A1 in Northumberland: Morpeth to Ellingham

Scheme Number: TR010041

6.7 Environmental Statement – Appendix 11.2 Ground Investigation Report

Part A

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

Regulation Reference:	APFP Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010041
Application Document Reference	TR010041/APP/6.7
Author:	A1 in Northumberland: Morpeth to Ellingham Project Team, Highways England

Version	Date	Status of Version
Rev 0	June 2020	Application Issue

Highways England

A1 IN NORTHUMBERLAND: MORPETH TO FELTON SCHEME

Ground Investigation Report

HAGDMS NO. 30125
FEBRUARY 2019

INTERNAL

QUALITY CONTROL

Issue/revision	Third issue
Remarks	S2 – Issued For Information
Date	February 2018
Prepared by	Matt Howard
Signature	[redacted]
Checked by	Jim Harbord
Signature	[redacted]
Authorised by	Bob Seedhouse
Signature	[redacted]
Project number	HE551459-WSP-HGT-M2F-RP-CE-518
Report number	HAGDMS No. 30125
File reference	

CONTENTS

TABLES

FIGURES

APPENDICES

1. EXECUTIVE SUMMARY

Approximately 13km of the A1 located between Morpeth and Felton, Northumberland has been identified for upgrading. 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 a combination of on-line carriageway widening and construction of a new off-line section of road and associated structures across a largely agricultural area. The route can be broadly split in to four sub sections;

- Section 1; (approximately 2.9km) Widening to the west of the existing A1 carriageway which is largely at grade. One cutting up to 4.0m deep is proposed and two embankments up to 3.5m in height are required where the scheme traverses two culverts. A new junction overbridge is proposed at Highlaws Junction.
- Section 2; (approximately 6.3km) New off-line road. Predominantly minor earthworks proposed with occasional moderately sized embankments between 3.5 and 8m in height and cutting 3.0 and 6.0m in height. Several new structures are proposed at Fenrother Junction, Burgham Junction and Causey Park Overbridge with new culverts or culvert extensions where the route dissects existing watercourses. Significant past mining activity has been identified in the vicinity of Causey Park.
- Section 3; (approximately 1.9km) Widening is predominantly to the west of the existing A1 carriageway which is largely at grade. The proposed widening passes close to Eshott Airfield. A new Junction overbridge is proposed at Westmoor Junction and two culvert extensions for Longdike Burn and Thirston Burn.
- Section 4; (approximately 1.7km) Widening predominantly to the east of the existing A1 with widening to significant embankments and cuttings up to 10.5m in height. A new structure is proposed to the east of the existing bridge across the River Coquet as part of the upgrade to dual carriageway to this section of the A1. Extension to the existing subway and culvert at Parkwood is also proposed.

A walkover and geomorphological mapping re-survey of the area of known instability on the northern banks of the River Coquet was undertaken in February 2018. The survey concluded that there was no significant change to the area since the former mapping campaign in February 2014 but further tension crack monitoring should be continued along with additional GI, undertaking of an up-to-date topographical survey and long-term groundwater monitoring.

Various phases of GI have been undertaken over the scheme evolution combining cable percussive, rotary coring, trial pitting and dynamic probing techniques, with the latest GI undertaken in 2017, largely at the location of proposed structures and localised alignment changes. Some soakaway testing, rising head permeability testing, geophysical surveys and downhole televiewers have also been deployed. 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. Notable areas of significant Made Ground were encountered adjacent to Longdike Burn (~4.0m thick), Eshott Airfield (~2.0m thick), and at the northern extents of the scheme in the form of

Embankment Fill (up to 16.5m thick), shallow granular remediation backfill in cuttings (up to 2.5m thick) and related to the northern abutment earthwork of the River Coquet (proven to 10.2m bgl).

Recent deposits of shallow Alluvium, generally less than 2.0m thick, comprising sand, silt, clay, peat have been proven adjacent to the minor watercourses, and sands and gravels adjacent to the River Coquet in the extreme northern part of the route. These overly extensive deposits of Devensian 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 in excess of 25m recorded in apparent glacial valleys, particularly around Westmoor Junction. Laboratory results show the in-situ cohesive till generally to lie on the wet side of the optimum moisture content.

Local to the notable watercourse that dissect the route, the groundwater levels are fairly stable between 0.5m and 1.0m bgl. Piezometers and standpipes installed within the Glacial Deposits recorded groundwater generally at depths of between 1.5 and 2.5m bgl.

The Stainmore Formation of the Carboniferous period underlies the superficial deposits over the majority of the route and comprises interbedded mudstones, siltstones and sandstones. Some of the strata, particularly on the older borehole logs, are undifferentiated. Minor coal seams with a typical thickness of 0.35m, but up to 2.1m, have been proven within the sequence. The Corbridge Limestone strata is a shelly unit within the Stainmore Formation that occurs only in the vicinity of the River Coquet between depths of 4.0m bgl and 50m bgl.

Rock head elevation is variable along the route and coincides with changes in the thickness of the glacial deposits. Bedrock was proven at ground level at the southern extents of River Coquet to >25m bgl local to Eshott Airfield. A relatively thin layer of residual soil representing the completely weathered zone of the underlying bedrock described as very weak Mudstone, Siltstone or Shale recovered as a stiff clay or clayey gravel was encountered overlying the intact rock. The recent boreholes indicate this stratum is generally around 0.5m to 1.0m thick.

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:

- Unidentified voids associated with shallow underground mine workings and abandoned shafts and adits; associated with shallow underground mine workings and abandoned shafts and adits are deemed only to be a risk in the vicinity Causey Park and Eshott Airfield.
- Presence of unforeseen poor ground; Weak & compressible soils; associated with areas of Alluvium, particularly in relation to the proposed River Coquet Bridge
- Shallow rock/ hard dig material; Large cuttings in rock at the northern extents of the scheme.
- Presence of aggressive ground conditions;
- Shortfall of quality fill material; Glacial deposits may require drying out for reuse.
- Insufficient GI data; particularly where scheme elements have moved or GI is yet to be completed.
- Determinants within soils which pose a risk to human health and to the environment;
- Instability of existing earthwork slopes on the mainline; known earthwork defects impacted by the scheme.
- Instability of existing River Coquet abutment earthwork; movement and tension cracks evident on northern slope.
- Instability of River Coquet valley; potential for large scale deep seated failures

- Construction work having a destabilising impact on existing River Coquet Foundations; extra loading on an unstable slope.
- High or perched groundwater with the cohesive glacial deposits; and
- Unexploded Ordnance associated with proximity of Eshott Airfield

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. Additional space has been left within the order limits to allow for known geotechnical hazards within cuttings M2FC011, M2FC013 and embankment M2FE07.

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 12 and 25m. Precast concrete box culverts, some encompassing extensions to the existing culverts, will be utilised where watercourses dissect the route and these should be founded on the glacial deposits. Some of the structure options are still in development.

A new crossing is required across the River Coquet, the design development of which is on-going. There are significant geotechnical risks at this location relating to instability of the river valley which are informing the ongoing design development and are summarised in the Risk Register.

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 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 cohesive material will more than likely require some degree of drying. A preliminary assessment of cut/fill balance would indicate a current overall surplus of material.

2. INTRODUCTION

2.1. SCOPE AND OBJECTIVE OF THE REPORT

The A1 in Northumberland: Morpeth to Felton; to be known thereafter as ‘the Scheme’, forms part of the Department for Transport’s (DfT) Roads Investment Strategy (RIS). The A1 Northumberland is the main link road through Northumberland to the North East of Newcastle, connecting England to Scotland. The purpose of the scheme is to upgrade the A1 north of Newcastle Upon Tyne and increase its capacity to perform as a Route of Strategic National Importance.

The upgrade will largely comprise widening the existing road to create a dual carriageway; however, a section of new road will be created for part of the route in order to provide a high quality horizontal and vertical alignment; using topography to minimise cut/fill, avoiding environmentally sensitive areas and nearby residential properties, and minimising effects on agricultural land by following field peripheries where possible.

In January 2006 Norwest Holst Soil Engineering Division carried out Stage 1 of the Ground Investigation (GI). The GI was carried out along the preferred route alignment at that time, adjacent to the existing A1 Trunk Road between Morpeth and Felton. Due to programme constraints it was necessary to carry out GI prior to junction and structure layouts and locations being finalised. A comprehensive Preliminary Geotechnical Report (ref 1) was produced by White Young Green in August 2006 which summarised the desk study information and ground conditions for the scheme area. The data contained within the Stage 1 GI allowed preliminary geotechnical design to be progressed and recommendations for additional ground investigation to be made. AGS data for the 2006 scheme was available although no geotechnical database was set up collating all the exploratory holes relevant to the scheme. In July 2006 the Highways Agency (now Highways England) confirmed that the A1 Morpeth to Felton Dualling Scheme would be paused until further notice.

In 2015 Jacobs were employed by Highways England to take the design of the Scheme, according to the Project Control Framework (PCF), to end of Stage 2 Option development. A Statement of Intent (ref 2), Preliminary Sources Study Report (PSSR) (ref 3) and Annex A (ref 4) were accordingly prepared by Jacobs and in November 2017 Ian Farmers Associates Limited completed a supplementary Ground Investigation across three potential route options incorporating online and offline dualling routes. The purpose of the investigation was to provide preliminary information on the subsurface ground and groundwater conditions along the various proposed routes of the new dual carriageway and specifically at anticipated structure locations.

In August 2016 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 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 presents a summary review of the existing information in relation to the scheme in its current form together with a review of any additional desk study information identified. It was agreed with Highways England that this GIR would build upon the GIR previously submitted by White Young Green (ref 1), incorporating the results of the 2017 GI, a full review of the existing information and any additional information will be incorporated into this report. This report therefore supplements the existing Preliminary Geotechnical Report (ref 1).

The report then presents the ground model for the scheme, incorporating the historic and recent ground investigation information together with its associated risks, in accordance with the guidelines issued by the Highways Agency in HD22/08.

2.2. DESCRIPTION OF PROJECT

As part of the DfT RIS, options are being developed to improve the A1 between Morpeth to 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. This encompasses:

- Section A – Morpeth to Felton. A combination of offline and online dualling;
- Section B – Alnwick to Ellingham. Online dualling only; and
- Section C – North of Ellingham. Improvements to the existing A1; measures to upgrade the performance and safety of the A1 north of Ellingham.

This GIR is for the southern section, Section A - Morpeth to Felton. Sections B and C are reported separately.

The PSSR (ref 3) reported on three route options for Section A and the subsequent ground investigation was tailored to cover all three routes to assist in the selection of the emerging preferred option. The three options investigated included;

- Orange Option: upgrade the existing road to dual carriageway, either widening to the east or the west depending on the local features that need to be considered.
- Green Option: build a new carriageway to the west of the existing road between Priests Bridge and Burgham Park.
- Blue Option: upgrade the majority of the existing road to dual carriageway, with approximately 1.2 miles (2 km) section of new carriageway to the east of the A1 near Causey Park Bridge.

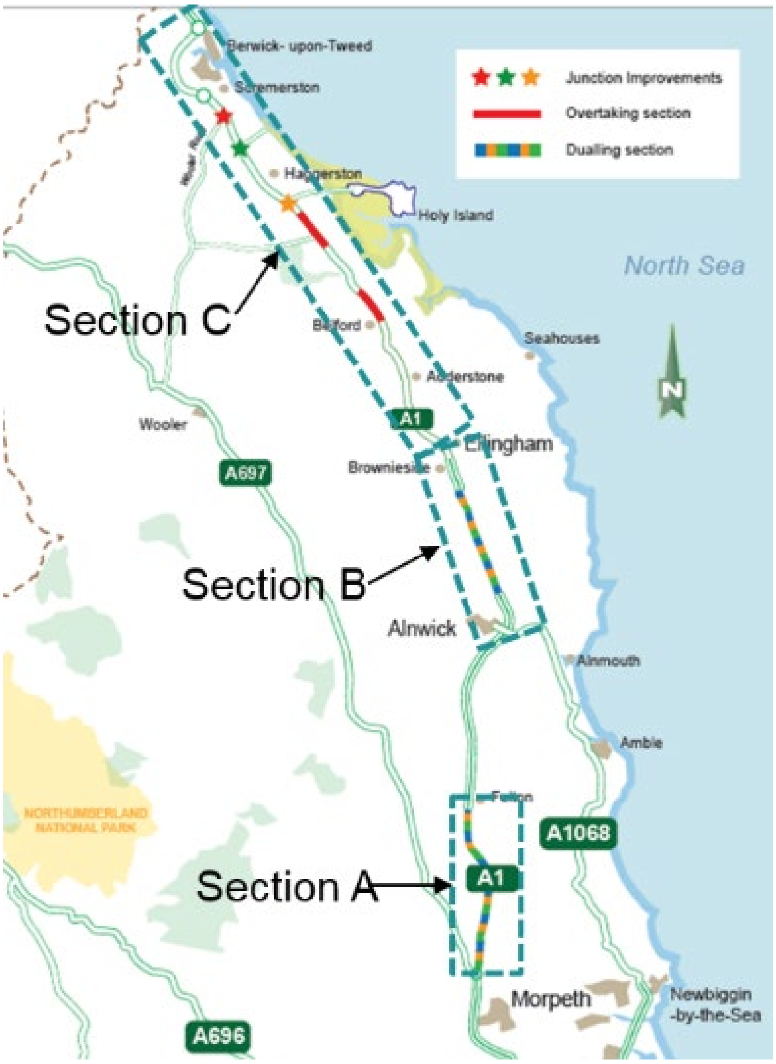


Figure 1 - Location of improvements From Newcastle to Berwick (DFT)

Following an engineering assessment of the three routes and a Public Consultation, the Green option has been chosen as the Preferred Route. This GIR is therefore concerned with the Green option only, although all the available ground investigation data will be collated where global material parameters are deemed appropriate.

SITE DESCRIPTION

Approximately 13km of the A1 proposed for upgrading is located between the existing sections of dual carriageway at Morpeth and Felton, Northumberland. The location of the scheme is shown in Figure 1. The proposed scheme involves a combination of on-line carriageway widening and construction of a new off-line section of road. The predominant land-use in the region is generally agricultural with small associated scattered settlements and the route generally traverses undulating pasture land, with arable land confined along river valleys. The proposed preferred route alignment is shown on the Geohazard Plans in Appendix C.

The subject section of road runs roughly south-north from Ch.10870 in the vicinity of the A192 Junction north of Morpeth (NGR 418221 588520), extending to Ch.23600 north of the B6345 overbridge west of Felton (NGR 417484 600838). The Preferred Route follows the line of the existing A1 carriageway over a distance of 2.9km to Ch.13700 before deviating offline to the west of the existing A1. Similarly, the northern section (Ch 20000 to 23600) runs parallel to the existing A1, with online widening to upgrade the existing road to dual standard. The central offline section of the route between Ch.13700 to 20000 aligns approximately parallel and to the west of the existing A1.

The route can be broadly split in to four sub sections;

- Section A1 Ch.10870 – Ch.13790; widening to the west of the existing A1 carriageway which is currently largely at grade. Two minor embankments up to 3.5m in height are required where the scheme traverses two culverts. One cutting up to 4.0m deep is encountered between Ch.11260 and Ch.11365.
- Section A2 Ch.13790 – Ch.20040; new off-line section of road. Predominantly minor earthworks proposed with occasional moderately sized embankments between 3.5 and 8m in height and cutting 3.0 and 6.0m in height. Significant past mining activity has been identified in the vicinity of Causey Park.
- Section A3 Ch.20040 – Ch.21910; widening is predominantly to the east of the existing A1 carriageway which is currently at grade. The proposed widening passes close to Eshott Airfield (NGR 417684 597792).
- Section A4 Ch.21910 – Ch.23600; widening predominantly to the east of the existing A1 with widening to significant embankments and cuttings up to 10.5m in height. A new structure is proposed to the east of the existing bridge across the River Coquet as part of the upgrade to dual carriageway to this section of the A1.

The earthworks schedule is set out in Table 1. The earthworks split and approximate height is based on the March 2018 design freeze. Earthworks <1.5m in height are considered to be minor earthworks and don't usually have slope stability issues. If an earthwork exceeds 1.5m at any point then the full length of the earthwork becomes part of either a cutting or embankment.

Given the multiple data sources containing pertinent information relating to the scheme, it was agreed with Highways England that the use of earthworks datasheets would be an efficient way of summarising the scheme information ready for detailed design in the next PCF stage. Earthwork datasheets which summarise the local geology and geotechnical risks for each of the individual earthworks can be found in Appendix A.

It should be noted that in some areas where several minor earthworks have been recorded next to each other on HA GDMS with similar ground conditions and geotechnical risk, these have been grouped into one earthwork datasheet for ease of assessment.

Table 1 - Earthworks Schedule

Sub Section	Chainage		Length (m)	Earthwork Asset Type (HD41/15)	Earthwork ID	Max Height (March 2018 Design freeze) (m)	Earthwork(s)
Section A1 (online)	10800	11110	310	Minor	M2FG01	-	At Grade
	11110	11260	150	Minor	M2FG02	-	At Grade
	11260	11370	110	Major	M2FC01	-3.8	Cutting
	11370	11530	160	Minor	M2FC02	-1.8	Split carriageways; Cutting on southbound carriageway
	11530	11640	110	Minor	M2FG03	-	At Grade
	11640	11900	260	Major	M2FE01	3.4	Embankment
	11900	12290	390	Minor	M2FC03	-1.65	Cutting
	12290	13240	950	Minor	M2FG04	-	At Grade
	13240	13480	240	Minor	M2FG05	-	At Grade
	13480	13800	320	Major	M2FE02	3.7	Embankment
Section A2 (offline)	13800	13950	150	Minor	M2FC04	-1.7	Cutting
	13950	14130	180	Major	M2FE03	6.7	Embankment
	14130	14390	260	Minor	M2FC05	-2.4	Cutting
	14390	15000	610	Minor	M2FC06	-1.9	Cutting
	15000	15400	400	Minor	M2FG06	-	At Grade
	15400	15525	125	Minor	M2FG07	-	At Grade
	15525	15910	385	Minor	M2FC07	-2.2	Cutting
	15910	16310	400	Minor	M2FG08	-	At Grade
	16310	16810	500	Minor	M2FC08	-1.95	Cutting
	16810	17300	490	Major	M2FE04	4.2	Embankment
	17300	17490	190	Minor	M2FG09	-	At Grade
	17490	18100	610	Major	M2FC09	-3.5	Cutting

Sub Section	Chainage		Length (m)	Earthwork Asset Type (HD41/15)	Earthwork ID	Max Height (March 2018 Design freeze) (m)	Earthwork(s)
	18100	18430	330	Major	M2FE05	3.0	Embankment
	18430	18780	350	Major	M2FC10	-5.4	Cutting
	18780	19130	350	Minor	M2FG10	-	At Grade
	19130	20050	920	Major	M2FE06	5.9	Embankment
Section A3 (online)	20050	20600	550	Minor	M2FG11	-	Grade
	20600	21020	420	Minor	M2FG12	-	Grade
	21020	21880	860	Minor	M2FG13	-	Grade
Section A4 (online)	21880	22460	580	Major	M2FC11	-10.8	Cutting
	22460	22670	210	**Coquet Bridge**			
	22690	23070	380	Major	M2FC12	-8	Cutting
	23070	23260	190	Major	M2FE07	13	Embankment
	23260	23600	340	Major	M2FC13	- 12	Cutting

The approach embankments to the proposed structures represent the most significant new earthworks, requiring embankments around 8m in height. The existing Highways England boundary will be amended to accommodate the widening and new section of road.

The A1 currently crosses the River Coquet on a bridge spanning approximately 210m in a steep sided valley. This will be retained and used for the northbound carriageway with a second bridge structure constructed to the east to carry the southbound carriageway. South of the Coquet is the River Lyne which is a minor river. There are also a significant number of smaller east to west flowing streams in the area that cross the route including the Floodgate Burn, Earsdon Burn, Eshott Burn, Longdike Burn and Back Burn. The affected structures are listed in Table 2.

Table 2 - List of Affected Structures

Structure Name	Chainage	Scheme Requirements
TBC – Route for Cotting Burn	10770	TBC - No change
Warreners House Interchange	10870	No structural options or amendment to the existing bridge
TBC – Route for Shieldhill Burn Culvert	11825	TBC - Culvert extension
Highlaws Junction Overbridge	12250	New Junction overbridge

Structure Name	Chainage	Scheme Requirements
Paradise Culvert Floodgate Burn	13660	Culvert extension for Floodgate Burn
Priests Bridge (Underbridge)	14035	New culvert for River Lyne
Fenrother Junction Overbridge	14910	New Junction overbridge
Causey Park Culvert	17060	New culvert
Causey Park Overbridge	17680	New Junction overbridge
TBC – Route for Eshott Burn Culvert	18310	TBC - New culvert
Burgham Culvert	19500	Culvert extension for Longdike Burn
Burgham Underbridge	19500	New Junction Underbridge
Bockenfield Culvert	19990	Culvert extension/ upgrade for Longdike Burn
West Moor Junction Overbridge	21700	New Junction overbridge
Glenshotton Culvert	21860	Culvert extension upgrade for Thirston Burn
River Coquet Bridge	22480 - 22710	New Bridge
Parkwood Subway	23100	Subway extension
Parkwood Culvert	23150	Culvert extension

2.3. GEOTECHNICAL CATEGORY OF PROJECT

The project is anticipated to involve conventional types of geotechnical activities, with no exceptional or difficult ground conditions or loading conditions. Consequently, it is proposed that this scheme be classed as a Geotechnical Category 2 project, with the exception of the new proposed structure over the River Coquet which is considered to be Geotechnical Category 3, being treated accordingly for the investigation and decision-making processes in accordance with HD22/08.

2.4. OTHER RELEVANT INFORMATION

Shallow coal workings are known to underlie the proposed route at two locations; one at Causey Park Hagg and the other adjacent to Eshott Airfield at the northern end of the site.

The River Coquet and Coquet Valley Woodland SSSI intersect the scheme. It is designated due to being a relatively unmodified river that supports a wide range of flora and fauna. Further details on the SSSI are available in the scheme PSSR and Environmental Impact Assessment (EIA).

3. EXISTING INFORMATION

A PSSR entitled 'A1 Morpeth to Felton Dualling TPI to Preferred Route Announcement' was produced in 2004 (ref 5) which provided a brief overview of the available desk study information at that time. A Preliminary Geotechnical Report (ref 1) followed the ground investigation in August 2006 and this report summarised the desk study information and ground conditions for the scheme area in detail. Subsequent to a scheme hiatus, an updated PSSR (ref 3) was produced to reflect the updated scheme design. The report contained a description of the site based upon site visits, historical mapping and published information followed by a description of the engineering proposals for the various route options culminating in a ground model and risk register based upon published historical 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.

3.1. TOPOGRAPHICAL MAPS (OLD AND RECENT)

A review of the historical and topographic maps for the site area is presented in ref 1, ref 5 and ref 3, although historical land use assessed in the most recent PSSR is only up to 1974, and entirely GIS based. Reference should be made to these reports for a full review of the information.

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. Where residential, educational and commercial properties occur, they are commonly at junctions with side roads. The A1 has been present in essentially its current configuration since prior to the 1890s, with the exception of the most northerly extent of the scheme. This section of the A1 encompasses the Felton Bypass and was constructed in the 1980's. The bridge carrying A1 over the River Coquet was constructed in 1981 at approximate Ch.22500.

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

3.2. GEOLOGICAL MAPS AND MEMOIRS

STRATIGRAPHY

A review of the published geology was undertaken in ref 1, ref 3 and ref 5, with the following sources utilised:

- BGS 1:63,360 (solid geology) Geological Map Sheet 9 1966. (ref 6).
- BGS 1:50,000 (solid and drift) Geological Map Sheet 9, Rothbury, 2009. (ref 7).
- BGS Memoir Geology of the Country around Rothbury, Amble and Ashington, 1935 (ref 8).

A drawing showing the geological mapping with the proposed route overlain is included in Appendix B.

The geological succession for the study area is given in Table 3 and the specific geology underlying each earthwork along the route is outlined in the earthworks datasheets in Appendix A.

Table 3 - Geological Succession

Deposit	Mapped Units	Geological Age	Spatial Distribution
Sands, clays and gravels	Alluvium	Recent	Confined local to water courses
Clay tills with glacial sands and gravels	Glacial Till/ Glaciofluvial Sand and Gravels	Devensian	Almost total cover of study area
Sandstone with thin mudstones, siltstones, coals and seatearths	Upper Stainmore Group (Millstone Grit Group)	Upper Carboniferous	South of Ch 9500
Sandstones with thin mudstones, siltstones, limestones and coals	Upper Stainmore Group (Upper Limestone Group)	Upper Carboniferous	North of Ch 9500

(Taken from ref 5)

Superficial

The proposed route is underlain by relatively shallow localised recent deposits of Alluvium comprising sand, silt, clay, peat adjacent to the minor watercourses, and sands and gravels adjacent to the River Coquet in the extreme northern part of the route. These overly extensive deposits of Devensian Glacial Till, Glaciolacustrine laminated clays and glacio-fluvial sand and gravels. The glacial deposits are encountered at the surface over most of the study area with thicknesses in excess of 25m recorded in apparent glacial valleys.

