4)	**k**	0.4 to 0.5 **0.4**	**-**

Table 10: Preliminary Parameter Ranges Structureless Grade Dm Chalk

CHALK GRADE DC (STRUCTURELESS)

Structureless Grade Dc Chalk is described as a structureless or remoulded mélange. The ground investigation encountered Structureless Grade Dc Chalk as gravels and cobbles in a white brown matrix.

No pH or water-soluble sulphate tests were carried out in this stratum. If buried concrete is proposed in this stratum, due consideration should be given to the requirement for assessment of the aggressivity of this stratum to concrete. HDPE is proposed as the bore liner.

The characteristic parameters from the GI, laboratory testing and empirical correlations are summarised in Table 11 [Ref 8].

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
SPT N SPT N(60)	N N(60)	4-83 4-83 (40)	-
Angle of Shearing Resistance CIRIA C574	Φ'	18-22 20	°
Bulk Density BS1377	γ_b	1.7-2.0 1.95 (2)	Mg/m^3
Cerchar Abrasivity	CA	0.08-0.14 (5)	CA Index
Chalk Crushing Value CIRIA C574	CCV	1.7-4.4 3.0 (11)	-
Coefficient of Volume Compressibility Lankelma	m_v	0.02-0.06 0.04 (Correlation from CPTs)	m^2/MN
Drained Deformation (Youngs) Modulus	E_d	8.2-147.9 40.0*	MPa
Dry Density	γ_d	1.28-1.97 1.6 (22)	Mg/m^3
Natural Moisture Content BS1377	mc	5.0-49.0 23.4 (26)	%
Moisture Condition Value BS1377	MCV	-	-
Optimum Moisture Content BS1377	OMC	14.0-19.0 16.0 (16)	%
Particle Size Distribution	%	Cobbles: 0.0-22.2	% passing

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
BS1377		Gravel: 10.8-81.9 Sand: 6.2-21.4 Silt: 11.7-59.0 Clay: 0.0-48.1 (13, 4 followed on by pipette)	
Point Load Index	$I_{s(50)}$	0.03-0.4 0.2 (14)	MPa
Liquid Limit BS5930:2015	^{w}L	25-61 30.2 (21)	%
Plastic Limit BS5930:2015	^{p}L	16-32 21.6% (21, 7 of which were NP)	%
Plasticity Index (Not plastic to very low plasticity) BS5930:2015	I_p	4-29 10.9 (21, 7 of which were NP)	-
Poisson's Ratio CIRIA C574	v	0.18-0.27 0.25	(Ratio)
Thermal Conductivity ASTM D 5334-08	W/(m.k)	0.044-1.875 1.154 (21)	Watts per metre-Kelvin
Unconfined Compressive Strength CIRIA C574	q_u	0-3MPa 1MPa	MPa
Undrained Shear Strength BS EN 1377-7 CIRIA 143	c_u	17.2-310.5 40.0* (Correlation from 40 SPTs)	kPa
Saturation Moisture Content	M_{sat}	14.0-25.0 21.1	(%)
Specific Gravity CIRIA C574	G_s	2.52-2.74 2.66 (4)	-

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
Unit Weight CIRIA C574	γ	17-20 19.5	kN/m^3
Earth pressure co-efficient (engineering judgment) (see Section 4.4)	**k**	0.4 to 0.5 **0.4**	**-**

*deformation modulus and undrained shear strength similarity in feasibility value are due to the approach to derive the feasibility design value.

Table 11: Preliminary Parameter Ranges Structureless Grade Dc Chalk

STRUCTURED CHALK (GRADE C TO A)

Structured Grade C to A Chalk is described as Structured with typical discontinuity apertures of 3 mm or less. Generally comprising very weak (Grade C) to moderately strong (Grade A) low to medium density Structured Chalk.

No pH or water-soluble sulphate tests were carried out in this stratum. If buried concrete is proposed in this stratum, due consideration should be given to the requirement for assessment of the aggressivity of this stratum to concrete. HDPE is proposed.

The characteristic parameters from the GI, laboratory testing and empirical correlations are summarised in Table 12 [Ref 8].

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
SPT N SPT N(60)	N N(60)	14 to 75 14 to 75 (6)	-

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
Angle of Shearing Resistance CIRIA C574	φ	25-28 26	°
Bulk Density BS1377	γ_b	1.84-2.14 1.98 (10)	Mg/m^3
Cerchar Abrasivity	CA	0.08-0.20 0.16	CA Index
Chalk Crushing Value CIRIA C574	CCV	3.2-4.2 3.6	-
Coefficient of Volume Compressibility Tomlinson Lankelma	m_v	0.01-0.03 0.02 (Correlation from CPTs)	m^2/MN
Drained Deformation (Youngs) Modulus	E_d	20.2-190.2 100	MPa
Dry Density BS1377	γ_d	1.49-1.81 (26)	Mg/m^3
Natural Moisture Content BS1377	mc	12.0-27.4 23.5 (12)	%
Moisture Condition Value	MCV	-	%
Optimum Moisture Content	OMC	-	%
Particle Size Distribution BS1377	%	Cobbles: 0.0-0.0 Gravel: 2.6-49.0 Sand: 7.0-10.5 Silt: 32.0-74.6 Clay: 8.5-15.8 (2 , 0 followed on by pipette)	% passing
Point Load Index	$I_{s(50)}$	0.02-0.26 (55)	MPa
Liquid Limit BS5930:2015	w_L	28-38 34	%

Parameter and Derivation		Results Range Characteristic Parameter (No. of tests)	Unit
		(4)	
Plastic Limit BS5930:2015	P_L	22 11 (4, 2 of which were NP)	%
Plasticity Index (Not plastic to very low plasticity clays) BS5930:2015	I_p	15-16 7.5 (4, 2 of which were NP)	-
Porosity CIRIA C574 BS 1377-2:1990	n	21.0-33.1 27.1	(%)
Poisson's Ratio CIRIA C574	v	0.18-0.27 0.24	(Ratio)
Thermal Conductivity ASTM D 5334-08	W/(m.k)	0.108-1.497 0.482 (6)	Watts per metre-Kelvin
Unconfined Compressive Strength	q_u	1.24-9.1 3.7	MPa
Undrained Shear Strength BS EN 1377-7 CIRIA C574	c_u	50-200 50 (For reworked material)	kPa
Saturation Moisture Content	M_{sat}	20-29 25 (15)	(%)
Specific Gravity BS EN 1997-2	G_s	2.71-2.75 2.73	-
Unit Weight CIRIA C574	γ	18.4-21.4 19.8	kN/m^3
Earth pressure co-efficient (engineering judgment) (see Section 4.4)	**k**	0.4 to 0.5 **0.4**	**-**

Table 12: Preliminary Parameter Ranges Structured Chalk (Grade C-A)

It should be noted that the drilling techniques employed (cable percussion/rotary) may have caused disturbance of the in-situ Chalk and the at surface recovery may not be fully representative of the actual intact state.

It is concluded that the stratum encountered in the GI are consistent with that expected for each material and nothing unusual has been observed.

4.4 COEFFICIENT OF EARTH PRESSURE AT REST, K VALUE

The London Crossrail project based their settlement estimates for tunnelling using a 7.18m diameter tunnel boring machine through Chalk and used k value of 0.5.

Subsequent back analysis using measurements taken during construction indicated k values ranged between 0.43 and 0.5, taken from Ground settlement behaviour in Chalk due to TBM excavations, Crossrail Learning Legacy paper published 2014, [REF 11].

A coefficient of earth pressure at rest of k 0.4 has been used over the width of the trough. A k of 0.4 is considered to be a moderately conservative value for representing the combined settlement behaviour of the structureless Chalk and the overlying Superficial Deposits.

4.5 VOLUME LOSS

Large settlements occur chiefly as a result of loss of ground due to over-excavation (volume loss) caused by the inability to control adverse ground conditions or operator error.

Systematic settlement is principally caused by the collapse of the overcut or annular space between the new pipe and excavation and to a lesser extent by elastic deformations of the soil ahead of the advancing bore. In HDD installations, the overcut allows drilling fluids to be injected, ensures good circulation, decreases pullback forces and facilitates cooling of cutting tools. During or after pipe installation, ground surrounding the annulus may collapse or squeeze onto the pipe, filling the void created by excavation equipment. Ground collapse continues upward until the void appears at the surface as a trough. Systematic settlements can be controlled by keeping the annulus filled with drilling fluids.

During the CrossRail Project [REF 11], initial estimates of settlement were based on a maximum 1% volume loss. However, measurements during construction indicated actual volume losses ranged from 0.1% to 0.35% within the Chalk. For the A27 HDD crossing a worst-case volume loss of 4% has been assumed. Presented are settlement troughs analysis of 2% to 10% for comparison purposes.

For settlement analysis a conservative k value of 0.4 will be adopted for the 711mm.

4.6 THE HDD METHODOLOGY AND GROUND CONDITIONS

Figure 5 shows the vertical relationship between the A27 (green) and the HDD bore (red and blue).

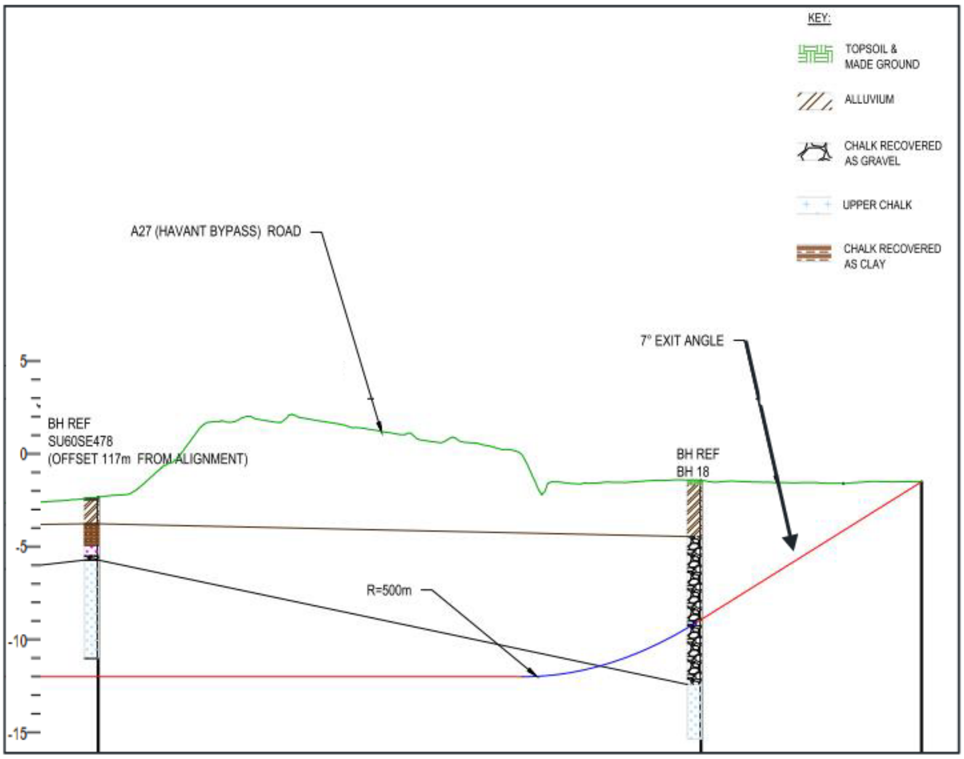


Figure 5: UK-HDD3B Section Extracted from Location Plan Drawing [12731-WIE-ZZ-XX-DR-C-90302-A01 presented in Appendix A]

Figure 6 shows the horizontal relationship between the A27 (grey) and the 4No. HDD bores (red).

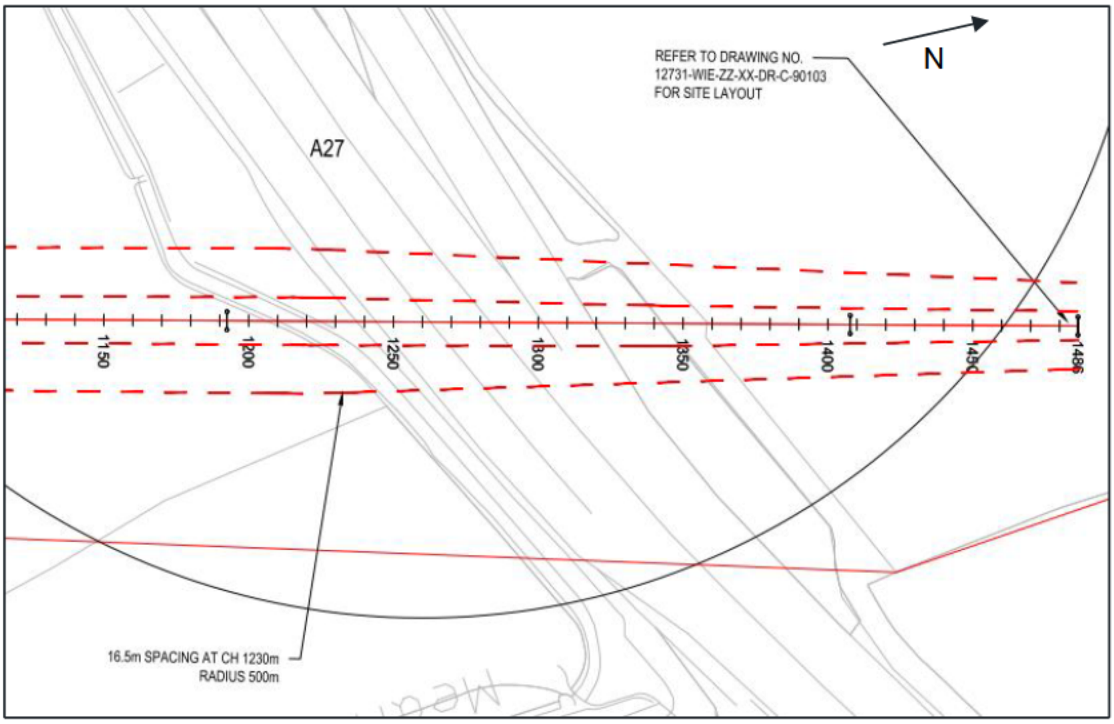


Figure 6: UK-HDD3B Section Extracted from Location Plan Drawing [12731-WIE-ZZ-XX-DR-C-90302-A01 presented in Appendix A]

The proposed construction sequence is provided below;

- Site establishment, install site offices, welfare.
- Excavate at HDD entry point for the HDD anchor block and construct.
- Install steel casing through the gravels into competent ground at each of the 4 entry points (Prevents drilling fluid losses).
- Install monitoring equipment on A27 to observe heave/settlement and obtain base levels in accordance with Highways England requirements.
- Install HDD rig at entry point.
- Directional drill pilot hole following the required profile circa 1486m with a bore diameter of 311mm diameter.
- Back ream bore to 711mm diameter.

