A1 in Northumberland: Morpeth to Ellingham

Scheme Number: TR010041

6.8 Environmental Statement – Appendix 11.3 Ground Investigation Report

Part B

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

June 2020

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

The A1 in Northumberland: Morpeth to Ellingham

Development Consent Order 20[xx]

Environmental Statement - Appendix

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CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

As part of improvement works to the A1 between Morpeth and Ellingham, it is proposed to upgrade an 8 km stretch of the A1, Alnwick to Ellingham. This report presents a summary review of the existing information in relation to the scheme together with a review of additional desk study information incorporating the historic and recent ground investigation information together with its associated risks. The scheme has been classed as a Geotechnical Category 2 project.

The proposed scheme involves on-line carriageway widening with the construction of a new access road to farm property. The existing A1 highway is to be widened to the east and the carriageway section to be widened stretches from Ch. 53200 to Ch. 61100. The works will include the construction of two overbridge structures; Heckley Fence and Charlton Mires Bridge, along with a series of upgrades to existing culverts and the drainage system. A series of earthworks and structures will also be constructed along the length of the upgrade. The split and height of the earthworks are based on the October 2018 Design Freeze.

Various phases of ground investigation (GI) have been undertaken over the area of the scheme combining cable percussive, rotary coring and trial pitting, with the most recent GI undertaken in 2018. Some soakaway testing was also undertaken in areas for drainage systems. The GIs have confirmed the proposed route is underlain by discrete areas of Made Ground, comprising both granular and cohesive deposits, and generally encountered as engineered or landscape fill associated with the existing A1 and its associated side roads and infrastructure.

Recent deposits of shallow Alluvium, generally less than 2.0m thick, comprising sand, silt, clay, peat have been proven adjacent to the minor watercourses. These overly extensive deposits of glacial till, glaciolacustrine laminated clays and glacio-fluvial sand and gravels. The predominately cohesive glacial deposits, which are classified as generally firm to stiff, low to intermediate plasticity clays, and are encountered at the surface over most of the study area with thicknesses recorded up to 20m. To the north of Charlton Mires, glacio-fluvial deposits were widespread, and at Charlton Mires and West Linkhall, bedrock was observed to be at considerably greater depth than across the remainder of the site, where the upper surface was encountered up to 20m bgl. Laboratory results show the in-situ cohesive till generally to lie on the wet side of the optimum moisture content.

Local to the notable watercourses that dissect the route, the groundwater levels are fairly high at around 1.5m bgl. Groundwater standpipes installed within the Glacial Deposits recorded groundwater generally at depths of between 1.5 and 3.5m bgl.

The main potential geotechnical hazards at the site are detailed in the geotechnical risk register and on the geohazard plans in an appendix to this report and are considered to be:

- Areas of soft soils;
- Unknown groundwater conditions;
- Intermittent laminated glacio-lacustrine deposits;
- Cobbles and boulders within the glacial till;
- Residual risk of unrecorded coal workings;
- Weak heavily weathered, laminated bedrock;
- Shallow rock/ hard dig material;
- Shortfall of quality fill material;
- Insufficient GI data in discrete locations;
- Determinants within soils which pose a risk to human health and to the environment.

Cuttings will be predominantly formed within the Glacial Till and for both cuttings and embankments, a slope angle of 1v:3h has been proposed for preliminary design to fix the various scheme boundaries for the DCO process.

Various options have been considered for the provision of cost effective solutions for the required structures. Piled foundations are the most likely foundation type at all the overbridge locations with pile lengths ranging between 9m and 20m. Precast concrete box culverts, some encompassing extensions to the existing culverts, will be utilised where watercourses dissect the route and these should be founded within the glacial deposits.

Earthworks drainage will take the form of longitudinal toe drains in cuttings and open drains at the crest of cuttings and toe of embankments. These will be incorporated into a drainage system involving the creation of swales and shallow retention basins and outlet structures. The basins will have side slopes of no steeper than 1v:3h.

Excavated material from cuttings and suitable as general fill for re-use in embankments is likely to be predominantly cohesive Class 2A. The material will likely require some form of treatment to lower the moisture content, i.e. drying or lime/cement stabilisation.

1 INTRODUCTION

1.1 SCOPE AND OBJECTIVE OF THE REPORT

The A1 in Northumberland: Alnwick to Ellingham; known hereafter as 'The Scheme' is part of the Department for Transport's (DfT) Road Investment Strategy (RIS). The A1 Northumberland is the main link road for England to Scotland through Northumberland, linking North East Newcastle to Berwick-upon-Tweed. The purpose of the scheme is to upgrade the A1 north of Newcastle and to increase its capacity to perform as a Route of Strategic National Importance.

The upgrade will comprise the widening of the existing carriageway to the east to create a dual carriageway with the construction of two overbridge structures and an upgrade of the drainage system.

In 2016, Jacobs were employed by Highways England to take the design of the Scheme, according to the Project Control Framework (PCF), to the end of Stage 2 Option development. A Statement of Intent (Ref 2), Preliminary Sources Study Report (Ref 1) and Annex A (Ref 3) were prepared by Jacobs.

In August 2017 WSP were awarded the Highways England task order to progress the Scheme through PCF Stage 3: Preliminary Design and Stage 4: Statutory procedures and powers. Work in this stage will focus on the preferred route preliminary design by assessing the environmental impact of the route, refining the cost estimate for the scheme and defining the preliminary design freeze.

This report provides a summary review of the existing information related to the scheme in its current form with any additional desk study information identified. This report presents the ground model for the scheme, incorporating the recent ground investigation information along with any associated historical investigations, together with its associated risks, in accordance with the guidelines issued by the Highways Agency in HD 22/08.

1.2 DESCRIPTION OF THE PROJECT

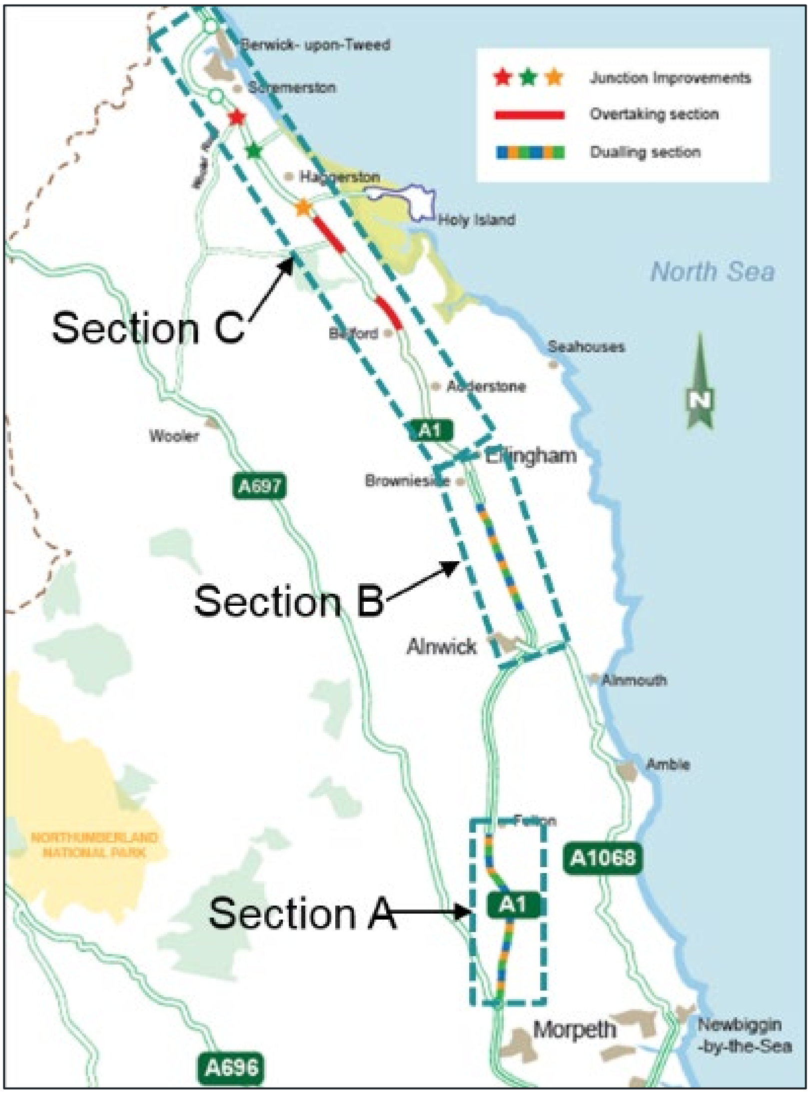
As part of the DfT RIS, options are being developed to improve the A1 between Morpeth and Ellingham, which encompasses thirteen miles of upgrade to dual the carriageway linking the Morpeth and Alnwick bypasses with the dual carriageway near Ellingham, to create a continuous high-quality dual carriageway from Newcastle to Ellingham. For the purpose of the design assessment and reporting, the scheme has been split into three subsections illustrated in Figure 1-1 Location of the A1 improvement works between Newcastle and Berwick (DFT). This encompasses:

- **Section A** - Morpeth to Felton – offline and online dualling options;
- **Section B -** Alnwick to Ellingham – online dualling option;
- **Section C** - North of Ellingham – a set of measures to improve the performance and safely of the A1 north of Ellingham.

This GIR is for the central section, Section B Alnwick to Ellingham. Sections A and C are reported separately.

The proposed option for dualling the carriageway requires the widening of the existing corridor to the east. In addition to the upgrade of the carriageway, the scheme shall include the construction of two new overbridge structures and the upgrade of culverts and the drainage system along the route.

Figure 1-1 - Location of the A1 improvement works between Newcastle and Berwick (DFT)



SITE DESCRIPTION

An 8 km stretch of the A1 is being upgraded and developed as part of improvement works to the A1 between Morpeth and Ellingham. The location of the site area is shown in Figure 1-1.

To enable the dualling of the carriageway, the highway is to be widened to the east. The carriageway section to be widened stretches from Ch. 53200 to Ch. 61100.

The route alignment can be found in the Geohazard Plans in Appendix C. The land on which the widening will take place is predominantly used for agricultural purpose, both pastural and arable, which gently undulates across the scheme.

The works will also include the construction of two overbridge structures; at Heckley Fence and Charlton Mires junction, along with a series of upgrades to existing culverts and the drainage system. A series of earthworks and structures will also be constructed along the length of the upgrade. The split and height of the earthworks are based on the October 2018 Design Freeze.

Earthwork datasheets have been compiled to summarise the scheme information, containing ground conditions and geotechnical risks. The table below illustrates the structures and earthwork split and design height.

Table 1-1 - Earthwork split - Alnwick to Ellingham

Chainage		Length (m)	Earthwork Asset Type (HD41/15)	Earthwork ID	Maximum Height (m)	Earthwork(s)
53200	53500	300	Minor	A2EG01	-	At Grade
53500	53800	300	Major	A2EC01	4.1	Cutting
53800	54300	500	Major	A2EE01	2.6	Embankment
54300	54653	353	Major	A2ESL01	4.5	Cutting (N. bound) Embankment (S. bound)
54653	55100	447	Minor	A2EG02	-	At Grade
55100	55510	410	Minor	A2EE02	1.8	Embankment
55510	55840	330	Minor	A2EG03	-	At Grade
55840	56700	860	Major	A2EC02	10.4	Cutting
56700	57720	1020	Major	A2EE03	3	Embankment
57720	58220	500	Major	A2EC03	3.3	Cutting
58220	58840	620	Major	A2EE04	2.7	Embankment
58840	58960	120	Minor	A2EG04	-	At Grade
58960	60100	1140	Major	A2EE05	4	Embankment
60100	60440	340	Minor	A2EE06	2	Embankment
60440	61100	660	Major	A2EC04	3.2	Cutting

The approach earthworks for the overbridge structures are the most significant of the new earthworks, where the embankments will reach a maximum height of 9m. Table 2-2 below provides the chainage of the proposed structures along the scheme.

Table 1-2 - Structures - Alnwick to Ellingham

Chainage	Structure Name	Scheme Requirements
54600	Denwick Burn Culvert	Extension to existing culvert
55300	Heckley Fence	New overbridge
58940	Charlton Mires	New junction overbridge
56920	Whitehouse Burn Culvert	Extension to existing culvert
59275	Linkhall Culvert	Extension to existing culvert
60385	Shipperton Culvert	Extension to existing culvert
Access track	Rock Culvert*	Extension to existing culvert

*Design in development at time of issue

1.3 GEOTECHNICAL CATEGORY OF THE REPORT

It is anticipated that the project will involve conventional types of geotechnical activities. No exceptional or difficult ground conditions or loading conditions are expected. Therefore, it is proposed that this scheme be classified as a Geotechnical Category 2 project and be treated in the investigation and decision-making processes in accordance with HD 22/08.

2 EXISTING INFORMATION

A Preliminary Sources Study Report (PSSR) entitled 'A1 in Northumberland: Alnwick to Ellingham" (ref 1) was produced in January 2017 to provide preliminary information of the project and the site. The report details information based on site visits, data from previous ground investigations and the collation of publicly available data. A preliminary Engineering Assessment and Risk Register were also provided as part of the report, based on the available information.

A summary of the pertinent findings of the previous desk study reporting is presented below. Key features relevant to the scheme have been annotated on the Geohazard Plans in Appendix C.

2.1 TOPOGRAPHICAL MAPS (HISTORICAL AND RECENT)

A review of the historical and topographic maps for the site area is presented in the PSSR (Ref 1 in Section 8 of this report). Reference should be made to this report for a full review of the information.

A topographic survey was undertaken in 2018, as part of the current Stage 3 works. The route gently rises in elevation from approximately 55m AOD at the southern extent of the scheme, to over 100m AOD in the north. Further details are provided in Section 4.2.1.

The existing regional road and field systems appear generally unaltered, with field boundaries and minor roads following the same alignments as shown on the 19th Century maps. However, the fields immediately adjacent to the existing A1, south of Charlton Mires have changed due to the construction of the Alnwick bypass in the 1970's and 1980's.

Discrete areas of industrial land use, generally clay pits and quarrying, have developed and subsequently been abandoned or demolished, with the land returned to agriculture.

2.2 GEOLOGICAL MAPS AND MEMOIRS

A review of the data from the following sources was undertaken. Table 2-1 below, provides a summary of the geology present across the study area based on these sources.

- BGS 1:50 000 1982 (Drift Geology) Geological Map Sheet 6 Alnwick 1982 (Ref 4);
- BGS 1:50 000 1975 (Solid Geology) Geological Map Sheet 6 Alnwick 1975 (Ref 5);
- BGS Onshore GeoIndex (Ref 6).

Table 2-1 - Table of Geological Succession

Strata	Geological Unit	Geological Age		Spatial Distribution
		Epoch	Period	
Clay, Silt, Sand and Gravel	Alluvium	Holocene	Quaternary	In the vicinity of existing watercourses
Peat	Peat	Holocene		Middlemoor Plantation near Rock South Farm
Clay, Silt, Sand and Gravel	Glacial Deposits- Glacial Till and Glacio-fluvial	Devensian		Glacial Till - Whole Site Glacio-fluvial - Charlton Mires and north to North Charlton
Limestone, Sandstone, Siltstone and Mudstone	Alston Formation / Type Limestone	Yoredale Group	Lower Carboniferous	Across the Site
Coal Seams	Scremerston Coal Member			Heckley Fence to Rock Lodge

2.2.1. MADE GROUND

Though not identified in published geology, Made Ground is located across the site typically in the form of hardstanding and worked ground associated with farming practices and areas of development.

2.2.2. SUPERFICIAL

The route in underlain by relatively shallow superficial deposits comprising Glacial Till, Glacio-fluvial deposits, Alluvium and peat, all of quarternary origin.

Glacial Till underlies the majority of the scheme between the southern extent and Charlton Mires (Chainage 53200 – 58400), while Glacio-fluvial deposits are limited to the north of Charlton Mires, between Chainages 58600 – 61100.

Alluvium and Peat are also present across the site in localised areas, predominantly near watercourses and in areas of lower elevation in the vicinity of Middlemoor Plantation, between Chainage 56900 – 57400.

2.2.3. BEDROCK

The superficial deposits are underlain by bedrock of the Lower Carboniferous. The Oxford Limestone and Alston Formation and Tyne Formation are present across the majority of the site, comprising a succession of sandstone, siltstone, mudstone and limestone with a number of thin coal seams within the strata.

The Scremeston Coal Member is located north of Heckley Fence up to Rock Lodge, comprising sandstone, siltstone, mudstone and coal. No significant coal seams have been identified in the immediate vicinity of the scheme.

2.2.4. STRUCTURAL GEOLOGY

Strata dip direction of the bedrock is generally to the south-east, varying between 10° and 24 °. Local variations in the dip and dip direction of the strata exist due to the eight roughly east - west trending geological faults which cross the area. The most prominent faults are listed below and are noted in the Geohazard plan in Appendix C:

- Inferred Fault at approximate Chainage 54200. Downthrow to the north;
- Inferred Fault at approximate Chainage 54270. Downthrow to the north;
- Inferred Fault at approximate Chainage 54960. Downthrow to the north;
- Inferred Fault at approximate Chainage 57120. Downthrow to the north;
- Inferred Fault at approximate Chainage 58140. Downthrow to the north;
- Inferred Fault at approximate Chainage 59720. Downthrow to the south-east.

2.3 HYDROLOGY

A number of West to East flowing watercourses have been identified crossing the existing carriageway alignment. The watercourses identified within 100m of the scheme are as follows:

Table 2-2 - Watercourses along the existing A1 carriageway

Watercourse	Approximate A1 Chainage
Denwick Burn	53477
Denwick Burn	53840
Denwick Burn	54150
Denwick Burn	55300
Denwick Burn	54600
Unnamed	56300
Whitehouse Burn	56916
Unnamed Drain	58606
Kittycarter Burn	59280
Shipperton Burn	60387
Unnamed	0650 (Rock Farm access road)

The PSSR (Ref 1) reports that there are no sections of carriageway within the proposed scheme that are in flood risk areas. However, an area approximately 20m east of chainage 2300 to 2550m is indicated to have a low to medium risk of flooding from Denwick Burn.

The risk of flooding has been assessed in the earthwork datasheets and Geohazard Plans, which can be found in Appendices A and C.

2.4 HYDROGEOLOGY

The available hydrogeology maps for the area have been reviewed in the 2017 PSSR (Ref 1), and illustrate the aquifer classification of the superficial and bedrock underlying the site area. Reference should be made to these reports for a full review of the sources of information.

The majority of the site is underlain by Glacial Till, classified as a Secondary undifferentiated aquifer, where the deposits have not been classified as either category A or B.

The Alluvium and glacio-fluvial deposits and bedrock across the site are assigned as Secondary A aquifers. According to the Environment Agency these represent 'permeable strata capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers'.

Peat, only identified near Rock South Farm, has been identified as unproductive, whereby the geological strata has 'negligible significance for water supply or river base flow.'

There are no records of groundwater abstractions of Groundwater Protection Zones at the site.

The groundwater is considered to be relatively shallow within the proposed route extents due to the presence of low permeability glacial materials overlying bedrock.

2.5 AERIAL PHOTOGRAPHS (HISTORICAL AND RECENT)

Aerial photography was collected from the National Collection of Aerial Photography as part of the collation of data for the 2017 PSSR (Ref 1). The photographs, dating to June 1972 showed that historically the area surrounding the site was largely arable farmland and woodland.

2.6 RECORDS OF MINES AND MINERAL DEPOSITS

A mining report CON29M was obtained 2017 PSSR (Ref 1). Though historical quarrying has taken place in the area, the route is not thought to be impacted by any recorded underground or opencast mining. There are no known current or proposed mining operations, however the route is known to be underlain by coal seams.

An assessment of publicly available data from the Coal Authority (Ref 8) has been made to support the findings of the PSSR (Ref 1). A Development High Risk Area (DHRA) was identified the within the alignment of the proposed access track to Rock South Farm, at approximate chainage 0700. This relates to the inferred subcrop of a coal seam beneath the route that may have been historically worked, although there are no records or evidence of workings to suggest this. Further DHRA's were observed near Heckley Fence, approximately 80m east of the current proposed alignment, associated with mine entry points or probable shallow coal workings. An unnamed inferred coal seam identified in BGS maps (Ref 5, 6), lies in the approximate location of the DHRA's and may be associated with the historic mining observations. A further abandoned mine shaft was identified on the BGS Sheet Map (Ref 6), located at the southern end of the inferred coal seam (though this was not identified in either of the online Map viewers).

Areas affected by mineral deposits at the proposed earthwork locations are listed in the earthworks datasheets in Appendix A and annotated on the Geohazard plans in Appendix C.

2.7 LAND-USE

The land-use in the region was reviewed as part of the 2017 PSSR (Ref 1). The surrounding land-use is predominantly agricultural. Farms and small-holdings with associated outbuildings scatter the landscape in the area. The farming in the area is used for both arable farming and livestock.

The closest villages in the vicinity of the A1 are Rennington and Denwick, located to the east of the alignment. North Charlton is located at the northern extent of the scheme, where the existing A1 becomes dual carriageway (Brownieside Dual carriageway).

An airstrip for the use of private light aircraft is located at Charlton Mires, to the immediate west of the alignment, and is aligned west to east.

Historically, the land in the area has largely been used for agricultural purpose. However, a number of small quarries, ponds and remains of ancient burial mounds and settlements have been identified as part of the historical map review in the PSSR (Ref 1).

The most relevant of these land-uses have been noted in the Earthworks datasheets and Geohazard plans in Appendix A and C.

Further information of land-use and soil survey information can be found in the PSSR (Ref 1).

2.8 ARCHAEOLOGICAL AND HISTORICAL INVESTIGATIONS

Three Archaeological sites in the area of North Charlton, East Linkhall Farm and West Linkhall were identified from information provided by the Archaeological Data Service (ADS) (Ref 9) These records have been further reviewed in the 2017 PSSR (Ref 1).

Archaeological monitoring was undertaken during the 2018 Ground Investigation. However, no notable findings were encountered. Reference should be made to the scheme Environmental Statement for further details on the archaeological details at the site.

2.9 EXISTING GROUND INVESTIGATIONS

Several ground investigations have been carried out across sections of the site, predominantly between Denwick and Charlton Mires, associated with the construction of the Alnwick Bypass. Limited historical investigation has taken place north of South Charlton (Ch 59000). Therefore, prior to the 2018 ground investigation there was limited existing information of the ground conditions at the northern half of the scheme.

Table 2-4 below, provides a summary of the historical ground investigation reports, the 2017 PSSR (Ref 1) provides further details of these historical ground investigations.

Table 2-3 - Existing Ground Investigations

Document Title / Ground Investigation	Year / Reference	Produced by
Alnwick Bypass, Stage 2- Technical Report	1970 / HAGDMS report number 7182	Geotechnical and Concrete Services Ltd.
Alnwick Bypass Stage 2	1979 / BGS Online borehole database	Northumberland County Council- County Surveyors Department
Heiferlaw Cutting, Alnwick Bypass Stage 2	1980 / BGS Online borehole database	Norwest Holst Soil Engineering Ltd.
Middlemoor Wind Farm and Shipperton Burn Wildlife Crossing Ground Investigation- Final Factual Report	2012 / HAGDMS report number 26725	Halcrow Group Ltd. Allied Exploration and Geotechnics Limited

2.10 CONSULTATIONS WITH STATUTORY BODIES AND AGENCIES

UTILITIES

Statutory service locations were identified in plans provided in the 2017 PSSR (Ref 1).

It was highlighted that a high voltage 66kV cable, associated with a wind farm, runs south along the eastern edge of the A1, crossing the A1 highway at CH 58800 and runs parallel to the western edge of the carriageway.

Further utilities run along the verge of the A1.

NATURAL ENGLAND/ ENVIRONMENT AGENCY

Consultations with English Nature and the Environment Agency have been carried out and are ongoing in relation to any potential environmental impacts to the scheme.

No additional information on land use or soil survey information has been obtained. No further discussion or analysis of the data in the historical PSSR is considered necessary for the scheme in its current form.

LOCAL AUTHORITIES

No further information on land use or soil survey information were sought from Local Authorities. No further discussion or analysis of the data in the historical PSSR is considered necessary for the scheme at the time of this report being issued.

2.11 FLOOD RECORDS

The 2017 PSSR (Ref 1) provides information relating to the flooding risk of the scheme area. No areas of the proposed carriageway are in flood risk areas. However, an area to the east of the highway in proximity to Denwick Burn is classified as having a low to medium risk of flooding. A further review was made of data published by the Environment Agency on HAGDMS (Ref 14). The medium to high risk flood areas are noted in the Geohazard Plan in Appendix C.

2.12 CONTAMINATED LAND

A comprehensive review of potential contaminants and waste has been provided in the 2017 PSSR (Ref 1). None of the historical BGS exploratory hole records reviewed noted any signs of visual or olfactory contamination.

No active or historical landfills or water transfer stations are located in the vicinity of the site. However, two active discharge consents are recorded at Charlton Mires.

The potential contaminants at the site have been summarised in the following figure Figure 2-1, extracted from the PSSR. However further contaminants may also be located in the study area.

Further detailed review of potential land contamination will be presented as part of the scheme's Environmental Statement report.

Figure 2-1 - Potential contamination at the site, PSSR, 2017 (Ref 1)

Source	Potential Contaminants
Existing Road Network (A1)	Embankment fill materials (PFA, ash), oils/hydrocarbons, Polycyclic Aromatic Hydrocarbons (PAHs), Benzene, Toluene, Ethyl benzene and Xylenes (BTEX), Methyl Tertiary Butyl Ether (MTBE), heavy metals, antifreeze, brake fluids, road salt.
Agriculture	Slurry (nitrate, ammonium, organics), pesticides, herbicides, fertilisers, pathogens, oils, fuels, PAHs.
Infilled Ponds / Quarries	Various unknown contaminants (including heavy metals, hydrocarbons, PAHs, ash, ground gas, asbestos)
Historical Tanks	Oils, fuels (diesel, red diesel, gasoline), pesticides, herbicides, fertilisers, slurry (nitrate, ammonium, organics),

3 FIELD AND LABORATORY STUDIES

3.1 WALKOVER SURVEY

A preliminary site walkover was carried out in 2016 as part of the preparation for the PSSR (Ref 1) and was limited to public rights of way. The walkover provided observations on the topography, ground conditions and existing structures and site constraints that may impact on the geotechnical risk. The findings of this walkover are documented in the 2017 PSSR.

An additional walkover of the majority of the site took place on 9th and 10th May 2018 by WSP representatives and employees of the Principal Contractor and Ground Investigation Contractor. The walkover was carried out to confirm access routes for the ground investigation. No additional features to those already identified in the desk study exercise were noted that represent a potential geotechnical hazard. Geohazard plans for the route are presented in Appendix C.

As part of the review of previous studies in the site area a review of HAGDMS data was carried out to determine any defects in the existing earthworks that may impact on the proposed earthworks.

Table 3-1 below provides a summary of the identified defects on the earthworks of the southbound carriageway, and the proposed earthworks they may impact.

Table 3-1 - Identified Earthwork Defects on the A1

HAGDMS Reference	HAGDMS Observation Description	A1 Impacted Scheme Element	Class	Location
14 A1 42595 520272	Extensive Burrows	A2EE01	1D	C
14_A1_42577_ 519979	Toe of slope excavated, approximately 0.6m high missing	A2ESL01	1D	C
14_A1_42578_519997	Area of burrows with small slip at the crest beneath the barrier. Some settlement of the crest beneath the barrier foundations.	A2ESL01	1D	C
14_A1_42594_520277	Ponding at toe, burrows throughout with small slip near crest at southern end. Slope generally uneven	A2ESL01 A2EG02	1D	C
14_A1_42592_520269	Combination of burrows and settlement	A2EC02	1D	C
14_A1_42573_519977	Slope bulge with small back scar above. Looks old, hummocky and uneven. Burrows noted. Crest 2.8m wide.	A2EE03	1D	C
1_A1_42635_520122	Slight slip at crest approx. 4m long 0.25m wide	A2EE04	1D	C
14-_A1_42577_520121	Small slip at crest 1.7m long	A2EE04	1D	C
14_A1_42635_607404	Large soil slip bulge. significant rabbit activity causing slope to fail and rotation of communications cabinet.	A2EE04	1A	C

3.2 GEOMORPHOLOGICAL / GEOLOGICAL MAPPING

Not used.

3.3 GROUND INVESTIGATION

A ground investigation was undertaken in 2018 to assist the preliminary design of the structures and earthworks along the alignment. A ground investigation was initially suggested within the PSSR (Ref 1), but was later adapted to encompass updated drainage layouts, structures and earthworks.

The aims of the recent ground investigation were to:

- Determine the ground and groundwater conditions for the proposed route alignment, with a particular focus on the location of proposed structures, earthworks and drainage system at the site;
- To produce a ground model for the site area;
- To determine geotechnical parameters for each of the structures and earthworks in the scheme;
- To assess the potential for contaminated land through soil and groundwater chemical analysis, including ground gas monitoring.
- Identify any geotechnical risks that may be included in the Geotechnical Risk Register and carried forward in the design.

GENERAL FIELDWORK DETAILS

The 2018 Ground Investigation was undertaken by SOCOTEC, who were commissioned by Geoffrey Osborne Ltd, between 9th July and 30th July and 5th September and 31st October. Groundwater monitoring was then carried out until 8th January 2019.

The fieldwork comprised the following and in accordance with MCHW 5.3, 1997 (Ref 10), BS 5930: 2015 (Ref 11), and ISO 1997:2007 (Ref 12:

- 13 no boreholes undertaken using cable percussive methods, followed on by rotary core drilling;
- 1 no borehole was carried out by cable percussive methods only;
- 1 no borehole was carried out by rotary open hole drilling, and followed on by rotary core drilling;
- 44 no machine excavated trial pits;
- 3 no hand-dug inspection pits to identify the depth of a High-Voltage 66kV cable;
- Standpipes and piezometers were installed in selected boreholes;
- Soakaway tests undertaken in 3 trial pits.

Groundwater was encountered in 21 trial pits and 6 boreholes during their construction, typically between depths of 1.0m and 3.5m bgl, as detailed in Table 4.

Groundwater standpipes were installed in nine boreholes along the scheme alignment. Groundwater dataloggers were placed in the installations and remained in position until 8th January 2019. Two return visits were made to download the data from the divers, groundwater samples were taken from the installations during the first return visit.

GROUND INVESTIGATION FACTUAL REPORT

A Factual Ground Investigation Report has been produced by SOCOTEC Ltd (Ref 13) following the completion of the works. The report details the exploratory hole logs, in-situ test data and laboratory test data. An AGS file containing the data from the 2018 Ground Investigation has also been produced by SOCOTEC Ltd. The Factual Report should be read in conjunction with this GIR report.

IN SITU TESTING

Standard Penetration tests were carried out during the progression of each of the boreholes, where ground conditions were suitable.

An approximate assessment of soil strengths was made by undertaking hand held vane tests on soil samples excavated from the trial pits.

Soakaway testing was also carried out in three trial pits at the proposed locations of detention ponds.

The results of the in-situ tests are included in the Factual Report, (Ref 13) and are illustrated on the geological long sections shown in Appendix D.

3.4 DRAINAGE STUDIES

No tests were undertaken as part of the drainage study, other than the soakaway tests as described in Section 3.

3.5 GEOPHYSICAL SURVEY

Not used.

3.6 PILE TESTS

Not used.

3.7 OTHER FIELD WORK

Not used.

3.8 LABORATORY TESTING

The following laboratory tests were carried out on samples collected during the 2018 ground investigation.

- Moisture contents
- Atterberg limits
- Particle size distribution by sieving and sedimentation
- Particle Density
- Unconsolidated undrained triaxial testing
- Small shear box
- Large shear box
- California bearing ratio
- Moisture condition value
- Oedometer testing
- SD suite 1 testing
- Loss on ignition testing
- Organic matter content
- Point load index testing
- Uniaxial compressive strength testing
- Water content of rock

Following the completion of the site works, groundwater samples were subsequently obtained from selected boreholes for chemical testing. Environmental chemical analyses for potential contamination, and chemical testing in accordance with BRE Special Digest was also undertaken on selected soil samples.

COPIES OF TEST RESULTS

The test results are contained within the appendices of the Factual Report (Ref 13) and are also included in the AGS data.

Table 3-2 - Groundwater Strikes during 2018 Fieldwork

Exploratory Hole Ref.	Ground Level (m OD)	Water Strike (m BGL)	Water Strike (m OD)	Water Strike Geology	Standing Water (m BGL) after 20 mins	Standing Water (m OD) after 20 mins
BH/17/01	83.55	3.6	79.95	Glacial Till (fine-grained)	3.07	80.48
BH/17/02	81.78	3.2	78.58	Sandstone	2.08	79.7
BH/17/04	96.56	4.2	92.36	Sandstone	3.6	92.96
BH/17/09	84.27	1.4	82.87	Glacio-fluvial deposits	not recorded	not recorded
BH/17/10	94.54	4.2	90.34	Glacial Till (fine-grained)	4.0	90.54
BH/17/13	95.39	3.2	92.19	Glacial Till (fine-grained)	2.95	92.44
TP/17/02	67.41	1.4	66.01	Glacial Till (fine-grained)	not recorded	not recorded
TP/17/04	76.57	0.9	75.67	Glacial Till (fine-grained)	not recorded	not recorded
TP/17/09A	95.68	2.3	93.38	Glacial Till (coarse-grained)	not recorded	not recorded
TP/17/10	101.32	3.2	98.12	Glacial Till (fine-grained)	no rise in level	no rise in level
TP/17/11	106.27	2.1	104.17	Glacial Till (fine-grained)	not recorded	not recorded
TP/17/12	103.01	3.3	99.71	Sandstone	3.1	99.91
TP/17/13	85.68	2.2	83.48	Sandstone	2.0	83.68
TP/17/15	85.3	2.6	82.7	Glacial Till (fine-grained)	2.0	83.3
TP/17/16	85.88	2.1	83.78	Glacial Till (coarse-grained)	not recorded	not recorded
TP/17/17	85.46	1.7	83.76	Alluvium	1.4	84.06
TP/17/18	86.77	2.4	84.37	Glacial Till (coarse-grained)	not recorded	not recorded
TP/17/19	86.34	3.4	82.94	Glacial Till (fine-grained)	3.1	83.24
TP/17/21	92.15	3.2	88.95	Glacial Till (fine-grained)	3.1	89.05
TP/17/22	87.95	3.3	84.65	Glacial Till (fine-grained)	2.3	85.65
TP/17/24	87.89	2.6	85.29	Glacial Till (fine-grained)	not recorded	not recorded
TP/17/25	86.96	1.5	85.46	Glacial Till (coarse-grained)	not recorded	not recorded
TP/17/30	86.05	1.7	84.35	Glacio-fluvial deposits	not recorded	not recorded
TP/17/31	87.49	2.5	84.96	Glacio-fluvial deposits	not recorded	not recorded
TP/17/43	90.37	2.2	88.17	Alluvium	2.15	88.22
TP/17/44	90.38	2.2	88.18	Glacial Till (coarse-grained)	not recorded	not recorded
TP/17/47	96.29	1.1	95.19	Glacial Till (fine-grained)	not recorded	not recorded

4 GROUND SUMMARY

The following section gives a summary of information obtained from the surveys and studies detailed in previous chapters, which have been used to produce a design ground model and identify and further assess any geotechnical risks presented in Section 7.

4.1 TOPOGRAPHY

The topography of the scheme can be summarised as follows:

- **CH53400 to CH58850** – The route runs in a north-west to south-east direction. The majority of the highway along this section is at grade, though embankments and cuttings of heights <5m are located between: 53500 – 53800 (cutting); 55700 – 56650 (cutting); 56750 - 57700 (embankment); 57850 – 58250 (cutting) and 58250 – 58850 (embankment).
- Limited existing earthwork height data was available from HAGDMS inspections, however a height of 6.5m was recorded at the cutting at CH56260 (Ref 14). Topographical survey data produced for the scheme has been used to assess the proposed earthwork heights.
- **CH58850 to CH61100** – Along this section, the highway continues in a north-west south-east direction, before meandering to a north-south orientation on the approach to North Charlton, at the termination of the scheme. Similar to that of the southern half of the scheme, the highway is predominantly at grade. However, an existing embankment is located between CH59580 and CH59620. A height of 4.4m was recorded at the embankment (Ref 14).

4.2 HISTORICAL DEVELOPMENT

The existing A1 from Alnwick to Charlton Mires was built in the 1980’s, the alignment, north of Charlton Mires has existed since before the 1860’s. The historical A1 route, now known as the B6341, lies to the west of the existing A1, south of Charlton Mires.

There are few isolated areas where historical development may impact on the proposed scheme. However, cases which may influence the improvement works are:

- At East Linkhall Farm, the former A1 alignment was straightened, cutting off the east-ward bend at the entrance to Charlton Hall. Hardstanding and woodland remains along the previous route.
- The remains of a medieval village camp and burial ground are located between East Linkhall Farm and North Charlton located to the east of the current A1. A further medieval camp is located at West Linkhall, to the east of the existing A1.
- Disused quarries are located near West Linkhall and Charlton Mires, within 300m of the A1.

4.3 GEOLOGY

The ground conditions recorded in the recent ground investigation are summarised below. The ground model at the site has been derived from historical ground investigation data undertaken within the site boundaries, the published geology, desk study information and data acquired during the recent ground investigation.

The ground model is illustrated in the geological long sections included in Appendix D and the material properties are discussed in Section 6.

TOPSOIL

Topsoil was encountered in the majority of the exploratory holes across the site. The topsoil thickness typically varies between 0.1 and 0.4m, consisting of slightly sandy, slightly gravelly clay. During the 2018 Ground Investigation the following exploratory holes did not encounter topsoil: HDP/17/02, HDP/17/03, TP/17/48, BH/17/14 and TP/17/05, Made Ground was instead encountered in the upper layers at these locations.

MADE GROUND

Made Ground was encountered in 5 of the 60 recent exploratory holes and a further 8 exploratory holes from historic investigations. The Made Ground encountered was highly variable, consisting of hardstanding as well as granular and cohesive deposits with fragments of broken brick and clay pipe.

Hardstanding was identified at locations TP/17/34 and TP/17/37. These holes are thought to lie along the route of the former A1.

Further Made Ground was encountered in the exploratory holes on tracks on agricultural land. During the formation of TP/17/05, BH/17/14 and TP/17/48, fragments and whole bricks and clay pipe were encountered within gravelly sandy clay and sandy gravel.

With the exceptions of Shipperton Burn, and the access track to Middlemoor windfarm Made Ground extended to a maximum proven depth of 1.0m bgl.

Shipperton Burn

A number of boreholes were undertaken in the vicinity of Shipperton Burn, associated with the culvert and access track to Middlemoor wind farm. The Made Ground was typically observed to be a firm sandy gravelly clay with medium cobbles content. The gravel and cobbles consisted of sandstone, limestone, quartz-dolerite. Fragments of plastic piping and gravel-sized fragments of concrete were also observed.

Middlemoor Windfarm Wildlife Crossing

During the 2012 ground investigation, Made Ground was identified in each of the boreholes to a maximum depth of 2.5m bgl. The Made Ground typically consisted of gravels and sands with a medium cobble content, overlying the natural Glacio-fluvial and Glacial Till deposits.

4.4 SUPERFICIAL GEOLOGY

Superficial geology was encountered in all exploratory holes across the scheme, with the exception of BH/17/11, HP/17/02 and WS01 - WS04. The site is predominantly underlain by glacial deposits, particularly Glacial Till, which is the primary constituent of the underlying superficial geology across the site. Alluvium and traces of peat were encountered in localised areas across the site.

The thickness of the deposits varies greatly across the site. The typical thickness of the deposits was approximately 3.0m. However, anomalously thick layers of superficial deposits were encountered at West Linkhall and Charlton Mires, exceeding depths of 13m bgl and extending to 19m bgl respectively.

ALLUVIUM

Based on published Geology, Alluvium was expected to be encountered in low-lying areas, associated with watercourses and local ponding in surface depressions.

During historical and recent ground investigations in the area, Alluvium was predominantly encountered in the vicinity of Heckley Fence, Denwick Burn and the Ellsnook and Kiln Plantation and minor watercourses that traverse the proposed alignment.

The alluvial deposits were observed to be generally shallow deposits, encountered directly beneath topsoil, and typically extending to a maximum depth of up to 1.7m bgl. However, at some locations close to watercourses, the alluvial deposits extended deeper. This was the case at the following exploratory holes:

- **TP/17/43 at the Kiln Plantation-** Alluvium to 2.7m bgl;
- **BH10 at Denwick Burn** – Alluvium to 3.3m bgl;
- **BH21 at Whitehouse Burn** – Alluvium to 3.3m bgl.

The Alluvium was typically described as cohesive, soft to firm, sandy silty clay with occasional lenses of sand and traces of peat or organic matter. Granular material was occasionally interbedded within the cohesive deposits, consisting of loose to moderately dense clayey sand and gravel with occasional peat traces.

PEAT

No peat layers were encountered during the recent ground investigation. However, during the historical ground investigations, thin layers of peat (2-4mm) were encountered at TPA24A (Ch 56100), and further 'peaty clay' observed in TPA12 at Ch54200. Traces of black organic matter were encountered intermittently within the Alluvium of numerous historical exploratory holes.

GLACIAL DEPOSITS

The route is primarily underlain by glacial deposits, most notably Glacial Till, which underlies the majority of the low-lying area of Northumberland. The deposits consist of a variety of sands and gravels with boulders and cobbles, in addition to clays and silts. Further explanation of the glacial geology of Northumberland should be sought in the PSSR (Ref 1).

An extensive amount of granular material was encountered in BH/17/08, BH/17/09 and TP/17/35, extending to a depth in excess of 9m bgl. The material comprised a combination of gravel and sand, and gravelly silty clay with gravel and occasional cobbles consisting of sandstone and limestone. Based on the nature of the deposits it is considered that this may represent the remains of a buried glacial channel. The materials as such have been described as 'glacial deposits.

Figure 4-1 below shows the approximate changes in elevation and depth of glacial deposits across the scheme.

Figure 4-1 - Glacial Deposits across the site

GLACIO-LACUSTRINE DEPOSITS

Glacio-lacustrine deposits have been identified by the presence of very soft to firm interlaminated clay and silt with frequent pockets of clay or sand. The deposits were encountered interbedded within other glacial deposits, most notably in the vicinity of Charlton Mires. Further deposits were also encountered south of Rock Lodge and Heckley Fence at chainages 57900 and 55000 respectively.

The deposits are typically interlaminated clay and silt, with occasional sand laminae, present at depths of 2.0 to 3.2m bgl, though at South Charlton depths of 1.4m to 5.7m bgl with a maximum thickness of 2.5m observed. Table 4-1 below shows the approximate thicknesses of the Glacio-lacustrine deposits where encountered across the site.

Table 4-1 - Glaciolacustrine deposit location and thickness

Location	Approximate Chainage	Date of GI/Exploratory holes	Approx depth to base of stratum (mbgl)	Proven Thickness (m)
Rock Lodge	57800-58400	TP/17/23, TPA35, TPA36, BH27	3.3	1.4
Heckley Fence	55000	TP18	>3.81	>1.53
Charlton Mires	58400-59000	TPA40, TPA40A, BH/17/06, BH/17/07, TP/17/29	4.5	1

GLACIO-FLUVIAL DEPOSITS

Glacio-fluvial deposits have been identified at and north of Charlton Mires, as typically thick layers of granular deposits of sand and gravel, interbedded with other glacial deposits.

The deposits largely consist of gravelly silty sand and gravel with low to medium cobble content. The gravel and cobbles consist of sandstone and mudstone

GLACIAL TILL

The route is primarily underlain by thick layers of cohesive Glacial Till deposits. The deposits generally comprise sandy gravelly silty clay, though granular layers of gravel, cobbles and boulders were also often encountered.

Cohesive Glacial Till is the principal constituent of the glacial deposits encountered along the route, often present beneath the Topsoil and / or Made Ground and, where present, beneath the Alluvium or interbedded with other glacial deposits.

The Glacial Till encountered in the most recent ground investigation can be described as sandy, gravelly, silty clay, with frequent cobbles and boulders. The cohesive deposits are interbedded with granular layers of gravelly, clayey sand.

The average thickness of glacial deposits was approximately 3m. However particularly thick deposits of more than 5m thick were encountered in BH/17/06 and BH/17/07 (19.22m and 12.9m respectively), BH24, BH25 and BH26 (6.19m to 7.6m thick Ch7300 – 57600), BH5, BH7 and BH8 (5.8m to 7.48m Ch53400 - 53900)

4.5 BEDROCK

Solid bedrock at the site was encountered in 12 of the recent boreholes. It was typically encountered between 2m and 5m bgl, beneath the superficial geology, though from Charlton Mires and West Linkhall, bedrock was encountered significantly deeper, being proven at 19.5m at BH/17/06. Extremely shallow bedrock was also encountered at BH/17/11, where no superficial deposits were encountered, and bedrock was encountered at 0.7m bgl.

Possible evidence of weathering was encountered across the site, predominantly in the form of weathered sandstone or mudstone as fragments or occasionally clay.

Where bedrock was encountered, it comprised mudstone, sandstone, limestone, siltstone and coal of the Alston Formation, Alston and Tyne formation (undifferentiated) and Scremerston Coal Formation

Across all the competent bedrock fractures were commonly observed, featuring varying degrees of orientation, from vertical to sub-horizontal.

ALSTON FORMATION

The Alston Formation was observed in eight exploratory holes across the site. The depth at which bedrock of the Alston formation was encountered varies across the scheme. At Charlton Mires, the bedrock was typically observed to be at depths in excess of 15m bgl, though at West Linkhall bedrock was not encountered at all during the progression of BH/17/08 and BH/17/09 to 10m and 13m bgl respectively.

However, in the southern extent of the site, in the region of Broxfield Farm, the upper surface of bedrock was encountered between 3.2m and 4.3m bgl.

Based on the BGS Onshore GeoIndex (Ref 6) faults are located at the northern and southern extent of the Alston Formation, at approximate chainages 58150 and 59700. Within 300m of these inferred faults the depth to which bedrock is encountered increases by over 10m. Therefore, the structural geology of the area may explain the varied depth of the bedrock across the scheme.

The Alston Formation is typically made up of limestone and sandstone. The sandstone layers vary in thickness between 0.2m and 3.96m, characterised as being medium strong to strong, often thinly bedded or interlaminated with weak mudstone.

The limestone bedrock varies in strength from extremely weak to strong, with layer thicknesses varied between 0.4m and 3.41m bgl. All the limestone encountered in the Alston Formation contained bioturbation and / or fossils.

Occasional mudstone layers were observed in BH/17/01 and BH10, identified as being medium strong thinly to medium bedded. The layers varied between 0.22m and 2.37m thickness with occasional lenses and laminae of sandstone.

The only presence of coal was observed in TPA38 at 3.3m to 3.6m bgl and in BH/17/01 between 8.65 and 8.82m bgl as minor very weak to weak layers.

ALSTON AND TYNE FORMATION (UNDIFFERENTIATED)

The Alston and Tyne (undifferentiated) formation was observed in 19 exploratory holes across the site. The upper surface of bedrock was typically encountered between 1.6m and 5m bgl.

One case of very shallow bedrock was identified across the scheme, at BH/17/11, where sandstone was encountered at 0.7m bgl. Bedrock was also encountered at particularly deep depths of approximately 7m bgl in BH/17/12 and BH24.

Sandstone was the most frequently observed lithology within the Alston and Tyne (undif) formation, encountered in 10 of the 19 exploratory holes with layer thickness varying between 0.3m and 2.9m. Weathered sandstone was observed in TPA15A, BH24 and BH-03 as sandstone fragments and blocks. Sandstone was also occasionally recovered as gravels and sands in BH/17/10, BH/17/12, BH/17/13 and BH/1714, however the majority of the observed lithology was judged to be competent medium strong to strong thinly sandstone.

Occasional mudstone and limestone layers were observed in the formation. Limestone was observed in BH/17/11, BH/17/13 and TPA22A with layer thickness of between 0.81m and 7.2m and identified as strong to very strong massive to bioclastic bedrock. Mudstone was observed in eight exploratory holes as occasionally weathered to shale or, in the most part as weak very thinly to thinly bedded rock.

Weak coal was observed between 10.06m and 12.27m bgl in BH/17/13.

SCREMERSTON COAL MEMBER

The Scremerston Coal Member was observed in 30 exploratory holes across the scheme.

Mudstone and siltstone were the most common of lithologies encountered within the formation.

Siltstone of the Scremerston Coal Member was encountered in 8 of the exploratory holes. The siltstone was first encountered in these exploratory holes between 4.1m and 9.72m bgl and illustrated layer thicknesses of between 0.2m and 4.3m. The siltstone has typically been characterised as slightly weathered extremely weak to medium strong, thinly laminated to medium bedded.

Mudstone of the Scremerston Coal Member was encountered in 9 exploratory holes from depths of between 2.2m and 9.4m bgl with layer thicknesses varying between 0.2m and 5.35m. The mudstone was described as being slightly weathered extremely weak and thinly laminated.

Sandstone was observed as both weathered and intact in 19 exploratory holes with layer thicknesses varying between 0.2m and 5.1m. The sandstone was described as typically being medium strong to strong thinly laminated to thickly bedded. The weathered sandstone was observed at depths of approximately 2-3m bgl, where the sandstone was recovered as gravel and sand.

Limestone of the Scremerston Coal Member was encountered in five exploratory holes across the site, from depths of 1.6m to 6.0m bgl. The limestone was typically described as being medium strong to strong thinly to medium bedded sandstone, with layer thickness of between and 0.26m and 3.1m.

Minor very weak, friable coal layers (thickness of 0.1 to 0.2m) were observed in BHA23, BHA26 and TPA23A at depths between 2.7m and 11.6m bgl.

COAL

As mentioned in the previous sections, occasional coal was encountered across the scheme. In total, minor coal seams were encountered in 6 boreholes and 2 trial pits. However, more commonly, coal was encountered as interlaminations within sandstone and mudstone or gravel and pockets of coal, which was observed in a further 9 boreholes and 15 trial pits.

The following table indicates the chainage and depth at which the coal seams were encountered across the site. No evidence of coal workings was encountered.

Table 4-2 - Coal seams encountered along the A1 route alignment

Borehole	Chainage	Depth (m bgl)	Level (m aod)	Correlation with BGS Onshore GeoIndex (Ref 6)
BH/17/01	54380	8.65 - 8.82	74.9 – 74.73	-
BH/17/13	55300	12.27 - 12.42	83.12 – 82.97	Correlates with coal seam at Heckley Fence (unnamed)
BHA23	55900	4.7 - 4.9	105.68 - 105.88	Correlates with Secondary Opencast coal resource area
BHA25A	56255	11.6 - 11.7	96.84 – 96.94	
BHA26	56250	9.3 - 9.4	102.25 - 102.35	
		11.8 - 11.9	99.75 – 99.85	
TPA23A	55940	2.7 - 2.8	106.34 – 106.44	
TPA38	58325	3.3 - 3.6	65.36 - 85.65	

4.6 STRUCTURAL GEOLOGY

There are no further details to note, other than those included in 2.2.4.

The bedrock encountered was often pervasively fractured. The fractures were generally closely spaced and varying from sub-horizontal to vertical orientation. Further details of the fracturing can be found in section 5.

4.7 HYDROLOGY / HYDROGEOLOGY

A total of 103 exploratory holes across the site (both recent and historical) encountered groundwater, 99 of which encountered groundwater during construction of the hole.

The Factual Report (Ref 13) details the groundwater depths and monitoring depths encountered during the 2018 ground investigation.

During the 2018 Ground Investigation, groundwater was encountered at depths between 1.0m and 4.2m bgl, often rising 0.2m within 20 mins. These are discussed in more detail in section 6.9.

4.8 GEOMORPHOLOGY

Not used.

4.9 MINING

The ground investigation carried out across the scheme to date has encountered only thin coal seams of around 0.3m thickness. In addition, there have been no occurrences of soft ground or voids that may indicate unrecorded historical coal workings.

4.10 MAN-MADE FEATURES

No further information to add beyond that of the existing information in Section 3.0.

5 GROUND CONDITIONS AND MATERIAL PROPERTIES

The following Section presents the characteristics of each material type presented in Chapter 5 and includes the data compiled from the historical and recent ground investigations.

Where appropriate, Geotechnical Parameter Values are reported. These values have been selected based on in-situ and laboratory test results, or from Derived Values obtained from theory, empirical relationships or correlations. It should be noted the descriptions given on the geotechnical laboratory test results sheets are technicians' descriptions and hence may differ to the engineer's descriptions given on the logs. Geological long sections are presented in Appendix D.

5.1 TOPSOIL

It is recommended for preliminary design purposes that the average thickness of topsoil is taken as 0.3m. Topsoil thicknesses were generally between 0.25m and 0.35m, however, it should be noted that topsoil with a thickness of 0.6m was observed in BH/17/12 at the northern extent of the scheme. No geotechnical testing was carried out on samples of topsoil. It is recommended that all topsoil be stripped prior to construction and stockpiled for reuse.

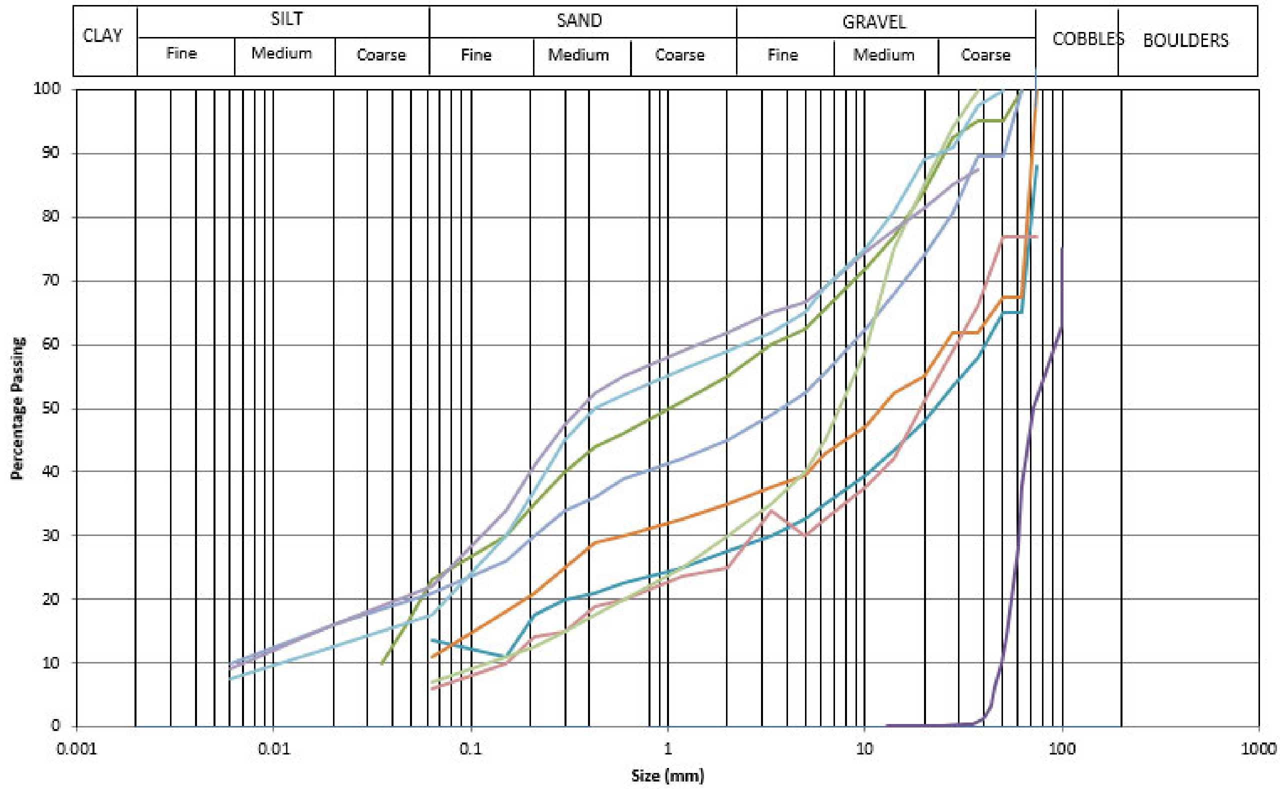
5.2 MADE GROUND

Made Ground was encountered in 13 exploratory holes across the scheme, 5 of which took place during the 2018 ground investigation. As a result of the limited amount of data the results are predominantly sourced from the Middlemoor Windfarm Wildlife Crossing ground investigation.

5.2.1. CLASSIFICATION

The composition of the Made Ground encountered on site, varied considerably. Generally encountered as a granular material, the Made Ground was observed to also comprise fragments of clay piping and possible sub-base material. The most notable locations of Made Ground have been highlighted in Section 4.3. The following plot (Figure 5-1) provides particle size distribution analysis of the Made Ground encountered at Middlemoor Windfarm access track. Based on the plot below (Figure 5-1), it is evident that the deposits are predominantly made up of sands and gravels with an occasional presence silt. BH-01 noted a particularly high proportion of cobbles which was not observed in the particle size distribution (PSD) analysis of the other samples.

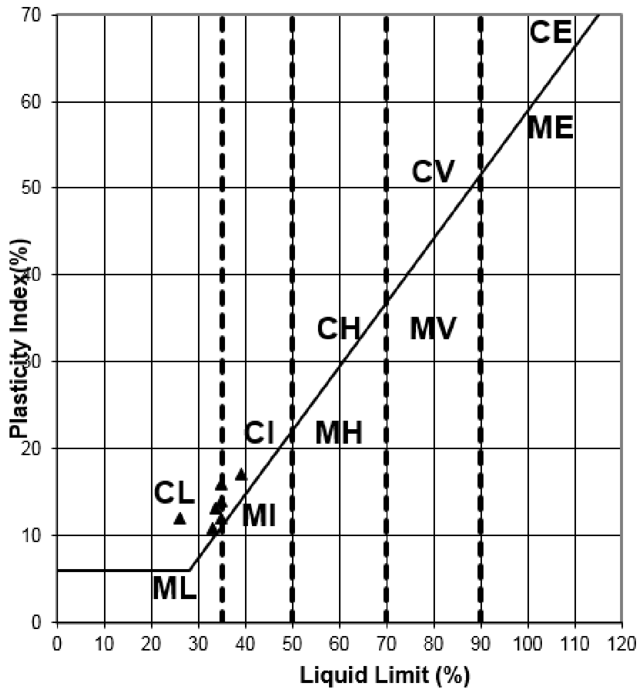
Figure 5-1 - Particle Size Distribution - Made Ground



ATTERBERG LIMITS

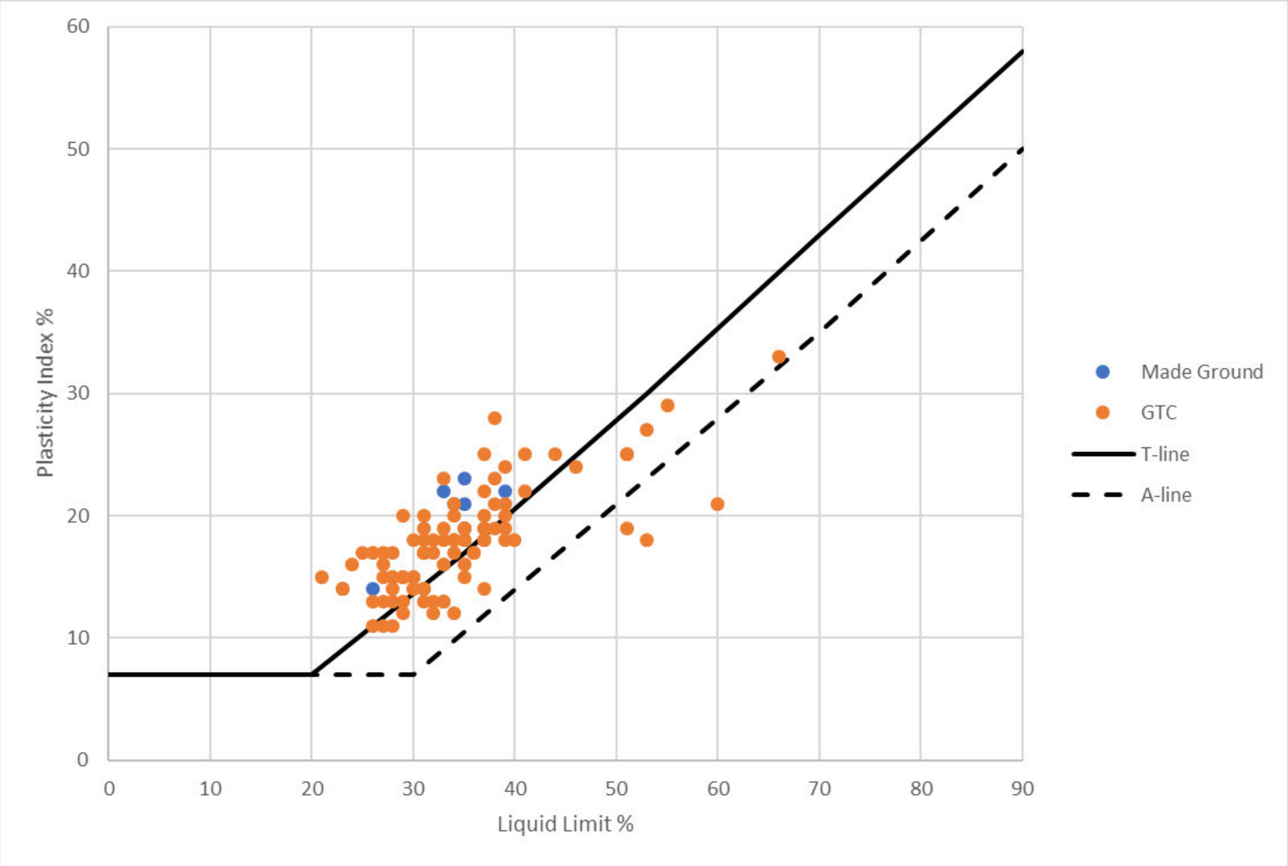
Due to the largely granular nature of the encountered Made Ground, few Atterberg tests have been carried out. The results of Atterberg tests are presented in the Figure 5-2.