Bedrock

The Stainmore Formation of the Carboniferous period underlies the superficial deposits for the majority of the route. This formation comprises interbedded mudstones, siltstones and sandstones. The Corbridge Limestone strata is a shelly unit within the Stainmore Formation that occurs in the vicinity of the River Coquet (Ch.22500). Minor coal seams occur within the sequence.

The Pennine Lower Coal Measures occur above the Stainmore Formation cropping into the base of the Glacial Till in the vicinity of Causey Park Hag (Ch.17850) and are a sequence of mudstones, shales, siltstones, sandstones and coal. The Victoria Seam was worked at Causey Park Mine (Ch.17930). Seatearth associated with these coal seams are known to have been worked in the region for use as brick manufacturing. A Marine Band described as fossil rich traverses the proposed route at Ch17975 immediately north of the coal seam, and curves back across the route again at Ch18360 and Ch18750.

The Causey Park Dyke is a tholeiitic intrusion which crosses the proposed route west to east at approximate Ch.17830 (immediately north of the proposed Causey Park Overbridge). This has not been intersected by any boreholes excavated in the locality to date, but it is described as a dark green, fine grained very strong quartz-micro-gabbro. It is thought to have been quarried as a road stone at Causey Park.

Structural Geology

Strata in the area has a regional dip of 3° to 5° in an east or east-south-easterly direction. The route proposal runs approximately along the strike of the underlying rock. The main geological faults which traverse the proposed route are detail below;

- Approximately Ch10930; an unnamed fault trending north east – south west, downthrown to the north west.
- Approximately Ch16000; Stobswoods fault trending east west, downthrown to the south.
- Approximately Ch17830; Causey Park Dyke. The dyke was formed by an igneous intrusion along a fault trending north-northwest to south-southeast, downthrown to the east-northeast by approximately 55m.
- Another fault, of unknown throw, trending east – west, converges with the dyke east of the proposed route and forms the northern limit of an area of coal workings.

LANDSLIDES

Based on a geomorphological field walk-over survey undertaken during the Stage 1 ground investigation, it was evident that extensive ground movement has affected the north facing valley side slopes of the River Coquet at the bridge crossing. A walk-over survey completed for the 2004 PSSR (ref 5) recorded 'signs of instability in the slope on which the north abutment stands'. The report also noted that 'on the east side of the abutment there was a clear back scarp with tension cracks behind it of approximately 300mm width'.

A detailed geomorphological mapping of the north valley side slopes at the River Coquet crossing was therefore undertaken in May 2006. The results of the detailed geomorphological mapping are provided in in the 2006 Geotechnical Report (ref 1). In summary, the report indicates the location of the proposed northernmost bankseat appears to be on the back scarp of a rotated landslip block and that the area to the east of the existing northern bankseat is dominated by complex deep-seated rotational landslips.

A geomorphological mapping exercise was undertaken in February 2018 to further investigation instability in the area of the existing and proposed structure and this is discussed further in Chapter 4.

The BGS 1:50,000 Geological Map for the region indicates an area of mass movement deposits underlying the existing A1 between Ch23090 and Ch23250, north of Parkwood Subway and underlying an area of where the road is on an embankment up to 7.0m high. The deposits are described as possible debris slides of rock and soil, including mud flows which commonly lie unconformably on bedrock. They are likely to be variable material dependent on the nature of the upslope material and the type of slip failure.

3.3. HYDROLOGY

A number of west to east flowing watercourses cross the alignment of the current A1 and the proposed future route option. A summary of these are listed in Table 4. Three of these rivers are being monitored as part of the EU Water Framework Directive, namely the River Coquet, Longdike

Burn and River Lyne. The latest information on quality from these is summarised in the 2016 PSSR (ref 3).

Table 4 – Summary of Watercourses

Watercourse	Chainage
Shieldhill Burn	11820
Floodgate Burn	13650
River Lyne	14040
Tributary to Fenrother Burn	14950
Tributary to Fenrother Burn (field drain)	14960 - 15390
Earsdon Burn	17060
Tributary to Earsdon Burn	17250
Eshott Burn (field drain)	18300
Longdike Burn	19960
Blackwood Hall Watercourse	20860
Glenshotton	21840
River Coquet	22530
Parkwood	23130

The risk to the proposed scheme associated with flooding from rivers is summarised in Table 4.7 in the 2016 PSSR (ref 3). Four watercourses; River Coquet, Longdike Burn, River Lyne and Earsdon Burn are classified as a high risk from flooding. The risk of flooding for each earthwork is discussed in the earthwork datasheets in Appendix A and annotated on the Geohazard plans in Appendix C.

3.4. HYDROGEOLOGY

A review of the hydrogeology maps for the site area is presented in ref 1, ref 3 and ref 5. Reference should be made to these reports for a full review of the sources of information.

The groundwater is considered to be relatively shallow within the proposed route extents due to the presence of low permeability Glacial Till overlying bedrock dominated by mudstones and shales of low permeability. Generally, the route overlies a minor aquifer with soils of low leaching potential and low permeability drift deposits of Glacial Till or Alluvium. The sandstones within the Stainmore Group are classified as minor aquifers.

3.5. AERIAL PHOTOGRAPHS (OLD AND RECENT)

The aerial photography obtained for the scheme and discussed within the 2004 PSSR (ref 5) is summarised in the 2006 Geotechnical Report (ref 1). A further assessment of more recent aerial photography is assessed in the 2016 PSSR (ref 3).

The aerial photography shows natural landforms and man-made features that confirm the site development as determined from the historical mapping described in the desk study reports.

3.6. RECORDS OF MINES AND MINERAL DEPOSITS

Two coal mining areas have been identified during previous desk study reports; one at Causey Park Hagg (Ch.17850) and the other adjacent to the airfield at the northern end of the site (Ch.20420 - 21400). A mining plan obtained for the coal workings at Causey Park Hagg shows the location of adits and roadways at this location. No mine plan is available for the workings at the northern end of the route although a disused colliery and an old coal shaft is indicated the historical mapping for the area.

A geophysical survey carried out in the vicinity of the mine workings at Causey Park identified a large linear dipolar anomaly (thought to be the dolerite dyke) and a number of smaller discrete anomalies underlying the proposed route.

The Design Basis Statement for the Causey Park Shallow Mine Workings Assessment produced as part of the 2006 Geotechnical report (ref 1) is included in Appendix H. The assessment includes a review of the desk study information, a summary of the intrusive and non-intrusive investigations completed at that time, along with proposals for further GI and mine treatment works.

The 2006 Geotechnical report (ref 1); concludes that; 'Due to the fact that (a) shallow mine workings are present along the route corridor, (b) that poor coals and fireclays are present within the Upper Stainmore Group and (c) the strike of the strata is parallel to the scheme alignment the entire route corridor has been assessed to have a moderate risk associated with the presence of shallow mine working'.

In April 2018 a site walkover was conducted with the landowner of the area around the proposed route through Causey Park to obtain local knowledge of recent mining related events. A memo containing plans and photographs of features discussed is included in Appendix H. In summary the following features were discussed:

- An area of open cast mining existed to the immediate west of the proposed route which was subsequently backfilled.
- Localised voids and settlement had occurred in an area to the east of the route with the last void opening around 6 years ago.
- A void had recently opened in a field to the west of the route.

Areas affected by mines or 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.

On the basis of the findings of the walkover, additional GI was commissioned along the route to further investigate the mining risk and this is discussed in Chapters 6 and 7.

3.7. LAND USE AND SOIL SURVEY INFORMATION

LAND USE

A comprehensive review of the current and historical land use was undertaken as part of the 2016 PSSR (ref 3). The current land use within the study area is largely agricultural, with the town of Morpeth to the south of the southern end of the study area and the village of Felton to the east of the northern end of the study area. There are a number of existing leisure land uses within the study area, such as Felmoor Park Holiday Park, Bockenfield Holiday Park, Burgham Park Golf and Leisure Club, and Eshott Airfield.

The review included a Pre-Desk Study Assessment from Zetica to assess the location of recorded UXO across the site. Records show that at least 12 high explosive bombs were recorded in close proximity to the proposed scheme, and some of these were recorded as unexploded.

A historical map review revealed higher risk features such as infilled ponds, infilled quarry's, garages, tanks or potentially infilled area of land is within 100m of the proposed scheme option.

Pertinent historical features at the proposed earthwork locations are listed in the earthworks datasheets in Appendix A and annotated on the Geohazard plans in Appendix C.

SOIL SURVEY INFORMATION

The Soil Survey of England and Wales, Soils of the Alnwick and Rothbury District map for the scheme is reviewed and discussed within the 2004 PSSR (ref 5) and summarised in the 2006 Geotechnical Report (ref 1). A summary was provided in an earlier report (ref 1) as follows;

''Most of the site is covered by soils classified as 'Stagnogleys' which are described as non-calcareous loam over clay soils, with clay-enriched subsoil. These soils are part of the Surface-Water Gley Soils group, which are slowly permeable, and seasonally waterlogged soils. These soils coincide with the presence of Glacial Till (Glacial Till typical depth 8.8m, but up to 25.6m) which is predominantly slowly permeable and seasonally waterlogged.

To the west of Fenrother, at Causey Park Bridge (in Earsdon Burn) and around the River Coquet Valley, the soils are 'Brown Earths'. They are deep or moderately deep brown or red soils with no prominent mottling or reduced layers above 40cm depth. All are non-calcareous and permeable or slowly permeable loams with or without clay.''

No additional information on land use or soil survey information has been obtained.

3.8. ARCHAEOLOGICAL AND HISTORICAL INVESTIGATIONS

The Archaeology Data Service has records for two archaeological investigations within the study area. These are discussed in the 2016 PSSR (ref 3).

Further detailed archaeological investigation is to be undertaken prior to construction and the findings will be detailed in a separate specialist report.

3.9. EXISTING GROUND INVESTIGATIONS

A summary of the relevant historical Ground Investigation Reports are listed in

Table 5.

Table 5 – Previous Geotechnical Studies

Document Title	Document Reference/Year	Produced By
A1 The Proposed Felton By-Pass (Edinburgh Thurso Trunk Road) Soil Survey.	March 1972 HAGDMS report number 3376	Tarmac Construction Limited
A1 (T) River Coquet, Felton Site Investigation.	June 1974 HAGDMS report number 3378	Tarmac Construction Limited
A1 Felton Park to Lane Head, Northumberland Ground Investigation. (ref 9)	August 1998 HAGDMS report number 9366	Allied Exploration & Geotechnics
A1 Felton Park to Lane Head Southern Extension (ref 10)	June 1999 HAGDMS report number 9368	Allied Exploration & Geotechnics
A1 Morpeth to Felton Dualling, Northumberland Report on a Ground Investigation Volumes 1 – 7 Factual Report. (ref 11)	April 2006 HAGDMS report number 20918	Norwest Holst Soil Engineering

A comprehensive review of the historical information is provided in the 2016 PSSR (ref 3) with the exception of the A1 Felton Park to Lane Head Investigations (ref 9 & 10) which are held by the BGS as confidential reports. This investigation is summarised below.

FELTON PARK TO LANE HEAD SITE INVESTIGATION

The aim of the Felton Park to Lane Head site investigation (ref 9) along with the scheme extension to the south (ref 10) was to establish the ground conditions along the existing A1 between the cutting south of the River Coquet and Lane Head Farm in order to upgrade the existing single carriageway route to a dual carriageway. Site work was carried out between the 5th May and 2nd June 1998 by Allied Exploration and Geotechnics Ltd (AEG) under contract to the Highways Agency.

The site investigation consisted of:

- The sinking of twenty nine cable percussive boreholes to a maximum depth of 20.00m bgl.
- Four of these boreholes were sunk from scaffold platforms due to difficult access.
- Three of these were continued using rotary percussive techniques.
- The mechanical excavation of fifty one trial pits.
- The sinking of forty five window sampling.

Nineteen of the trial pits and eleven of the boreholes are considered relevant to the current dualling scheme. The ground information and test data from the relevant exploratory holes have used to produce the ground model beneath the route.

SUMMARY GROUND CONDITIONS

Embankment Fill

The existing embankment fill is cohesive in nature and comprises either firm to stiff but occasionally soft, grey, brown and reddish brown with slightly sandy to very sandy clay with fine to coarse gravel. Occasional laminations, sand pockets and partings, timber and cobbles and boulders are noted. Recorded thicknesses lie in the range greater than 3.7m to 10.3m.

Dolerite Fill

Dolerite fill was encountered within the existing cuttings. These deposits comprise gravel and cobble sized angular dolerite fragments in a sand/clay matrix and are thought to be associated with remediation works that have been undertaken in these cuttings. These materials can be observed over the full stretch of the cutting slope surface and are also known to extend beneath the existing carriageway. Recorded thicknesses lie in the range 0.6m to 1.6m.

Glacio-Lacustrine Deposits

These deposits were classified as either Glacio-lacustrine Silts, Glacio-lacustrine Sands with an upper and lower sand unit and Glacio-lacustrine Laminated Clays. Recorded thicknesses lie in the range 1.8m to 6.3m.

Glacial Till

The Glacial Till comprises firm and firm to stiff, brown, silty to very silty, slightly sandy to very sandy clay with fine to medium gravel and subordinate pockets and bands of fine to medium sand. These deposits have a recorded thickness of up to 4.6m.

Bedrock

Bedrock was encountered in the majority of the exploratory holes at relatively shallow depths in the range 1.4m to 3.1m bgl along the top of the cutting south of the River Coquet, and at 0.1m to 0.8m bgl along the berm. The exploratory holes confirmed a variable sequence of mudstones, sandstones, siltstones and coal seams

Groundwater

All the boreholes in the cutting south of the River Coquet were reported as dry during drilling. However, post GI monitoring of standpipe piezometers confirmed a groundwater table in the bedrock at depths in the range 4.9m to 9.3m bgl or 58.4m to 60.2m OD.

3.10. CONSULTATIONS WITH STATUTORY BODIES AND AGENCIES

UTILITIES

The locations of Statutory Utilities and services are identified on the Scheme Drawings presented in the 2016 PSSR (ref 3). The PSSR draws attention to a high pressure gas main running parallel to and west of the existing A1 in the vicinity of Ch.17310. It is proposed that this main will be diverted as part of the scheme. WSP have subsequently gone back out to site to determine the diversion details (C3s) for a variety of the affected Statutory Utilities and services.

NATURAL ENGLAND/ ENVIRONMENT AGENCY

Consultations with English Nature and the Environment Agency have been carried out in and are ongoing in relation to any potential environmental impacts to the scheme, particularly in relation to the proposed new River Coquet crossing.

The southern river valley slope defined as ancient semi natural woodland and the southern slope and River extents are defined as Site of Special Scientific Interest (SSSI). It is designated due to being a relatively unmodified fast flowing river that supports a wide range of flora and fauna.

Approval is required from Natural England and the Environment Agency in order to complete any boreholes within the River Coquet River Valley.

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

LOCAL AUTHORITIES

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

COAL AUTHORITY

No additional information has been obtained from the Coal Authority with regards to the areas of coal mining discussed in Section 3.6. No further discussion or analysis of the data in the historic PSSRs is considered necessary for the scheme in its current form.

A permit to undertake the additional ground investigation referenced in Section 3.6 was obtained from the Coal Authority prior to these works being undertaken.

3.11. FLOOD RECORDS

A review of the flood mapping published by the Environment Agency is available on HAGDMS and shows that the areas of the site that fall within the high to medium flood zones (annual likelihood of greater than 1 in 30 to 1 in 100) are generally contained close to or within the banks of the watercourses in the route corridor, the most significant being the River Lyne, Earsdon Burn, Longdike Burn and the River Coquet.

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

3.12. CONTAMINATED LAND

A comprehensive review of the potential contaminants within the study area is provided in the 2016 PSSR (ref 3). An extract from the report is presented in Figure 2. A number of discrete areas were identified in the desk study where there is an increased risk of encountering contaminated land includes the following;

- Eshott Airfield (formerly RAF Eshott);
- Foot and mouth burial pits;
- Garage at Priest's Bridge;
- Historical filling station at Causey Park Bridge;
- Historical Landfills (The Helm and Eshott);
- Infilled ponds and quarries.

The areas of potential contamination which were considered to be of importance to the scheme were investigated as part of the Stage 1 GI in 2006. Boreholes and trial pits were located and samples collected and scheduled to assess the areas of potential contamination. Forty soil samples were tested as part of the Norwest Holst ground investigation in 2006. The 2016 PSSR reports only one of the samples tested recorded exceedances of the LQM/CIEH S4ULs for Human Health Risk Assessment for commercial/industrial end use.

Notably, the 2004 PSSR (ref 5) documented the presence of a foot and mouth burial pit at Highlaws Farm, located to the north of the farm lane and to the north west of the proposed Highlaws Junction at approximate Ch.12200. The nature of the pits and any measures taken to prevent contaminated material migrating from them is unknown. The Preliminary Geotechnical Report (Ref 1) found no elevated biological or chemical contamination of water from two boreholes within the vicinity of these pits.

Potential sources of contaminants at the proposed earthwork locations are listed in the earthworks datasheets in Appendix A.

Table 4-14 Potential contaminants that may be encountered within the study area

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.
WW2 Airfield and associated buildings	Aviation fuel (kerosene), gasoline, diesel, antifreeze, solvents, fire-fighting agents, lubricants, hydraulic fluids, Polychlorinated Biphenyls (PCBs), asbestos, PAHs, Volatile and Semi-Volatile Organic Compounds (VOCs and SVOCs), heavy metals.
Garage and historical filling station	Oils/hydrocarbons, PAHs, BTEX, MTBE, VOCs and SVOCs, heavy metals, antifreeze, brake fluids, solvents, asbestos.
Infilled Ponds / Quarries and historical landfills	Various unknown contaminants (including heavy metals, hydrocarbons, PAHs, ash, ground gas, asbestos).
Foot and mouth burial pits	Pathogens, heavy metals, oils/hydrocarbons.
Tanks	Oils, fuels (diesel, red diesel, gasoline), pesticides, herbicides, fertilisers, slurry (nitrate, ammonium, organics),

Figure 2 – Summary of Potential Contaminates From 2016 PSSR

3.13. OTHER RELEVANT INFORMATION

AS-BUILT CONSTRUCTION RECORDS

As-built construction records were available for the existing bridge at the River Coquet and these have been reviewed for any salient information. The bridge comprises three continuous spans of 49m, 83m and 49m and the width is approximately 13m. The superstructure comprises prestressed post tensioned concrete with abutments of reinforced concrete bankseats on spread footings. The piers are reinforced concrete walls and the south pier is founded on bored concrete piles with the north pier on spread footings. Copies of the relevant drawings are included in Appendix D.

Six photographs provided by an individual who had worked on the construction of the existing River Coquet bridge are also included in Appendix D. It is not clear which part of the site is shown on these photographs.

4. FIELD AND LABORATORY STUDIES

4.1. WALKOVER SURVEY

A preliminary walk over survey was carried out during 2002 as part of the PSSR (ref 4) but this was limited to public rights of way. A detailed walkover survey was subsequently carried out during the course of the Ground Investigation in January/February 2006. This highlighted several areas of interest which were then subject to geomorphological mapping in April 2006 and discussed in detail in the 2006 GR (ref 1).

A further site walkover was conducted in October 2016 and the stop locations and observations are discussed in the PSSR (ref 3). The walkover considered the site constraints for the online and offline options. The most noteworthy of observations related to several slips located in the vicinity of the northern slope of the River Coquet in and the area subject to the previous geomorphological mapping. Scarp features and slumped blocks were observed on the southern edge of the footpath although it was unclear if there were any changes to the slope since the geomorphological mapping exercise in 2006.

A general walkover and drive-through were undertaken during the recent 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.

In addition, targeted site inspections were undertaken at locations where a review of HAGDMS identified several existing earthwork defects where the proposed route follows the existing A1. These have been summarised in Table 6.

Table 6 - Summary of Earthwork Defects

Earthwork Observation ID	HAGDMS Observation Description	A1 Impacted Scheme Element	Class	Location
14_A1_42928_520472	Slip	Cutting M2FC11	1D	C
14_A1_42928_520473	Slip	Cutting M2FC11	1D	C
14_A1_42928_520475	High moisture content	Cutting M2FC11	1D	C
14_A1_42928_520480	None entered	Cutting M2FC11	1D	C
14_A1_42929_520486	Slope erosion	Cutting M2FC11	1D	C
14_A1_42929_520487	Slip	Cutting M2FC11	1D	C
14_A1_42927_520468	Slip	Cutting M2FC12 / River Coquet	1A	D
14_A1_42984_520375	Slip, Tension Cracks	Cutting M2FC12/ River Coquet	1A	C
14_A1_42984_564468	Slip, Slope Bulge, Tension Cracks, Dislocated Trees, Terracing, Dislocated Fence	Cutting M2FC12/ River Coquet	1A	C
14_A1_42926_520457	Tension Cracks	Cutting M2FC12	1D	C

Earthwork Observation ID	HAGDMS Observation Description	A1 Impacted Scheme Element	Class	Location
14_A1_42926_520462	Slope Bulge	Cutting M2FC12	1D	C
14_A1_42926_564463	Slip, Slope, Bulge, Dislocated Trees and Terracing	Cutting M2FC12	1D	C
14_A1_42984_578468	Tension Cracks	Cutting M2FC12/ River Coquet	1D	C
14_A1_42985_520379	Slip, Subsidence	Cutting M2FC12	1D	C
14_A1_42985_520382	Slope Bulge and Seepage	Cutting M2FC12	1D	C
14_A1_42985_520383	None Recorded	Cutting M2FC12	1D	C
14_A1_42985_520386	Slip	Cutting M2FC12	1D	C
14_A1_42987_520389	Slope Bulge, Subsidence	Embankment M2FE07	None Assigned	
14_A1_42987_520390	None Recorded	Embankment M2FE07	None Assigned	
14_A1_42924_520452	Subsidence	Embankment M2FE07	1D	C
14_A1_42988_520394	Small slip at crest	Cutting M2FC13	1D	C

The site specific walkover information is detailed in the relevant earthwork datasheets contained in Appendix A.

4.2. GEOMORPHOLOGICAL/GEOLOGICAL MAPPING

A walkover and geomorphological mapping survey of the area of known instability on the northern banks of the River Coquet was undertaken in February 2018. A memo was produced following the field work and this discusses the observations and recommendations for the site. The memo, which includes recent photographs and the results of the mapping exercise together with recommendations for further works, is contained in Appendix E.

4.3. GROUND INVESTIGATION

DESCRIPTION OF FIELDWORK

Rationale for Fieldwork

Although previous ground investigations have been undertaken in relation to the scheme, an additional investigation was required to allow the preliminary design of certain elements of the scheme. The preferred route follows a similar corridor to the original offline proposal for which ground investigation had been undertaken historically but the location of structures and localised alignment changes were not accounted for by the original GI. The recent intrusive fieldworks, designed and supervised by Jacobs, comprised of boreholes, drilled using multiple techniques, machine dug trial pits and soakaway tests at several locations. The GI was intended to supplement the information already gathered from previous GIs and focused on earthworks including high embankments, deep cuttings and new or modified structures.

The objectives of the recent GI were:

- To establish the ground, groundwater and drainage conditions for the proposed route option, focusing on key locations where structures, earthworks and drainage elements are proposed.
- Update or confirm the ground model that has already been produced.
- Define the geotechnical parameters for earthworks and structural foundations.
- Evaluate the risk of shallow mine workings.
- To assess the potential for contaminated land through soil and groundwater chemical analysis, including ground gas monitoring.
- To ascertain further information on the whether shallow mine workings underlain part of the site.

General Fieldwork Details

The GI was largely carried out between 24th July and 6th September 2017 with the exception of BHA1741 excavated adjacent to the northern bank of the River Coquet during a night shift on 26th of October 2017 due to access restraints. The exploratory hole numbering system was prefixed by BHA17 or TPA17 to distinguish this ground investigation from previous investigations.

The fieldwork comprised of the following and in accordance with MCHW 5.3, 1997 (ref 13), BS10175: 2011+A1:2013 (ref 14), BS 5930: 2015 (ref 15), and ISO 1997:2007 (ref 16);

- Thirty-four boreholes undertaken by light cable percussion boring methods.
- Eleven of the cable percussion boreholes were continued using rotary drilling and coring techniques.
- One borehole was undertaken by rotary drilling and coring techniques only.
- Three boreholes were undertaken using a percussive window sampler rig instead of the initially scheduled trial pits due to access constraints.
- Fifty-one trial pits were dug by mechanical excavator.
- Nine of these trial pits were excavated for soakaway testing.
- Dynamic probe testing was undertaken at twelve locations.
- A rising head permeability test was undertaken in BH A1737.
- Standpipes and piezometers were installed in selected boreholes as summarised in below.