- Weld HDPE SDR 9 at the playing fields north of the A27 into as few continuous lengths as is feasible, test with water and set on temporary rollers.
- Attach pipe to pull back swivel assembly and pull the HDPE pipe into the bore using the HDD rig.
- Repeat 3 further times at each of the entry point locations for the 4No. bores required.

4.7 PREDICTED GROUND SETTLEMENT

Settlement analysis has been undertaken in the computer modelling software XDisp. Results are presented for 4No. locations, A,B,C,E and F, as shown in section and on plan on Figures 7 and 8, respectively. In addition Section D-D has been derived from the predicated settlements for Points A, B and C. The settlements have been conservatively calculated for the lowest level of the embankment at 4mOD. This gives the maximum settlement for the embankment and hence the road. The actual road and embankment levels rise above this level which will result in a greater cover to the HDD with a corresponding reduced magnitude of settlement.

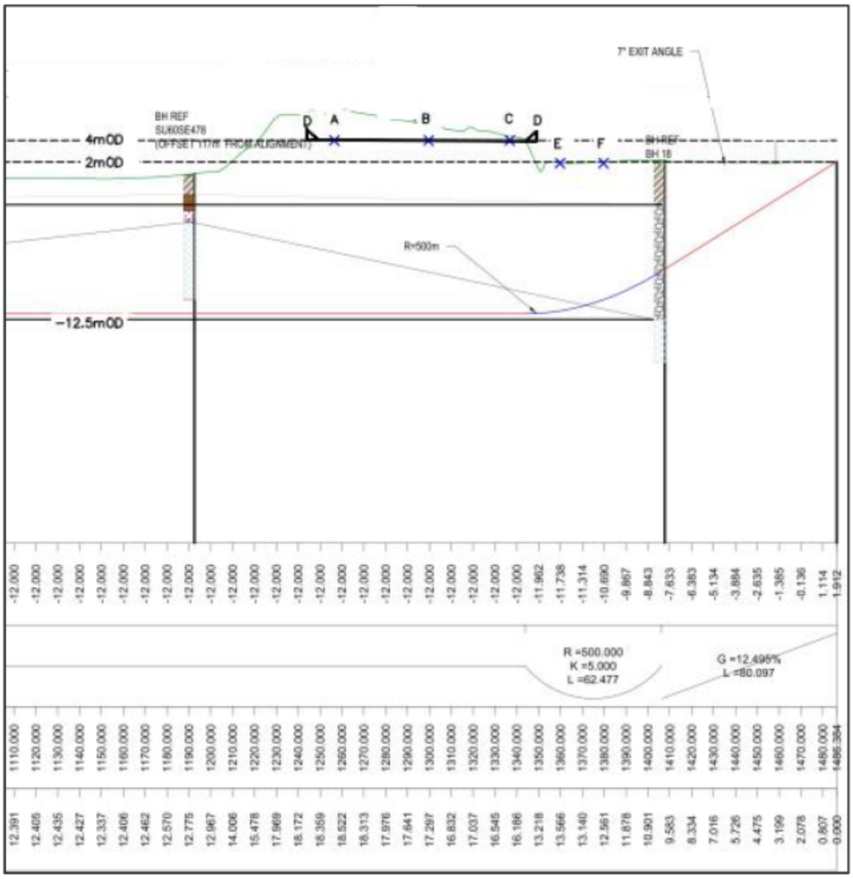


Figure 7: A27 Settlement Analysis Points in Section

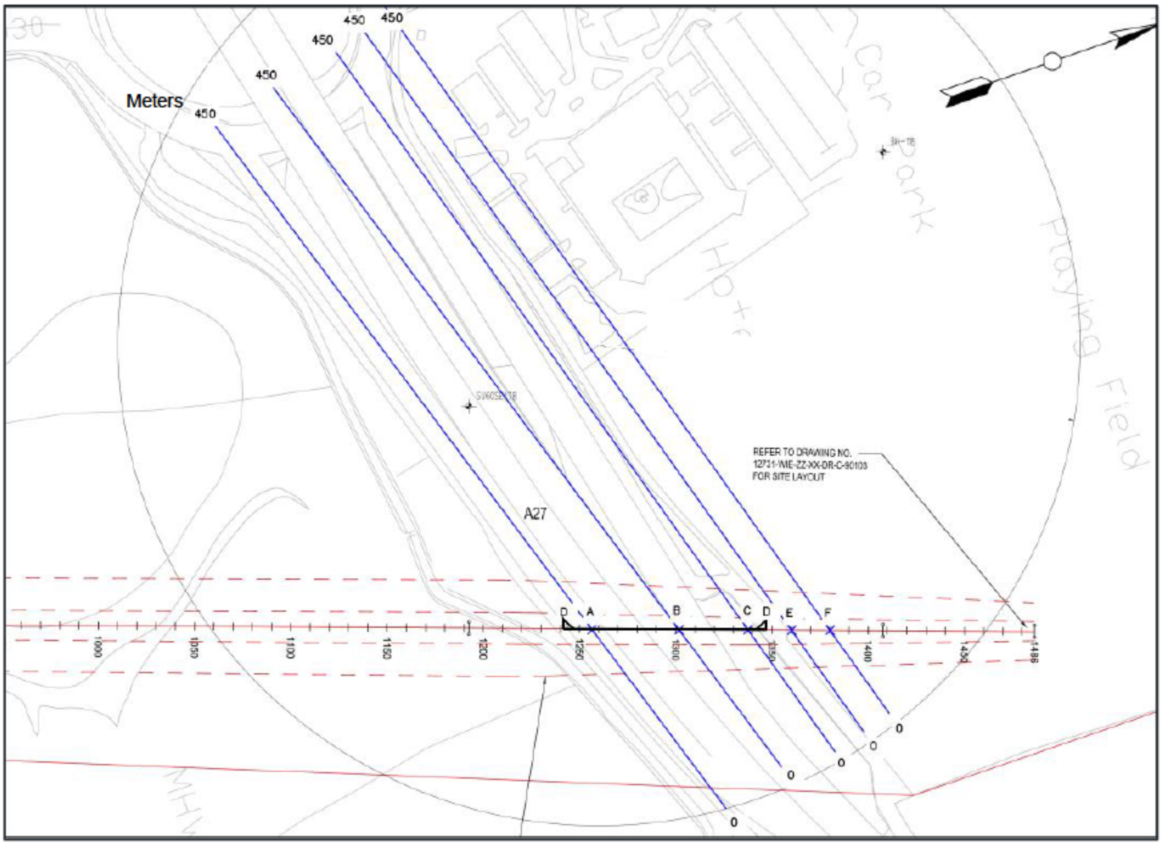


Figure 8: A27 Plan Showing Section Lines Through Each Point A,B,C, E and F.

The ground model inputs used in XDisp are shown in Table 13.

	Point A	Point B	Point C	Point E	Point F
Depth of cover	15.54m	15.54m	15.54m	13.28m	**12.23m**
Embankment/Superficial Deposits	4mOD to -2mOD	4mOD to -2mOD	4mOD to -2mOD	2mOD to -2mOD	2mOD to -2mOD
Chalk	-2mOD to -12.5mOD	-2mOD to -12.5mOD	-2mOD to -12.5mOD	-2mOD to -12.5mOD	-2mOD to -12.5mOD
k (earth pressure)	0.4	0.4	0.4	0.4	0.4

Table 13: Ground Model Used For XDisp Inputs

Table 14 shows the predicted settlement and gradient (maximum gradient across the settlement trough) at each point for increasing values of volume loss.

	A		B		C		Section D - D	E		F	
Volume Loss %	Settlement (mm)	Gradient	Settlement (mm)	Gradient	Settlement (mm)	Gradient	Gradient	Settlement (mm)	Gradient	Settlement (mm)	Gradient
2	0.9	1:19244	0.9	1:19677	1	1:19479	1:509268	1	1:17539	1.1	1:9865
4	1.8	1 9622	1.9	1:9838	2	1 9739	1:254627	2	1:8769	2.3	1:4933
6	2.6	1 6414	2.7	1:6559	3	1 6493	*1:169753*	3	1:5846	3.4	1:3288
8	3.5	1:4811	3.7	1:4919	4	1:4869	*1:127315*	4	1:4385	4.6	1:2466
10	4.4 Figure 9	1 3848	4.6 Figure 10	1:3935	5 Figure 11	1 3896	*1:101852* Figure 12	5.1 Figure 13	1:3508	5.7 Figure 14	1:1973

Table 14: Calculated Settlements against Volume Loss.

Graphical representations of the surface displacement (settlement) across the line of the HDD crossing for each point is presented below in Figures 9 to 14, for a worst case 4% volume loss.