Figure 5-2 - Plasticity Chart - Made Ground



The plasticity index of the Made Ground varies between 11% and 17% illustrating a low to intermediate plasticity clay. The material lies within the cohesive Glacial Till cluster and on or close to the T-Line (Ref 22) when plotting Liquid Limit against Plasticity Limit (Figure 5-3), indicating that the cohesive Made Ground potentially originates from naturally won Glacial Till.

Figure 5-3 - Made Ground and Glacial Till and T-line (Boulton and Paul, 1975)



Moisture Content

The moisture content of the Made Ground varies between 6.4% and 25.7%. There was no correlation in moisture content with depth, instead the moisture content in the samples stayed generally consistence with depth.

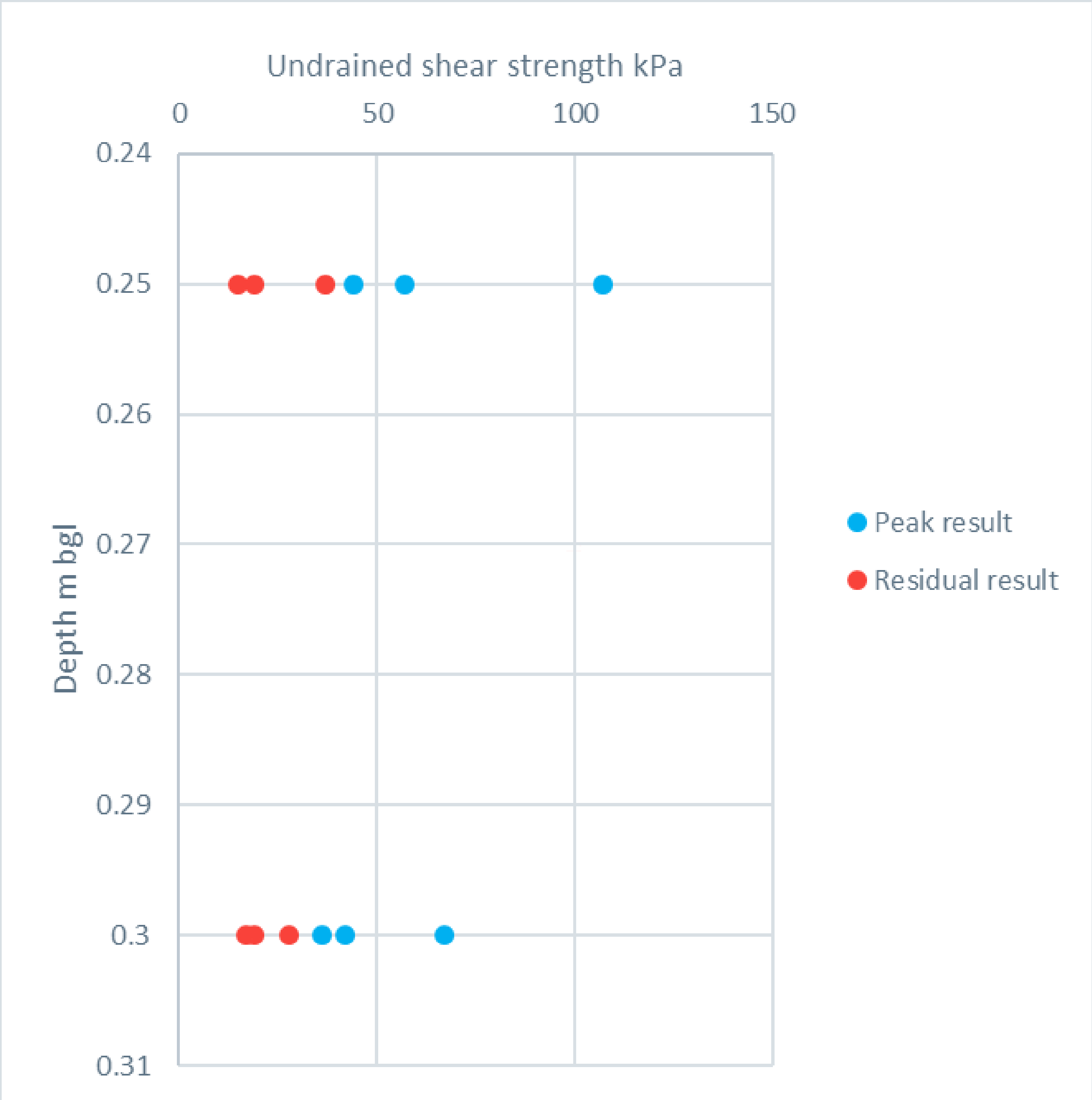
SPT N Value

Only one Standard Penetration Test was carried out in Made Ground, resulting in a N_{60} value of 29, given an SPT Hammer energy ratio of 64%, and based on equation $N_{60} = \frac{Er}{60}N$ (Annex A BS 22476-3).

Shear Strength

Six Hand Shear Vane tests were undertaken in Made Ground across the site, giving peak results of between 36 and 107kPa and residual results between 15 and 37 kPa. Figure 5-4 illustrates the results.

Figure 5-4 - Hand Shear Vane results - Made Ground



5.2.2. EFFECTIVE STRESS PROPERTIES

No consolidated undrained triaxial tests were performed on Made Ground. An assessment of the PSD test results, using the equation $\varphi'_{cv,k} = 30° + \varphi'_{ang} + \varphi'_{PSD}$ (BS 8002:2015), indicates an angle of shearing resistance of 34°.

5.2.3. SUMMARY OF GEOTECHNICAL PARAMETERS

It is anticipated that the global design parameters will be adapted for local conditions for specific design.

As mentioned, there are considerable compositional differences in the Made Ground across the site. This should therefore be taken into consideration when using the values in the summary table below.

Table 5-1 - Summary of Geotechnical Parameters for Made Ground

Material Property	No. of tests	Max	Min	Mean	Suggested Global Design Parameter*
Natural Moisture Content %	13	25.7	6.4	16.5	15
Plastic Limit %	8	23	14	20	21
Liquid Limit %	7	39	26	33.9	35
Plasticity Index %	7	17	12	13.6	14
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	7	CI	CL	-	CL
Bulk Density Mg/m^3 BS8002:2015	-	2.08	-	-	2.08
SPT N Value	1	27	-	-	27
CBR %	2	15	10	12.5	12.5
Undrained shear Strength kPa Peak (residual)	6	107 (37)	36 (15)	59 (22.5)	28
BS EN ISO 14688-2 Undrained shear strength classification	-	High	Very Low	Medium	low
Effective angle of friction (derived from PSD)	-	34	-	-	34

*It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design. Values to be treated with caution given inherent variability of Made Ground deposits

5.3 ALLUVIUM

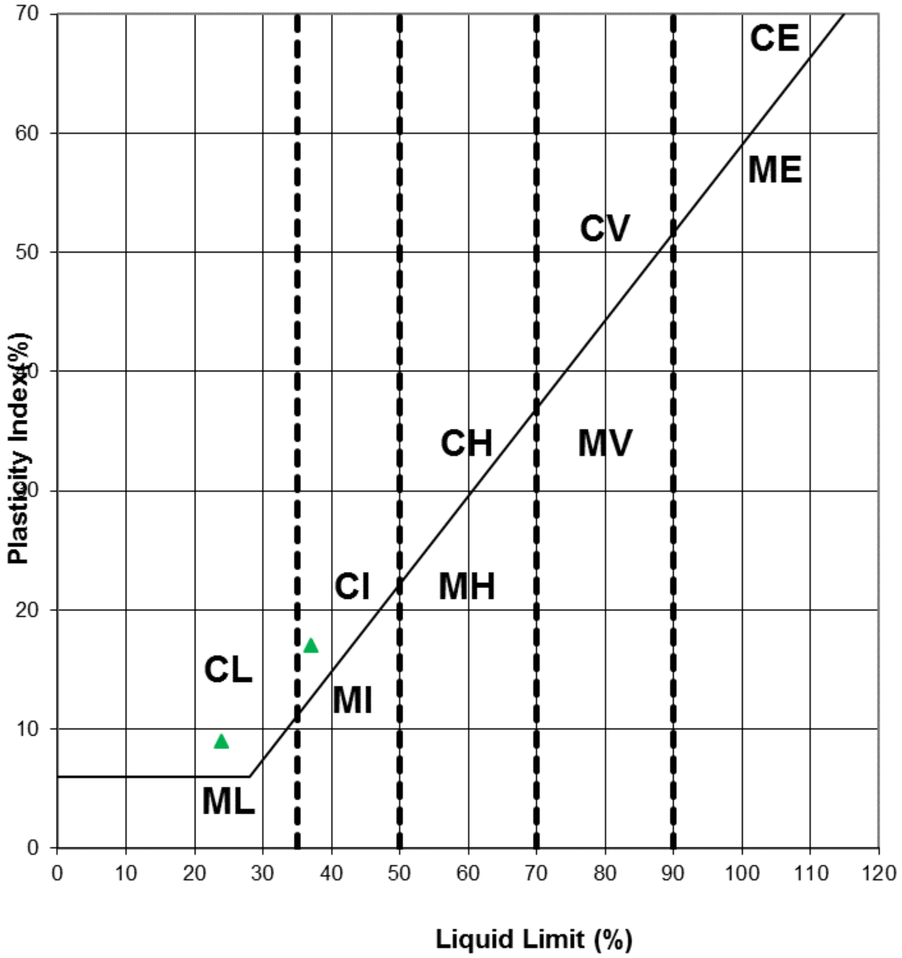
CLASSIFICATION

The alluvial deposits identified on site were typically described as fine-grained material of bluish brown, to mottled orange or yellow, sandy clay with frequent lenses of fine to medium sand. Frequent lenses of organic matter, including traces of peat, were also regularly encountered in the deposits. No PSDs were carried out on the alluvial deposits.

ATTERBERG LIMITS

Two Atterberg tests were carried out in the Alluvium, indicating a low to intermediate plasticity clay. The results are plotted on Figure 5-5.

Figure 5-5 - Atterberg Limits - Alluvium



5.3.1. MOISTURE CONTENT

Moisture content tests were carried out on five samples of Alluvium across two trial pits. The results indicate values of between 14% to 29%, with an average of 21.6%. The Alluvium results are relatively high, and lie in the mid to upper quartile of the global results as would be anticipated for the material, and typically in between the Plastic Limit/Liquid Limit results when plotted against depth.

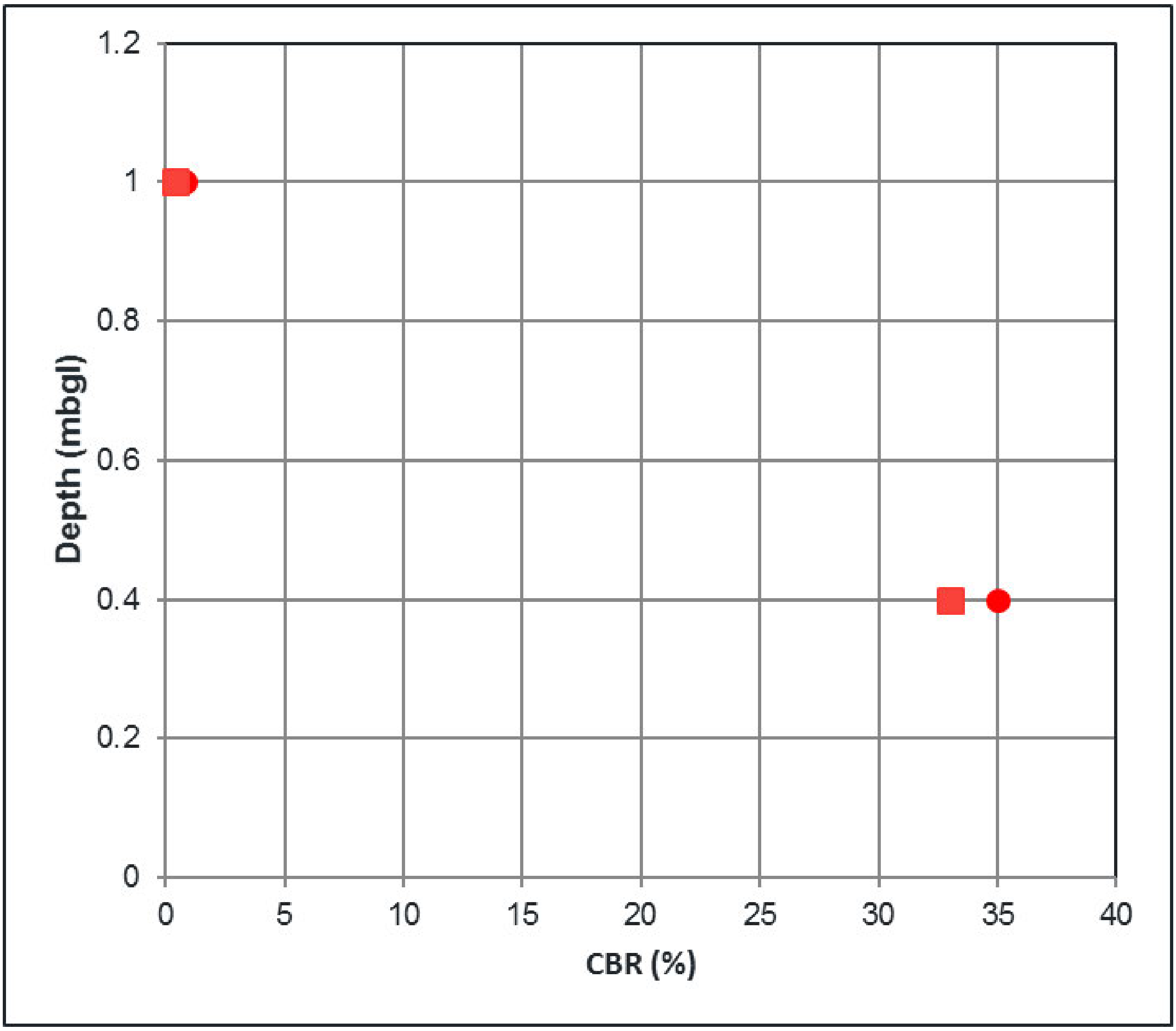
5.3.2. SPT N VALUE

No SPTs were carried out in Alluvium during the 2018 or historical ground investigations.

5.3.3. CBR

Two laboratory unsoaked CBR tests were carried out in alluvial deposits, at TP/17/17 and TP/17/43.Figure 5-6 below illustrates the results. TP/17/43 recorded considerably higher CBR values (33%, 35%) from than what would be anticipated for Alluvium, placing it in the upper half of the all CBR values collected globally.TP/17/17 likely provides more representative values, of 0.4% and 0.8%.

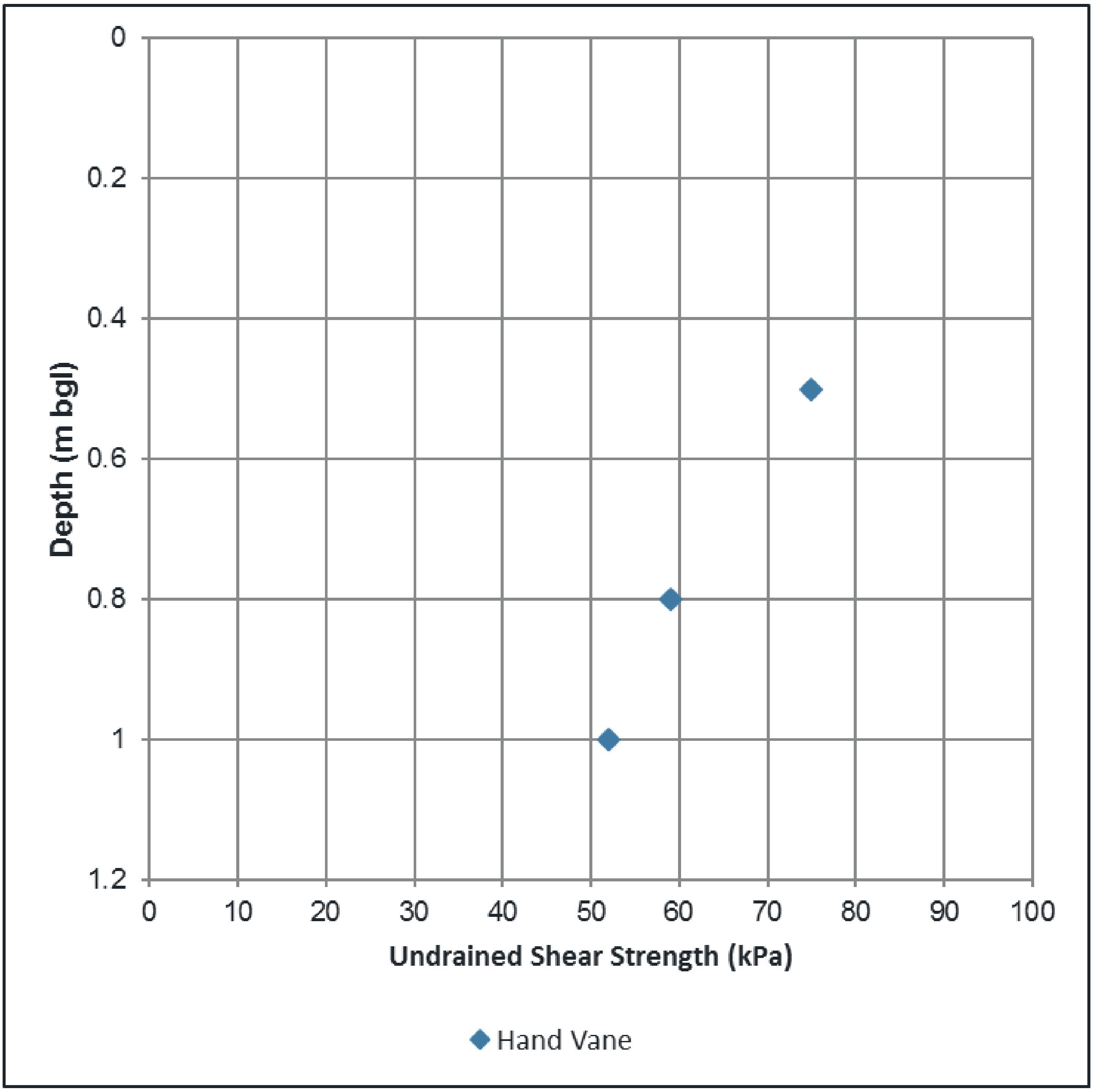
Figure 5-6 - CBR vs. depth - Alluvium



SHEAR STRENGTH PROPERTIES

Three hand shear vane tests were undertaken in the alluvial deposits at depths of between 0.5m and 1.0m bgl. The tests showed peak undrained strength results of 52-75kPa, with 17-34kPa for residual undrained strength, indicating a very low to medium strength material. No further laboratory tests were undertaken to determine the undrained shear strength of Alluvium.

Figure 5-7 - Undrained shear strength - Alluvium



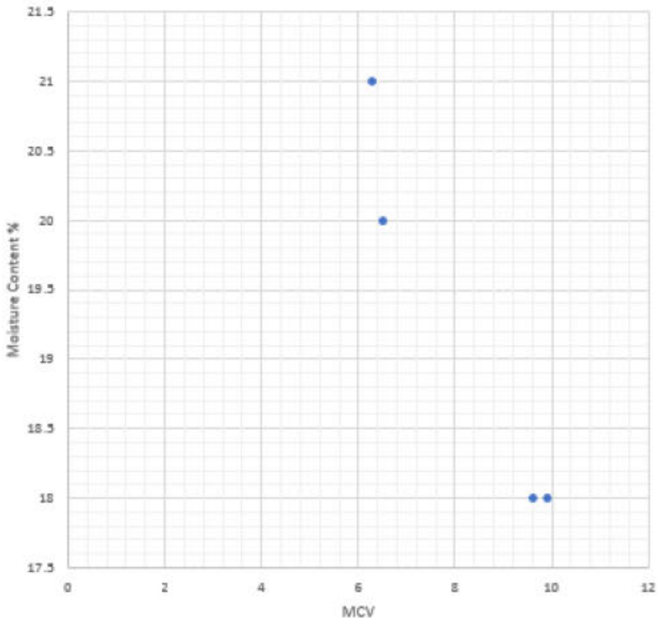
EFFECTIVE STRESS PROPERTIES

One small shear box test was carried out on a remoulded sample of Alluvium, from TP/17/43 at 1m bgl. A value of peak angle of effective friction of 29.5° was determined, the residual was not obtained.

MOISTURE CONDITION VALUE (MCV)

Figure 5-8 shows the four Moisture Condition Value tests carried out on samples of Alluvium, with MCV values ranging between 6.3 and 9.9.

Figure 5-8 - MCV vs. depth - Alluvium



SUMMARY OF GEOTECHNICAL PARAMETERS

Table 5-2 - Summary of Geotechnical Parameters for Alluvium

Material Property	No. of tests	Max	Min	Mean	Suggested Global Design Value*
Natural Moisture Content %	5	29	14	21.6	20
Plastic Limit %	2	20	15	17.5	17
Liquid Limit %	2	37	24	30.5	30
Plasticity Index %	2	17	9	13	13
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	2	CI	CL	CL	CL
Bulk Density kg/m^3	3	2.22	2.22	2.22	2.22
SPT N Value	0	-	-	-	
CBR %	2	0.8	0.4	0.6	0.6
Undrained shear strength kPa Peak (residual)	3	75 (34)	52 (17)	62 (23)	34
BS EN ISO 14688-2 Undrained shear strength classification	-	medium	Very low	medium	medium
MCV	4	9.9	6.3	8.1	8
Effective angle of friction	1	29.5	-	-	29

*It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design.

5.4 GLACIAL DEPOSITS

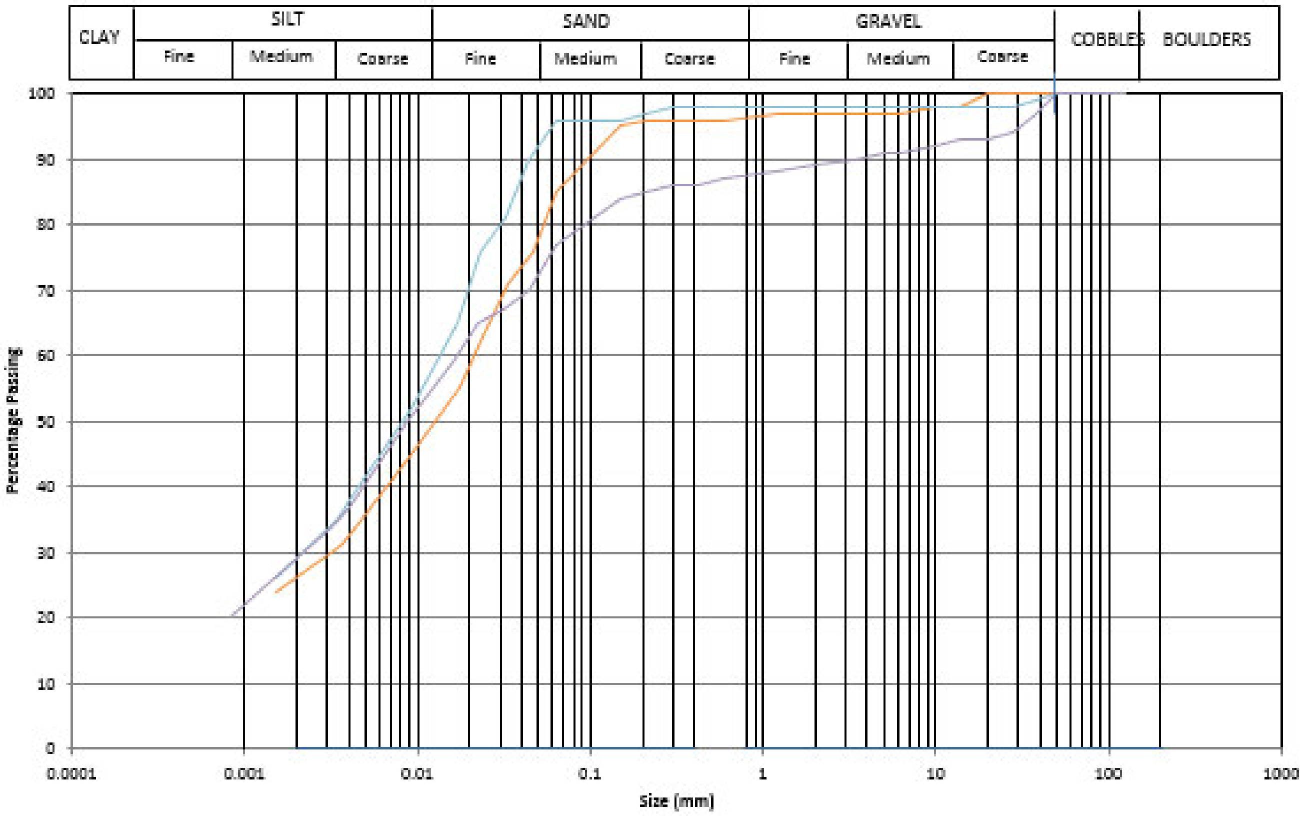
GLACIO-LACUSTRINE DEPOSITS

Classification

Glacio-lacustrine deposits were encountered at depths between 1.5m and 5.7m bgl. The deposits are characterised by the soft and laminated nature of the clay and silt, and typically described as soft to very soft brown slightly sandy, thinly laminated clay and silt.

Three PSD tests, compiled in Figure 5-9 were carried out in the Glacio-lacustrine deposits, indicating slightly sandy slightly gravelly clay.

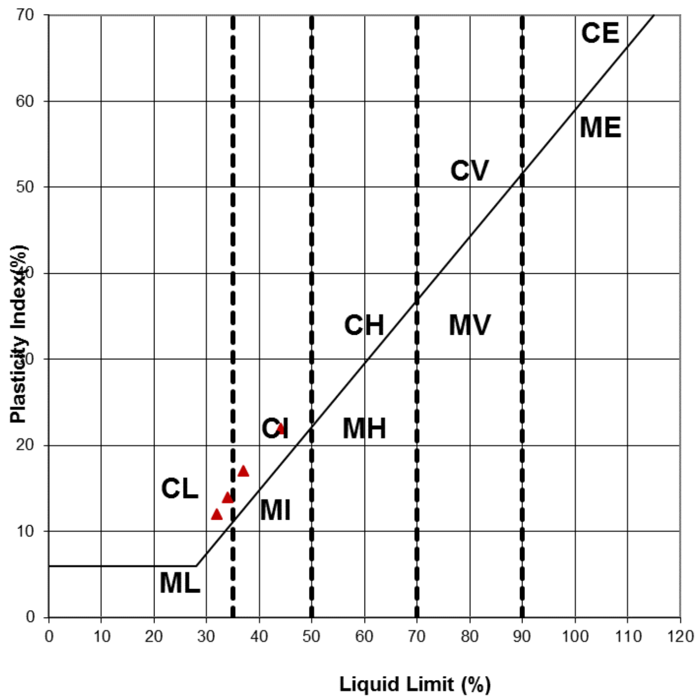
Figure 5-9 - Particle Size Distribution - Glaciolacustrine deposits



5.4.1. ATTERBERG LIMITS

Four Atterberg tests were undertaken in the Glacio-lacustrine deposits at Charlton Mires, indicating a low to intermediate plasticity clay with a plasticity index varying between 14% and 22% and an average of 16%. Figure 5-9 illustrates the classification of the deposits.

Figure 5-10 – Atterberg limits - Glaciolacustrine deposits

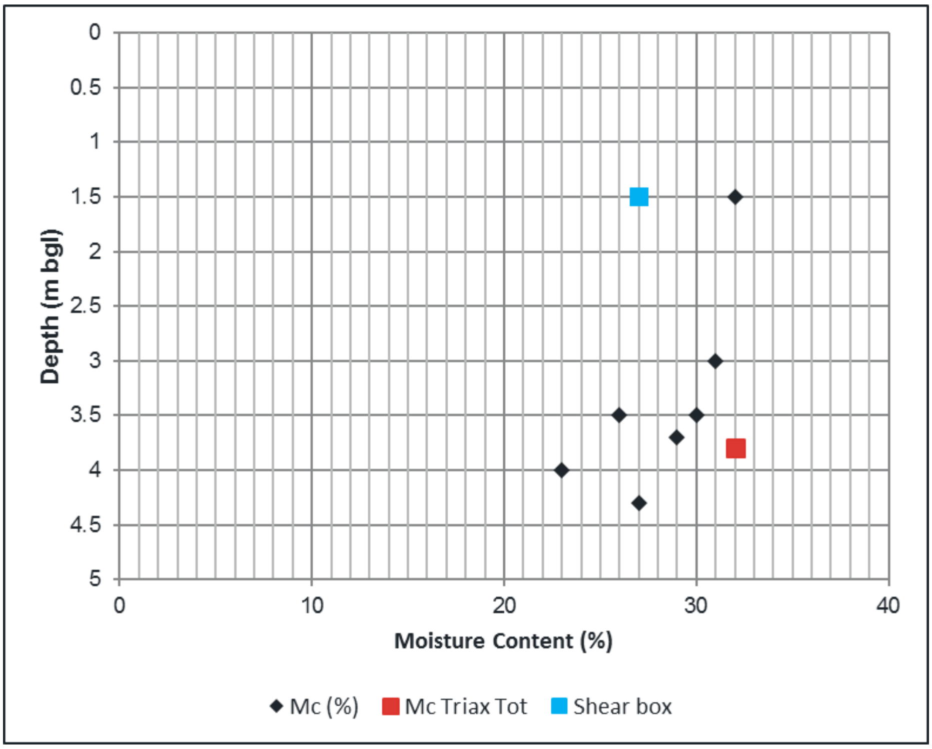


MOISTURE CONTENT

Seven Moisture Content tests were carried out on samples of Glacio-lacustrine deposits, a further two moisture content tests were carried out as part of triaxial and shear box tests.

The moisture content values exhibited in the Glacio-lacustrine deposits were fairly high, presenting a moisture content of 23% - 32% which is typical of a Glacio-lacustrine material.

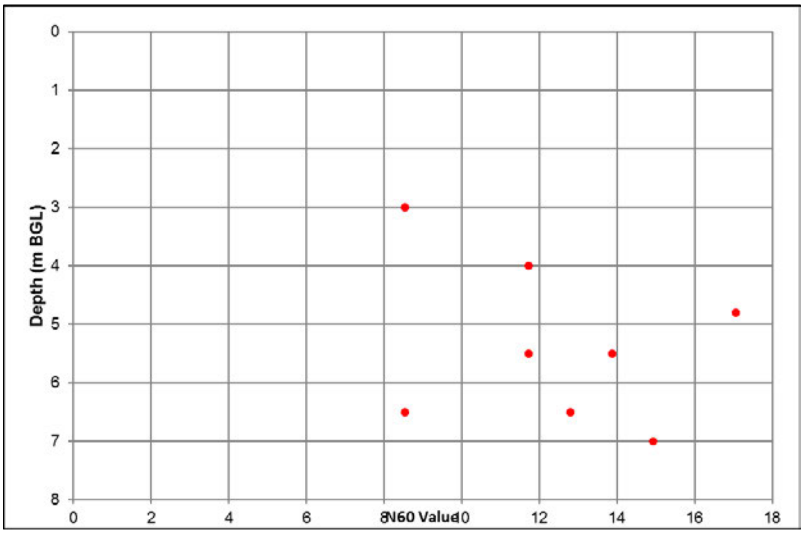
Figure 5-11 - Moisture Content - Glaciolacustrine deposits



SPT N VALUE

Eight SPT tests were carried out within the Glacio-lacustrine deposits, with N_{60} values ranging between 9 and 17. An anomalous result of 50 in BH/17/06 is shown, located within 0.1m of the boundary to very dense Glacial Till. This SPT is therefore considered to represent the density of the underlying Glacial Till rather than the Glacio-lacustrine deposits. Figure 5-12 below, shows the corrected SPT N results against depth.

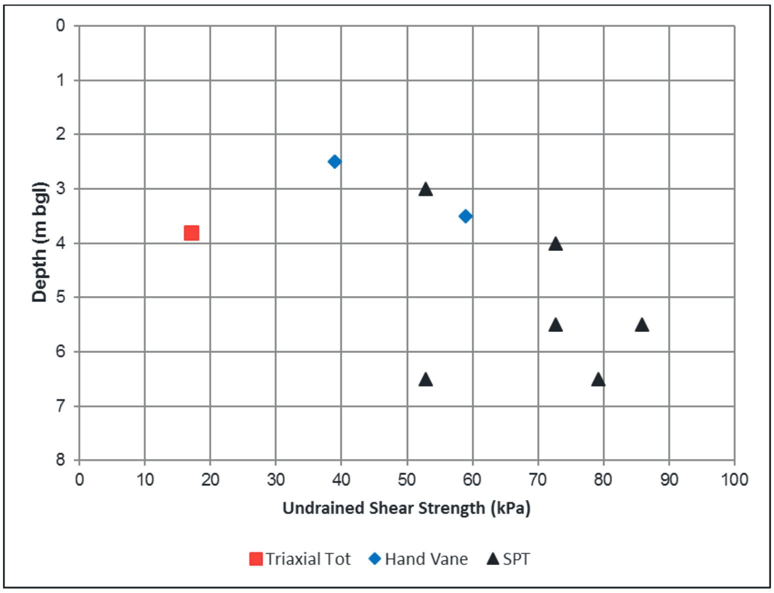
Figure 5-12 – SPT N60 vs depth - Glaciolacustrine deposits



SHEAR STRENGTH PROPERTIES

One Undrained Unconsolidated triaxial test was carried out at 3.8m bgl from BH/17/06, indicating an undrained shear strength value of 17kPa. Two Hand Shear Vanes were also undertaken in the Glacio-lacustrine deposit giving peak results of 39 and 59kPa. The measured values indicate a very low to medium strength material. Figure 5-13 below illustrates the measured shear strength values with the derived shear strength values from SPT, based on an f1 value of 6.6 (Ip of 16%). The results illustrated a very low to high strength material.

Figure 5-13 - Undrained shear strength - Glaciolacustrine deposits



COMPRESSIBILITY

No one-dimensional oedometer tests were carried out on samples of Glacio-lacustrine Deposits. Using the relationship of mv = 1/F2N, with a F2 value of 0.65 (based on a Ip of 16%), indicates typical values of between 0.10 and 0.19 m2/MN.

SUMMARY OF GEOTECHNICAL PARAMETERS

Table 5-3 - Summary of Geotechnical Parameters for Glaciolacustrine Deposits

Material property	No. of tests	Max	Min	Mean	Suggested Global Design Value*
Natural Moisture Content %	10	32	23	28	30
Plastic Limit %	4	22	20	20.5	20
Liquid Limit %	4	44	32	36.8	36
Plasticity Index %	4	22	14	16.3	16
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	4	CI	CL	CI	CL
Undrained shear strength cu (kPa)	11	105.6	17	66	39-92 between 2.5m and 7m bgl.
BS EN ISO 14688-2 Undrained shear strength classification	-	High	Very low	Medium	Medium-high
Coefficient of Volume Compressibility (m^2/MN)$^+$	-	0.19	0.10	-	0.19
Bulk Density Mg/m^3	2	19.5	19.3	19.4	19.4
SPT N Value	8	16	8	11.6	8-14 between 3m and 7m bgl.
Effective angle of friction *(Based on relationship in 5.2.1)*	4	27.7	25.2	26.8	25

*It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design.

$^+$ Value derived from SPT tests

5.5 GLACIO-FLUVIAL DEPOSITS

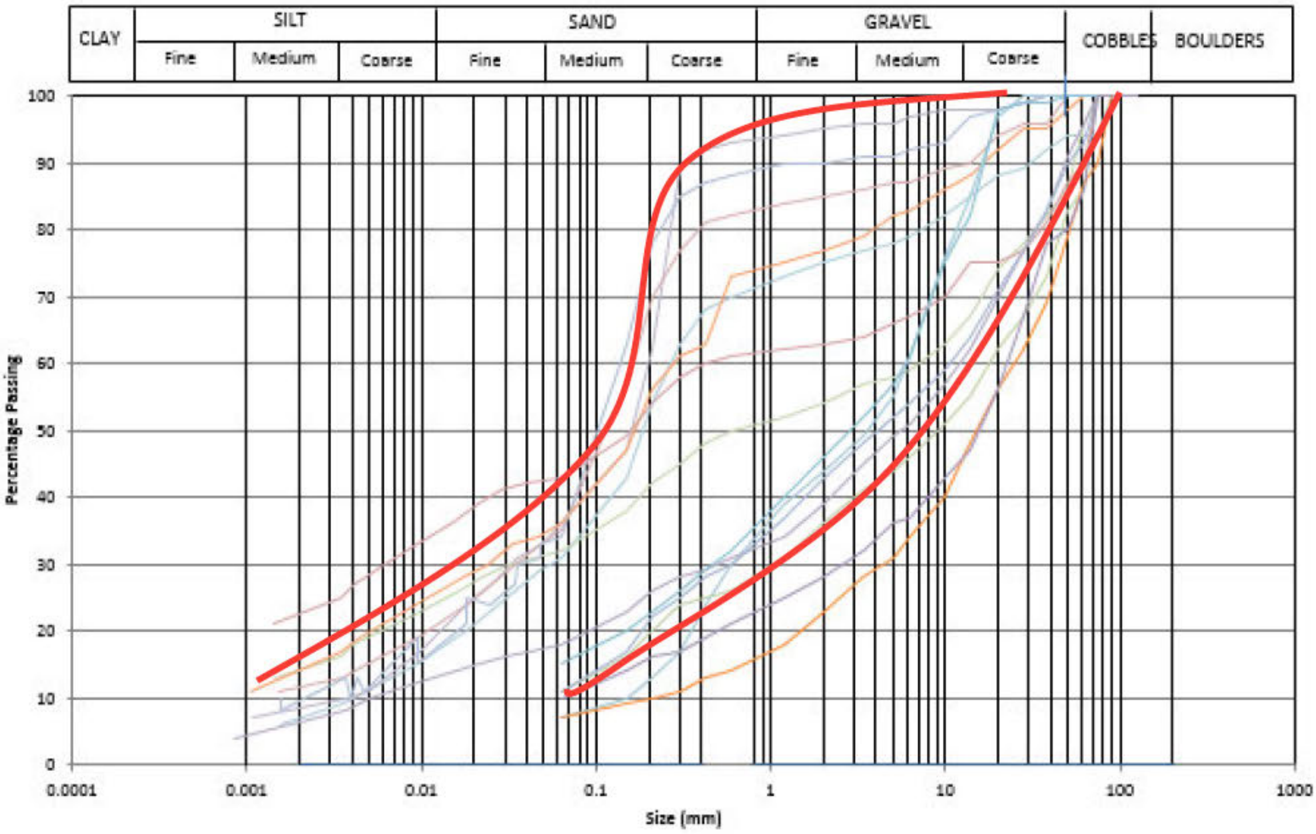
CLASSIFICATION

Glacio-fluvial deposits are typically identified by the high proportion of sands and gravels which were typically rounded to subrounded, occasionally in addition to cobbles and boulders. The deposits are generally described as 'Orangey brown gravelly sandy silty sand and gravel with low to medium cobble content. Gravel is subrounded to rounded fine to coarse of sandstone. Cobbles are subrounded to rounded of sandstone'.

Despite being predominantly granular, two successful plasticity tests were undertaken on the Glacio-fluvial deposits, indicating the occasional presence of low to intermediate plasticity clay layers or pockets.

The PSD plot below shows the size envelope for the Glacio-fluvial deposits, where sand makes up between 28% and 95% of a typical sample.

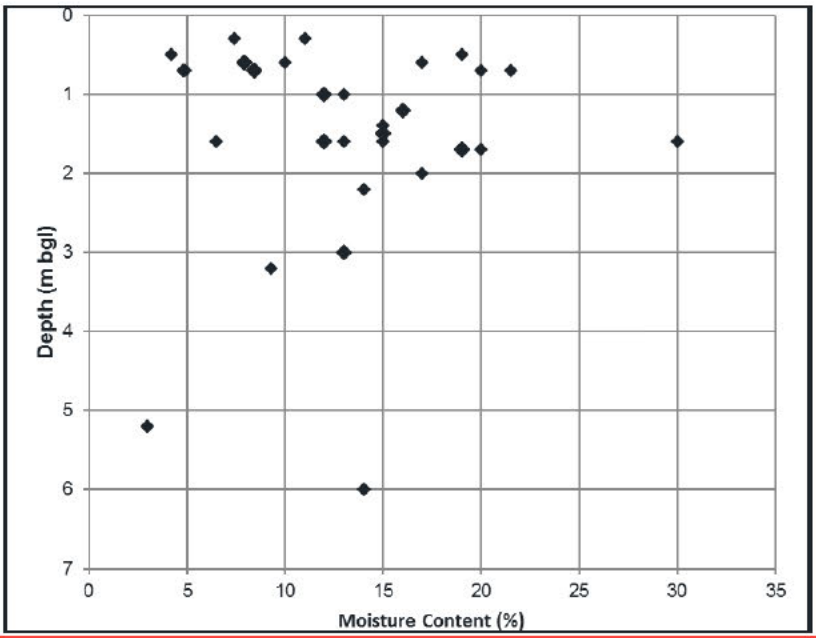
Figure 5-14 - Particle Size Distribution - Glacio-fluvial deposits



MOISTURE CONTENT

The natural moisture content of the Glacio-fluvial deposits varies between 3% and 30%, with an average of 13.6%. Figure 5-15 below shows the moisture content results, which do not show a marked change with depth. The results lie within the typical bracket of results shown in the cohesive and granular Glacial Till deposits across the site.

Figure 5-15 - Moisture Content- Glacio-fluvial deposits

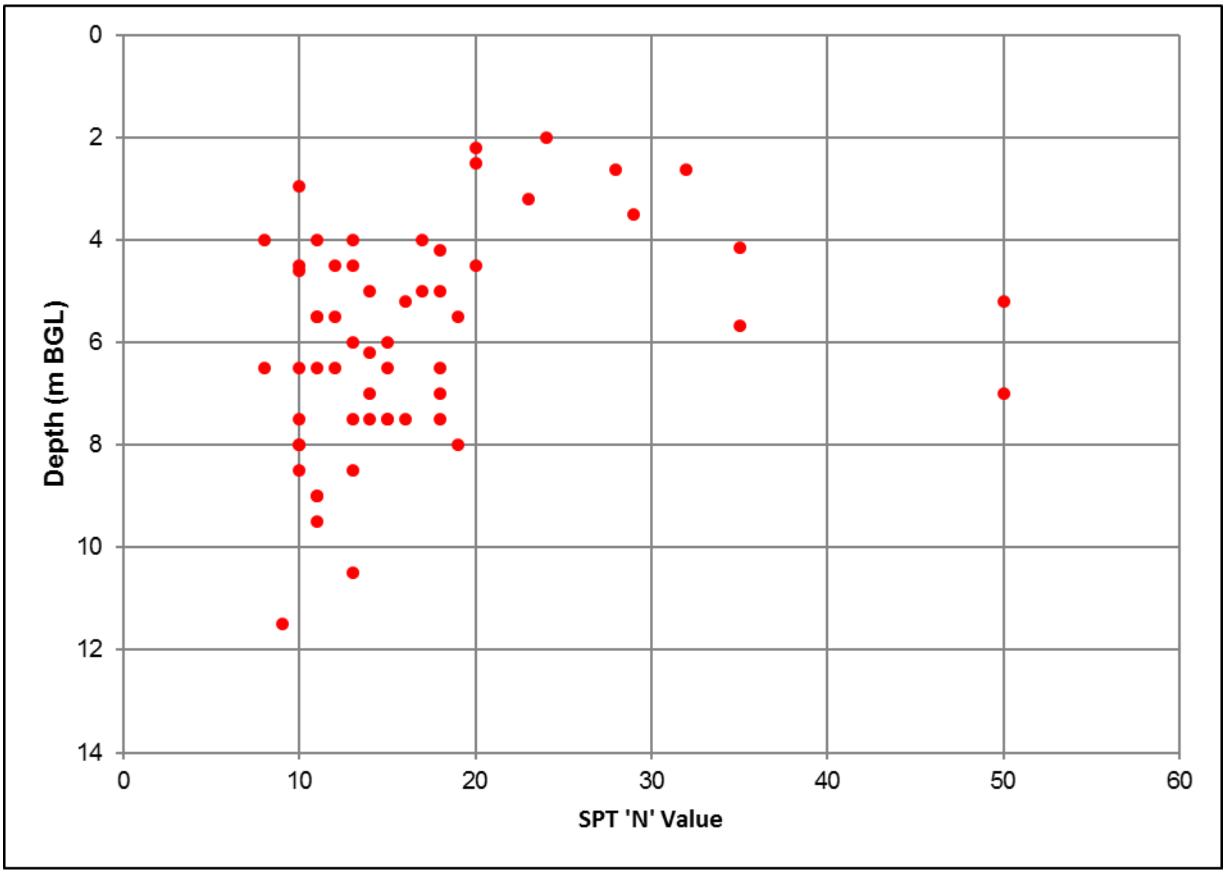


SPT

N Values

53 SPT tests were carried out in the Glacio-fluvial deposits, with a N values ranging between 8 and refusal, indicating a loose to very dense material. The plot below shows a scattered set of results, particularly at shallow depths, which may represent desiccation of the upper part of the stratum. A typical range of SPT is shown as 11-21, with corresponding N_{60} values ranging between 8.5 and refusal.

Figure 5-16 - SPT N Value vs. depth - Glacio-fluvial deposits



EFFECTIVE STRESS PROPERTIES

The angle of friction for Glacio-fluvial deposits was derived from the following relationship, based on an Ip of 13%.

$$\varphi'_{cv} = (42° - 12.5log_{10}Ip)$$

28° was take as the typical design value.

COMPRESSIBILITY

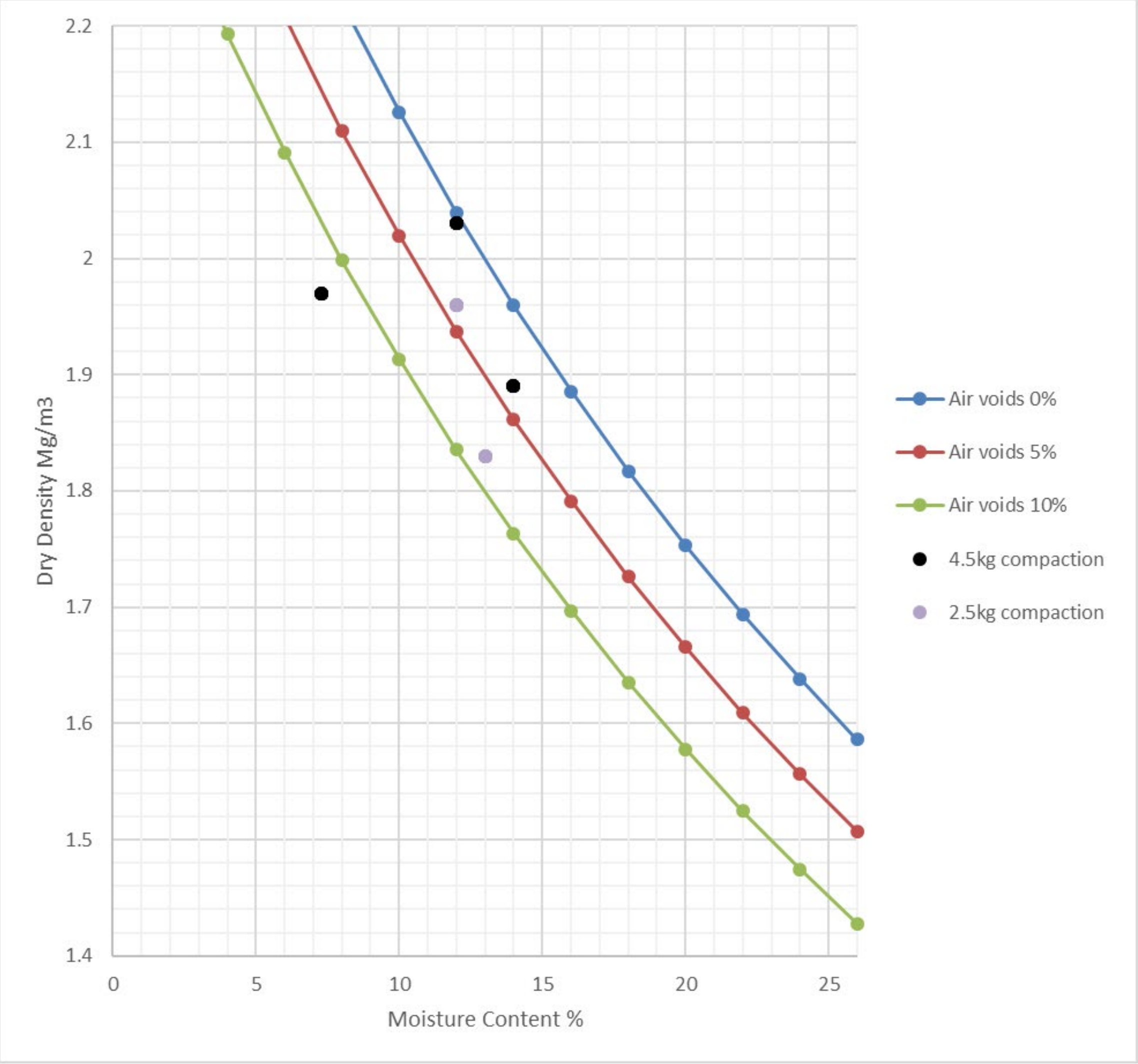
A one-dimensional oedometer test was carried out on a sample within a discrete cohesive layer in the Glacio-fluvial deposits from BH/17/12 at 1.2m bgl, illustrating a volume compressibility (m_v) of 0.11m^2/MN and coefficient of compressibility (c_v) of 20m^2/yr for in-situ + 100kPa.

5.5.1. COMPACTION TESTS

Five compaction tests were undertaken on samples of the Glacio-fluvial deposits using both the 2.5kg and 4.5kg rammer methods. The results range between 1.89 Mg/m^3 to 2.03 Mg/m^3 Maximum Dry Density (MDD) and 7.3% and 14% Optimum Moisture Content (OMC) for 4.5kg compaction, and between 1.83 Mg/m^3 and 1.96 Mg/m^3 (MDD) and 12% to 13% (OMC) for light 2.5kg compaction tests. These compare with an average natural moisture content of 13.0%.

The plot below shows the optimum moisture content against dry density.

Figure 5-17 - Optimum Moisture Content vs. Dry Density - Glacio-fluvial deposits



Based on a specific gravity of 2.7, the moisture acceptability upper limit to achieve 95% compaction is approximately 13.5 % and 15% (2.5kg and 4.5kg respectively) and lower limit of 12% to achieve 90% compaction for both compactive efforts.

CBR

Three unsoaked CBR tests were carried out on Glacio-fluvial deposits. The results gave the following results, CBR at top of sample 2.6-27% (Av.13%) and at base of sample, 2.4 and 34% (Av. 17%). A further in-situ CBR was carried out in glacio-fluvial deposits during an historical ground investigation, giving a result of 0.5%.

SUMMARY OF GEOTECHNICAL PARAMETERS

Table 5-4 - Summary of Geotechnical Parameters for Glacial-Fluvial Deposits

Material property	No. of tests	Max	Min	Mean	Suggested Global Design value*
Natural Moisture Content %	27	30	3	13	13
Plastic Limit %	3	23	18	21	21
Liquid Limit %	2	40	30	35	35
Plasticity Index %	2	17	8	13	13
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	2	CI	CL	CL	CL
Bulk Density Mg/m3	11	2.08	1.63	1.94	1.9
SPT N Value	58	50	8	16	11 *(between 4 – 10.0m bgl)*
CBR %	3	34	2.4	15	15
Consolidation coefficient mv (MN/m2)	4	39	1.9	21	21
Optimum Moisture Content %	5	14	7.3	11.7	12
Effective angle of friction (derived from Plasticity Index)	-	-	-	-	28°

*It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design.

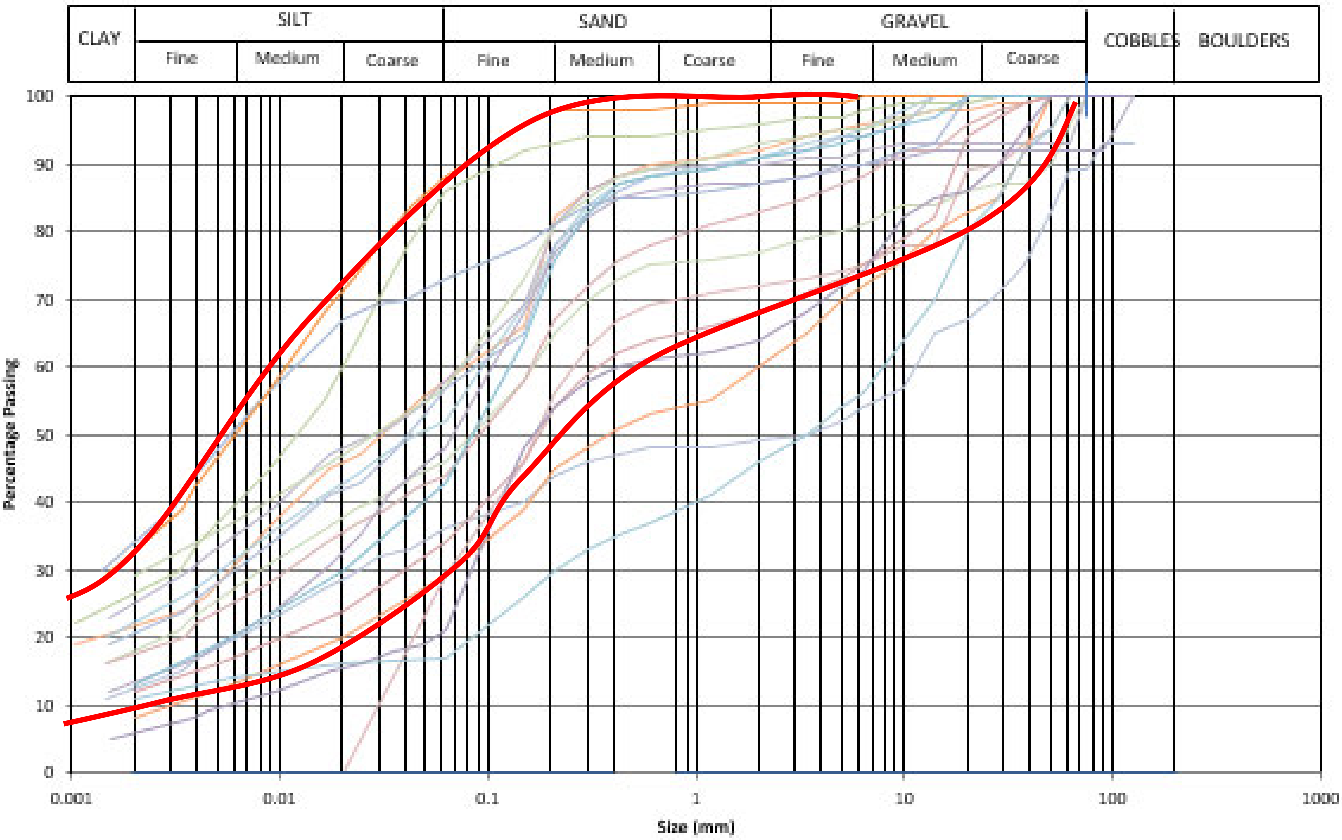
5.6 GLACIAL TILL – COHESIVE DEPOSITS

The Glacial Till deposits are the most commonly encountered of the superficial deposits across the global site. The till is comprised of both fine-grained and coarse- grained material. The parameters for both deposit types are assessed below.

CLASSIFICATION

The cohesive till is the major constituent of the Glacial Till. The descriptions on the exploratory logs in the ground investigation reports describe the Glacial Till as typically being firm to stiff, slightly gravelly, slightly sandy clay. The Particle Size Distribution plot below highlights that the cohesive till is predominantly made up of fines (28-88%) with 10-33% clay-sized material.

Figure 5-18 - Particle Size Distribution - Fine-grained Glacial Till



ATTERBERG LIMIT

95 Atterberg tests were carried out on the cohesive glacial till. The plot below, indicates the material is largely a low to intermediate plasticity clay with occasional silts and high plasticity clays.

The plastic limit ranged from 12% to 30% with an average of 19% and the liquid limit ranged from 21% to 69% with an average of 40%. The resulting Plasticity Index of the Cohesive Till ranged from 3% to 43% with an average of 21%. The plasticity chart in

Figure 5-19 indicates the cohesive till to be typically of the low to intermediate plasticity.

Figure 5-20 and Figure 5-22 show that the Till within the top 4.0m presented a plasticity index of between 10% to 20%, with no discernible change with depth featuring a similar scatter to the moisture content with depth whereby no marked change with depth was observed. Figure 5-19 illustrates the moisture content, liquid limit and plastic limit against depth, where moisture content is seen to typically be approximately Plastic Limit - 3%.