Exploratory hole location plans of the site are presented in the Factual Report, HAGDMS No. 30315 (ref 12).

Groundwater strikes were encountered in 19 No. boreholes at depths ranging from 1.6m bgl (BHA1722) and 15.20m bgl (BHA1723), and 1no. trial pit at 2.1m bgl (TPA1705) as detailed in Table 7. Groundwater was not encounter in any of the window sample holes. On completion, groundwater monitoring equipment was installed in 16 No. boreholes. On completion of the site works, groundwater samples were obtained from selected boreholes for chemical testing. The groundwater installation details and subsequent monitoring is summarised in Section 6.7.

Gas monitoring equipment was installed in 9 No. boreholes. The response zones were installed to coincide with depths at which coal seams were encountered in order to measure potential gas levels. Gas installation details are provided in.

Further GI was undertaken in April 2018 by SOCOTEC, who were commissioned by Geoffrey Osborne Ltd on behalf of Highways England to ascertain further information on the shallow mine workings underlying part of the site. The scope of the investigation was specified by WSP and comprised four rotary (open-hole) boreholes to depths of 35m bgl.

GROUND INVESTIGATION FACTUAL REPORT

A Factual Report (ref 12) has been produced by Ian Famers Associates, containing a full description of the investigation techniques used, the exploratory logs and the results in-situ and laboratory testing. The Factual Report should be read in conjunction with this GIR report.

A separate Factual Report (ref 22) was produced by SOCOTEC relating to the additional rotary holes.

An AGS file containing all the exploratory hole logs, in-situ and laboratory test results has also been provided by Ian Famers Associates.

RESULTS OF IN-SITU TESTS

Standard Penetration Testing was carried out in the majority of boreholes where ground conditions were suitable.

Super heavy dynamic probe testing was undertaken at twelve borehole locations. Inspection pits were excavated to 1.20m prior to commencing the dynamic probing.

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

The results of the in-situ tests are included on the exploratory hole logs presented in the Factual Report, HAGDMS No. 30315 (ref 12) and are illustrated on the geological long sections shown in Appendix F.

4.4. DRAINAGE STUDIES

None undertaken other than the soakaway tests and rising head permeability tests described previously.

4.5. GEOPHYSICAL SURVEY

A downhole optical televiewer survey was carried out by Borehole Logging Solutions Ltd acting on behalf of Ian Farmers in BHA1741 between 3.2m bgl and 30mbgl.

4.6. PILE TESTS

Not used.

4.7. OTHER FIELD WORK

Not used.

4.8. LABORATORY INVESTIGATION

DESCRIPTION OF TESTS

Geotechnical soil analysis was undertaken of samples obtained during the investigation as follows:

- Moisture contents
- Plasticity indices
- Particle size distribution by wet sieving and sedimentation
- Unconsolidated Undrained Triaxial testing
- Consolidated Undrained Triaxial Testing
- One dimensional consolidation testing
- Organic Matter Content
- Compaction Tests
- California Bearing Ratio
- Calibrated Moisture Condition Value
- Moisture Condition Value
- Point Load Index
- Uniaxial Compressive Strength

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 and are also included in the AGS data. A copy of the geotechnical factual report by Ian Famers Associates is submitted separately as HAGDMS report No. 30315.

Table 7 - Groundwater Strikes During 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
BHA1704	110.27	2.5	107.77	Glacio-lacustrine	2.0	108.27
BHA1704	110.27	6.8	103.47	Granular Till	3.8	106.47
BHA1705	80.01	8.0	72.01	Cohesive Till	2.5	77.51
BHA1706	83.69	3.2	80.49	Granular Till	3.1	80.59
BHA1709	82.86	3.9	78.96	Granular Till	3.6	79.26
BHA1710	90.34	5.4	84.94	Granular Till	5.4	84.94
BHA1713	91.23	3.3	87.93	Cohesive Till	3.0	88.23
BHA1719	84.14	5.0	79.14	Cohesive Till	3.8	80.34
BHA1722	78.49	1.6	76.89	Granular Till	1.2	77.29
BHA1723	85.48	15.2	70.28	Granular Till	13.10	72.38
BHA1725	81.08	2.7	78.38	Cohesive Till	2.0	79.08
BHA1726	79.89	3.8	76.09	Cohesive Till	2.2	77.69
BHA1729	83.41	4.3	79.11	Weathered Sandstone	3.7	79.71
BHA1732	75.06	5.3	69.76	Cohesive Till	4.8	70.26
BHA1733	63.18	2.6	60.58	Granular Till	2.5	60.68

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
BHA1733	63.18	4.6	58.58	Glacio-lacustrine	3.4	59.78
BHA1736	60.45	3.2	57.25	Cohesive Till	2.7	57.75
BHA1736	60.45	7.2	53.25	Cohesive Till	4.6	55.85
BHA1737	60.53	5.4	55.13	Cohesive Till	3.7	56.83
BHA1742	49.24	3.2	46.04	Granular Till	3.0	46.24
BHA1744	74.11	3.4	70.71	Granular Till	3.0	71.11
BHA1744	74.11	7.8	66.31	Cohesive Till	7.5	66.61

5. GROUND SUMMARY

The following paragraphs give a summary of the salient information obtained from the studies detailed in Chapters 3 and 4 which has been used to produce the design ground model and to further identify and assess the geotechnical risks presented in Chapter 7.

Geological long sections have been produced for the scheme and are presented in Appendix F. A geohazard plan highlighting the geotechnical risks for the scheme is presented in Appendix C.

5.1. TOPOGRAPHY

The topography of the scheme is summarised as follows:

- Ch.10870 – Ch.13800; through this section the carriageway runs in a North - South direction and the carriageway itself is on the whole at grade (slope less than 1.5m high). Two minor embankments up to 3.0m in height are required where the scheme traverses two culverts, Shieldhill Burn and Floodgate Burn. A significant cutting up to 6.0m deep is encountered between Ch.11260 and Ch.11365. The A1 skirts Hebron Hill to the east of the route which rises to a height of 129m before gently falling to around 85m where the road traverses Floodgate Burn.

- Ch.13800 – Ch.20040; the new off-line section of road which is a mix of minor earthworks, moderately sized embankments between 3.5 and 6.0m in height and cuttings between 3.5 and 5.0m in height. There are two low points; one at the River Lyne where the topography slowly rises to 102m in the vicinity of Tindale Hill before descending again towards a second low point at Earsdon Burn. The route bypasses Causey Park Hag to the west of the route where significant past mining activity has been identified in the vicinity of Causey Park, prior to joining the existing A1 immediately north of Helm with a spot height of 107m. The A1 follows a south east- north west direction at this location.

- Ch.20040 – Ch.21910; widening is predominantly to the west of the existing A1 carriageway which is currently at grade. The largest proposed earthwork in this section relates to the approach embankment to Westmoor Junction overbridge north of the airfield.

- Ch.21910 – Ch.23600; The topography through this section is marked by a series of deep cuttings up to 10.5m deep and the carriageway crosses the River Coquet between Ch22400 – 22670 which has a relatively steep sided river valley. The existing A1 crosses another low point on an 8.0m embankment through a forested section marked as Park Wood where a subway traverses under the road and an unnamed watercourse drains to the east towards the town of Felton.

5.2. HISTORICAL DEVELOPMENT

The road has been present in essentially its current configuration since prior to the 1890s and there are limited historical or geographical changes or features that will impact on the scheme. The issues of note are:

- Causey Park Hag; surface mining in old quarry an area of underlying mining with mine shafts and adits located within the boundaries of the scheme.
- Existing A1 realigned immediately north of Longdike burn in the 1960’s with Eshott Airfield to the east of the A1

- New section of the A1 (Felton Bypass) between West Moor Junction and Lanehead constructed in the 1980's which included the River Coquet crossing.

5.3. 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 F and the material properties are discussed in Section 6.

TOPSOIL

Topsoil was encountered in the majority of exploratory holes along the proposed route. A summary of the average depths of Topsoil along the route is given in Table 8.

Table 8 - Typical Topsoil Depths

Route Section	Typical Topsoil Depth (m)
Ch.10870 – Ch.13800	0.1 – 0.9 (Average depth = 0.3)
Ch.13800 – Ch.20040	0.1 – 0.6 (Average depth = 0.3)
Ch.20040 – Ch.21910	0.1 – 0.5 (Average depth = 0.27)
Ch.21910 – Ch.23600	0.1 – 0.9 (Average depth = 0.28)

It should be noted that the Topsoil thicknesses recorded in holes formed as part of investigation prior to the 2006 ground investigation sometimes record greater depths of Topsoil than those recorded on the logs for the 2006 and recent ground investigations in certain areas.

MADE GROUND

Made Ground was encountered in 60 exploratory holes (17 boreholes, 23 trial pits and 13 window samples). The deposits were generally encountered as engineered or landscape fill associated with the existing A1 and its associated side roads and infrastructure. Occasionally thin deposits (0.3 to 0.5m thickness) of apparent Made Ground were encountered within the offline section adjacent to field boundaries and these are thought to be associated with farming processes and potential land drain construction.

The composition of Made Ground was variable comprising both granular and cohesive deposits including sandy gravelly clay, clayey gravelly sand and slightly clayey sand. Cobbles and boulders are of various lithologies, along with fragments of plastic bottles, glass, brick, clinker, burnt shale, concrete, pottery, geotextile and drinks cans were noted in a number of the exploratory holes. The deposits were encountered in thicknesses varying between 0.2m and 16.2m and were generally associated with exploratory holes formed post construction of the A1. Notable area of significant Made Ground are described in the subsequent paragraphs.

Longdike Burn

Made Ground described as dark grey/black clayey sandy angular to subangular fine to coarse gravel sized fragments of ash, asphalt/ tar, pottery and concrete with a strong hydrocarbon odour was encountered in BH1028 and TP1278. These exploratory holes were excavated adjacent to Bockenfield Bridge where Longdike Burn is culverted under the existing A1 at around Ch.20000 and local to where the proposed new offline section merges with the existing A1. The material is encountered underlying the topsoil to a maximum depth of 3.9m bgl and is thought to be as a result of a possible historic culvert diversion of the Burn where a small bypass was constructed in the 1960s. A layer described as dense black coal with beds of weak weathered mudstone is referred to as possible Made Ground and encountered at the base of TP1278.

Eshott Airfield

Made Ground was encountered in seven of the more recent exploratory holes excavated in the verge adjacent to the existing A1 southbound carriageway, and bordering Eshott airfield (Ch. 20450 – 20900). The material was encountered at the ground surface or beneath the topsoil and was proven to depths of between 0.3m and 2.0m bgl. The material was generally described as black or grey clayey gravel/ gravelly clay with subangular gravel and cobble sized fragments of various lithologies including brick, tiles and concrete. Asbestos, door locks and glass noted. The material is thought to be associated with levelling of the verge following realignment of the A1 in the 1960’s.

River Coquet

There is an area of Made Ground to the east of the northern bridge abutment, and it is in this area m any of the instability features have been identified as discussed in the geomorphological mapping section of this report. BH1037 excavated within the river bank north of the River Coquet encountered Made Ground between ground level and 10.2m bgl. The material was described as brown slightly sandy very gravelly clay. Gravel sized fragments are subangular to subrounded fine to coarse of various lithologies including sandstone, mudstone and ironstone. Between 7.3m and 10.2m bgl the material is noted as possible or reworked/ disturbed weathered mudstone and is thought to be related to the abutment earthwork

M2FE07 Embankment Fill

Made Ground was encountered in nine of the more recent exploratory holes excavated after the Felton bypass was constructed within the northern most embankment of the scheme. The Made Ground at this location is encountered between ground level extending to depths of 16.5m bgl and is predominantly described as cohesive; dark brown/ grey sandy slightly gravelly clay. Gravel sized fragments are subangular to subrounded fine to coarse of various lithologies including sandstone, mudstone and quartz. Cobble sized fragments are subrounded of sandstone.

The maximum embankment height at this location is recorded as approximately 13.0m, however BH1044 excavated at the crest of the embankment indicates Made Ground up to 16.5m bgl suggesting possible over excavation at the time of construction. No other recent holes go through the full thickness of embankment material.

Granular Made Ground was encountered in BH1043 between 0.1m and 3.1m bgl excavated directly adjacent to Parkwood Subway. The material is described as dark grey/ brown slightly sandy very clayey fine to coarse gravel sized fragments of mudstone, sandstone, brick, clinker and ash with occasional cobble sized fragments.

Granular Backfill in Cuttings

As part of remediation work to the cuttings (M2FC05 and M2FC06) within the northern extents of the scheme, extensive areas of the slope have been excavated and replaced with material described as dense sandy coarse angular gravel/ cobbles of dolerite or limestone aggregate. The backfill is encountered between ground level to a maximum of depth 2.5m bgl and in places can be observed over the full stretch of the cutting slope surface.

ALLUVIUM

Based on the Geological Maps, the Alluvium deposits were expected to be confined to the lower lying areas of the scheme and associated with the main watercourses as listed in Table 4. Discrete layers of Alluvium can also be found where there are areas of prolonged surface flooding, or notable surface depressions where historic and/ or recent ponds can be found. These areas are listed in Table 9.

Alluvium was encountered in 21 exploratory holes along the length of the proposed route (7 boreholes, 5 trial pits and 9 window samples). Of these 16 were located in the vicinity of the known watercourses. The top of the stratum was encountered between the ground surface and 0.5m bgl and the stratum base was encountered between 0.3m and 3.6m bgl, with stratum thickness varying from 0.2m to 2.4 m (average 1.0m). BH1028 was the exception to these relatively shallow deposits where the alluvial material was encountered below the Made Ground and between 3.9 m and 5.6m bgl in the vicinity of Longdike Burn at Ch.20, 000. The alluvial material is predominantly cohesive and described as soft orange brown to brown grey, occasionally mottled and friable, sandy gravelly Clay with occasional rootlets or organic matter. Granular Alluvium is infrequently found interbedded with the cohesive alluvial deposits and described as orangey brown/ grey clayey slightly gravelly fine to coarse SAND with occasional rootlets. These granular stratum are generally less than 1.0m thick.

Table 9 - Alluvial Areas Not Associated with Watercourses

Location (Ch.)	Borehole Reference	Description	Extents (m bgl)	Source
12100	BH1003	Dark orange brown slightly sandy very organic SILT with frequent rootlets	Up to 0.5	Surface water/ ponding
15100 - 15400	BHA1710 TPA1705 WS1509	Soft mottled orange brown and blue grey slightly sandy CLAY with occasional pockets of fine and medium sand/ Dark brown mottled grey clayey fine to coarse SAND	0.3 – 1.5	Land drain/ surface water
17690	BHA1722	Soft dark orange brown mottled blue grey sandy CLAY with occasional pockets of sand and sand partings	Up to 1.5	Surface flooding, edge of area of mining

GLACIAL DEPOSITS

The route corridor and surrounding area is mostly overlain by glacial deposits and more specifically Glacial Till. The glacial deposits include extensive formations of tills, silts, sands and gravels which cover much of lowland Northumbria. The Stage 1 Ground Investigation Report [ref 1] describes the complex stratigraphy of glacial deposits, comprising a sequence of cross-cutting lodgement till units, in extensive detail. Reference to Section 5.3 in the Preliminary Geotechnical Report should be undertaken to fully understand the depositional environment and geomorphology of the Glacial

Deposits. A summary of the approximate depth of the Glacial Deposits along the proposed route is provided in Table 10.

Table 10 – Depth of Glacial deposits/ Depth to Bedrock Along the Proposed Route

Location	Approximate Chainage	Approximate Depth to base of Stratum (m bgl)
Southern extent of scheme	11000	4.5
Highlaws Junction	11500	17.0
Start of offline section of route	14000	19.4
Fenrother Junction	15000	4 – 8.0
Open fields	15700	2.5
Earsdon Burn	17000	14.0
Causey Park Overbridge	17700	8.0 – 16.0
Open fields	18700	4.5
End of offline section	19900	20.0
Route adjacent to Eshott Airfield	20500	25.3
Southern extent of River Coquet	22500	None present - bedrock at surface
Cutting North of River Coquet	22950	13.0
Parkwood Culvert	23100	8.0
Northern extent of scheme	23600	12.0

Cohesive Glacial Till

Cohesive Glacial Till was the principal drift material encountered historically and during the recent GI, being present across the whole route. The material was encountered along the proposed route in 309 exploratory holes (129 boreholes, 158 trial pits and 22 window samples). The stratum was encountered underlying the Topsoil where Made Ground or Alluvial deposits were absent and was frequently interbedded with material considered to be granular till, and laminated clays deemed to represent Glacio-lacustrine deposits.

The top of the cohesive Till stratum was encountered between ground level and 11.2m bgl, where the cohesive till was overlain by significant deposits of Made Ground, Alluvium and Glacio-lacustrine deposits in BH1028, with an overall average top of stratum of 0.55m bgl. The stratum base was encountered between 0.6m bgl and 25.55m bgl, equivalent to a level of 36.3m OD in BH1029, with an average depth to base of 5.3m bgl across the scheme. The cohesive Glacial Till can be described as firm to very stiff, generally stiff dark grey/ brown slightly sandy, slightly gravelly Clay, with occasional cobbles and boulders of mudstone, siltstone and sandstone. Gravel is subrounded to subangular of mudstone, siltstone, sandstone and coal.

Granular Glacial Deposits

Material considered to represent granular Glacial Till or Glaciofluvial Sands and Gravels was encountered in 98 exploratory holes (40 boreholes, 50 trial pits and 8 window samples). The stratum was typically encountered as discrete layers within the Cohesive Till with the top of the stratum present between 0.2m and 15.2m bgl (average 2.7m bgl) and the stratum base encountered between 0.3m and 15.3m bgl (average 3.5m bgl). The stratum thickness was found to vary from 0.1m to 3.2m with an average thickness of 0.85m. The granular Glacial Till is generally described as brown fine to coarse sand or gravel. Gravel is subangular to subrounded fine to coarse of various lithologies including sandstone, mudstone and quartz.

Between Ch.22000 and 23100 at the northern extents of the scheme the geological mapping indicates the underlying material to be Glaciofluvial Sands and Gravels. Although it appears that material considered to be cohesive Till is still dominant in these areas, there appears to be more frequent and persistent layers of material of a granular nature. Lenses of granular material in excess of 1.7m thick are found at relatively shallow depths (<5.0m bgl) and are described as medium dense brown slightly gravelly very clayey fine to coarse Sand/ very sandy subangular to subrounded fine to coarse Gravel. Gravel is fine to medium of various lithologies including sandstone, mudstone and quartz.

Glaciolacustine Deposits

The Glaciolacustrine deposits are generally described as firm to stiff, occasionally soft, thinly laminated, slightly sandy, slightly gravelly clay with occasional interlaminations of silty sand. Occasionally the material is described as soft to stiff laminated sandy Silt of low to intermediate plasticity, although these descriptions appear to be confined to exploratory holes excavated prior to 2006 and excavated between Ch.21910 – Ch.23600of the scheme.

The material is distributed within in 46 exploratory holes (27 boreholes, 18 trial pits and 1 window sample). The majority of these exploratory holes are located north of Ch.19500 where the proposed route merges onto the existing A1. The material is found in discrete and reoccurring layers within the exploratory holes and is frequently interbedded with the other glacial deposits. The top of the stratum was encountered between 0.1m and 9.7m bgl (average 3.0m bgl) and the stratum base was encountered between 2.4m and 18.65m bgl (average 5.6m bgl), with stratum thickness varying from 0.2m to 11.2m (average 2.5m).

Table 11 – Extents of Glaciolacustrine Deposits along the Proposed Route

Location	Approximate Chainage	Date of GI/ Exploratory Holes	Approximate Depth to base of Stratum (m bgl)	Proven Thickness* (m)
Highlaws Junction	11500	2017 (BHA1703 and TPA1753)	3.6	1.7
Fenrother Junction	15000	2006 (TP1233, TP1234)	2.7	1.0
Burgham Underbridge	19500	2006/ 2017 (BHA1733, TP1270 – TP1272)	3.2 – 9.5	>0.8 – 6.8
Longdike Burn	19950	2006/ 2017 (BHA1735, BH1028, WS1515)	2.3 – 10.1	0.2 – 4.5

Location	Approximate Chainage	Date of GI/ Exploratory Holes	Approximate Depth to base of Stratum (m bgl)	Proven Thickness* (m)
Route adjacent to Eshott Airfield	20400	2006/ 2017 (BH1029, BH1030 TPA1729, TP1280)	3.6 – 18.65	0.1 – 11.2
Westmoor Junction	21700	2006/ 2017 (BHA1736, BHA1737, BH1030, BH1031, TP1289, TP1290, TP1293, TP1294)	3.2 – 10.8	0.9 – 2.3
Northern extent of scheme	23200 - 23600	2006, 1998, 1971 (BH01/98 – BH06/98, BH1045, BH34, BH35, BH35A, BH37 - BH39, TP02 – TP06, TP08	4.0 – 9.5	0.2 – 8.8

**more than one stratum layer present in some exploratory holes*

BEDROCK

The bedrock encountered along the alignment of the proposed route comprised a variety of strata belonging to the Stainmore Group and Lower Pennine Group including Sandstone, siltstone, mudstone, Limestone and relatively thin coal deposits. Given the minor differences between the units of interbedded mudstone, siltstone and sandstone, it was not feasible to differentiate between the two groups based on the rock descriptions. Rock head elevation is variable along the route and coincides with changes in the thickness of Glacial Deposits as detailed in Table 10 and was proven in excess of 50m bgl (13.7m OD).

Weathered Bedrock Horizon

A relatively thin layer of residual soil representing the completely weathered zone of the underlying bedrock was encountered overlying the intact rock across the majority of the route and it was especially obvious where rock head was closer to the ground surface. The material is thought to represent grades 4 and 5 on the ISRM rock mass weathering scale.

The completely weathered deposits are generally described as very weak Mudstone, Siltstone or Shale recovered as a stiff clay or firm to stiff sandy gravelly clay and the gravel is composed of material from the underlying parent rock (predominantly mudstone and to a lesser extent siltstone). Where the material is thought to represent weathered sandstone, the deposits were described as very dense grey very silty sand or weak coarse grand sandstone recovered as clayey sand. The recent boreholes indicate this stratum is generally around 0.5 to 1.0m thick and is predominantly cohesive in nature.

Frequently the Coal Measures were described as partially weathered (rock mass weathering scale grades 2 and 3) comprising Gravel derived from the destructured or non intact Mudstone/ Siltstone and to a lesser extent Sandstone which occurred at varying depths throughout the exploratory holes. At shallow depths, the broken material is likely to be the partially weathered underlying bedrock. Where the material is encountered at more significant depths it is possible that this is a result of weakened zones in the bedrock and often the gravel is coupled with zones of limited or no core recovery.

It is also possible that the poor recovery and/ or non-intact nature of the material are a result of a weakened zone related to localised faults associated with the tectonic environment at this location or areas of underground mine workings. Alternatively, the poor recovery and or shattered core could be associated with the susceptibility of the material to weathering or problems with the drilling technique. Several of the most recent boreholes note that the fractured material is due to probable drilling disturbances.

Mudstone

A large proportion of the bedrock encountered underlying the scheme was described as Mudstone. The material was encountered in 52 exploratory holes (47 boreholes, 3 trial pits, 2 window samples) This was proven between depths of 0.6m and 47.25m bgl with a maximum stratum thickness of 13.0m. It predominantly comprised dark grey to black extremely weak to weak Mudstone, occasionally strong and frequently described as carbonaceous and micaceous or finely laminated with subordinate horizons of coal. Occasionally the material was described as Shale or calcareous, largely in the historical descriptions. The Mudstone was regularly described as thinly to thickly interbedded with Sandstone and less frequently with Limestone (Undifferentiated Coal Measures). The undifferentiated beds are generally encountered underlying Westmoor Junction and in the cutting to the north and south of the River Coquet.

Discontinuities were frequently described as horizontal to sub horizontal, very closely to closely spaced occasional medium spaced, planar rough to smooth, occasionally undulating. The second was less frequent and described as vertical to subvertical (60° to 90°), closely spaced planar, occasionally stepped rough, with occasional iron oxide staining.

Sandstone

66 exploratory holes (65 boreholes and 1 trial pit) encountered Sandstone material between the ground level in the vicinity of the River Coquet, proven to a depth of 46.2m bgl. Stratum thickness varies between 0.1m and 10.18 (average 2.4m). The intact Sandstone was described as grey, fine to medium grained Sandstone and generally classified as weak becoming medium strong to very strong but occasionally remaining weak even at depth. Frequently the Sandstone was described as interbedded with Mudstone or occasionally Siltstone (Undifferentiated Coal Measures).

Siltstone

Siltstone was encountered relatively less frequently across the scheme in 24 exploratory holes and is predominantly described as moderately strong to strong, occasionally weak dark grey/ brown occasionally carbonaceous Siltstone. The material is recorded with thicknesses of between 0.05m and 2.1m, but typically 0.35m and proved to depths of up to 35.25m below ground level. The Siltstone is occasionally described as interbedded with Sandstone (Undifferentiated Coal Measures).