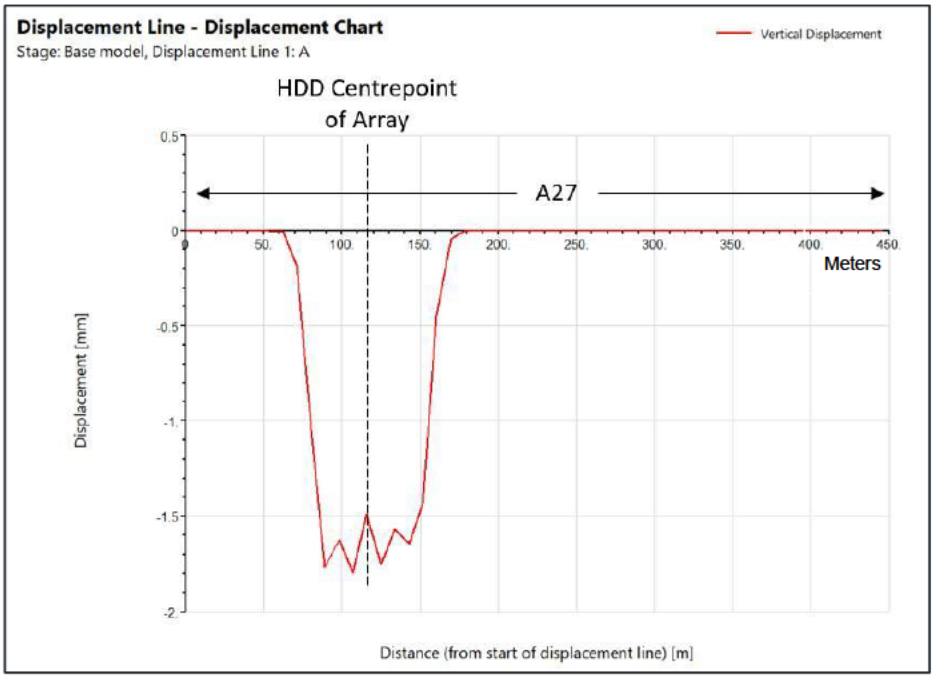


Figure 9: A27 Settlement – 4% volume loss at Point A

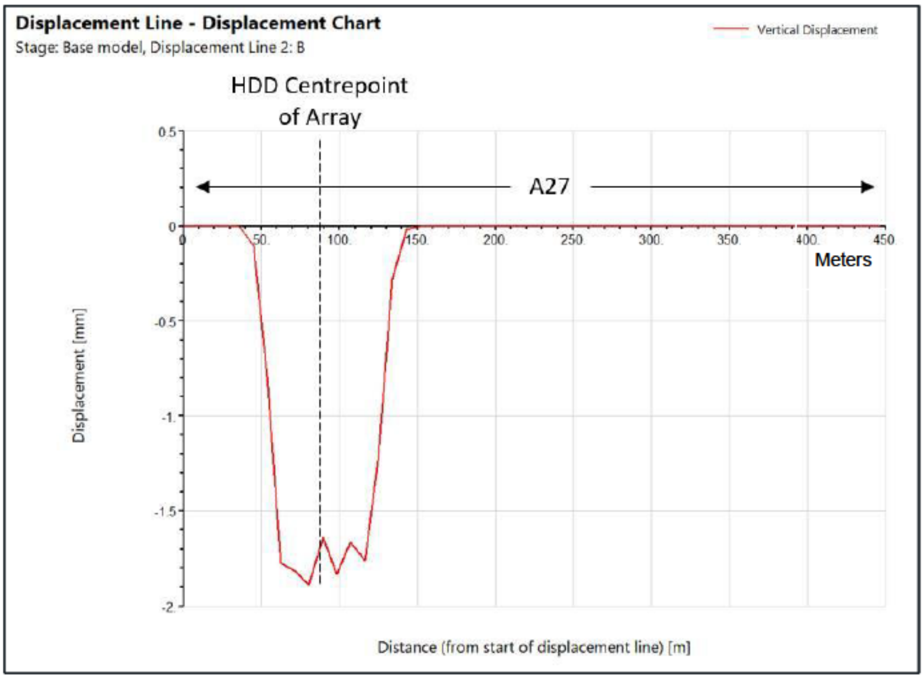


Figure 10: A27 Settlement – 4% volume loss at Point B

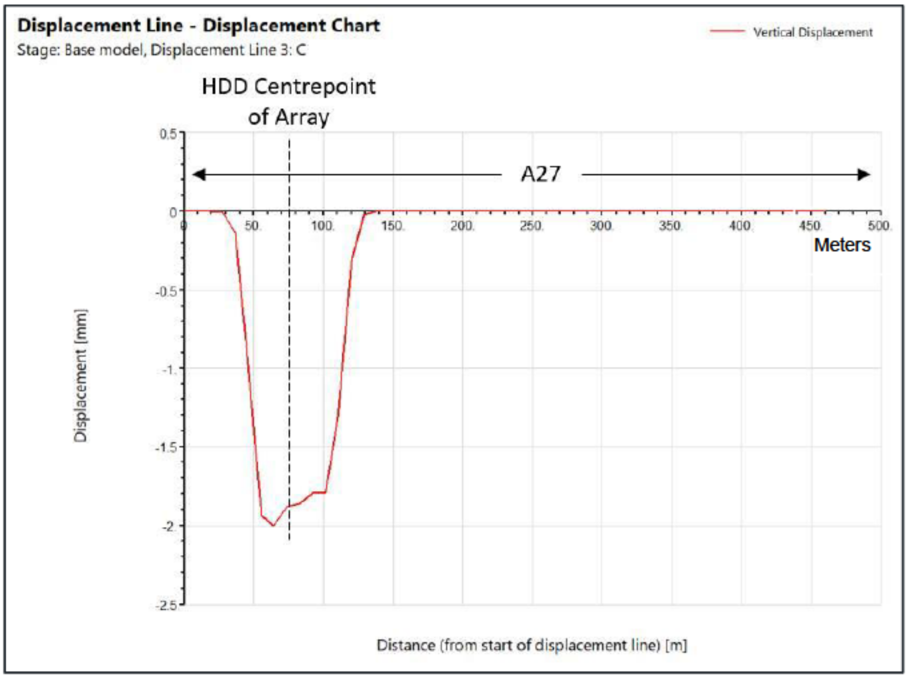


Figure 11: A27 Settlement – 4% volume loss at Point C

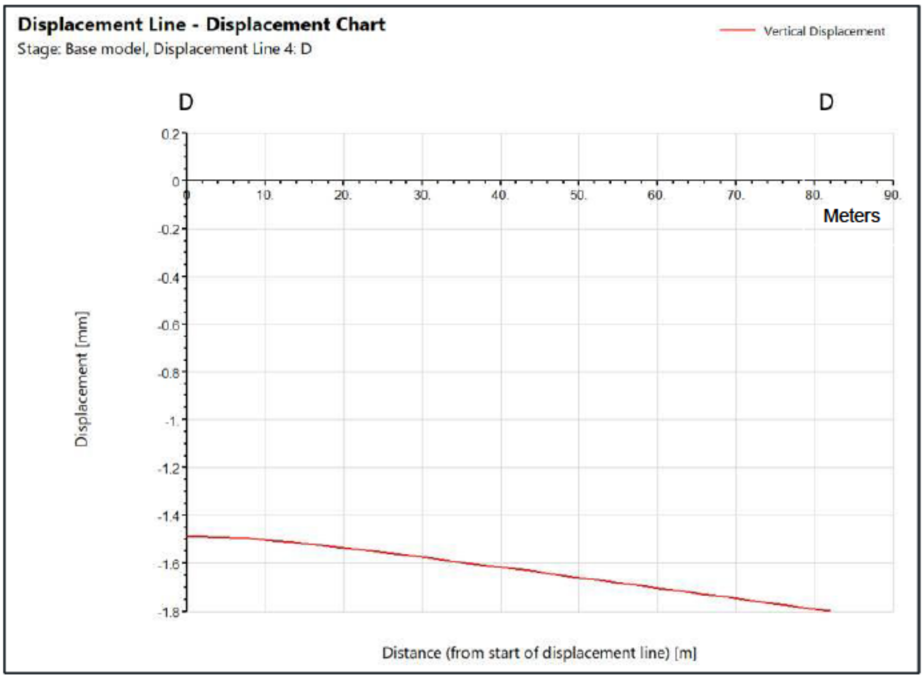


Figure 12: A27 Settlement – 4% volume loss at Section D-D

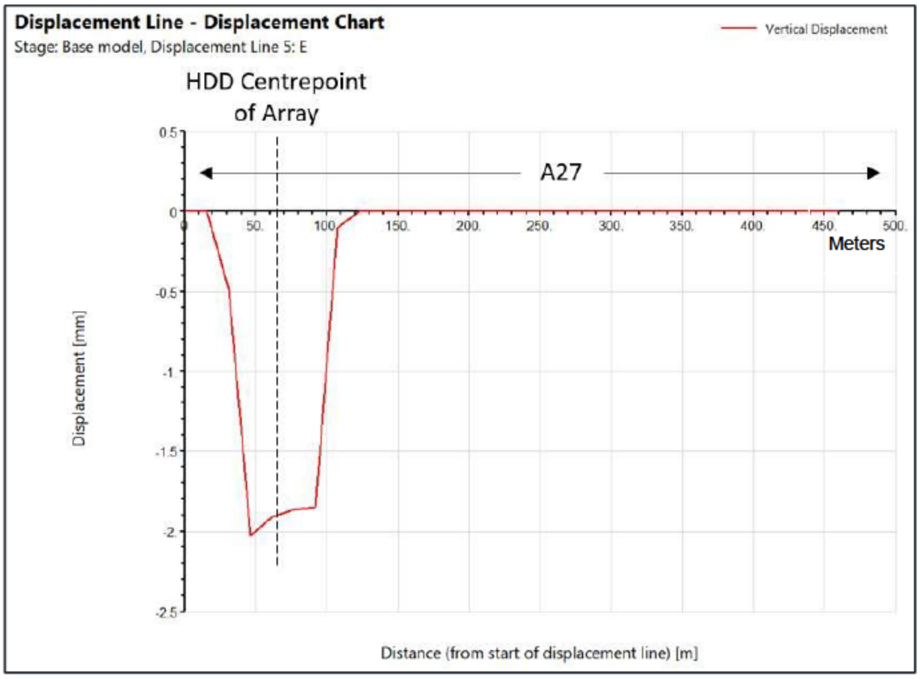


Figure 13: A27 Settlement – 4% volume loss at Point E

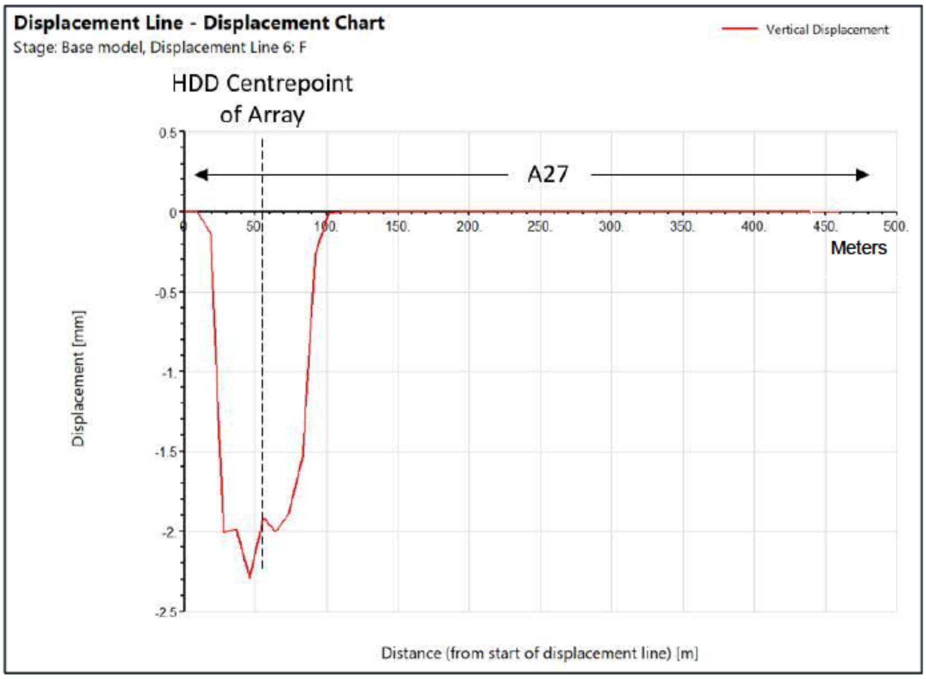


Figure 14: A27 Settlement – 4% volume loss at Point F

In summary, a volume loss of between 2% and 4% is considered conservative and as demonstrated in Section 4.6, this will induce settlements of approximately 1.1mm to 2.3mm respectively (worst case Point F). A highly unlikely 10% volume loss will induce settlements of approximately 5.7mm (worst case Point F).

4.8 RISKS AND MITIGATION

4.8.1. Volume Loss

During the Cross Rail Project [REF 11], initial estimates of settlement were based on a maximum 1% volume loss. However, measurements during construction indicated actual volume losses ranged from 0.1% to 0.35% within the Chalk. For the A27 HDD crossing a worst-case volume loss of 4% has been assumed.

In the absence of any specific highway limitations, a maximum of 5mm settlement is based on the limits of Network Rail for works under the railway which is assumed to be sufficiently onerous when considering the impact of movements on the highway.

Large gradient changes are important in terms of serviceability of the carriageway, i.e. efficient drainage, geometry and development of surface defects. The maximum gradients calculated across the A27 HDD crossing settlement troughs are negligible and are considered highly unlikely to affect the serviceability of the carriageway.

4.8.2. Volume Loss Mitigation

HDD construction relies on the drilling fluid to provide support to the excavated bore prior to installation of the permanent ducts and final grouting of the bore. Control of the drilling fluid pressures and volumes is therefore important to minimise volume losses.

The proposed route for the UK-HDD3B should not cause the ground to collapse. In general ground collapse caused by directional drilling is fortunately uncommon, the risk of collapse is minimised by drilling in the homogenous competent Chalk. The UK-HDD3B design has sufficient depth below surface for the expected ground conditions which means that at the point of the A27 crossing volume loss will be at a minimum;

A volume loss of 4% is considered to be an upper bound assumption (worst case) below the A27 HDD crossing. However, actual volume losses achieved during construction can be confirmed by monitoring over the 1.2km of HDD alignment prior to the A27 crossing. This will allow the Contractor to modify his drilling operations to reduce volume losses to an as low as reasonably practicable acceptable limit before the A27 crossing.

4.8.3. Heave Risk

Heave analysis cannot be calculated, as it is dependent on the construction process and the control exercised by the Contractor. In particular, ensuring that the down hole drilling fluid pressures do not exceed the prevailing overburden pressures is essential.

4.8.4. Heave Mitigation

Heave will be mitigated by constant monitoring and adjustment to the drilling process (circulation and annular pressures). In fissured Chalk or the presence of solution features (karstic Chalk) there is the risk of drilling fluid migration to the surface and this will need to be controlled by the use of an appropriate drilling fluid mix and pressures, see Section 4.8.6.

4.8.5. Lost Circulation

Lost circulation is the loss of drilling fluid from the bore through cracks, crevices, or porous formations. It can be partial or complete, depending on the conditions. Lost circulation is sometimes referred to as lost returns, either partial or complete, because part or all of the fluid fails to return to the surface from the bore. When circulation is lost, the drilling fluid is not able to perform one of its major functions, transportation of the cuttings along the HDD bore and back to surface. If the cuttings are not removed from the hole, they are likely to pack around the drill string above the bit, which ultimately will result in stuck pipe and possible loss of down hole assembly equipment (DHA).

4.8.6. Lost Circulation Mitigation

Lost circulation materials (LCM) are materials that bridge across openings in the formation, providing a foundation for the build-up of a filter cake. Almost every conceivable material has been used including sawdust, alfalfa pellets, chicken feathers, ground walnut shells, cotton seed hulls, hog hair, and many others. There are also a variety of gelling agents or mixtures that form stiff gels when mixed with water or salt water.

Many of the LCMs are organic and may have the potential to promote undesired organic growth or degrade water quality or both. Inorganic materials, such as mica flakes and gilsonite, or inert materials such as some of the plastics can be used, although they are not always as effective. The best materials will be a mixture of flake and fibres of various sizes in order to effectively bridge openings in the formation.

4.8.7. Frac Outs

A frac-out occurs when the circulation pressure exceeds the overburden pressure (i.e. shallow or loose sections of the bore), or the fluid finds a preferential seepage pathway (such as fault lines and fractures, infrastructure or loose material).

Loss to surface breakout most commonly occurs within the first 30m from entry and a competent Contractor will avoid this. The HDD Contractor will have a person walking the drill alignment as far as reasonably practicable checking for breakout. If detected the drilling is stopped immediately and the spill contained and removed. Once the drill is under the marshes the drill will be at a depth of circa 14mbgl greatly reducing the chance of a break out. The A27 crossing has a minimum cover of 12.23m which significantly mitigates the risk of frac outs however the following section further considers mitigation measures.