Figure 5-19 - Plasticity Classification and Moisture Content- Cohesive Glacial Till

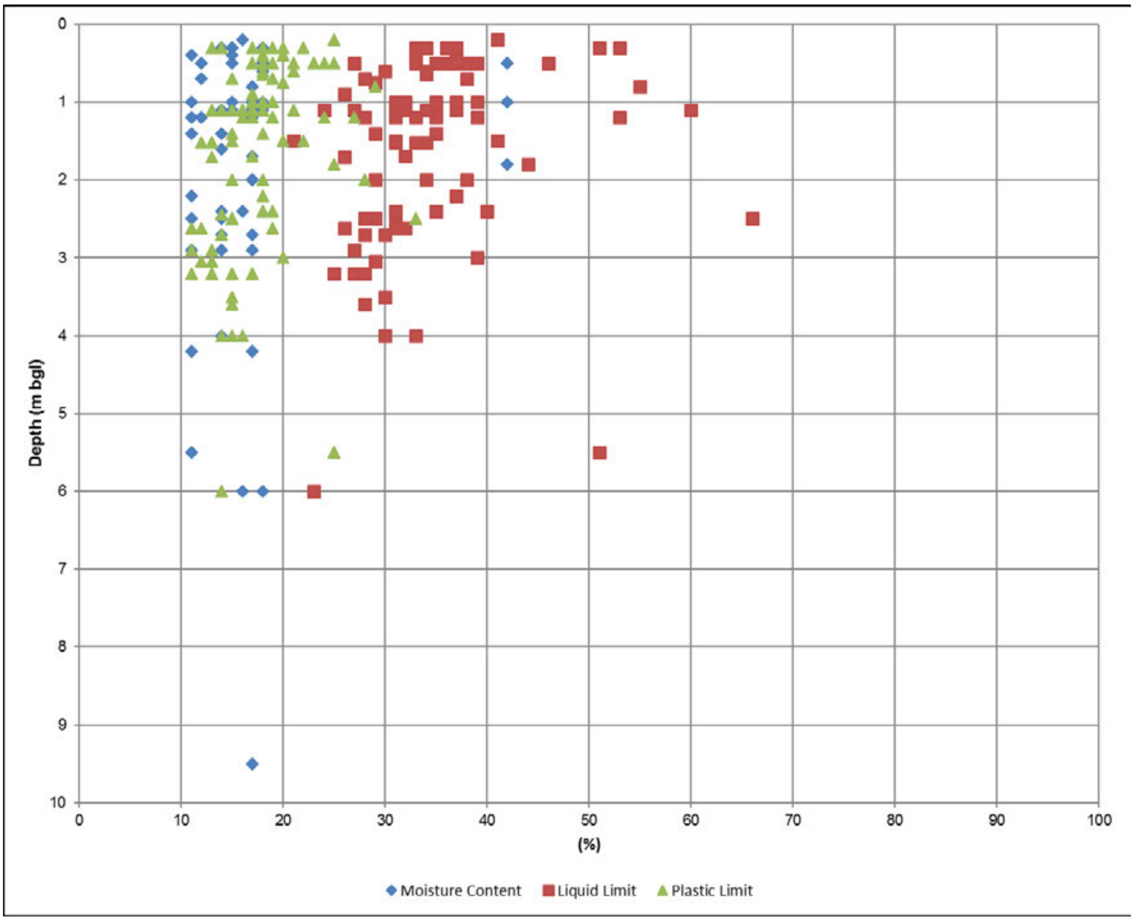


Figure 5-20 - Plasticity Index - Cohesive Glacial Till

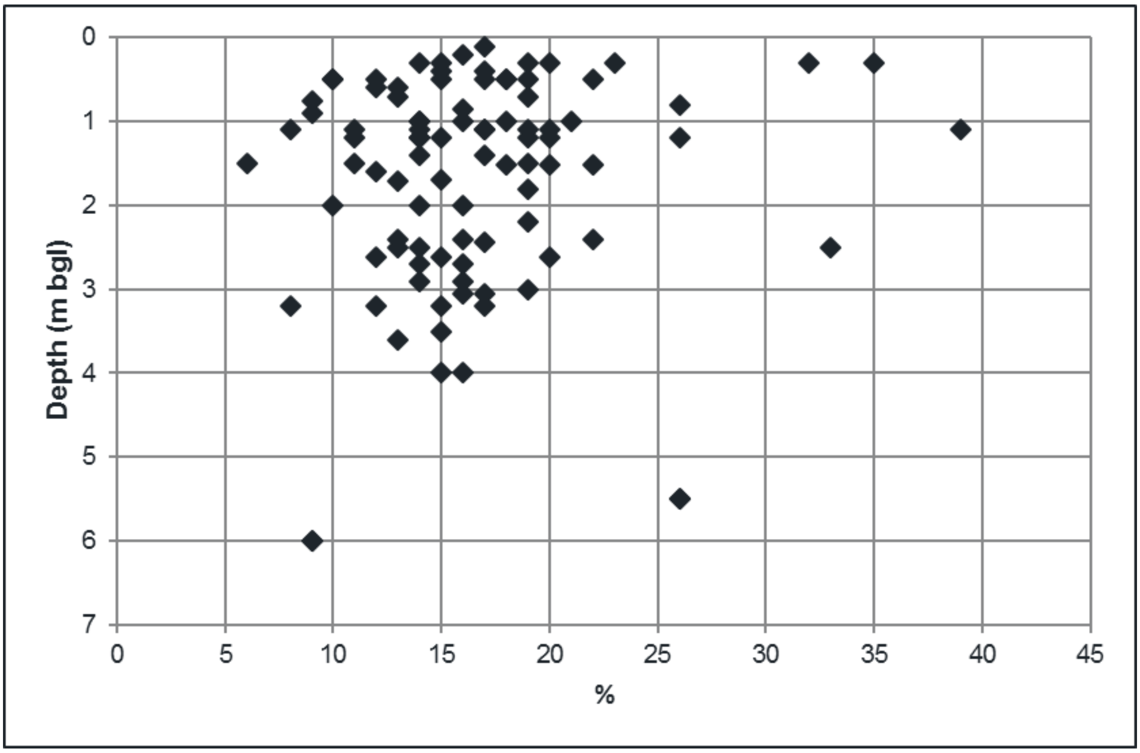
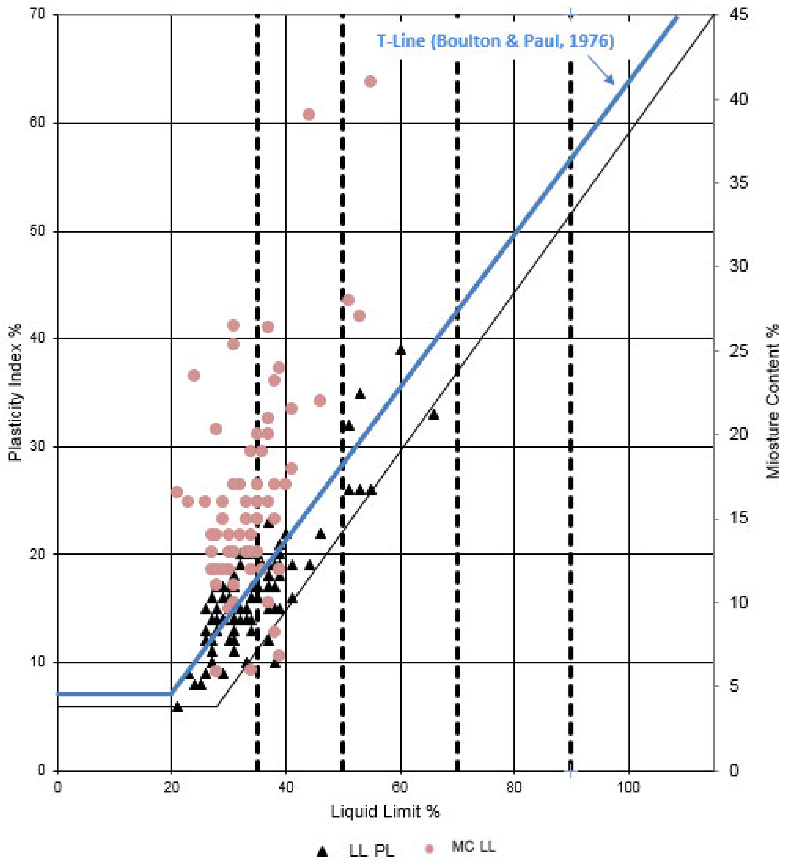


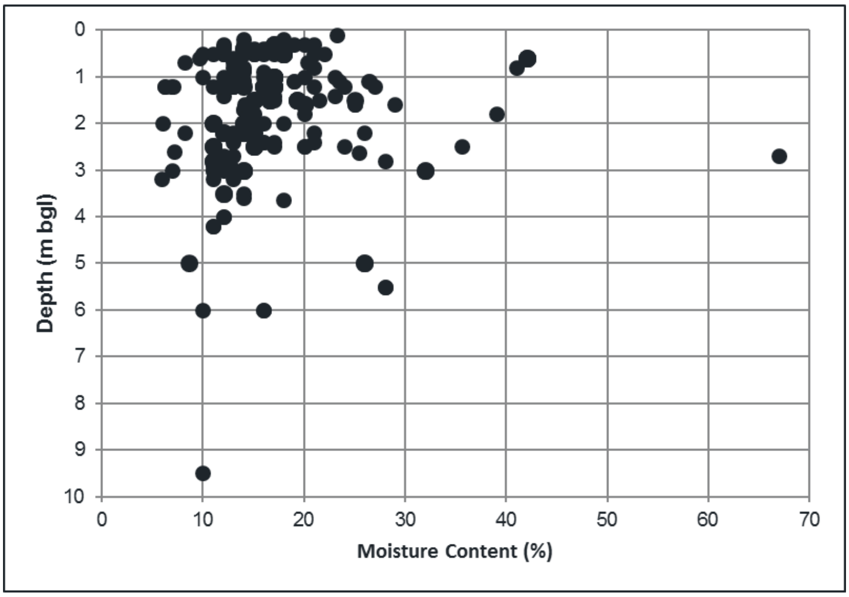
Figure 5-21 - Plasticity Classification



5.6.1. MOISTURE CONTENT

175 Moisture Content tests were undertaken with values ranging between 6% and 67%. The moisture content results which coincide with plasticity testing are seen in Figure 5-18. It can be seen from Figure 5-22 that there is a slight increase in moisture content within the upper 2.5m of these deposits.

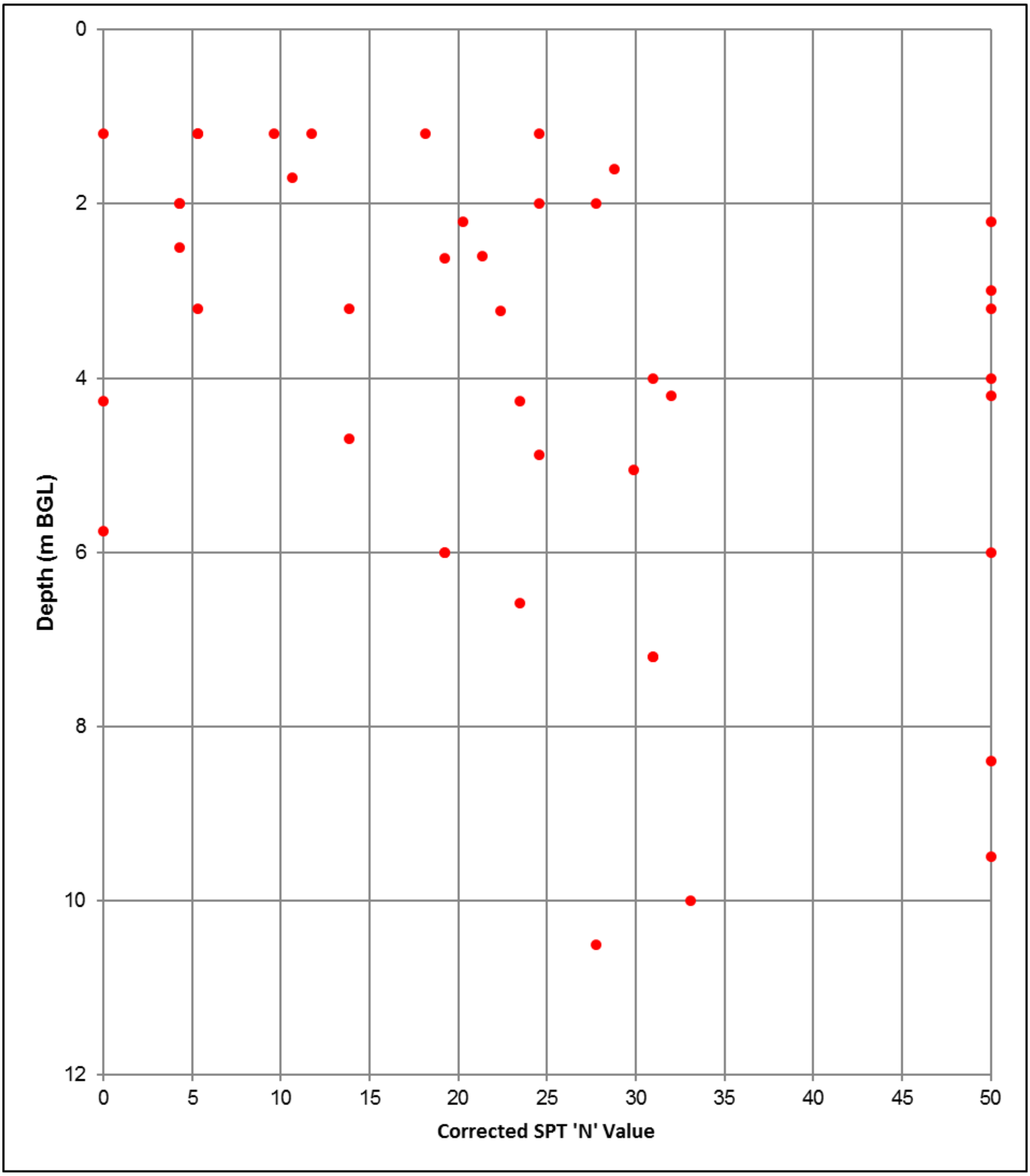
Figure 5-22 - Moisture Content - Cohesive Glacial Till



SPT N VALUES

40 SPT N Values were recorded in the cohesive Glacial Till across the site, varying from an N_{60} Value of 4 to >50. Figure 5-23 below illustrates a typical increase in N_{60} Value with depth.

Figure 5-23 – Corrected SPT N Values - Cohesive Glacial Till



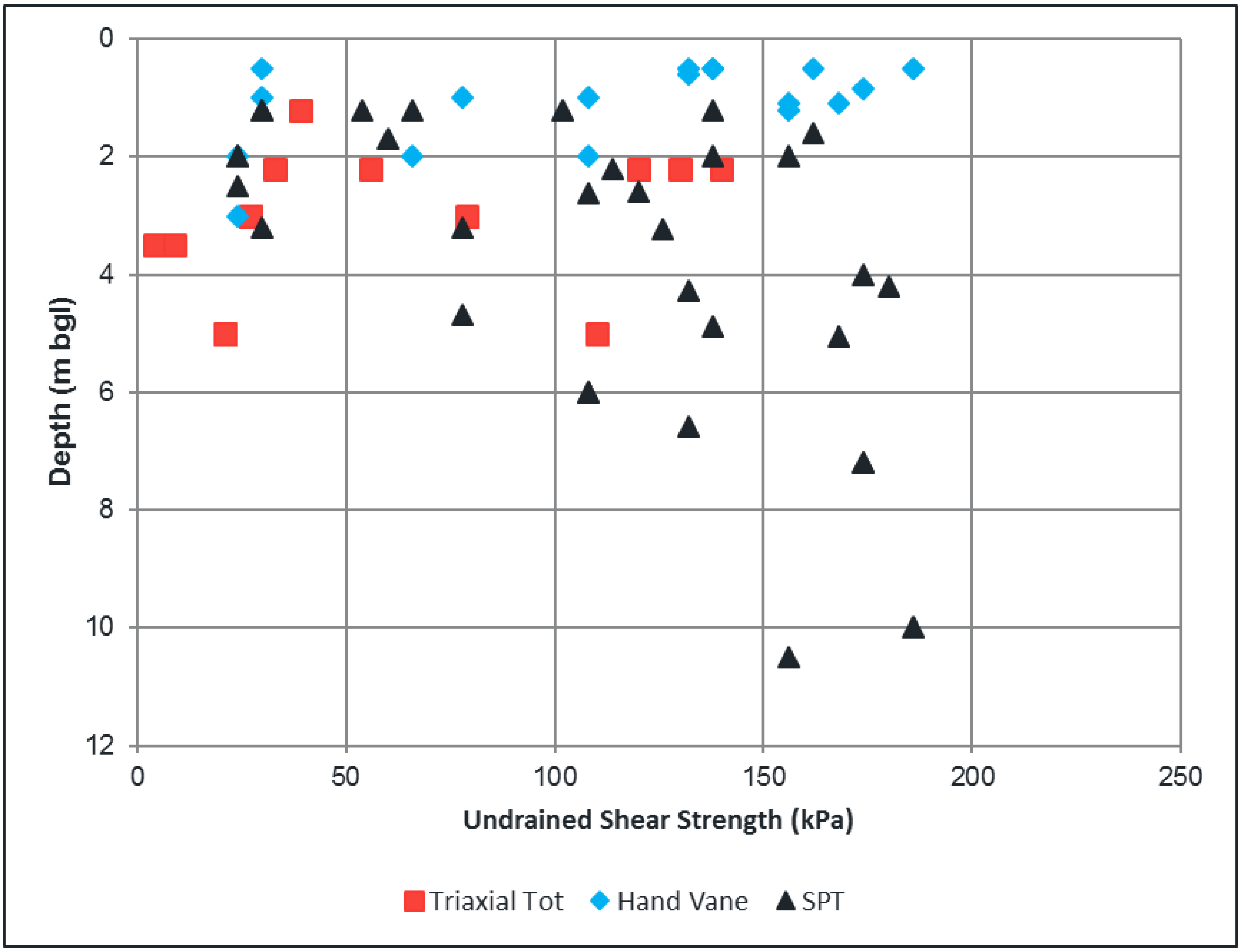
SHEAR STRENGTH

15 unconsolidated undrained triaxial tests were carried out in the Glacial Till, along with 15 hand shear vane tests carried out within trial pits. The values of undrained shear strength are illustrated in the Figure 5-24 below.

The very low values, of <10kPa, were obtained from BH/17/14, at a depth of 3.5m bgl, corresponding to material described as soft to firm slightly gravelly sandy silty clay. The plot below, illustrates a general increase in shear strength with increased depth.

Derived shear strength values were also determined from SPT N values, using the relationship cu = 6N where the Plasticity Index is 16%.

Figure 5-24 - Undrained Shear Strength - Cohesive Glacial Till

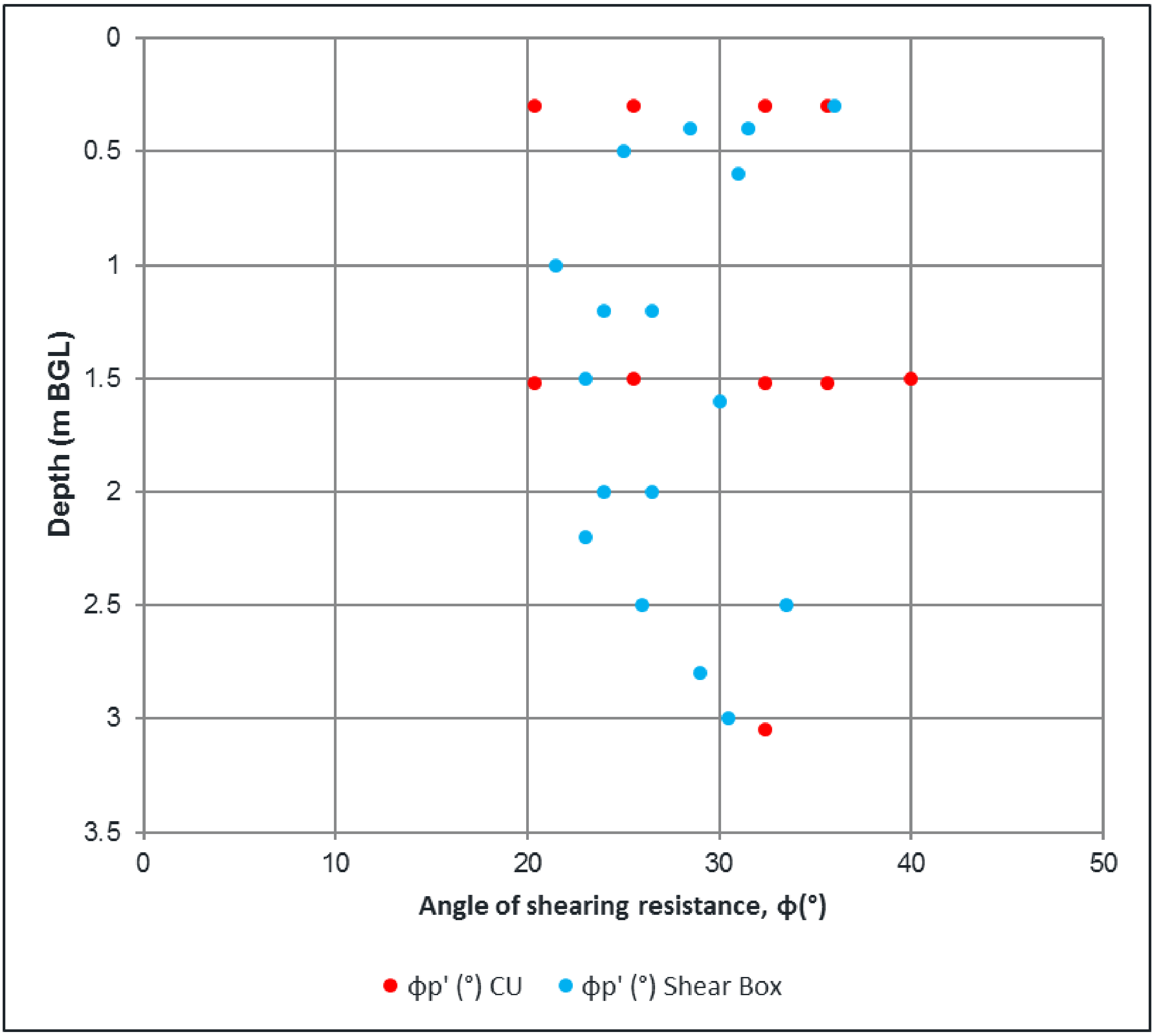


EFFECTIVE STRESS PROPERTIES

Single stage consolidated undrained triaxial testing with measurement of pore water pressure was carried out on ten samples of cohesive till from historical ground investigations. Due to a lack of suitable samples, shear box testing was carried out on samples at natural moisture content to provide an indication of potential effective stress parameters. Figure 5-25 below shows the results from each of these tests. The results vary from 20.4º to 40º with an average of 29º. The values from the shear box testing are likely to represent lower bound conditions.

This collaborates reasonably with correlations using the plasticity data, where an average plasticity index of 19% would also indicate a corresponding Φ' peak of 26˚ according to the method presented in BS8002:2015 and developed by Gibson 1953 (Ref 24).

Figure 5-25 - Angle of Shearing resistance - Cohesive Glacial Till

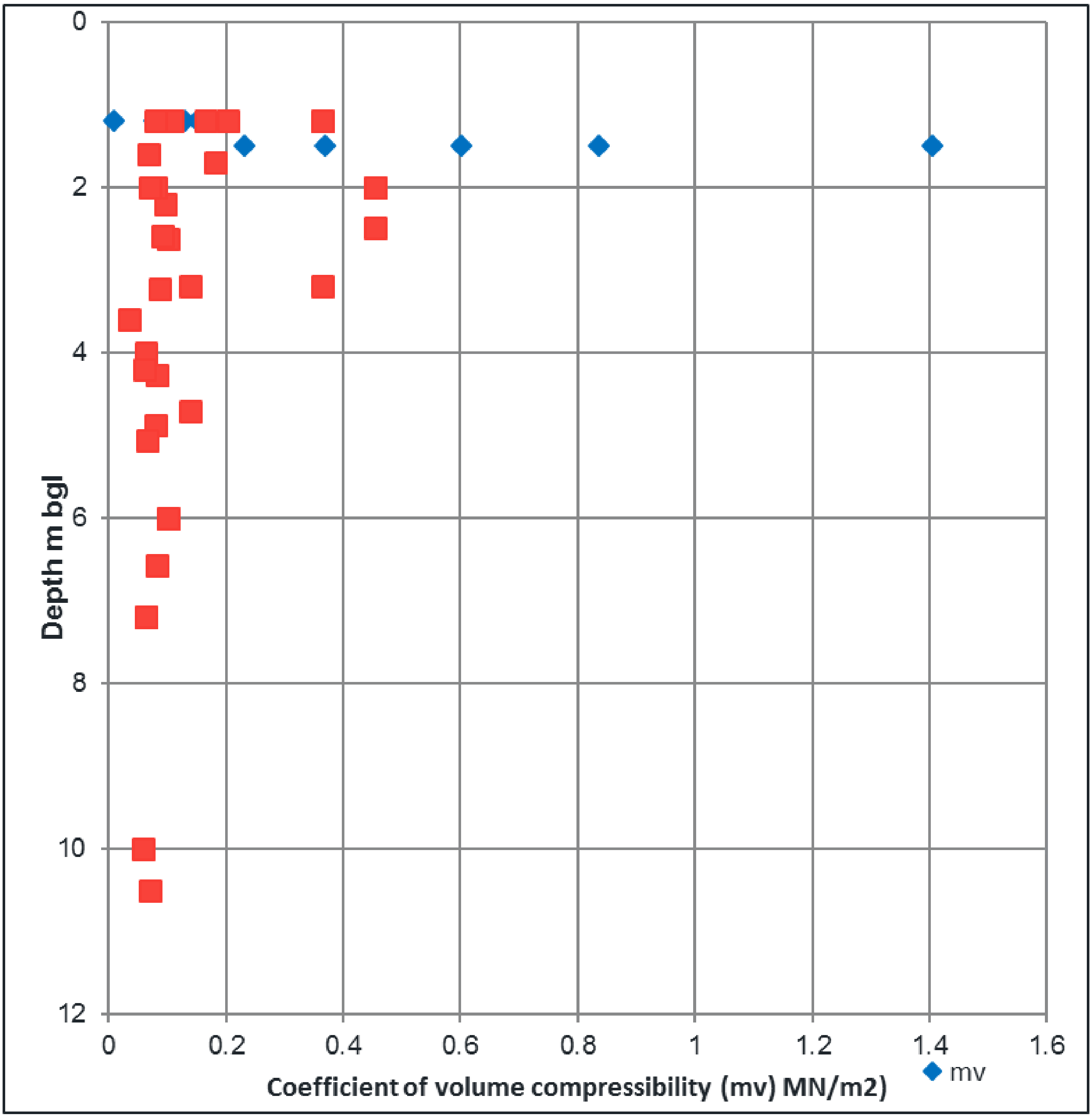


COMPRESSIBILITY

Two oedometer tests were carried out in cohesive till, at depths of 1.2m bgl in BH/17/04 and 1.5m in BH-03. The material was described as firm brown slightly sandy slightly gravelly clay. The coefficient of consolidation (cv), determined by root time, varied with increased stress increments between 0.87m^2/year and 21m^2/year. The coefficient volume compressibility value (mv) also varied with stress increments, between 0.0091m^2/MN and 1.404m^2/MN. Figure 5-26 illustrates the coefficient of compressibility with depth in the fine-grained glacial till. Further values of volume compressibility coefficients were derived using the relationship of m_v=1/f_2N (Ref 17), where f_2=0.55.

The derived values show good general comparison with the measured values. However, the test results from the historical ground investigation indicates a significantly higher set of values.

Figure 5-26 - Coefficient of Compressibility - Cohesive Glacial Till



COMPACTION TESTS

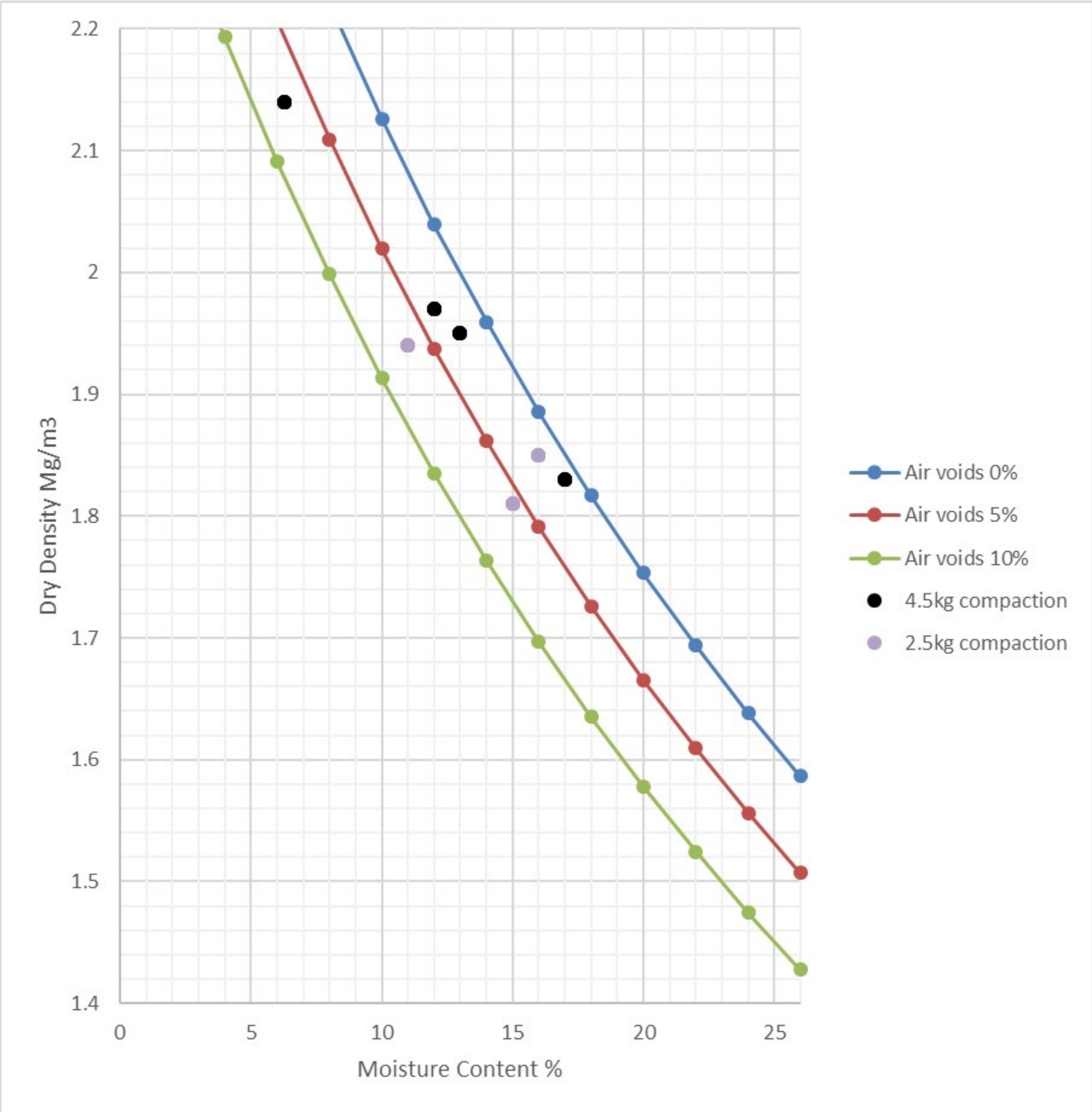
13 compaction tests were undertaken using both 2.5kg and 4.5kg rammers. Maximum dry densities were observed to be between 1.83 and 2.14Mg/m^3 for a 4.5kg rammer, and 1.81 and 1.94Mg/m^3 for a 2.5kg rammer. The overall average for the compaction tests was 1.87Mg/m^3.

These results correspond to Optimum Moisture Contents of between 6.3% and 17% for the 4.5kg rammer, and between 11% and 16% for the 2.5kg. This compares with an average natural moisture content of 16.5%.

Eight particle density tests were undertaken on glacial till samples, with results ranging between 2.65 and 2.7Mg/m^3, with average of 2.68Mg/m^3.

The results of the compaction tests carried out as part of the 2018 ground investigation, are shown in Figure 5-27. Based on a specific gravity of 2.7, the moisture acceptability upper limit to achieve 95% compaction is approximately 13.5% and lower limit of 10% to achieve 90% compaction. These figures indicate the natural cohesive till to lie on the wet side of the optimum moisture content.

Figure 5-27 - Dry Density and Optimum Moisture Content - Cohesive Glacial Till



PERMEABILITY

5.6.2. Each of the three soakaway tests undertaken during the 2018 Ground Investigation, were undertaken Glacial Till. However, due to 25% of effective depth not being achieved in any of the trial pits, the soil infiltration rate could not be determined. However, given the cohesive and clay-rich nature of the strata it is anticipated that the permeability would be very low and in the region of $<10^{-9}$m/s (Ref 15).

CBR TEST

20 unsoaked laboratory CBR Tests were carried out on remoulded samples of fine-grained Glacial Till. The samples were taken from depths of between 0.1 and 2.2m bgl. Results vary, between 0.1% and 36% for the top of the samples, and between 0.1 and 35% for the base of the samples.

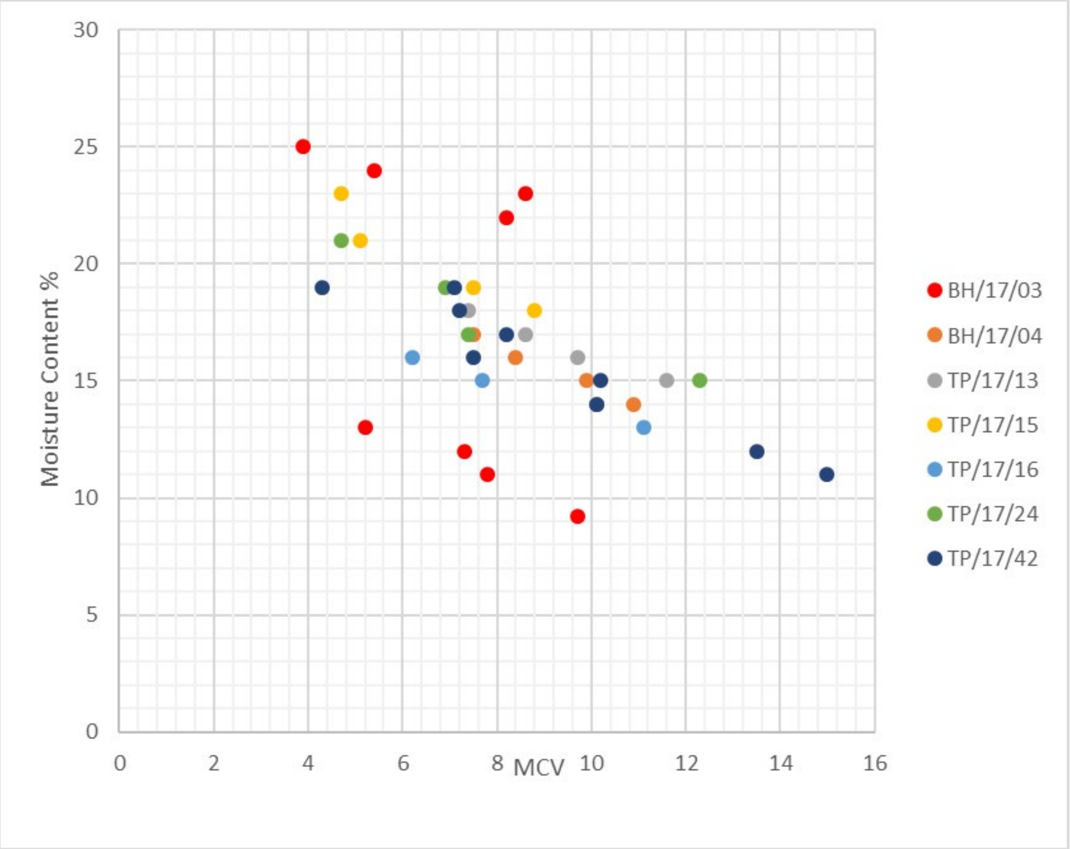
MOISTURE CONDITION VALUE (MCV)

Six MCV tests were undertaken in the cohesive glacial till materials. The results are shown on Figure 5-28 below. It is noted that there is considerable scatter in the range of moisture contents corresponding to each value of MCV, particularly in the test results for BH/17/03. However, overall there is good correlation between all the test results.

The MCV values range between 3.9 and 15, with an average of 8.26. Given the acceptable moisture content range for 95% Maximum Dry density and 10% air voids (giving 12-16% for 2.5kg and 8-15% for 4.5kg), the equivalent MCV's range between 6 and 12.

5.6.3. The reciprocal slopes of the calibration lines indicate sensitivities typical in the range 0.68 to 1.75 corresponding to low to moderate sensitivity (CIRIA C504).

Figure 5-28 - Moisture Condition Value - Cohesive Glacial Till



SUMMARY OF GEOTECHNICAL PARAMETERS

The table below provides a summary of the parameters. It is anticipated that the global design parameters will be adapted for local conditions for specific design.

Table 5-5 - Summary of Geotechnical Parameters – Cohesive Glacial Till

Material Property	No. of tests	Max	Min	Mean	Suggested Global Design value*
Natural Moisture Content %	138	67	5.9	16.5	17
Plastic Limit %	91	33	11	17.7	18
Liquid Limit %	91	66	21	34.4	34
Plasticity Index %	91	39	6	16.7	16
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	91	CH	CL	CI	CL
Bulk Density Mg/m^3	52	2.28	1.59	2.05	2.05
SPT N Value	40	50	4	26	10-30
Undrained shear strength (kPa) *(triaxial, HSV and derived from SPT)*	58	324	4	126	50-150
BS EN ISO 14688-2 Undrained shear strength classification		Very high strength	Extremely low strength	High strength	
Coefficient of volume compressibility MN/m^2	2	1.404	0.0091	0.397	
Optimum moisture content % 2.5kg	3	16	11	14	14
Optimum moisture content % 4.5kg	10	17	6.3	10.8	11
CBR %	20	35	0.1	10.14	2.5
Effective Angle of Shear Resistance °	28	51	20.4	29.3	25 to 28

*It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design.

5.7 GLACIAL TILL - GRANULAR DEPOSITS

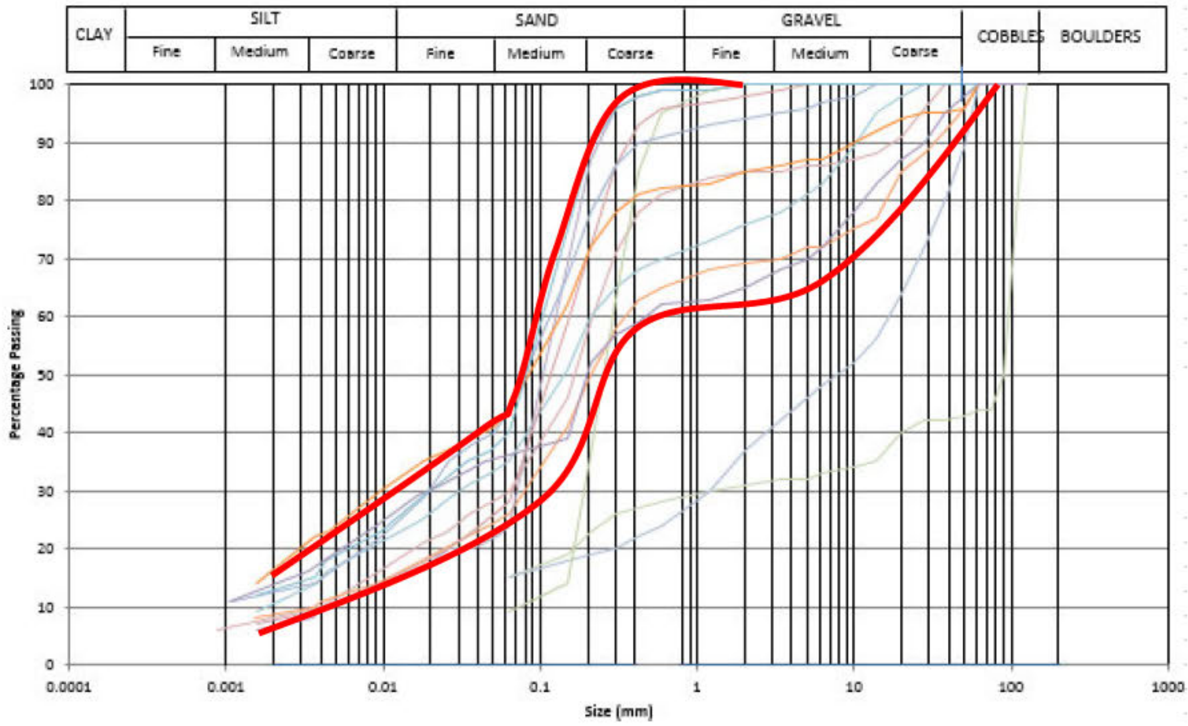
CLASSIFICATION

The granular glacial till is typically observed as pockets within the cohesive glacial till. The material is generally described as medium dense to dense sand and gravel.

The results of grading analyses are summarised in Figure 5-29 below and illustrates the grading analysis of the granular glacial till across the site. The results indicate a predominantly well graded sand and gravel with fine material generally less than 23%.

No in situ or laboratory determinations were made of bulk density.

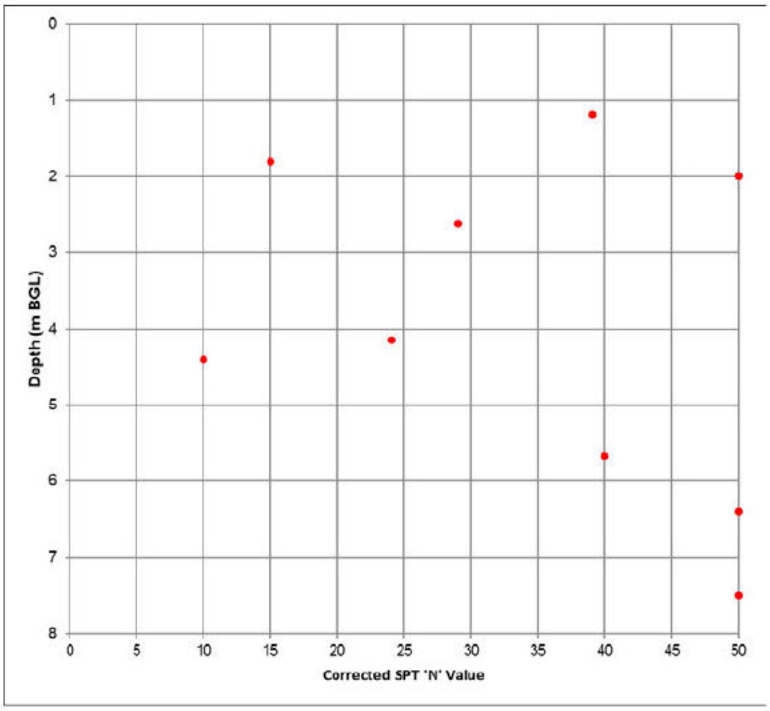
Figure 5-29 - Particle Size Distribution - Granular Glacial Till



SPT N VALUES

Nine SPTs were undertaken on the granular Glacial Till between 1.2 and 7.5m bgl. The N_{60} values range between 10 and refusal.

Figure 5-30 – Corrected SPT N Values - Granular Glacial Till



The SPT N values in the coarse-grained material vary between 14 and greater than 50. The results generally indicate an in-situ density of medium dense.

CBR

One unsoaked CBR test was carried out in the granular glacial till, at a depth of 0.5m bgl. A result of 11% was taken at the base of the sample, and 8.8% at the top of the sample.

EFFECTIVE ANGLE OF FRICTION

No shear strength testing was carried out on samples of the granular glacial deposits. Using the relationship established by Peck et al (Ref 16) and typical SPT value of 30 for the material, a phi value of 36º can be assumed. This compares well when using the method provided in BS8002:2015 using the results of the PSD tests, which indicates a phi value of 34º.

SUMMARY OF GEOTECHNICAL PARAMETERS

The table below provides a summary of the parameters. It is anticipated that the global design parameters will be adapted for local conditions for specific design.

Table 5-6 - Summary of geotechnical parameters - Granular Glacial Till

Material property	No. of tests	Max	Min	Mean	Suggested Global Design value*
Natural Moisture Content %	19	22.3	8.7	15.7	16
SPT N Value	8	50	15	37	30
CBR %	1	11	8.8	9.9	10
Effective angle of friction (derived from SPT N)	-	-	-	-	36

*It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design.

5.8 WEST LINKHALL

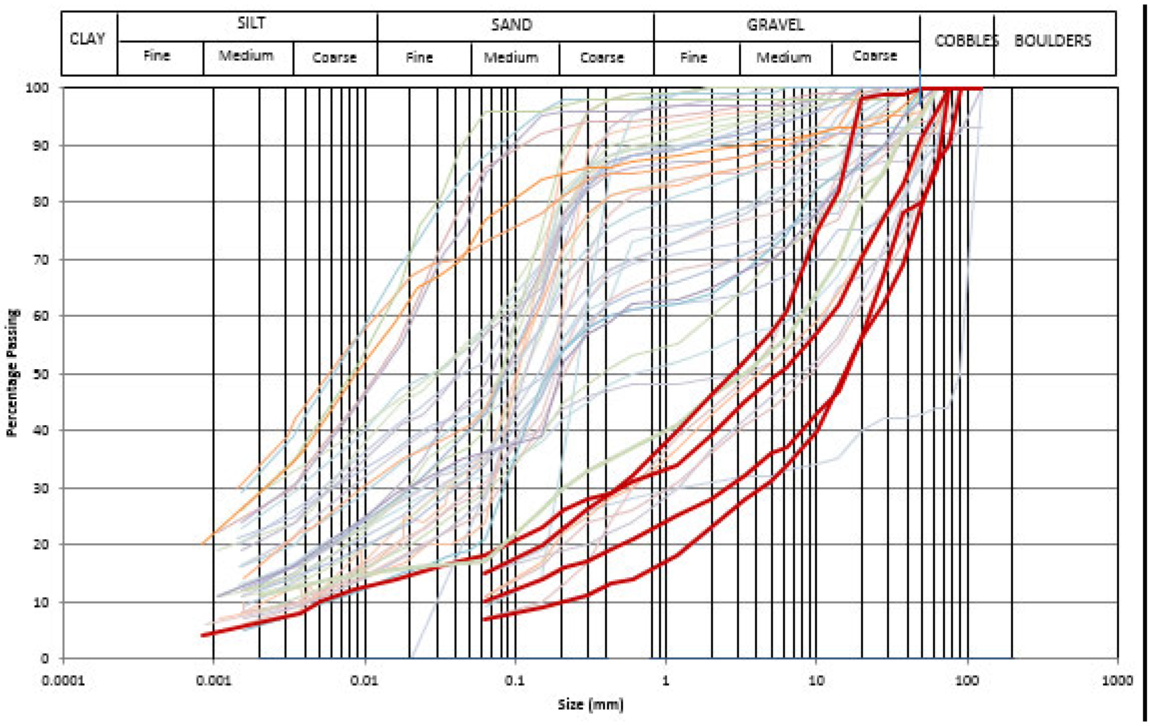
WEST LINKHALL

At West Linkhall, the ground conditions are different to those of the surrounding area. As observed in the exploratory holes logs BH/17/08, BH/17/09 and TP/17/35, the ground is typically more granular, presenting difficulties during excavation and progression of the trial pit and boreholes. The ground conditions have been identified as granular glacial deposits.

The PSD plot below provides a comparison of particle size of glacial deposits across the global site, against those assessed from West Linkhall. As seen, the percentage of gravel and cobbles are significantly higher at West Linkhall than seen elsewhere across the site.

Figure 5-31 - Particle Size Distribution - West Linkhall

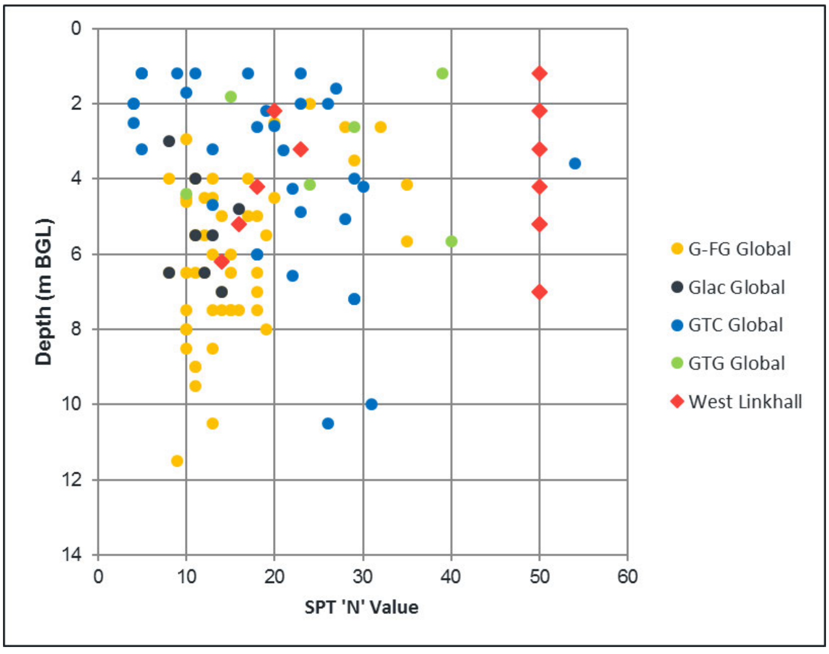
Red highlighted lines indicate those sourced from West Linkhall



SPT

The plot below presents very scattered SPT N value data of the West Linkhall deposits against the rest of the glacial deposits across the global site. At West Linkhall the N values show an unusual general decline in density of the glacial deposits with depth. This coincides with the SPT and depth relationship seen in the global Glacio-fluvial deposits. The numerous refusals seen in Figure 5-31, highlight the widespread gravel and occasional cobbles encountered at West Linkhall,

Figure 5-32 - SPT N Value - West Linkhall and Global glacial deposits



MOISTURE CONTENT

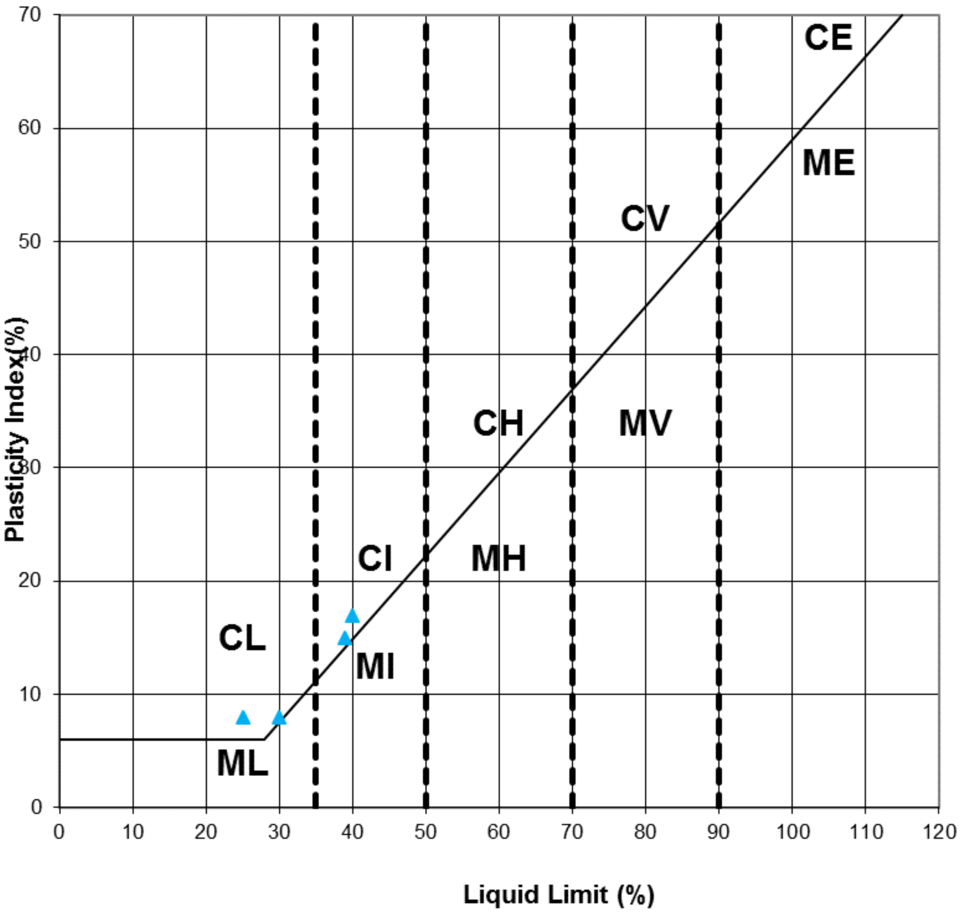
The ground across this area is predominantly granular, however occasional cohesive pockets were encountered amongst the granular material.

Eight moisture content tests were carried out on the glacial strata at West Linkhall. The moisture content varies between 3% to 14%, with a typical value of 10% was taken forward.

ATTERBERG LIMIT

Four of six Atterberg tests were successfully undertaken at West Linkhall (the two unsuccessful tests were classed as non-plastic). The tests indicated a low to intermediate plasticity clay.

Figure 5-33 - Plasticity Chart - West Linkhall intermediate plasticity clay



SUMMARY OF GEOTECHNICAL PARAMETERS

The table below provides a summary of the glacial deposit parameters at West Linkhall. It is anticipated that the global design parameters will be adapted for local conditions for specific design.

Table 5-7 - Summary of Geotechnical Parameters - Glacial deposits at West Linkhall

Material Property	No. of tests	Max	Min	Mean	Suggested Global Design value*
Natural Moisture Content %	8	14	3	10	10
Plastic Limit %	4	24	17	21.5	21.5
Liquid Limit %	4	40	25	33.5	33.5
Plasticity Index %	4	17	8	12	12
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	4	CI	CL	CL	CL
Bulk Density Mg/m^{3}BS8002:2015	-	2.08	-	-	2.08
SPT N Value	9	50	14	32	14-26
CBR %	1	15	10	12.5	12.5
Effective angle of friction ° (derived from PSD)	-	-	-	-	32

*It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design.

5.9 BEDROCK- ALSTON FORMATION

The data from the historical and recent ground investigations has not shown areas of completely/highly weathered horizon of the Alston Formation. One sample was identified as a weathered sandstone, described as micaceous thinly bedded sandstone fragments within a subordinate brown sandy clay. The formation was typically observed to comprise medium strong sandstone and mudstone or strong limestone and occasional siltstone layers.

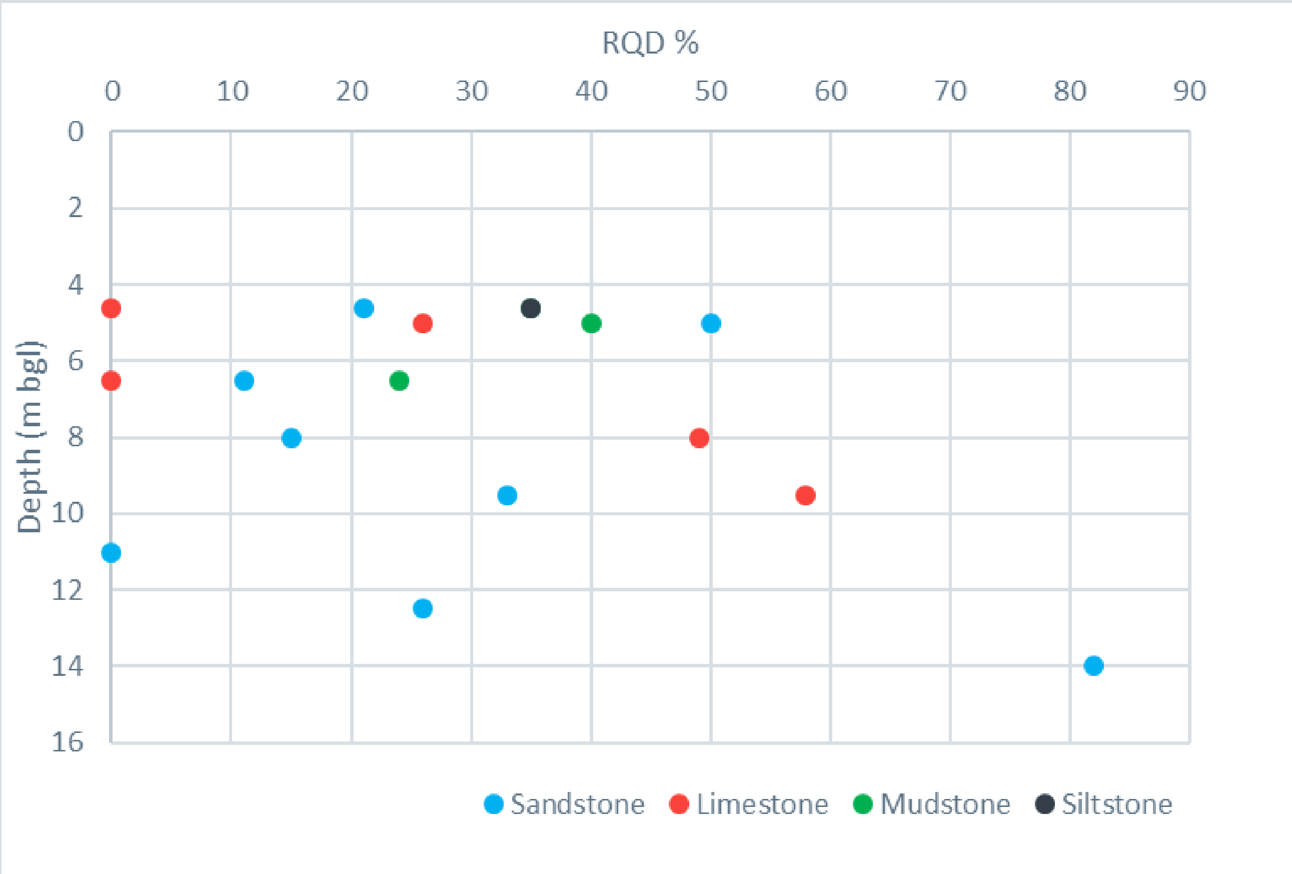
CORE RECOVERY

Where bedrock was encountered across the scheme the Total Core Recovery (TCR) was generally very good, with values of TCR between 78% and 100% with an average of 92%. The sandstone generally shows a slightly higher TCR value with an average of 95%, whilst the encountered limestone records the slightly lower average TCR at 90%. Assumed zones of core loss were observed throughout the strata. The table below highlights these areas where observed.

Table 5-8 - Assumed Zones of Core Loss

Borehole Ref	Top of Core Loss (m bgl)	Base of Core Loss (m bgl)	Total Core Loss thickness (m)
BH/17/01	11	11.18	0.18
BH/17/02	7.1	7.35	0.25
	11.6	11.7	0.1
	13	13.18	0.18
BH/17/06	16.1	16.36	0.26
	19	19.17	0.17

Figure 5-34 - RQD vs. Depth - Alston Formation



The Rock Quality Designation (RQD) values within the rock range between 0% and 82% and the large variability is indicative of the varied nature of the rock. Figure 5-34 shows the RQD values verses depth for the various rock types encountered. It should be noted that often the RQD measurement was taken across two or more lithologies. Therefore, the plot above only provides the values against a specific lithology. The mudstone provides the highest mean value for the RQD at 33%, whilst the limestone gives the lowest of 19%.

DISCONTINUITY DATA

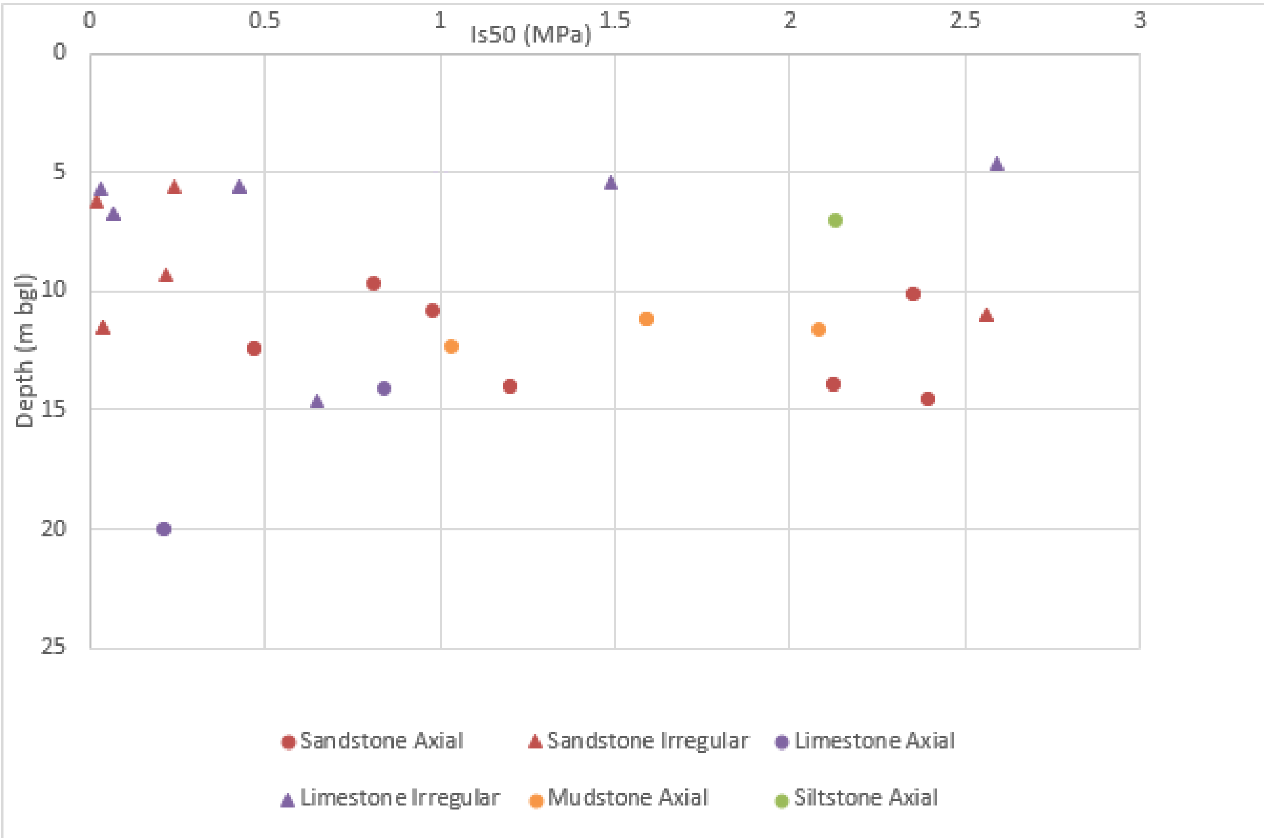
Fractures have been observed throughout the intact bedrock and have typically been described as:

- **Discontinuity Set 1**: 'closely spaced, horizontal, inclined and vertical undulating and stepped, smooth to rough, infill, very tight to open with brown staining'
- **Discontinuity Set 2**: 'Sub vertical, undulating to stepped rough with brown staining.'

STRENGTH TESTS

27 Point Load Testing and 2 Uniaxial Compressive strength tests were carried out on samples of sandstone, limestone, mudstone and siltstone of the Alston Formation. Figure 5-35 below provides a plot of the size corrected (Is50) values (which were provided by the Contractor within the Factual Report) against depth below ground level. Each of the strata shows a wide variation in Is50 values, between 0 and 3MPa.

Figure 5-35 - Point Load Testing Is50 - Alston Formation



The axial tests gave results between 0.21 and 2.39MPa with an average of 1.41MPa, indicating typically medium strength material. No diametric tests were carried out. The irregular lump tests gave a slightly broader range of results, varying between 0.02 and 2.59, with an average of 1.00MPa.