Limestone

The Corbridge Limestone is a shelly unit within the Stainmore Formation that occurs in the vicinity of the River Coquet. The material is distributed within in 12 boreholes in the immediate vicinity of the river valley between depths of 4.0m bgl and 50m bgl (13.7m OD to 56.8m OD) with recurring stratum of thicknesses varying between 0.11m and 8.78m (average 2.3m). The material is described as generally weak but sometimes strong grey silty (historically impure or muddy) fine grained thinly to moderately bedded Limestone with very occasional thinly laminated weak black calcareous Mudstone.

Coal

Coal seams with thicknesses of between 0.05m and 2.1m, but typically 0.35m in thickness were encountered in 30 exploratory holes and proved to depths of up to 35.25m below ground level. Of these, three exploratory holes encountered coal recorded in excess of 1.0m thick (BH11, TPE, and TPI) and these were excavated between Ch22200 and Ch22360, between elevations of 64.0m OD and 66.6m OD which is above the existing A1 carriageway level. The majority of exploratory holes recording coal have been excavated north of Ch.21600 or the proposed Westmoor Junction.

The deposits are described as extremely weak to weak, occasionally strong but historically 'poor quality' black sometimes slightly weathered or fissile Coal. Occasionally the coal is recovered as a non intact sandy gravel. The material is frequently described as thinly interlaminated with organic mudstone and the grading between these materials appears to be difficult to distinguish in places.

Causey Park Dyke

Three borehole and two trial pits were carried out within the vicinity of the tholeiitic intrusion which has been mapped to underlie the proposed route. These exploratory holes were excavated to a maximum depth of 17.0m (68.04m OD). No boreholes have encountered the material to date.

5.4. STRUCTURAL GEOLOGY

No further information to add beyond that of the existing information in Section 3.2.

5.5. HYDROLOGY/ HYDROGEOLOGY

Groundwater strikes within the exploratory holes from the recent Ground Investigations were recorded between 0.2m bgl to 27.10m bgl, typically as perched groundwater in the Made Ground or glacial deposits and standing groundwater within the Coal Measures. These are discussed in more detail in section 6.9.

5.6. GEOMORPHOLOGY

The results of a geomorphological mapping exercise completed for the River Coquet valley is contained in Appendix E.

5.7. MINING

Further to the information presented in Section 3.6 and Appendix H, there is evidence of a potential risk from historic mining in the vicinity of the route around Causey Park. Additional ground investigation undertaken on the route alignment did not encounter any voids and where coal was encountered it was unworkably thin (around 0.20m). This corresponded to similar thicknesses of coal encountered in some historic boreholes. Though some zones of no recovery occurred in the area, these generally correspond to depths where very weak mudstone (recovered as mudstone gravel) are recorded on nearby logs. It is therefore considered that the lack of recovery is due to core loss due to the drilling fragmenting and washing out the very weak mudstone gravel.

It is considered that no boreholes have conclusively encountered workings in the documented mining areas to date including those formed recently specifically to investigate this risk. However, it is clear that near-surface mining has taken place in the vicinity of the route and allowance treatment of unexpected workings should be made.

5.8. MAN-MADE FEATURES

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

6. GROUND CONDITIONS AND MATERIAL PROPERTIES

The following paragraphs present the characteristics of each material type presented in Chapter 5 from and includes the data compiled from the historic 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.

Graphical plots produced as part of the 2006 GIR [ref 1] have been updated and where appropriate to include the recent GI information. Where plots do not show a trend or there are very limited results, these have not been included as figures in this report. Deviations or confirmation of material property trends identified in the 2006 report are discussed in the subsequent paragraphs.

Geological long sections have been produced for the scheme and are presented in Appendix F.

6.1. TOPSOIL

It is recommended for preliminary design purposes that the average thickness of topsoil is taken as 0.3m as demonstrated in Table 8. No geotechnical testing was carried out on samples of topsoil.

6.2. MADE GROUND

Testing on the Made Ground was predominately undertaken across the five main areas as discussed in Section 5 as well as occasional discrete pockets of Made Ground material outside of these areas.

CLASSIFICATION

Nineteen particle size distribution (PSD) tests were performed on samples of Made Ground and the results are displayed in Figure 3 and Figure 4 which show material classified as granular Made Ground and cohesive Made Ground respectively.

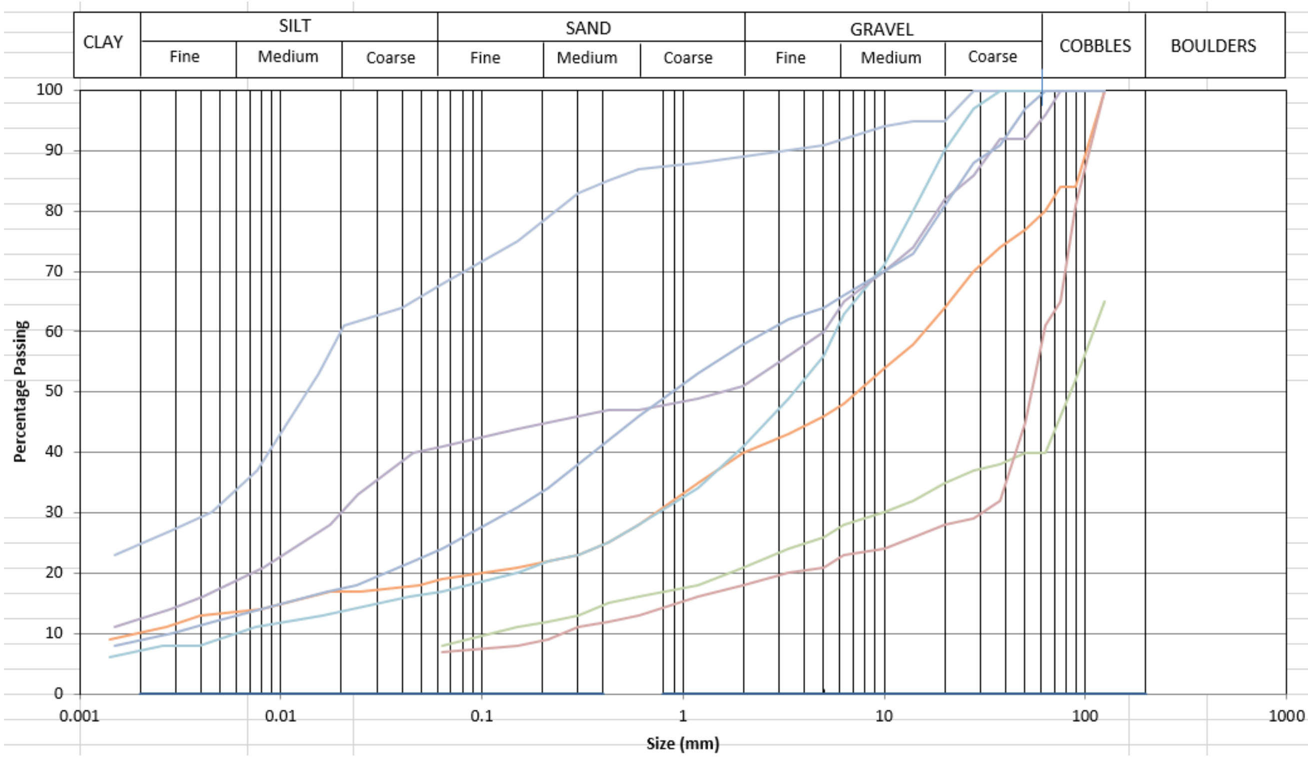


Figure 3 – PSD for Granular Made Ground

Samples of granular Made Ground which have been graded were largely sourced from the backfilled material in the cuttings north of the River Coquet, Embankment M2FE07 and adjacent to Eshott airfield. On the basis of the curves alone, the granular deposits would generally classify as slightly silty sandy poorly or gap graded gravel with occasional cobbles. The cohesive deposits generally classifying as sandy gravelly clay/ silt. One of the deposits described as granular returned a PSD with fines of around 68%, this was described as 'roadstone' on the window sample log and is therefore noted to be a spurious result. The grading shows the material to have a highly variable fines content.

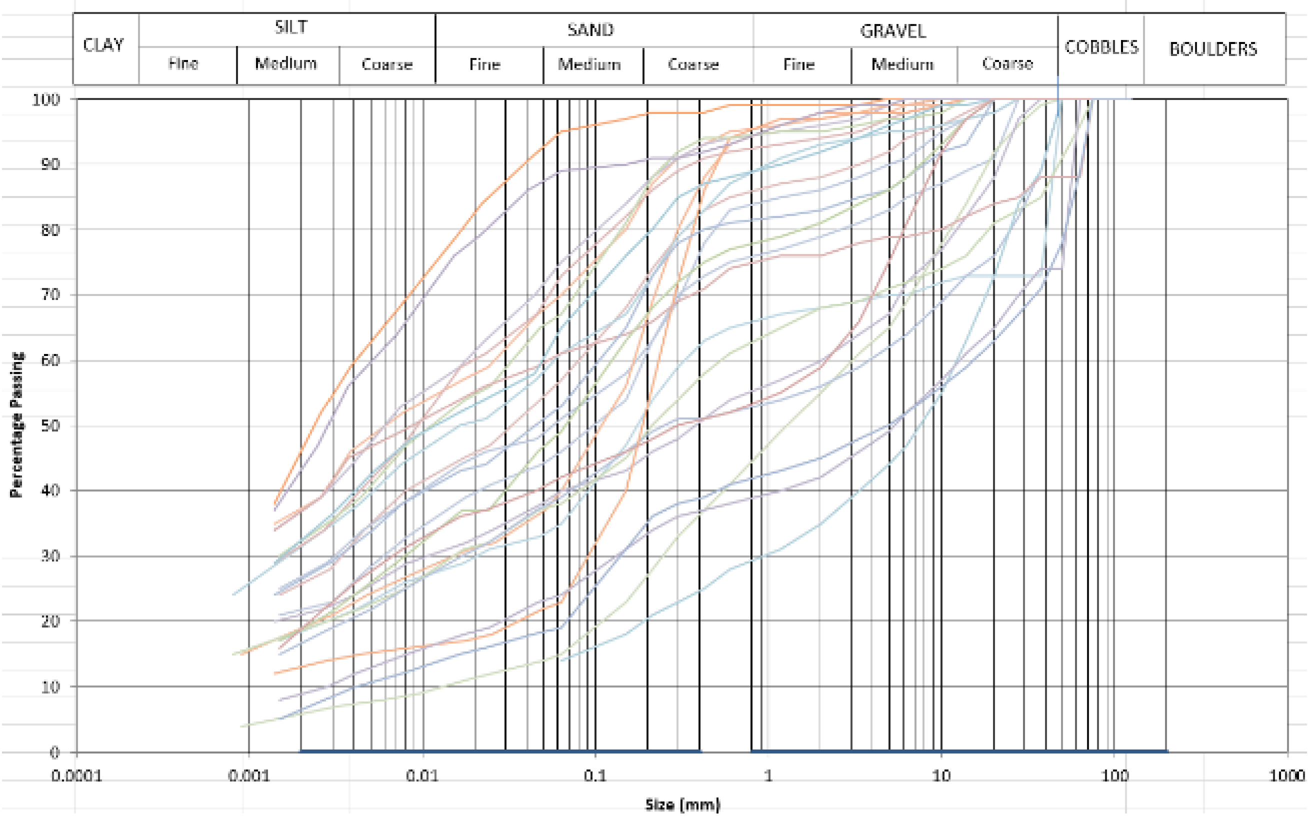


Figure 4 – PSD for Cohesive Made Ground

ATTERBERG LIMITS

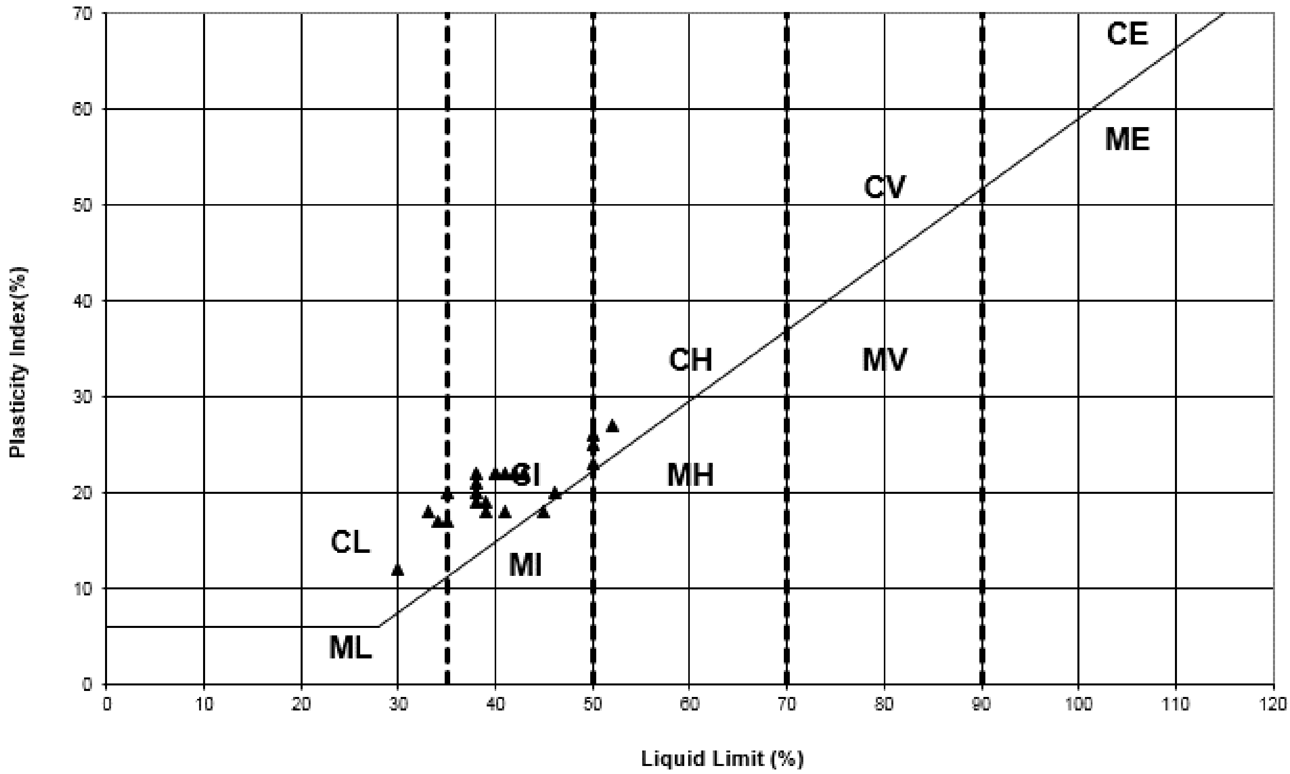


Figure 5 – Plasticity Chart for Made Ground

As depicted on Figure 5, where the Made Ground deposits are cohesive, these were classified as principally an intermediate plasticity clay. The plasticity index varied between 11% and 27%, but generally between 18% and 22%. The results of classification testing on the cohesive Made Ground all lie within the range of values identified for the Cohesive Till. This indicates, as would be expected, that the Made Ground is typically derived from locally won material. A large proportion of cohesive material tested was recovered from the exploratory holes excavated with M2FE07 and within the reworked material on the northern bank of the River Coquet.

MOISTURE CONTENTS

Moisture contents within the Made Ground varied between 2.7% and 33% with the majority of the results falling between 10% and 25%. There is no correlation between the moisture content and depth of the sample within the Made Ground.

SPT 'N' VALUES

Twenty three SPT values are recorded within Made Ground Deposits and varied from 6 to >50 with an average of 35. Figure 6 shows a plot of N-Value with depth. SPTs undertaken in areas of known Embankment Fill (BH1044 and BH1043 within M2FE07) show a marked increase of N-Values with depth. Several of the SPT values shown as 50 or greater are associated with an area of presumed reworked Mudstone on the northern river bank of the River Coquet. In addition, across the site the Made Ground is described as occasionally containing cobbles or cobble sized fragments including brick and concrete.

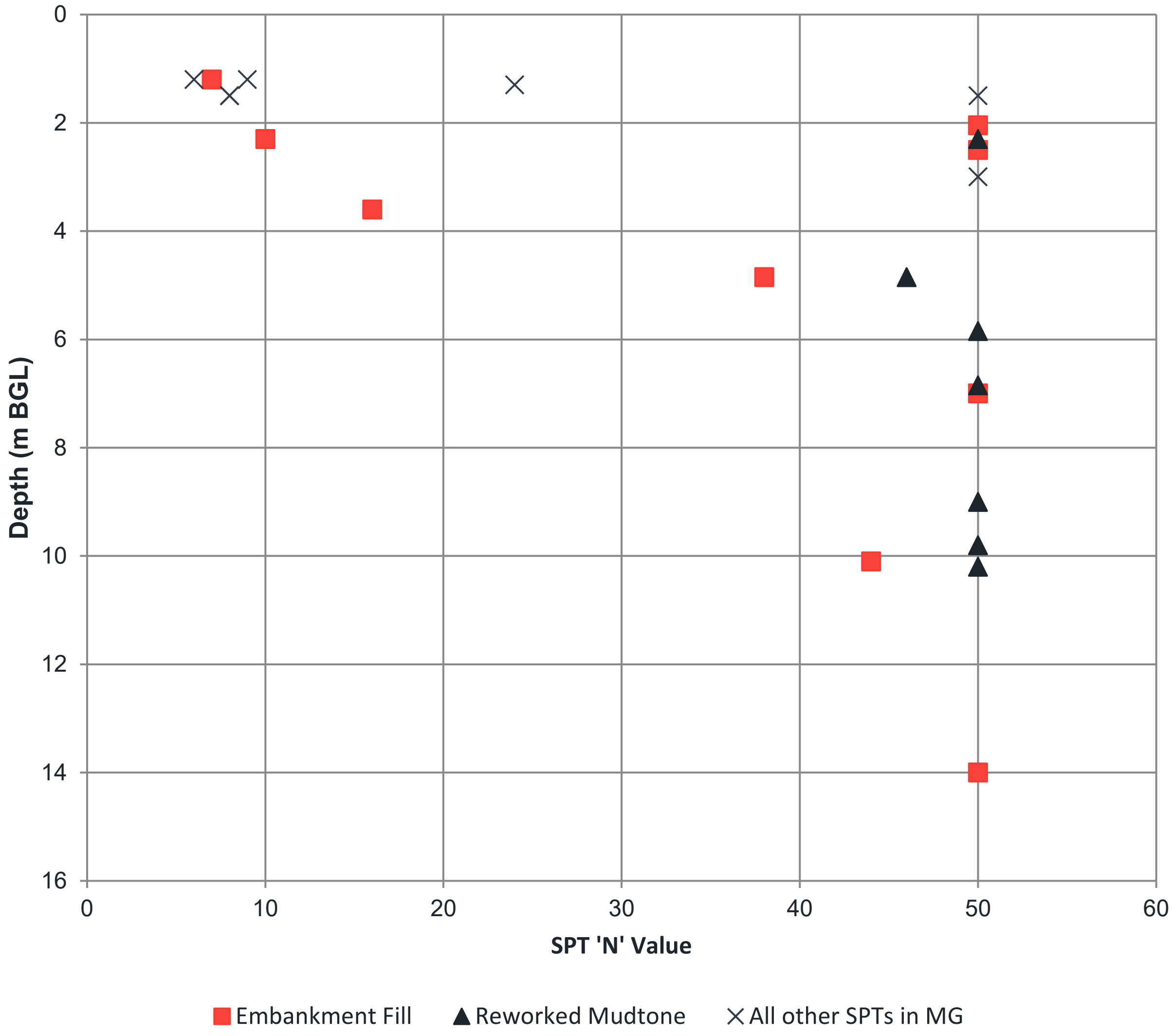


Figure 6 – SPT vs Depth for Made Ground

SHEAR STRENGTH PROPERTIES

Four undrained triaxial tests and fifty eight hand shear measurements were undertaken on samples of the Made Ground. The undrained shear strength results ranged from 9kPa to 160kPa, with a mean value of 78.5kPa. Figure 7 shows a general scatter of shear strength with depth.

The lowest value of 9kPa was obtained from a sample excavated within the Made Ground at 3.85m bgl within the northern river bank of the River Coquet and in the vicinity of an area with known stability issues. The highest value was obtain from material known to represent engineered fill at with embankment M2FE07.

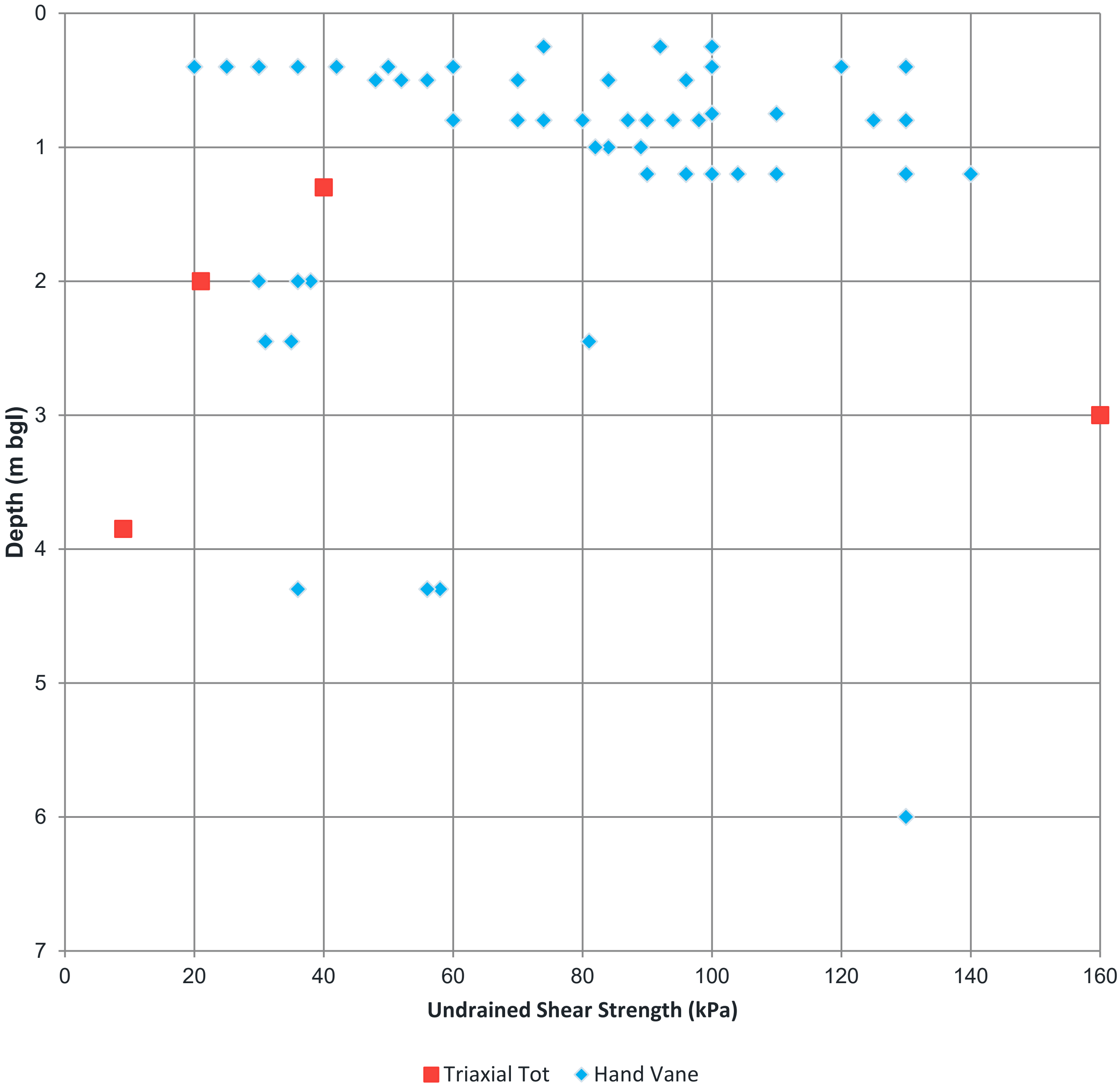


Figure 7 - Undrained Shear Strength vs Depth for Made Ground

EFFECTIVE STRESS PROPERTIES

Two single stage consolidated undrained triaxial tests performed on Made Ground excavated within embankment M2FE07 at 4.3 and 5.7m bgl recorded shear strengths (c') of 0kPa with the angle of shearing resistance (φ') of 20° and 26.5° respectively.

COMPRESSIBILITY

Two oedometer test were carried at depths of 3.0m bgl and 12.6m bgl in BH1044 where the deposits were described as Made Ground; generally firm to stiff slightly sandy slightly gravelly Clay. The values of the coefficient volume compressibility, mv, varied from 0.029 to 0.154m^2/MN depending on the imposed effective stress. The coefficient of consolidation, cv, ranged from 4.14 to 9.81m^2/year depending on the loading situation.