4.8.8. Frac Out Mitigation

The route of UK-HDD3B has been carefully selected to ensure it is suitable for the trenchless methodology of directional drilling, i.e. strata, depth and no faulting. Calculations have been conducted to select a rig size that minimises the annular pressure that causes frac outs at surface. Mitigation forms;

- Monitoring of drilling fluid returns and volumes warn of inadequate hole cleaning;
- Drilling fluid to be of sufficient viscosity and for the ground being drilled;
- Real time downhole annular pressure monitoring to warn of over pressurising by drilling fluid; and
- Maintain lost circulation materials on site to seal any breakout

A key component of avoiding breakout is effective removal of the cuttings from the borehole. If cuttings are not removed they form cuttings beds on the base of the borehole, decreasing the cross-sectional area of the borehole. This causes an increase in annular pressure and therefore increases the risk of breakout. Cuttings in the bore also lead to increased drilling forces and can eventually cause equipment to be lost or stuck downhole.

The HDD Contractor will need to be proactive in ensuring that cuttings are effectively removed and will spend additional time and effort to reduce the risk of both breakout and stuck equipment.

4.8.9. Deviation

The position of the drill is real-time monitored by directional guidance equipment (gyroscopic steering tool, itself is accurate to within millimetres) positioned behind the steerable drilling assembly. The steering downhole assembly accuracy is +/-500mm. The accurate position of the bore is known at all times, the HDD will not pass under the A27 if it is not in the correct elevation or alignment.

4.9 ANNULAR PRESSURE MONITORING

Annular Pressure Monitoring is standard to the guidance equipment and measures the pressure in the borehole annulus in real-time. The actual value can be compared with depth of overburden, a minimum 12.23m, to avoid damaging the ground surrounding the HDD during hole drilling (heave). By avoiding any over-pressuring of the surrounding ground, the risk of surface breakout and heave is greatly reduced.

4.10 FLINTS

The drill depth has been designed to keep the bore within the Chalk layer. The flint content is not considered high enough (Tarrant Chalk) from the data available (BH18 and BH19) to constitute a risk to the completion of the drill.

The Contractor will need to be mindful that the flint exists and conduct several cleaning runs prior to the pull back of the ducts to ensure they do not become stuck on a flint or drag along the bottom of the bore. To counter this the Contractor will need to ensure the duct is positively buoyant within the bore during pullback.

4.11 MONITORING

Monitoring of surface movements induced by construction of the A27 HDD crossing is at the discretion of Highways England. In deciding whether monitoring is required, due consideration should be given to the likelihood that excessive movements will occur considering the conservative soil model and parameters adopted in the analysis (notably the k value), the resultant low levels of predicted settlements, even with the worst case 4% volume loss assumed and the control methods available to an experienced HDD Contractor to limit volume loss/settlement and prevent heave. On the other hand, the consequences of the predicted settlements being exceeded needs to be considered in terms of the serviceability and safety of the highway. Should Highways England impose the requirement for monitoring, then the following is proposed;

Only the Armco barrier is to be monitored with 10 reflective fixed prisms each side of the highway, spaced at 2m centres. A trigger level of +/-5mm is proposed for the Armco barrier. Should trigger levels be approached a notification can automatically be sent by email to relevant parties. Pre (1month), during and post monitoring (1 month) should be undertaken. A surveying tolerance of +/-1mm should be specified.

The proposal is for 2No. Automated Total Stations (ATS) to be installed to carry out the monitoring readings to prisms every hour.

The ATS's should be installed in the fields on either side of the A27 carriageway in order to view the crest and toe of the embankment. These will be fixed into to concrete bases (1m x 1m x 500mm) which will be in place prior to the HDD operation (minimum 1 Month).

Coordinates of the locations of the concrete bases will be supplied. A 3m high mast should be fixed to the concrete base with 20mm drilled drop-in anchors and fixed into place with sheer nuts. A protective cage should be installed at the top of the mast to hinder potential theft or damage. The instruments will be placed on a ~3m high mast. The mast should be fixed to the 1m x 1m x 500mm base and stabilised using 4 steel ropes. The ropes should be connected from the top of the mast to ground anchors. The ground anchors should be installed 2m from the centre of the mast.

Line-of-sights to prisms must be kept clear at all times but isn't considered an issue at this stage. Power should be supplied by battery, solar panels and/or wind turbines. Access and permissions are to be arranged.

Readings should be taken remotely every hour and the data should be transmitted via the GPRS mobile network to a server where the data is processed for viewing, likely on a password protected webpage.

Surveying equipment should be calibrated as per the manufacturers' recommendations.

4.12 EMERGENCY PROCEDURES

The A27 crossing HDD drilling will stop if heave or settlement is triggered at a differential +/- 5mm within 5m either side of the A27 or the Armco barrier. Appropriate measures to reduce settlement or heave will be undertaken.

4.13 THE GEOTECHNICAL FEEDBACK REPORT

The strongest recommendation to the Aquind team is that WSP undertake the GFR for retention on the HAGDMS [Ref 9] system. The HDD Contractor will record all required data following the requirements of CD622 [Ref 1].

4.14 SPECIFIC RISK REGISTER - A27 HDD CROSSING

See Section 7.

5 CONCLUSIONS

There are no known buried services or apparatus in the proximity of the A27 HDD Crossing which could be affected by the works.

The minimum depth of cover (12.23m at Point F), nature of the geology and diameter of the HDD significantly reduces the risk of settlement/heave to the A27 asset.

A volume loss of between 2% and 4% is considered conservative and as demonstrated in Section 4 could induce settlements of approximately 1.1mm to 2.3mm approximately (Point F). A highly unlikely 10% volume loss could induce settlements of approximately 5.7mm (Point F).

In the absence of any specific highway limitations, a maximum of 5mm settlement is based on the limits of Network Rail for works under the railway which is assumed to be sufficiently onerous when considering the impact of movements on the highway.

The maximum gradients calculated across the A27 HDD crossing settlement troughs are negligible and are highly unlikely to affect drainage, geometry or cause surface defects.

Heave, loss of circulation, frac outs, loss to surface and annular pressure will be monitored by the competent HDD Contractor; chiefly by surface monitoring, monitoring drillng pressures and the circulation returns. The adverse risk to the A27 is considered very low based on the minimum depth of cover.

The accurate position of the bore is known at all times, the HDD will not pass under the A27 if it is not in the correct elevation or alignment.

If required by Highways England, pre (1month), during and post monitoring (1 month) will be undertaken. It is proposed only the Armco barrier is monitored with reflective prisms.

A stop works trigger of +/- 5mm differential heave/settlement measured on the Armco barrier is proposed, whereby the Contractor will re-assess the pilot hole and/or re-ream.

6 REFERENCES

1 CD622 Managing geotechnical risk - Standards for Highways, Highway Engalnd, 2019.

2 REPORT No 20170202-TJM-AQUIND-UK CABLE ROUTE DESK STUDY REPORT – ISSUED V0, February 2017.

3 REPORT No 20170622-TJM-AQUIND-UK CABLE ROUTE DETAILED DESK STUDY-REPORT-ISSUED V0, June 2018.

4 Stockton and Waterman, Aquind UK-France HVDC Interconnector: HDD Feasibility Assessment, WIE12731-111-R-1-4-3, June 2019.

5 Stockton Ltd, Aquind Interconnector: Project Execution Plan for the UK Landfall, 100-694 PLA-01, June 2019.

6 Preliminary Environmental Information Report, WSP, PINS Ref: EN020022, 2019.

7 Geotechnics Ltd, 2019, UK - France HVDC Interconnector Onshore Work Package 2, PE181481.

8 Cable route, HDD and Landfall Geotechnical Interpretative Design Development Report, WSP, 70019402-GIDDR2, 2019.

9 The Highways England Geotechnical Data Management System (HAGDMS). http://www.hagdms.co.uk/

10 Trenchless and Minimum Excavation Techniques, CIRIA Special Publication 147.

11 Ground settlement behaviour in Chalk due to TBM excavations, Crossrail Learning Legacy paper, 2014.

7 A27 CROSSING HDD GEOTECHNICAL RISK REGISTER

7.1 THE A27 HDD CROSSING RISK ASSESSMENT

The risk assessment presented in Table 10 is solely intended for the A27 HDD crossing, and not the entire UK-HDD3B route.

7.2 RISK ASSESSMENT

Table 1 Risk Matrix

		Impact				
		1	2	3	4	5
Likelihood	1	N	N	N	N	T
	2	N	N	T	T	S
	3	N	T	T	S	I
	4	N	T	S	I	I
	5	T	S	I	I	I

Note:

Intolerable	I
Significant	S
Tolerable	T
Negligible	N

	Likelihood:
1	Very unlikely
2	Rarely occurs
3	Possible but not common
4	Likely
5	Very Likley

	Impact:
1	Minor injuries
2	Significant injury
3	Serious injury
4	Major injury
5	Fatality

	Risk type key:
HS	Health and Safety
T	Time
C	Cost
R	Reputation
E	Environment
M	Maintenance

	Risk stage key:
GI	Ground Investigation
CON	Construction
PW	Permanent Work

Table 2 Geotechnical Risk Register

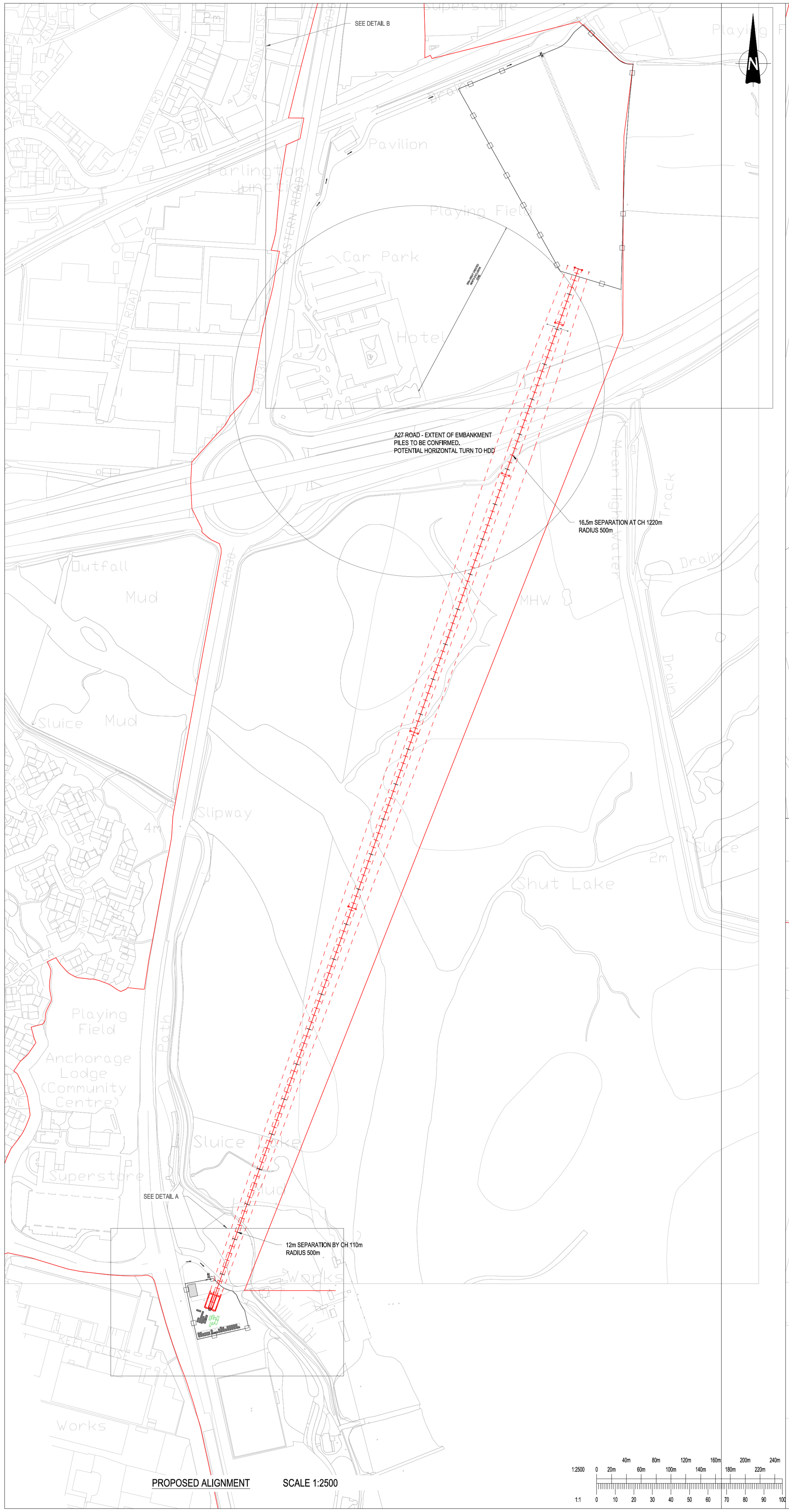
Ref	Hazard/ aspect	Risk Stage	Consequences	Impact	Likelihood	Risk	Risk Type	Potential Risk Control Measures / Action	Impact	Likelihood	Residual Risk	Owner and Action	Current Risk Ranking
GEO-1	Chalk Bedrock: karstic features or voids, possible dissolution due to construction	CON	Difficulties in drilling, loss of alignment or potential adverse movements.	4	2	T	T, C	The ground investigation did not encounter any features or indicate potential of features. Any identified features are to be avoided where possible, if not possible to avoid the potential to seal via grouting/bentonite is potentially viable.	2	2	N	Contractor	Negligible
GEO-2	"Hard bands" within strata affecting drilling, excavation and trenching activities	CON	Potential harder bands of Grade A Chalk and/or flint may obstruct drilling or alignment and impact excavations.	4	3	S	C, T	Selection of suitable construction plant and equipment should be used that is capable of undertaking works within Structured Grade A Chalk and possible flint bands.	4	2	T	Contractor	Tolerable
GEO-3	Unexploded Ordnance Device	CON	Activation of UXO devices causing injury or fatality to site personnel.	5	3	I	C, T, R, HS	Due to the depth of the bore under the A27 it is highly unlikely that UXO will be encountered.	4	2	N	Contractor	Neglible
GEO-4	Services: Buried Utilities	ICON	Striking a utility could incur cost, delay and undesirable project attention. In the worst-case scenario, it can cause injury or death. All utilities are of concern but ones of greatest risk are sewers, high pressured gas lines, high voltage electrical lines (commonly high concentration when nearing electrical substations and sewers are of particular concern when crossing HDD alignments due to their size and depths.	5	3	I	C, T, R, HS	None identified from search of available utility records. Due to the depth of the crossing it is considered unlikely that any utilities will be encountered.	4	2	T	Contractor	Tolerable