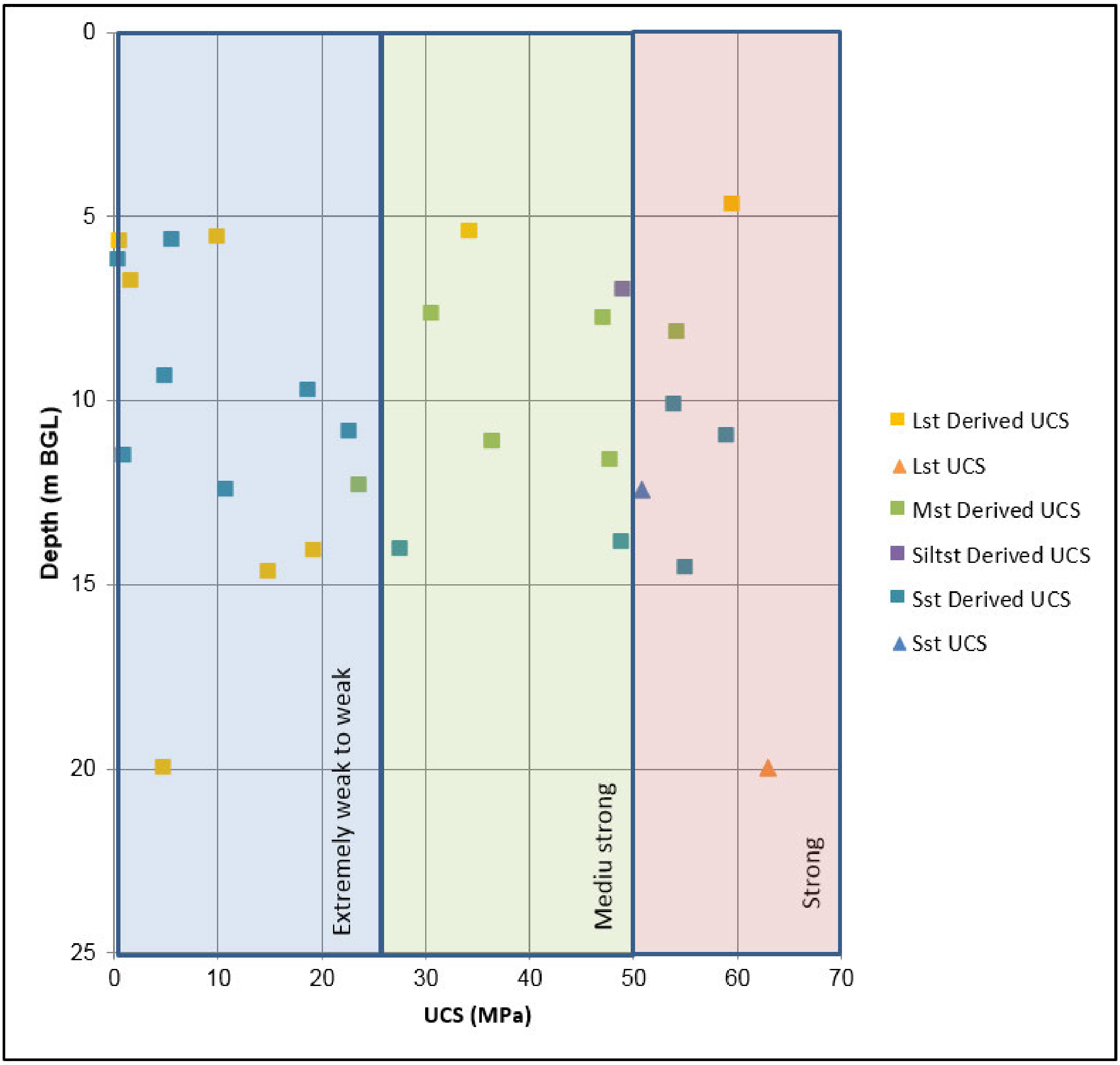
The graphs do not indicate a clear difference in strength range between the lithologies. The borehole log descriptions have noted the sandstone as typically medium strong to strong and mudstone as the typically weaker lithology, often described as weak to extremely weak. However, the test results contradict this, indicating the mudstone to be medium strong to strong.

Two UCS tests were carried out on samples of sandstone and limestone of the Alston Formation with values of 50.9MPa and 63MPa, respectively. No suitably sized samples were available for the mudstone.

The total number of tests on each material type undertaken relative to the sample area is generally fairly low. Where the rock is described as weak, these areas were more than likely to experience lower total core recovery. It is thought the samples generally recovered and therefore subsequently tested may be more representative of stronger bands within each material and therefore the results may not be representative of the overall rock mass. This is particularly relevant to the mudstone material.

The relationship between UCS and the point load index can be expressed as UCS = C * I_{s50} where C is a correction factor. The results were subsequently multiplied by a correlation factor of 23 (Hoek and Bray Ref 18) for (to which the point load tests have generally been standardised) in order to derive the results of the point load testing into UCS values. Given the limited numbers of UCS results available on individual rock types it was not possible to refine this correlation factor across the various bedrock classifications. Figure 5-36 shows the derived UCS values alongside the direct UCS results.

Figure 5-36 - UCS vs. Depth - Alston Formation



FRICTIONAL ANGLE ALONG DISCONTINUITIES

In areas of rock cutting, the number and nature of discontinuities can greatly affect the stability of the slope. The impacting qualities include the number and intersection of the release planes, whether these terminate at the slope, the friction angle, the angle between the plane azimuth, the slope face azimuth and any groundwater pressures.

Angles of basic sliding friction are published in Table 2.2 Tomlinson 2001 (Ref 21). For the Alston Formation, values of between 27 and 34° are advised for a clean fracture in siltstone and sandstone, and 34 to 40° for limestone. As the table does not include mudstone, marl is considered to the closest equivalent, reflecting the lowest angle range of 20 to 27°.

BEARING CAPACITY

The ultimate bearing capacity can be assessed using the RQD and UCS to determine the impact of fracture frequency. The following has been taken from Peck et al (Ref 16)

- **Where RQD > 90%** there is no reduction in bearing pressure
- **Where RQD is between 50% - 90%** the rock bearing pressure should be reduced by a factor of between 0.25 and 0.7
- **Where RQD <50%** bearing pressure should be reduced by a factor of between 0.25 and 0.1.

For example, where a characteristic material UCS value of 53MPa is taken for the rock with RQD generally below 50%, then the bearing capacity for the rock would be estimated in the region of 5.3MPa

SUMMARY OF GEOTECHNICAL PROPERTIES

5.9.1. The table below provides a summary of the parameters. It is anticipated that the global design parameters will be adapted for local conditions for specific design.

Table 5-9 - Summary of Geotechnical Parameters - Alston Formation

Stone Properties	No. of Tests	Min	Max	Mean	Suggested Global Design value*
Sandstone					
Water Content %	13	0.5	2.3	1	1
Bulk Density (kg/m3)	-	-	-	-	24
Point Load IS50 MPa	14	0.2	2.56	1.38	1 - 20
UCS MPa	1	-	-	50.9	
Friction Angle °	-	-	-	-	27-34*
Mudstone					
Water Content %	7	1.1	6.2	2.3	1.1
Bulk Density (kg/m3)	-	-	-	-	24
Point Load IS50 MPa	8	0.03	1.59	0.73	5 - 20
UCS MPa	-	-	-	-	
Friction Angle °	-	-	-	-	27-34*
Siltstone					
Water Content %	7	0.2	2.1	8.4	1.3
Bulk Density (kg/m3)	-	-	-	-	24

Point Load IS50 MPa	6	0.02	2.59	1.64	1 - 5
UCS MPa	0	-	-	-	
Friction Angle °	-	-	-	-	27-34*
Limestone Properties					
Water Content %	-	-	-	-	-
Bulk Density (kg/m3)	-	-	-	-	25
Point Load IS50 MPa	-	-	-	-	5 - 40
UCS MPa	1	-	-	63	
Friction Angle °	-	-	-	-	27-34*
* Based on Tomlinson 2001 (Ref 21).					

*It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design.

5.10 BEDROCK – TYNE LIMESTONE FORMATION AND ALSTON FORMATION (UNDIFFERENTIATED)

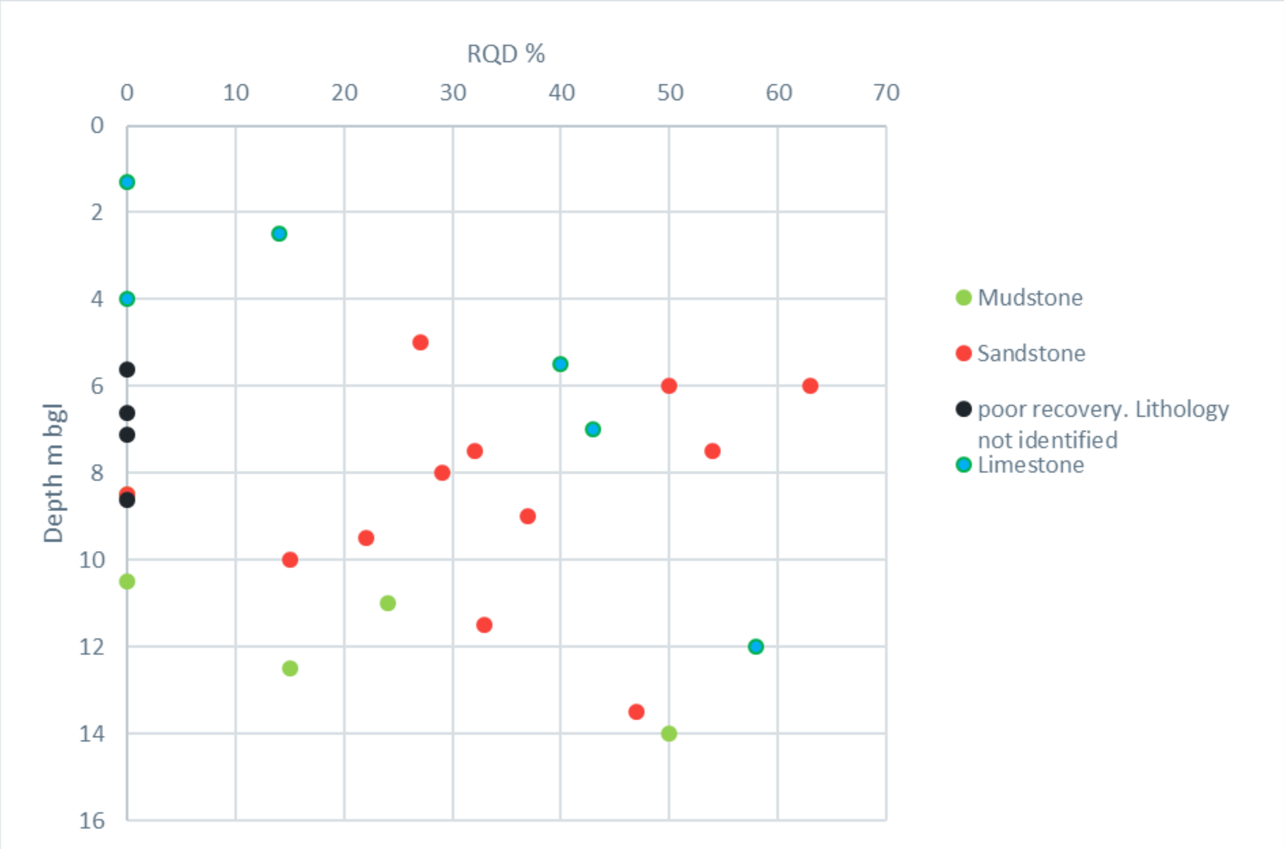
CORE RECOVERY

Where core recovery was observed, the TCR of the Alston and Tyne Formation varied between 36% and 100% with an average of 79%. Two assumed zones of core loss (AZCL) was observed in the Tyne Formation and Alston Formtion (undif.). This was observed in BH/17/13, between 7.5 and 8.04m bgl and 12.0 and 12.27m bgl.

The RQD varied between 0% and 63% with an average of 24%. Approximately 4.4m of 0% RQD was observed in BH/17/10 and 1.5m observed in boreholes BH/17/11, BH/17/12 and BH/17/13 within the mudstone, limestone and sandstone lithologies. There is no obvious relationship between the bedrock lithology and the RQD. The plot below provides the RQD against depth. It should be noted that often the RQD measurement was taken across two or more lithologies. Therefore, the plot only provides the values against a specific lithology.

Sandstone featured the highest RQD, with an average of 34%, whilst the limestone illustrated the widest variety in RQD values, with an average of 25.8%. The mudstone gave the lowest RQD values within the formation, of 17.8%.

Figure 5-37 - RQD vs. depth - Tyne Limestone Formation and Alston Formation (undifferentiated)



DISCONTINUITY DATA

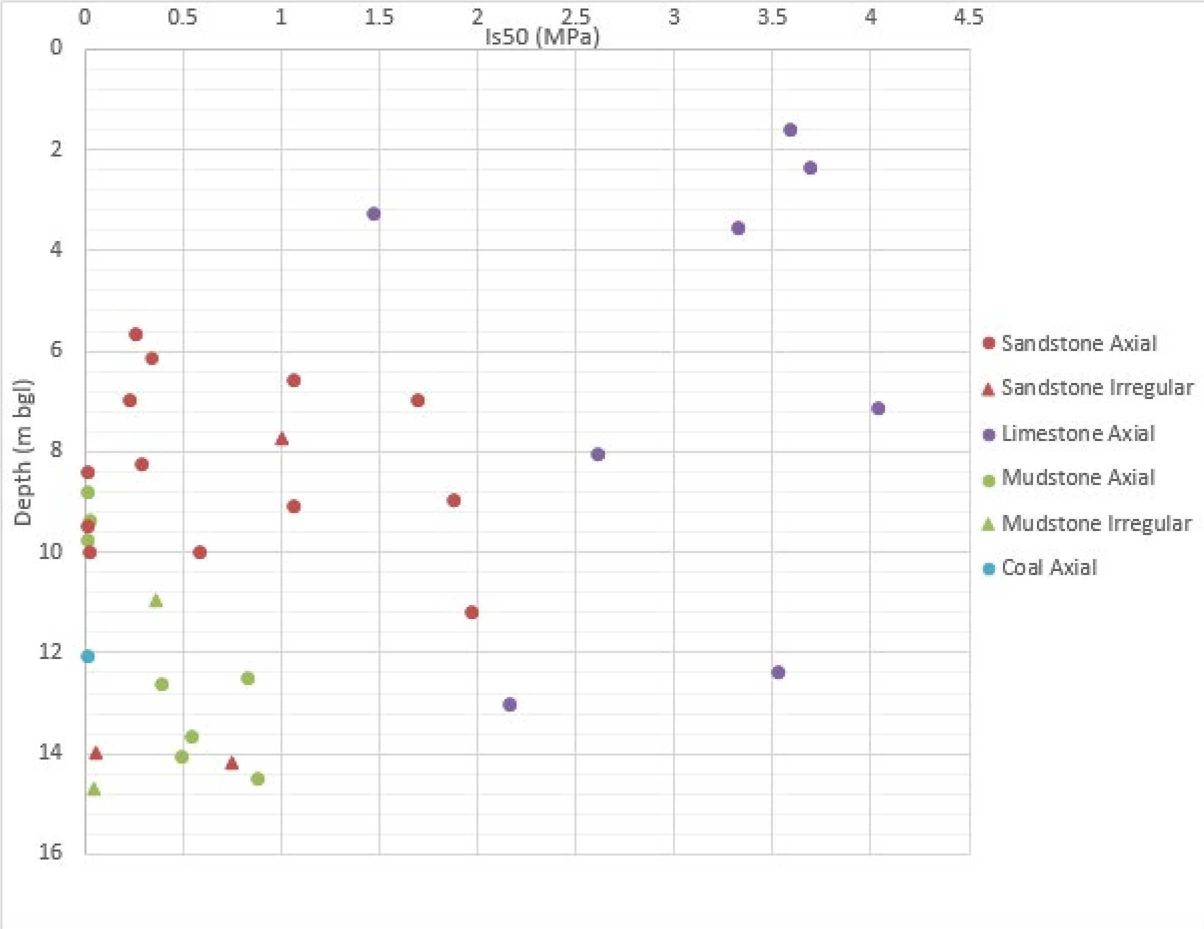
Fewer fractures were observed in this formation than in the Alston Formation and Scremerston Coal Member. This is may be due to high rock strength properties in this formation However, examples were noted within the borehole log for BH/17/14. The fractures are typically described as:

- Discontinuity Set 1: 'closely spaced, sub-horizontal, undulating rough, partially open with brown and grey staining
- Discontinuity Set 2: 'incline to vertical, undulating to stepped, rough to smooth, very tight to open and incipient with orange staining.

STRENGTH TESTS

35 Point Load tests and 3 UCS tests were undertaken on core samples of the Alston and Tyne Limestone Formation. The corrected Is50 results from the Point Load Tests are presented in the plot below. The limestone and sandstone are shown to be typically stronger than the other lithologies, particularly the limestone which illustrated properties indicative of strong to very strong bedrock. Coal, as would be anticipated, has a very low Is50 value indicating an extremely weak rock.

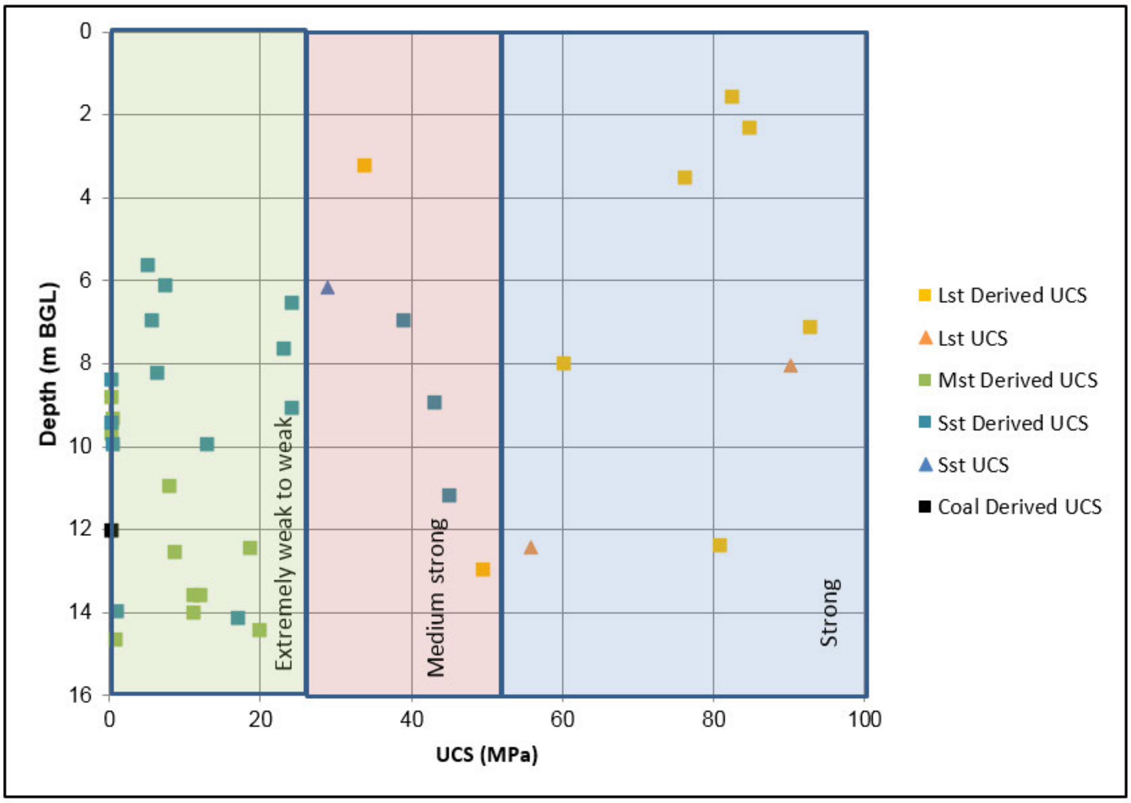
Figure 5-38 - Point Load Testing Is50 - Tyne Limestone Formation and Alston Formation



Two of the UCS tests were undertaken in the limestone giving results of 55.8 to 90.3MPa, indicating a strong bedrock. A further UCS was undertaken on a sandstone sample, returning a result of 28.8MPa indicative of a medium strong bedrock.

The relationship between UCS and the point load index can be expressed as UCS = C * Is50 where C is a correction factor. The results were subsequently multiplied by a correlation factor of 23 (to which the point load tests have generally been standardised) in order to derive the results of the point load testing into UCS values. Given the limited numbers of UCS results available on individual rock types it was not possible to refine this correlation factor across the various bedrock classifications. The plot below illustrates the measured and derived UCS values for each of these lithologies.

Figure 5-39 - UCS vs depth - Alston and Tyne Formation (undifferentiated)



The chart indicates the limestone as a typically strong bedrock. The sandstone shows scattered UCS values, varying between extremely weak and medium strong bedrock.

FRICTIONAL ANGLE ALONG DISCONTINUITIES

In areas of rock cutting, the number and nature of discontinuities can greatly affect the stability of the slope. The impacting qualities include the number and intersection of the release planes, whether these terminate at the slope, the friction angle, the angle between the plane azimuth, the slope face azimuth and any groundwater pressures.

Angles of basic sliding friction are published in Table 1.2 Tomlinson 2001 (Ref 21). For the Tyne and Alston Formation (undifferentiated), values of between 27 and 34° are advised for a clean fracture in siltstone and sandstone, and 34 to 40° for limestone. As the table does not include mudstone, marl is considered to the closest equivalent, reflecting the lowest angle range of 20 to 27°.

BEARING CAPACITY

The ultimate bearing capacity can be assessed using the RQD and UCS to determine the impact of fracture frequency. The following has been taken from Peck et al (Ref 16).

- **Where RQD > 90%** there is no reduction in bearing pressure
- **Where RQD is between 50% - 90**% the rock bearing pressure should be reduced by a factor of between 0.25 and 0.7
- **Where RQD <50%** bearing pressure should be reduced by a factor of between 0.25 and 0.1.

For example, where a characteristic material UCS value of 53MPa is taken for the rock with RQD generally below 50%, then the bearing capacity for the rock would be estimated in the region of 5.3MPa.

SUMMARY OF GEOTECHNICAL PROPERTIES

The table below provides a summary of the parameters. It is anticipated that the global design parameters will be adapted for local conditions for specific design.

Table 5-10 - Summary of Geotechnical Parameters – Tyne Limestone and Alston Formation

Stone Properties	No. of Tests	Min	Max	Mean	Suggested Global Design value*
Sandstone					
Water Content %	14	0.1	4.3	1.3	1.3
Bulk Density (kg/m3)	-	-	-	-	24
Point Load IS50 MPa	14	0.02	1.97	0.75	1 - 40
UCS MPa	1	-	28.8	-	
Friction Angle °	-	-	-	-	27-34*
Mudstone					
Water Content %	10	2.9	6.5	4.3	4.3
Bulk Density (kg/m3)	-	-	-	-	24
Point Load IS50 MPa	10	0.02	0.9	0.3	1 - 20
UCS MPa	-	-	-	-	
Friction Angle °	-	-	-	-	27-34*
Siltstone					
Water Content %	2	2.3	2.8	2.55	2.55
Bulk Density (kg/m3)	-	-	-	-	24
Point Load IS50 MPa	-	-	-	-	1 - 5**
UCS MPa	-	-	-	-	
Friction Angle °	-	-	-	-	27-34*
Limestone					
Water Content %	8	0.2	1.2	0.5	0.5
Bulk Density (kg/m3)	-	-	-	-	25
Point Load IS50 MPa	8	1.48	4.04	3.1	40 - 80
UCS MPa	2	56	90	73	
Friction Angle °	-	-	-	-	27-34*
Coal					
Water Content %	1	-	4.1	-	4.1
Bulk Density (kg/m3)	-	-	-	-	
Point Load IS50 MPa	1	-	0.02	-	n/a
UCS MPa	0	-	-	-	
Friction Angle °	-	-	-	-	-

* Based on Tomlinson 2001 (Ref 21).
** Based on log descriptions only

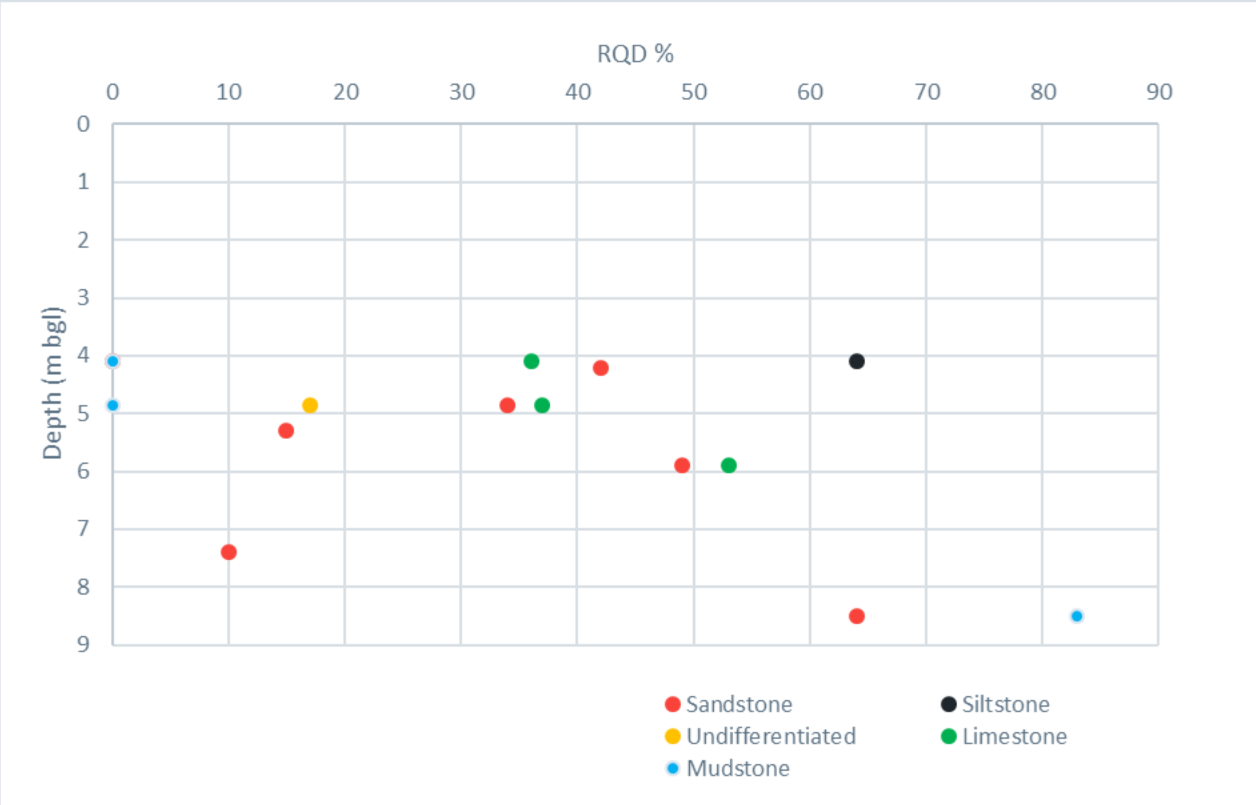
It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design.

5.11 BEDROCK – SCREMERSTON COAL MEMBER

CORE RECOVERY

Where the intact rock was encountered within the Scremerston Coal Member across the scheme, the Total Core Recovery (TCR) was on the whole relatively good, and ranged between 77% and 100%, with an average of 89%. The RQD, however, varied considerably between 0% and 83%, with an average of 34%. There was no obvious relationship between the RQD and lithology, both the highest and lowest RQD were recorded in the mudstone.

Figure 5-40 - RQD - Scremerston Coal Member



It should be noted that often the RQD measurement was taken across two or more lithologies. Therefore, the plot above only provides the values against a specific lithology.

DISCONTINUITY DATA

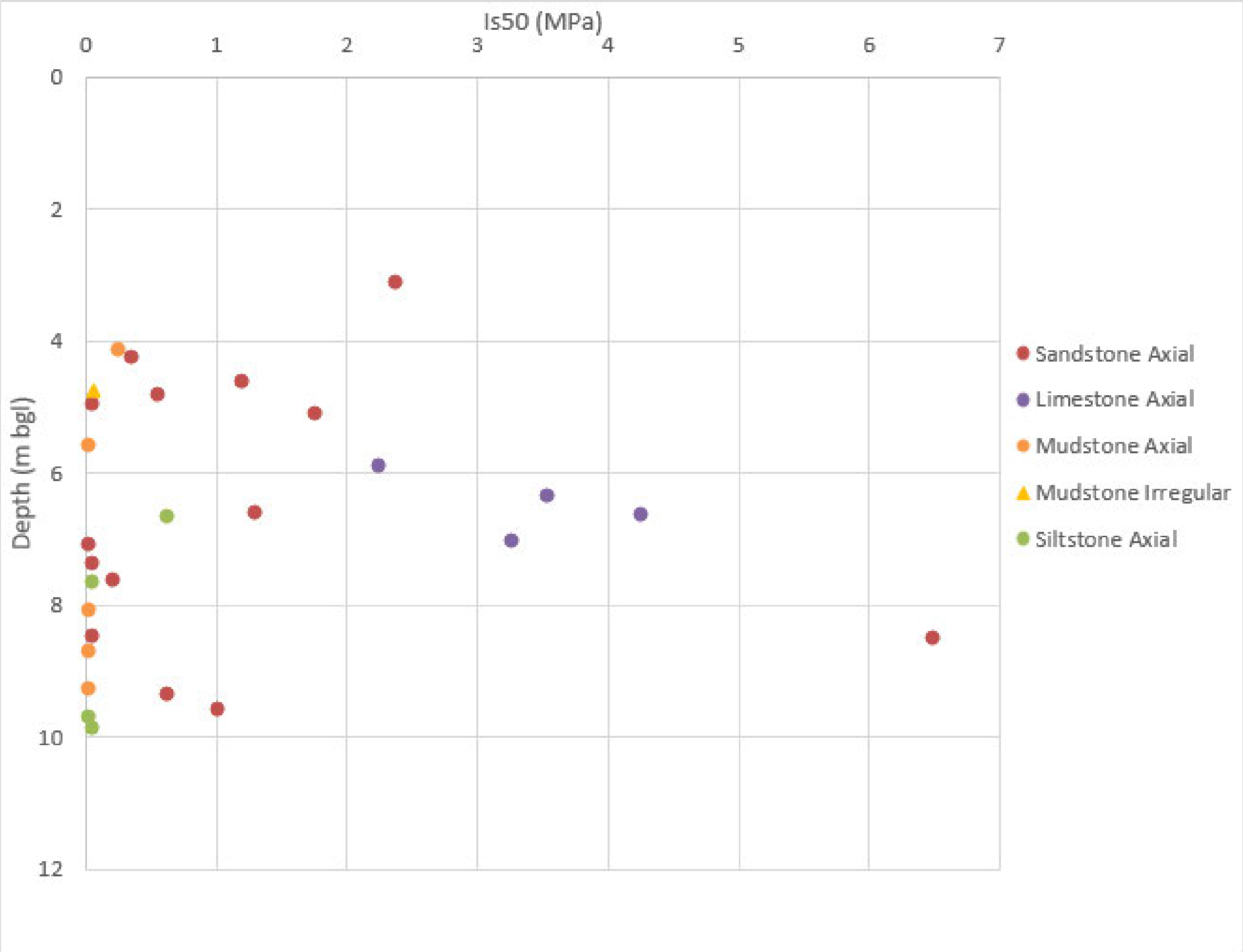
Fractures have been observed throughout the intact bedrock and have typically been described as:

- Discontinuity Set 1: ‘horizontal to 10 degrees, closely spaced, planar to undulating, rough to clean’
- Discontinuity Set 2: ‘20-25 degree to vertical, planar, rough and clean’

STRENGTH TESTS

30 Point Load Tests were undertaken on samples of different lithologies across the Scremerston Coal Member. The corrected Is50 values are presented in the Figure 5-41 below.

Figure 5-41 - Point Load Testing Is50 - Scremerston Coal Member

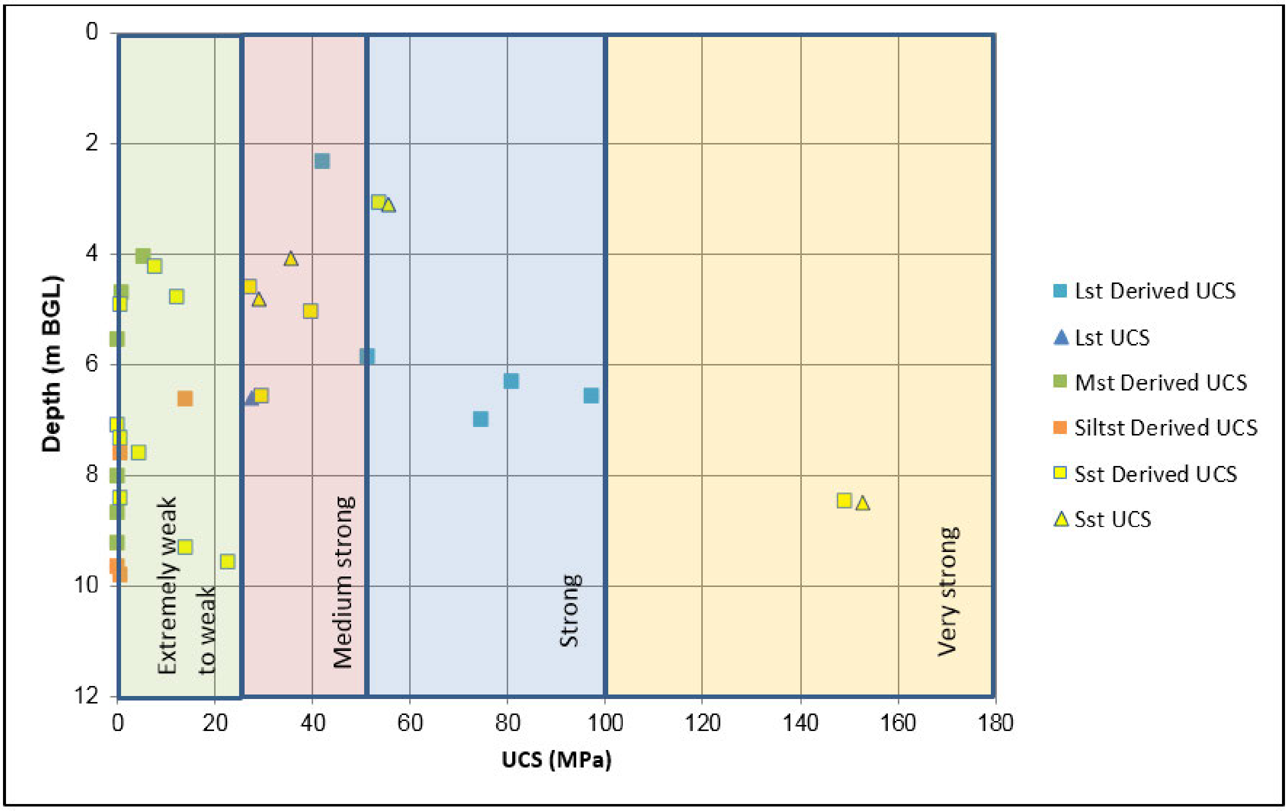


The limestone is typically the strongest of the lithologies within this unit, presenting Is50 values of between 1.85 and 4.25MPa. However, a sample of sandstone from BH/17/05A, provided an Is50 value of 6.49MPa. This anomalously high Is50 result for sandstone was encountered at 7.65m bgl in BH/17/05A and this value is not considered to be representative of the rock mass, given the majority of lower values for Is50 results and descriptions present in the Factual Report.

Five UCS tests were carried out on samples of sandstone and limestone from the Scremerston Coal Member. The UCS values for the sandstone range between 28.8MPa and 153MPa, whilst the limestone had a result of 27.6 MPa.

The relationship between UCS and the point load index can be expressed as UCS = C * I_{s50} where C is a correction factor. The results were subsequently multiplied by a correlation factor of 23 (to which the point load tests have generally been standardised) in order to derive the results of the point load testing into UCS values. Given the limited numbers of UCS results available on individual rock types it was not possible to refine this correlation factor across the various bedrock classifications. The plot below illustrates the measured and derived UCS values for each of these lithologies.

Figure 5-42 - UCS vs. Depth - Scremerston Coal Member



FRICTIONAL ANGLE ALONG DISCONTINUITIES

In areas of rock cutting, the number and nature of discontinuities can greatly affect the stability of the slope. The impacting qualities include the number and intersection of the release planes, whether these terminate at the slope, the friction angle, the angle between the plane azimuth, the slope face azimuth and any groundwater pressures.

Values of between 27 and 34° have been taken as angles of basic sliding friction for clean fractures in siltstone and sandstone, and 34 to 40° for limestone, from Table 2.2 Tomlinson 2001 (Ref 21). As the table does not include mudstone, marl is considered to the closest equivalent, reflecting the lowest angle range of 20 to 27°.

BEARING CAPACITY

The ultimate bearing capacity can be assessed using the RQD and UCS to determine the impact of fracture frequency. The following has been taken from Peck et al (Ref 16).

- **Where RQD > 90%** there is no reduction in bearing pressure
- **Where RQD is between 50% - 90%** the rock bearing pressure should be reduced by a factor of between 0.25 and 0.7
- **Where RQD <50%** bearing pressure should be reduced by a factor of between 0.25 and 0.1.

For example, where a characteristic material UCS value of 53MPa is taken for the rock with RQD generally below 50%, then the bearing capacity for the rock would be estimated in the region of 5.3MPa

SUMMARY OF GEOTECHNICAL PARAMETERS

The table below provides a summary of the parameters. It is anticipated that the global design parameters will be adapted for local conditions for specific design.

Table 5-11 - Summary of Geotechnical Parameters - Scremerston Coal Member

Stone Properties	No. of Tests	Min	Max	Mean	Suggested Global Design value*
Sandstone					
Water Content %	15	0.9	6.8	4	3
Bulk Density (kg/m3)	-	-	-	-	24
Point Load IS50 MPa	14	0.02	2.36	0.69	1 - 40
UCS MPa	3	28.8	55.6	40	
Friction Angle °	-	-	-	-	27-34*
Mudstone					
Water Content %	10	0.1	7.9	4.88	4.5
Bulk Density (kg/m3)	-	-	-	-	24
Point Load IS50 MPa	6	0.02	6.49	1.11	1
UCS MPa	-	-	-	-	
Friction Angle °	-	-	-	-	27-34*
Siltstone Properties					
Water Content %	4	0.4	0.7	0.5	0.5
Bulk Density (kg/m3)	-	-	-	-	24
Point Load IS50 MPa	6	0.62	4.25	2.6	1 - 5
UCS MPa	0	-	-	-	
Friction Angle °	-	-	-	-	27-34*
Limestone Properties					
Water Content %	-	-	-	-	-
Bulk Density (kg/m3)	-	-	-	-	25
Point Load IS50 MPa	-	-	-	-	1 - 20
UCS MPa	1	-	-	27	
Friction Angle °	-	-	-	-	27-34*
The Design Parameter will be adapted for local conditions for specific design, including detailed design *Based on Tomlinson 2002 (Ref 21)					

*It is anticipated that the global design parameters will be adapted for local conditions for specific design items during detailed design.

5.12 GROUNDWATER LEVELS

GENERAL GROUNDWATER REGIME

Given the predominantly cohesive nature of the drift material encountered underlying the scheme, groundwater strikes encountered during the GI provide an inconsistent depiction of true ground water levels within the area. Subsequently groundwater monitoring installations were installed in a selection of exploratory holes and at various depths along the scheme route.

Groundwater was encountered at particularly shallow depths, at approximately 1.0m or less, in close proximity to watercourses. Shallow groundwater was encountered in the vicinities of Denwick Burn, Heckley Fence, CH56200, Ellsnook Plantation and Rock, in the following exploratory holes: TP/17/04, TP/17/25, BH13, BH15, BH18, BH19, BH25, BH28, BH30, TP19, TPA10, TPA24A, TPA32, TPA33, TPA39.

Groundwater monitoring equipment was installed in 9 of the holes formed as part of the recent investigation with response zones targeting the groundwater strikes and potential earthworks. The exploratory holes were subsequently monitored for approximately 3 months following completion of the works.

As part of the ground investigation fieldworks, data loggers were placed into the 9 installations. The data loggers remained in place between August 2018 and January 2019.

It should be highlighted that the summer of 2018 was considerably drier and warmer than usual. Therefore, to gain an improved representation of the typical groundwater conditions of the site, the groundwater monitoring was continued into the winter of 2019. However, it should still be noted that the groundwater conditions may be more severe than indicated in the results. This risk has been taken forward in the Risk Register in Appendix E.

The results of the monitoring showed groundwater levels of between 1.5 and 5.5m bgl until mid-November with levels remaining fairly constant. After Mid-November, levels generally rose, likely corresponding with high rainfall periods. Following the rise in levels, groundwater was typically 2m bgl or greater with the exception of BH/17/14 and BH/17/01 where groundwater was observed to rise up to 1.0m bgl.

Significant depressions in groundwater level were observed in BH/17/13 and BH/17/06 during an isolated period. However, these are considered to be anomalous and likely a result of external effects impacting the pressure measurement in the data loggers.

Information relating to installations, strikes and groundwater monitoring are recorded on the individual earthwork datasheets contained in Appendix A. In addition, the highest inferred groundwater level has been annotated on to the geological long sections in Appendix F.

GROUNDWATER IMPACT

To date the historical and recent groundwater monitoring results would indicate that groundwater levels are relatively high across the scheme, particularly local to watercourses and within areas that have been highlighted on the geohazard plans to have a high probability of surface water flooding. This will have a significant impact on the drainage design for the scheme and particularly in relation to soakaway design and locations.

5.13 GROUND CHEMISTRY & CONTAMINATED LAND

SOIL

Selected soil samples from the study area were tested in order to assess potential risks to human health and the environment from the materials present as well as to determine the appropriate waste classification should offsite disposal of the material be required. A summary of the results is presented in the table below.

Table 5-12 - Contaminant results - soil

Deteminand	Minimum value (mg/kg)	Maximum value (mg/kg)	Average (mg/kg)
Boron	0.7	2.4	1.13
Antimony	<0.1	1.4	0.48
Arsenic	3.7	362	17.79
Cadmium	<0.19	0.6	0.27
Chromium	12.9	33.5	24.35
Hexavalent chromium	<0.1	0.2	0.2
Copper	9.3	34.8	20
Lead	9.7	37.4	20
Manganese	88.2	3,700	1,104
Mercury	<0.1	0.12	0.12
Molybdenum	<0.5	1.3	0.74
Nickel	11.7	43	23.78
Selenium	<0.5	0.8	0.69
Vanadium	16.8	68.4	36.9
Zinc	27.8	110.7	58
Barium	55.2	297	143
Beryllium	0.46	1.21	0.77
Iron	16,300	72,700	35,776
pH (pH units)	5.9	8.7	7.58
Free cyanide	<0.5	<0.5	n/a
Total cyanide	<0.5	1.9	0.82
Phenol index	<0.5	<0.5	n/a
Total organic carbon (%)	0.57	4.1	1.43
Acenaphthene	<0.08	<0.08	n/a
Acenaphthylene	<0.08	<0.1	n/a
Anthracene	<0.08	0.34	n/a
Benzo(a)anthracene	<0.08	1.43	0.43
Benzo(a)pyrene	<0.08	1.52	0.38
Benzo(b)fluoranthene	<0.08	1.81	0.37
Benzo(ghi)perylene	<0.08	0.89	0.23

Deteminand	Minimum value (mg/kg)	Maximum value (mg/kg)	Average (mg/kg)
Benzo(k)fluoranthene	<0.08	0.62	0.37
Chrysene	<0.08	1	0.28
Dibenzo(ah)anthracene	<0.08	0.3	0.21
Fluoranthene	<0.08	2.2	0.48
Fluorene	<0.08	0.09	0.09
Indeno(123cd)pyrene	<0.08	1.08	0.25
Naphthalene	<0.08	<0.1	n/a
Phenanthrene	<0.08	0.73	0.86
Pyrene	<0.08	1.78	0.48
Benzene	<0.01	<0.0125	n/a
Ethylbenzene	<0.01	0.014	n/a
Toluene	<0.01	0.0125	n/a
Xylenes	<0.03	0.042	n/a
MTBE	<0.02	<0.025	n/a
GRO C5-C6 aliphatic	<0.2	<0.25	n/a
GRO C6-C7 aliphatic	<0.2	<0.25	n/a
GRO C7-C8 aliphatic	<0.2	<0.25	n/a
TPH Aliphatic C8-C10	<4	6.17	n/a
TPH Aliphatic C10-12	<4	<5.19	n/a
TPH Aliphatic C12-C16	<4	<5.19	n/a
TPH Aliphatic C16-C21	<4	7.56	5.97
TPH Aliphatic C21-C35	<8.8	33.8	16.9
TPH Aromatic C8-C10	<4	<4.99	n/a
TPH Aromatic C10-C12	<4	<4.99	n/a
TPH Aromatic C12-C16	<4	6.86	4.63
TPH Aromatic C16-C21	<4	6.81	6.63
TPH Aromatic C21-C35	<8.76	82.4	21.64

Asbestos screening was carried out in all samples with no asbestos detected in any of the tested samples.

SOIL LEACHATE

Soil leachate testing was not carried out as groundwater sampling and analysis was completed.

GROUNDWATER

Groundwater samples were obtained from borehole installations for subsequent chemical analysis. A summary of the results is presented in the table below.

Table 5-13 - Contaminant results - groundwater

Determinand	Minimum value (mg/l)	Maximum value (mg/l)	Average (mg/l)
Boron	<0.1	0.15	0.065
Antimony	<0.1	<0.1	n/a
Arsenic	<0.001	0.005	0.0026
Cadmium	<0.0001	0.0011	0.0007
Chromium	<0.001	0.001	n/a
Hexavalent chromium	<0.003	<0.003	n/a
Copper	<0.001	0.008	0.005
Lead	<0.001	0.014	0.0048
Mercury	<0.0001	0.0004	n/a
Molybdenum	0.001	0.111	0.017
Nickel	0.001	0.013	0.005
Selenium	<0.001	0.002	0.0015
Zinc	<0.002	0.182	0.06
Barium	0.08	3.28	0.55
Beryllium	<0.01	<0.1	n/a
Calcium	18	502	146
Magnesium	5	86	28
Ammoniacal nitrogen (as N)	0.03	1	0.26
Chloride	18	207	54
Nitrate	<0.2	8.3	4.4
Conductivity (uS/cm)	654	1187	933
Dissolved organic carbon	1.1	16	5.78
pH (pH units)	7.1	8.8	7.82
Free cyanide	<0.02	<0.02	n/a
Total cyanide	<0.02	0.08	0.04
Phenol	<0.0009	0.0163	0.006
Acenaphthene	<0.00001	<0.0001	n/a
Acenaphthylene	<0.00001	<0.0001	n/a
Anthracene	<0.00001	<0.0001	n/a
Benzo(a)anthracene	<0.00001	0.00002	n/a
Benzo(a)pyrene	<0.00001	<0.0001	n/a
Benzo(b)fluoranthene	<0.00001	0.0001	n/a
Benzo(ghi)perylene	<0.00001	<0.0001	n/a

Determinand	Minimum value (mg/l)	Maximum value (mg/l)	Average (mg/l)
Benzo(k)fluoranthene	<0.00001	<0.0001	n/a
Chrysene	<0.00001	<0.0001	n/a
Dibenzo(ah)anthracene	<0.00001	<0.0001	n/a
Fluoranthene	<0.00001	0.00019	0.00016
Fluorene	<0.00001	0.00022	0.00016
Indeno(123cd)pyrene	<0.00001	<0.0001	n/a
Naphthalene	<0.00001	0.00039	0.000335
Phenanthrene	<0.00001	0.0006	0.00039
Pyrene	<0.00001	0.000023	0.00013
Benzene	<0.005	<0.005	n/a
Ethylbenzene	<0.005	<0.005	n/a
Toluene	<0.005	<0.005	n/a
Xylenes	<0.015	<0.015	n/a
MTBE	<0.01	<0.01	n/a
GRO C5-C6 aliphatic	<0.1	<0.1	n/a
GRO C6-C7 aliphatic	<0.1	<0.1	n/a
GRO C7-C8 aliphatic	<0.1	<0.1	n/a
TPH Aliphatic C8-C10	<0.01	<0.1	n/a
TPH Aliphatic C10-12	<0.01	<0.1	n/a
TPH Aliphatic C12-C16	<0.01	<0.1	n/a
TPH Aliphatic C16-C21	<0.01	0.157	0.04
TPH Aliphatic C21-C35	0.068	1.27	0.3
TPH Aromatic C8-C10	<0.01	<0.1	n/a
TPH Aromatic C10-C12	<0.01	<0.1	n/a
TPH Aromatic C12-C16	<0.01	<0.1	n/a
TPH Aromatic C16-C21	<0.01	<0.1	n/a
TPH Aromatic C21-C35	0.012	0.293	0.07

GROUND GAS

No ground gas monitoring has been undertaken as part of this investigation.

WASTE CLASSIFICATION / WASTE ACCEPTANCE

The waste classification hazardous properties assessment has been carried out in accordance with the WM3 Technical Guidance – Waste Classification: Guidance on the Classification and Assessment of Waste (1st Edition v1.1 May 2018).

None of the materials tested are likely to be classified as hazardous waste. Therefore, these materials would be classified under the European Waste Catalogue (EWC) as '17 05 04 Soil and Stones other than those mentioned in 17 05 03'.

It is recommended that further waste classification assessment is undertaken prior to any offsite disposal.

Waste acceptance criteria (WAC) analysis has not been undertaken as part of this ground investigation. Due to these materials being unlikely to be classified as hazardous waste, the inert WAC and inert threshold limits should be applied to any materials that require offsite disposal.

CONTAMINATED LAND

In the United Kingdom, the presence of contamination within soil or groundwater at a site is generally only of concern if an actual or potentially unacceptable risk to a sensitive receptor exists.

The risk assessment process begins with screening chemical concentrations in soil or groundwater against generic conservative screening values in a process called Generic Quantitative Risk Assessment (GQRA). GQRAs are performed to assess risks to human health and controlled waters receptors.

Human Health Risk Assessment

The human health Generic Assessment Criteria (GAC) used to assess the risks from soil chemical concentrations have been developed by WSP using the CLEA Workbook v1.071 modelling tool. A potential risk exists if the recorded soil concentration exceeds the GAC for that chemical.

The results of the soil analysis have been compared against GAC for a commercial / industrial end use for 1% soil organic matter (SOM).

The human health risk assessment indicates that only three soil samples exceeded the conservative GAC. The exceedances relate to slightly acidic pH concentrations recorded within TP/17/20 at 0.3m, BH/17/06 at 0.15m and TP/17/14 at 0.2m, pH was reported to be 6.2, 5.9 and 6.4 respectively, below the GAC of 6.5. These pH values were all recorded within samples of topsoil.

Controlled Waters Risk Assessment

There are several watercourses that cross the study area as well as superficial and bedrock aquifers in the underlying geology.

Generic controlled waters assessments are usually conducted by comparing directly measured concentrations in groundwater with standard assessment criteria, or Water Quality Standards (WQS) that are protective of surface waters or groundwater resources.

Appropriate published WQS are selected based on both a hierarchy of relevance to England and Wales and the nature of the receptor. In this case, the assessment has been completed using WQS protective of both groundwater (Secondary A aquifer) and surface waters. The following WQS have been used:

Aquifers

- UK Drinking Water Quality Standards (DWS) from The Water Supply (Water Quality) Regulations 2016
- World Health Organisation (WHO) Guidelines for Drinking Water Quality, Fourth Edition, Volume 1 (2011)
- WHO Petroleum Products in Drinking Water (2008)

Surface Waters

- Environmental Quality Standards (EQS) from The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015

There were several exceedences of the groundwater concentrations when conservatively compared to UK DWS and EQS.

Concentrations of TPH Aromatic C21-C35, chromium III, lead, molybdenum, barium, ammoniacal nitrogen and cyanide were reported above the DWS in one or more groundwater samples analysed.

Concentrations of TPH Aromatic C21-C35, chromium III, copper, lead, mercury, nickel, zinc, fluoranthene, phenol and cyanide were reported above the EQS in one or more groundwater samples analysed.

All of the monitoring installations with the exception of one, have response zones targeting Glacial Till and the underlying bedrock. In consideration of the strata which the response zones are targeting and the limited potential sources of contamination identified in the location of the monitoring wells, these concentrations appear to be representative of the background concentrations related to the regional geology.

6 GEOTECHNICAL RISK

6.1 CURRENT ASSESSMENT OF GEOTECHNICAL RISKS

The geotechnical risk register is included in Appendix E. It is based on the risk register included in the Jacobs PSSR [Ref 1] and has been updated to incorporate the findings detailed in this report. In summary the main potential geotechnical hazards at the site are considered to be:

- Areas of soft soils
- Unknown groundwater conditions
- Intermittent laminated glacio-lacustrine deposits.
- Cobbles and Boulders within the glacial till.
- Residual risk of unrecorded coal workings
- Weak heavily weathered, laminated bedrock
- Shallow rock/ hard dig material;
- Shortfall of quality fill material;
- Insufficient GI data in discrete locations;
- Determinants within soils which pose a risk to human health and to the environment;

Before control, the degree of risk is calculated to be up to a value of 15, which is equivalent to a high risk. The strategy to respond to the geotechnical risks identified for this project is noted below:

- Avoid the risk, or
- If unavoidable, transfer the risk, or
- If non-transferable, mitigate the risk, or
- If unable to mitigate, accept and manage the risk

In summary, by undertaking measures to control the risks such as a desk study exercise, ground investigation and detailed design using the latest standards and 'best practice', after control, the degree of risk is considered to be significantly reduced.

6.2 PRELIMINARY REVIEW OF GEOTECHNICAL OPTIONS

INTRODUCTION

WSP has been commissioned to complete works to end of Stage 4 of the CDF Framework which includes preliminary design but not detailed design or production of a GDR. In order that the rationale behind geotechnical design decisions be captured and recorded in a document that would be available on HA GDMS is was agreed with HE SES that a section would be added to the GIR outlining these design decisions. The rationale behind the preliminary geotechnical design was as follows:

- To provide enough information to fix the various scheme boundaries for the DCO process.
- To demonstrate that the proposed design was feasible form a geotechnical perspective
- To allow sufficient information for scheme costing
- To not be over-prescriptive in fixing the design prior to detailed design once the above goals were achieved.

The following represents a discussion of the decisions made in relation to the various elements of design where geotechnical design was required.

EARTHWORKS

As per the earthwork datasheets, all the cuttings will be formed within the Glacial Till, with the exception of A2EC04 (Ch 60400-61100) and sections of A2EC03 (between Ch57800-58000) where glaciofluvial deposits and Glaciolacustrine deposits were encountered during the GI's.

For the cuttings in Glacial Till, a slope angle of 1v:3h has been utilised for preliminary design based on the plasticity index and peak internal angle of friction testing which indicates a design value of phi' of 25° and a conservative c' of 0kPa.

All earthworks will have crest and toe drainage.

Where embankments are greater than 1.5m high, it has been assumed that a starter layer 0.5m thick of imported Class 6C will be required.

For the purposes of preliminary design, a design CBR of 2.5% has been assumed as based on a cautious estimate from the CBR and Plasticity Index data. It is likely that during detailed design several design CBRs specific to the local ground conditions will be required. It is considered likely that the design CBR for embankments will be dependent on the effects of any lime modification of the as dug material.

Some of the embankment slopes may be slackened to improve the aesthetics and landscaping options.

STRUCTURAL FOUNDATIONS

Various options have been considered for the provision of a cost effective and feasible solution for the construction of the required structures along the A1 Trunk road and these are discussed within the various the Structures Options Reports. Where a piled foundation is anticipated, preliminary design ground models have been produced to assess the likely pile lengths and these are included in Appendix G. A summary of the foundation options addressed to date is provided below.

Table 6-1 - Foundation options

Structure		Chainage	Scheme Requirements
Scheme Overbridges	Heckley Fence	55300	The final solutions are likely to be construction of a single span bridge with prestressed precast concrete beams. Piled foundations are the most likely foundation type at all the locations. To date bored piles into rock are being assumed. Pile lengths ranging between 9 and 20m across the two sites are currently being assessed, with Charlton Mires appearing to have the worst ground conditions. Reinforced soil at both ends of the structure may be used to retain the embankments and the pile supported abutments.
	Charlton Mires	58940	
Linkhall Culvert		59275	Precast concrete box culvert extension is the preferred option.
Whitehouse Burn Culvert		56920	Precast concrete box culvert extension is the preferred option.
Shipperton Culvert		60385	Precast concrete box culvert extension is the preferred option.

DRAINAGE

Earthworks drainage will take the form of longitudinal toe drains in cuttings and open drains at the crest of cuttings and toe of embankments. These will be incorporated into a drainage system involving the creation of swales and shallow detention basins and outlet structures. Given the low permeability of the glacial till in which the basins will be constructed, the basins have been sized on the basis that there will be no infiltration and all the water will require discharge to water courses.

The general arrangement of the basins indicates an invert approximately 0.5m bgl with the - base another 0.5m below the invert level. The basins will have side slopes of 1v:3h. Given the shallow groundwater across much of the site the basins have been kept as shallow as the required invert levels to avoid inundation by groundwater.

It should be noted that GI specifically specified for the detention basins has not been undertaken at each location due to amendments in designs following completion of the recent GI. It is therefore recommended that further GI be undertaken once the drainage design is finalised so that groundwater levels can be obtained at the proposed locations.

REUSE OF SITE SOILS

Excavated material from cuttings and suitable as general fill for re-use in embankments is likely to be predominantly cohesive Class 2A. As the natural moisture content of the existing soils is higher than optimum, the cohesive material will require some degree of treatment, for example lime conditioning or drying.

It is considered that trials of lime treatment would be advisable to inform the detailed design in order to obtain design parameters for the modified cohesive glacial till.

MINING ISSUES

The PSSR (Ref 1) and accompanying risk register noted that the contents of the Coal Authority Coal Mining Report explained that the route is not influenced by past recorded workings and that there are no future mining operations planned at the present time.

It was noted that the route is underlain by known coal seams but that there are no records of working to these seams. There remains the possibility that these coal seams may have been worked at some time in the past. The PSSR (Ref 1) indicated that proposed Bridge structures to be treated as areas where possible unrecorded workings would pose an unacceptable risk

The ground investigation carried out across the scheme to date has encountered only thin coal seams of around 0.3m thickness. In addition, there have been no occurrences of soft ground or voids that may indicate unrecorded historical coal workings.

It is noted that there is an area within the redline boundary for the proposed access road to South Rock Farm that is shown as a Development High Risk Area (DHRA) on the Coal Authority's online Interactive Map Viewer. This area is shown in relation to an inferred outcrop of a coal seam, considered to possibly be the Greenses coal seam, reported as being 71cm thick (2'4") on the 1:63,360 scale BGS plan dated 1956. The coal seam is shown to be overlain by alluvial deposits along the proposed road alignment. One trial pit (TP/17/43) located close to the inferred outcrop indicated alluvium to 2.7m depth with occasional pockets (<5mm) of black coal/lignite from 1.5m depth. Based on the proposed works for the access route to South Rock Farm which comprises the construction of a new track to the west of the existing and embankments with a proposed height of <3m, it is considered that there is a risk of instability resulting from unrecorded coal workings affecting the proposed road, and therefore appropriate mitigation should be used.

Further DHRAs are located within proximity of Heckley Fence, in relation to probable shallow mine workings and mine entry shafts. Nearby exploratory holes indicate ground conditions of glacial till to approximately 5.0m bgl, with occasional made ground and alluvium, underlain by a series of sandstone, mudstone and limestone layers with a 0.15m thick coal seam at 12.27m bgl encountered in BH/17/13. No voids or broken ground were encountered and a typical maximum return flush of 95% was observed. However, between 14m and 15m bgl in BH/17/14 0% flush was returned. This coincided with extremely weak mudstone, this therefore may reflect the drilling causing the break-up and washing out of the weak strata.

At the time of writing this report, Heckley Fence is considered to be an option for an overbridge. If this option is to be progressed the risk from coal mining hazards should be considered further. The Coal Mining Risk Assessment in Appendix E provides further assessment of the coal mining risk at both Heckley Fence and South Rock Farm.

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Appendix A

EARTHWORK AND STRUCTURE DATASHEETS

Last Update: 15/04/2019
Design Revision: Rev 01

Earthwork Details: A2EE01 (CH 53800- 54300)

A2EE01		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	
General Details	Northbound	14_A1_42595 At Grade	53800	54380	-	-	-	
	Southbound	14_A1_42577 At Grade	53750	54380	-	-	-	
Earthwork Details	HAGDMS Defects	HAGDMS Reference	Approx Chainage		Description		Class	Location
		14_A1_42577 _519979	54200		Class 1D Toe of slope has been excavated. Approximately 0.6m height of material is missing		1D	C
		14_A1_42595 _520272	54200		Extensive Burrows		1D	C
	Preliminary Earthwork Proposals	Side Long Ground (S. bound 53800-53900 maximum slope height 2.6m; 4112 – 54300 (2.4m); (N. bound 53900 – 54112 maximum slope heights 1.6m).						