SUMMARY OF GEOTECHNICAL PARAMETERS

Table 12 - Summary of Geotechnical Parameters for Made Ground

Properties	Min	Max	Mean	No. of Tests	Suggested Global Design Parameter*
Natural Moisture Content (%)	2.7	33	19	39	19
Plastic Limit (%)	N/P	41	21	29	21
Liquid Limit (%)	25	55	41	27	38
Plasticity Index (%)	11	27	21	27	20
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	CL	CH	CI	27	n/a
Bulk Density (Mg/m^3)	1.84	2.19	2.1	8	2.10
SPT 'N' Value (blows per 300mm)	6	>50	35	23	8[1]
Undrained Shear Strength Cu (kPa)	9	160	79	62	30
BS EN ISO 14688-2 Undrained shear strength classification	Extremely low	Very High	High	62	n/a
Peak Internal Angle of Friction (degrees)	20	27	-	2	20
Consolidation coefficient of compressibility (Oedometer) (m^2/MN)	0.029	0.154	-	2	0.15

*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

[1]Discounting values of in excess of 50 obtained in the area of densely compacted embankment fill.

6.3. ALLUVIUM

CLASSIFICATION

Three PSD tests undertaken on the alluvial material are presented in Figure 8 and indicate very sandy deposits with variable silt/ clay content with a fines fraction ranging from 25 to 71%.

ATTERBERG LIMITS

Eleven Atterberg tests were performed on material considered to represent the cohesive Alluvium. Two returned as non plastic and one of these samples is described as containing pockets of sand. The cohesive alluvium can be classified as predominantly a low plasticity clay. The plasticity index varied between 12% and 33%, but generally between 12% and 22% with one result returning as a low plasticity silt.

MOISTURE CONTENTS

Moisture contents within the Alluvium varied between 13% and 32% with an average value of 25%. The majority of the results fall between 20% and 30% and this is relatively higher compared to the surrounding deposits as would be expected.

SPT 'N' VALUES

Given the relatively shallow distribution of the Alluvium, limited SPTs were performed within the material. Three tests recorded N values of 1, 7 and 21. The highest result corresponds with a layer of soft clay described as containing pockets of sand and sand partings.

CBR

One CBR test was undertaken on material described as soft mottled orange brown and blue grey slightly sandy CLAY with occasional pockets of fine and medium sand at 0.35m bgl within an area that experience periodic surface water flooding. The CBR was recorded as 0.34% at the top and bottom of the sample.

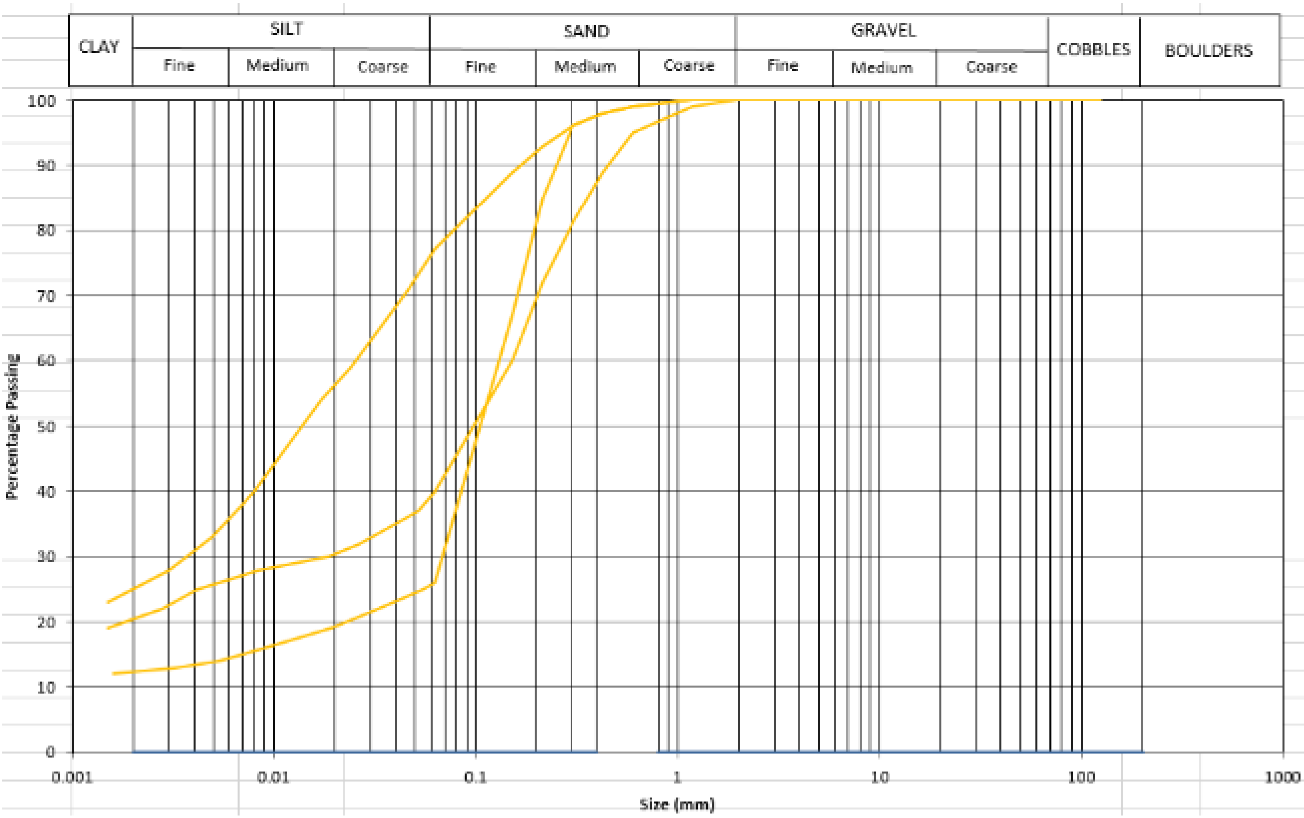


Figure 8 – PSD for Alluvium

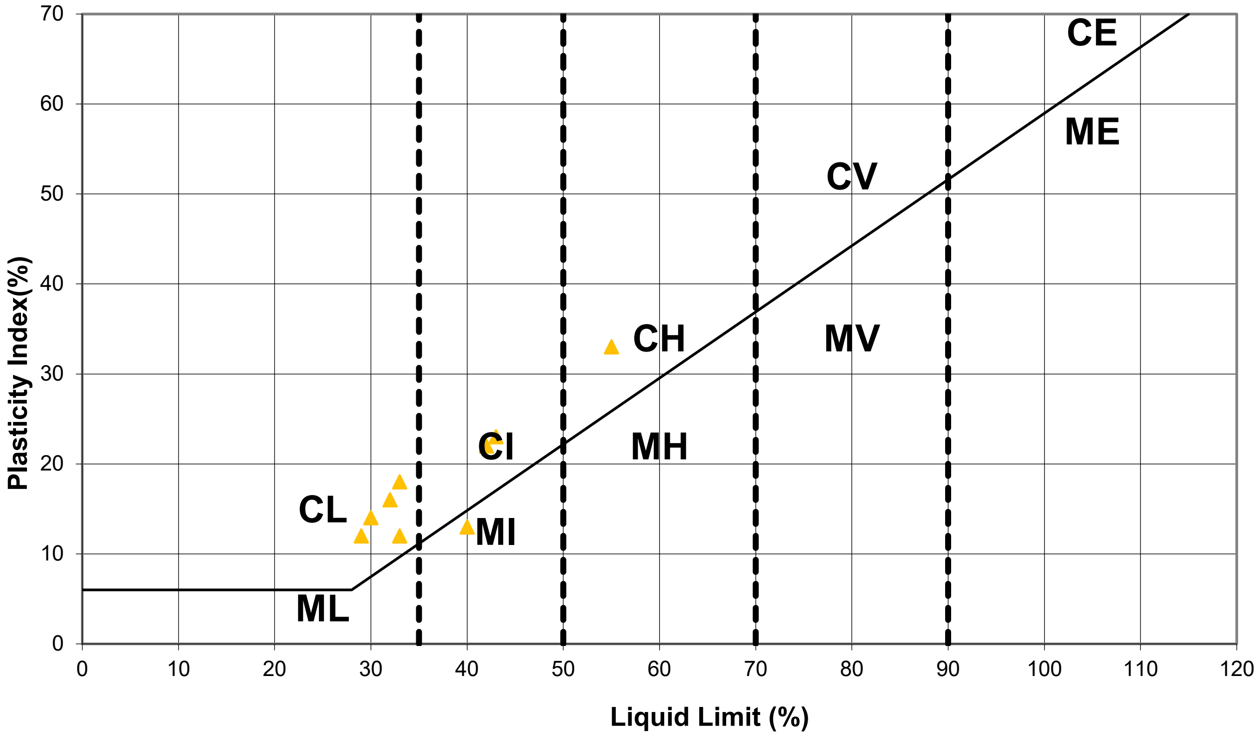


Figure 9 – Plasticity Chart for Alluvium

SHEAR STRENGTH PROPERTIES

Twelve Hand Shear Vane tests and a single quick undrained triaxial test were carried out on the Alluvium. The triaxial test carried out on a sample of alluvium from BH1010 adjacent to the River Lyne recorded a peak undrained strength of just 9kPa indicating an extremely low strength material. Hand shear vane tests were carried out at shallow depths in inspection or trial pits and gave an average peak undrained shear strengths of 46kPa (medium strength) and residual of 26kPa (low strength).

Six of the Hand Shear Vane tests were performed on material described in BH1015 as dark brown clayey fine to coarse Sand with frequent rootlets. The results gave fairly consistent values of between 30 kPa and 46 kPa and it is suggested that the material is tending to be actually more cohesive nature.

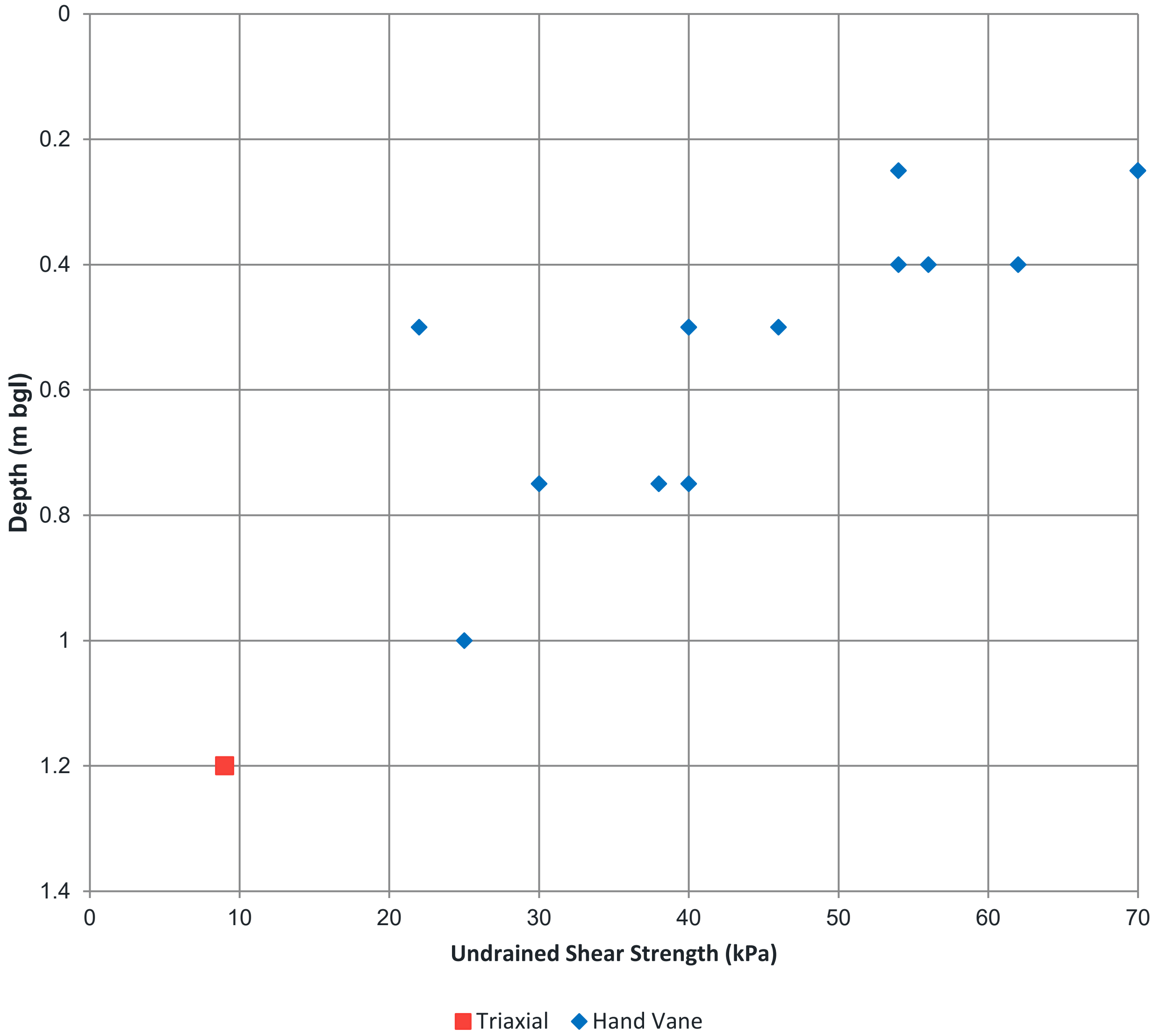


Figure 10 – Undrained Shear Strength vs Depth for Alluvium

COMPRESSIBILITY

No in-situ or laboratory determinations of compressibility were carried out on the Cohesive Alluvium.

SUMMARY OF GEOTECHNICAL PARAMETERS

Table 13 - Summary of Geotechnical Parameters for Alluvium

Properties	Min	Max	Mean	No. of Tests	Suggested Global Design Parameter*
Natural Moisture Content (%)	13	32	25	13	25
Plastic Limit (%)	15	27	19	11	19
Liquid Limit (%)	29	55	38	11	38
Plasticity Index (%)	12	33	18	11	18
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	CL	CH	CI	11	n/a
Bulk Density (Mg/m^3)	1.85	1.99	-	2	1.85
SPT 'N' Value (blows per 300mm)	1	21	-	3	#
Peak Undrained Shear Strength Cu (kPa)	9	70	46	14	35
Residual Undrained Shear Strength Cu (kPa)	16	38	26	12	20
BS EN ISO 14688-2 Undrained shear strength classification	Extremely low	Medium	Medium	12	n/a
CBR (%)	0.34	0.34	-	1	Less than 2.5

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

#Not considered appropriate to provide global value given minimal number of tests and their distribution across the site

6.4. GLACIAL DEPOSITS – COHESIVE

CLASSIFICATION

Figure 11 shows the particle size distribution for the cohesive glacial deposits and the red envelope annotated on to the chart highlights where the largest density of the results lie, with occasional outliers beyond the envelope. The majority of the results within this envelope indicate that typically the cohesive till has a fine fraction between 45 to85% and a clay size fraction of 18 to45%. This corresponds to a matrix dominated till texture according to CIRIA C504, with a dominant fraction lying between granular (45 to70% fines) and cohesive (70 to100% fines). The low granular content indicates that the coarse fraction of the cohesive till is unlikely to play a large part in influencing the geotechnical characteristics of the Glacial Till and the shear strength, compressibility and density of the cohesive till will largely be influenced by the fines fraction.

The cohesive till typically has 15 to 25% sand size content and up to 20% gravel size content. The absence of cobbles and boulder can be attributed to the unrepresentative nature of the sampling process where coarser particles are seldom sampled. Given the higher cobble content from trial pit material, it is likely the test result completed from these locations are those most representative of the in situ Glacial Deposits.

ATTERBERG LIMITS

Atterberg tests were carried out on 397 samples of the cohesive till and seven of these were proven to be non-plastic. 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 12 indicates the Cohesive Till to be typically of the low to intermediate plasticity. Figure 13 shows that the Till within the top 2.0m presented a plasticity index of between 20% to 30%, decreasing to between 15% to 20% below 2.0m bgl and therefore reducing slightly with depth.

Based on a typical clay size percentage of 30% and the average PI of 21% the activity of the Cohesive Till is 0.73 and may be classed as 'Inactive'.