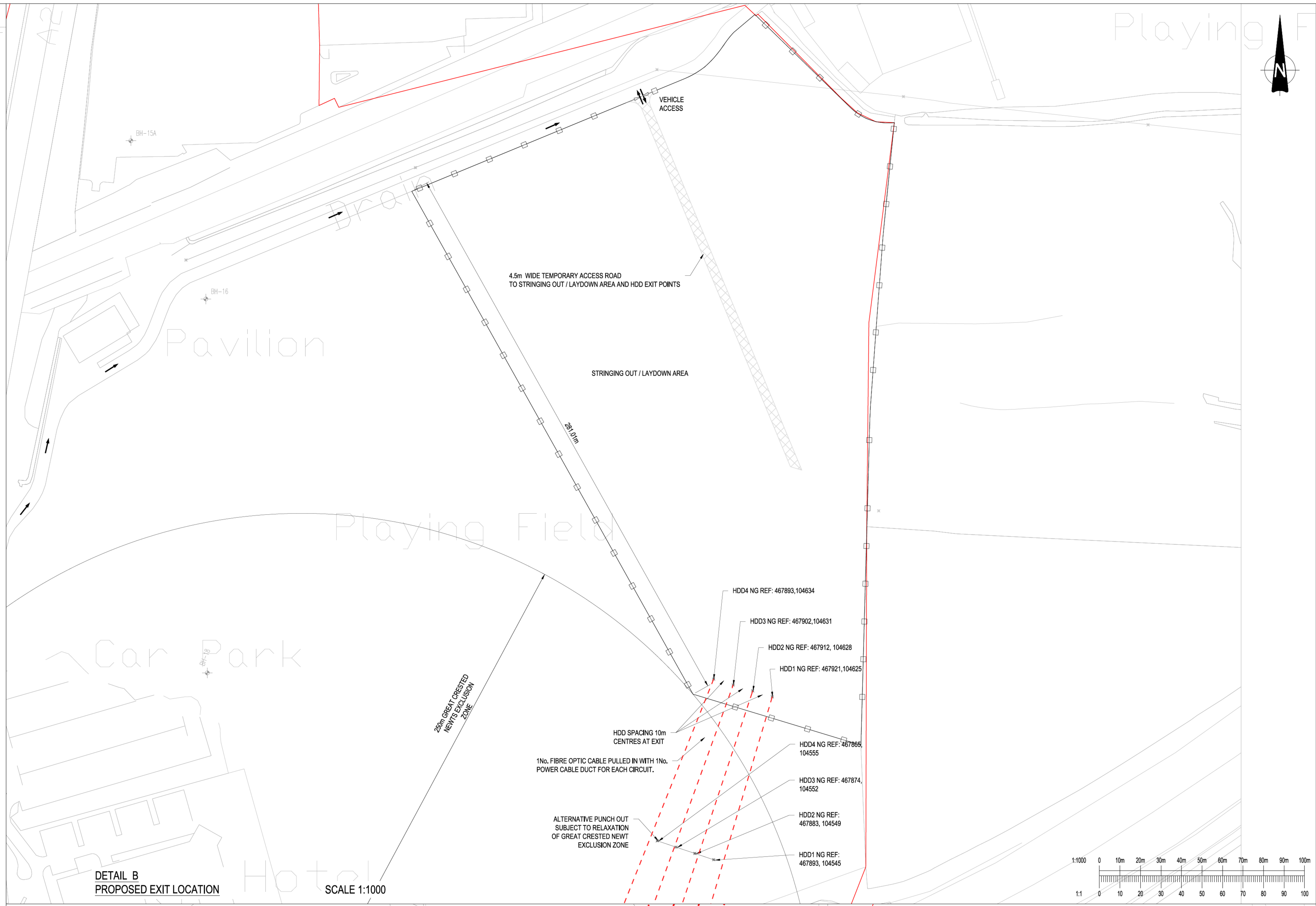
GEO-5	Adverse Heave	CON	Greater than 5mm differential displacement of the A27 carriageway	5	3	I	C, T, R, HS	Should the requirement of real time monitoring be in place - The A27 crossing HDD drilling will stop if heave is identified at a differential ± 5mm. Appropriate measures to reduce heave will be undertaken. Confirmed by monitoring over the 1.2km of HDD alignment prior to the A27 crossing. Ensuring that the down hole drilling fluid pressures do not exceed the prevailing overburden pressures.	2	1	N	Contractor	Negligible
GEO-6	Adverse settlement	CON	Greater than 5mm differential displacement of the A27 carriageway	5	3	I	C, T, R, HS	Should the requirement of real time monitoring be in place - The A27 crossing HDD drilling will stop if settlement is identified at a differential ± 5mm. Appropriate measures to reduce settlement will be undertaken. The gradient predicted are insignificant at 4% volume loss. Confirmed by monitoring over the 1.2km of HDD alignment prior to the A27 crossing. Controlled by keeping the annulus filled with drilling fluids.	2	1	N	Contractor	Negligible
GEO-7	Frac Outs / Loss to surface breakout	CON	Loss of carriageway alignment. Ruptures in the carriageway requiring an intervention for repair.	5	3	I	C, T, R, HS	Should the requirement of real time monitoring be in place- The A27 crossing HDD drilling will stop if a frac outs and/or a loss to surface breakout occurs. The route of UK-HDD3B has been carefully selected to ensure it is suitable for the trenchless methodology of HDD. The HDD Contractor will have a person walking the drill alignment as far as reasonably practicable checking for breakout.	2	1	N	Contractor	Negligible
GEO-8	Excessive Volume Loss	CON	Volume loss greater than the worst case 4% loss modelled causing excessive displacements (>5mm) at the A27 carriageway	5	3	I	C, T, R, HS	Real time monitoring in place - The A27 crossing HDD drilling will stop if heave or settlement is identified at a differential ± 5mm. Appropriate measures to reduce settlement or heave will be undertaken. HDD construction relies on the drilling fluid to provide support to the excavated bore prior to installation of the permanent ducts and final grouting of the bore. Control of the drilling fluid pressures and volumes is therefore important to minimise volume losses.	2	1	N	Contractor	Negligible
GEO-9	Unexpected ground conditions	CON	The geology is significantly different to that found in BH18 and BH19 impacting above ground assets and affecting productivity.	5	3	I	C, T, R, HS	Whilst boreholes BH18 and BH19 are not directly on the alignment of the HDD, the geology in the vicinity is highly unlikely to vary significantly from that identified. Based on the depth of the HDD, it is considered highly unlikely that the HDD will not be in Chalk.	2	1	N	Contractor	Negligible

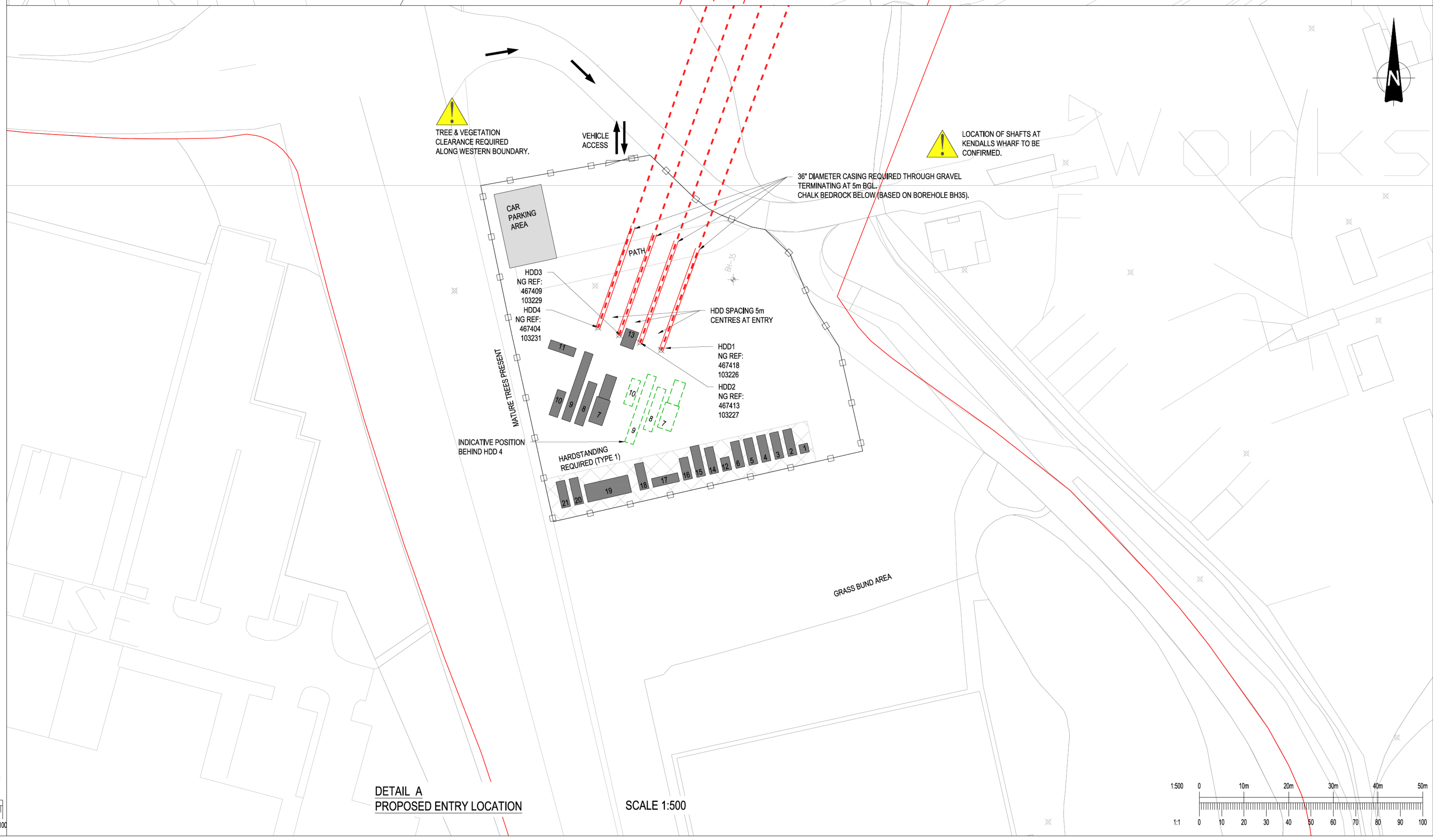
GEO-10	Ground and/or Groundwater contamination	CON	Potential risk to health and environment from contaminated materials or water.	4	3	S	C, T, R, HS, E	Contamination is highly unlikely to affect the immediate A27 HDD crossing, based on the depth of the bores. Spoil and fluid returns will be managed by the Contractor at the entry and exit pits.	2	2	N	Contractor	Negligible
GEO-11	High groundwater in excavations	CON	Inundation of launch and reception chambers, potential collapse of excavations resulting in risk to personnel	5	3	S	C, T, R, HS, E	Contractor to consider use of groundwater exclusion methods i.e. sheet pile cut-off or control by pumping.	5	1	T	Contractor	Tolerable
GEO-12	Potential for deviation of the HDD	CON	Break-out of HDD through the A27 Embankment and/or the A27 carriageway.	3	2	T	C, T, R, HS, E, M	The position of the drill is real-time monitored by directional guidance equipment (gyroscopic steering tool, itself is accurate to within millimetres) positioned behind the steerable drilling assembly. The steering downhole assembly accuracy is +/-500mm. The accurate position of the bore is known at all times, the HDD will not pass under the A27 if it is not in the correct elevation or alignment. A trigger for a stop will be set at +/- 750mm.	1	2	N	Contractor	Negligible

Appendix A

SITE LOCATION AND SITE LAYOUT PLANS







NOTES:

1) LAYOUT BASED ON DRILLING FROM ON-SHORE TO OFF-SHORE, AND THEN PULLING DUCT FROM OFF-SHORE TO ON-SHORE.

2) DUCT WILL REQUIRE TO BE FABRICATED OFF-SITE, AND FLOATED TO OFF-SHORE PULL IN POINT.

3) LAYOUTS ARE BASED ON PRELIMINARY HDD DESIGN ONLY. HDD DESIGN WILL REQUIRE TO BE FINALISED IN CONJUNCTION WITH CONFIRMATION OF ALL GROUND & GEOTECHNICAL INFORMATION, SERVICES CONSTRAINTS, DUCT SPECIFICATION AND FULL HDD DESIGN CALCULATIONS.