Published Geology

Superficial	Solid
Glacial Till	Alston Formation
	Tyne Limestone Formation and Alston Formation (CH54000-54250)

Other relevant information	
- Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• Soft alluvial deposits located at TPA12. There is the potential for further soft and compressible soils in the vicinity of A2EE01 • Shallow groundwater encountered in TP/17/04, at 0.9m. • An EHV cable is located to the east of the A1, running parallel to the highway. Two cables for Vodafone and National Grid are located in the western verge of the A1

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
TP/17/02	Topsoil	0.1	2.2	67.41	-
	Firm slightly gravelly sandy SILT with medium cobble and low boulder content	1.0			
	Firm to stiff slightly sandy gravelly CLAY with medium cobble and low boulder content	2.2			
BH7	Topsoil	0.24	6.1	68.6	
	Slightly sandy silty CLAY	0.88			
	Silty sandy CLAY. Gravel between 3 and 3.3m bgl	6.1			
TPA10	Topsoil	0.2	3.2	69.63	-
	Loose silty SAND	1.1			
	Soft clayey SAND and GRAVEL	1.5			
	Stiff CLAY	3.2			
TPA11	Topsoil	0.2	3.3	73.6	-
	Firm to stiff CLAY. Occasional boulders of sandstone and pockets of sand	1.5			
	Stiff CLAY	3.3			
TP/17/03	Topsoil	0.15	3.8	75.05	-
	Stiff slightly sandy gravelly CLAY with low cobble content.	0.9			
	Stiff slightly sandy gravelly CLAY with low to medium cobble and boulder content.	2.4			
	Very stiff slightly sandy gravelly CLAY	2.7			
	Stiff gravelly CLAY with low to medium cobble content	3.8			

BH8	Topsoil	0.24	6.1	75	
	Silty sandy CLAY with gravel	0.64			
	Silty sandy CLAY with large sandstone fragments. Gravel between 3 and 3.3m bgl.	6.1			
TPA12	Topsoil	0.2	3.5	76.92	-
	Loose SAND	1			
	Firm to soft silty clayey SAND to clayey SILT.	1.3			
	Soft peaty CLAY with some fine sand	1.5			
	Firm CLAY	2.1			
	Firm to stiff CLAY with pockets of moist sand at 2.3m	2.3			
	Stiff CLAY	3.5			
TP/17/04	Topsoil	0.2	1.2	76.57	-
	Stiff slightly sandy slightly gravelly CLAY with low to medium cobble and boulder content	0.55			
	Stiff slightly sandy gravelly CLAY with low to medium cobble and boulder content.	1.2			
TPA13	Topsoil	0.2	3.2	80.19	-
	Firm sandy CLAY	0.6			
	Firm to stiff CLAY	1.1			
	Soft moist clayey SAND with some gravel	1.4			
	Firm to stiff CLAY with some boulders	3.2			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2	67.21-79.99	0.2	Firm slightly sandy slightly gravelly CLAY
Alluvium (only TPA12	1.5	75.42	1.3	Loose SAND to soft peaty CLAY with some sand
Glacial Till (fine grained)	1.1-6.1	62.5 – 79.09	5.9	Firm to stiff silty sandy CLAY
Glacial Till (coarse grained) (TPA10 and TPA13)	1.5	68.13 – 78.79	0.3-1.2	Loose clayey SAND and GRAVEL

Groundwater

Hole Reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded post GI monitoring (m bgl)
BH7	3.02	-	-
BH8	2.19	-	-
TP/17/02	1.4	-	-
TP/17/04	0.9	Slight inflow	-
TPA10	1	Moderate water strike, reduced to a very slow flow	-
TPA11	1.3	Slight seepage	-
TPA12	2.1	Strong isolated flow of water	-

TPA13	3.1	Slight water strike	-

Summary of Test Results

Stratum	Alluvium		Glacial Till (fine grained)		Glacial Till (coarse grained)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content %	5	*14-29 (21.6)	11	9.6-42 (20.2)	19	*8.7-22.3 (15.7)
Liquid Limit %	2	*24-37 (30.5)	6	27-55 (38)	-	-
Plastic Limit %	2	*15-20 (17.5)	6	11-29 (21)	-	-
Plasticity Index %	2	*9-17 (13)	6	12-26 (17)	-	-
Cu (kN/m^2)	3	*17-75 (42.5)	58	*4-324 (126)	-	-
MCV	4	*6.3-9.9 (8.1)	37	*3.9-15 (8.26)	-	-
Max Dry Density (mg/m^3)	-	-	13	*1.81-2.14 (1.97)	-	-
Bulk Dry Density (mg/m^3)	3	*2.03-2.22 (2.1)	4	1.79-2.19 (2.03)	2	1.96-2.05 (2.0)
Optimum Moisture Content %	-	-	13	*6.3-17 (11.5)	-	-
Coefficient of compressibility mv (MN/m^2)	-	-	2	*0.0091-1.404 (0.397)	-	-
CBR %	2	*0.4-0.8 (0.6)	20	*0.1-35 (10.14)	1	*8.8-11 (9.9)
Effective angle of friction (°)	1	*29.5	3	24-31 (28)	1	*34.5
*Results sourced from data outside of A2EE01						

Summary of Geotechnical Risks

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Hard Dig	Cobbles and boulders were encountered in the glacial till
Weak compressible soils	Alluvium is present in isolated areas across the site.
Existing Earthwork defects	HAGDMS records show existing earthwork defects

Last Update: 07/05/2019
Design Revision: Rev 01

Earthwork Details: A2EE02 (CH 55100-55510)

<table>
<tr><th colspan="2">A2EE02</th><th rowspan="2">HAGDMS Reference</th><th colspan="2">Chainage</th><th rowspan="2">Max Slope Height (m)</th><th rowspan="2">Typical Slope Height (m)</th><th colspan="2" rowspan="2">Elevation Range (m OD)</th></tr>
<tr><th></th><th></th><th>From</th><th>To</th></tr>
<tr><td rowspan="2">General Details</td><td>Northbound</td><td>14_A1_42594</td><td>54400</td><td>55300</td><td>-</td><td>-</td><td colspan="2">-</td></tr>
<tr><td>Southbound</td><td>14_A1_42578</td><td>54400</td><td>55300</td><td>-</td><td>-</td><td colspan="2">-</td></tr>
<tr><td rowspan="3">Earthwork Details</td><td rowspan="2">HAGDMS Defects</td><td>HAGDMS Reference</td><td colspan="2">Approx Chainage</td><td colspan="2">Description</td><td>Class</td><td>Location</td></tr>
<tr><td colspan="7">None Recorded</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="7">Embankment on both sides of the A1.</td></tr>
</table>

Published Geology

Superficial	Solid
Glacial Till	Oxford Limestone Member (CH55100-55150)
	Tyne Limestone Formation and Alston Formation (CH54000-54250)

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• Alluvial deposits are present in isolated areas across the site. • The surrounding area is agricultural land. • Overhead Lines cross the A1 at approximately CH55100 • An EHV cable runs in the eastern verge of the A1, moving into the alignment of the A1 at approx. CH 55300 • Two cables run in the western verge of the A1.

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
TP19	Topsoil	0.23	2.13	86	-
	Soft sandy CLAY	0.68			
	Loose Clayey Sandy GRAVEL	1.37			
	Soft SILT with bands of grey fine sand	2.13			
TPA19	Topsoil	0.3	3.3	94.38	-
	Loose to moderately compact SAND with fines, varying to slightly clayey sand	0.8			
	Firm to stiff CLAY with numerous pockets and layers of damp sand and gravel with fines	1.5			
	Soft very sandy gravelly CLAY varying to medium dense SAND and GRAVEL with fines, with layers of clay.	2.1			
	Firm CLAY	3.3			
BH/17/13	Topsoil	0.4	15	95.39	0-1 Plain 1-10.0 Slotted
	Soft to firm slightly sandy slightly gravelly CLAY, frequent pockets of fine to coarse sand. Frequent intact plant remains	1.2			
	Soft to firm slightly sandy slightly gravelly CLAY.	4.2			
	Firm slightly sandy slightly gravelly CLAY.	5.6			
	Sandstone recovered as lightly cemented slightly sandy gravel	6			
	Strong thinly bedded fine to medium SANDSTONE	7.68			
	Medium Strong to strong thinly bedded fine to medium SANDSTONE with frequent mudstone laminations and fractures	10.06			

	Weak very thinly to thinly bedded MUDSTONE with fractures	12.27			
	Weak COAL	12.42			
	Strong argillaceous bioclastic LIMESTONE	13.23			
	Medium strong to strong thinly bedded SANDSTONE to SILTSTONE	14.54			
	Weak thinly bedded MUDSTONE	15			
BH/17/14	Slightly Gravelly sandy CLAY with low cobble content. Rare fragments of vitreous clay pipe	0.7	15	95.35	0-1 Plain 1-4 Slotted
	Firm slightly sandy slightly gravelly CLAY	2.5			
	Soft to firm slightly gravelly sandy silty CLAY	4.5			
	SANDSTONE recovered as fine to coarse sand	5			
	Weak fine to medium grained SANDSTONE with thin laminae of black coal and fractures.	6.06			
	Medium strong to strong SANDSTONE with veins of organic matter and fractures.	8.88			
	Moderately strong to strong SANDSTONE. Thinly to thickly laminated with extremely weak to weak MUDSTONE. Fractures observed	11.78			
	Extremely weak MUDSTONE thinly to thickly laminated with SILTSTONE. Fractures observed.	15			
TP/17/47	Topsoil	0.3	3.0	96.29	-
	Firm slightly sandy slightly gravelly CLAY with cobbles.	1.1			
	Soft sandy very gravelly CLAY with medium cobble and low boulder content.	2.0			
	Firm to stiff slightly sandy gravelly clay with occasional cobbles.	3.0			
TP/17/48	Sandy GRAVEL of sandstone with fragments of whole and broken brick.	0.5	3.6	94.91	-
	Firm to stiff slightly sandy slightly gravelly silty CLAY with low cobble content.	1.3			
	Stiff slightly sandy slightly gravelly silty CLAY with low cobble content and high boulder content.	2.5			
	Stiff slightly sandy slightly gravelly silty CLAY with low cobble content.	3.6			
BH13	Topsoil	0.2	3.6	94.4	-
	Sandy silty CLAY with organic traces and gravel	2.3			
	Silty sandy CLAY	3.6			
TPA20	Topsoil	0.2	3.2	95.93	-
	Firm sandy CLAY varying to moderately compact silty SAND with large pockets of wet clayey gravelly sand.	1.3			
	Firm to stiff CLAY with wet pockets of loose gravelly sand at 1.8m. Stiff at 2.2m	3.2			
TP/17/09A	Topsoil	0.2	2.3	95.68	-
	Firm to stiff slightly gravelly sandy CLAY	2.2			
	Gravelly very silty SAND	2.3			
BH14	Topsoil	0.27	3.6	97.5	-

	Silty Sandy CLAY	1.2			
	Silty slightly sandy CLAY	3.6			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum layer thickness (m)	Typical Description
Topsoil	0.3	85.7-97.2	0.3	Soft to firm slightly sandy slightly gravelly CLAY.
Made Ground (BH/17/14, TP/17/48)	0.5-0.7	94.6	0.5-0.7	Sandy gravelly CLAY with low cobble content. Rare fragments of vitreous clay pipe / Sandy GRAVEL of sandstone with fragments of whole and broken brick
Alluvium (BH/17/13, BH13)	1.2-2.3	92.1-94.19	0.8-2.0	Soft to firm sandy CLAY with organic traces and gravel.
Glacial Till (fine-grained)	2.13-5.6	83.87 – 93.9	1.3-4.4	Firm to stiff gravelly sandy CLAY with low cobble and boulder content.
Glacial Till (coarse- grained) (TP/17/09A, TP19)	1.37-2.3	84.63 – 93.38	0.1 - 0.69	Loose clayey sandy GRAVEL / Gravelly very silty SAND
Sandstone	11.78 - 14.54	80.85 – 83.57	0.40.81 – 2.9	Medium strong to strong thinly bedded SANDSTONE with fractures.
Limestone (BH/17/13)	13.23	82.16		Strong argillaceous bioclastic LIMESTONE
Mudstone	>15.0	80.3	0.46 - 3.22	Extremely weak to weak thinly bedded MUDSTONE
Coal (BH/17/13)	12.42	82.97	0.15	Weak COAL

Groundwater

Hole Reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded post GI monitoring (m bgl)
BH/17/13	3.2	-	2.14-2.58
BH/17/14	-	-	1.04-2.2
BH13	2.44	-	0.58
BH14	3.66	-	1.22
TP/17/09A	2.3	Seepage	-
TP/17/47	1.1	-	-
TP19	0.68	Very strong water strike.	-
TPA20	1.8	Strong strike	-

Summary of Test Results

Stratum	Made Ground		Alluvium		Glacial Till (fine grained)		Glacial Till (coarse grained)		Sandstone		Limestone	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content %	13	*6.4-25.7 (16.5)	5	*14-29 (21.6)	20	5.9-26.4 (16)	19	*8.7-22.3 (15.7)	-	-	-	-
Liquid Limit %	7	*26-39 (33.9)	2	*24-37 (30.5)	8	28-37 (41.6)	-	-	-	-	-	-
Plastic Limit %	7	*14-23 (20)	2	*15-20 (17.5)	91	11-20 (17.25)	-	-	-	-	-	-
Plasticity Index %	7	*12-17 (13.6)	2	*9-17 (13)	91	11-19 (15.6)	-	-	-	-	-	-
Cu (kN/m^2)	6	*15-107 (40)	3	*17-75 (42.5)	11	4-140 (63.3)	-	-	-	-	-	-
MCV	-	-	4	*6.3-9.9 (8.1)	37	*3.9-15 (8.26)	-	-	-	-	-	-
Max Dry Density (mg/m^3)	-	-	-	-	1	1.78-1.94 (1.87)	-	-	-	-	-	-
Bulk Dry Density (mg/m^3)	-	-	3	*2.03-2.22 (2.1)	7	2.04-2.25 (2.13)	2	1.96-2.05 (2.0)	-	-	-	-
Optimum Moisture Content %	-	-	-	-	1	9.1-19 (13.8)	-	-	-	-	-	-
Coefficient of compressibility mv (MN/m^2)	-	-	-	-	2	*0.0091-1.404 (0.397)	-	-	-	-	-	-
CBR %	2	*10-15 (12.5)	2	*0.4-0.8 (0.6)	3	0.1-1.9 (0.97)	1	*8.8-11 (9.9)	-	-	-	-
Effective angle of friction (°)	2	*30	1	*29.5	2	26-30.5 (28.3)	1	*34.5	-	27-34***	-	27-34***
Water Content for Rock %	-	-	-	-	-	-	-	-	14	0.1-4.3 (1.3)	2	0.4-1.2 (0.8)
Point Load MPa	-	-	-	-	-	-	-	-	14	0.02-1.97 (0.75)	2	2.16-3.53 (2.85)
UCS MPa	-	-	-	-	-	-	-	-	1	28.8	1	55.8

Stratum	Mudstone		Coal	
	No. of tests	Results	No. of tests	Results
Effective angle of friction (°)	-	27-34*	-	-
Water Content for Rock %	7	2.9-6.5 (4.3)	1	4.1
Point Load MPa	7	0.03-0.88 (0.46)	1	0.02
UCS MPa	-	5**	-	0.6**
*Results taken from data outside of A2EE02 ** Derived from Point load values. ***Tomlinson 2001				

Summary of Geotechnical Risks

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Weak compressible soils	Alluvium is present in isolated areas
Hard Dig	Cobbles and boulders were encountered in the glacial till

Last Update: 07/05/2019
Design Revision: Rev 01

Earthwork Details: A2EE03 (CH 56700-57720)

A2EE03		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	
General Details	Northbound	14_A1_42576 Embankment	56740	56920	3.8	-	-	
		1_A1_42575 Embankment	56920	57630	3.8	~1.7	-	
	Southbound	14_A1_42632 Embankment	56740	56920	2.5	-	-	
		14_A1_42574 Embankment	56920	57630	2.6	-	-	
Earthwork Details	HAGDMS Defects	HAGDMS Reference	Approx Chainage		Description		Class	Location
		14_A1_42573_ 519977	57625		Small slope bulge with back scar above recorded in 2013. Slope is hummocky and uneven with burrows noted.		1D	C
	Preliminary Earthwork Proposals	*Embankment on both sides of the A1.*						

Published Geology

Superficial	Solid
Glacial Till	Scremerston Coal Member (CH56700 – 57140)
Peat (CH56940-57400)	Tyne Limestone Formation and Alston Formation (CH57140-57720)

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• Alluvium encountered in TP/17/17/ and BH21. • Underbridge at CH56920 to allow farm traffic between fields. • Water pipe crosses the A1 from east to west at CH 56740 • An EHV cable runs parallel to the A1 on the eastern verge • Three further cables run on the western verge

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
TPA29	Topsoil	0.1	3.5	91.95	-
	Firm sandy CLAY	0.65			
	Firm to stiff CLAY	1.5			
	Firm CLAY with soft pockets and layers	1.9			
	Soft CLAY	2.1			
	Firm CLAY with fragments of sandstone	2.7			
	Moderately compact GRAVEL	3.5			
BH21	Silty sandy CLAY	0.9	4.3	87.9	-
	Silty CLAY	2.3			
	CLAY with shale fragments	3.3			
	SHALE	4.3			
TPA30	Topsoil	0.2	2.7	86.43	-
	Firm SAND with fines	0.4			
	Firm CLAY with abundant angular sandstone boulders	1.3			
	Firm rubbly shaley CLAY becoming weak clay	2.2			
	Slightly weathered weak fissile thinly bedded shaley MUDSTONE	2.7			
TP/17/13	Topsoil	0.3	2.2	85.68	-
	Stiff sandy gravelly CLAY with low cobble content	0.7			

	Very stiff slightly sandy gravelly CLAY	1.5			
	SANDSTONE recovered as sandy gravelly clay	2.2			
TPA31	Topsoil	0.25	1.8	85.49	-
	Firm sandy CLAY	0.55			
	Firm CLAY	1.2			
	Firm to stiff CLAY	1.5			
	Moderately weathered weak to medium strong sandy MUDSTONE	1.8			
BH22	Topsoil	0.27	5.4	85.7	-
	Silty sandy CLAY	4.4			
	SANDSTONE	5.4			
BH/17/05	Topsoil	0.35	4.05	85.49	-
	Firm slightly sandy gravelly CLAY	0.8			
	Medium dense sandy GRAVEL	2.25			
	Stiff slightly gravelly very sandy CLAY	3.6			
	Stiff slightly sandy CLAY with rare boulders	4.05			
BH/17/05A	Possible Glacial Till	2.4	10	85.47	-
	Medium strong to strong LIMESTONE with fractures	3			
	Strong thinly to medium bedded SANDSTONE with fractures	3.91			
	Extremely weak to very weak thinly laminated MUDSTONE	4.3			
	Strong to very strong locally thinly laminated SANDSTONE with fractures	5.25			
	Strong thinly to thickly laminated SANDSTONE and very weak SILTSTONE with fractures.	6.3			
	Medium strong thinly interlaminated SANDSTONE and SILTSTONE with fractures	7.39			
	Very weak to weak very thinly interlaminated SILTSTONE and MUDSTONE with fractures	8.15			
	Medium strong to strong thinly laminated SANDSTONE with fractures	8.94			
	Strong LIMESTONE with fractures	9.72			
	Medium strong thinly bedded SILTSTONE with fractures	10			
TP/17/14	Topsoil	0.5	1.7	87.15	-
	Gravelly very silty SAND with low cobble content	1.1			
	Very gravelly very silty SAND	1.7			
TP/17/15	Topsoil	0.35	2.6	85.3	-
	Firm to stiff slightly sandy slightly gravelly CLAY	1			
	Firm very sandy CLAY. Frequent pockets and lenses of sand	1.6			
	Soft very sandy SILT. Frequent bands of possible black coal	2.6			
BH24	Silty slightly sandy CLAY	0.9	7.62	85.8	-
	SILT and silty CLAY	3.05			
	Silty SAND	7.31			
	Fragments of SANDSTONE with some sandy clay	7.34			
	CLAY	7.62			
TP/17/16	Topsoil	0.3	2.3	85.88	-
	Firm sandy gravelly CLAY with low to medium cobble content.	0.7			
	Firm slightly sandy gravelly CLAY	1			
	Gravelly slightly clayey SAND with low cobble content	1.3			
	Clayey SAND	2.3			
TPA32	Topsoil	0.2	2	85.69	-

	Loose moist SAND and GRAVEL with fines. Running sand below	1.5			
	Loose SAND with gravel and some fines. Running sand.	2			
TP/17/17	Topsoil	0.3	1.7	85.46	-
	Firm sandy CLAY with frequent lenses of sand	1			
	Soft very sandy CLAY with rare wood fragments	1.7			
BH25	Silty CLAY	1.04	7.6	85.6	-
	Silty SAND and GRAVEL	2.74			
	Silty CLAY with siltstone fragments	3.23			
	SAND and GRAVEL	3.65			
	Very silty CLAY	7.5			
	SAND and GRAVEL	7.6			
TP/17/18	Topsoil	0.25	3	86.77	-
	Stiff gravelly very sandy CLAY	1.4			
	Slightly gravelly very silty SAND	2.4			
	Very silty SAND	3			
TPA33	Topsoil	0.25	2.0	86.16	-
	Firm very sandy gravelly CLAY	0.7			
	Loose SAND and GRAVEL fines. Soft to very soft running sand	1.3			
	Very soft west SILT and silty CLAY	2.0			
BH26	Topsoil	0.21	6.4	86.5	-
	Sandy CLAY	0.88			
	Clayey SAND	3.44			
	Silty sandy CLAY	6.4			
TP/17/19	Topsoil	0.25	3.6	86.34	-
	Firm very sandy CLAY with occasional gravel	1			
	Firm slightly sandy gravelly CLAY with medium cobble and low boulder content.	2.6			
	Firm sandy gravelly CLAY with medium cobble and low boulder content.	3.6			
TPA34	Topsoil	0.3	3.3	89.26	-
	Firm sandy CLAY	0.5			
	Firm CLAY with abundant sandstone rubble	1.4			
	Firm to stiff CLAY	1.9			
	Stiff CLAY	2.3			
	Very soft to running silt SAND with some clay, becoming soft to firm laminated clay with very soft wet silty sand bands	3.3			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum layer thickness (m)	Typical Description
Topsoil	0.25	84.95-91.85	0.25	Soft to firm slightly sandy gravelly CLAY
Alluvium (TP/17/17, BH21)	0.9-3.3	83.76-84.6	1.4-3.3	Soft to firm silty CLAY with rare wood fragments
Glacial Till (fine-grained)	1.4-7.31	78.49-89.25	0.3-4.26	Firm to stiff very silty sandy gravelly CLAY with low to medium cobble content
Glacial Till (coarse- grained)	0.4-7.6	78.0-86.03	0.1-2.56	Loose SAND and GRAVEL
Sandstone	2.2-8.94	76.53-88.45	0.31-2.0	Medium strong to strong thinly bedded SANDSTONE
Limestone (BH/17/13)	9.72	75.75	0.6-0.78	Mediums strong to strong LIMESTONE with fractures.
Mudstone	1.8-4.3	81.17-83.73	0.3-1.0	Extremely weak to weak thinly laminated MUDSTONE
Siltstone	10	75.47	0.28-0.76	Very weak to medium strong thinly bedded SILTSTONE with fractures.

Groundwater

Hole Reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded post GI monitoring (m bgl)
BH21	2.93	-	-
BH22	4.	-	-
BH24	27	-	-
BH25	3.14	-	-
BH26	2.13	-	1.8
TP/17/13	2.2	-	-
TP/17/15	2.6	Fast inflow	-
TP/17/16	2.1	Seepage	-
TP/17/17	1.7	Fast inflow	-
TP/17/18	2.4	Wet	-
TP/17/19	3.4	-	-
TPA29	1.9 2.2 2.4	Slight strike Moderate strike Strong strike	-
TPA30	17	Seepage	-
TPA31	1.7	-	-
TPA32	0.7 1.2	Very strong strike at 1.2m	-
TPA33	0.8	-	-
TPA34	2.1	Moderately strong	-

Summary of Concrete Classification Results and Other Test Results

Stratum	Alluvium		Glacial Till (fine grained)		Glacial Till (coarse grained)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content %	2	20-29 (24.5)	19	7.2-26.5 (17.3)	9	8.7-19 (14)
Liquid Limit %	1	37	12	26-39 (33)	-	-
Plastic Limit %	1	20	12	15-23 (18.8)	-	-
Plasticity Index %	1	17	12	9-21 (14.3)	-	-
Cu (kN/m^2)	2	5275 (63.5)	8	66-300 (169.5)	-	-
MCV	4	6.3-9.9 (8.1)	12	*4.7-11.6 (817)	-	-
Max Dry Density (mg/m^3)	-	-	13	*1.81-2.14 (1.97)	-	-
Bulk Dry Density (mg/m^3)	1	2.1	7	1.85-2.08 (1.98)	2	1.96-2.05 (2.0)
Optimum Moisture Content %	-	-	13	*6.3-17 (11.5)	-	-
Coefficient of compressibility mv (MN/m^2)	-	-	2	*0.0091-1.404 (0.397)	-	-
CBR %	1	0.38-0.8 (0.6)	1	0.8-0.38 0.59	1	8.8-11 (9.9)
Effective angle of friction (°)	1	*29.5	2	26.5-31.5 (29)	1	*34.5

Stratum	Mudstone (Scremerston Coal)		Siltstone (Scremerston Coal)		Sandstone (Scremerston Coal)		Limestone (Scremerston Coal)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Effective angle of friction (°)	-	27-34***	-	27-34***	-	27-34***	-	27-34***
Water Content for Rock %	3	0.1-3.2 (2.13)	2	0.1-0.3 (0.2)	5	1.1-3.7 (2.74)	8	*0.2-1.2 (0.475)
Point Load MPa	3	0.03-6.49 (2.19)	2	1.85-6.49 (4.17)	5	0.24-2.36 (1.37)	8	*1.48-4.04 (3.1)
UCS MPa	-	5**	1	153	2	35.9-55.6 (45.75)	-	*55.8-90.3 (73.05)
*Results taken from outside of A2EE03 **Based on Point Load Test values ***Tomlinson 2001								

Summary of Geotechnical Risks

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Weak compressible soils	Alluvium is present in isolated areas
Hard Dig	Cobbles and boulders were encountered in the glacial till

Last Update: 07/05/2019
Design Revision: Rev 01

Earthwork Details: A2EE04 (CH58220-58840)

A2EE04		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	
General Details	Northbound	14_A1_42636 At Grade	58200	58350	-	-	-	
		14_A1_42629 At Grade	58400	58800	-	-	-	
		14_A1_42628 At Grade	58800	58900	-	-	-	
		14_A1_42635 Embankment	58220	58840	2.7	1.5	-	
Earthwork Details	HAGDMS Defects	HAGDMS Reference	Approx Chainage		Description		Class	Location
		14-_A1_42577_520121; 14_A1_42635_520122	58350		Small slip observed at the crest (4m long 0.25m wide; 1.7m long)		1D	C
		14_A1_42635_607404	58500		Large soil slip bulge recorded in 2017. Significant rabbit activity causing the slope to fail and rotation of the comms cabinet		1A	C
	Preliminary Earthwork Proposals	*Embankment on both sides of the A1.*						

Published Geology

Superficial	Solid
Glacial Till (CH58220-58400, 58560-58640)	Alston Formation
Alluvium (CH58400-58560)	
Glaciofluvial deposits (CH58560-58840)	

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	
	• Glaciolacustrine deposits present in the area. Further soft and compressible soils are likely to be present. • An EHV cable runs within the A1 alignment. • Two further cables are located in the western verge of the A1, a third cable is located at the junction at CH 58400. • An overhead line crosses the A1 from east to west at CH586200. • A water pipe runs along the western verge of the A1, between CH58650 to CH58850. • A gas pipe runs along the western verge between CH58740 to CH58850. • A further pipe runs along the western verge of the A1 between CH58780 to CH58800. • A BT cable joins at western verge of the A1 at CH 58300, running parallel to the A1. A branch of the cable crosses the A1 at the junction to B6341. A further branch also follows the B6347.

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
BH29	Topsoil	0.15	4.27	90.4	-
	Sandy silty CLAY	2.3			
	Sandy silty CLAY	2.62			
	Thinly bedded SANDSTONE fragments with subordinate sandy clay.	3.66			
	SANDSTONE and SILTSTONE	4.27			
TPA38	Topsoil	0.25	3.6	88.95	-
	Firm sandy CLAY	0.55			
	Firm CLAY with pockets of soft clayey	1.5			

	sand and gravel at 1.4-1.5m bgl				
	Firm to stiff CLAY	2.3			
	Stiff CLAY	3.3			
	Very weak COAL	3.6			
TP/17/23	Topsoil	0.3	3.5	91.23	-
	Firm sandy gravelly CLAY with low cobble content.	1.4			
	Firm slightly gravelly sandy CLAY with low cobble content.	3			
	Very soft slightly gravelly sandy CLAY/SILT	3.5			
TP/17/22	Topsoil	0.3	3.3	87.95	-
	Firm slightly sandy very gravelly CLAY with high cobble content and medium boulder content.	1.9			
	Stiff very gravelly CLAY with low cobble content.	3.3			
BH30	Topsoil	0.06	3.3	87	-
	Sandy CLAY	1.22			
	Sandy silty CLAY	2.74			
	Micaceous thinly bedded SANDSTONE	3.3			
TP/17/24	Topsoil	0.3	2.6	87.89	-
	Firm slightly gravelly very sandy CLAY with low cobble content	1.5			
	Stiff slightly sandy slightly gravelly CLAY with medium cobble content	2.6			
TPA39	Topsoil	0.2	2.0	87.04	-
	Firm sandy CLAY	0.5			
	Loose soft wet clayey SAND and GRAVEL	1.1			
	Soft loose SAND with fines and occasional boulders, becoming moderately compact sand	1.8			
	Soft CLAY	2.0			
TP/17/25	Topsoil	0.3	2.4	86.96	-
	Firm sandy gravelly CLAY with low to medium cobble content.	1			
	Very sandy clayey GRAVEL	1.6			
	Stiff slightly gravelly sandy CLAY. Occasional pockets of sand	2.4			
BH31	Topsoil	0.03	4.75	87.4	-
	Sandy silty CLAY	2.44			
	Sand and GRAVEL	3.44			
	Silty sandy CLAY	4.75			
TPA40	Topsoil	0.2	3.2	87.7	-
	Firm sandy CLAY varying to clayey sand with some gravel and occasional cobbles	1.3			
	Moderately compact silty SAND with clay bands	1.8			
	Soft to firm laminated clayey SILT	1.9			
	Soft laminated CLAY with clayey SILT	3.2			
TPA40A	Topsoil	0.2	2.6	86.86	-
	Firm sandy CLAY	0.4			
	Firm CLAY with sandy pockets, varying to soft to very soft snady clay	1.4			
	Very soft very sandy CLAY	1.7			
	Loose to moderately compact SAND and GRAVEL with some very soft clay	2.6			
HP/17/03	Firm slightly sandy gravelly CLAY, with low cobble content and gravel of rare brick. Frequent rootlets	0.75	1	87.46	-
	Firm slightly sandy gravelly CLAY with low cobble content.	1			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum layer thickness (m)	Typical Description
Topsoil	0.25	86.66-90.93	0.25	Firm slightly gravelly CLAY or SAND
Made Ground	0.75	86.71	0.75	Firm slightly sandy gravelly CLAY, with low cobble content and gravel of rare brick. Frequent rootlets
Glaciolacustrine (TP/17/23, TPA40, TPA40A)	1.7-3.5	84.5-87.73	0.3-1.4	Very soft to soft laminated CLAY/SILT
Glacio-fluvial deposits (BH31,TPA40,TPA40A)	1.8-3.44	83.96-85.9	0.5-1	Loose to moderately compact SAND and GRAVEL
Glacial Till (fine-grained)	1.0-4.75	82.65-87.78	0.2-1.6	Firm to stiff slightly sandy slightly gravelly CLAY with low cobble content.
Glacial Till (coarse-grained) (TP/17/25, TPA39)	1.6-1.8	85.3	0.6-1.3	Loose clayey SAND and GRAVEL
Sandstone	3.3-3.6	83.7-86.7	0.56-1.04	Micaceous thinly bedded SANDSTONE
Coal (TPA38)	3.6	85.35	0.3	Very weak COAL and carbonaceous shale

Groundwater

Hole Reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded post GI monitoring (m bgl)
BH29	2.4	-	-
BH30	2.62	-	0.64
BH31	2.4	-	-
TP/17/22	3.3	Fast inflow	-
TP/17/24	2.6	Fast inflow	-
TP/1725	1 1.5	Damp Slight inflow	-
TPA38	1.4 3.1	Slight seepage Moderate seepage	-
TPA39	1 1.5	Moderately strong Very strong	-
TPA40	1.5	-	-
TPA40A	1.6	Strong strike	-

Summary of Test Results

Stratum	Made Ground		Glaciolacustrine deposits		Glacio-fluvial deposits		Glacial Till (fine grained)		Glacial Till (coarse grained)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content %	13	*6.4-25.7 (16.5)	10	*23-32 (28)	27	*3-30 (13)	15	10-29 (16.7)	2	17
Liquid Limit %	7	*26-39 (33.9)	4	*32-44 (36.8)	2	*30-40 (35)	5	31-40 (35)	-	-
Plastic Limit %	7	*14-23 (20)	4	*20-22 (20.5)	3	*18-23 (21)	5	17-23 (18.6)	-	-
Plasticity Index %	7	*12-17 (13.6)	4	*14-22 (16.3)	2	*8-17 (13)	5	10-22 (16.4)	-	-
Cu (kN/m^2)	6	*15-107 (40)	11	*17-105.6 (66)	1	200	1	145	-	-
MCV	-	-	-	-	-	-	4	15-21 (18)	-	-
Max Dry Density (mg/m^3)	-	-	-	-	5	1.83-2.03 (1.935)	13	*1.81-2.14 (1.97)	-	-
Bulk Dry Density (mg/m^3)	-	-	2	19.3-19.5 (19.4)	11	2.08-1.63 (1.94)	6	1.9-2.28 (2.09)	1	2.05
Optimum Moisture Content %	-	-	-	-	5	7.3-14 (11.7)	13	*6.3-17 (11.5)	-	-
Coefficient of consolidation mv (MN/m^2)	-	-	-	-	1	0.0037-0.18 (0.11)	2	*0.0091-1.404 (0.397)	-	-
CBR %	2	*10-15 (12.5)	-	-	-	-	3	2.7-36 (15.1)	1	*8.8-11 (9.9)
Effective angle of friction (°)	2	*30	-	-	5	*29-35.5	3	24-36 (29.5)	1	*34.5

Stratum	Sandstone (Alston Formation)		Coal	
	No. of tests	Results	No. of tests	Results
Effective angle of friction (°)	-	27-34***	-	27-34***
Water Content for Rock %	13	0.5-2.3 (1.1)	1	4.1*
Point Load MPa	13	*0.22-2.39 (1.38)	1	0.02*
UCS MPa	1	50.9*	-	5**

*Results taken from data outside of A2EE04
** Derived from Point Load Test values
*** Tomlinson 2001
**** Derived from Plasticity Index

Summary of Geotechnical Risks

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Weak compressible soils	Glaciolacustrine deposits are present
Hard Dig	Cobbles and boulders were encountered in the glacial till and are widespread throughout the glacio-fluvial deposits

Last Update: 07/05/2019
Design Revision: Rev 01

Earthwork Details: A2EE05 (CH58960-60100)

A2EE05		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	
General Details	Northbound	14_A1_42627_520077 At Grade	58960	59300	-	-	-	
		14_A1_42626_520092 At Grade	59300	59400	-	-	-	
		14_A1_42625_520087 At Grade	59400	59750	-	-	-	
		14_A1_42624_520093 At Grade	59750	60400	-	-	-	
	Southbound	14_A1_42614_520067 At Grade	58960	59300	-	-	-	
		14_A1_42615_520072 At Grade	59300	59500	2.5	~1.5	-	
		14_A1_42616_520058 At Grade	59500	59700	4.4	-	-	
		14_A1_42617_520068 At Grade	59700	60160	-	-	-	
Earthwork Details	HAGDMS Defects	HAGDMS Reference	Approx Chainage		Description		Class	Location
		None recorded						
	Preliminary Earthwork Proposals	*Embankment on both sides of the A1.*						

Published Geology

Superficial	Solid
Glacio-fluvial deposits (CH58960-59920)	Alston Limestone (CH58960-59700)
Glacial Till (CH59920-60100)	Tyne Limestone Formation and Alston Formation (CH59700-60100)

Other relevant information	
- Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• Scheduled Monuments recorded near West Linkhall • Boreholes in West Linkhall located in a large dip in the field. Here, intact bedrock was not encountered to terminal depth of the borehole >13m bgl. • Three Cables run along the Western verge of the A1, occasionally into the alignment of the existing A1. • The water cable runs along the eastern verge of the existing A1. • The BT cable follows the western verge to ~CH59020 where it crosses the eastern verge. The A branch of the cable crosses the alignment again at ~CH 59780 and ~CH60050

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
BH/17/06	Topsoil	0.3	20.3	87.3	0-5.7 Plain 5.7-9.4 Slotted
	Dense very gravelly very clayey SAND with occasional cobbles	2.4			
	Soft slightly sandy silty CLAY with rare gravel	4.8			
	Soft to firm thinly interlaminated CLAY/SILT	5.7			
	Very dense, very gravelly, very clayey SAND, ranging to sandy slightly gravelly CLAY	9.4			

	Very stiff slightly gravelly sandy silty CLAY	10.32			
	Very sandy silty GRAVEL	13.32			
	Very stiff slightly sandy gravelly CLAY	13.6			
	Very sandy silty GRAVEL	13.7			
	Very stiff slightly sandy very gravelly CLAY	19.52			
	Medium strong LIMESTONE with abundant fossils	20.3			
BH/17/07	Topsoil	0.2	13.1	87.87	-
	Soft slightly sandy slightly gravelly CLAY	3.5			
	Soft thinly laminated CLAY/SILT. Occasional fine sand on laminae	4.2			
	Firm to stiff slightly gravelly sandy CLAY	8.3			
	Firm to stiff slightly sandy slightly gravelly CLAY. Occasional pockets of clay	8.4			
	Very stiff to still slightly sandy gravelly CLAY	13.1			
TP/17/29	Topsoil	0.2	4	86.75	-
	Firm slightly gravelly sandy clay with low cobble content.	1.2			
	Firm slightly gravelly silty CLAY	1.5			
	Firm thinly laminated SILT	3			
	Firm thinly interlaminated CLAY/SILT. Frequent sand on laminae	4			
TP/17/30	Topsoil	0.3	1.7	86.05	-
	Gravelly very silty SAND	1.7			
TP/17/31	Topsoil	0.3	2.5	87.49	-
	Gravelly very silty SAND with low cobble content	1.7			
	Slightly gravelly clayey SAND with medium cobble content.	2.5			
TP/17/33	Topsoil	0.2	1.5	87.16	-
	Slightly gravelly very silty SAND with low cobble content.	1.5			
TP/17/32	Topsoil	0.3	1.7	87.44	-
	Very gravelly SAND with medium cobble content	0.7			
	Very sandy clayey GRAVEL with medium cobble and boulder content.	1.7			
BH/17/08	Firm sandy gravelly CLAY with low cobble content	1.2	10	87.69	-
	Slightly sandy gravelly CLAY. Frequent pockets of sand	5.2			
	Zone of minimal core recovery – Recovered GRAVEL with occasional cobbles	5.4			
	Zone of minimal core recovery – Recovered GRAVEL with occasional cobbles	10			
BH/17/09	Topsoil	0.1	13	84.27	0-1 Plain 1-5 Slotted
	Gravelly silty SAND	0.6			
	Soft to firm gravelly sandy silty CLAY with low cobble content	2.0			
	Medium dense sandy slightly clayey GRAVEL with low cobble content	6.9			
	Zone of Minimal Recovery. Recovered GRAVEL with occasional cobbles	13			
TP/17/35	Topsoil	0.2	2.6	92.17	-
	Clayey very sandy GRAVEL with high cobble and boulder content	2.6			
TP/17/36	Topsoil	0.3	3.5	92.68	-
	Slightly sandy slightly gravelly CLAY/SILT	0.7			

	Very gravelly very silty SAND with low cobble content	1.4			
	Slightly gravelly silty SAND	3.1			
	Gravelly slightly clayey SAND with low cobble content	3.5			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum layer thickness (m)	Typical Description
Topsoil	0.3	84.17-92.38	0.3	Slightly gravelly slightly clayey SAND / Slightly gravelly slightly sandy CLAY
Glaciolacustrine (BH/17/06, BH/17/07, TP/17/29)	4.0-5.7	81.6-83.67	0.7-3.3	Soft to firm thinly interlaminated CLAY/SILT. Occasional sand on laminae
Glacial Till (fine-grained)	5.2-19.52	67.78-85.25	>1.3-8.9	Firm to very stiff sandy gravelly CLAY with low cobble content.
Glacial Till (coarse-grained) (BH/17/06)	13.7	73.6	0.1-3.7	Dense to very dense SAND and GRAVEL
Glacio-fluvial	1.5-13	71.27-89.18	0.4-4.8	Very gravelly clayey SAND with low to medium cobble and boulder content

Groundwater

Hole Reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded post GI monitoring (m bgl)
BH/17/06	-	-	3.36-3.71
BH/17/09	1.4 2	-	2.4-2.81
TP/17/30	1.7	Medium inflow	-
TP/17/31	2.5	Slow inflow	-

Summary of Test Results

Stratum	Glaciolacustrine deposits		Glacio-fluvial deposits		Glacial Till (fine grained)		Glacial Till (coarse grained)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content %	10	23-32 (28)	23	3-20 (11.6)	15	6.2-32 (17.6)	3	12-17 (14.7)
Liquid Limit %	4	32-44 (36.8)	2	30-40 (35)	5	11-33 (38.2)	-	-
Plastic Limit %	4	20-22 (20.5)	2	22-23 (22.5)	5	14-27 (21.4)	-	-
Plasticity Index %	4	12-22 (16.3)	2	8-17 (13)	5	8-26 (16.8)	-	-
Cu (kN/m^2)	3	17-59 (38.3)	1	204	3	21-145.2 (64.4)	-	-
MCV	-	-	-	-	37	*3.9-15 (8.26)	-	-
Max Dry Density (mg/m^3)	-	-	1	1.97	13	*1.81-2.14 (1.97)	-	-
Bulk Dry Density (mg/m^3)	2	19.3-19.5 (19.4)	6	1.77-2.08 (1.96)	3	1.94-2.02 (1.98)	2	*1.96-2.05 (2)

Stratum	Glaciolacustrine deposits		Glacio-fluvial deposits		Glacial Till (fine grained)		Glacial Till (coarse grained)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Optimum Moisture Content %	-	-	1	7.3	13	*6.3-17 (11.5)	-	-
Coefficient of consolidation mv (MN/m^2)	-	-	1	*0.0037-0.18 (0.11)	2	*0.0091-1.404 (0.397)	-	-
CBR %	-	-	-	-	1	20-21 (20.5)	2	10-34 (21.5)
Effective angle of friction (°)	-	-	3	29-35.5 (33)	28	20.4-51 (29.3)	-	34*

Stratum	Limestone		Siltstone (Alston Formation)	
	No. of tests	Results	No. of tests	Results
Effective angle of friction (°)	-	27-34	-	27-34
Water Content for Rock %	8	0.2-1.2 (0.48)	1	0.4
Point Load MPa	8	1.48-4.04 (3.1)	1	0.21
UCS MPa	2	55.8-90.3 (73)	1	63
*Results taken from data outside of A2EE05 ***Tomlinson 2001				

Summary of Geotechnical Risks

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Weak compressible soils	Glaciolacustrine deposits are present
Hard Dig	Cobbles and boulders were encountered in the glacial till and are widespread throughout the glacio-fluvial deposits
Very deep bedrock	Intact bedrock was not encountered near West Linkhall (BH/17/08 and BH/17/09). Bedrock at Charlton Mires was also encountered approximately 20m bgl.
Unknown ground conditions	Due to circumstances on site, BH/17/07 was not able to be progressed further that 13m bgl.

Last Update: 07/05/2019
Design Revision: Rev 01

Earthwork Details: A2EE06 (CH60100-60440)

<table>
<tr><th colspan="2" rowspan="2">A2EE06</th><th rowspan="2">HAGDMS Reference</th><th colspan="2">Chainage</th><th rowspan="2">Max Slope Height (m)</th><th rowspan="2">Typical Slope Height (m)</th><th colspan="2" rowspan="2">Elevation Range (m OD)</th></tr>
<tr><th>From</th><th>To</th></tr>
<tr><td rowspan="3">General Details</td><td>Northbound</td><td>14_A1_42624_520093 At Grade</td><td>59750</td><td>60400</td><td>-</td><td>-</td><td colspan="2">-</td></tr>
<tr><td rowspan="2">Southbound</td><td>14_A1_42617_520068 At Grade</td><td>59700</td><td>60160</td><td>-</td><td>-</td><td colspan="2">-</td></tr>
<tr><td>14_A1_42570_519975 At Grade</td><td>60160</td><td>61500</td><td>~1.3</td><td>~1.3</td><td colspan="2">-</td></tr>
<tr><td rowspan="3">Earthwork Details</td><td rowspan="2">HAGDMS Defects</td><td>HAGDMS Reference</td><td colspan="2">Approx Chainage</td><td colspan="2">Description</td><td>Class</td><td>Location</td></tr>
<tr><td colspan="7">None recorded</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="7">Side Long Ground</td></tr>
</table>

Published Geology

Superficial	Solid
Glacio-fluvial Deposits	Tyne Limestone Formation and Alston Formation (undifferentiated)
Glacial Till	

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• Area of thick superficial deposits • Close to archaeological monuments • Area at risk of flooding (up to 1 in 30 annual risk) near Shipperton Burn. • The water pipe follows the western edge of the old A1, near Charlton Hall. • The EHV cable runs along the eastern to middle of the alignment of the A1. • Three further cables run along the western verge / alignment of the A1. • A BT cable runs along the eastern edge of the old A1 alignment, near Charlton Hall.

Summary of Relevant Exploratory Holes

<table>
<tr><th>Hole reference</th><th>Summary of Log</th><th>Depth to base (m bgl)</th><th>Final Depth (m)</th><th>Ground Level (mOD)</th><th>Installation details [Response Zone] (m bgl)</th></tr>
<tr><td rowspan="8">BH/17/10</td><td>Topsoil</td><td>0.2</td><td rowspan="8">10</td><td rowspan="8">94.54</td><td rowspan="8">-</td></tr>
<tr><td>Gravelly silty SAND. Gravel of mudstone and sandstone</td><td>1.2</td></tr>
<tr><td>Stiff slightly sandy gravelly silty CLAY. Gravel of limestone sandstone with rare black organic matter</td><td>1.65</td></tr>
<tr><td>Soft becoming stiff slightly sandy gravelly CLAY. Gravel of various lithologies</td><td>2.65</td></tr>
<tr><td>Firm slightly gravelly sandy silty CLAY. Gravel of various lithologies</td><td>4.2</td></tr>
<tr><td>Firm to stiff gravelly silty CLAY. Gravel of various lithologies</td><td>5.2</td></tr>
<tr><td>SANDSTONE. Recovered as very sandy gravel</td><td>5.5</td></tr>
<tr><td>Minimal recovery. Recovered material of GRAVEL and COBBLES of siltstone and limestone. Core loss presumed to be from weaker material</td><td>10</td></tr>
<tr><td rowspan="3">HP/17/01</td><td>Topsoil</td><td>0.25</td><td rowspan="3">1.3</td><td rowspan="3">95.38</td><td rowspan="3">-</td></tr>
<tr><td>Firm sandy gravelly CLAY. Gravel fo sandstone, limestone and occasional black lignite. Rare brick fragments <20mm</td><td>0.8</td></tr>
<tr><td>Soft to firm slightly sandy slightly gravelly CLAY. Gravel of sandstone</td><td>1.3</td></tr>
</table>

WS-01	Firm sandy slightly gravelly CLAY. Gravel of sandstone, limestone, mudstone and coal	0.5	2		-
	Clayey sandy gravelly CLAY. Gravel of sandstone, limestone, mudstone and coal	2			
WS-02	Firm sandy gravelly CLAY. Gravel of sandstone, limestone, mudstone and coal.	0.55	3.85	97.34	-
	Very clayey very sandy GRAVEL with medium cobble content. Gravel of sandstone, limestone and quartz-dolerite. Cobbles of quartz- dolerite and concrete.	3.5			
	Extremely weak MUDSTONE. Destructured	3.85			
WS-03	Firm sandy gravelly CLAY. Gravel of sandstone, limestone, mudstone, coal and quartz-dolerite. Plastic wrapper and pieces of plastic pipe	0.6	1.8	97.41	-
	Clayey very sandy GRAVEL. Gravel of quartz-dolerite	1.2			
	Clayey sandy GRAVEL. Gravel of quartz-dolerite and concrete.	1.8			
WS-04	Firm sandy gravelly CLAY. Gravel of sandstone, limestone, mudstone and coal.	0.6	3.85	97.12	-
	Very clayey GRAVEL with occasional organic matter. Gravel of quartz-dolerite.	1.4			
	Clayey SAND and GRAVEL with occasional clay pockets, medium cobble content and occasional organic matter. Gravel of sandstone, limestone, quartz-dolerite, mudstone and coal. Cobbles of quartz-dolerite and concrete.	2.5			
	Extremely weak SILTSTONE. Destructured.	3.85			
WS-05	Firm silty sandy slightly gravelly CLAY. Gravel of mudstone and sandstone.	0.5	2.1	97.11	-
	Clayey gravelly SAND. Gravel of sandstone, mudstone and coal.	1.6			
	Extremely weak MUDSTONE/ SILTSTONE. Destructured.	2.1			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum layer thickness (m)	Typical Description
Topsoil	0.2	94.34-95.13	0.2	Firm slightly gravelly sandy CLAY.
Made Ground (Observed in HP/17/01, WS01-WS-05)	2.5-3.5	93.91-94.61	0.55-3.5	Firm sandy gravelly CLAY. Gravel of sandstone, limestone, mudstone and coal. / Clayey sandy GRAVEL with medium cobble content. Gravel of sandstone, limestone, mudstone and coal and quartz-dolerite. Cobbles of quartz-dolerite and concrete.
Glacio-fluvial deposits (BH/17/10, WS-05)	1.2-1.6	93.3	1	Gravelly silty SAND. Gravel of sandstone and mudstone.
Glacial Till (BH/17/10)	0.5-5.2	89.34	0.5-4	Soft to stiff gravelly sandy CLAY Gravel of various lithologies.
Weathered bedrock (siltstone/mudstone)	3.85	92.64-93.56	0.35->1.35	Extremely weak. Destructured.
Bedrock	10	84.54	>4.5	Sandstone. Recovered as very sandy Gravel. Zone of minimal recovery. GRAVEL and COBBLES of sandstone, siltstone and limestone

Groundwater

Hole Reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded post GI monitoring (m bgl)
BH/17/10	4.2	-	-
WS-05	1.1	-	-

Summary of Concrete Classification Results and Other Test Results

Stratum	Made Ground		Glacio-fluvial deposits		Glacial Till (fine grained)		Sandstone (Tyne and Alston)		Siltstone (Tyne and Alston)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content %	10	6.4-25.7 (16.2)	1	21	5	11-23.2 (16.2)	-	-	-	-
Liquid Limit %	5	33-39 (33.2)	2	*30-40 (35)	91	*11-33 (17.7)	-	-	-	-
Plastic Limit %	6	19-23 (21.3)	3	*18-23 (21)	91	*21-66 (34.4)	-	-	-	-
Plasticity Index %	5	11-17 (13.4)	2	*8-17 (13)	91	*6-39 (16.7)	-	-	-	-
Cu (kN/m^2)	4	36-57 (44.8)	1	71	4	41-198 (119.2)	-	-	-	-
MCV	-	-	-	-	37	*3.9-15 (8.26)	-	-	-	-
Max Dry Density (mg/m^3)	-	-	5	*1.83-2.03 (1.935)	13	*1.81-2.14 (1.97)	-	-	-	-
Bulk Dry Density (mg/m^3)	-	-	8	*1.63-2.07 (1.9)	56	*1.59-2.28 (2.07)	-	-	-	-
Optimum Moisture Content %	-	-	5	*7.3-14 (11.7)	13	*6.3-17 (11.5)	-	-	-	-
Coefficient of consolidation mv (MN/m^2)	-	-	1	*0.0037-0.18 (0.11)	2	*0.0091-1.404 (0.397)	-	-	-	-
CBR %	2	*10-15 (12.5)	-	-	20	*0.1-35 (10.14)	-	-	-	-
Effective angle of friction (°)	1	30	5	*29-35.5 (33.2)	28	*20.4-51 (29.3)	-	27-34***	-	27-34***
Water Content for Rock %	-	-	-	-	-	-	14	*0.1-4.3 (1.3)	2	*2.3-2.8 (2.55)
Point Load MPa	-	-	-	-	-	-	14	*0.02-1.97 (0.75)	1	*0.75
UCS MPa	-	-	-	-	-	-	1	*28.8	-	5**

Stratum	Mudstone (Tyne and Alston)		Limestone (Tyne and Alston)	
	No. of tests	Results	No. of tests	Results
Effective angle of friction (°)	-	27-34**	-	27-34**
Water Content for Rock %	10	*2.9-6.5 (4.3)	8	*0.2-1.2 (0.5)
Point Load MPa	10	*0.02-0.88 (0.328)	8	*1.48-4.04 (3.055)
UCS MPa	-	5**	2	*55.8

***Based on Tomlinson 2001
** Based on Point Load Testing Is50 values
*Results taken from data outside of A2EE06

Summary of Geotechnical Risks

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Weak compressible soils	Potential for alluvium near Shipperton Burn
Hard Dig	Cobbles and boulders were encountered in the glacial till and are widespread throughout the glacio-fluvial deposits
Very deep bedrock	Intact bedrock was not encountered in BH/17/10, at depths of 10m bgl.
Flooding	In proximity to Shipperton Burn, an annual flood risk of 1 in 30 has been identified.

Earthwork Details:

A2EC01– CH.53680-53800		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	Slope Length (m)
General Details	Northbound	14_A1_42589 Cutting	53500	53800	-	-	-	-
	Southbound	14_A1_42586 Cutting	53500	53800	-	-	-	-
Earthwork Details	HAGDMS Defects	N/A						
	Preliminary Earthwork Proposals	*Cutting on both Eastern and West sides of the A1. Cutting to be no more than in 2.5 slope.*						

Published Geology

Superficial	Solid
Topsoil	Alston Formation – limestone, sandstone, siltstone and mudstone
Glacial Till (fine-grained and coarse grained)	

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• Due to close proximity to Denwick Burn, alluvium is likely to be present in the area, particularly on the eastern side of the A1 Highway. • Area may be impacted by flooding. The area has a 1 I 30 annual risk of being flooded. • A Northern Powergrid EHV cable runs on the eastern verge of the A1, parallel to the highway. • Two cables for Vodafone and National Grid run parallel to the western verge of the A1.

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
TPA9	Topsoil	0.3	2.6	70.01	-
	Firm to stiff CLAY with abundant gravel	1.5			
	Soft clayey SAND and GRAVEL with clay bands	1.7			
	Stiff clay	2.6			
BH6	Topsoil	0.2	5.36	67.00	-
	Sandy gravelly CLAY	3.1			
	Sandy silty CLAY	5.36			
TP/17/02	Brown slightly sandy slightly gravelly CLAY	0.1	2.2	67.4	-
	Firm slightly sandy slightly gravelly CLAY with medium cobble and low boulder content	1			
	Firm to stiff slightly sandy gravelly CLAY with medium cobble and low boulder content	2.2			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
TOPSOIL	0.3	66.8-69.7	0.3	Topsoil
Glacial Till (fine-grained)	1.5	68.5-67.4	1.2	Firm to stiff CLAY with abundant gravel between 0.3m and 1.5m
Glacial Till (coarse-grained) [Only BH6]	1.7	68.3	0.2	Soft clayey SAND and GRAVEL with clay bands
Glacial Till (fine-grained)	5.36	61.64	3.7	Sandy gravelly silty CLAY

Groundwater

Hole Reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded post GI monitoring (m bgl)
BH6	2.62	Rose To 2.1m	-
TP/17/02	1.4	-	-

Summary of Test Results

Stratum	Glacial Till (fine-grained		Glacial Till (coarse-grained)	
	No. of tests	Results	No. of tests	Results
Moisture Content %	2	18-39 (28.5)	19	*8.7-22.3 (15.7)
Liquid Limit %	2	41-44 (42.5)	-	-
Plastic Limit %	2	25	-	-
Plasticity Index %	2	16-19 (17.5)	-	-
Cu (kN/m^2)	58	*4-324 (126)	-	-
MCV	37	*3.9-15 (8.26)	-	-
Max Dry Density (mg/m^3)	13	*1.81-2.14 (1.97)	-	-
Bulk Dry Density (mg/m^3)	50	*1.59-2.28 (2.05)	2	*1.96-2.05 (2)
Optimum Moisture Content %	13	*6.3-17 (11.5)	-	-
Coefficient of compressibility mv (MN/m^2)	2	*0.0091-1.404 (0.397)	-	-
CBR %	20	*0.1-35 (10.14)	1	*8.8-11 (9.9)
Effective angle of friction (°)	28	*20.4-51 (29.3)	1	*34.5
*Results taken from data outside of A2EC01				

Summary of Geotechnical Hazards

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Hard Dig	Cobbles and boulders were encountered in the glacial till

Last Update: 7/05/2019
Design Revision: Rev 01

Earthwork Details:

A2E C02 – CH.55500-56700		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	Slope Length (m)
General Details	Northbound	14_A1_42593 At Grade	55300	55650	-	-		-
		14_A1_42592 Cutting	55650	56700	6.5m	2.5		~ ≤16.0
	Southbound	14_A1_42579 At Grade	55300	55900	-	-		-
		14_A1_42580 Cutting	55900	56400	-	2.5		~ ≥5.2
		14_A1_42581 At Grade	56400	56750	-	-		-
Earthwork Details	HAGDMS Defects	Earthwork Classification	Observation No.		Feature		Class	Location Index
		14_A1_42592_520269	520269		Combination of burrows and settlement		1D	C
	Preliminary Earthwork Proposals	*Cutting on both sides of the A1. Cutting gradient to be no steeper than 1 in 3. Occasional minor embankments on eastern side of the A1.*						

Published Geology

Superficial	Solid
Glacial Till	Scremerston Coal Member

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• No worked coal outcrops are known to be present across the site. However due to the presence of minor coal seams there is a possibility of unknown worked coal being encountered. • Soft ground including possible alluvium and laminated clay/silt deposits may be present, particularly in proximity to water courses. • Northern Powergrid EHV cable runs to the east of the A1, parallel to the highways along the verge and occasionally into the lay-by's • Two cables for Vodafone and National Grid, run parallel to the A1, predominantly in the verge and occasionally into the highway.