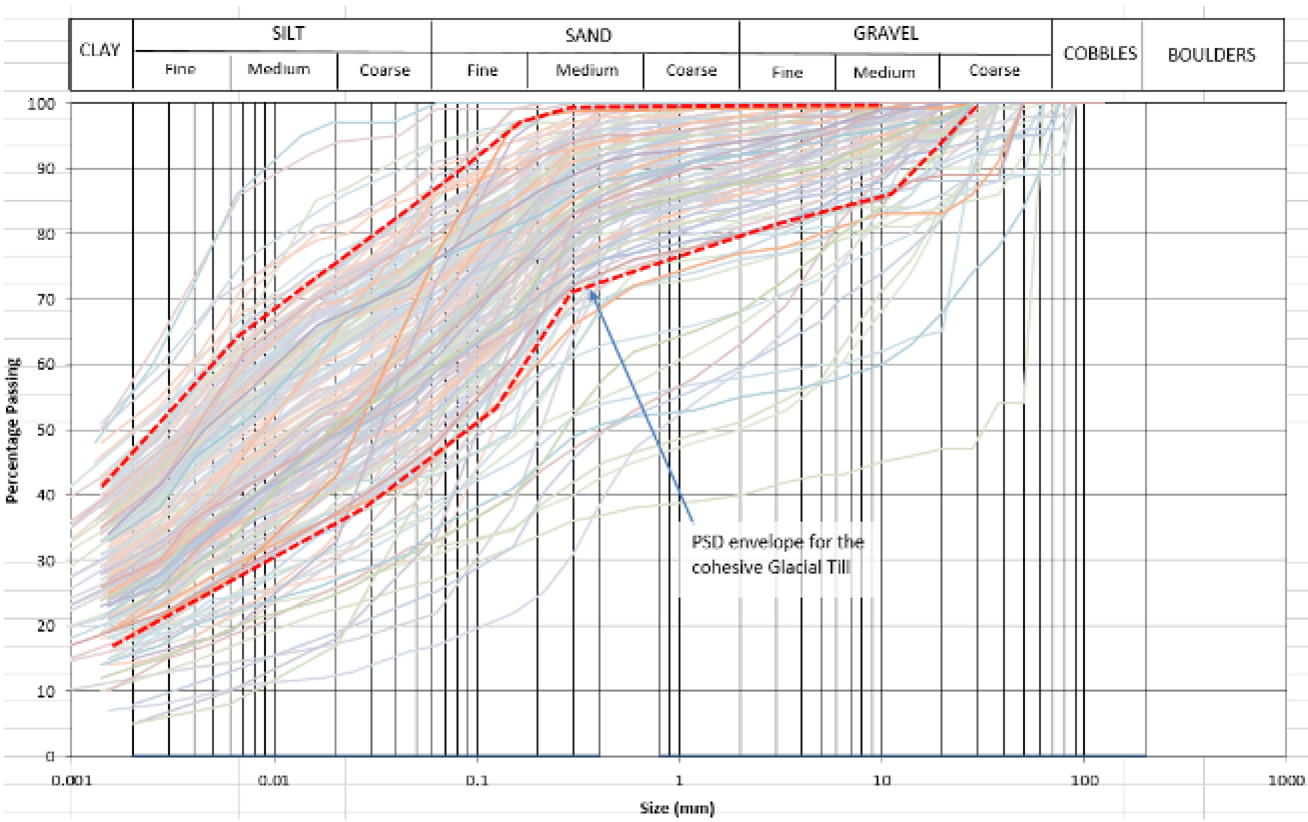


Figure 11 – PSD for Cohesive Glacial Till

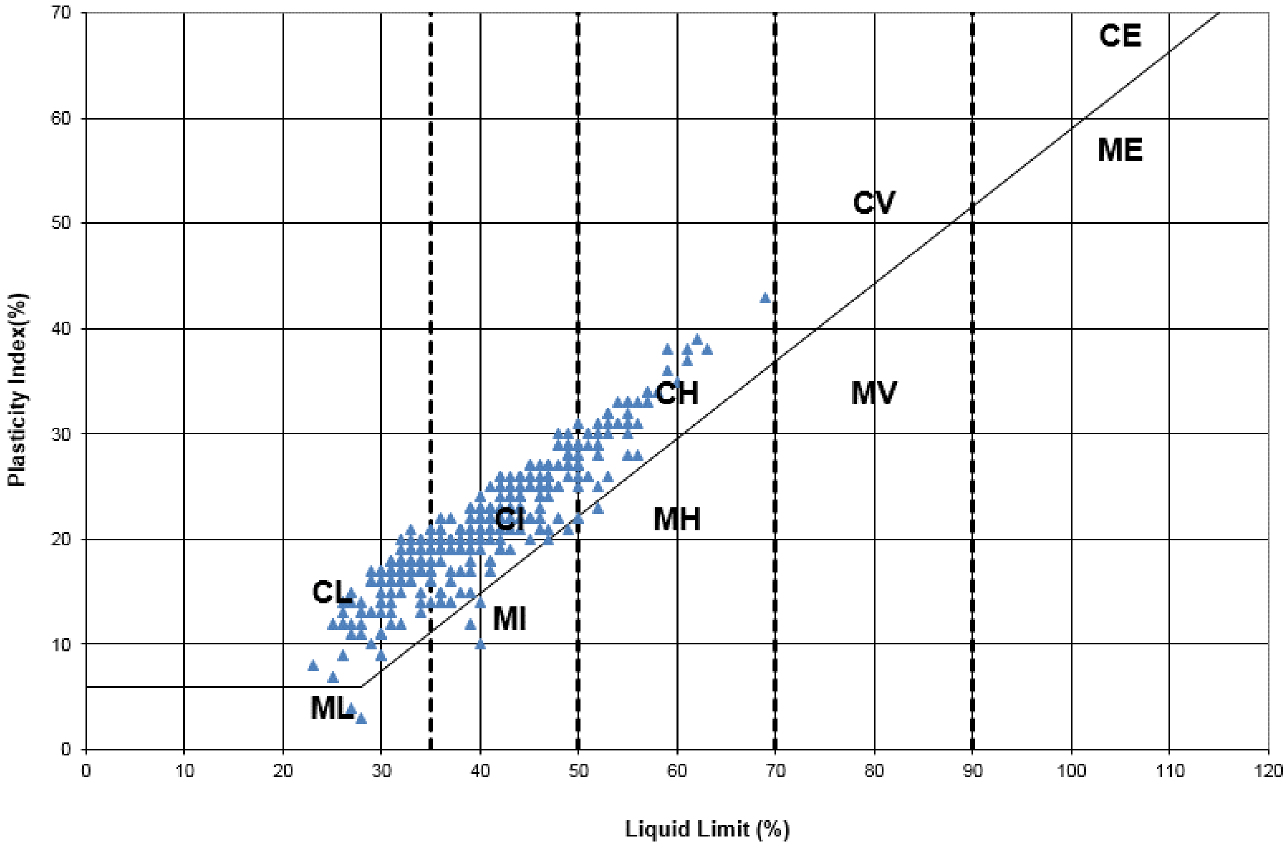


Figure 12 – Plasticity Chart for Cohesive Glacial Till

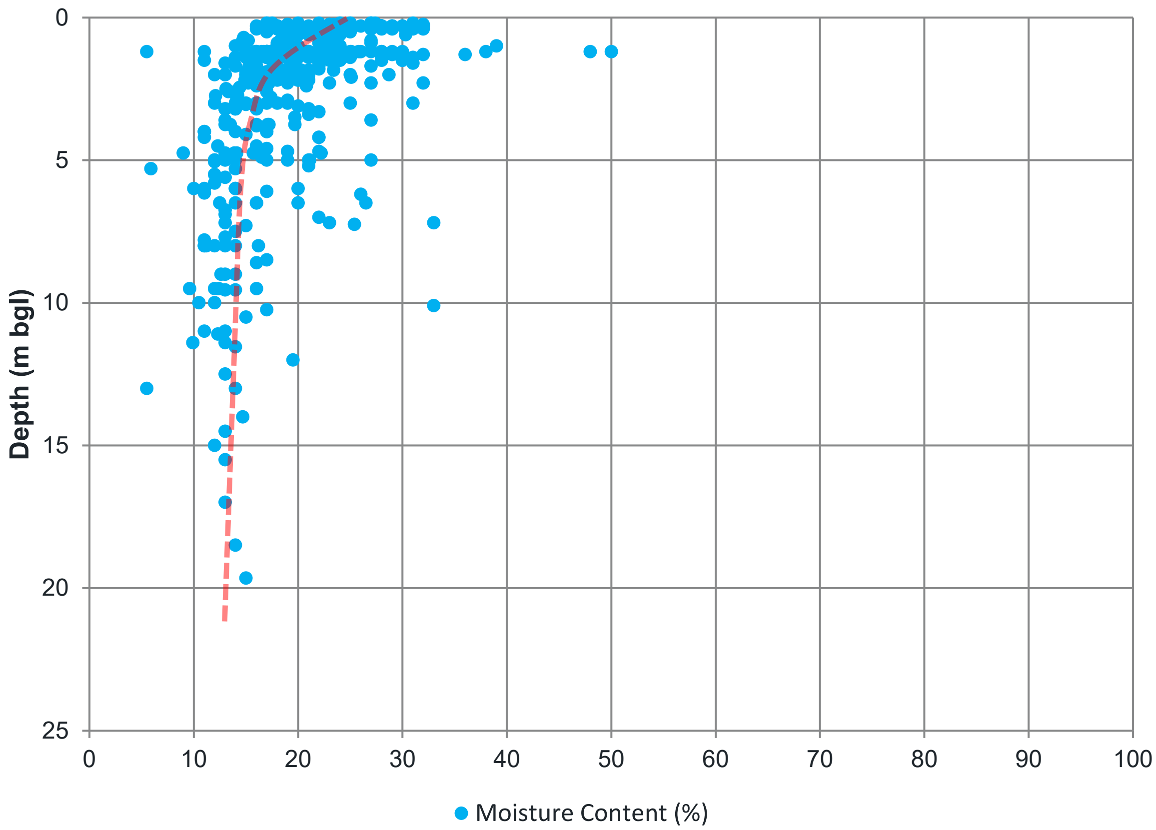


Figure 13 –Moisture Content vs Depth for Cohesive Glacial Till

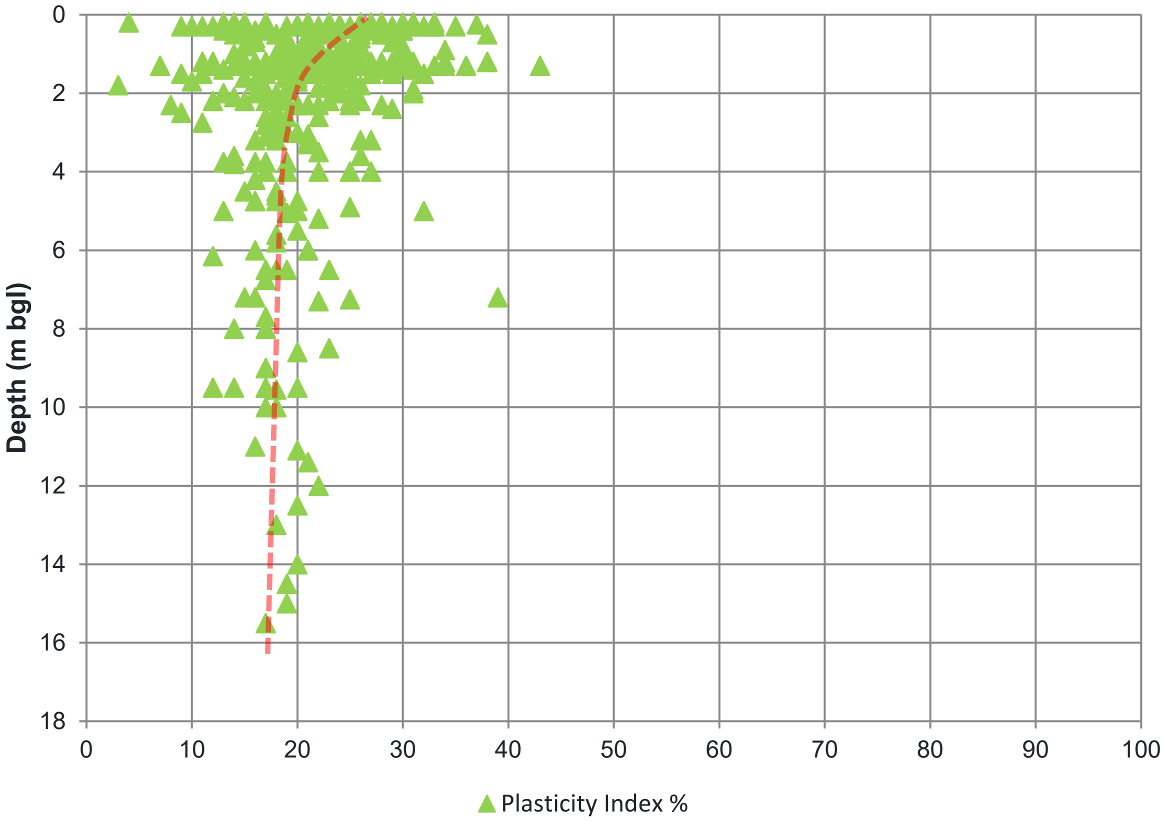


Figure 14 –Plasticity Index vs Depth for Cohesive Glacial Till

MOISTURE CONTENT

The natural moisture content of the Cohesive Till ranged from 5.5 to 50% with an average value of 19.6%. As with the plasticity index, there is a marked increase in moisture content within the top 2.0m of the Till and this is also depicted on Figure 13.

SPT 'N' VALUES

SPT values within the Cohesive Till were highly varied ranging from 4 to >50 but generally between 10 and 50. A total of 274 SPTs were carried out within the Cohesive Till and the results indicate a marginal trend for increasing N value with depth with an average corrected N value of 25.

SHEAR STRENGTH

Hand-Shear Vane tests carried out within trial pits and U100 samples measured peak shearing resistance values of between 10kPa and 176kPa with an average value of 91kPa, and where evaluated, residual shearing resistance values of between 8kPa and 100Pa with an average value of 40kPa. The highest proportion of tests results fall between 50kPa and 130kPa. The results are plotted on Figure 15.

Seventy nine Quick Undrained Triaxial tests were undertaken on samples of the Glacial Till which gave undrained shear strengths values of between 17kPa and 230kPa with an average of 88kPa, a similar average magnitude to the results of the Hand-Shear Vane tests. These deposits were predominately described as stiff to very stiff and indicate the material is over consolidated. These results are also plotted on Figure 15.

It should be noted that shear strength values can also been derived from SPT N values using the relationship Cu=5.3N and assuming an average Plasticity Index of 21% (after Stroud and Butler, 1975). The derived values indicate a much wider spread of results compared to the measured with values given between 21kPa and 265kPa with an average value of 133kPa.

Based on the above discussion a shear strength range of between 60kPa - 80kpa is therefore proposed for the Glacial Till deposits.

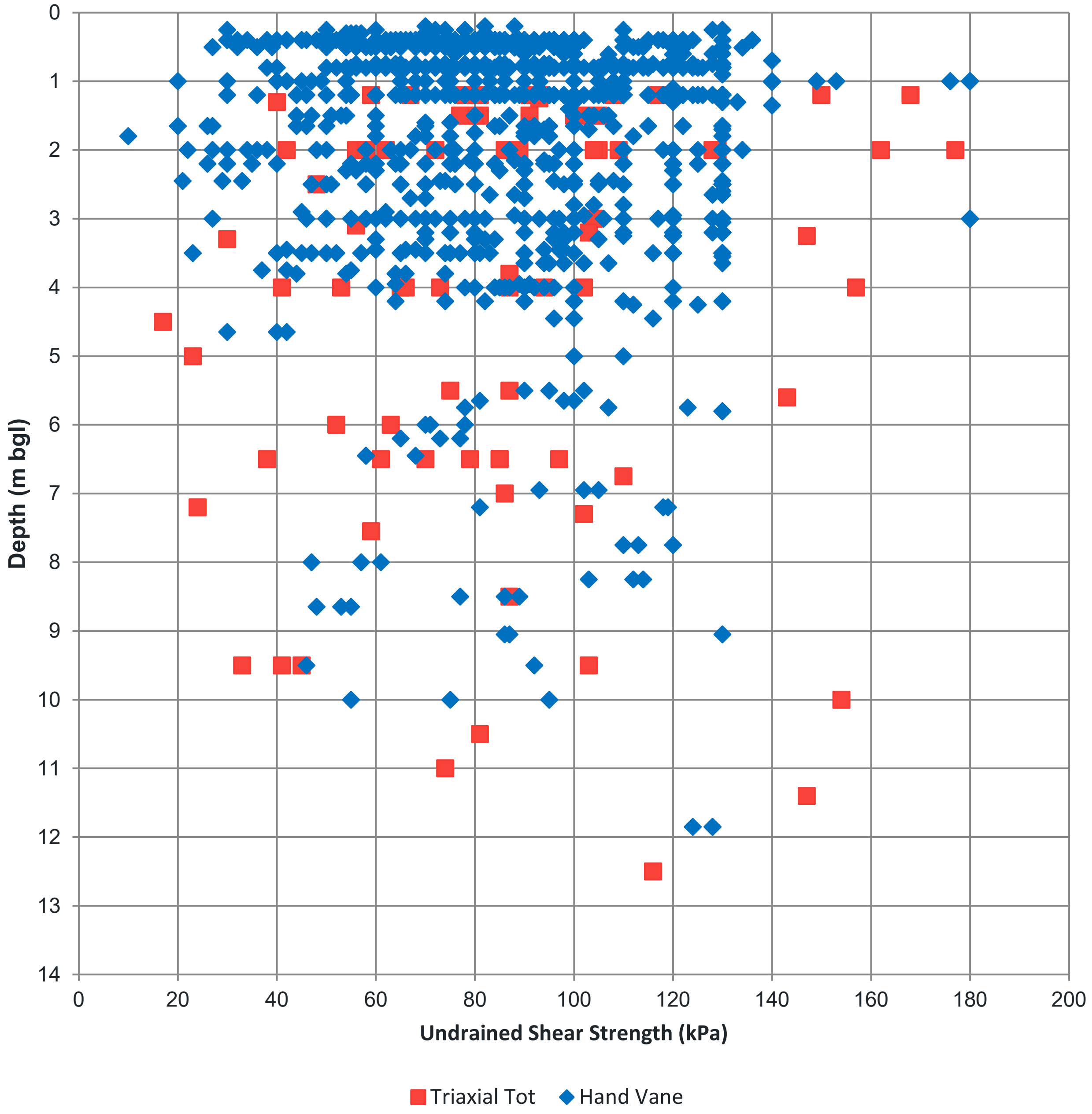


Figure 15 – Shear Strength vs Depth for Cohesive Glacial Till

Single stage undrained triaxial testing with measurement of pore water pressure was carried out on 13No. samples of cohesive till. The results of the effective stress testing are presented in Figure 16 and were undertaken on material sampled between 1.2m and 5.5m bgl. Phi values between 21˚ to 31.5˚ with an average of 28 degrees were obtained corresponding to c'=0kPa. This collaborates with the plasticity data, where an average plasticity index of 28 would also indicate a corresponding Φ' peak of 28˚ according to the method presented in BS8002:2015 and developed by Gibson 1953 (ref 17).

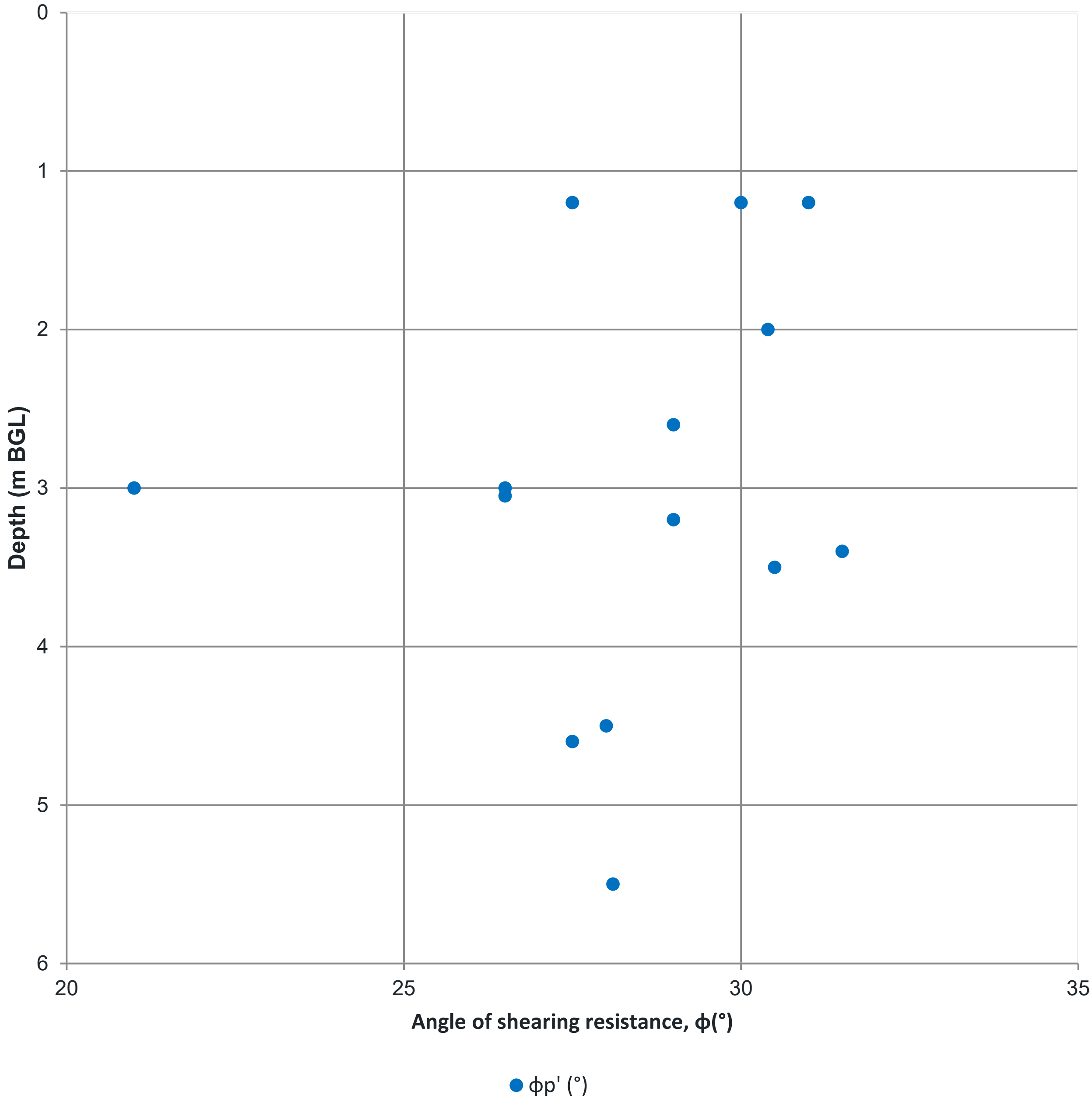


Figure 16 – Phi vs Depth for Cohesive Glacial Till

COMPRESSIBILITY

A total of 37 one-dimensional oedometer tests were carried out on samples of Cohesive Till sampled between 2.0m bgl and 9.5m bgl. The values of the coefficient volume of compressibility, m_v, varied greatly, depending on depth and imposed stress, and ranged from 0.00068 to 0.85m^2/MN. These have been plotted on to Figure 17.

Along with the results of the shear strength tests using the relationship of $m_v = 1/F_2N$ (ref 18). This correlation indicates a typical value of $m_v = 0.01m^2/MN$ and the values tend to indicate generally a lower compressibility than the results of oedometer testing. The results appear to show a reduction in the coefficient volume compressibility verses depth and the values indicate the cohesive till to be of low to medium compressibility which would be as expected for an overconsolidated material.

The coefficient of consolidation, c_v, was similarly variable and ranged from 0.62 to 17.61m^2/year, although some of the results appear very high. Excluding the outliers the results generally lie at around 3.4 m^2/year

A review of the results should be undertaken with reference to the design situation to ascertain the appropriate design value.

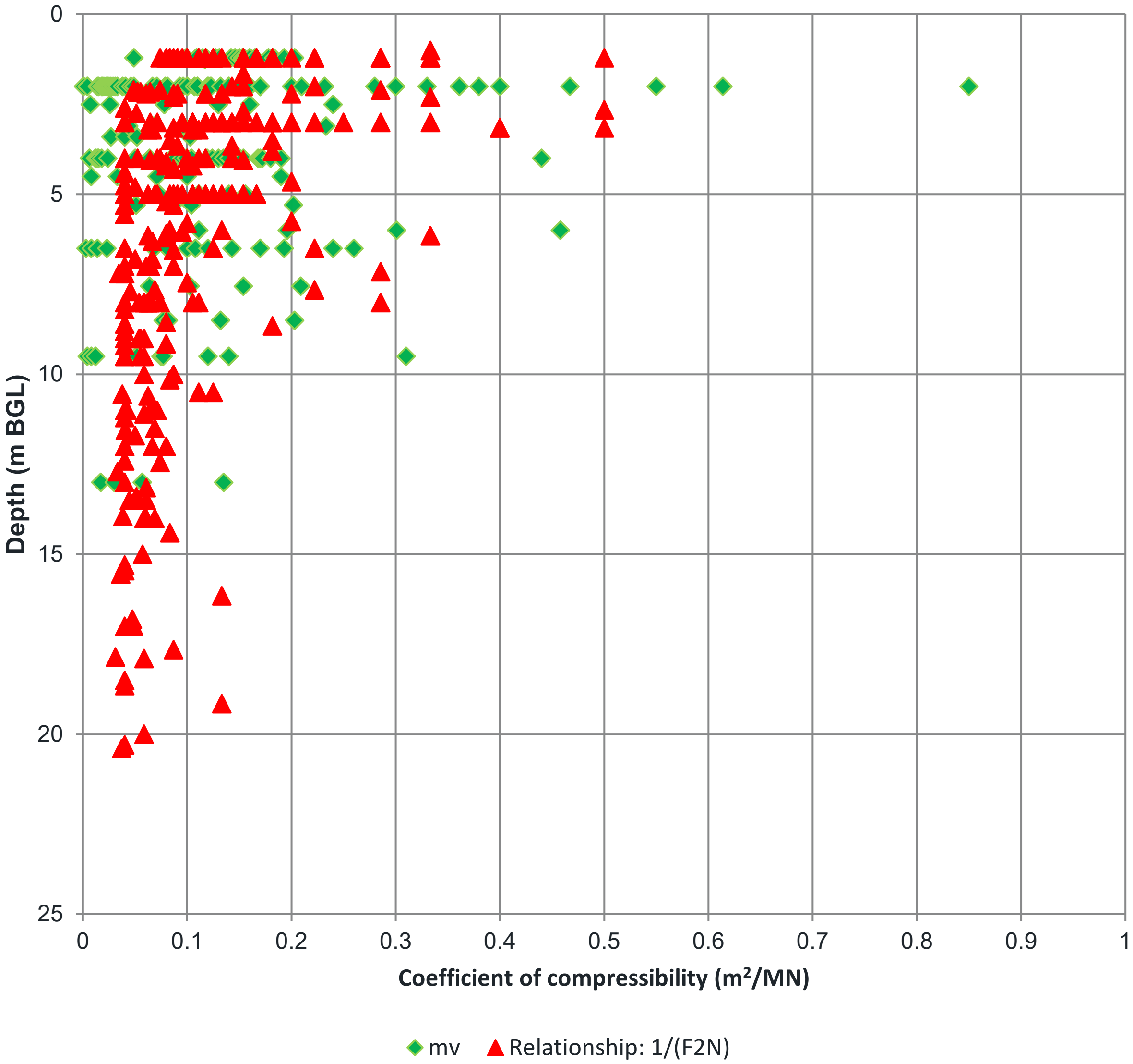


Figure 17 – Coefficient of Compressibility Vs Depth for Glacial Till

PERMEABILITY

Six soakaway tests were performed within pits formed within the cohesive Glacial Till as part of the recent investigation. All of these tests recorded minimal or no infiltration rates and therefore the permeability could not be calculated. Two falling head tests were historically performed in BH1018 and BH1023. The results gave permeability's of $1.3x10^{-7}$ and $1.7x10^{-7}$ respectively and this is indicative of a poor or impervious material.

COMPACTION TESTS

Seventy-three compaction tests compaction tests using both the 2.5kg and 4.5kg rammer identified maximum dry densities ranging between 1.61 to 1.96 Mg/m^3 for the 2.5kg rammer and 1.85 to 2.06 Mg/m^3 for the 4.5kg rammer with an overall average of 1.87 Mg/m^3

These results correspond to Optimum Moisture Contents of between 11% and 20% with an average of 15%, and between 10% and15% with an average of 12% for the 2.5kg and 4.5kg rammers respectively. This compares with an average natural moisture content of 19.6%.

Particle density tests were undertaken on 12 samples of Till giving results of between 2.57 to 2.7 Mg/m^3 with and average particle density of 2.65 Mg/m^3. The results of the compaction tests are shown in Figure 18. Based on a particle density of 2.65, the moisture acceptability upper limit to achieve 95% compaction is approximately 13%. These figures indicate the natural cohesive till to lie on the wet side of the optimum moisture content.

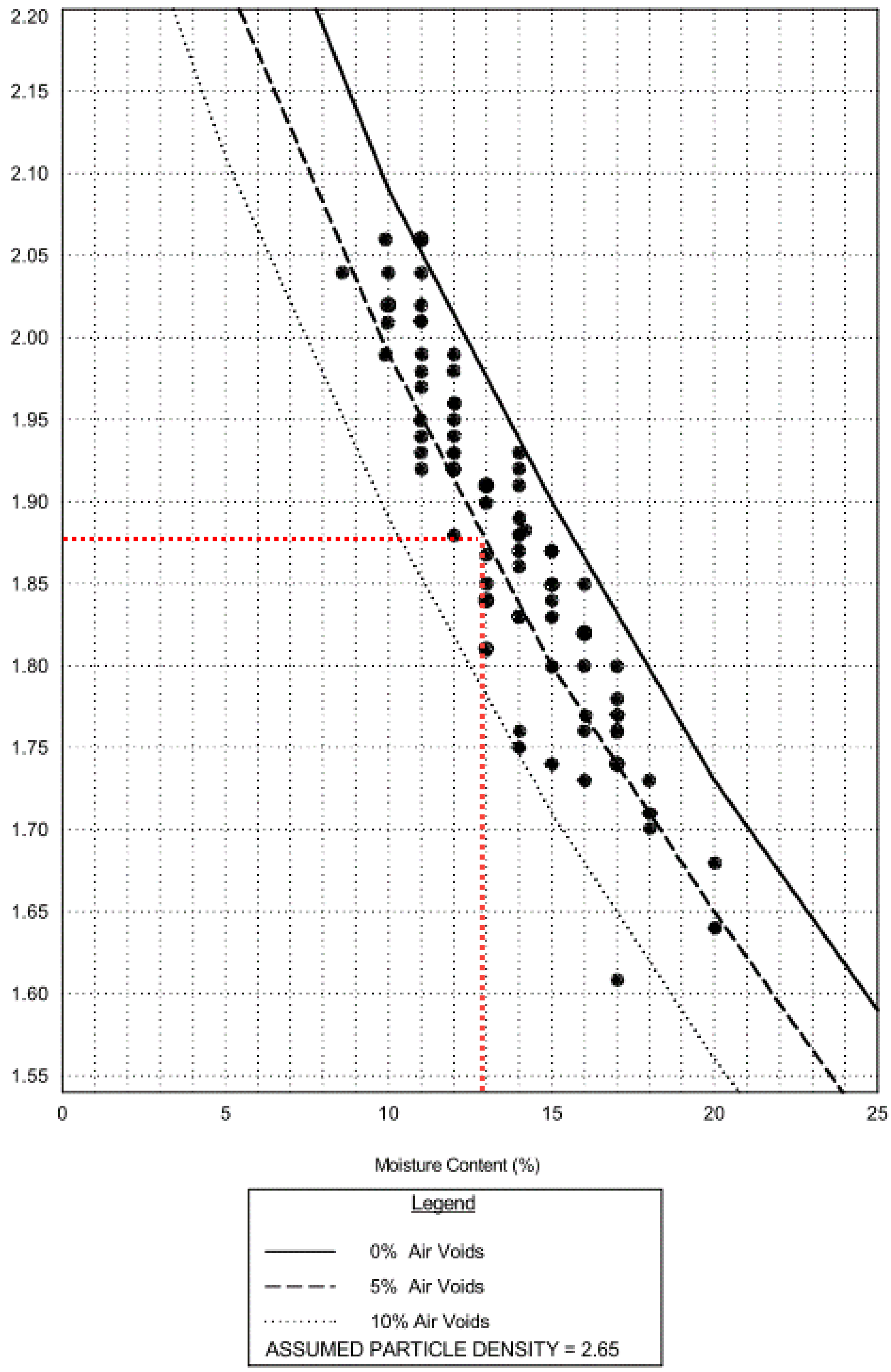


Figure 18 – Maximum Dry Density vs Optimum Moisture Content for Cohesive Glacial Till

CBR TESTS

Laboratory assessment of CBR was carried out on samples of Cohesive Till remoulded at natural moisture content in both the soaked (18 tests) and unsoaked condition (7 number tests). The results are taken from depths of between 0.2m and 2.0m bgl and gave 1.0 to 8.0 % and 0.74 to 10% for the top and bottom of the soaked samples respectively (average 3.6%) and 0.2 to 8.3 % and 0.23 to 8.8% for the top and bottom of the unsoaked samples (average 5.5%).