4) ENVIRONMENTAL LICENSES AND APPROVALS MAY BE REQUIRED, AND ARE NOT CONSIDERED WITHIN THE PROPOSED LAYOUTS.

KEY:
1. 50 KVA GENERATOR 2M X 2M
2. TOILET BLOCK 6M X 2M
3. DRY/CHANGE ROOM 6M X 2M
4. CANTEEN 6M X 2M
5. OFFICE 6M X 2M
6. OFFICE 6M X 2M
7. 21 TON TRACKED 360 EXCAVATOR
8. DRILL PIPE STORAGE 10M X 2M
9. HDD DRILL RIG 16M X 2M
10. POWER PACK 6M X 2M
11. CONTROL CABIN 6M X 2M
12. MUD LAB 3M X 2M
13. MUD ENTRY PIT 3M X 4M
14. HIGH PRESSURE MUD PUMP 6M X 2M
15. MUD MIXING TANK 7M X 2M
16. 350 KVA GENERATOR 5M X 2M
17. RECYCLING UNIT 6M X 2M
18. WATER STORAGE TANK 6M X 2M
19. DRY DRILLING FLUID STORAGE 4M X 10M
20. WORKSHOP 6M X 2M
21. STORES 6M X 2M

KEY:

PROPOSED HDD ALIGNMENT

SECURITY FENCING

STOCKTON

A01	06.06.19	FINAL FEASIBILITY ISSUE	KK
P05	08.05.19	HDD ENTRY POSITIONS MOVED TO THE WEST AT THE REQUEST OF THE CLIENT	KK
P04	16.11.18	ENTRY POSITION MOVED AND ALTERNATIVE PUNCH OUT LOCATION OPTION ADDED. RE-ISSUED FOR INFORMATION.	MC
P03	24.10.18	DETAIL B SECURITY FENCING AMENDED	KK
P02	22.10.18	BELLMOUTH ADDED TO TEMPORARY ACCESS ROAD	KK
P01	19.10.18	ISSUED FOR INFORMATION	KK

AQUIND

UK-HDD-3B
(PORTSEA ISLAND TO MAINLAND)
PROPOSED SITE LAYOUT

STOCKTON DRILLING LIMITED

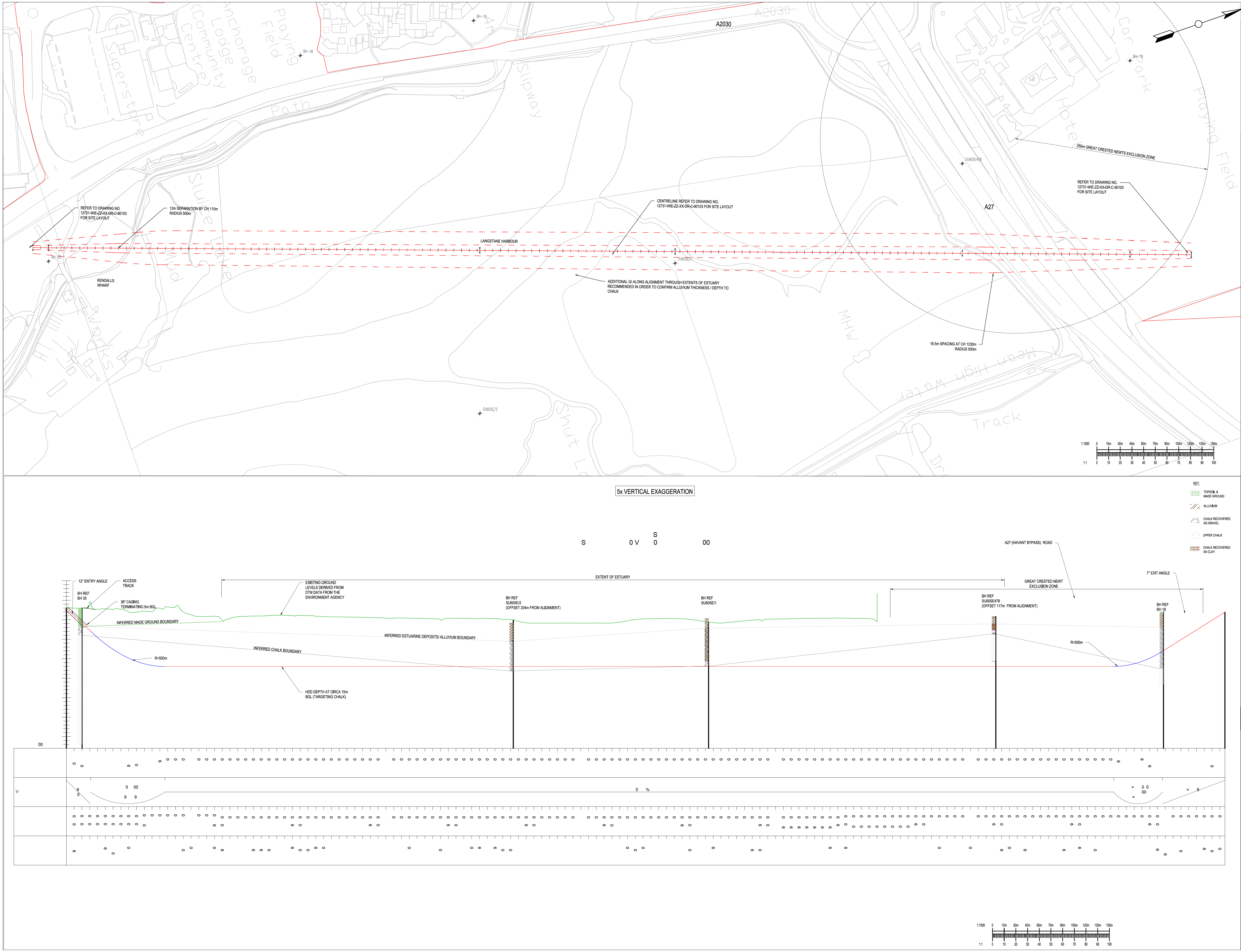
S B Y

MD	CG	Stockton
KK	17.10.18	AS SHOWN

12731-WIE-ZZ-XX-DR-C-90102 A01

12731-WIE-ZZ-XX-M2-C-80001-GI, 12731-WIE-ZZ-XX-M2-C-OS XREF, A0-Wat-BS-S, ACAD-Alignment HDD3-Model, UK-HDD3_Site_Compound

N:\Projects\WIE12731_Stockton_HDD\111 - Aquind\7_CAD\90\



NOTES:

1) HDD PROFILE IS BASED ON PRELIMINARY HDD DESIGN ONLY. HDD DESIGN WILL REQUIRE TO BE FINALISED IN CONJUNCTION WITH CONFIRMATION OF ALL GROUND & GEOTECHNICAL INFORMATION, SERVICES CONSTRAINTS, DUCT SPECIFICATION AND FULL HDD DESIGN CALCULATIONS.

2) ENVIRONMENTAL LICENSES AND APPROVALS MAY BE REQUIRED, AND ARE NOT CONSIDERED WITHIN THE PROPOSED LAYOUTS.

STOCKTON

A01	06.06.19	FINAL FEASIBILITY ISSUE	KK
P02	08.05.19	ALIGNMENT UPDATED TO SUIT HDD ENTRY LOCATIONS	KK
P01	10.01.18	ISSUED FOR INFORMATION	KK

AQUIND

UK-HDD-3B (PORTSEA ISLAND TO MAINLAND) PROPOSED HDD PLAN & SECTION

STOCKTON DRILLING LIMITED

S B Y

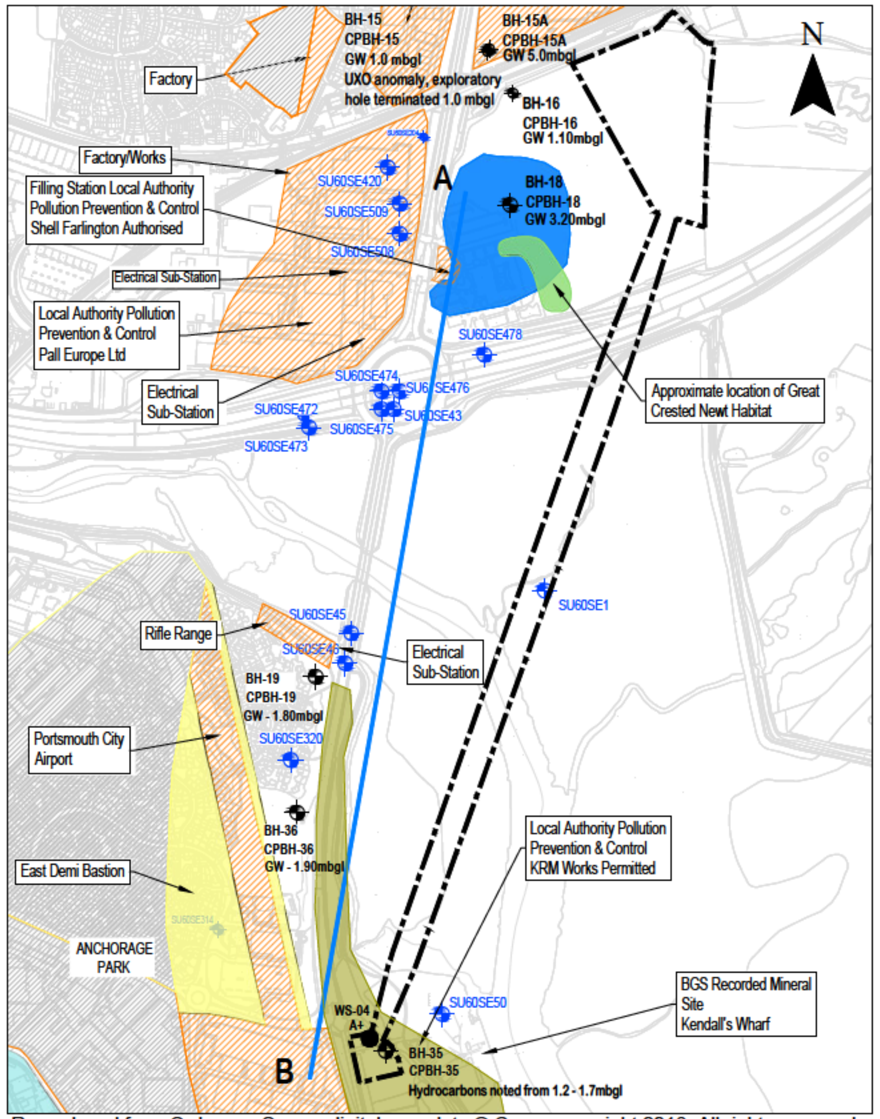
MD	CG	WIE12731
KK	17.10.18	AS SHOWN

12731-WIE-ZZ-XX-DR-C-90302 A01

102735_Contours_AL5K_OSGB, 12731-WIE-ZZ-XX-M2-C-60001-GI, 12731-WIE-ZZ-XX-M2-C-OS XREF, A0-Wat-BS-S, HDD ALIGNMENT 3Alignment HDD3-Model, UK-HDD3_Site_Compound

N:\Projects\WIE12731_Stockton_HDD\111 - Aquind\7_CAD\90\

File name \\UK.WSPGROUP.COM\CENTRAL DATA\PROJECTS\62100XXX\62100616 - AQUIND VO NO.3\E MODELS AND DRAWINGS\300 - SITE\320 - TASK 7 UK ROUTE\GEOTECHNICAL REV E\DRAWINGS\CURRENT\GI SPEC\ROUTE 3D GI AS DUG\UK HDD CROSS SECTIONS REV 2.DWG, printed on 25 October 2019 10:26:34, by Appleby, Sue



CONSTRAINT PLAN EXTRACT

SCALE 1:12 500

SATELLITE IMAGE OF HDD LOCATION (2017)

CONSTRAINTS KEY

- SU61SE14 HISTORICAL BOREHOLE LOCATION
- HISTORICAL INFILLED POND
- HISTORICAL LANDFILL
- HISTORICAL INDUSTRIAL LAND USE
- ASSUMED HISTORICAL INDUSTRIAL LAND USE
- ARCHAEOLOGICAL FEATURE
- ASSUMED ARCHAEOLOGICAL FEATURE
- RECLAIMED LAND
- A+ PROVEN PRESENCE OF ASBESTOS THROUGH LABORATORY TESTING

GEOLOGY KEY

- INFERRED GEOLOGY BOUNDARY
- ? GROUND CONDITIONS SHOWN BETWEEN EXPLORATORY HOLES ARE INFERRED AND ARE ILLUSTRATIVE ONLY
- TARMAC
- MADE GROUND
- BEACH AND TIDAL FLAT DEPOSITS
- RIVER TERRACE DEPOSITS (COHESIVE)
- CHALK - Dm
- CHALK - Dc
- STRUCTURED CHALK