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
TPA21	Topsoil	0.2	3.2	100.96	-
	Firm CLAY	1.6			
	Firm CLAY with soft pockets of wet clayey sand and soft clay.	2.3			
	Stiff CLAY	3.1			
	Wet GRAVEL and SAND with fines	3.2			
TP/17/10	Topsoil	0.2	3.5	101.32	-
	Firm to stiff slightly gravelly sandy CLAY with low cobble content.	1.6			
	Stiff slightly sandy slightly gravelly CLAY with low cobble and boulder content.	2.8			
	Stiff slightly sandy gravelly silty CLAY.	3.2			
	Firm slightly sandy very gravelly CLAY.	3.5			
BH15	Topsoil	0.2	3.7	102.4	-
	Silty sandy CLAY with stones	0.8			
	Silty CLAY	2.4			

	Micaceous SHALE	3.7			
TPA22	Topsoil	0.2	3.6	104.51	-
	Firm to stiff CLAY	1.1			
	Soft wet to moist SAND with fines	1.5			
	Firm shaley CLAY with soft to firm pockets of clayey sand and shaley rubble.	2.5			
	Firm to stiff CLAY with numerous small boulders (upto 0.3m D)	3.4			
	Slightly weathered moderately weak interbedded shaley MUDSTONE and SANDSTONE.	3.6			
TPA22A	Topsoil	0.2	2.25	106.59	-
	Loose SAND with some fines and clay bands	0.6			
	Firm to stiff CLAY with occasional very soft pockets. Limestone boulder.	2.2			
	Very strong massive LIMESTONE	2.25			
BH16	Topsoil	0.18	3.8	106	
	Silty sandy CLAY with stones	2.9			
	Micaceous SHALE	3.8			
TP/17/11	Topsoil	0.2	2.6	106.27	-
	Firm slightly sandy slightly gravelly CLAY with low cobble content.	0.5			
	Firm slightly sandy gravelly CLAY with low cobble content.	1.6			
	Firm slightly sandy slightly gravelly CLAY with low cobble content. Frequent pockets of sand	2.1			
	Soft to firm sandy very gravelly CLAY with medium cobble content and rare boulders	2.6			
TPA23	Topsoil	0.2	2.9	108.01	-
	Soft CLAY	1.4			
	Soft damp to wet clayey sandy GRAVEL with occasional cobbles	2			
	Wet loose running SAND	2.4			
	Firm to stiff CLAY	2.7			
	Rubble of angular cobbles and boulders	2.9			
TPA23A	Topsoil	0.2	3.5	109.14	-
	Firm to stiff CLAY with sandstone cobbles and occasional boulders	1.4			
	Soft wet clayey silty SAND with soft clay bands	1.7			
	Firm to stiff CLAY	2.3			
	Slightly weathered very weak shaley fissile MUDSTONE	2.7			
	Very weak COAL	2.8			
	Slightly weathered weak clayey SHALE varying to shaley mudstone	3.5			
BHA23A	Dark brown CLAY	1.6	12	109.36	-
	CLAY	3.4			
	Weathered MUDSTONE	3.7			

	Soft weathered MUDSTONE	5.0			
	Slightly weathered moderately weak silty MUDSTONE. Horizontally and vertically fractured.	7.7			
	Slightly weathered laminated MUDSTONE	7.9			
	Slightly weathered medium bedded moderately strong SILTSTONE with horizontal fractures.	9			
	Faintly weathered medium bedded moderately strong to strong SILTSTONE with horizontal fractures.	12			
TPA24	Topsoil	0.15	3.7	110.32	-
	Firm to stiff CLAY	1.5			
	Stiff CLAY	2.2			
	Firm to soft CLAY with wet pockets of sandy clay	3.1			
	Stiff CLAY. Limestone boulder	3.5			
	Weathered very weak shaley CLAY interbedded with firm to stiff clay	3.7			
BH17	Topsoil	0.2	3.8	110.6	-
	Sandy silty CLAY	2.9			
	MUDSTONE	3.8			
TPA24A	Topsoil	0.2	3.1	110.32	-
	Soft sandy CLAY with sandstone boulders	0.9			
	Soft CLAY	2.0			
	Moderately Weathered SANDSTONE	3.1			
BH18	Topsoil	0.03	9.1	110.5	-
	Brown sandy silty CLAY – Glacial Till	2.4			
	Grey Weathered SHALE	3			
	Grey silty slightly micaceous MUDSTONE	6.8			
	Grey shale	7.2			
	Medium strong grey shaley SANDSTONE	9.1			
BHA24A	CLAY	1.9	11	109.38	-
	SILTSTONE	2			
	Moderately to slightly weathered laminated, moderately weak SILTSTONE	11			
TPA25	Topsoil	0.2	3.6	111.61	-
	Firm fissured sandy CLAY with occasional cobbles	1.5			
	Stiff CLAY	3.55			
	Slightly weathered moderately strong, highly fractured SANDSTONE	3.6			
TPA25A	Topsoil	0.2	3.4	110.27	-
	Firm to stiff fissured CLAY	1.4			
	Soft clayey SAND, some gravel, occasional boulders	2.3			

	Firm to stiff CLAY	2.9			
	Moderately weathered weak MUDSTONE	3.4			
BH19	Topsoil	0.27	6.1	110.2	-
	Sandy CLAY, silty in places with some stones	3.44			
	SHALE	4.1			
	Shaley slightly micaceous MUDSTONE	6			
	SHALE	6.1			
BHA25A	CLAY	2.8	12	108.5	-
	Weathered to moderately weathered MUDSTONE	6			
	Slightly weathered thinly bedded strong LIMESTONE	6.4			
	Slightly weathered thinly bedded MUDSTONE	11.6			
	Black friable COAL	11.7			
	Slightly to faintly weathered moderately weak MUDSTONE	12			
BHA26	Yellow to grey CLAY	1.9	13.5	111.65	-
	Moderate to slightly weathered laminated, moderately weak to weak SILTSTONE	6.2			
	Slightly weathered medium bedded strong LIMESTONE	9.3			
	Black friable COAL	9.4			
	Slightly weathered laminated weak silty MUDSTONE	11.8			
	Black Friable COAL	11.9			
	Slightly to faintly weathered laminated, moderately weak silty MUDSTONE	13.1			
	Slightly to faintly weathered laminated moderately weak SILTSTONE	13.5			
BH/17/03	Firm slightly sandy gravelly CLAY-Topsoil	0.35	10	107.91	0-1 Plain 1-5 Slotted
	Firm slightly gravelly sandy CLAY with low cobble content	2.2			

	Soft sandy gravelly CLAY with low cobble content	3.7			
	SANDSTONE. Recovered as gravel	4.1			
	Stiff to very stiff CLAY with abundant mudstone lithorelicts- W.MUDSTONE	4.35			
	Extremely weak thinly to thickly laminated carbonaceous MUDSTONE	5.74			
	Strong thinly bedded LIMESTONE	6.15			
	Soft slightly gravelly CLAY- W. Mudstone	6.34			
	Strong thinly bedded LIMESTONE	7.4			
	Ex. Weak thinly laminated MUDSTONE	7.59			
	Medium Strong to strong thinly bedded LIMESTONE	7.85			
	Ex. Weak to very weak thinly laminated SILTSTONE	8.06			
	Ex. Weak to very weak thinly laminated MUDSTONE	9.41			
	Very Weak thinly to thickly laminated SILTSTONE	10			
TPA26	Topsoil	0.2	2.4	106.5	-
	Firm to stiff fissured CLAY	0.45			
	Stiff CLAY with some fissuring and silt infill	1.4			
	Moderately compact moist SAND with fines and gravel	1.6			
	Stiff CLAY	1.9			
	Slightly weathered moderately weak flaggy SANDSTONE. Poorly cemented pronounced vertical joint.	2.4			
TP/17/12	Topsoil	0.3	3.3	103.01	-
	Slightly sandy slightly gravelly CLAY with low to medium cobble and boulder content. Frequent lenses of sand	2.3			
	Firm to stiff slightly sandy gravelly CLAY with low cobble content.	3.0			
	SANDSTONE. Recovered as cobble and gravel in a clay matrix	3.3			
BH20	Topsoil	0.27	5.4	99	-

	Silty slightly sandy CLAY	4.1			
	Shaley micaceous SILTSTONE	4.6			
	Silty weathered SHALE	5.4			
TPA27	Topsoil	0.1	3.4	98.69	-
	Firm sandy CLAY	0.6			
	Firm CLAY	2			
	Stiff CLAY	3.4			
BH/17/04	Topsoil – firm slightly sandy gravelly CLAY	0.37	9.9	96.56	0-1 Plain 1-5 Slotted
	Firm slightly sandy gravelly CLAY	4.2			
	Extremely weak to weak thinly laminated to medium bedded SANDSTONE	6.58			
	Extremely weak to medium strong thinly laminated SILTSTONE	7.04			
	Very weak to weak thinly to thickly laminated SANDSTONE	9.9			
TPA28	Topsoil	0.1	3.3	95.37	-
	Firm sandy CLAY	0.6			
	Firm fissured CLAY	1.8			
	Firm to stiff CLAY with pockets of soft clay between 3.0-3.2m	3.3			
TPA29	Topsoil	0.1	3.5	91.95	-
	Firm sandy CLAY. Fissured with silty infill	0.65			
	Firm to stiff CLAY	1.5			
	Firm CLAY with soft pockets and layers	1.9			
	Soft CLAY	2.1			
	Firm CLAY with fragments to boulders of shaley sandstone	2.7			
	Moderately compact GRAVEL of sandstone and shaley sandstone with matrix of clayey sand	3.5			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2	1091.7-111.4	0.2	Topsoil
Glacial Till	1.1-4.2	89.35-109.75	0.4-3.83	Sandy silty CLAY/ SAND and GRAVEL
Scremerston Coal Member-Siltstone/Sandstone/Mudstone	>13.5	<86.66	>9	Moderately to slightly weathered laminated to thinly bedded SILTSTONE Moderately weathered very weak fissile boulders of SANDSTONE. To Moderately to slightly weathered, medium strong, medium bedded shaley SANDSTONE Weathered SHALE

Stratum	Glacial Till (fine grained)		Glacial Till (coarse grained)	
	No. of tests	Results	No. of tests	Results
Moisture Content %	25	6-26 (16.6)	20	*8.7-22.3 (15.8)
Liquid Limit %	18	26-53 (34)	-	-
Plastic Limit %	18	12-20 (15.6)	-	-
Plasticity Index %	18	13-35 (19.7)	-	-
Cu (kN/m^2)	8	39-285 (172.3)	-	-
MCV	12	*4.7-11.6 (817)	-	-
Max Dry Density (mg/m^3)	13	*1.81-2.14 (1.97)	-	-
Bulk Dry Density (mg/m^3)	7	2.03-2.19 (2.11)	2	*1.96-2.05 (2)
Optimum Moisture Content %	13	*6.3-17 (11.5)	-	-
Coefficient of compressibility mv (MN/m^2)	2	*0.0091-1.404 (0.397)	-	-
CBR %	3	0.71-8.2 (4.0)	6	*0.5-11 (3.6)
Effective angle of friction (°)	6	20.4-35.6 (26.8)	1	*34.5

Stratum	Mudstone (Scremerston Coal)		Siltstone (Scremerston Coal)		Sandstone (Scremerston Coal)		Limestone (Scremerston Coal)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Effective angle of friction (°)	-	27-34***	-	27-34***	-	27-34***	-	27-34***
Water Content for Rock %	7	4.6-7.9 (6)	5	0.4-2.9 (1)	9	0.9-6.8 (4.9)	8	*0.2-1.2 (0.475)
Point Load MPa	7	0.02-0.06 (0.03)	5	0.62-4.25 (2.8)	11	0.02-1 (0.26)	8	*1.48-4.04 (3.1)

UCS MPa	-	5**	1	27.6	1	28.8	-	*55.8-90.3 (73.05)
*Results taken from outside of A2EE03 **Based on Point Load Test values ***Tomlinson 2001								

Groundwater

Hole reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded Post GI monitoring (m bgl)
BH/17/04	4.2	-	2.63-3.6
BH15	2.62	Rose to 0.91m	-
BH16	2.7	Rose to 1.6m	-
BHA26	2.8	-	-
BH19	2.4	Rose to 0.95m	-
BH20	3.3	Rose to 1.3m	-
BHA23A	1.8 5.0	Fast inflow	-
BHA25A	9.6	Slight seepage	-
BHA26	2.8	Standing at 1.4m	-
TP/17/10	3.2	No rise in level	-
TP/17/11	2.1		-
TP/17/12	2.8 3.3	Damp	-
BH18	0.88	-	-
BHA24A	2.8	Slight seepage at 1.8m	-
TPA24A	1.5 2.0	Moderate strike. Slight strike at 0.8m Strong strike. Standing at 2.8m	-
TPA25	3.4	Rose to 3.2m in 10 mins	-
TPA21	3.1	Very strong strike. Rose to 2.1m in 30 mins	-
TPA22A	1.5	Slight strike	-
TPA23	2	Very strong inflow, particularly from sand	-
TPA23A	2.7	Moderate strike	-
TPA27	1.4	Slight seepage	-
TPA28	1.4	Slight seepage	-
TPA29	1.9 2.2 2.4	Slight strike Moderate strike Strong strike	-
BH/17/03	-	-	2.24-3.14

Summary of Geotechnical Hazards

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Hard Dig	Cobbles and boulders were encountered in the glacial till

Last Update: 07/05/2019
Design Revision: Rev 01

Earthwork Details:

A2E C03 – CH.57750-58200		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	Slope Length (m)
General Details	Northbound	14_A1_42572 At Grade	57700	57850	-	-		-
		14_A1_42637 Cutting	57850	58240	2.5	1.7		~ ≤6.7
	Southbound	14_A1_42631 At Grade	57750	57850	-	-		-
		14_A1_42633 At Grade	57850	58240	1.9	1.9		≤5.3
Earthwork Details	HAGDMS Defects	Earthwork Classification	Observation No.		Feature		Class	Location Index
		None						
	Preliminary Earthwork Proposals	*Regrade on western side of the A1. To the east a 2.9m cutting is proposed*						

Published Geology

Superficial	Solid
Glacial Till	Scremerston Coal Member
	Tyne Limestone and Alston Formation (CH57750-57980)

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• Soft sandy deposits are located within the Glacial Till, in the vicinity of TP/17/21 at ~ CH58100, between 0.45m-3.5m • Glaciolacustrine deposits of soft laminated clay and silty sand were observed in TPA36. Possibility of soft deposits being encountered elsewhere across the site too. • Northern Powergrid EHV Cable Crosses the highway from east to west verge • Two cables for Vodafone and National Grid runs along the eastern verge of the A1, parallel to the highway. • No worked coal outcrops are known to be present across the site. However due to the presence of minor coal seams there is a possibility of unknown worked coal being encountered.

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
TPA36A	TOPSOIL	0.2	3.4	92.54	-
	Firm CLAY	1.8			
	Soft to firm clayey SAND and GRAVEL	2.1			
	Firm to stuff CLAY with soft pockets	3.4			
BH28	TOPSOIL	0.1	4	92.6	-
	Sandy CLAY	3.63			
	SANDSTONE	4			
TP/17/21	Soft slightly sandy CLAY- TOPSOIL	0.45	3.5	92.15	-
	Firm slightly sandy gravelly CLAY with low cobble content	2.8			
	Soft very sandy CLAY. Rare pockets of gravel of sandstone and coal	3.5			
TPA36	Topsoil	0.2	4	92.87	-
	Firm to stiff sandy CLAY (sandy clay between 0.2 and 0.5m)	2.5			
	Soft laminated silty CLAY interbedded with running silty sand	3.2			
	Firm to stiff CLAY	3.6			
BH27	TOPSOIL	0.27	6.1	90.8	-
	Silty slightly sandy CLAY	1.09			
	Silty sandy CLAY	1.9			
	Silty sandy laminated CLAY	3.3			
	Sandy silty CLAY	4.0			
	SHALE. Sandy in parts	6.1			

BH29	TOPSOIL	0.15	4.27	90.4	-
	Sandy silty CLAY with fragments	2.3			
	Sandy silty CLAY	2.62			
	Micaceous thinly bedded SANDSTONE fragments with subordinate sandy clay	3.66			
	SANDSTONE and SILTSTONE	4.27			
TP/17/20	Soft slightly sandy CLAY with rootlets – TOPSOIL	0.5	3.5	90.87	-
	Firm slightly sandy gravelly CLAY	1.4			
	SAND	1.8			
	Firm to stiff sandy gravelly CLAY with low cobble content.	3.5			
TPA35	TOPSOIL	0.2	3.3	89.91	-
	Firm sandy CLAY	0.5			
	Firm CLAY	1.4			
	Firm to stiff CLAY	1.9			
	Moderately compact CLAY	2.5			
	Very soft laminated CLAY with clayey silt	3.3			
TPA37	TOPSOIL	0.25	2.7	92.11	-
	Firm sandy CLAY	0.7			
	Soft CLAY	1.3			
	Soft to firm becoming very soft silty CLAY	1.7			
	Very soft clayey SILT	2.7			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3	92.5	0.3	Soft slightly sandy CLAY
Glacial Till (fine-grained)	3.6	89	3.3	Firm brown silty CLAY
Glacial Till (coarse-grained) **[encountered in TPA36A and TP/17/20]**	1.4-4	87.07-91.24	0.9-3.73	Clayey SAND and GRAVEL with occasional boulders.
Glaciolacustrine deposits **[encountered in TPA35, BH27, TPA36]**	3.2	89.7-86.6	0.7-1.4	Soft laminated silty CLAY [Interbedded with running silty sand in TPA36]
Scremerston Coal Member	>6.1	<84.7	>2.1	SANDSTONE/ SILTSTONE/ SHALE sandy in parts

Stratum	Glacial Till (fine grained)		Glacial Till (coarse grained)		Glaciolacustrine Deposits	
	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content %	4	14-28 (21.3)	1	13	10	*23-32 (28)
Liquid Limit %	3	34-39 (36)	-	-	4	*32-44 (36.8)
Plastic Limit %	3	15-19 (17)	-	-	4	*20-22 (20.5)
Plasticity Index %	3	1720 (19)	-	-	4	*12-22 (16.3)
Cu (kN/m^2)	2	29-145 (87)	-	-	12	*17-105.6 (66.3)
MCV	12	*4.7-11.6 (817)	-	-	-	-
Max Dry Density (mg/m^3)	2	1.69-1.85 (1.78)	-	-	-	-

Bulk Dry Density (mg/m^3)	1	2.04	2	*1.96-2.05 (2)	2	*1.94
Optimum Moisture Content %	2	16-17 (16.5)	-	-		
Coefficient of compressibility mv (MN/m^2)	2	*0.0091-1.404 (0.397)	-	-	-	-
CBR %	1	1.8-4.6 (3.2)	6	*0.5-11 (3.6)	-	-
Effective angle of friction (°)	28	*20.4-51 (29.3)	1	*34.5	-	-

Stratum	Mudstone (Tyne and Alston formation)		Siltstone (Scremerston Coal)		Sandstone (Scremerston Coal)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results
Effective angle of friction (°)	-	27-34***	-	27-34***	-	27-34***
Water Content for Rock %	10	*2.9-6.5 (4.3)	4	*0.4-0.7 (0.5)	15	*0.9-6.8 (4)
Point Load MPa	10	*0.02-0.88 (0.33)	6	*0.62-4.25 (2.6)	14	*0.02-2.36 (0.69)
UCS MPa	-	5**	2	*27.6-153 (90)	3	*28.8-55.6 (40)
*Results taken from outside of A2EE03 **Based on Point Load Test values ***Tomlinson 2001						

Groundwater

Hole reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded Post GI monitoring (m bgl)
TP/17/21	3.2	Rose to 3.1m after 20mins	-
BH28	3.2	-	-
TPA36	2.5	Moderate strike	-
TPA36A	2.3	General seepage	-
BH27	2.74	-	-
BH29	2.4	-	-
TPA35	1.9	Strong strike	-
TPA37	1.8	Strong strike	-

Summary of Geotechnical Risks

Hazard	Process / Activity
Hard Dig	Across the global site, cobbles and boulders were encountered within the glacial till. Therefore, hard dig should be anticipated.
High/Perched Groundwater	Due to the fine-grained nature of the Glacial Till and variable groundwater depths observed during, the potential for perched groundwater should be anticipated.

Last Update: 07/05/2019
Design Revision: Rev 01

Earthwork Details:

A2E C04 – CH.60400-61100		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	Slope Length (m)
General Details	Northbound	14_A1_42623	60400	>61100	-	-		-
	Southbound	14_A1_42570	60150	>61100	~1.3	1.3		5.4
Earthwork Details	HAGDMS Defects	Earthwork Classification	Observation No.		Feature		Class	Location Index
		None						
	Preliminary Earthwork Proposals	*Minor cutting on the western side of the A1*						

Published Geology

Superficial	Solid
Glacio-fluvial deposits	Tyne Limestone Formation and Alston Formation (undifferentiated)

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• Shallow bedrock was observed in BH/17/11 at 0.7m bgl. • 1 in 30 annual risk of flooding in locations in proximity to watercourses • Cables and pipes lie to the east and west of the A1 and occasionally under the alignment. • A Northumbrian Water pipe and BT cable follows the footprint of the old A1, between Ch60150 and Ch60450. At approx. CH61100 the water pipe crosses the A1 alignment to the west. The BT cable cuts the A1 at approx. chainage 60700 to the west of the A1. • The Northern Powerhouse EHV cable runs in the alignment of the A1 highway until CH60500, where its cuts to the west towards the windfarm at Northern Charlton.

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
TP/17/39	Slightly sandy slightly gravelly SILT-TOPSOIL	0.5	3	99.29	-
	Slightly gravelly silty SAND	3			
BH/17/11	Firm slightly sandy gravelly CLAY-TOPSOIL	0.7	10	98.87	0-1 (plain) 1-10 (slotted)
	SANDSTONE recovered as very gravelly sand	1.3			
	Strong LIMESTONE	8.5			
	Weak MUDSTONE	10			
TP/17/38	Slightly gravelly sandy CLAY - TOPSOIL	0.4	2	97.81	-
	Very sandy very silty GRAVEL of sandstone, with medium cobble content of sandstone.	1.6			
	Very sandy clayey GRAVEL of sandstone, quartzite and mudstone, with medium cobble content. Cobbles of sandstone.	2			
BH/17/12	Slightly gravelly clayey SAND – TOPSOIL	0.6	13	100.54	-
	Medium dense slightly clayey SAND	3.6			
	Firm to stiff slightly gravelly very sandy CLAY. Firm slightly sandy slightly gravelly CLAY	7.2			
	SANDSTONE	8			
	Strong SANDSTONE	11.5			
	SAND	11.81			
	Medium strong to strong SANDSTONE	13			
BH-01	MADE GROUND	2.5	4.82	97.9	Standpipe installed at 3.5m
	Firm silty sandy CLAY /SILT	2.8			
	Very clayey gravelly SAND	3.5			

	Very high strength to extremely weak MUDSTONE (destructured)	4.82			
BH-02	MADE GROUND	0.45	25	96.39	-
	Firm sandy slightly gravelly CLAY	1.7			
	Clayey sandy GRAVEL with high cobble content.	2.5			
BH-03	MADE GROUND	0.6	4.1	96.25	-
	Firm and stiff sandy slightly gravelly CLAY	1.95			
	Very high strength to extremely weak MUDSTONE destructured	4			
	Extremely weak to very weak SANDSTONE destructured	4.1			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.4-0.7	99.94-97.41	0.4-0.7	Firm slightly sandy gravelly CLAY.
Made Ground **[encountered in BH-01, BH-02 and BH-03]**	0.45-2.5	95.5	0.45-2.5	Firm to stiff slightly gravelly CLAY. Gravel of mudstone, coal, flint, sandstone and limestone
Glacial Till **[encountered in BH/17/12, BH-01, BH-02 and BH-03]**	1.95-7.2	93.34-94.3	1.0-3.6	Firm to stiff sandy gravelly CLAY / clayey SAND and GRAVEL
Glaciofluvial deposits	2-3.6	95.81-96.94	1.4-3.1	Slightly gravelly silty SAND/ Very sandy clayey GRAVEL
Tyne Limestone Formation and Alston Formation (undifferentiated) [Bedrock encountered at very shallow depths of 0.7m bgl in BH/17/11]	>13	<87.5	>9.3	SANDSTONE, recovered as very gravelly sand / Strong LIMESTONE / Weak fissile MUDSTONE

Groundwater

Hole reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded Post GI monitoring (m bgl)
BH/17/11	-		5.5-5.53
BH-01	3.5	Rose to 3.02m (20mins)	
BH-02	1.2	Rose to 1.5m (15mins)	

Summary of Concrete Classification Results and Other Test Results

Stratum	Made Ground		Glacial Till (fine grained)		Glacial Till (coarse grained)		Glaciofluvial deposits	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content %	3	14.1-20 (17.5)	8	8.6-35.6 (18.6)	2	20.9-22.3 (21.6)	12	6.5-30 (14.7)
Liquid Limit %	2	26-35 (30.5)	4	21-66 (39)	-	-	1	*30
Plastic Limit %	2	14-19 (16.5)	4	15-33 (21.25)	-	-	1	*22
Plasticity Index %	2	12-16 (14)	4	6-33 (17.8)	-	-	1	*8
Cu (kN/m^2)	3	67-189 (121)	5	39-300 (137.2)	-	-	1	180
MCV	-	-	12	*4.7-11.6 (817)	-	-	-	-
Max Dry Density (mg/m^3)	-	-	38	1.69-2.13 (1.87)	-	-	4	1.83-2.03 (1.93)

Bulk Dry Density (mg/m^3)	1	1.6	4	1.5-2.15 (1.8)	2	*1.96-2.05 (2)	6	1.63-2.06 (1.9)
Optimum Moisture Content %	-	-	13	6.3-17 (12.3)	-	-	4	12-14 (12.8)
Coefficient of compressibility mv (MN/m^2)	1	0.37-1.4 (0.69)	2	*0.0091-1.404 (0.397)	-	-	1	0.0037-0.18 (0.109)
CBR %	-	-	20	0.1-36 (9.8)	6	*0.5-11 (3.6)	1	2.4-2.6 (2.5)
Effective angle of friction (°)	1	30	2	25.5-40 (32.8)	1	*34.5	1	33.5

Stratum	Mudstone (Tyne and Alston formation)		Sandstone (Tyne and Alston formation)		Siltstone (Tyne and Alston formation)		Limestone (Tyne and Alston formation)	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Effective angle of friction (°)	-	27-34***	-	27-34***	-	27-34***	-	27-34***
Water Content for Rock %	3	5.5-6.5 (5.9)	14	*0.1-4.3 (1.3)	4	*0.4-2.8 (1.68)	6	0.2-0.7 (0.37)
Point Load MPa	3	0.02-0.03 (0.02)	14	*0.01-2.04 (0.75)	4	*0.36-3.53 (1.7)	6	3.13
UCS MPa	-	5**	1	*28.8	-	-	1	90.3
*Results taken from outside of A2EE04 **Based on Point Load Test values ***Tomlinson 2001								

Summary of Geotechnical Risks

Hazard	Process / Activity
Hard Dig	Across the global site, cobbles and boulders were encountered within the glacial till. The glacio-fluvial deposits comprise gravel cobbles and occasional boulders.
High/Perched Groundwater	Due to the fine-grained nature of the Glacial Till and variable groundwater depths observed during, the potential for perched groundwater should be anticipated.
Shallow bedrock	Shallow bedrock encountered at BH//17/11 at depths of 0.7m bgl.

Heckley Fence Bridge

Last Update: 08/10/2018
Design Revision: 001

General Details	Type	Chainage	Approximate Grid Reference	Total Length (m)	Overall Width (m)		
	Overbridge	55300	418949 617300	325.00	58.00		

Earthwork Details Online (existing earthwork)		HAGDMS Reference	Verge Width (m)	Slope Angle (°)	Slope Height (m)	Slope Length (m)
	Northbound	At Grade 14_A1_42593/4	-	-	-	-
	Southbound	At Grade 14_A1_42578/9	-	-	-	-

		Earthwork	Observation No.	Feature	Class	Location Index
Earthwork Details Online (existing earthwork)	HAGDMS Defects	14_A1_42578	519997	Slip, Animal burrowing	1D	C
		14_A1_42594	520278	Animal burrowing		
			520277	Slip, Animal burrowing	1D	C

Preliminary Earthwork Proposals	Embankments to the north and south of the overbridge with gradient of 1(v) in 3(h).

Published Geology

Superficial	Solid
Glacial Till	Tyne Limestone and Alston Formation (undifferentiated)

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• EHV cable located in the agricultural field to the east of the A1. • Virgin and Vodafone cables located in the western verge of the A1. • The site elevation is approximately 95m OD • Historical maps indicate that up until the construction of the existing road the site was occupied by fields. • Potentially contaminative uses: none • Immediately outside the highways boundary is agricultural land, vegetated by grass. Trees and shrubs are located at the verge and highway boundary. • The bedrock is a secondary A aquifer of permeable strata.

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
BH13	Topsoil	0.3	3.6	94.4	N/A
	Sandy silty gravelly CLAY with organic traces and gravel - Alluvium	2.3			
	Sandy silty gravelly CLAY – Glacial Till	>3.6			
TPA20	Topsoil	0.2	3.2	95.93	N/A
	Firm sandy CLAY with pockets of sand, varying to silty SAND	>3.2			
BH/17/13	Firm sandy gravelly CLAY with some cobbles - Topsoil	0.4	15		0 – 1.0 Plain 1.0-10.0 Slotted 10.0 – 15.0 Sealed
	Soft TO firm slightly sandy slightly gravelly CLAY. Gravel of sandstone. Frequent pockets of sand. Frequent intact plant remains - Alluvium	1.2			
	Soft to firm sandy gravelly CLAY. Gravel of sandstone – Glacial Till	5.6			
	Weak to strong MUDSTONE and SANDSTONE– Tyne and Alston Formation (undifferentiated)	12.27			
	Weak black COAL -Tyne and Alston Formation (undifferentiated)	12.42			
	Weak to strong SANDSTONE, SILTSTONE and MUDSTONE - Tyne and Alston Formation (undifferentiated)	>15			

BH/17/14	Gravelly sandy clay. Gravel and cobbles are of sandstone. Occasional clay pipe - MADE GROUND	0.7	15		0 -1.0 Plain 1.0 - 4.0 Slotted 4.0 – 15.0 Sealed
	Firm sandy gravelly CLAY, gravel of sandstone and mudstone – Glacial Till	4.5			
	Extremely weak to strong MUDSTONE and SANDSTONE - Tyne and Alston Formation (undifferentiated)	>15.0			
TP/17/47	Firm sandy gravelly clay - MADE GROUND	0.3	3.0		N/A
	Firm sandy gravelly CLAY with cobbles. Gravel and cobbles of sandstone, mudstone and limestone – Glacial Till	3.0			
TP/17/48	Sandy gravel of brick – MADE GROUND	0.5	3.6		N/A
	Firm to stiff sandy gravelly silty CLAY with low cobble and boulder content – Glacial Till	3.6			

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3		0.3	Firm gravelly sandy CLAY. Gravel of sandstone and limestone
Made Ground	0.5		0.5	Sandy gravelly CLAY with occasional gravel of brick and fragments of clay pipe.
Glacial Till	5		4.5	Firm gravelly, sandy and silty CLAY with low to medium cobble content. Gravel and cobbles of limestone, sandstone and mudstone
Tyne and Alston Formation (undifferentiated)- Sandstone/ Siltstone / Mudstone	>15		>11.0	Extremely weak to strong LIMESTONE, SANDSTONE, SILTSTONE and MUDSTONE
Tyne and Alston Formation (undifferentiated)- Coal	12.42		0.15	Weak black COAL

Groundwater

Hole reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded Post GI monitoring (m bgl)
BH/17/13	3.2	Rose to 2.95 after 20 mins	
BH/17/14	3.2	No groundwater encountered	
BH13	2.44	Water strike, rose to 0.58m	
TPA20	1.8	Strong strike	

Summary of Laboratory and In-situ Geotechnical Test Results

Stratum	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	SPT 'N' Value	cu (kN/m2)	mv (m2/MN)	P/L IS_{50} (MN/m2)	UCS (MPa)
Made Ground	-	-	-	-	-	-	-	-	-
Glacial Till	5.9 - 21	28 - 37	11 - 18	11 - 19	4 - 50	9 - 283	-	-	-
Alston Formation	-	-	-	-	-	-	-	0.02 - 6.84	28.8 - 55.8

Summary of Concrete Classification Results and Other Test Results

Stratum	pH	Soluble Sulphate (mg/l)	Total sulphur solid %	Total sulphur as SO4 water mg/l
Glacial Till	8.2 - 8.3	52 - 959	0.02 - 0.1	-
Groundwater	7.7 - 7.9		-	60 - 494

Summary of Geotechnical Risks

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Shallow mine workings	The potential for voids at the site related with historic mining has been identified at the site. See Coal Mining Risk Assessment for further details.

South Charlton Overbridge

Last Update: 07/05/2018
Design Revision: 001

General Details	Type	Chainage	Approximate Grid Reference	Total Length (m)	Overall Width (m)		
	Overbridge	58942	417715 620726	244	63.0		

Earthwork Details Online (existing earthwork)		HAGDMS Reference	Verge Width (m)	Slope Angle (°)	Slope Height (m)	Slope Length (m)
	Northbound	At Grade 14_A1_42627/8	-	-	-	-
	Southbound	At Grade 14_A1_42614 14_A1_42571	-	-	-	-
Preliminary Earthwork Proposals		Embankments to the north and south of the overbridge with gradient of 1(v) in 3(h).				

Published Geology

Superficial	Solid
Glaciofluvial deposits	Alston Formation – Limestone, Sandstone, Siltstone and Mudstone
Glaciolacustrine	
Glacial Till	

Other relevant information - Walkover information - Historical information - Mining & Quarrying - Geo-Environmental Issues - Utilities	• A water pipe is located to the east of the A1, within the field boundary. • Virgin, Vodafone and EHV cables run within the western verge of the highway and in the carriageway. • A gas pipe is located within the western verge or within the field boundary off the A1. • The site elevation is approximately 87.0m OD • Historical maps indicate that the same road and junction layout at Charlton Mires, has existed since before 1926. • Approximately 75m east of the current junction at Charlton Mires, the land has been classified as having a 1 in 30 risk of flooding from surface water. • Soft laminated glacio-lacustrine deposits of clay and silt underlie the site of the proposed overbridge. • Potentially contaminative uses: Chemicals Used in the farm yard / agricultural use. • Immediately outside the highways boundary is agricultural land of pasture, farm yard and outbuilding. Trees and shrubs are located at the verge and highway boundary. • The bedrock and glaciofluvial deposits is a secondary A aquifer of permeable strata.

Summary of Relevant Exploratory Holes

Hole reference	Summary of Log	Stratum	Depth to base (m bgl)	Final Depth (m)	Ground Level (mOD)	Installation details [Response Zone] (m bgl)
BH/17/06	Gravelly silty SAND, gravel of sandstone	Topsoil	0.3	20.3	87.3	0 – 5.7 Plain 5.7 – 9.4 Slotted 9.4 – 15.0 Sealed
	Dense gravelly clayey SAND. Gravel of sandstone	Coarse Glacial Till	2.4			
	Soft interlaminated CLAY/SILT	Glaciolacustrine	5.7			
	Very dense gravelly, clayey SAND	Coarse Glacial Till	9.4			
	Very stiff lightly gravelly sandy silty CLAY	Fine Glacial Till	10.3			
	Very sandy silty ang to subang GRAVEL of siltstone and sandstone	Coarse Glacial Till	13.3			
	Very stiff slightly sandy gravelly CLAY	Fine Glacial Till	13.6			
	Very sandy silty GRAVEL of siltstone and sandstone	Coarse Glacial Till	13.7			
	Very stiff slightly sandy very gravelly CLAY	Fine Glacial Till	19.52			
	Medium strong LIMESTONE	Alston Fm	>20.3			
BH/17/07	Gravelly silty SAND, gravel of sandstone	Topsoil	0.2	13.1	87.87	N/A
	Soft gravelly very sandy CLAY	Fine Glacial Till	3.5			

	Thinly laminated CLAY / SILT	Glaciolacustrrine	4.2			
	Firm gravelly very sandy CLAY. Occasional cobbles of sandstone	Fine Glacial Till	8.4			
	Very stiff to stiff slightly sandy gravelly CLAY	Fine Glacial Till	13.1			
TP/17/29	Gravelly Silty SAND with few cobbles. Cobbles and gravel of sandstone	Topsoil	0.2	4.0		N/A
	Firm gravelly sandy CLAY with low cobble content. Gravel of sandstone and mudstone and cobbles of sandstone	Fine Glacial Till	1.5			
	Firm thinly interlaminated CLAY/SILT	Glaciolacustrrine	4.0			
TP/17/30	Sandy gravelly CLAY/SILT. Gravel of sandstone	Topsoil	0.3	1.7		N/A
	Gravelly very silty SAND. Gravel of sandstone	Glacio-fluvial	1.7			

Summary of Ground Conditions (West abutment)

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2	87.1	0.2	Gravelly silty SAND gravel of sandstone. Sandy gravelly CLAY / SILTY. Gravel of sandstone
Upper Glacial Till	2.0	85.3	1.8	Dense gravelly clayey SAND. Gravel of sandstone Firm gravelly sandy CLAY with low cobble content. Gravel of sandstone and mudstone and cobbles of sandstone
Glacio-fluvial deposits (only TP/17/30)	1.7	86.17	1.4	Gravelly very silty SAND. Gravel of sandstone
Glaciolacustrine deposits	5.7	81.6	3.7	Soft to firm gravelly sandy CLAY with occasional interlaminated CLAY/SILT Interlaminated layer found between 4.0 and 5.7m bgl. Dense to very dense gravelly, clayey SAND
Lower Glacial Till	19.5	67.8	13.8	Very stiff gravelly very sandy CLAY. Occasional cobbles of sandstone. Very dense gravelly, clayey SAND. Very sandy silty ang to subang GRAVEL of siltstone and sandstone
Alston Formation	20.3	67	>1.0	Medium strong LIMESTONE

Summary of Ground Conditions (East abutment)

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2	87.67	0.2	Gravelly silty SAND with occasional cobbles. Cobbles and gravel of sandstone and mudstone. Sandy gravelly CLAY/SILT. Gravel of sandstone
Upper Glacial Till	3.5	84.37	3.3	Gravelly silty SAND. Gravel of sandstone Soft gravelly very sandy CLAY
Glaciolacustrine deposits	4.2	83.67	0.7	Thinly laminated CLAY / SILT
Lower Glacial Till	>13.1	74.77	8.9	Firm gravelly very sandy CLAY. Occasional cobbles of sandstone. Very stiff to stiff slightly sandy gravelly CLAY

Groundwater

Hole reference	Depth Recorded in GI (m bgl)	Description	Depth Recorded Post GI monitoring (m bgl)
BH/17/06	Not encountered	-	3.36-3.71

Summary of Laboratory and In-situ Geotechnical Test Results

Stratum	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	SPT 'N' Value	cu (kPa)	Eu MPa	E' MPa	Phi (°)
Upper Glacial Till (fine-grained)	6.2-32 (19.8)	53	27	26	4-50 (19)	18-225 (93.3)	28.3	17	*20
Upper Glacial Till (coarse-grained)	12-17 (14.5)	-	-	-	39-50 (44)	-	-	44	*39
Glaciofluvial Deposits	20	-	-	-	*16	-	-	16	*26
Glaciolacustrine	23-32 (28.4)	32-44 (36.8)	20-22 (20.5)	12-22 (16.3)	8-16 (21)	17-105.6 (57.7)	31.5	18.9	*25
Lower Glacial Till (fine-grained)	10-28 (20)	23-51 (37)	14-25 (19.5)	9-26 (17.5)	18-50 (32)	21-300 (216)	48	28.8	*30
Lower Glacial Till (coarse-grained)	15	-	-	-	50	-	-	50	*42
*Taken from GI outside of South Charlton overbridge area.									

Stratum	Phi (°)	PLT Is50 (MPa)	UCS (MPa)
Alston Formation (Limestone)	**27-34	0.21	*75
* Taken from GI outside of South Charlton overbridge area **Based on Tomlinson 2001 (Ref.19)			

Summary of Concrete Classification Results and Other Test Results

Stratum	pH solid	pH water	Total sulphur solid %	Total sulphur as SO4 water mg/l
Topsoil	5.9-7.7			
Glacial Till	7.9-8.3	8.3-8.5	1.14	98

Summary of Geotechnical Risks

Hazard	Process / Activity
Perched Groundwater	Presence of shallow groundwater due to low permeability of the Glacial Till
Weak compressible soils	Glacio-lacustrine deposits are present in proximity to the site of the overbridge.
Hard Dig	Cobbles and boulders were encountered in the glacial till and are widespread in the glacio-fluvial deposits.
Unknown ground conditions	Due to issues on site, BH/17/07 was unable to be progressed to bedrock. Therefore, the depth to competent bedrock is unknown.

Appendix B

GEOLOGY AND BOREHOLE PLANS (MAY 2019 ALIGNMENT)

Project Id:	170731	Title:	Site Plan
Project Title:	A1 A2E Northumberland	Scale:	1:2500
Location:	A1 Alnwick to Ellingham	Engineer:	WSP
Client:	Highways England	Contractor:	Socotec

Legend Key

- Locations By Type - Empty
- Locations By Type - BH
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RO+RC
- Locations By Type - TP
- Locations By Type - WS
- HE551459-WSP-HGN-A2E-M3-CH-00003_P10 - 2D Highway

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free

Structural Geology

- Coal Seam
- Fault

GI Phase Prefixes:

2018 Ground Investigation Exploratory Holes- BH/17/XX; TP/17/XX and HP/17/XX

2012 Middlemoor Windfarm - BH-XX and WS-XX

Alnwick Bypass Stage I or II- BH XXX and TP XXX, BHAXX and TPAXX

1993 Willowburn to Denwick - BH3XX

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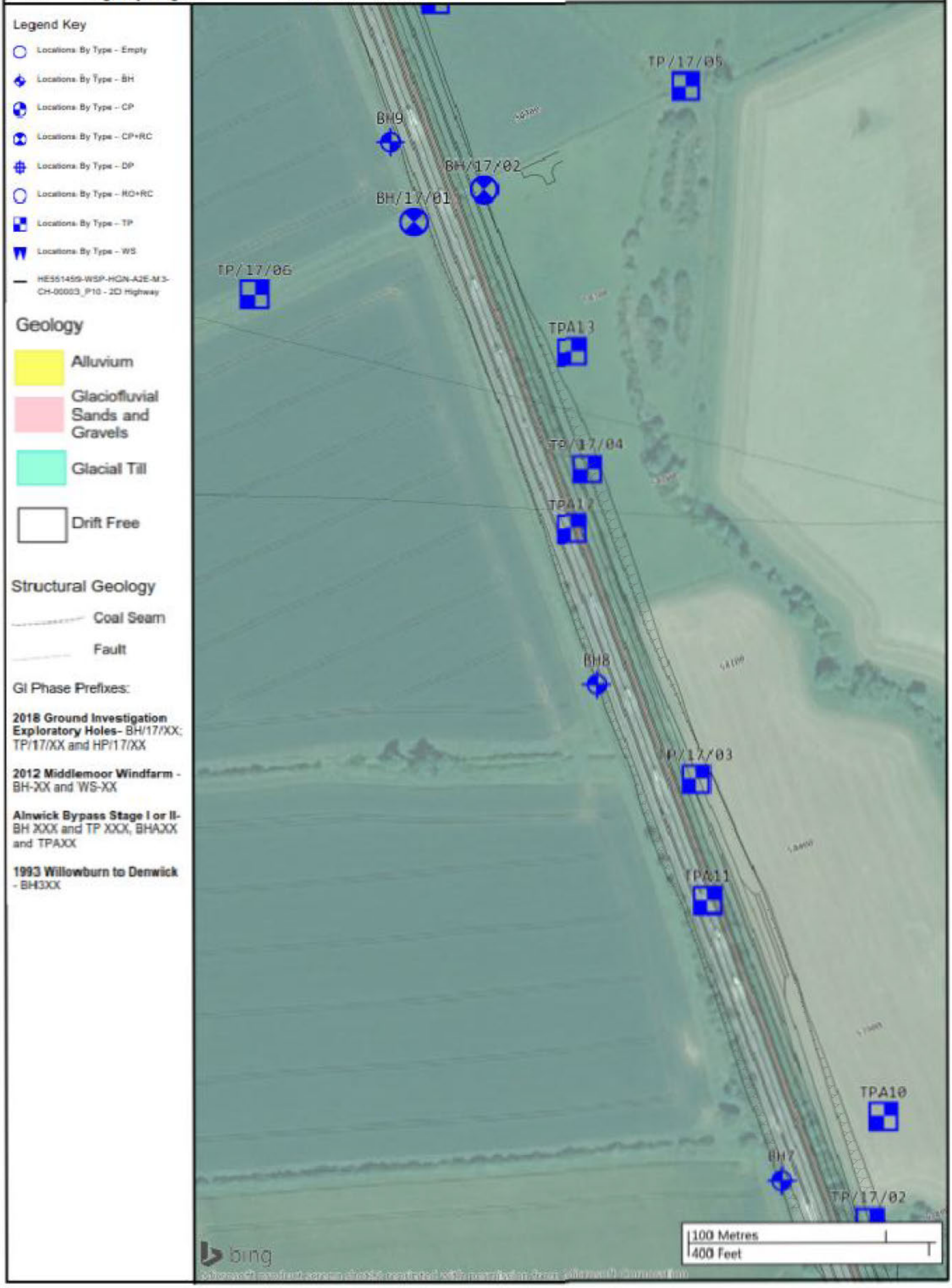
Project Title:	A1 A2E Northumberland	Scale:	1:2500
Location:	A1 Alnwick to Ellingham	Engineer:	WSP
Client:	Highways England	Contractor:	Socotec



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Project Title:	A1 A2E Northumberland	Scale:	1:2500
Location:	A1 Alnwick to Ellingham	Engineer:	WSP
Client:	Highways England	Contractor:	Socotec

wsp

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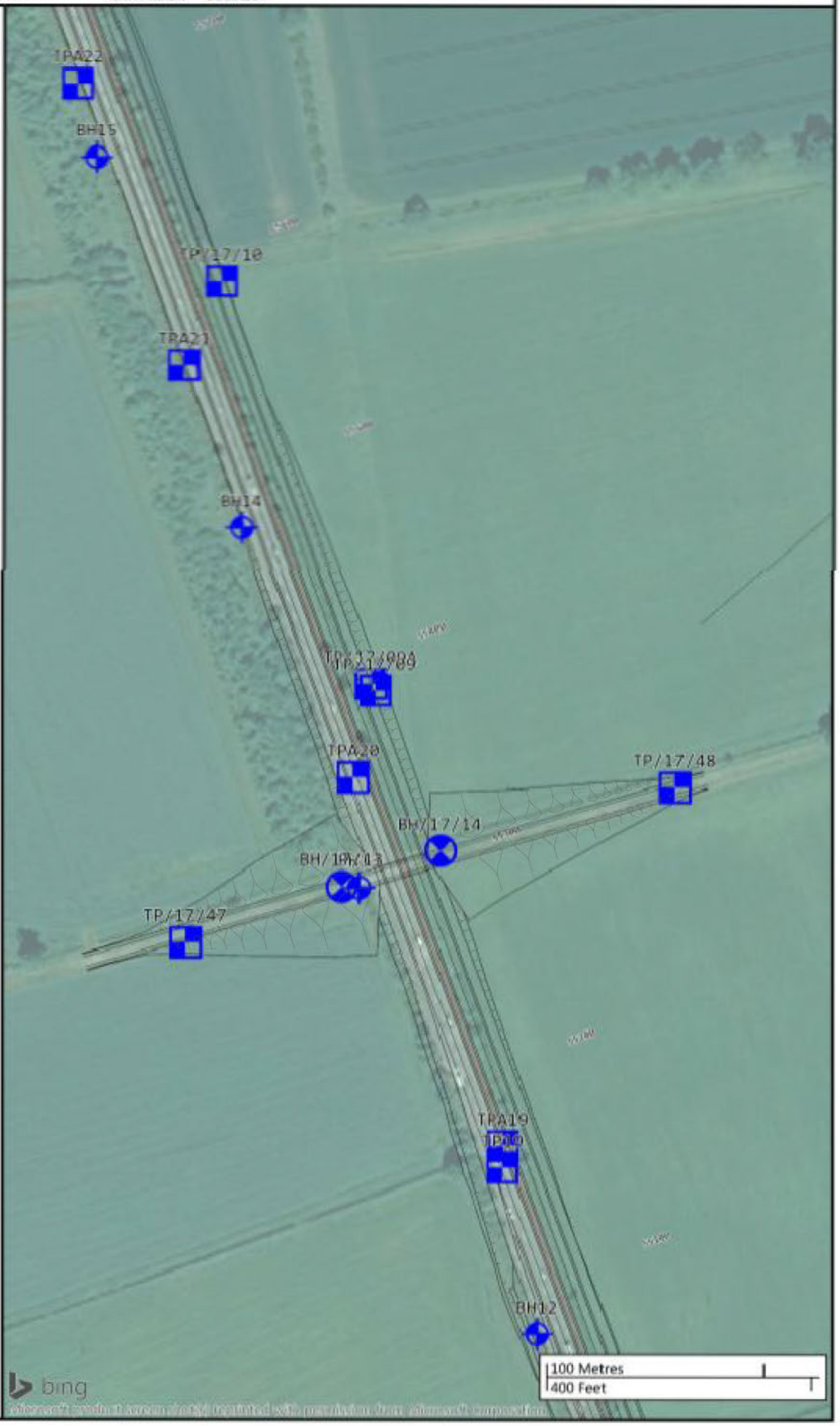
1993 Willowburn to Denwick - BH3XX



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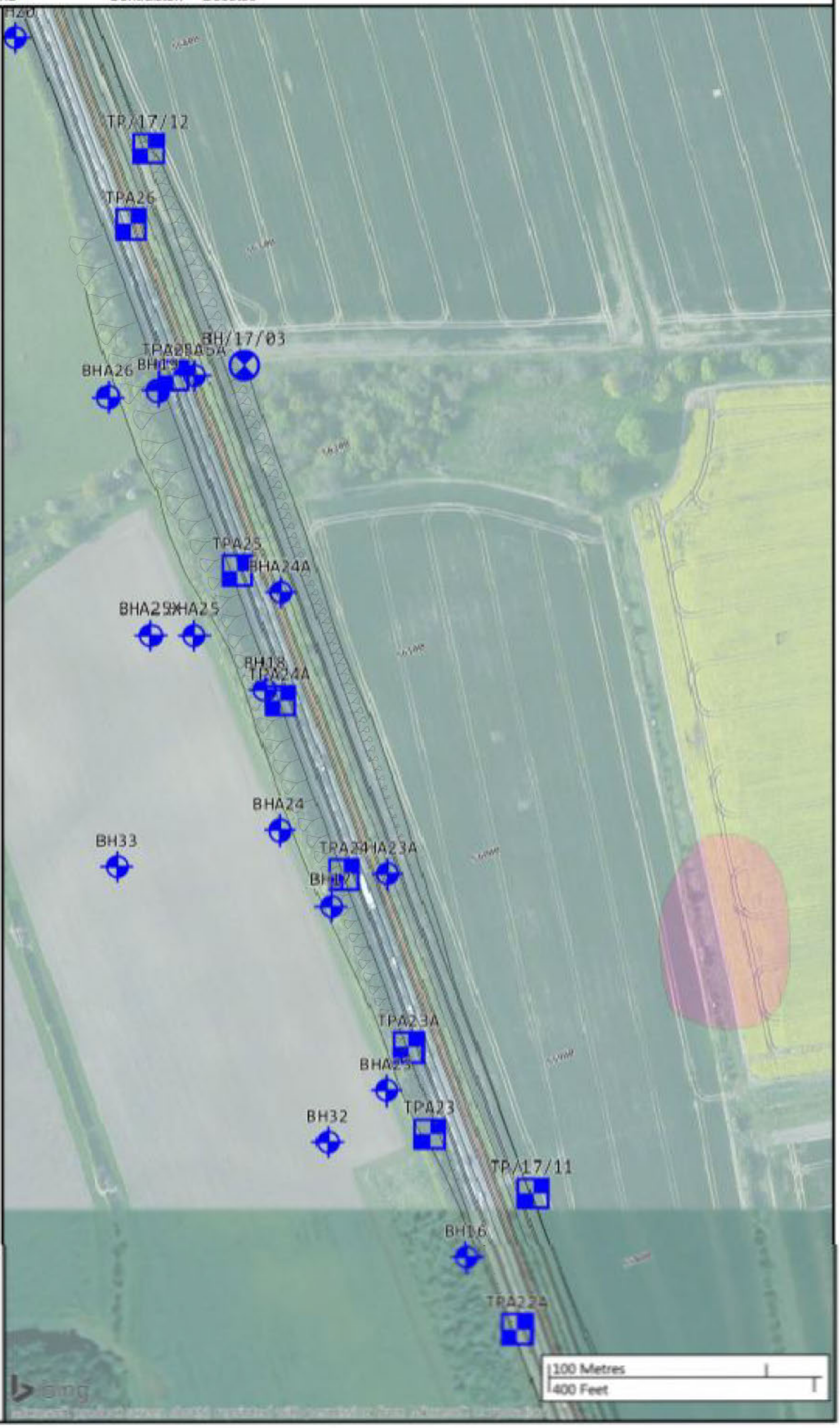

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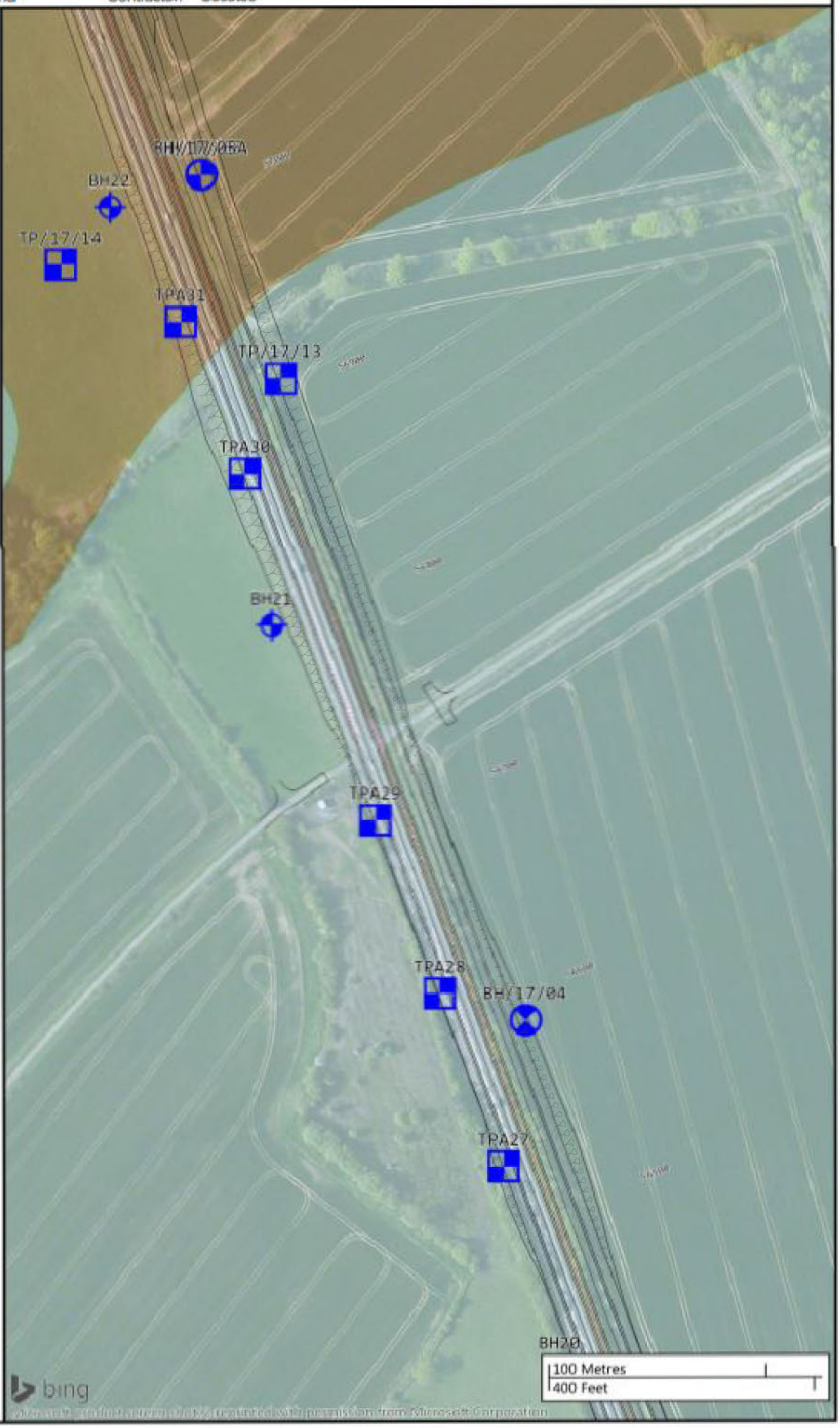

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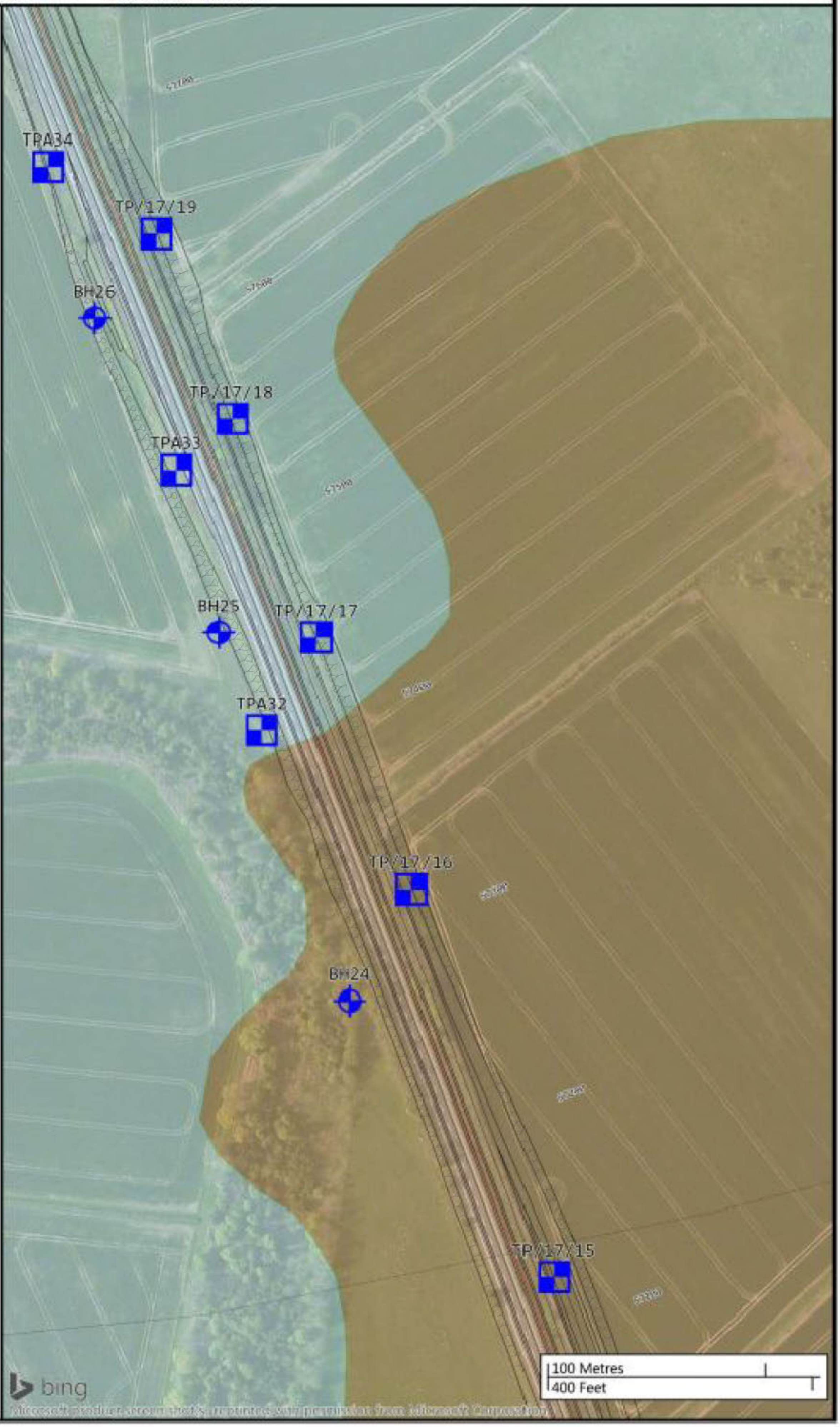

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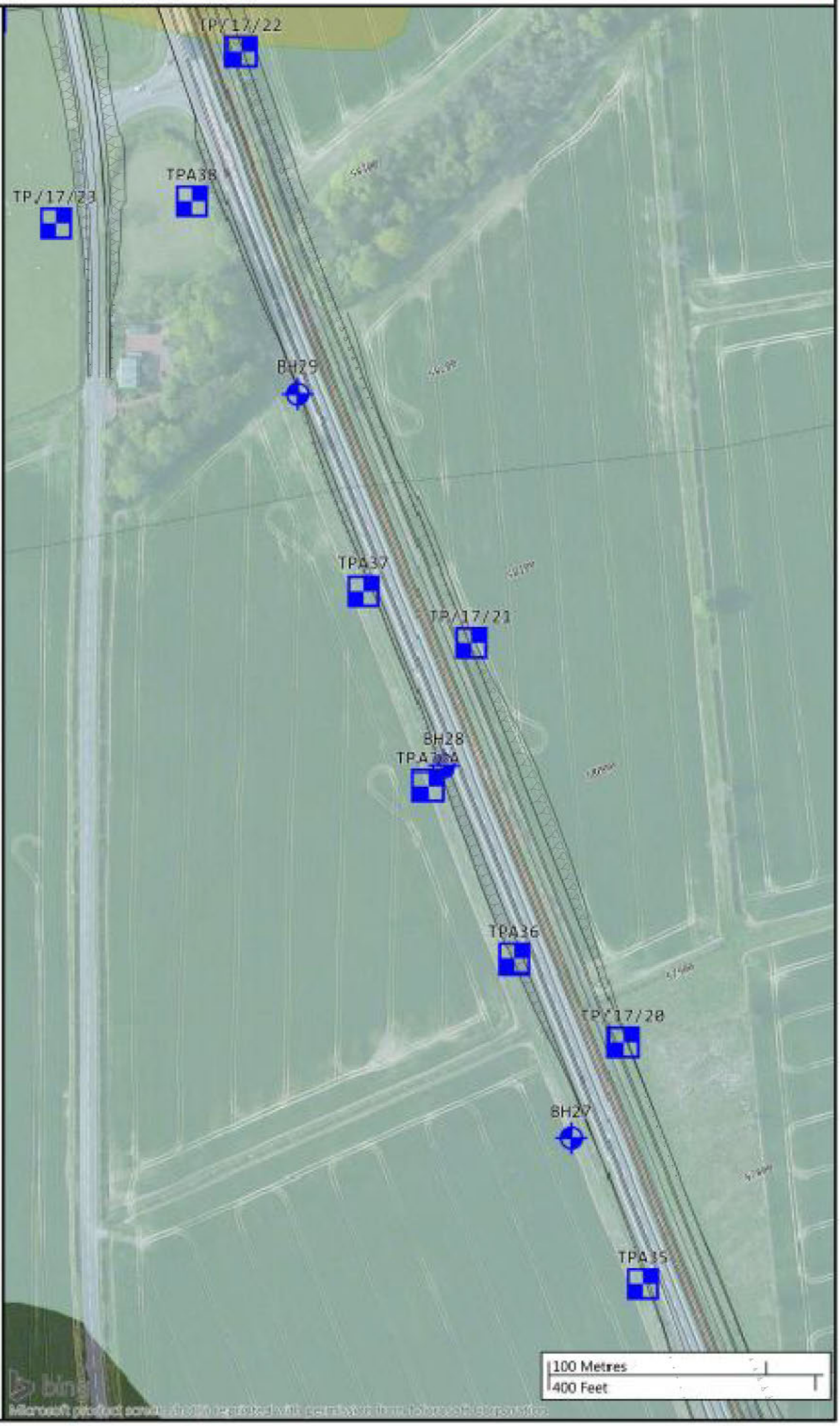