MOISTURE CONDITION VALUE (MCV)

A total of 19 MCV/moisture content determinations were performed on the cohesive Till. It is noted that there is considerable scatter in the range of moisture contents corresponding to each value of MCV. Values of between 0.9 and 15.3 with an average value of 8.7 have been obtained and the results are displayed on Figure 19. The natural moisture content of each sample is shown in brackets in the key.

The reciprocal slopes of the calibration lines indicate sensitivities in the range 0.5 to 1.6 corresponding to low to moderate sensitivity (CIRIA C504).

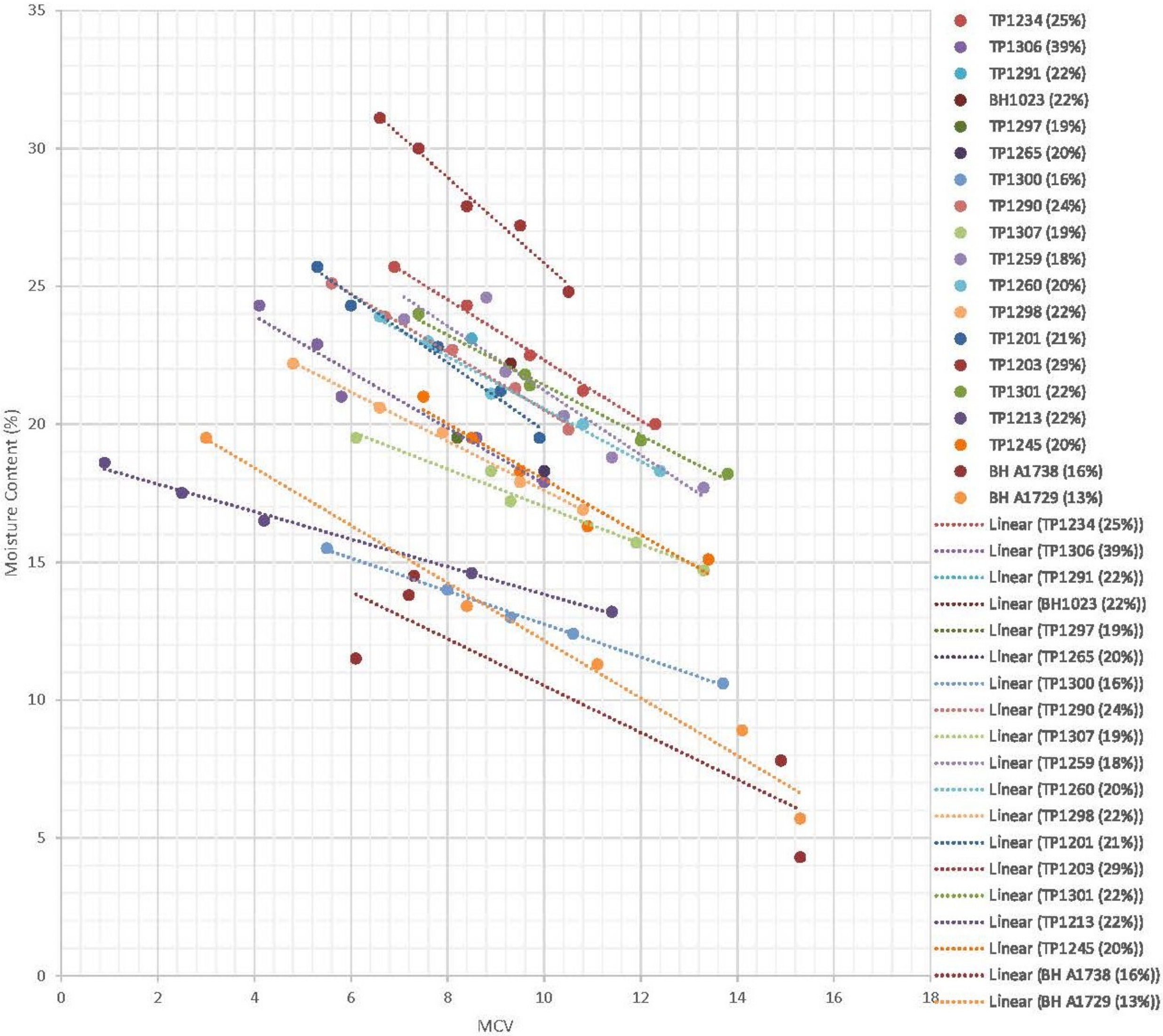


Figure 19 – MCV vs Moisture Content for the Cohesive Glacial Till

LIME CONDITIONING

Historically two laboratory lime consumption determinations were carried out on samples of Cohesive Till and measured values of 3.45% and 4.6% respectively. It is not clear where or when these tests were completed. A preliminary design value of 4% was historically recommended based on these two tests. The Preliminary Geotechnical Report [ref 1] stated that low plasticity tills are expected to be highly sensitive to moisture content and working of this material may have to be restricted to drier seasons.

SUMMARY OF GEOTECHNICAL PARAMETERS

Table 14 – Summary of Geotechnical Parameters for Cohesive Glacial Till

Properties	Min	Max	Mean	No of Tests	Suggested Global Design Parameter*
Natural Moisture Content (%)	5.5	50	20	463	Upper 2m: 25 Below 2m: 15
Plastic Limit (%)	NP	30	19	397	19
Liquid Limit (%)	21	69	40	397	40
Plasticity Index (%)	3	43	21	385	Upper 2m: 26 Below 2m: 20
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	ML	CH	CI	-	n/a
Bulk Density (Mg/m^3)	1.51	2.7	2.08	246	2.08
SPT 'N' Value (blows per 300mm)	4	>50	27	274	25
Undrained Cohesion c_u (Laboratory and Hand Shear Vane) (kPa) (Residual values*)	10 8*	230 100*	90 40*	1524	60 to 80
BS EN ISO 14688-2 Undrained cohesion classification	Very Low	Very High	High	-	n/a
Consolidation coefficient of compressibility (Oedometer) (m^2/MN)	0.00068	0.85	-	37	0.15$^+$
Optimum Moisture Content (%)	10	20	15	73	13

Properties	Min	Max	Mean	No of Tests	Suggested Global Design Parameter*
Permeability (m/s)	$1.3x10^{-7}$	$1.7x10^{-7}$	Poor or impervious material	8	$1.x10^{-7}$
California Bearing Ratio (%) (Soaked[~] and Unsoaked[1])	0.74[~] 0.2[1]	10[~] 8.8[1]	3.6[~] 5.5[1]	18[~] 7[1]	2.5
Moisture Condition Value (%)	0.9	15.3	8.7	18	9[~]
Lime Consumption	3.45	4.6	-	2	#
Effective Angle of Shear Resistance (derived from drained TXL results) (degrees)	21	32	28	13	26

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

[#]Further testing required to make assessment

[+]Surcharge of 100kPa

[~]at global natural moisture content

6.5. GRANULAR GLACIAL DEPOSITS

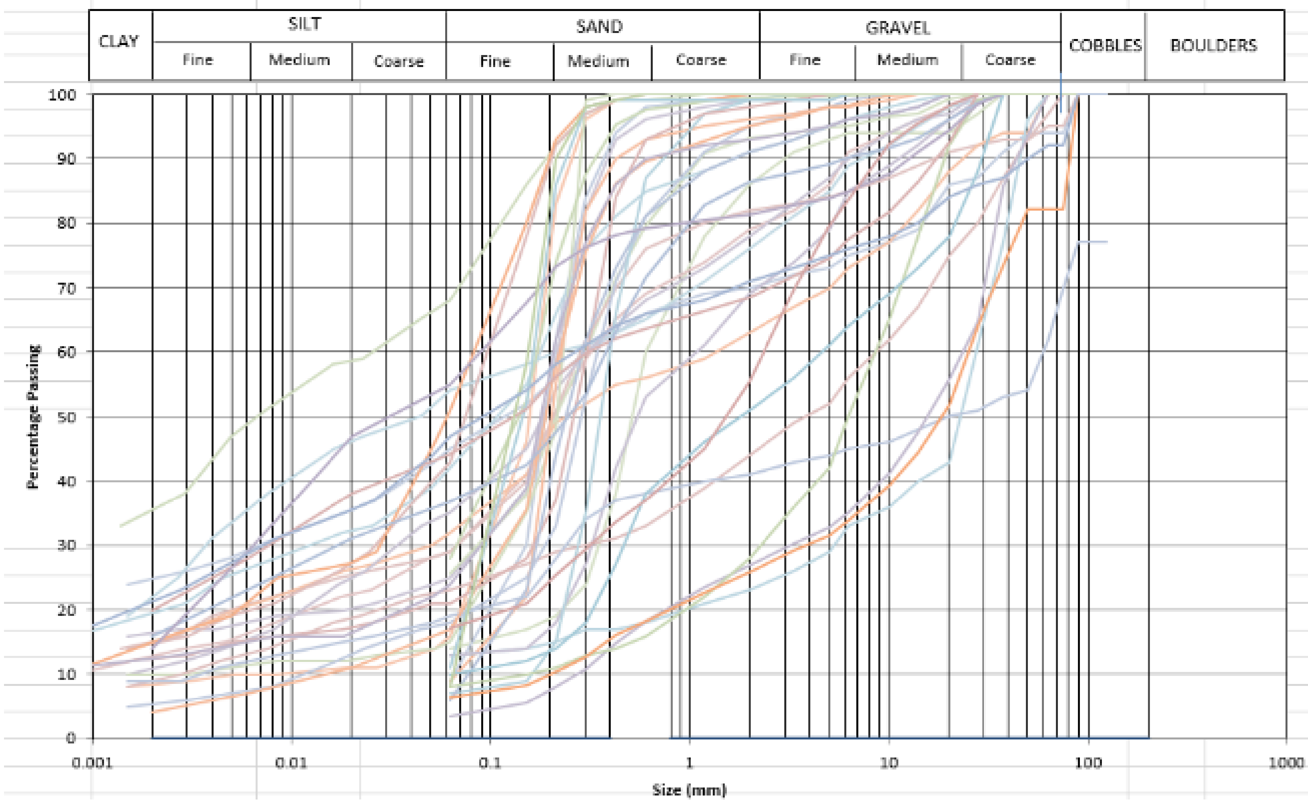


Figure 20 - PSD for Granular Glacial Deposits

CLASSIFICATION

The results of grading analyses are summarised in Figure 20 and indicate a typically well graded sand and gravel with fine material generally less than 18%. The boundary between the Granular and Cohesive Glacial Till was observed to be gradual and therefore a number of samples of both Cohesive Till and Granular Till exhibit transitional properties with percentage fines lying generally between 20 to 55%. One sample recorded fines of 68% however the material was described as a brown very clayey medium SAND.

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

SPT

A total of 30 SPTs were carried out within the granular glacial deposits at depths of between 2.0m bgl and 15.0m bgl. The results range between 5 and 50 with an average SPT value of 19. The results generally indicate an in situ density of medium dense although a large proportion of the material descriptions describe the material as loose becoming medium dense. It is however possible that some of the lower value SPTs may be attributed to the in situ test being undertaken below the water level, and prior to the water levels inside and outside of the casing reaching equilibrium during excavation. SPTs obtained under these conditions should be taken forward with caution.

MCV

One test was performed on a sample described as gravelly very silty fine to coarse Sand with occasional cobbles. The results of the 5 point test gave MCV of between 7.0 and 13.7. The reciprocal slope of the calibration line indicates a low moisture sensitivity as would be expected for a predominantly granular material.

SHEAR STRENGTH

No shear strength testing was carried out on samples of the granular glacial deposits. Using the relationship established by Peck et al (ref 19) and an average SPT value of 19 for the material, a phi value of 33˚ can be assumed.

Table 15 – Summary of Geotechnical Parameters for Granular Glacial Deposits

Properties	Min	Max	Mean	No of Tests	Suggested Global Design Parameter*
Natural Moisture Content (%)	7.6	26	20	10	20
SPT 'N' Value (blows per 300mm)	5	50	19	30	19
Bulk Density (Mg/m^3)	2.1	2.25	2.2	5	2.2

Properties	Min	Max	Mean	No of Tests	Suggested Global Design Parameter*
Moisture Condition Value (%)	7.0	14		1	n/a

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

6.6. GLACIOLACUSTRINE DEPOSITS

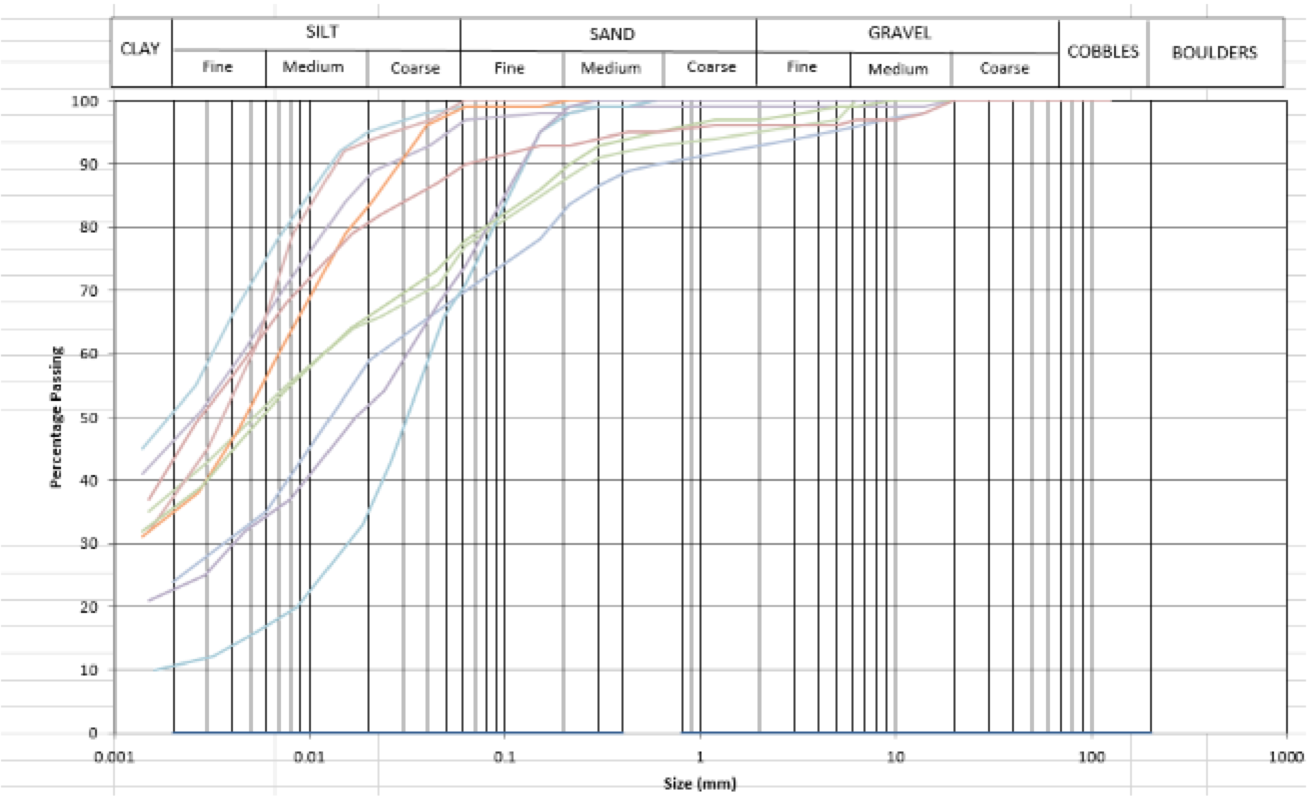


Figure 21 - PSD for Glaciolacustrine Deposits

CLASSIFICATION

The Glaciolacustrine Deposits are predominantly described as cohesive; thinly laminated, slightly sandy slightly gravelly clay. The results of ten grading analyses are summarised in Figure 21 and indicate the material to have a fines content of 70 to100% with 20 to 50% of particles in the clay size.

MOISTURE CONTENT

Sixty four moisture content tests undertaken on the Glaciolacustrine Deposits are displayed in Figure 22 which indicates the results varied between 7.3% to 35.9% with an average of 25%.

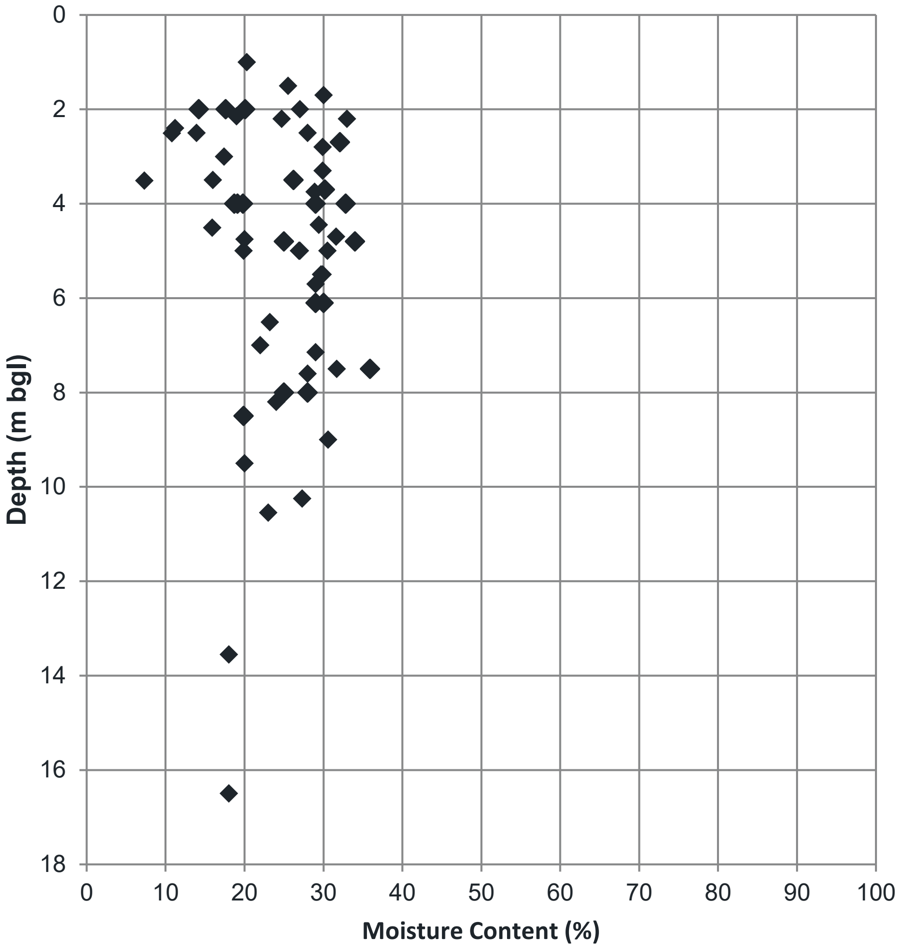


Figure 22 – Moisture Content Vs Depth for the Glaciolacustrine Deposits

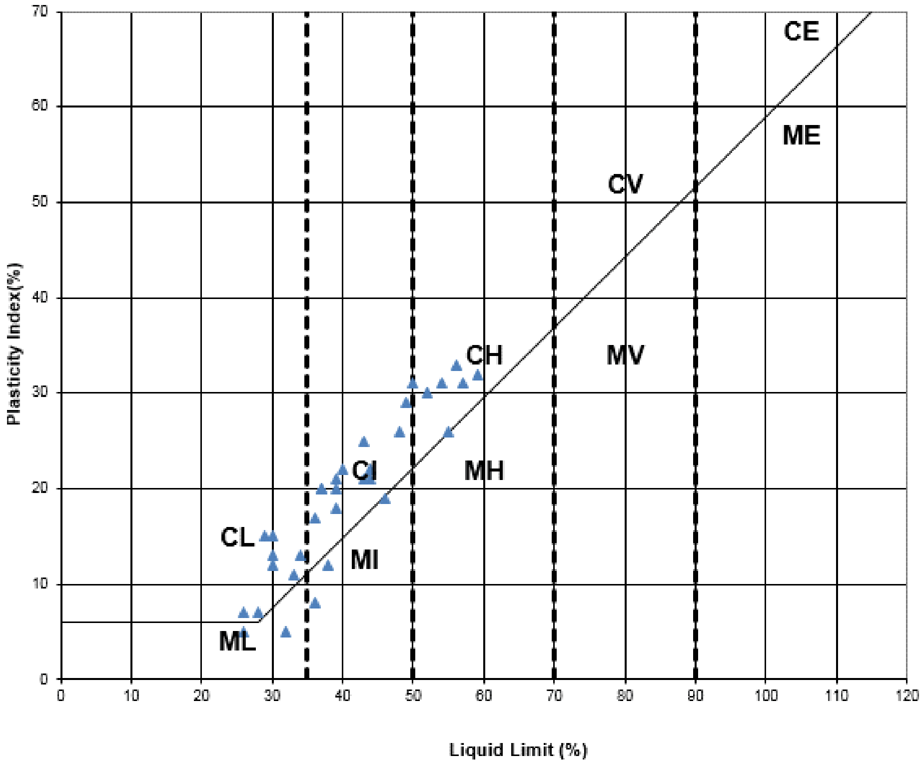


Figure 23 – Plasticity Chart for the Glaciolacustrine Deposits

ATTERBERG LIMITS

The overall average plasticity index of the material is 19.7% which is marginally lower than that of the Cohesive Glacial Till. The plasticity chart presented in Figure 23 indicates a large spread of results from low plasticity silt to intermediate to high plasticity clay and there appears to be some regional variability in accordance with the extents of the deposits detailed in Table 11.

The deposits encountered in the northern extent of scheme generally indicate a low to intermediate silt/ clay and a large proportion of the material descriptions refer to low to intermediate plasticity Clay or Silt. The plasticity index in this area ranges between 5 and 26 with an average of 13 (average Liquid Limit of 35)

Around the proposed Westmoor Junction the plasticity is recorded as predominantly Intermediate clay with an average plasticity index of 23.5 (average Liquid Limit of 45). High plasticity clay with an average plasticity index of 32 (average Liquid Limit of 57) is recorded in the vicinity of Fenrother Junction.

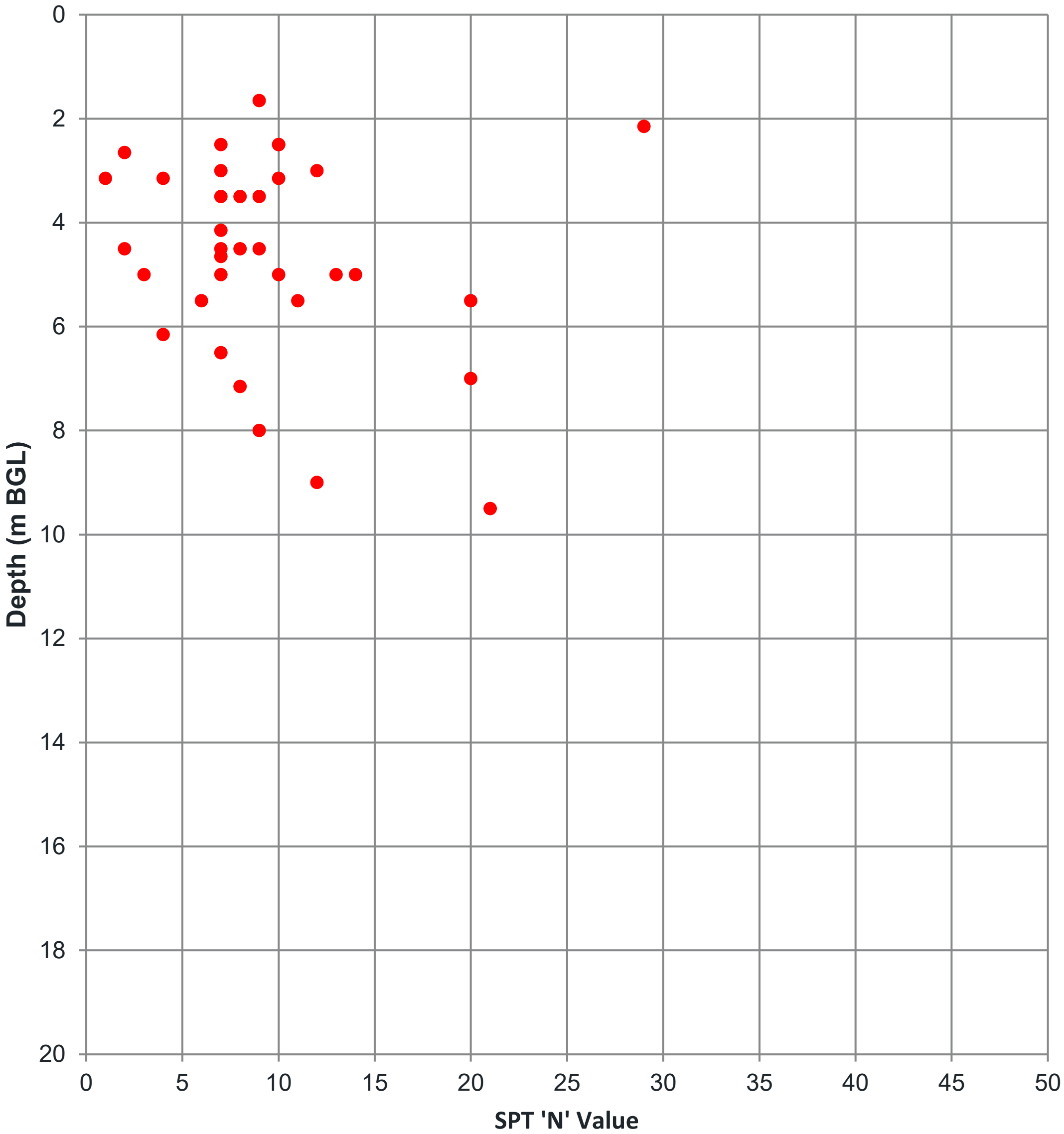


Figure 24 - SPT N Values vs Depth for Glaciolacustrine Deposits

SPT values within the Glaciolacustrine deposits were highly varied ranging from 1 to 50 but generally <20. Five results of gave values of between 49 and 50 but these were associated with material described as containing cobbles of sandstone in BH1030. Figure 24 shows a plot of N-Value with depth and indicates a marginal trend of increasing N value with depth although deeper tests are associated with BH1030. Excluding the results from BH1030, the remaining 35 results gave an average SPT of 9 for the deposits indicative of a soft or loose material.