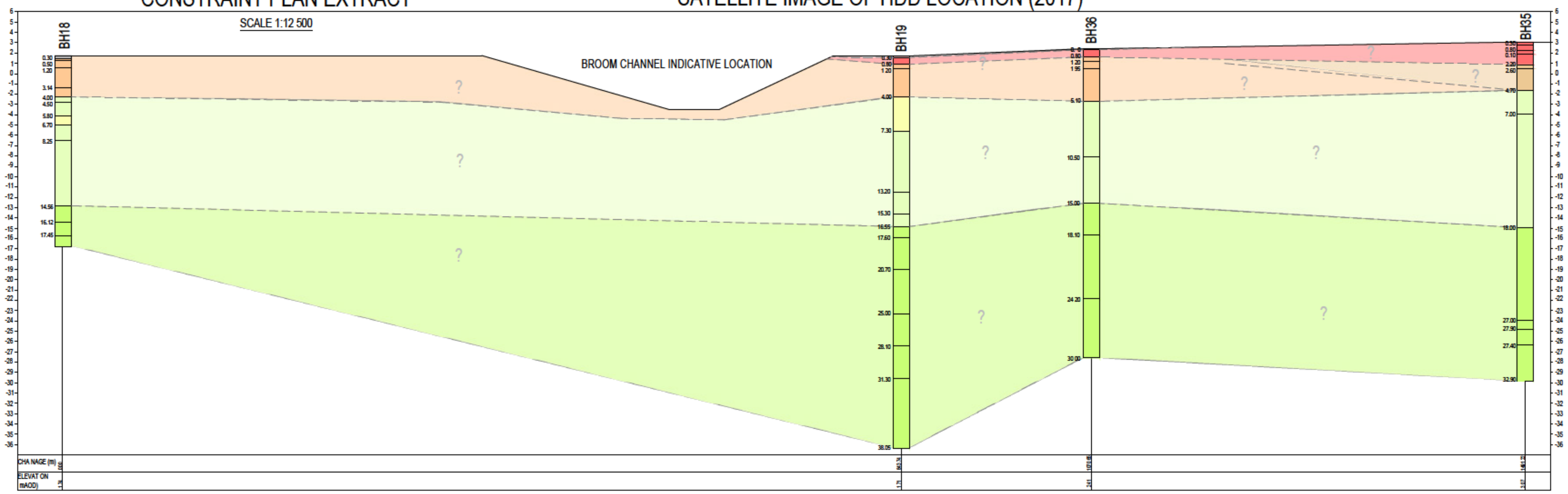
KEY

DO NOT SCALE

- BH-01 CPBH-01 BOREHOLE AND CPT LOCATION AND NUMBER
- WS-01 WINDOW SAMPLE LOCATION AND NUMBER
- A–B SECTION LINE
- INDICATIVE UK-HDD3B ZONE TYPICALLY CONSIST OF ENTRY AND EXIT PIT, LAYDOWN AREA AND CABLE ARRAY OF TWO CABLE PAIRS. PLEASE REFER TO TABLE 1-2 FOR DATA SOURCE REFERENCE
- GW GROUNDWATER

	BH18	BH19	BH36	BH35
EASTING (m)	467643	467321	467290	467437
NORTHING (m)	104638	103858	103633	103234
mAOD	1.740	1.710	2.410	3.070
DISTANCE AND DIRECTION OF SECTION LINE	76m EAST	106m WEST	97m WEST	116m EAST

REV	DATE	BY	DESCRIPTION	CHK	APP
01	10/10/2019	SA	FINAL ISSUE	TM	TM



INDICATIVE GEOLOGICAL SECTION

SCALE 1:2500 HORIZ 1:500 VERT

ALL FEATURES, DIMENSIONS, SLOPES AND GROUND LEVELS ARE ILLUSTRATIVE ONLY. IT SHOULD BE NOTED THAT GROUND CONDITIONS SHOWN BETWEEN EXPLORATORY HOLES ARE INFERRED AND ARE ILLUSTRATIVE ONLY; THEY MAY OR MAY NOT REPRESENT CONDITIONS THAT MAY BE ENCOUNTERED

DRAWING STATUS: FINAL

wsp

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wsp.com

CLIENT: AQUIND

ARCHITECT:

PROJECT: UK - FRANCE INTERCONNECTOR

TITLE: UK CABLE ROUTE UK-HDD 3B

SCALE @ A3: 1:5000	CHECKED: TM		APPROVED: TM
PROJECT No: 70019402	DESIGNED: JK	DRAWN: SMA	DATE: October 19

DRAWING No: 70019402-WSP-HGT-G-DR-GE-0117 REV: 01

Appendix B

BOREHOLE LOGS

BOREHOLE RECORD - Dynamic Sampler and Rotary

Project	UK - FRANCE HVDC INTERCONNECTOR - PACKAGE 2	Engineer	WSP
Borehole	BH18	Project No	PE181481
Client	AQUIND LIMITED	National Grid Coordinates	467642.56 E 104637.71 N
Ground Level	1.74 m OD	Scale	1:50

Sampling / Properties

Depth	Sample Type	Depth Cased & (to Water)	Strength kPa	w %	SPT N (FI)
0.30	B				
0.30	ES				
0.50	B				
0.50	ES				
1.00	ES				
1.20	B				
1.20- 1.65	D	(Dry)			S12
1.50	D			16	
1.60- 2.00	B				
2.00	E				
2.30- 2.75	#	(Dry)			S8
2.30- 2.80	B				
2.90	D			16	
3.20	D			17	
3.40- 4.00	UT	(3.20)	63	21	
4.30	D			21	
4.80	D				
5.10- 5.55	D	(3.20)			S12
5.60- 6.70	B				
6.00	D			21	
6.50	D				
6.70- 7.80	B				
6.70- 7.15	D	5.60 (5.70)			S30
7.50	D			21	
7.80- 8.25	D	5.60 (5.70)			S64
8.25- 9.65	B				

Strata

Description	Depth	Level m OD
	G.L.	1.74
TOPSOIL Dark brown slightly sandy gravelly SILT. Sand is fine, gravel is subangular to subrounded chert and siltstone, frequent rootlets.	0.30	1.44
Light brown slightly sandy slightly gravelly SILT. Gravel is subangular to subrounded fine to coarse flint, chert and sandstone.	0.50	1.24
Yellowish brown slightly sandy GRAVEL. Gravel is subangular to subrounded fine to coarse flint, chert and sandstone. Sand is fine.	1.20	0.54
Very stiff orange brown slightly sandy slightly gravelly CLAY. Gravel is angular to subrounded fine to coarse flint and subrounded to rounded fine to medium weak low density white chalk. Occasional cobbles of flint. At 2.00m, Very gravelly, gravel dominated by chalk, flints becoming rare. At 3.00m, Slightly gravelly.	3.14 ▽	-1.40
Firm to stiff light grey clayey SILT.	4.00	-2.26
White silty subangular to rounded fine to coarse GRAVEL. Gravel is weak low density white chalk. Matrix is of pale brown silt. Grades into unit below. At 4.28m, Cobble of flint.	4.50	-2.76
CHALK, recovered as white silty subangular to rounded fine to coarse GRAVEL. Gravel is weak low density white chalk. (Grade Dc) 4.70m to 4.75m, Rare coarse gravel size flints. Between 5.60m and 5.80m, No recovery.	5.80	-4.06
CHALK, recovered as very stiff white gravelly SILT. Gravel is subangular to subrounded fine to coarse weak medium density white chalk and, rarely, subangular to subrounded fine to coarse flint. (Grade Dm)	6.70	-4.96
CHALK, recovered as white subangular to subrounded fine to coarse silty GRAVEL. Gravel is of weak becoming medium strong, medium density white chalk and, rarely, medium to coarse flint. (Grade Dc) At 7.35m, Occasional chalk cobbles.	8.25 ▽	-6.51

Continued by Rotary techniques

Core Run/Depth (Core Dia/Time)	Depth Cased	TCR/SCR / Type	Length Max/Min	RQD %	SPT (FI)	General	Detail
8.25- 9.65 (93mm) 8.83- 8.92 9.00	8.25	100 0 C D		0		Structureless CHALK, composed of silty subangular to subrounded fine to coarse GRAVEL and COBBLES. Clasts are weak medium density white. Matrix is white. Rare angular to subangular medium to coarse flint gravel. (Grade Dc).	At 8.25m, chalk remains structureless, with sections of competent core. Between 8.83m to 8.92m, recovered as competent core, not full circumference.
9.65-11.15 (93mm) 9.65-11.15	8.25 (1.40)	100 0 B		0			

Boring

Depth	Hole Dia	Technique	Crew
1.20	0.30	Inspection Pit	ADS
8.25	0.10	Dynamic Sampler	ADS
18.50	0.12	Rotary Core	ADS

Progress

Depth of Hole	Depth Cased	Depth to Water	Date	Time
G.L.			18/09/18	08:00
8.20	8.25		18/09/18	18:00
8.20	8.25	1.40	19/09/18	08:00
18.50	18.50		19/09/18	18:00

Groundwater

Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater
3.20					
8.25					

Remarks

Inspection pit hand excavated to 1.20m depth and no services were found.
Scanning for UXO carried out by CPT Magnetometer probe prior to drilling commencing.
Aquifer protection was undertaken by installing a 1.00m thick bentonite seal at 3.50m depth and reducing casing diameter to 140mm.
The Borehole was terminated at a depth of 18.50m on the instruction of WSP.
A downhole diver/datalogger was installed within the standpipe on 27th November to monitor water levels over a 6month period.
A 50mm standpipe piezometer was installed to 4.50m with a slotted section from 1.00m to 4.50m with flush lockable protective cover. Backfill details from base of hole: bentonite

Symbols and abbreviations are explained on the accompanying key sheet.
All dimensions are in metres.
Logged in accordance with BS5930:2015

Logged by MK
Checked by HLD
Figure 1 of 2
16/04/2019

geotechnics

BOREHOLE RECORD - Dynamic Sampler and Rotary

Project	UK - FRANCE HVDC INTERCONNECTOR - PACKAGE 2	Engineer	WSP
Borehole	BH18	Project No	PE181481
Client	AQUIND LIMITED	National Grid Coordinates	467642.56 E 104637.71 N
Ground Level	1.74 m OD	Scale	1:50

Drilling / Properties/Sampling

Core Run/Depth (Core Dia/Time)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %	SPT N (FI)
10.31-10.36		C			(NA)
10.90		D			
11.02-11.15		C			
11.25-12.75 (93mm)	11.25	90 0		0	
11.25-12.75		B			
11.90		D			
12.01-12.16		C			
					(AZCL)
12.75-14.25 (93mm)	11.25	100 0		0	
12.75-14.25		B			
13.50		D			(NA)
14.25-15.85 (93mm)	14.25	100 15		15	
14.55-14.68		C			
14.56-15.52		B			
14.68-14.81		D			(12)
15.40		D			
15.85-17.45 (93mm)	14.25	100 6		6	
15.85-17.45		B			
16.57-16.70		C			(NI)
16.80		D			
17.45-18.45 (93mm)	14.25	100 36		0	
17.45-18.45		B			
17.60		D			(10)
18.40		D			

Strata

Description General	Description Detail	Depth	Legend	Level m OD
	Between 11.15m and 11.25m, No recovery. Between 11.44m and 11.54m, competent core, showing joint: subvertical, planar, smooth, clean. Between 12.40m and 12.60m, Competent chalk, recovered non-intact. Between 13.07m and 13.13m, Recovered as competent core, showing joint: 40 deg, planar, smooth, clean.	14.56		-12.82
Medium strong medium density white CHALK. Fractures are subhorizontal to 30 deg, very closely spaced (20, 40, 60), planar, smooth, clean, and rarely subvertical, planar, smooth, clean. Occasional pale brown staining on surfaces. Frequent drilling breaks. (Grade A4)		16.12		-14.38
Medium strong medium density white CHALK. Non-intact.	Between 16.12m and 17.45m, core is competent but heavily broken. Evidence of subhorizontal to 20 deg and subvertical to 70 deg, very closely spaced joints, planar rough or smooth clean commonly with pale brown staining on surfaces, occasionally with <1mm green clay infill.	17.45		-15.71
Medium strong medium density white CHALK. Fractures are subhorizontal to 70 deg, very closely spaced (10, 20, 40), planar, smooth, clean, and rarely subvertical, planar, smooth, clean. Occasional pale brown staining on surfaces. Frequent drilling breaks. (Grade A4)		18.50		-16.76

End of Borehole

Drilling				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks: seal up to 4.50m, gravel filter up to 1.00m, bentonite seal up to 0.20m, concrete up to ground level.

Symbols and abbreviations are explained on the accompanying key sheet.

All dimensions are in metres.