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- Glaciofluvial Sands and Gravels
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- Drift Free

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Geology

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- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free

Structural Geology

- Coal Seam
- Fault

GI Phase Prefixes:

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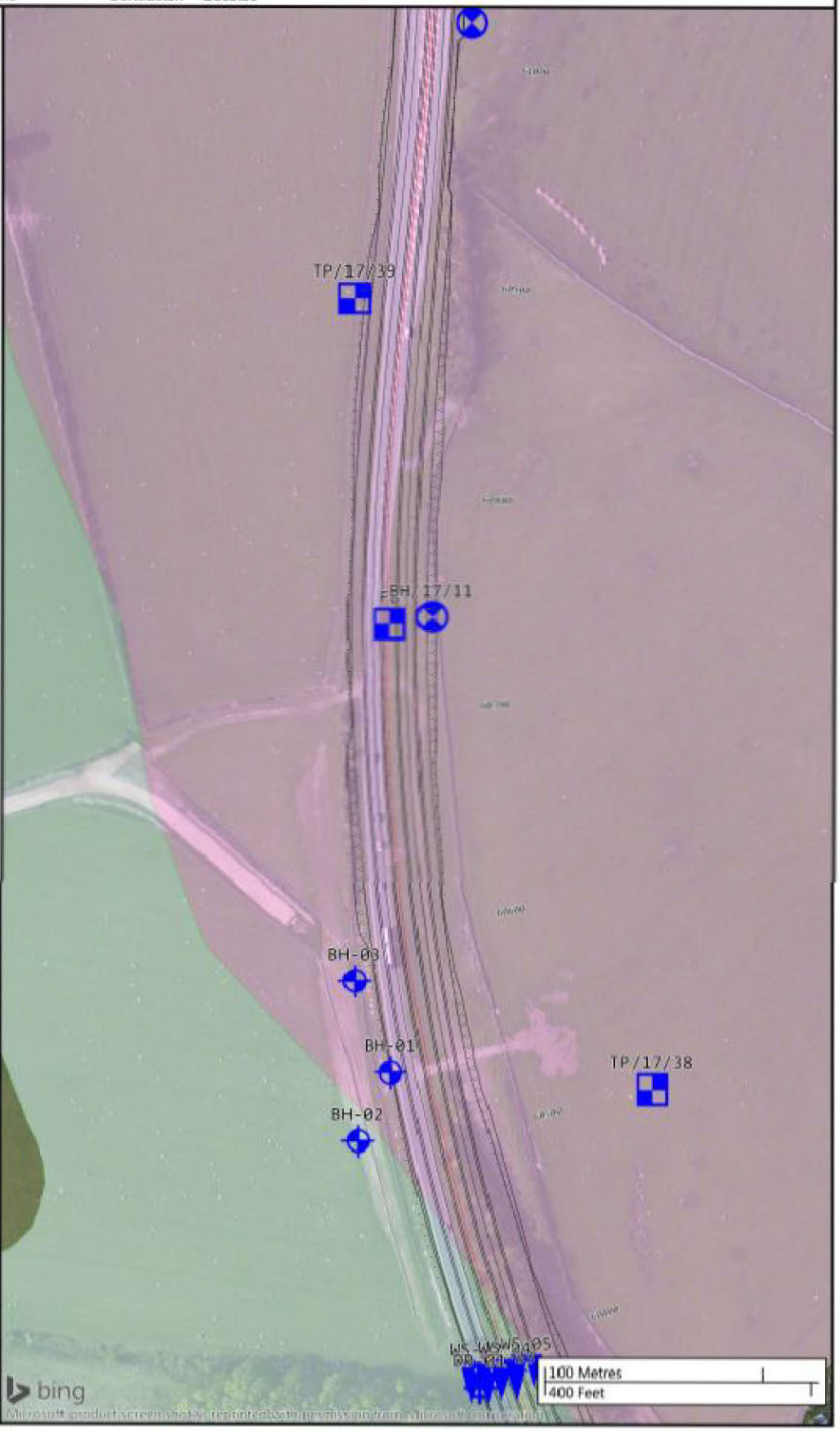
2012 Middlemoor Windfarm - BH-XX and WS-XX

Alnwick Bypass Stage I or II- BH XXX and TP XXX, BHAXX and TPAXX

1993 Willowburn to Denwick - BH3XX



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Geology

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Structural Geology

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GI Phase Prefixes:

2018 Ground Investigation Exploratory Holes- BH/17/XX; TP/17/XX and HP/17/XX

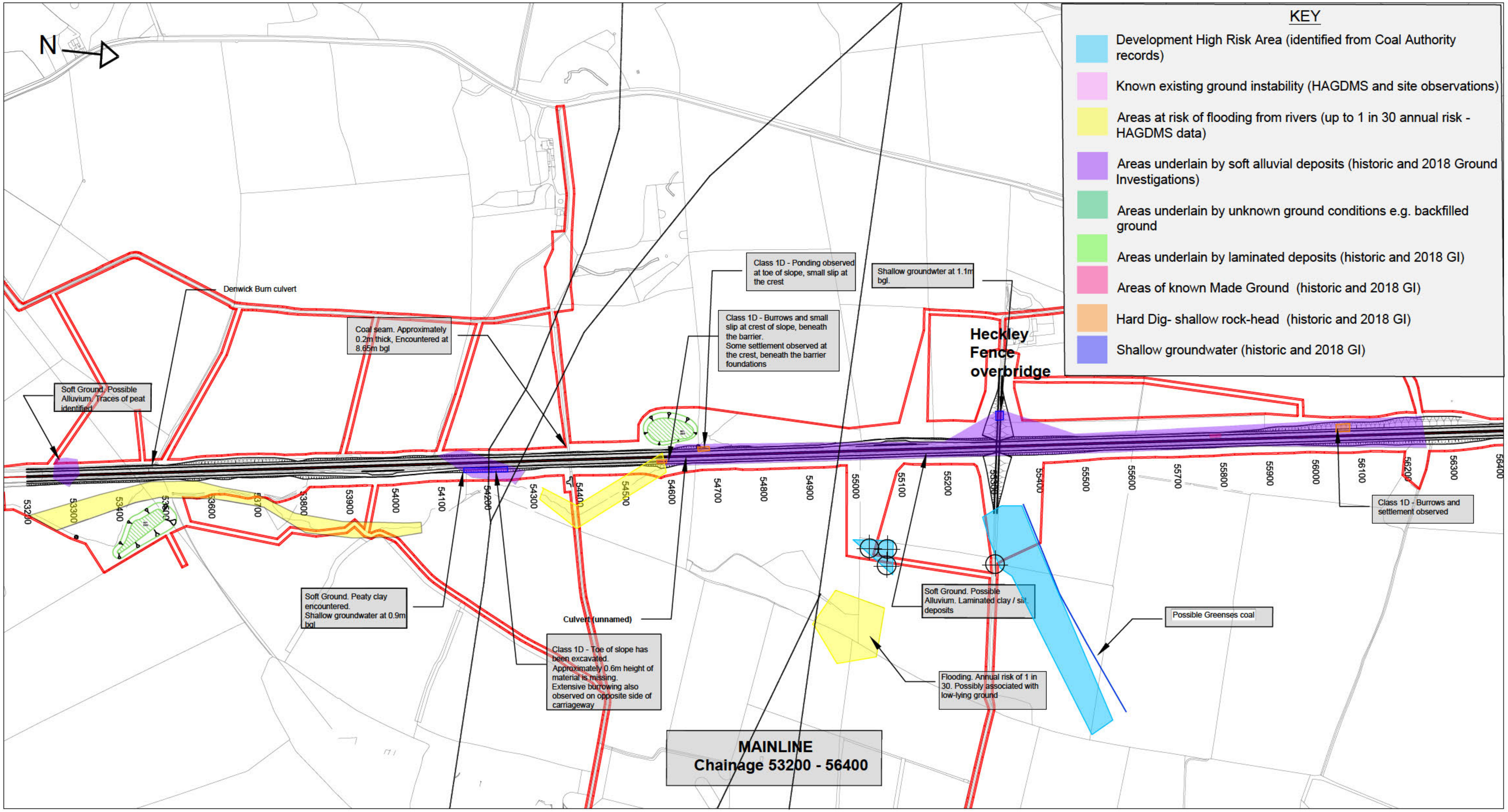
2012 Middlemoor Windfarm - BH-XX and WS-XX

Alnwick Bypass Stage I or II- BH XXX and TP XXX, BHAXX and TPAXX

1993 Willowburn to Denwick - BH3XX

Appendix C

GEOHAZARD PLANS



NOTES

1. To be read in conjunction with the A1 A2E Ground Investigation Report and A2E Factual Ground Investigation Report
2. For indicative cross-sections please refer to long section drawings

Red Line Boundary
Possible Mine shafts
Proposed Detention Basin
Inferred Fault
Inferred Coal Seam

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd
P02	11/19	Amendments following HE review	HS	MH	BS	BS
P01	09/19	First Issue	OM	JH	BS	BS

Suitability: ISSUE
Status: S1

Project Title: A1 in Northumberland
Alnwick to Ellingham

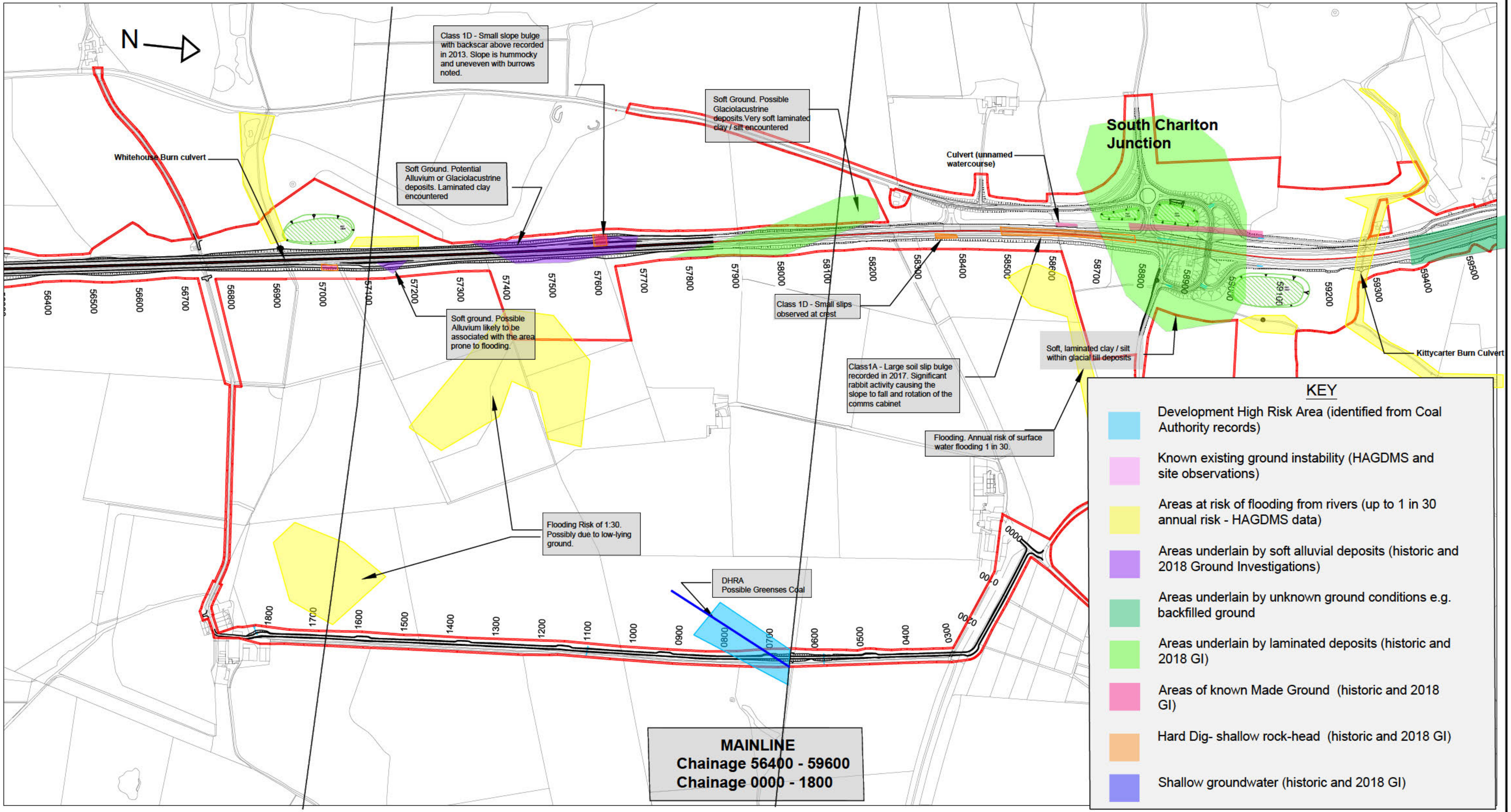
Drawing Title: Geohazard Plan
Sheet 1 of 3

wsp
8 First Street,
Manchester
M15 4RP
wsp.com

Client: highways england

Scale	Drawn	Eng. Check	Approved	Authorised
1:10000	OM	JH	BS	GH
Original Size: A3	Date: 17/04/2019	Date: 02/05/2019	Date: 09/2019	Date: 09/19

Drawing Number
HE PIN: HE551459 | Originator: WSP | Volume: HGT | Revision: P02
A2E (Section) | (Type) | (ID) | (Direction) | DR (Type) | CE (Role) | 000001 (Number) | PW Stage Code: 3



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P02	11/19	Amendments following HE review	HS	MH	BS	BS
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Suitability: ISSUE
Status: S1

8 First Street,
Manchester
M15 4RP

wsp.com

Client: highways england

Project Title: A1 in Northumberland
Alnwick to Ellingham

Drawing Title: Geohazard Plan
Sheet 2 of 3

Scale	Drawn	Eng. Check	Approved	Authorised
1:10000	OM	JH	BS	GH
Original Size	**Date**	**Date**	**Date**	**Date**
A3	17/04/2019	02/05/2019	09/2019	09/19

Drawing Number
HE PIN: HE551459
Originator: WSP
Volume: HGT
Revision: P02

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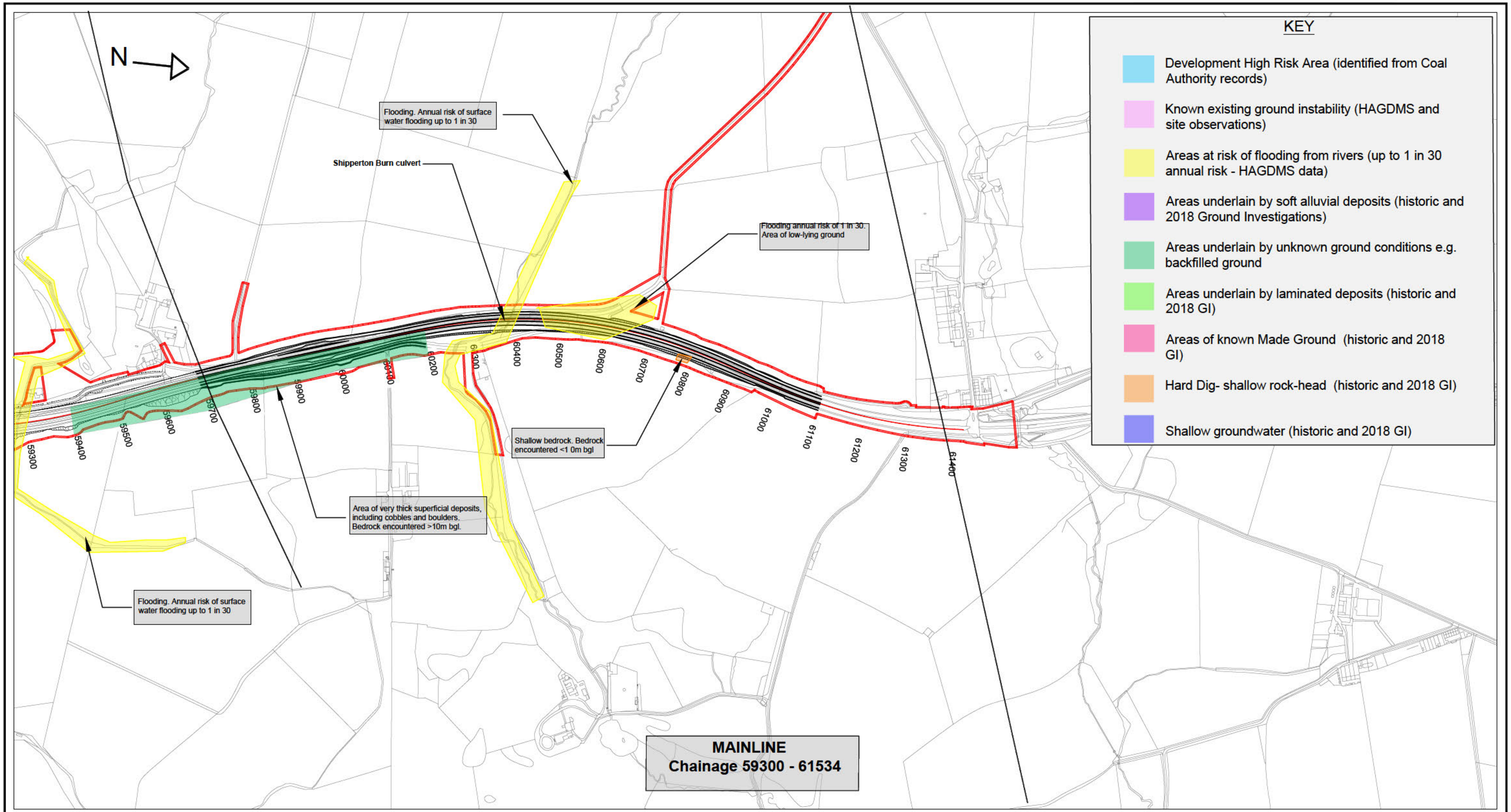
PW Stage Code: 3



NOTES

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Red Line Boundary

Possible Mine shafts

Proposed Detention Basin

Inferred Fault

Inferred Coal Seam

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd
P02	11/19	Amendments following HE review	HS	MH	BS	BS
P01	09/19	First Issue	OM	JH	BS	BS

Suitability: ISSUE

Status: S1

wsp

8 First Street,
Manchester
M15 4RP

wsp.com

Client: highways england

Project Title: A1 in Northumberland
Alnwick to Ellingham

Drawing Title: Geohazard Plan
Sheet 3 of 3

Scale	Drawn	Eng. Check	Approved	Authorised
1:10000	OM	JH	BS	GH
Original Size	Date	Date	Date	Date
A3	17/04/2019	02/05/2019	05/19	09/19

Drawing Number

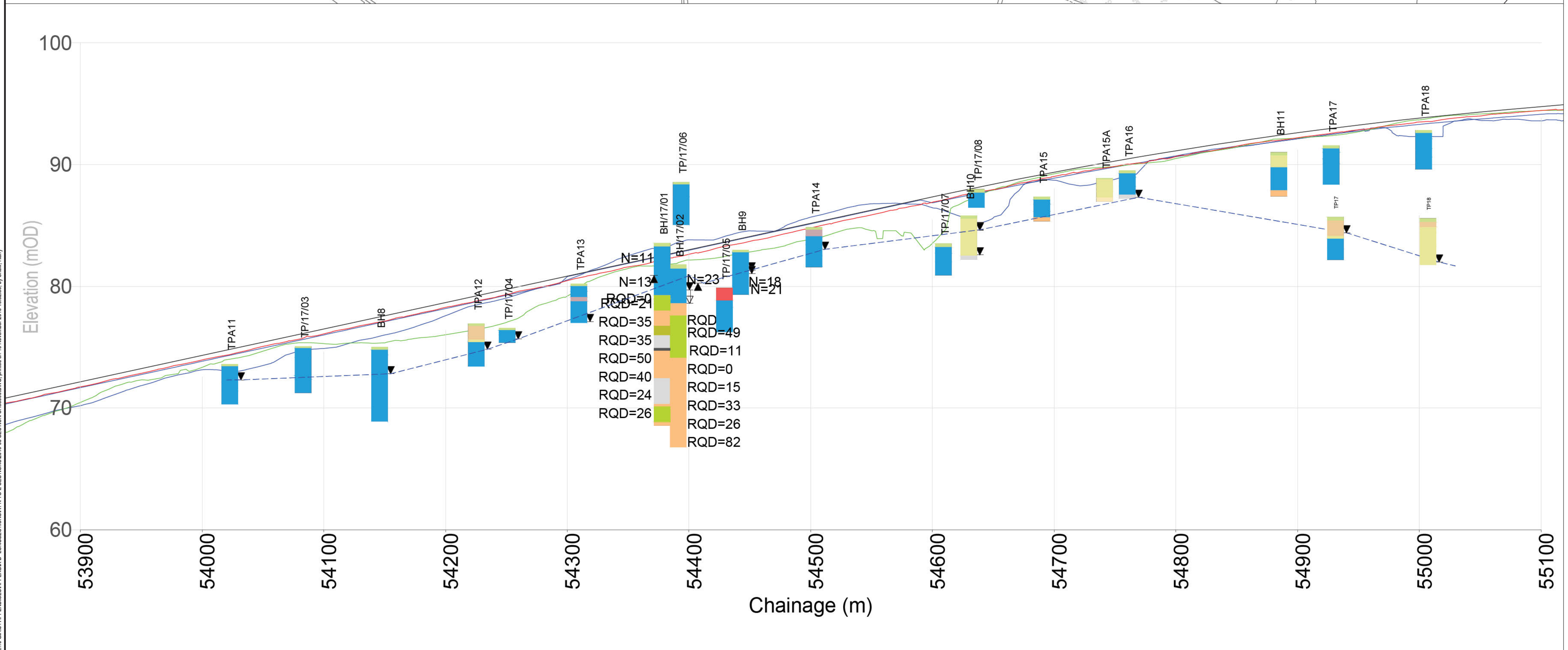
HE PIN	Originator	Volume	Revision
HE551459	WSP	HGT	P01

Section	Type	ID	Direction	Type	Role	Number	PW Stage Code
A2E				DR	CE	000003	3

Appendix D

LONG SECTIONS (MAY 2019 ALIGNMENT)

DO NOT SCALE



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	Window sample
	Trial Pit
	Proposed alignment
	Existing ground level
	Inferred ground level of SB edge of earthworks
	Inferred ground level of NB edge of earthworks
	Inferred groundwater level
	Groundwater level
	Groundwater strike
	Maximum recorded groundwater
N = 20	SPT 'N' Value
RQD = 14	Rock Quality Designation

Key

Superficial

	Topsoil
	Made Ground
	Cohesive Alluvium
	Cohesive fluvio glacial
	Granular Alluvium
	Glaciolacustrine
	Glaciofluvial Sand and Gravel
	Cohesive Glacial Till
	Granular Glacial Till

Solid

	Limestone
	Mudstone
	Siltstone
	Sandstone
	Coal
	Undiff sst/mst/slst
	Weathered undifferentiated bedrock
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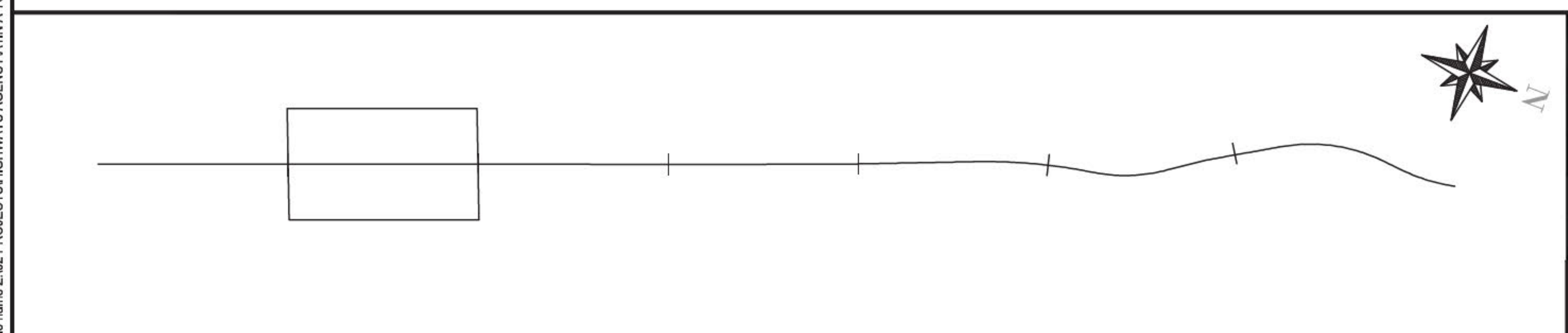
	Weathered Sandstone



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PROJECT: A1 IN NORTHUMBERLAND

TITLE: GEOLOGICAL LONG SECTION CH53900 TO CH55100 SHEET 2 OF 7

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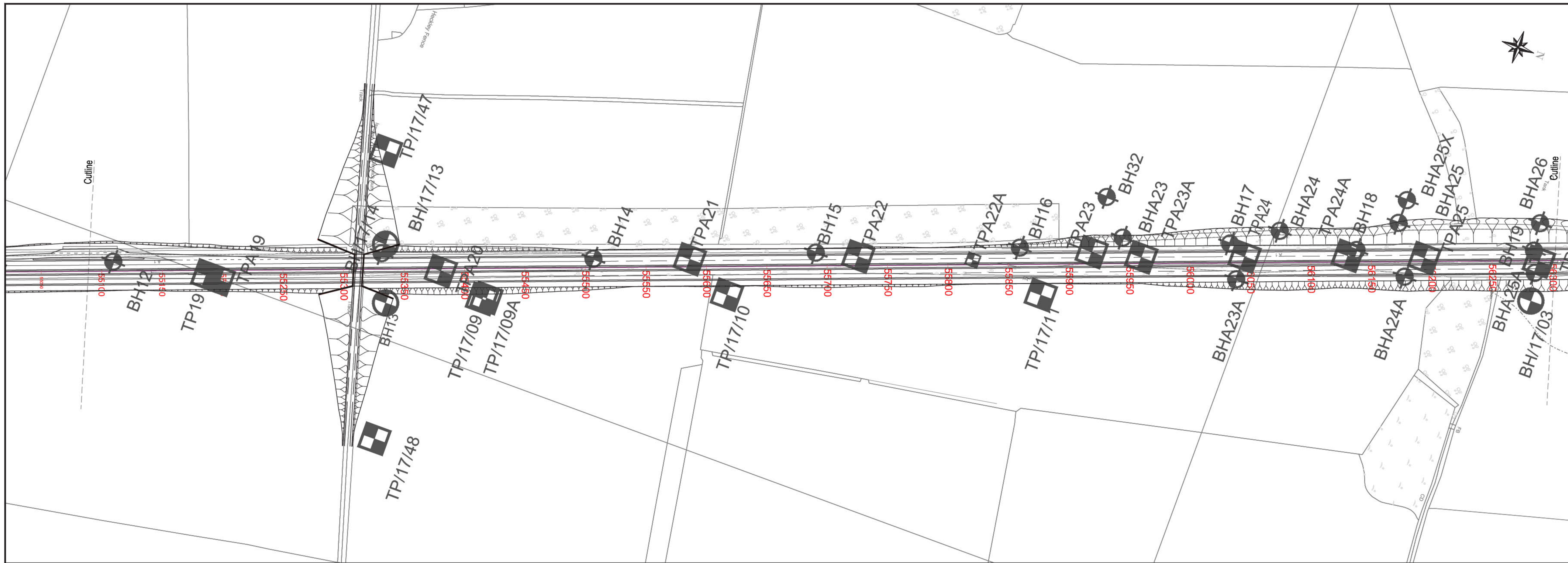

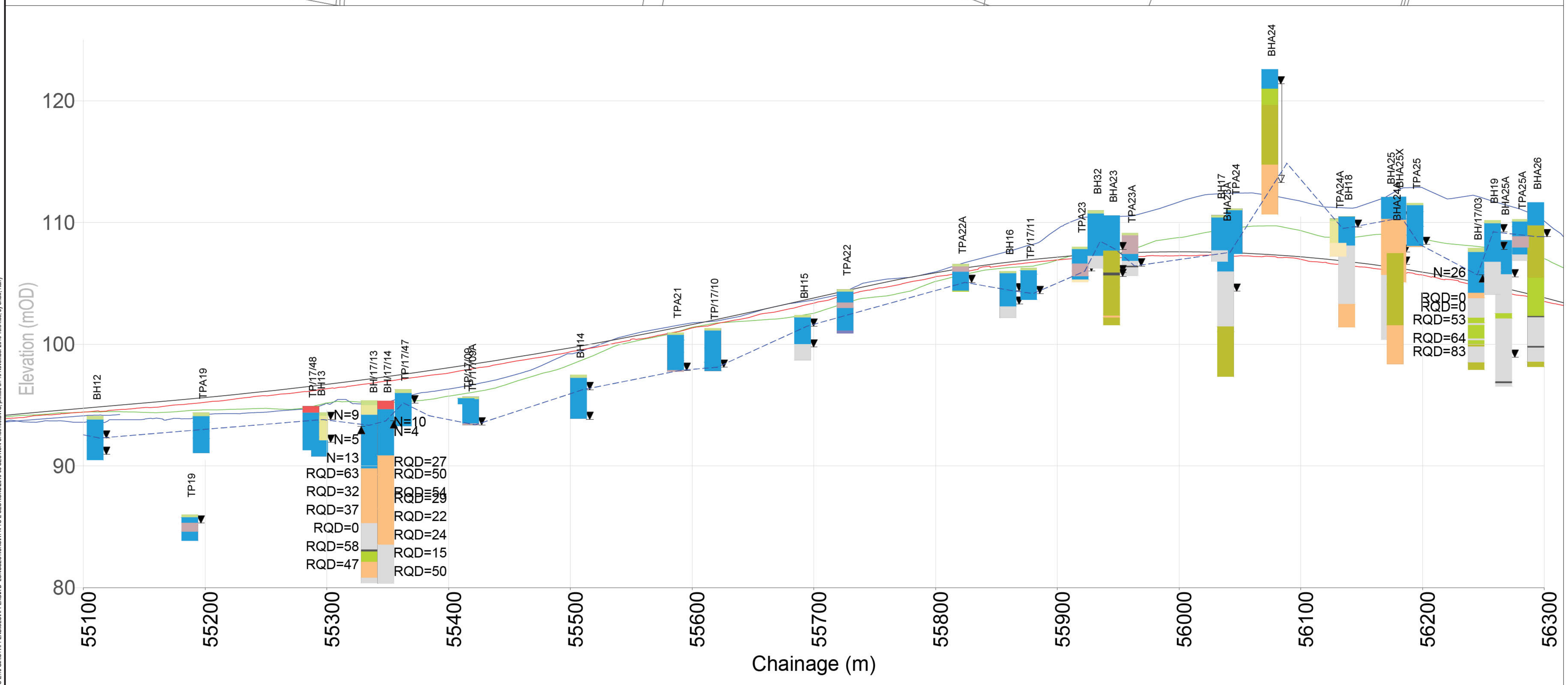

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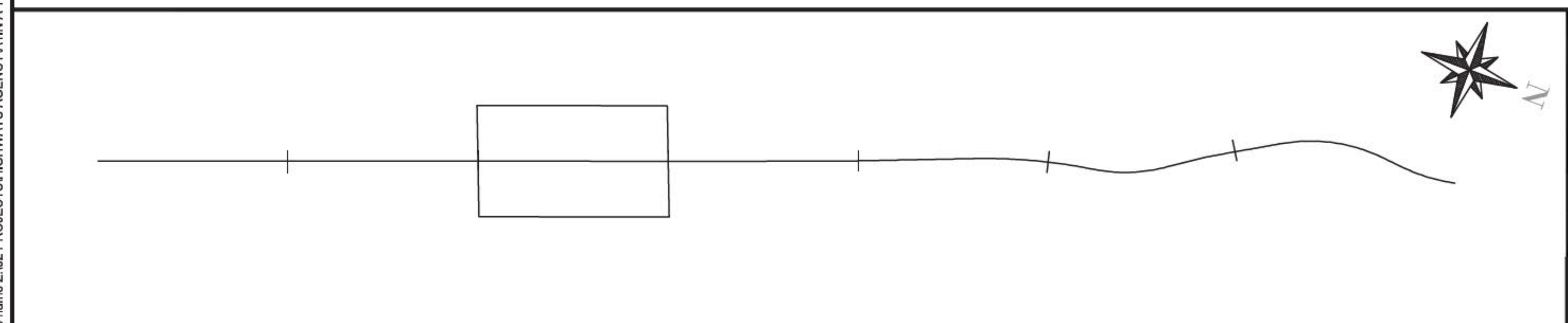

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TITLE: GEOLOGICAL LONG SECTION CH55100 TO CH56300 SHEET 3 OF 7

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70044137	PW	PW	MAY 19

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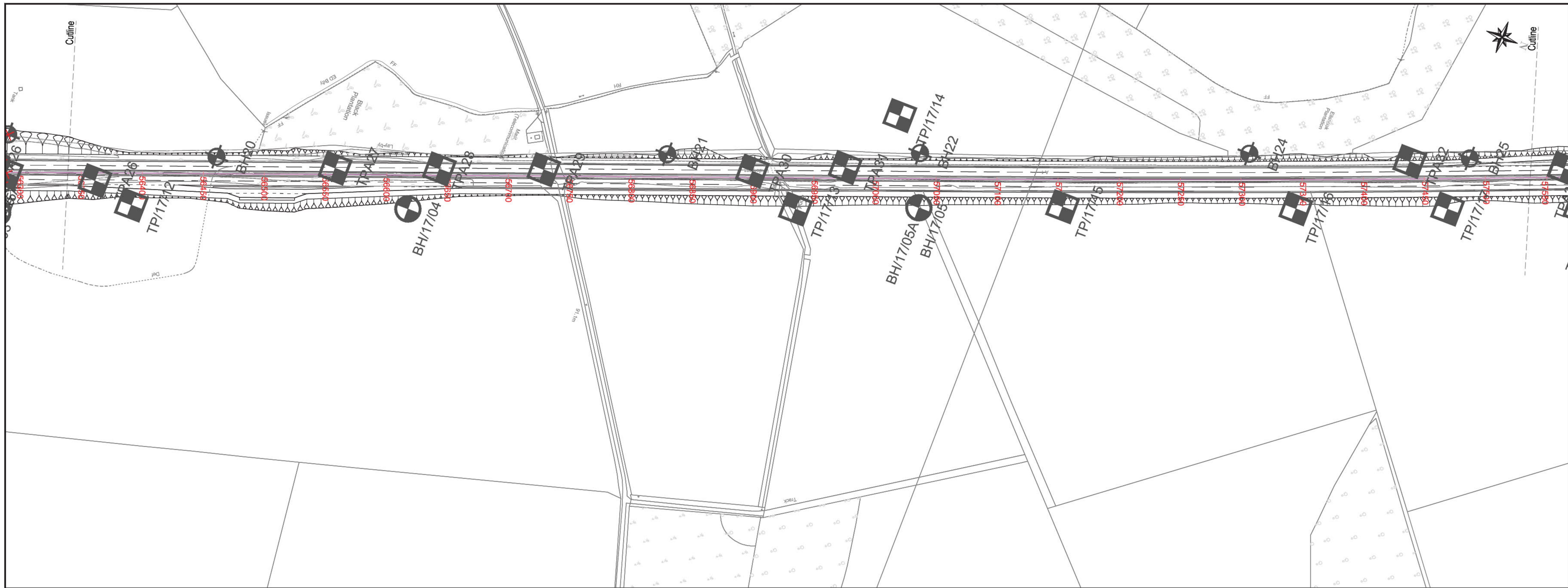

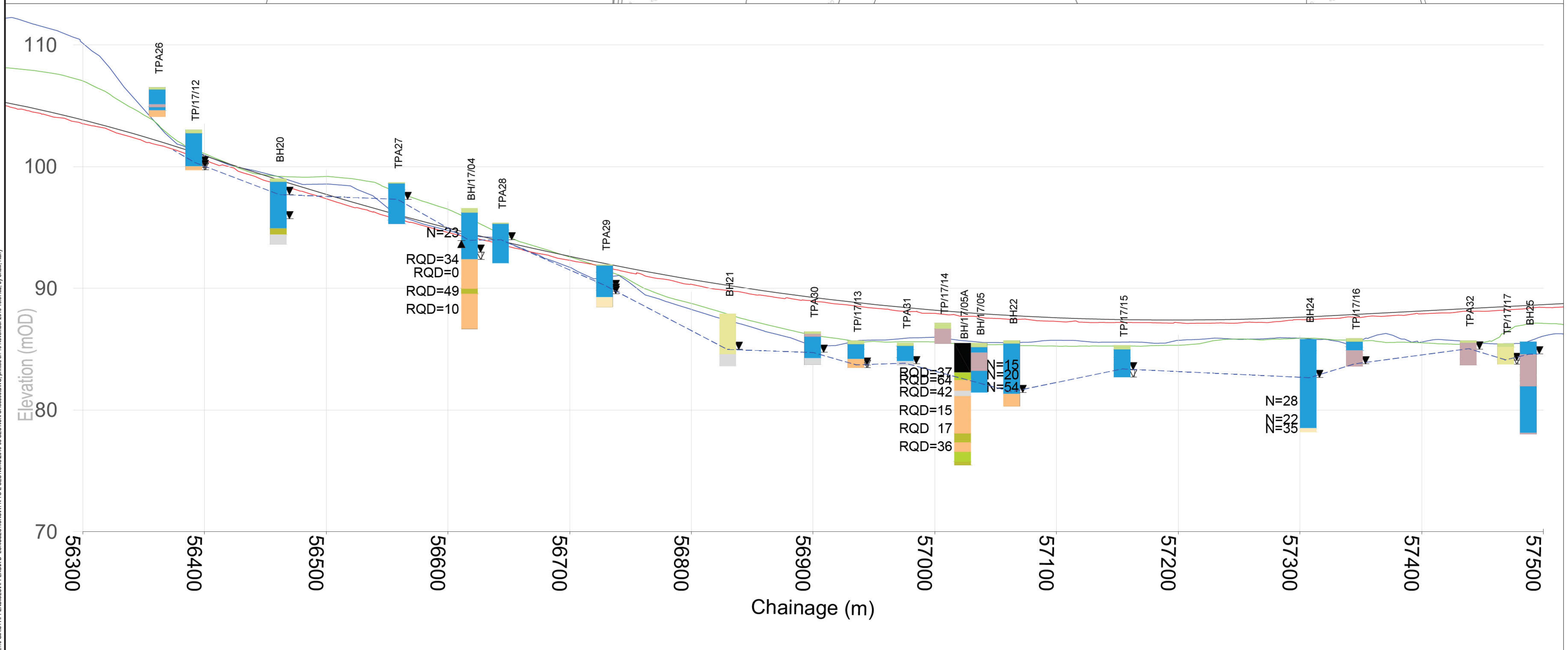

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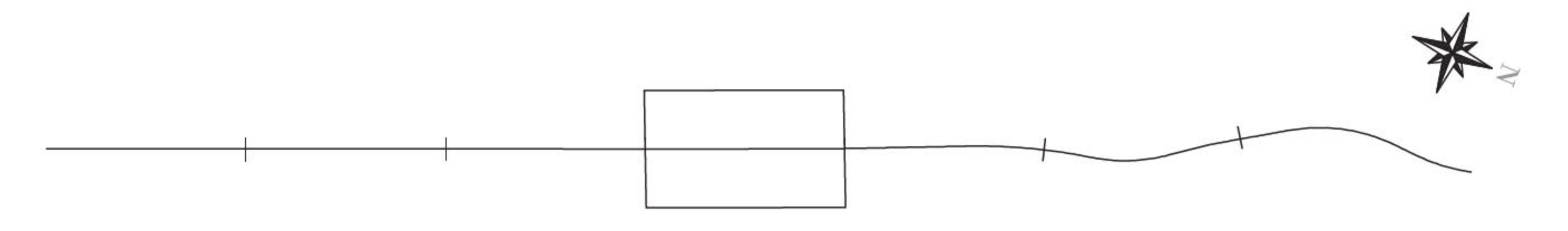

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TITLE: GEOLOGICAL LONG SECTION CH56300 TO CH57500 SHEET 4 OF 7

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PROJECT No: 70044137	DESIGNED: PW	DRAWN: PW	DATE: MAY 19

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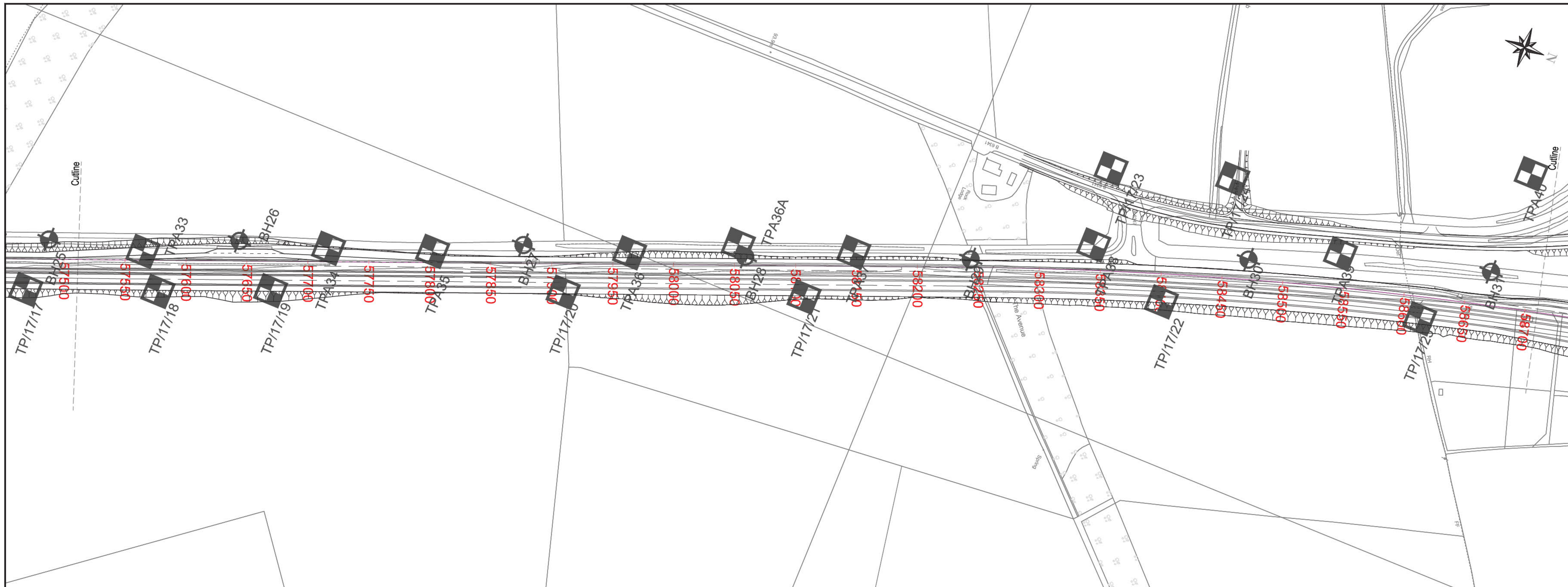

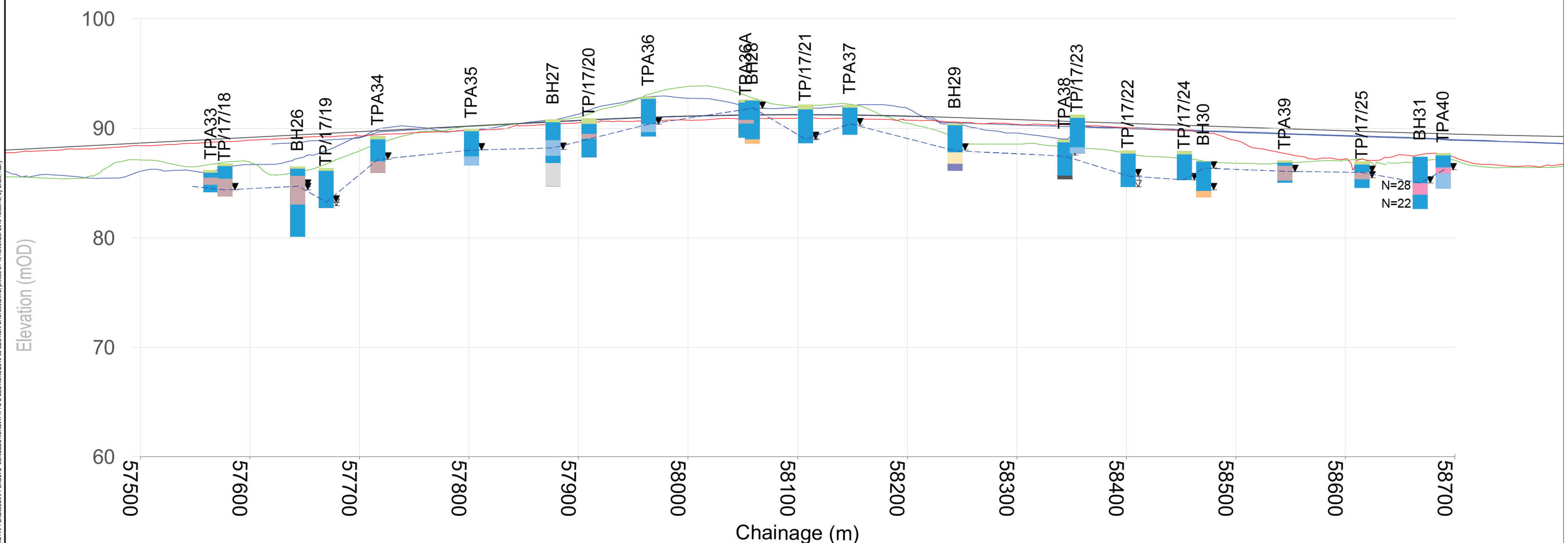

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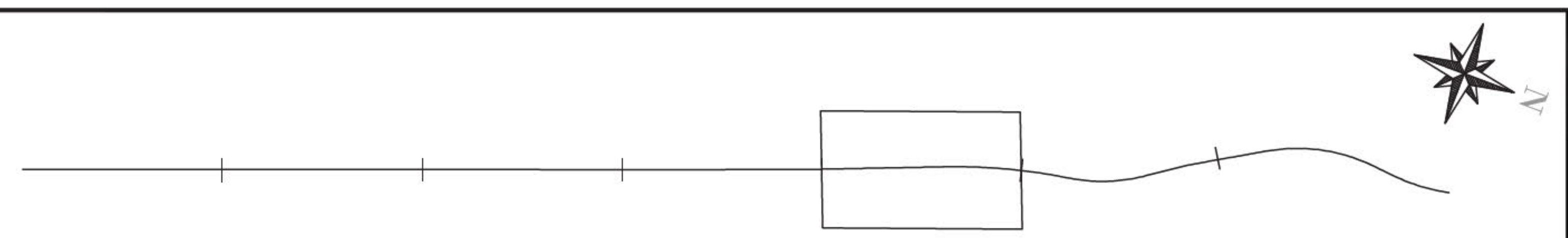

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TITLE: GEOLOGICAL LONG SECTION CH57500 TO CH58700 SHEET 5 OF 7

SCALE @ A1: H = 1000 V = 100	CHECKED: MH		APPROVED: GH
PROJECT No: 70044137	DESIGNED: PW	DRAWN: PW	DATE: MAY 19

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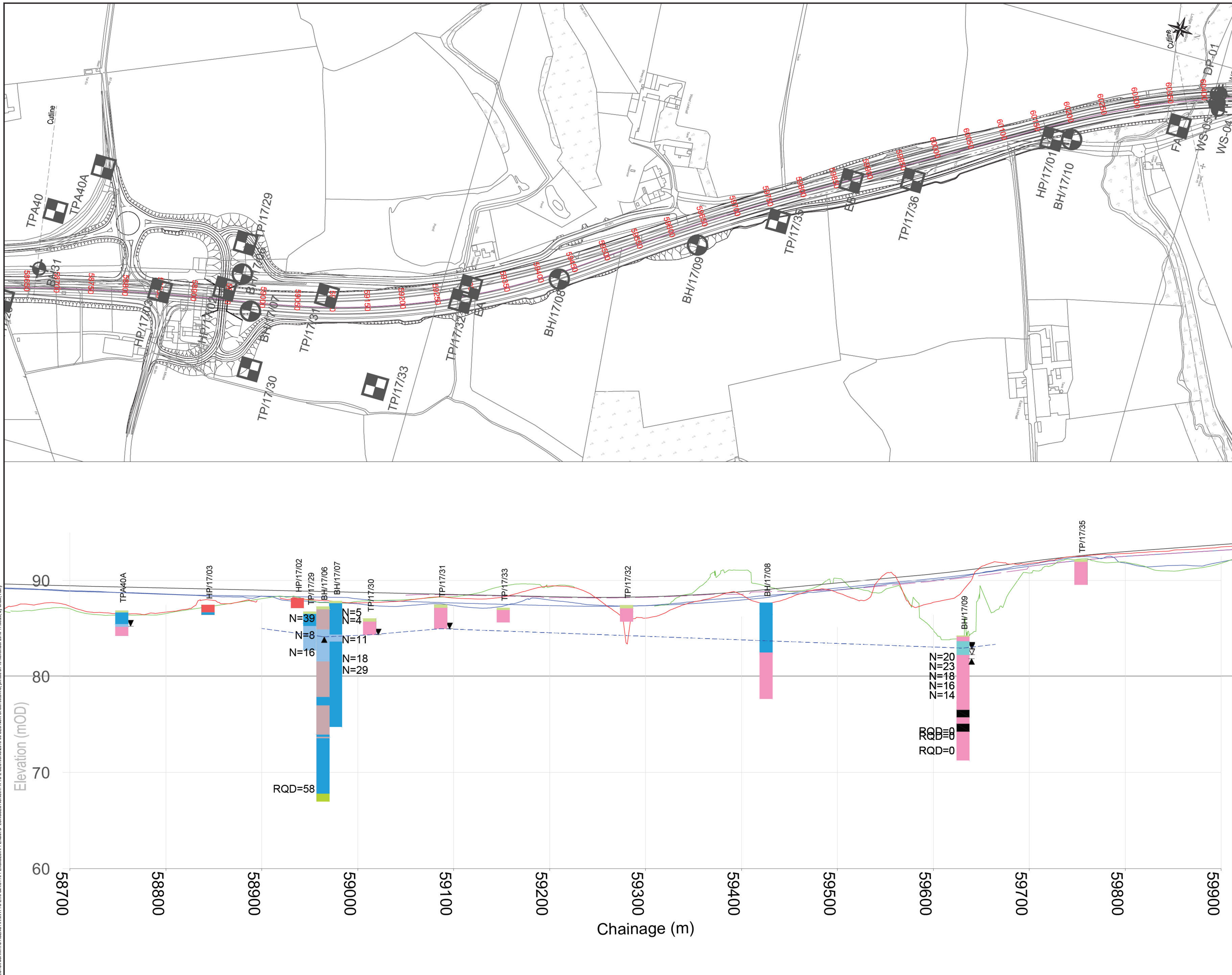

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TITLE: GEOLOGICAL LONG SECTION CH58700 TO CH59900 SHEET 6 OF 7

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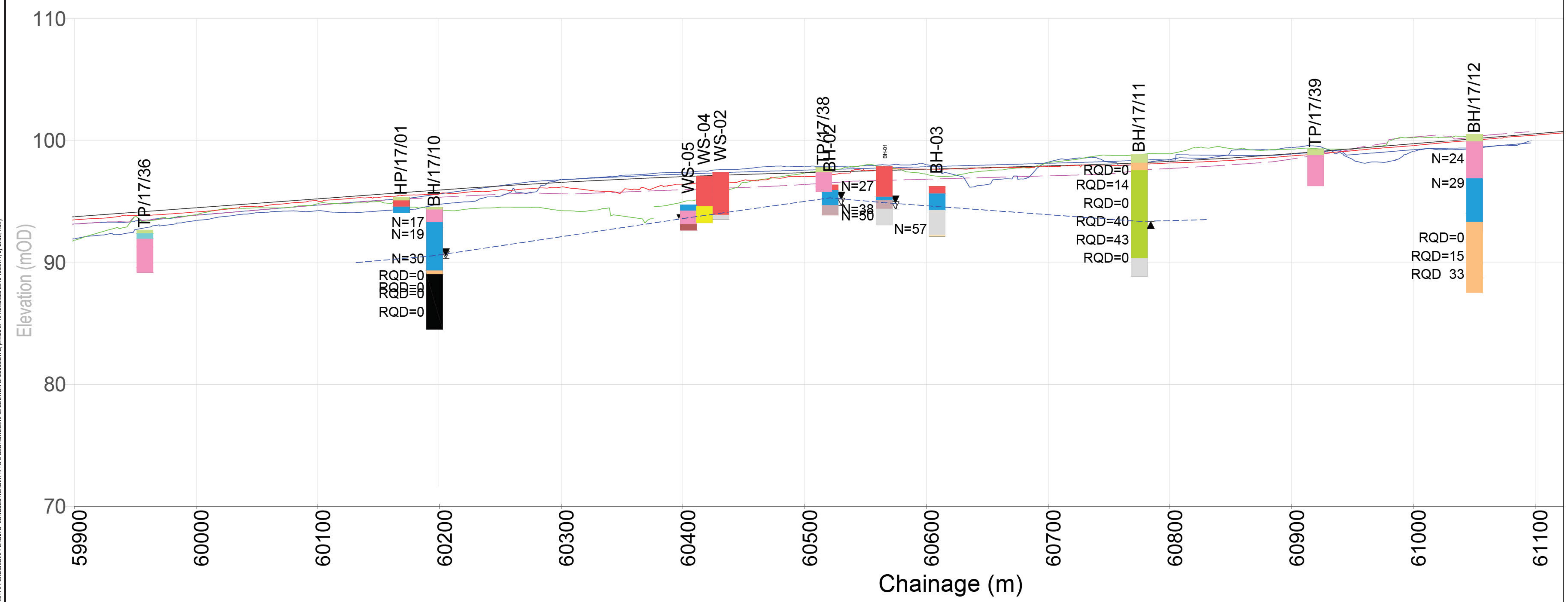

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CLIENT:

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TITLE: GEOLOGICAL LONG SECTION CH59900 TO CH61100 SHEET 7 OF 7

SCALE @ A1:	CHECKED:	APPROVED:
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PROJECT No:	DESIGNED:	DRAWN:	DATE:
70044137	PW	PW	MAY 19

DRAWING No:	REV:
HE551459-WSP-HGT-A2E-DR-CE-000013	P01

Appendix E

COAL MINING RISK ASSESSMENT

Highways England

A1 IN NORTHUMBERLAND ALNWICK TO ELLINGHAM

Coal Mining Risk Assessment

HE551459-WSP-HGT-A2E-RP-CE-00002
NOVEMBER 2019

PUBLIC

Highways England

A1 IN NORTHUMBERLAND ALNWICK TO ELLINGHAM

Coal Mining Risk Assessment

PUBLIC

PROJECT NO. 70044137

OUR REF. NO. HE551459-WSP-HGT-A2E-RP-CE-00002

DATE: NOVEMBER 2019

Highways England

A1 IN NORTHUMBERLAND ALNWICK TO ELLINGHAM

Coal Mining Risk Assessment

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QUALITY CONTROL

Issue/revision	First issue	Second issue
Remarks	Issued for Information	Issued for Information
Date	August 2019	November 2019
Prepared by	Olivia McBarnet	Olivia McBarnet
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Checked by	Matt Howard	Matt Howard
Signature	[redacted]	[redacted]
Authorised by	Bob Seedhouse	Bob Seedhouse
Signature	[redacted]	[redacted]
Project number	70044137	70044137
Report number	HE551459-WSP-HGT-A2E-RP-CE-00002	HE551459-WSP-HGT-A2E-RP-CE-00002
File reference		

CONTENTS

FIGURES

APPENDICES

1 INTRODUCTION

1.1 SCOPE AND OBJECTIVE OF THE REPORT

WSP has been commissioned by Highways England to undertake an assessment of the risks posed by historic coal mining, to the A1 in Northumberland: Alnwick to Ellingham; known hereafter as 'The Scheme', which forms part of the Department for Transport's (DfT) Road Investment Strategy (RIS).

A Ground Investigation Report (GIR) is to be produced for the scheme, in accordance with HD22/08. The majority of the site is not considered to be at risk of hazards associated with historic coal mining. However, five Development High Risk Areas (DHRAs), as defined by the Coal Authority, exist within the scheme red line boundary, one impinging beneath a track to Rock South Farm and the others in the area of Heckley Fence associated with various historic coal mining hazards.

This report presents the coal mining information in further detail, providing an assessment of the risk of the potential historic coal mining hazards across the scheme.

The format of this report is based on the model report template in the Coal Authority's Risk based approach to development management.

The scope of the works undertaken are as follows:

- Collate and review readily available information, including geological Coal Authority and ground investigation data;
- Produce a ground model for the scheme, focussing on the distribution of coal seams and recorded coal workings likely to affect the proposed improvement works;
- Assess the risks posed to the improvement works by historic coal mine workings;
- Identify potential mitigation measures to reduce the risks to acceptable levels.

1.2 SITE DESCRIPTION AND LOCATION

Two areas were identified as being of interest, at the track to Rock South Farm, and Heckley Fence. These locations are described below.

The DHRA at Rock South Farm is located approximately 350m south of Rock Midstead. The DHRA, located in proximity to a watercourse and a small woodland, known as the Kiln Plantation, traverses agricultural land and the track to Rock South Farm. In the currently proposed scheme layout, a new access track is to be constructed parallel to the existing track. The existing track shall remain, for use by pedestrians and horse-rider. the track is to be upgraded. The new track will not require the construction of significant earthworks. Minor cutting and embankment is with a maximum cutting of approximately 1.5m and embankment of 1.6m.

The DHRAs at Heckley Fence, are located on flat agricultural land to the east of the mainline. One of the DHRAs is in close proximity to the probable location of an overbridge. The overbridge structure is anticipated to comprise approach embankments and piled foundations. The location of the DHRAs and Geohazard Plans can be found in Appendix B and Appendix C.

2 SOURCES OF INFORMATION

A Preliminary Sources Study Reports (PSSR) issued by Jacobs in 2017 (Ref. 1) and ground investigation factual reports from historic and recent ground investigations (GI) across the scheme, were used to compile information on historic coal mining of the seams. The following sources were used in the reports, and have been reviewed as part of the assessment of mining risk:

- BGS 1:50 000 1982 (Drift Geology) Geological Map Sheet 6 Alnwick 1982;
- BGS 1:50 000 1975 (Solid Geology) Geological Map Sheet 6 Alnwick 1975;
- CON29M Non-Residential Mining Report – Ref: 51001291374001;
- Historic and 2018 Ground Investigations.