Logged in accordance with BS5930:2015

Logged by MK
Checked by HLD
Figure 2 of 2
16/04/2019

geotechnics

BOREHOLE RECORD - Dynamic Sampler and Rotary

Project	UK - FRANCE HVDC INTERCONNECTOR - PACKAGE 2	Engineer	WSP
Client	AQUIND LIMITED	National Grid Coordinates	467321.01 E 103857.80 N
Borehole	BH19	Project No	PE181481
Ground Level	1.71 m OD	Scale	1:50

Sampling / Properties

Depth	Sample Type	Depth Cased & (to Water)	Strength kPa	w %	SPT N (FI)
0.15- 0.30	B				
0.30- 0.40	B				
0.40- 0.80	B				
1.10- 1.20	B				
1.20- 1.65	UT				
1.90- 2.05	D				
2.40- 3.75	B				
2.60- 2.75	D				
2.75- 2.90	D				
2.90- 3.35	D	(1.80)			S22
3.75- 3.90	D				
4.00- 4.45	D	4.00 (Dry)			S15
4.60- 4.80	D				
4.95- 5.10	D				
5.10- 5.55	#	4.00 (Dry)			S27
5.20- 7.15	B				
5.90- 6.05	D				
6.05- 6.20	D				
6.20- 6.65	D	4.00 (1.80)			S11
7.15- 7.30	D				
7.30- 7.75	D	4.00 (1.80)			S16
8.00- 9.50	B				
8.35- 8.50	D				
8.50- 8.60	D				
8.60- 9.05	D	7.50 (1.80)			S8
9.50- 9.70	D				
9.70-10.15	#	7.50 (1.80)			S10

Strata

Description	Depth	Level m OD
	G.L.	1.71
TOPSOIL: Grass over firm slightly sandy gravelly clay with many rootlets. Gravel is subangular to subrounded various lithologies including chert.	0.15	1.56
MADE GROUND: Stiff light brown slightly sandy gravelly clay with occasional fragments of brick, metal and plastic. Gravel is subangular to subrounded various lithologies including chert.	0.80	0.91
Firm greyish brown slightly sandy locally sandy slightly gravelly CLAY. Gravel is subangular fine to coarse chert.	1.20	0.51
Firm to stiff light bluish grey mottled yellowish brown and white slightly sandy slightly gravelly CLAY. Gravel is subrounded fine chalk. At 1.85m, Angular coarse chert. At 2.00m, Becoming gravelly to very gravelly. Gravel is subangular to subrounded fine to medium chalk and angular to subangular fine to coarse flint. At 2.90m, Becoming very stiff.	4.00	-2.29
CHALK, recovered as creamy white slightly sandy slightly gravelly SILT. Gravel is very weak medium density white subangular occasional angular to subangular fine to medium flint gravel. (Grade Dm). At 5.70m, Becoming more off white in colour. At 6.90m, Becoming gravelly.	7.30	-5.59
CHALK, recovered as slightly sandy silty locally very silty subangular GRAVEL. Clasts are very weak medium density white. Matrix is off white with some slight yellowish discolouration, occasional angular to subangular fine to medium flint gravel. (Grade Dc). From 9.00m, Clasts are very weak and weak medium and high density. At 9.60m, Heavily stained orangish brown.		

Boring / Progress / Groundwater

Depth	Hole Dia	Technique	Crew
1.20	0.30	Inspection Pit	ADS
13.20	0.14	Dynamic Sampler	ADS
38.05	0.12	Rotary Core	ADS

Depth of Hole	Depth Cased	Depth to Water	Date	Time
G.L.			26/09/18	08:00
9.70	10.20		26/09/18	18:00
9.70	10.20		27/09/18	08:00
25.00	16.20		27/09/18	18:00
25.00	16.20		01/10/18	08:00
38.05	16.20		01/10/18	18:00

Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater
1.80					
5.40			20		

Remarks

Inspection pit hand excavated to 1.20m depth and no services were found.
Scanning for UXO carried out by CPT Magnetometer probe prior to drilling commencing.
Aquifer protection was undertaken by installing a 1.00m thick bentonite seal at 2.50m depth and reducing casing diameter to 140mm.
A downhole diver/datalogger was installed within the standpipe on 27th November to monitor water levels over a 6month period.
A 50mm standpipe piezometer was installed to 5.00m with a slotted section from 1.00m to 5.00m with flush lockable protective cover. Backfill details from base of hole: bentonite seal up to 5.00m, gravel filter up to 1.00m, bentonite seal up to 0.50m, concrete up to

Symbols and abbreviations are explained on the accompanying key sheet.
All dimensions are in metres.
Logged in accordance with BS5930:2015

Logged by JJ
Checked by HLD
Figure 1 of 4
16/04/2019

geotechnics

BOREHOLE RECORD - Dynamic Sampler and Rotary

Project	UK - FRANCE HVDC INTERCONNECTOR - PACKAGE 2	Engineer	WSP
Borehole	BH19	Project No	PE181481
Client	AQUIND LIMITED	National Grid Coordinates	467321.01 E 103857.80 N
Ground Level	1.71 m OD	Scale	1:50

Sampling / Properties / Strata

Depth	Sample Type	Depth Cased & (to Water)	Strength kPa	w %	SPT N (FI)	Description	Depth	Level m OD
						Between 10.20 and 10.50m, Occuring as silty gravelly sand.		
10.50-12.80	B					At 10.60m, Becoming silty locally slightly silty.		
						Between 11.20 and 11.30m, Subangular coarse flint gravel.		
11.50-11.70	D							
11.70-12.15	D	10.20 (1.10)			S22	Between 11.70 and 12.10m, Very silty probable due to drilling process of SPT.		
12.80-13.00	D							
13.00-13.20	D							
13.20-13.65	D	10.20 (2.00)			S42		13.20	-11.49

Continued by Rotary techniques

Core Run/Depth (Core Dia/Time)	Depth Cased	TCR/SCR / Type	Length Max/Min	RQD %	SPT (FI)	General	Detail	Depth	Level m OD
13.20-14.70 (93mm)	13.20 (1.15)	13 0		0	(AZCL)	Structureless CHALK composed of slightly sandy silty and very silty subangular GRAVEL. Clasts are very weak medium density white. Matrix is off white. Many angular to subangular fine to coarse flint gravel. (Grade Dc).			
14.50-14.70		D			(NA)				
14.70-16.00 (93mm)	13.20 (1.15)	81 0		0	(AZCL)				
14.95		D			(NA)			15.30	-13.59
15.70		D			(NI)	Very weak medium density off white unstained CHALK. No describable fracture sets - non intact. (Grade Dc).			
					(NR)				
16.20-17.60 (93mm)	16.20 (1.10)	75 24		0	(AZCL)				
16.55-16.65		C			(43)	Very weak and weak medium and high density off-white CHALK. Fractures are 1) subhorizontal, spacing unclear clean or infilled (0/10/10) with comminuted chalk sometimes slight yellowish staining. 2) subvertical, spacing unknown clean. Drilling induced fractures are of various orientations closely locally extremely closely spaced (2/10/80) clean. (Grade C5).	Subangular to angular fine flint gravel at 16.55 and 17.10m.	16.55	-14.84
17.30-17.40		C						17.60	-15.89
17.60-19.10 (93mm)	16.20 (1.20)	93 70		14	(AZCL)				
18.12-18.25		C			(19)				
18.80-18.88		C			(NI)	Weak high density off white CHALK. Fractures are set 1) Subhorizontal closely spaced (70/100/220) clean sometimes with grey staining. Set 2) Dipping 70 to 90 degrees spacing unknown with grey staining and	At 17.70m, Drilling induced fractures are locally extremely to very closely spaced (2/50/250) clean angular to subangular fine to coarse flint gravel.		
19.10-20.70 (93mm)	16.20 (1.20)	100 78		10					
19.82-20.05		C			(16)				

Boring				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks ground level.

Symbols and abbreviations are explained on the accompanying key sheet.
All dimensions are in metres.
Logged in accordance with BS5930:2015

Logged by JJ
Checked by HLD
Figure 2 of 4
16/04/2019

geotechnics

BOREHOLE RECORD - Dynamic Sampler and Rotary

Project	UK - FRANCE HVDC INTERCONNECTOR - PACKAGE 2	Engineer	WSP
Borehole	BH19	Project No	PE181481
Client	AQUIND LIMITED	National Grid Coordinates	467321.01 E 103857.80 N
Ground Level	1.71 m OD	Scale	1:50

Drilling / Properties/Sampling

Core Run/Depth (Core Dia/Time)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %	SPT N (FI)
20.14-20.32		C			
20.70-22.30 (93mm)	16.20 (1.15)	94 78		56	(AZCL)
20.80-21.00		C			
21.84-22.07		C			
22.30-23.90 (93mm)	16.20 (1.15)	100 97		46	(10)
22.30-22.60		C			
23.30-23.60		C			
23.90-25.00 (93mm)	16.20 (1.10)	100 88		54	
24.12-24.26		C			
24.46-24.66		C			
25.00-26.60 (93mm)	16.20 (1.30)	91 81		30	(AZCL)
25.75-26.15		C			
26.40-26.52		C			
26.60-28.10 (93mm)	16.20 (1.30)	100 83		45	(11)
26.80-27.10		C			
27.18-27.38		C			
27.70-27.80		C			
28.10-29.60 (93mm)	16.20 (1.30)	100 95		72	(6)
29.60-31.10 (93mm)	16.20 (1.30)	97 77		45	

Strata

Description General	Description Detail	Depth	Legend	Level m OD
black specks. (Grade A3).	At 19.10 to 19.70m, Drilling induced fractures are locally extremely to very closely spaced (2/50/250) clean angular to subangular fine to coarse flint gravel. At 20.05m, Unidentified 3mm diameter burrowing structure present.	20.70		-18.99
Weak high density off white CHALK with orangish brown staining present. Fractures are set 1) Subhorizontal closely and medium spaced (100/200/320) clean rarely infilled (0/15/20) with extremely weak coarse chalk and heavy grey staining. Set 2) Subvertical spacing unknown clean. (Grade A2)	Between 21.55m and 24.80m, Drilling induced fractures due to flints. Subangular to subrounded fine to coarse flint gravel.	25.00		-23.29
Weak high density off white CHALK. Fractures are set 1) Subhorizontal closely spaced (70/100/220) clean sometimes with grey staining. Set 2) Dipping 70 to 90 degrees spacing unknown with grey staining and black specks. (Grade A3).	Between 25.75m and 26.20m Subhorizontal fractures infilled with discoloured grey comminuated chalk. Between 26.15 and 26.40m, 1 no subvertical fracture rough undulating and clean possibly drilling induced.	28.10		-26.39
Medium strong medium to high density off white unstained CHALK. Fractures are subhorizontal medium spaced (180/280/460) clean occasionally discoloured grey or orangish brown. (Grade A2).	Between 29.25 and 29.33m, Communiated slightly clayey chalk gravel with slight grey discolouration.			

Drilling: Depth	Hole Dia	Technique	Crew	Progress: Depth of Hole	Depth Cased	Depth to Water	Date	Time	Groundwater: Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks

Symbols and abbreviations are explained on the accompanying key sheet.

All dimensions are in metres.

Logged in accordance with BS5930:2015

Logged by JJ
Checked by HLD
Figure 3 of 4
16/04/2019

geotechnics

BOREHOLE RECORD - *Dynamic Sampler and Rotary*

Project	UK - FRANCE HVDC INTERCONNECTOR - PACKAGE 2	Engineer	WSP	Borehole Project No	BH19 PE181481
Client	AQUIND LIMITED	National Grid Coordinates	467321.01 E 103857.80 N	Ground Level	1.71 m OD

Drilling / Properties/Sampling

Core Run/Depth (Core Dia/Time)	Depth Cased & (to Water)	Type TCR/SCR%	Length Max/Min	RQD %	SPT N (FI)
					(16)
					(AZCL)
31.10-32.65 (93mm)	16.20 (1.30)	96 73		46	
31.30-31.70		C			
31.70-31.90		C			(5)
31.90-32.16		C			
32.16-32.40		C			
32.65-34.15 (93mm)	16.20 (1.30)	70 100		100	
33.00-33.14		C			
33.14-33.31		C			
33.31-33.53		C			(5)
33.52-33.72		C			
33.73-33.87		C			
33.87-34.03		C			
34.15-35.55 (93mm)	16.20 (1.30)	98 81		78	
34.15-34.25		C			
34.45-34.65		C			
34.65-34.93		C			(8)
34.93-35.05		C			
35.15-35.25		C			
35.25-35.47		C			
35.47-35.54		C			
35.55-36.55 (93mm)	16.20 (1.30)	100 73		50	
35.65-35.75		C			
35.85-36.15		C			(7)
36.35-36.45		C			
36.55-38.05 (93mm)	16.20 (1.30)	100 78		63	
36.55-36.75		C			
36.75-37.00		C			
37.00-37.06		C			
37.06-37.14		C			(7)
37.25-37.48		C			
37.56-37.64		C			
37.68-37.78		C			
37.99-38.05		C			
38.05-38.33		D			S60/ 170

Strata Scale 1:50

Description General	Description Detail	Depth	Legend	Level m OD
	At 30.35m, Subhorizontal fracture with heavily grey discoloured communiated chalk infill (2mm) 30mm penetration into rock. Between 30.45 and 31.10m, 1 no subvertical fracture clean and unstained with occasional very closely and closely spaced drilling induced fractures.	31.30		-29.59
Moderately strong medium to high density off white unstained CHALK. Fractures are closely and medium spaced (100/200/300) frequently clean occasional infilled (0/1/3) with comminuted chalk and flint. (Grade B2-3).	Between 31.70m and 32.00m, Shallow <10 degree fractures. At 32.16m, 10 degree fracture due to cut - open no infill. At 33.31m, Grey silt infill. Between 33.32m and 33.80m , Shallow <10 degree fractures. At 33.72m, Low angle <10 degree fractures - drilling induced closed tight no infill. At 33.88m, 10 degree fracture (due to cut) open, infilled with grey silt. Between 34.26m and 36.80m, Shallow <10 degree fractures. At 37.00m, Subhorizontal fracture (drilling induced). At 37.47m, Subhorizontal fracture (drilling induced). Between 37.53 and 37.57m, Discontinuity at 65 degrees. Between 37.63 and 37.69m, Discontinuity at 60 degrees open planar stepped no infill.	38.05		-36.34
End of Borehole				

Drilling				Progress					Groundwater					
Depth	Hole Dia	Technique	Crew	Depth of Hole	Depth Cased	Depth to Water	Date	Time	Depth Struck	Depth Cased	Rose to	in Mins	Depth Sealed	Remarks on Groundwater

Remarks AGS

Symbols and abbreviations are explained on the accompanying key sheet.
All dimensions are in metres.

Logged in accordance with BS5930:2015

Logged by JJ
Checked by HLD
Figure 4 of 4
16/04/2019

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