In addition to these, further information was gathered from the following to aid the coal mining risk assessment:

- Coal Authority Interactive Map Viewer (Ref. 2)
- National Library of Scotland (Ref. 3)

3 IDENTIFICATION AND ASSESSMENT OF SITE SPECIFIC COAL MINING

3.1 FEATURES IDENTIFIED

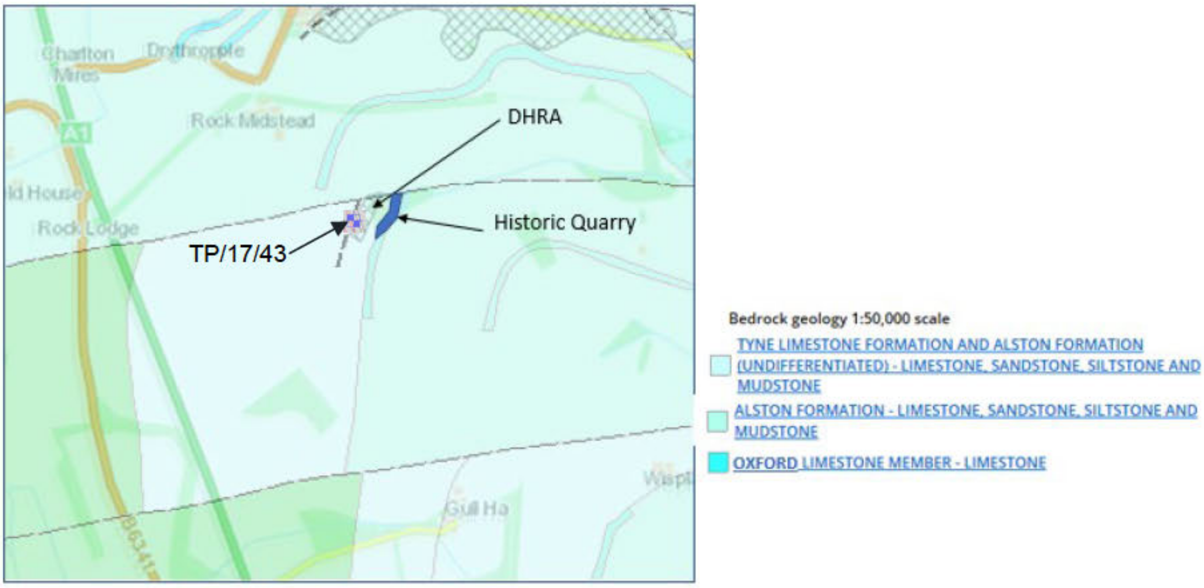
3.1.1 ROCK SOUTH FARM TRACK

The ground conditions at the DHRA at Rock South Farm typically comprise of glacial till to at least 2.3m bgl. However, in close proximity to the watercourse, in TP/17/43 (2018), alluvium was observed to at least 2.7m bgl. There is no ground investigation data available for depths greater than 2.7m bgl. According to the BGS, the bedrock of Tyne Limestone and Alston Formation comprising siltstone, sandstone, limestone and mudstone has a typical dip of 6-10 degrees to the south-south-west. An inferred north-east to south-west coal seam underlies the area, dipping at an unknown angle to the south-east, beneath the track. The BGS map indicates the DHRA may be associated with the inferred coal seam, located west of the Kiln Plantation.

The following potential mining hazard was identified. This is further assessed in this report:

- Coal outcrops (where a workable coal seam is present at or close to the surface) were highlighted in the Coal Authority Interactive Map Viewer.

Figure 3-1 - Bedrock and Development High Risk Area (DHRA) map at Rock South Farm (British Geological Survey Onshore GeoIndex).



3.1.2 HECKLEY FENCE

No GI data is available directly at the location of the DHRAs near Heckley Fence. However, the ground conditions nearby indicate glacial till to approximately 5.0m bgl, underlain by a series of sandstone, mudstone and limestone layers, with a 0.15m thick coal seam at 12.27m bgl encountered in BH/17/13 (2018). Occasional made ground and alluvium was also observed at shallow depths in the superficial deposits. The BGS map indicates the DHRA and associated mining risk are likely related to the nearby inferred coal seam, with a north-east south-west trajectory with unknown dip to the south-east.

The following potential mining hazards were identified. These are further assessed in this report:

- Probable shallow coal mine workings for which no recorded plans exist, were highlighted in the Coal Authority Interactive Map Viewer. However, it is considered likely that any workable coal, at shallow depths of less than 50 mbgl, was mined before records were kept;
- Coal outcrops (where a workable coal seam is present at or close to the surface) were highlighted in the Coal Authority Interactive Map Viewer;
- Mine entry shafts were identified on the Coal Authority Interactive Map viewer. One mine shaft was identified on the BGS Sheet Maps;
- Mine entries with Potential Zone of Influence were identified on the Coal Authority Interactive Map viewer.

Figure 3-2 shows identified coal mining hazards and geology within the red-line boundary in the area of Heckley Fence.

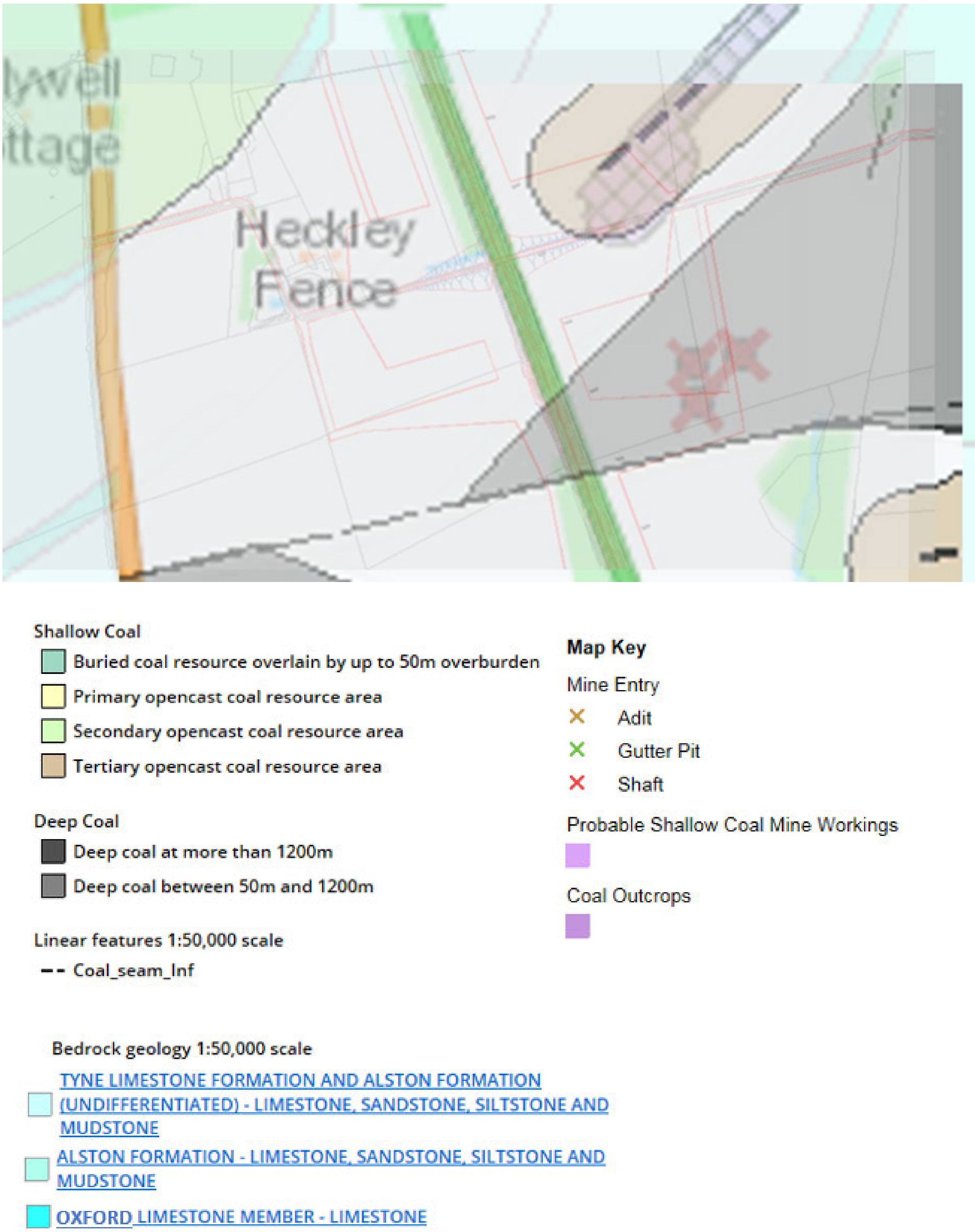


Figure 3-2 – Geology and coal mining hazards within the red-line boundary at Heckley Fence (BGS Onshore GeoIndex, Coal Authority Intervative Map Viewer).

3.2 ASSESSMENT OF RISK

A non-residential CON29M mining report was acquired by Jacobs for input into the PSSR. The report did not pick up any mining related risks across the length of the scheme, or within approximately 120m of the A1 and Rock South Farm track alignment.

3.2.1 ROCK SOUTH FARM TRACK

COAL OUTCROPS

As seen in Figure 3-1, the coal outcrops are consistent with the inferred coal seam identified by the BGS. No evidence was identified to indicate particularly shallow coal seams, or outcrops at the location during the ground investigation. However, it should be noted that no investigation was undertaken at this location at depths greater than 2.7m bgl.

A historic quarry to the east of the track, seemingly picks out the Oxford Limestone member. Historic maps (Ref 3) indicate a lime kiln to have existed just south of the quarry, this would infer that the coal may have been locally quarried for this use.

Due to the proposed construction at this location, the risk of hazards associated with historic mining is considered to be low.

3.2.2 HECKLEY FENCE

PROBABLE SHALLOW COAL MINE WORKINGS

As seen in Figure 3-2, an inferred coal seam, identified in the BGS map, approximately 200m from the existing A1, indicates a dip to the south-east with an unknown dip angle. An abandoned pit shaft was also identified in the BGS Sheet Map 6, at the southern extent of the coal seam, in the area identified as having probable shallow coal mine workings and tertiary opencast coal resource. (Please refer to Appendix B.)

Exploratory holes, undertaken as part of the recent GI at Heckley Fence, did not encounter any voids or broken ground and typically gave a maximum return flush of 95%. However, between 14m and 15m bgl in BH/17/14 0% flush was returned. This coincided with extremely weak mudstone, therefore instead of indicating potential voiding, this may reflect the drilling causing the break-up and washing out of the weak strata. However, this cannot be proven based on the existing ground investigation and therefore further ground investigation should be considered during detailed design.

Coal was only observed as a thin 0.15m thick seam in BH/17/13, between 12.27m and 12.42m bgl, a similar thickness to those observed elsewhere across the scheme. However, based on the South-easterly dip direction of the coal seam, and its inferred termination approximately 200m east of BH/17/13, it is possible that the encountered coal is a minor section of a larger coal seam and may not be representative of the coal which may be present in the area, though this is not backed up by observed evidence in nearby exploratory holes. Further ground investigation would be required to determine the presence of a larger coal seam at this location.

A review of the CON29M report did not highlight any risk of shallow coal mine workings within 100m of the A1. A further review of historic mapping, dating back to the 1850s also does not show any evidence of historic coal mining.

Though none of the exploratory holes or published data have provided conclusive evidence of there being coal workings in the affected area, it is considered that there still remains a risk of shallow coal workings in the vicinity of Heckley Fence.

COAL OUTCROPS

The coal outcrops are consistent with the above-mentioned inferred coal seam identified by the BGS. The minor coal seam identified in BH/17/13 at approximately 12.3m bgl, suggests it is not a workable seam. However as previously discussed, it is possible that the encountered seam may not be representative of the coal present in the area. No further positive evidence of coal was observed, providing no conclusive evidence of coal outcrops in the area.

MINE ENTRY SHAFTS AND MINE ENTRIES WITH POTENTIAL ZONE OF INFLUENCE

The CON29M report did not pick up any known risk of mine entries. However, three mine entry shafts were identified on the Coal Authority Interactive Map Viewer, with a further shaft identified near the track at Heckley Fence (please refer to Appendix B).

The three shafts are located approximately 300m south of the inferred coal seam. The further abandoned shaft, identified on the BGS Sheet Map, is located at the southern edge of the inferred coal seam (though this was not identified in either of the online Map viewers, as seen in Figure 1). It is possible that the shaft on the BGS mapping and the CA mapping are the same feature, transposed at slightly different locations on the two sets of mapping.

As previously mentioned, no strong evidence of workable seams was encountered during the ground investigation, located within 200m of the identified mine entries. However, there is also no evidence to disprove their existence, and the presence of mine entries in the area indicates that there is still the potential for the presence of workable seams.

4 MITIGATION STRATEGY

4.1 GENERAL

The choice of suitable mitigation measures is dependent on the risk owners attitude towards the risk. Appropriate measures will balance the probability of the risk and the likely impact should it occur, with the cost and practicality of removing or reducing the probability of the risk.

Based on the available information to date, three key mining related risks to sections of the scheme are mine entries, shallow workings and coal outcrops.

4.2 MINE ENTRIES

Based on the available information, mine entry shafts are likely to be located south of Heckley Fence. Though the CON29M report and PSSR did not highlight any risk of shafts or mine workings in the area, it is recommended that further investigation be carried out at and in the vicinity of Heckley Fence and the proposed area of construction in the form of trial pitting and/or boreholes, to identify potential historic mine entries, workings and their extents.

Near the area of potential mine shafts, a diversion of an existing 20kV over-head line (OHL) is proposed, however in the DHRA the electric route is to be retained, where wooden pylons carry the distribution line. It is recommended that, if new pylons are to be installed, and should shafts be identified during the GI, the pylons should be located to avoid the area of shafts (it should be noted that the existing pylons roughly coincide with the area where the shafts are depicted). If this is not possible, treatment of any shafts should be carried out, and consist of their filling, using either backfill and additional grouting where backfill alone is considered to be inadequate or capping if the shaft is found to be of significant depth.

The potential mine shaft at the track of Heckley Fence as depicted on the BGS mapping is considered to be east of the proposed overbridge and approach embankments. However, should the presence of a mine shaft be confirmed, treatment will still be required in the nature of either backfilling and grouting or capping if the shaft is found to be of significant depth, to avoid any possibility of future collapse.

It would also be considered sensible for the Contractor to avoid the areas of mine entries as much as is possible during construction to avoid further risk.

4.3 SURFACE COAL/ COAL OUTCROPS

Though coal outcrops were identified by the Coal Authority at Rock South track and Heckley Fence, no evidence was observed in the exploratory holes to confirm their presence. However, it is considered that there is insufficient information to fully rule out their presence and further ground investigation is likely to be required as part of detailed design. It is currently considered that there is a low risk of encountering coal outcrops.

4.4 SHALLOW MINING

Given the lack of evident shallow workings across the site, in general it is considered that there is a low risk of encountering shallow coal workings across the site. However, it is possible that shallow coal workings are present within the red-line boundary.

It should be highlighted that no structures are proposed along the track to Rock South Farm. The work is to comprise the construction of a track on the western edge of the existing track, with minor earthworks associated, therefore any unexpected mining features would relate to the management of risk to the track. However, at Heckley Fence, where an overbridge structure with associated embankments is proposed, should mining features be encountered, more considerable treatment works will be required. It is therefore recommended that at Heckley Fence further ground investigation be carried out, to the east of the A1, to gain further information on the location of any voids or worked coal seams.

If evidence of shallow workings were encountered, and treatment deemed to be necessary, then a grid of grouted probe holes is recommended, to infill any voids of broken ground. The probes would likely be drilled to within 2m below the anticipated seam depth, and a 'grout curtain' be used to prevent the migration of grout outside of the footprint of the structure and earthworks.

A high strength geogrid beneath embankment or road pavement foundation to control settlement in the case of surface movement due to the collapse of any unrecorded workings could also be utilised as required. This may represent a cost-effective solution where mining underlies proposed modified farm tracks.

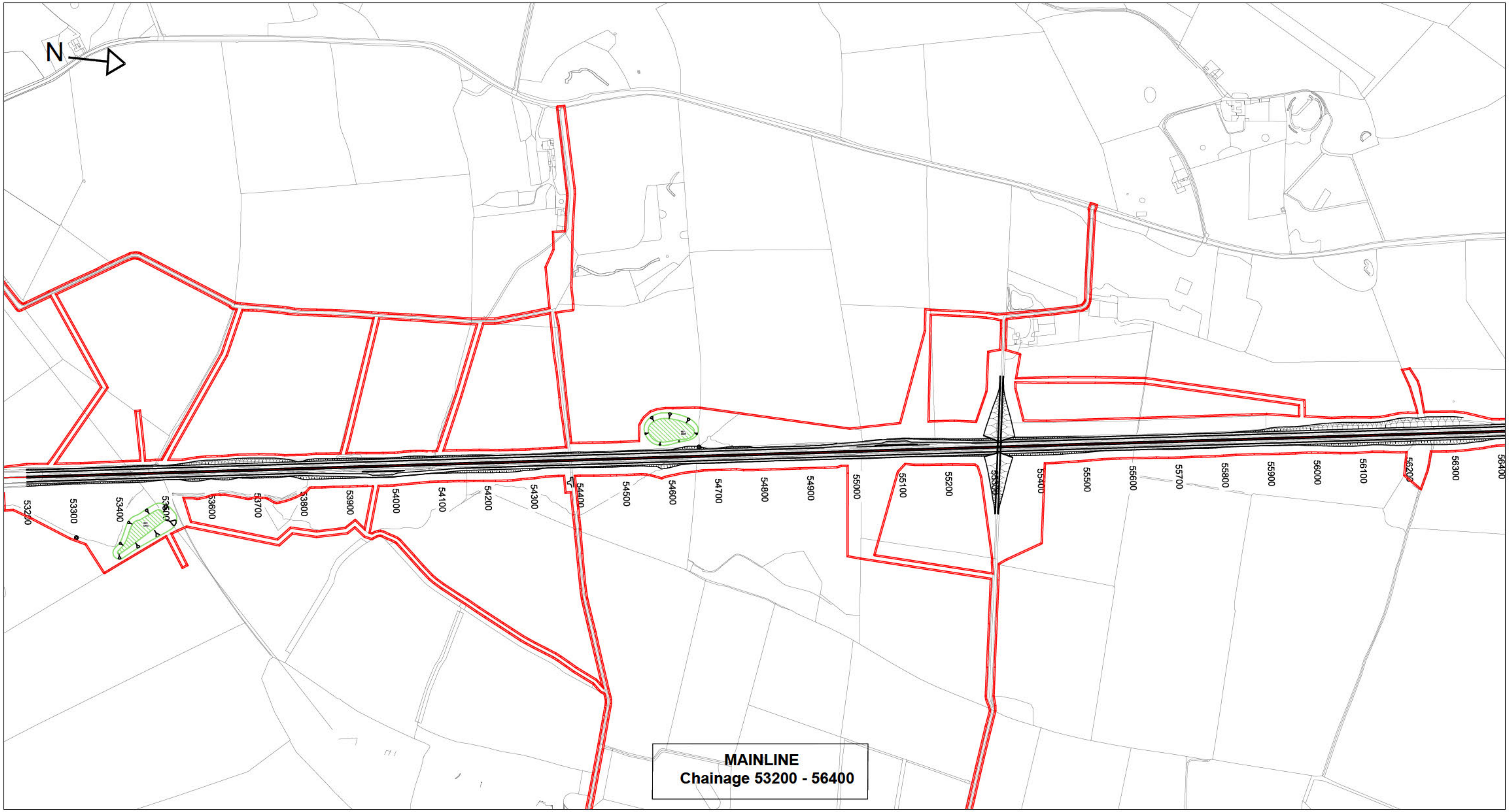
It is expected that the Design and Build Contractor provide full details of any required remedial measures as part of the CA's permitting system prior to any treatment. Records of any treatment would be detailed in the scheme Geotechnical Feedback Report as set out in HD 22/08.

5 REFERENCES

1. A1 in Northumberland. Alnwick to Ellingham. Preliminary Sources Study Report. Version 3.0. HAGDMS No. 29384. January 2017. Jacobs
2. Coal Authority Interactive Map Viewer http://mapapps2.bgs.ac.uk/coalauthority/home.html
3. National Library of Scotland http://maps.nls.uk
4. Risk based approach to development management' Version 4. 2017, The Coal Authority,
5. Highways Agency (2008) HD 22/08 - Managing Geotechnical Risk. DMRB 4.1.2. The Stationary Office. 2008. Highways Agency.
6. CIRIA C758. Construction over abandoned mine workings. 2002. PR Healy, JM Head.

Appendix A

DRAWINGS



NOTES

- Proposed Highway Alignment

Red Line Boundary

Proposed Detention Basin

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd
P02	10/19	Amendments following HE review	OM	MH	BS	DM
P01	09/19	First Issue	OM	MH	BS	GH

Suitability: Suitable for Information

Status: S2

Project Title: A1 in Northumberland
Alnwick to Ellingham

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Drawing Title: Alignment Plan
Sheet 1 of 3

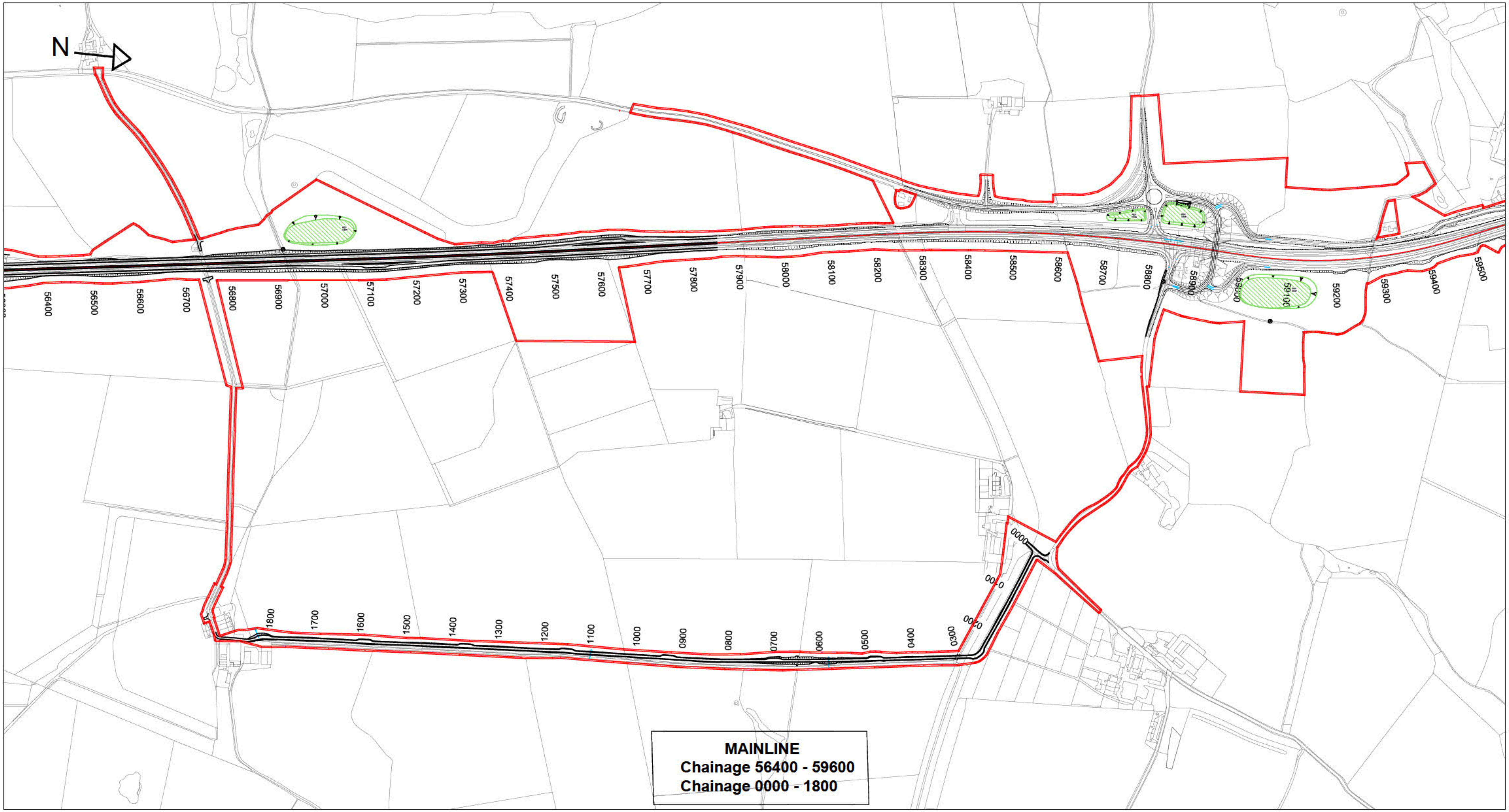
Scale	Drawn	Eng. Check	Approved	Authorised
1:10000	OM	MH	BS	GH
Original Size	Date	Date	Date	Date
A3	30/05/2019	09/2019	09/2019	09/19

Client: highways england

Drawing Number

HE PIN	Originator	Volume	Revision
HE551459	WSP	HGT	P02

Section	Type	ID	Direction	Type	Role	Number	PW Stage Code
A2E				DR	CE	000004	3



NOTES

- Proposed Highway Alignment.

Red Line Boundary

Proposed Detention Basin

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd
P02	10/19	Amendments following HE review	OM	MH	BS	DM
P01	09/19	First Issue	OM	MH	BS	GH

Suitability: Suitable for information

Status: S2

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Client: highways england

Project Title: A1 in Northumberland Alnwick to Ellingham

Drawing Title: Alignment Plan Sheet 2 of 3

Scale	Drawn	Eng. Check	Approved	Authorised
1:10000	OM	MH	BS	GH
Original Size: A3	Date: 30/05/2019	Date: 09/2019	Date: 09/2019	Date: 09/19

Drawing Number

HE PIN	Originator	Volume	Revision
HE551459	WSP	HGT	P02

Section	Type	ID	Direction	Type	Role	Number	PW Stage Code
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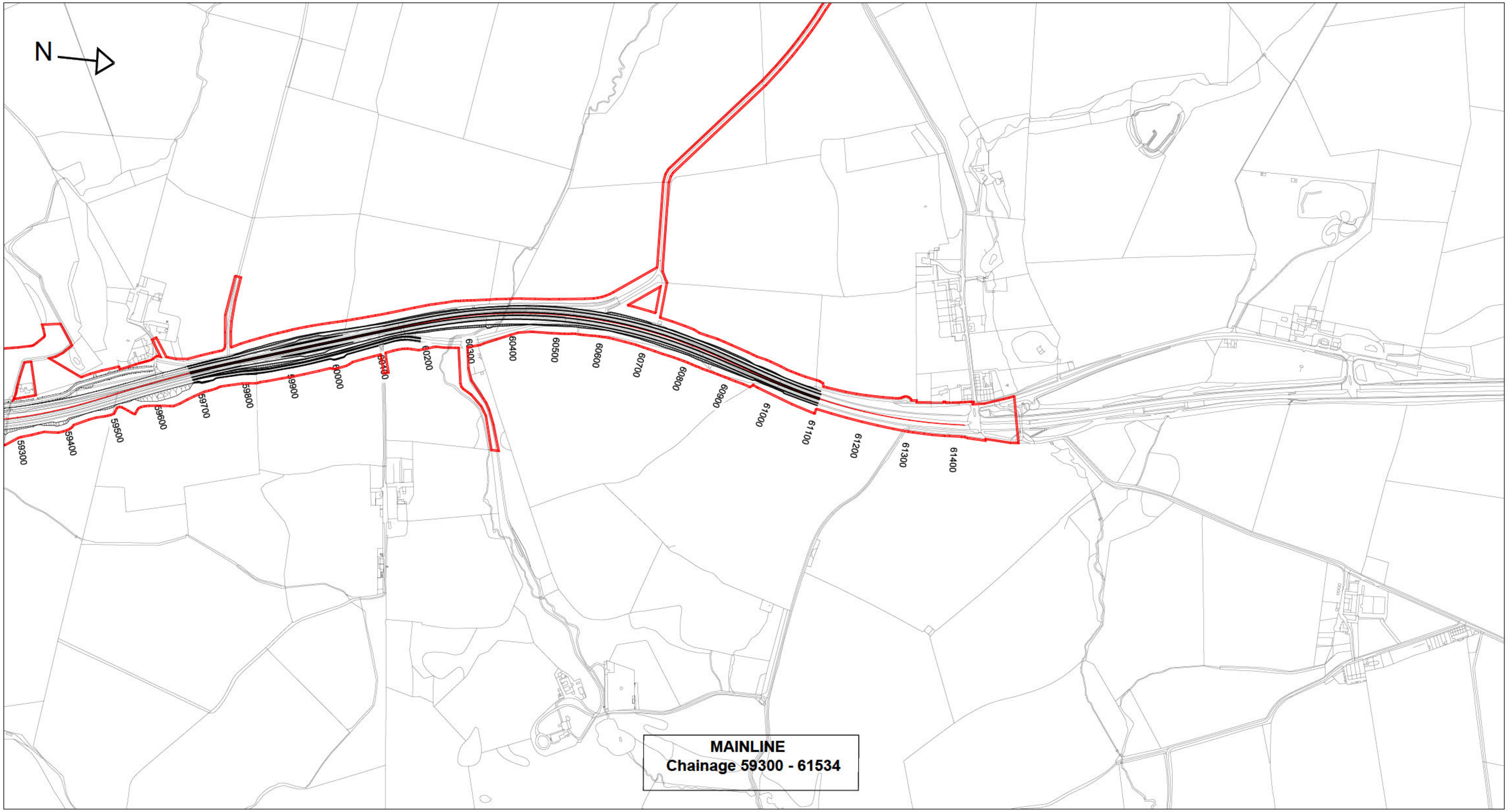
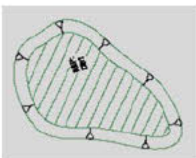


NOTES

- Proposed Highway Alignment.

Red Line Boundary



Proposed Detention Basin

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd
P02	10/19	Amendments following HE review	OM	MH	BS	DM
P01	09/19	First Issue	OM	MH	BS	GH

Suitability: Suitable for Information

Status: S2

Project Title: A1 in Northumberland
Alnwick to Ellingham

Drawing Title: Alignment Plan
Sheet 3 of 3

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Client: highways england

Scale	Drawn	Eng. Check	Approved	Authorised
1:10000	OM	MH	BS	GH

Original Size	Date	Date	Date	Date
A3	30/05/2019	09/2019	09/2019	09/19

Drawing Number

HE PIN	Originator	Volume
HE551459	WSP	HGT

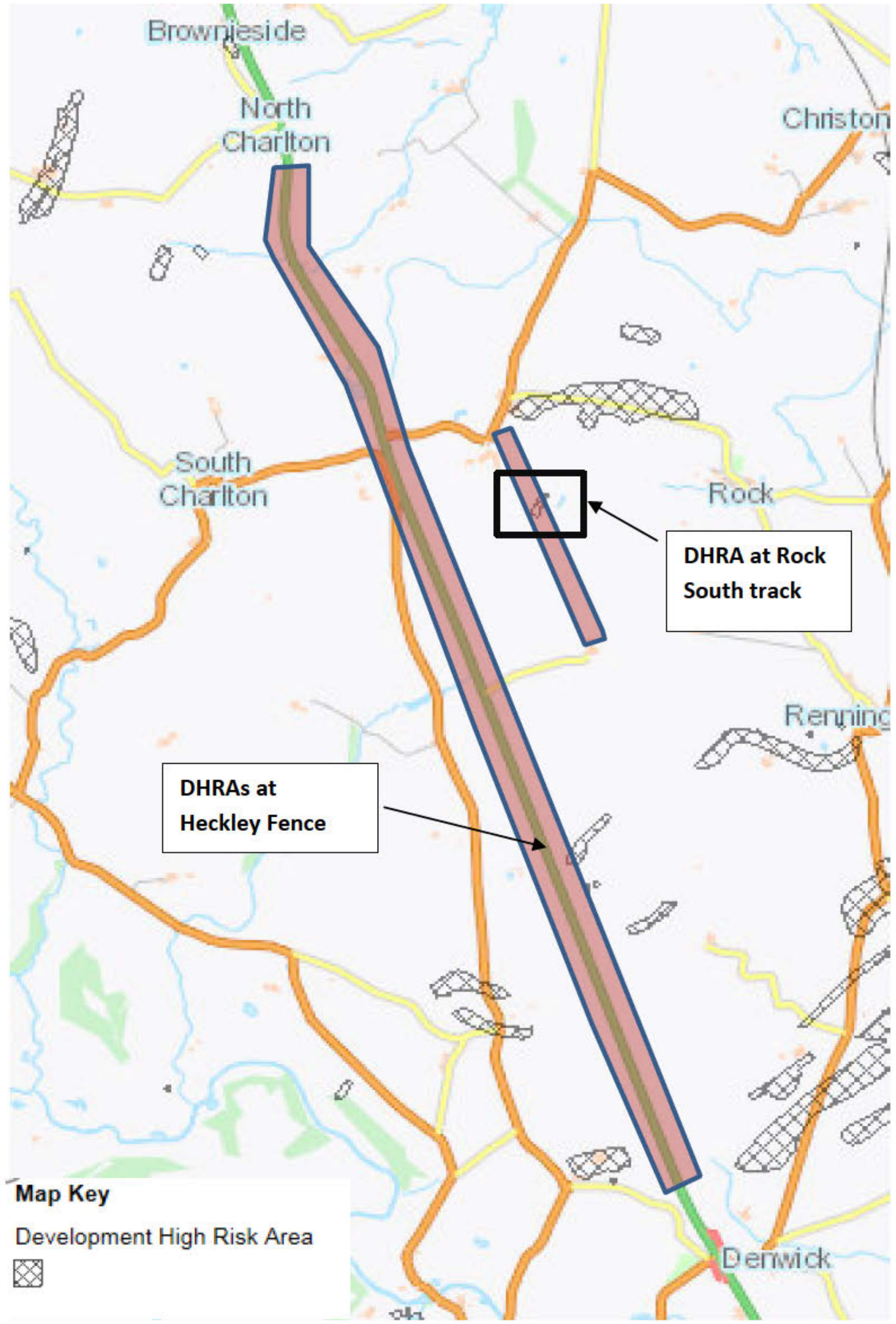
Section	Type	ID	Direction	Type	Role	Number
A2E				DR	CE	000006

Revision: P02

PW Stage Code: 3

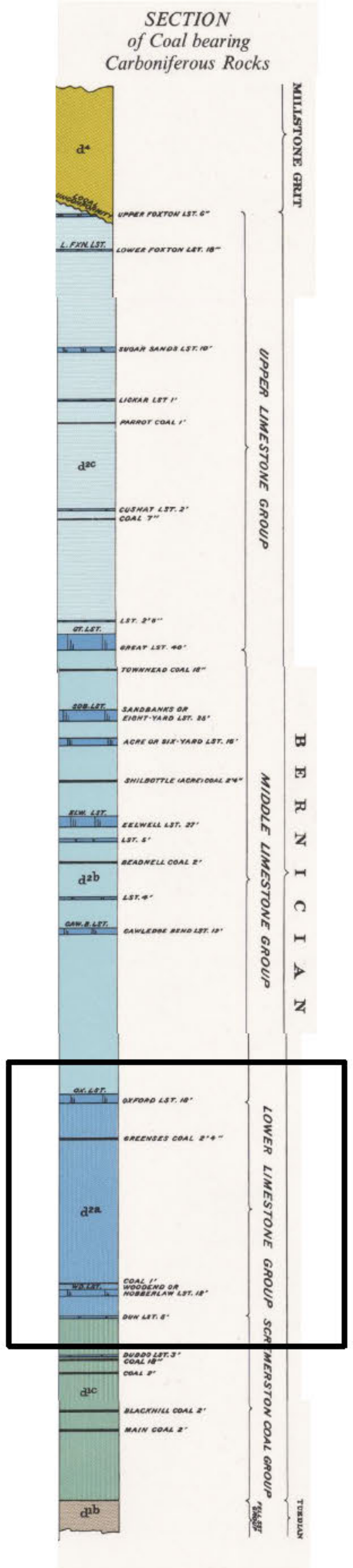
Appendix B

DATA FROM BGS



Location of Development High Risk Areas

(Coal Authority Interactive Viewer, 2019. http://mapapps2.bgs.ac.uk/coalauthority/home.html)



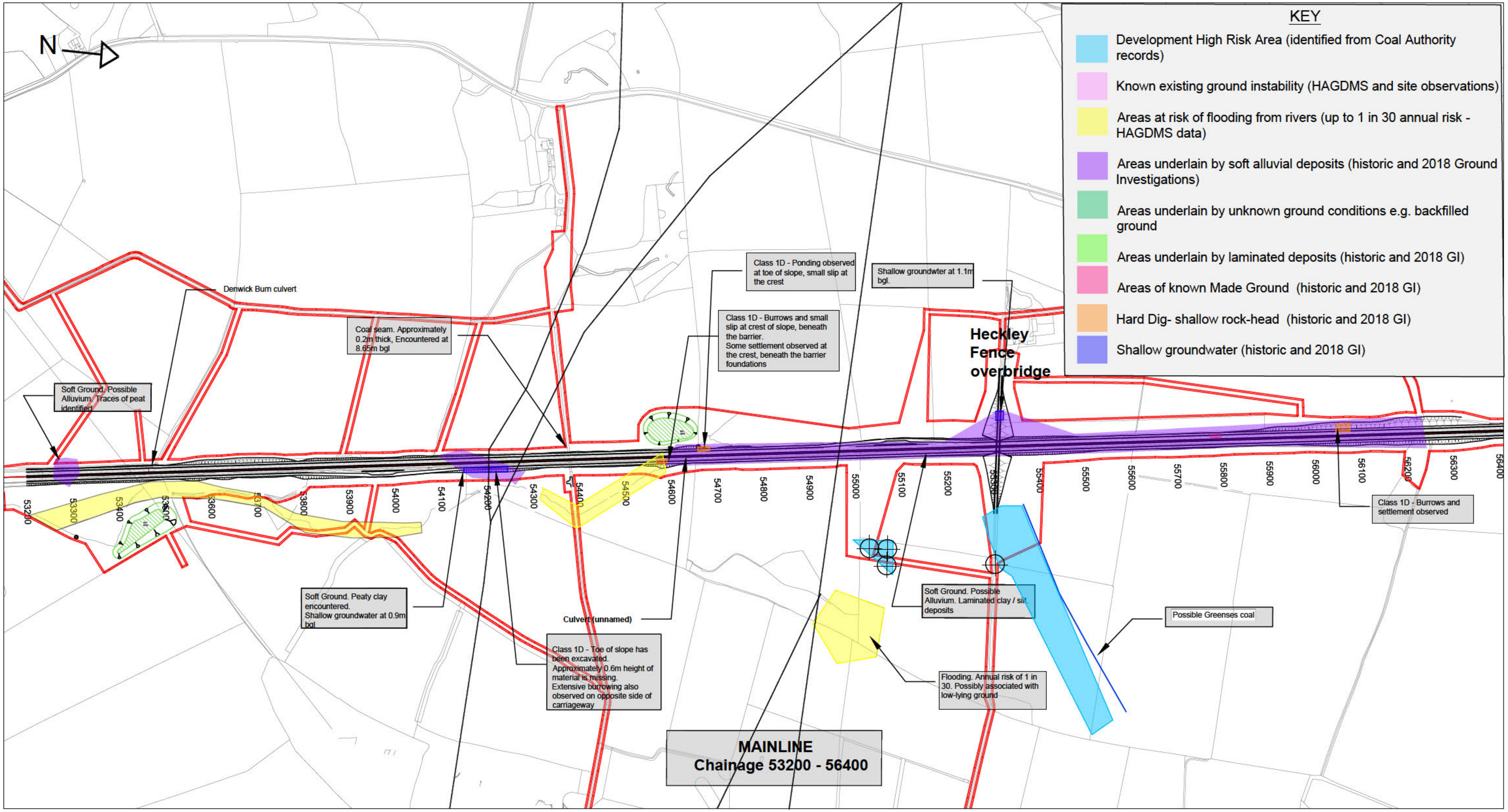
Heckley Fence

Red-Line Boundary and Alignment, May 2019

BGS Map Sheet 6. Alnwick. 1975 Scale 1:50 000

Appendix C

GEOHAZARD PLANS



NOTES

1. To be read in conjunction with the A1 A2E Ground Investigation Report and A2E Factual Ground Investigation Report
2. For indicative cross-sections please refer to long section drawings

Red Line Boundary

Possible Mine shafts

Proposed Detention Basin

Inferred Fault

Inferred Coal Seam

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd
P02	11/19	Amendments following HE review	HS	MH	BS	BS
P01	09/19	First Issue	OM	JH	BS	BS

Suitability: ISSUE

Status: S1

Project Title: A1 in Northumberland Alnwick to Ellingham

Drawing Title: Geohazard Plan Sheet 1 of 3

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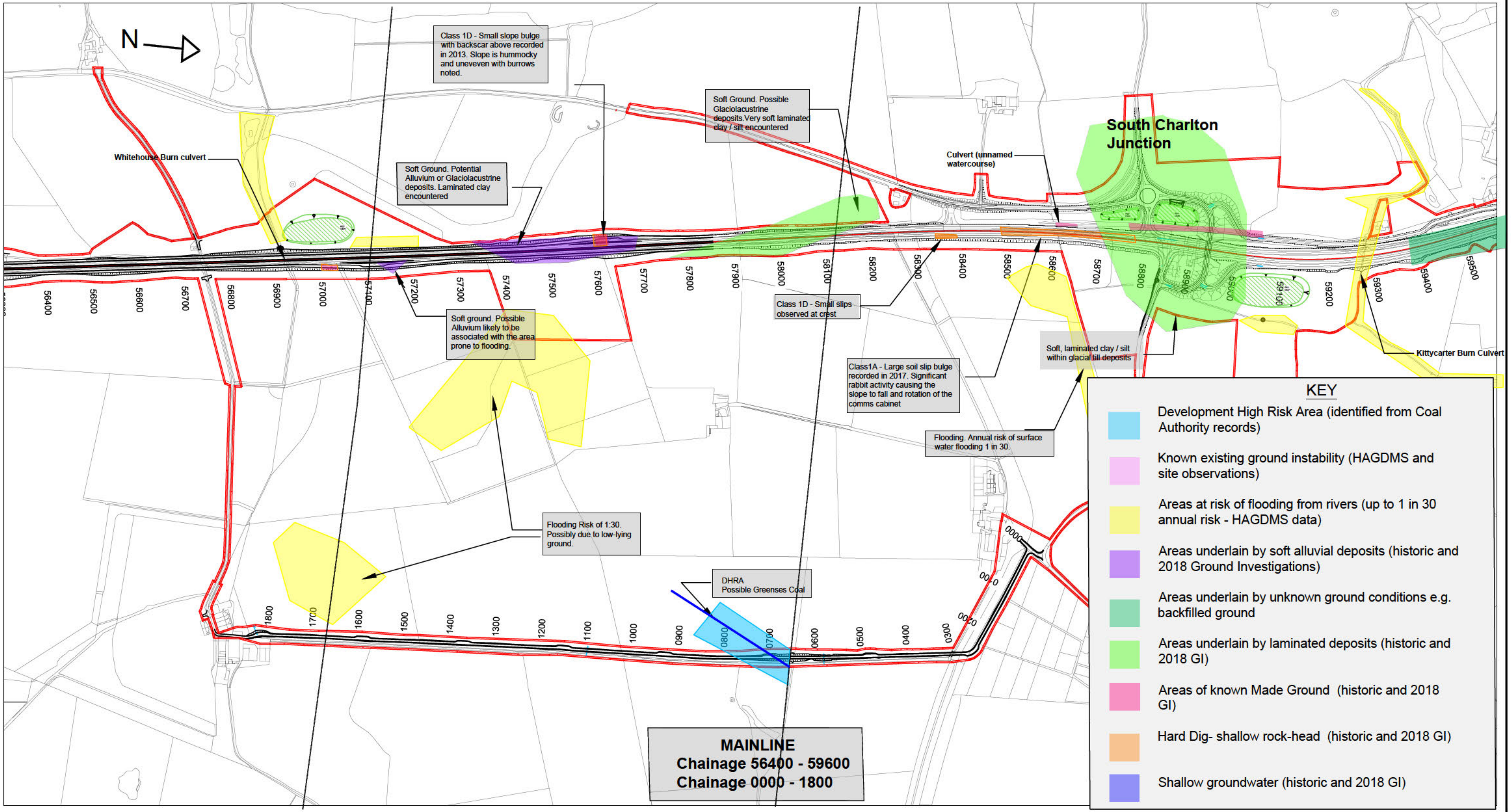
Scale	Drawn	Eng. Check	Approved	Authorised
1:10000	OM	JH	BS	GH
Original Size	Date	Date	Date	Date
A3	17/04/2019	02/05/2019	09/2019	09/19

Drawing Number

HE PIN	Originator	Volume				Revision
HE551459	WSP	HGT				P02
A2E			DR	CE	000001	PW Stage Code: 3
Section	Type	ID	Direction / Type	Role	Number	



NOTES

1. To be read in conjunction with the A1 A2E Ground Investigation Report and A2E Factual Ground Investigation Report
2. For indicative cross-sections please refer to long section drawings

Red Line Boundary

Possible Mine shafts

Proposed Detention Basin

Inferred Fault

Inferred Coal Seam

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd
P02	11/19	Amendments following HE review	HS	MH	BS	BS
P01	09/19	First Issue	OM	JH	BS	BS

Suitability: ISSUE
Status: S1

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Project Title: A1 in Northumberland
Alnwick to Ellingham

Drawing Title: Geohazard Plan
Sheet 2 of 3

Scale	Drawn	Eng. Check	Approved	Authorised
1:10000	OM	JH	BS	GH
Original Size	Date	Date	Date	Date
A3	17/04/2019	02/05/2019	09/2019	09/19

Drawing Number
HE PIN: HE551459
Originator: WSP
Volume: HGT
Revision: P02

Section	Type	ID	Direction	Type	Role	Number
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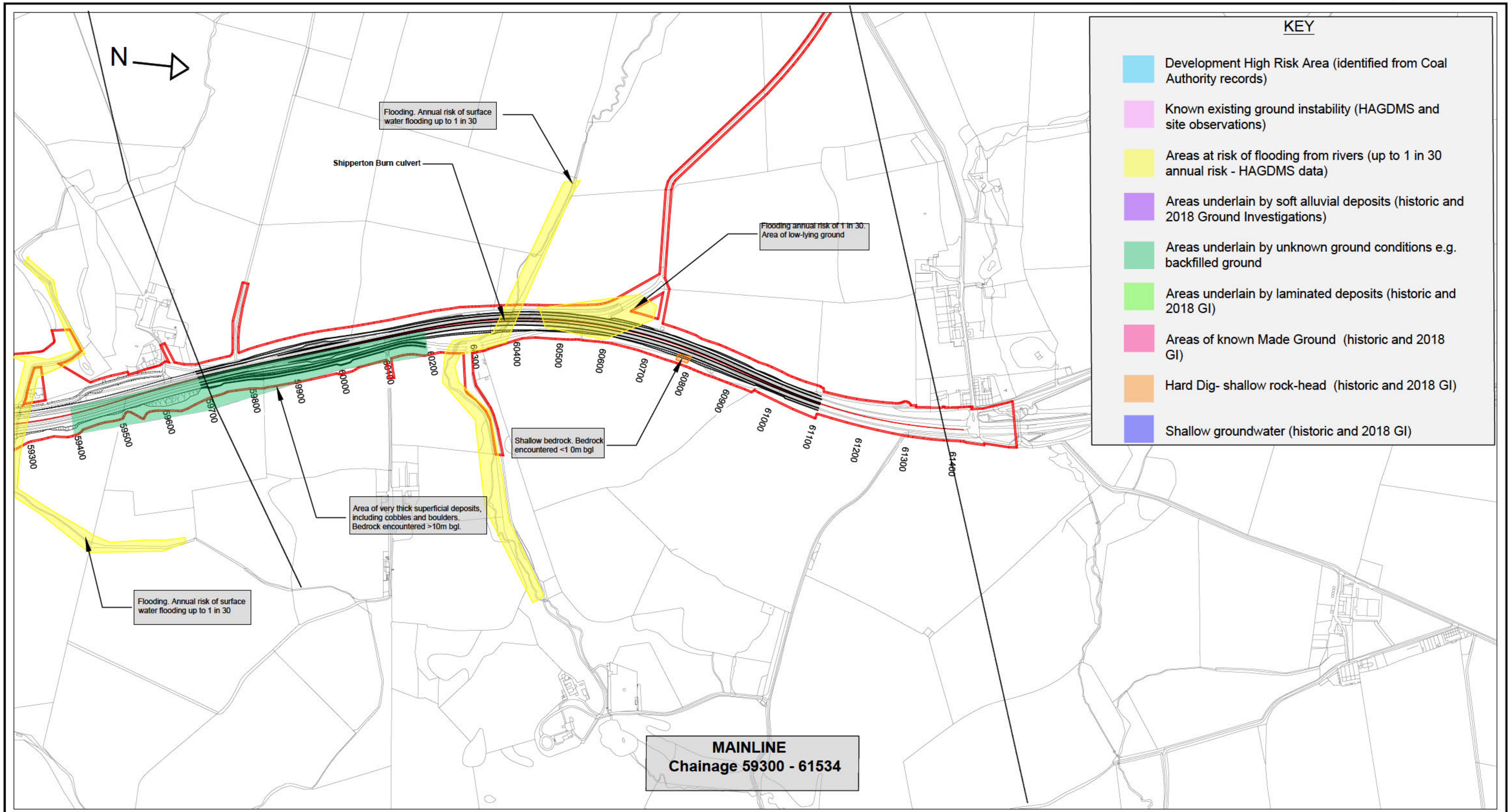
PW Stage Code: 3



NOTES

1. To be read in conjunction with the A1 A2E Ground Investigation Report and A2E Factual Ground Investigation Report
2. For indicative cross-sections please refer to long section drawings

Red Line Boundary

Possible Mine shafts

Proposed Detention Basin

Inferred Fault

Inferred Coal Seam

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd
P02	11/19	Amendments following HE review	HS	MH	BS	BS
P01	09/19	First Issue	OM	JH	BS	BS

Suitability: ISSUE

Status: S1

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Project Title: A1 in Northumberland
Alnwick to Ellingham

Drawing Title: Geohazard Plan
Sheet 3 of 3

Scale	Drawn	Eng. Check	Approved	Authorised
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Original Size	Date	Date	Date	Date
A3	17/04/2019	02/05/2019	05/19	09/19

Drawing Number
HE PIN: HE551459
Originator: WSP
Volume: HGT

Section	Type	ID	Direction	Type	Role	Number
A2E				DR	CE	000003

Revision: P01

PW Stage Code: 3

Appendix F

RISK REGISTER

GEOTECHNICAL RISK EVALUATION MATRIX

PROBABILITY (P)		
Very High	Very likely >75%	5
High	Probable 40-75%	4
Medium	Poss ble 10-40%	3
Low	Unlikely 2-10%	2
Very Low	Negligible <2%	1

IMPACT (I)		TIME	COST
Very High	5	>50%	>20%
High	4	25-50%	10-20%
Medium	3	10-25%	5-10%
Low	2	2-10%	1-5%
Very Low	1	<2%	<1%

RISK		IMPACT (I)				
		5	4	3	2	1
PROBABILITY (P)	5	25	20	15	10	5
	4	20	16	12	8	4
	3	15	12	9	6	3
	2	10	8	6	4	2
	1	5	4	3	2	1

Risk Ratings

1 to 4	Low Risk
5 to 10	Medium Risk
12 to 16	High Risk
20+	Critical Risk

Sources: Probability and impact nomenclature and scorings are based on a number of sources including -

HD22 /02 Managing Geotechnical Risk

Describing probability: The limitations of natural language (Hillson)

Probability frequencies and the % increase of costs are WSP derived values

Risk rating nomenclature, scorings & guideline actions are taken from the following sources:

Name of Project: A1 in Northumberland Alnwick to Ellingham Dualling

Date of last update: 30-06-2019

Risk Rating (R) X Probability (P) = Impact (I)

GEOTECHNICAL RISK ASSESSMENT

No	Hazard	Risk	Risk Management Measures undertaken to date	Risk Rating following Risk Management undertaken to date			Proposed Risk Management Measures	Anticipated Risk Rating following proposed Risk Management Measures			Comments or further information
				P	I	R		P	I	R	
1	Areas of weak and compressible soils (alluvium, glaciolacustrine deposits and peat).	Unacceptable or differential settlement, subsidence and / or failure of the ground which may result in damage or failure of structures, pavement and earthworks. Inadequate CBR value for fill and / or sub-grade	A review of historical ground investigation identified areas of soft ground and provided some information on ground conditions along the route. A ground investigation has been carried out to target the areas of soft ground along the route to acquire detailed information on the ground conditions. Areas of soft ground to be shown on geohazard plans	3	3	9	Detailed design to consider these risks for structure foundation design, road pavement foundation, and earthworks.	1	3	3	
2	High or perched groundwater	Shallow groundwater may impact works during construction, particularly with risk to flooding excavations. Detention basins may become flooded with groundwater.	A review of historical ground investigation data identified areas where shallow groundwater was observed. The Ground investigation included groundwater monitoring installations and soakaway assessments in locations of potential detention basins.	2	4	8	Detailed designer to review groundwater monitoring data. Detention basins shall be kept to minimum depth where shallow groundwater has been identified.	1	4	4	It is noted that the GI was carried out during a period of particularly dry weather and groundwater levels may be higher than monitoring data shows. Additional monitoring may be considered during the winter 2019/20
3	Lenses of laminated glacio-lacustrine deposits.	Potential for failure of earthworks following construction along the planes of weakness.	A review of historical ground investigation data in the area has identified the potential for areas of glacio-lacustrine deposits in some areas of the site. Where these areas have been targeted and confirmed with GI the zones of laminated clays have been identified and highlighted on the geohazard plans	2	3	6	Parameters for design and calculations shall take this into account for such materials.	1	3	3	
4	Presence of cobbles and boulders, hard dig and shallow rock	Difficulties in excavating material for shallow foundations and / or earthworks. May present delays to programme	A review of historical ground investigation in the area has identified areas of hard dig. Ground investigation identified the presence of extensive cobbles and boulders within the Glacial Till.	2	3	6	Detailed design to consider shallow rockhead for structural foundation design and excavations.	1	3	3	

No	Hazard	Risk	Risk Management Measures undertaken to date	Risk Rating following Risk Management undertaken to date			Proposed Risk Management Measures	Anticipated Risk Rating following proposed Risk Management Measures			Comments or further information
				P	I	R		P	I	R	
5	Unknown workings within shallow coal seams	Potential for ground failure due to excessive settlement or insufficient bearing capacity. Rising groundwater levels may cause future instability through impacting mine landscape. Contaminated mine water may enter the drainage system.	A CON29M report was obtained as part of the PSSR indicating the risk of shallow workings beneath the site to be very low. Ground investigation data indicates the presence of a shallow thin coal (less than 300mm thick) in some locations. PSSR that the risk that this has been mined to be very low. Ground investigation carried out across the site which did not identify any evidence of mine workings.	2	4	8	Residual risk of encountering unrecorded coal workings to be considered during detailed design and construction Further ground investigation is recommended at the proposed location of Heckley Fence Overbridge	2	4	8	CA Interactive Online Viewer shows one DHRA beneath the route to South Rock Farm and further DHRA's at Heckley Fence at the location of a 20kV OHL. A Coal Mining Risk Assessment shall be prepared to support the planning application.
6	Weak heavily weathered laminated bedrock	Failure in bearing of piles within bedrock as block leading to failure of the structure.	Ground investigation carried out across the site to provide detailed data on the condition of bedrock in areas of significant structures, i.e. bridges.	1	4	4	Detailed design to review ground conditions at structure locations	1	4	4	
7	Potential contamination of watercourses and environments from existing road network and agricultural land-use. Potential contamination may include hydrocarbons, pesticides, fertilisers and asbestos.	Potential for creating pollution pathways and contaminating groundwater and surface waters. Contaminated soil may require waste disposal treatment which may lead to programme delays and increased programme costs.	The ground investigation included the collection of groundwater and soil samples in order assess potential for and extents of any ground or groundwater contamination. Assessment of GI data has indicated low risk of ground or groundwater contamination.	2	3	6	There may remain unknown areas of contamination within the site. Contractor to remain vigilant for visual and/or olfactory evidence of ground or groundwater contamination during site works.	1	3	3	
9	Insufficient Ground Investigation data	GI is limited in some areas of the scheme due to access restrictions and design development during Stage 3.	The 2018 ground investigation targeted locations of proposed structures, and detention ponds. However, GI was curtailed around Charlton Mires due to access restrictions and detention basin locations were not fully resolved prior to GI fieldworks. It has been recommended that additional GI be considered in these areas prior to detailed design.	3	3	9	It has been recommended that additional GI be considered at South Charlton Mires and detention basins prior to detailed design.	1	3	3	

No	Hazard	Risk	Risk Management Measures undertaken to date	Risk Rating following Risk Management undertaken to date			Proposed Risk Management Measures	Anticipated Risk Rating following proposed Risk Management Measures			Comments or further information
				P	I	R		P	I	R	
10	Re-use of site materials as fill material	The material on site may not be suitable to be used as fill across the scheme due to natural moisture content being higher than optimum content. Material may require drying or treatment. May need to import fill for construction	Ground investigation and laboratory testing has been undertaken to confirm the natural moisture content and optimum moisture content of the site soils. This has indicated during or treatment will be required for re-use of site won materials as a Class 2 material.	3	3	9	Contractor should consider the use of treatment trials prior to commencing site earthworks. Contractor to consider programming earthworks processes during drier months and avoid carrying our operations during winter to make best use of site materials.	1	3	3	

Appendix G

DESIGN GROUND MODEL

Project No		Project Name			
Date		Client			
Calculation Ref		Page No		Total No of Pages	
Calculation By		Checked By			

Section C: Calculation Details

Ref		Comments

South Charlton Overbridge

Ground Model Summary (January 2019)

Parameter		Units	Fine-grained Glacial Till (Upper)	Granular Glacial Till (Upper)	Glaciolacustrine Deposits	Fine-grained Glacial Till (Lower)	Granular Glacial Till (Lower)	Limestone
Elevation[3]	Top	(m AOD)	87 (W)	87 €	85 (W) 84.5 €	81.5 (W) 83 €	74 (W)	68 (W)
	Base		85 (W)	84.5 (E)	81.5 (W) 83 (E)	74 (E; W)	68 (W)	-
γ (Bulk)		kN/m^3	16	17	18	19	17	25
γ (Saturated)		kN/m^3	16	20	18	19	20	25
C'		kN/m^2	C' not required for pile design					
UCS		MPa	N/A	N/A	N/A	N/A	N/A	25
ϕ'		°	24.5	39.0	27.1	30.2	42.0	35.0
RQD (Average)		%	N/A	N/A	N/A	N/A	N/A	1
E_u		MPa	7.5	41	16.67	33.33	48	40817.5
E'		MPa	4.5	36	10	20	29	
v^2		N/A	0.2	0.2	0.2	0.2	0.2	0
M_C		%	15.7	-	29	16	-	Soil Parameters
P_L		%	27.0	-	20.7	14	-	
L_L		%	53.0	-	36.7	23	-	
I_P		%	26.0	-	16	9	-	
C_u		kPa	22	-	42	100	-	
Assume $E_h = 1.0E_v$								
Groundwater Elevation		(m AOD)	g/w at 84.5m AOD to East					

GEOTECHNICAL CERTIFICATE

Scheme Title: A1 in Northumberland - Alnwick to Ellingham

Report Title: Ground Investigation Report

Project Title: A1 Morpeth to Ellingham dualling

(*-Delete as appropriate) Certificate Seq. No. WSP1

HAGDMS No: 31531

GEOTECHNICAL CERTIFICATE

Form of Certificate to be used by the Designer for certifying the design of geotechnical works

1. We certify that the Reports*, ~~Design Data*, Drawings* or Documents*~~ for the Geotechnical Activities listed below have 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*/Client's* requirements

iv. with the exception of any item listed below or appended overleaf, the documentation has been prepared in accordance with the relevant standards from the Design Manual for Roads and Bridges and the Manual of Contract Documents for Highway Works

where the certificate is accompanying revision to design data already certified the following statement shall also be included

v. ~~*The design elements covered by this certificate are not detrimental to the design elements previously certified and not amended by this certificate*~~

2. LIST OF REPORTS, DESIGN DATA, DRAWINGS OR DOCUMENTS

Scheme Title: A1 in Northumberland - Alnwick to Ellingham

Report Title: Ground Investigation Report

HA GDMS Report Number: 31531

3. DEPARTURES FROM STANDARDS

None

list of any departures from relevant standards if none write 'none'

~~*4. INCORPORATION OF GEOTECHNICAL DATA INTO CONSTRUCTION DETAILS~~

~~*where the certificate is accompanying final design data the following statement shall also be included*~~

~~*The Reports, Design Data Drawings or Documents listed in 2. above have been accurately translated onto the construction drawings or other design documents bearing the unique numbers listed below/appended overleaf.*~~

Sign[redacted]

Designer (Designers Geotechnical Advisor)

Name[redacted]

Date: ....17/1/20..................

On behalf of

........WSP UK LTD.

*Signed: ....

*Contractor (Agent or Contracts Director)

*Name: ....

*Date: ....

*On behalf of

....

This Certificate is:

(a) received* (see note)
(b) received with comments as follows:* (see note)
(c) returned marked "comments" as follows:* (see note)

Signed: ....

Overseeing Organisation Geotechnical Advisor

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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If you have any enquiries about this document A1inNorthumberland@highwaysengland.co.uk or call **0300 470 4580***.

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