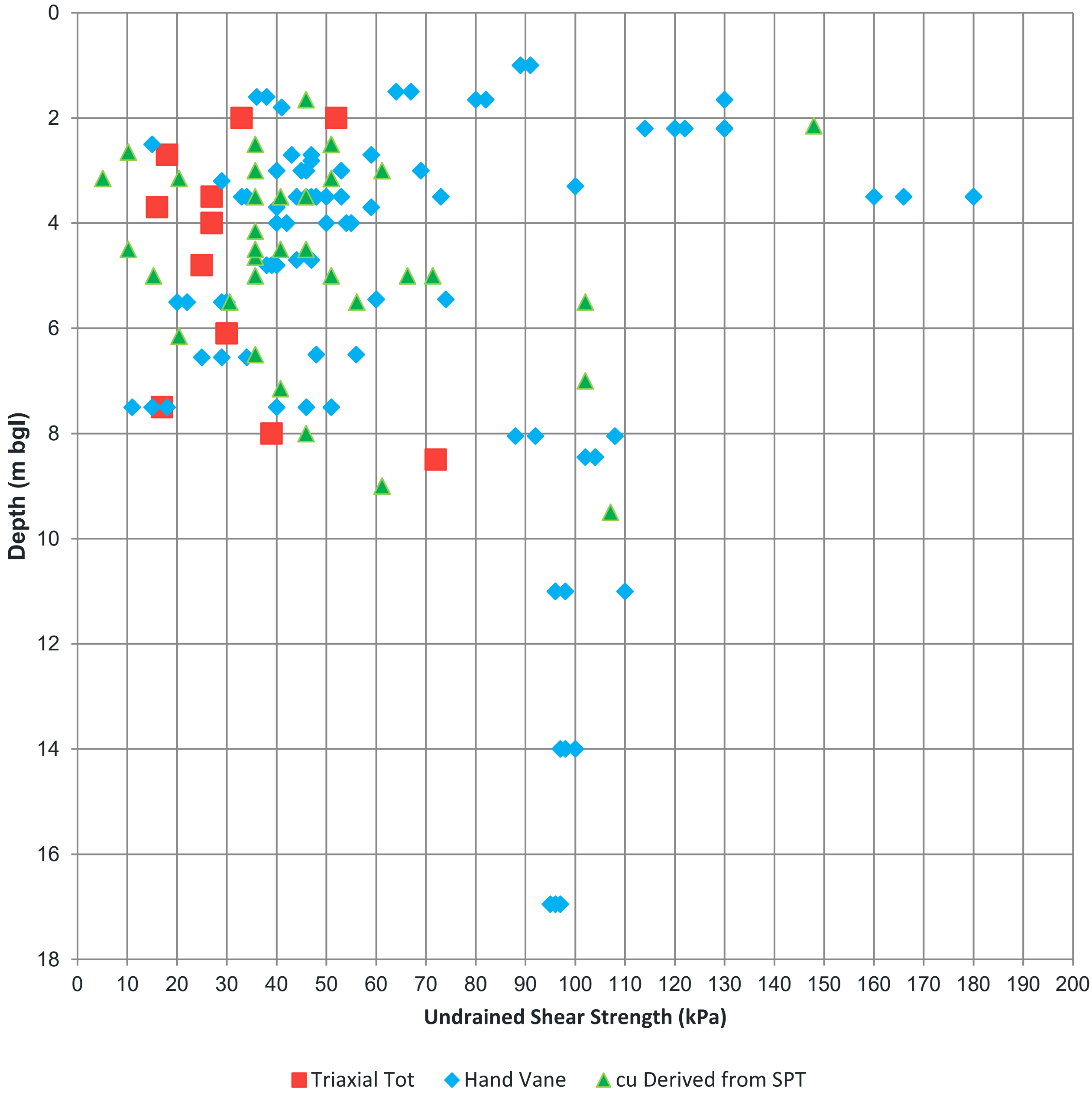


Figure 25 - Shear Strength vs Depth for Glaciolacustrine Deposits

Twelve Quick Undrained Triaxial tests were undertaken on samples obtained at depths of between 2.0m bgl and 8.5m bgl gave undrained shear strengths values of between 16kPa and 70kPa with an average of 32kPa. Deposits encountered in the northern most cutting of the scheme (M2FC06) generally gave values of less than 20kPa.

Shear strength values have also been derived from SPT N values using the relationship Cu=5.1N and assuming an average Plasticity Index of 20% (ref 18). The derived values indicate a much wider spread of results relative to the laboratory measured results with values given between 5.1kPa and 255kPa with an average value of 74kPa. However, it is worth noting that a proportion of the SPTs recorded in these deposits were undertaken on loose to medium dense laminated sand.

Ninety four Hand-Shear Vane tests carried out within trial pits and U100 samples measured peak shearing resistance values of between 11kPa and 180kPa which is a similar range to those of the Glacial Till deposits but with a lower average value of 72kPa.

One single stage undrained triaxial testing with measurement of pore water pressure was carried out on a sample of Glaciolacustrine material which was encountered in BH04/98 between 1.8m bgl and 4.0m bgl. A Phi value of 32˚ with a corresponding cu of 3kPa was recorded for the thinly interlaminated fine sandy Clay of low to intermediate plasticity. The shear strength results are plotted on Figure 25.

COMPRESSIBILITY

A total of seven one-dimensional oedometer tests were carried out on samples of Glaciolacustrine Deposits sampled between 2.0m bgl and 8.0m bgl. The values of the coefficient volume of compressibility, m_v, ranged from 0.0062 to 0.58m^2/MN and this was dependent on the imposed stress during the test. Using the relationship of $m_v = 1/F_2N$ indicates a typical values of between 0.15 and 0.3 m^2/MN, and largely shows a higher coefficient of compressibility than the results of oedometer testing. The results are displayed on Figure 26.

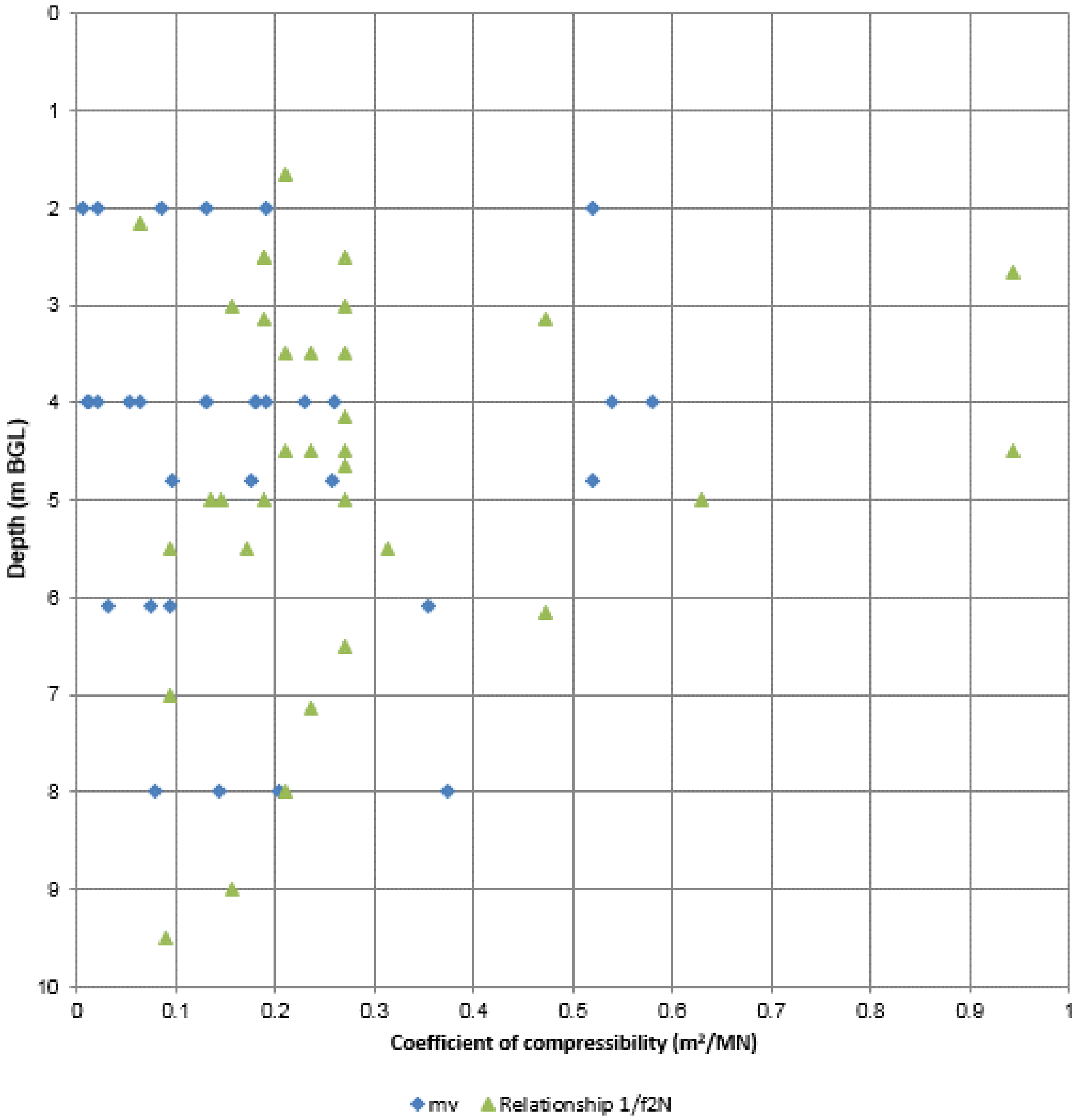


Figure 26 - Coefficient of Compressibility Vs Depth for Glaciolacustrine Deposits

The coefficient of consolidation, c_v, ranged from 1.3 to 12.0m^2/year. Excluding the outliers the results generally lie at around 3.5 m^2/year, similar to that of the Glacial Till. A review of the results should be undertaken with reference to the design situation to ascertain the appropriate design value.

COMPACTION TESTS

Compaction testing carried out on the Glaciolacustrine Deposits gave maximum dry density values between 1.78 Mgm^{-3} and 1.94 Mgm^{-3}. Three Optimum moisture content testing gave values of between 11% and 14%.

CBR TESTS

Nine unsoaked CBRs were undertaken on Glaciolacustrine material encountered in the northern most cutting of the scheme (M2FC06). The results are taken from depths of between 1.0m and 7.5m bgl and gave 0.2 to 5.0% and 0.2 to 7.4% for the top and bottom of the samples respectively (average 2.0%).

Table 16 – Summary of Geotechnical Parameters for Glaciolacustrine Deposits

Properties	Min	Max	Mean	No of Tests	Suggested Global Design Parameter*
Natural Moisture Content (%)	7.3	36	25	64	25
Plastic Limit (%)	14	29	22	34	22
Liquid Limit (%)	26	59	41	34	41
Plasticity Index (%)	5	33	20	34	28
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	ML	CH	CI - CI	-	n/a
Bulk Density (Mg/m^3)	1.87	2.19	2.01	27	2.01
SPT 'N' Value (blows per 300mm)	1	29	9	35	7
Undrained Cohesion c_u (Hand Shear Vane and Laboratory Testing) (kPa)	11	180	71	106	20 to 40
BS EN ISO 14688-2 Undrained cohesion classification	Very Low	Very High	Low to medium	-	n/a
Coefficient of Volume Compressibility (m^2/MN)	0.0062	0.58	0.17	7	0.25$^+$

Properties	Min	Max	Mean	No of Tests	Suggested Global Design Parameter*
Optimum Moisture Content (%)	11	14	13	3	11
California Bearing Ratio (%)	0.2	7.4	2.0	9 (unsoaked)	Less than 2.5
Effective Angle of Shear Resistance (derived from drained TXL results) (degrees)	-	-	32	1	26

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

+Surcharge of 100kPa

6.7. BEDROCK – STAINMORE FORMATION

COMPLETELY / HIGHLY WEATHERED BEDROCK

Classification

Seven PSD tests were performed on samples considered to be weathered bedrock and the results are displayed on Figure 27, which separates the granular partially weathered deposits and cohesive completely weathered deposits based on the strata descriptions.

Four of the samples were described as weathered sandstone ranging from slightly clayey Sand to clayey angular and tabular gravel of fine to coarse gravel of sandstone to yellow subangular Cobbles of sandstone with much sand. The remaining tests were performed on what was considered as weathered mudstone described as sandy fine to coarse subangular tabular fine to coarse Gravel of shale/ mudstone, locally grading to slightly sandy Clay.

Three of the curves indicate a fines content above 35% fines with one curve showing a fines content of >75% but this was not reflected on the borehole description of the strata that the samples were derived from.

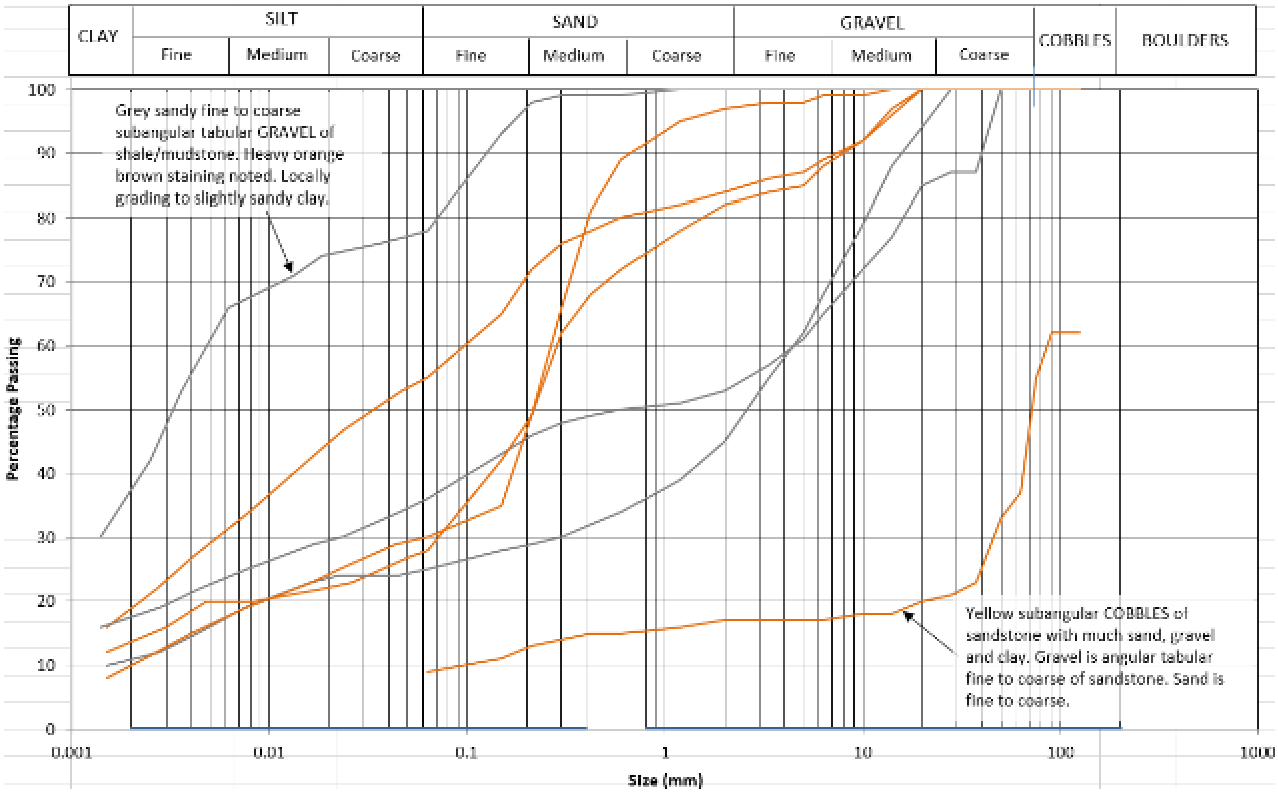


Figure 27 - PSD for Cohesive and Granular Weathered Bedrock

MOISTURE CONTENT

Five moisture content tests on the weathered bedrock gave results of 9.5 to 20% and 14.5 to 17.0% for the weathered mudstone and weathered sandstone respectively with an overall average of 15.2%

ATTERBERG LIMITS

Figure 28 depicts that where the weathered bedrock was cohesive, these were classified as low to intermediate clay or silt. The plasticity index varied between 10% and 17% with liquid limits of between 30% to 43%.

SPT 'N' VALUES

SPT values within the weathered deposits were highly varied ranging from 6 to >50 but generally between 10 and 50. Six results recorded values greater than 50 and up to 180 with 22 tests recorded as 50 (or refusal) as would be expected at the soil rock interface.

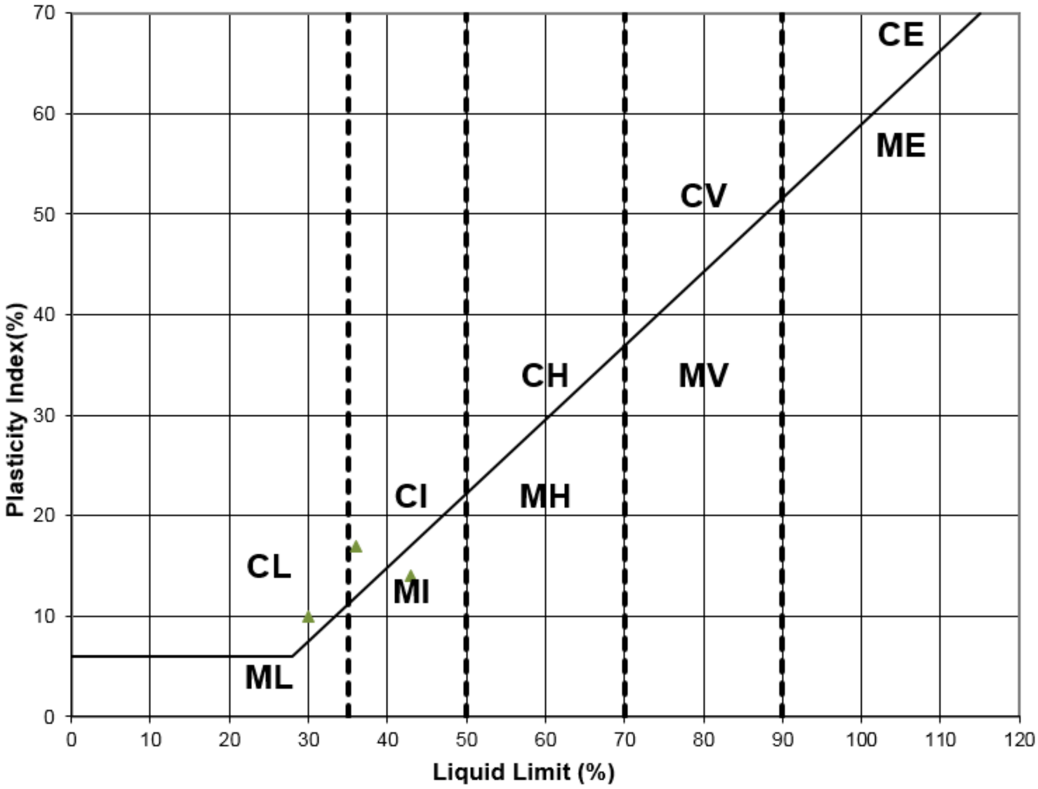


Figure 28 - Plasticity Chart for Weathered Bedrock

STRENGTH TESTS

Point load testing was undertaken on a limited number of granular lumps of the weathered Mudstone extracted from BH1038 and between depths of 3.15m bgl and 21m bgl. Three of the tests returned results of less than 0.1MPa (using a standard calibration constant of 23, this would equate to a strength of 2.3MPa). Two of the test gave results >20MPa equating to a calibrated UCS of >460MPa and therefore deemed anomalous. Excluding the five aforementioned results, the calibrated UCS results indicate a large range between 6.5 and 146MPa with an average of 53MPa, indicative of a strong rock.

It should be noted that point load tests on rock where the UCS is generally below 25MPa are likely to yield some ambiguous results, particularly in rocks containing marked planes of weakness such as bedding planes.

Table 17 – Summary of Geotechnical Parameters for Weathered Bedrock

Properties	Min	Max	Mean	No of Tests	Suggested Global Design Parameter*
Natural Moisture Content (%)	9.5	20	15	5	15
Plastic Limit (%)	19	29	23	3	23
Liquid Limit (%)	30	43	36	3	36
Plasticity Index (%)	10	17	14	3	14
Plasticity Classification (CL, CI, CH, ML, MI, MH etc.)	CL	CI	-	-	n/a
SPT 'N' Value (blows per 300mm)	6	>50	40	39	40
Mudstone Point Load IS_{50} (MPa)~	0.28	6.35	2.29	14	#
Mudstone Calibrated UCS (MPa)~	6.44	146	53	14	#

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

~Excludes anomalous results

#It is considered that such deposits should be treated as a soil for design purposes and hence a strength parameter for intact rock within the matrix is not a required design parameter

6.8. INTACT BEDROCK - STAINMORE FORMATION

CORE RECOVERY

Where the intact rock was encountered across the scheme, the Total Core Recovery (TCR) was on the whole relatively good, with a TCR of between 6 and 100% and average TCR of 86% (excluding the zones of core loss/ areas of no recovery). There appears to be only a marginal difference between the various intact rock lithology's, with Limestone recording the lowest average TCR of 78% increasing to 89% for the Siltstone. The Mudstone and Sandstone gave average TCR of 86% and 87% respectively.

Occasional core loss was experienced during drilling which was recorded on the logs, particularly during the most recent site specific GI's in 2006 and 2017. Eight core loss zones greater or equal to 1.0m have been highlighted in red in Table 18. At shallower depths the core loss may be attributed to the transition between the service pits to rotary coring. Some core loss was also experienced at the switch between cable percussive and rotary coring or below the level of an SPT.

In addition to the sites highlighted in red below, there are three specific areas which record zones of core loss that although individually don't exceed 1.0m, cumulatively they highlight possible problematic areas (highlighted in amber). One of these areas encompasses BHA1722, BHA1723 and BH1046 in the vicinity of the proposed Causey Park overbridge and within an area known for deep and surface mine workings. The two other areas are in the vicinity of structure locations at Westmoor Junction (BH1031 and BHA1736) and the River Coquet (BHA1739).

Table 18 - Summary of Assumed Zones of Core Loss

Borehole Reference	Top of Core Loss (m bgl)	Base of Core Loss (m bgl)	Total Core Loss Thickness (m)
BH A1703	12.7	12.9	0.2
BH A1703	14.8	15.3	0.5
BH A1703	16.3	17.55	1.25
BH A1703	18.8	19	0.2
BH A1704	15.5	15.6	0.1
BH A1707	9.9	11.01	1.11
BH A1707	17	17.63	0.63
BH A1722	7	7.6	0.6
BH A1722	8	8.2	0.2
BH A1722	10	10.12	0.12
BH A1723	17.25	17.89	0.64
BH A1723	18.25	18.88	0.63
BH A1723	19.75	19.93	0.18
BH A1729	6	6.44	0.44
BH A1729	7	7.55	0.55
BH A1736	17.3	17.8	0.5
BH A1736	18.3	18.8	0.5
BH A1736	19.3	19.5	0.2
BH A1738	5	5.9	0.9
BH A1739	1.2	1.45	0.25
BH A1739	2.4	2.92	0.52

Borehole Reference	Top of Core Loss (m bgl)	Base of Core Loss (m bgl)	Total Core Loss Thickness (m)
BH A1739	3.9	4.25	0.35
BH A1739	5.4	5.72	0.32
BH A1739	8.4	8.6	0.2
BH A1739	9.9	10.39	0.49
BH A1739	11.25	11.45	0.2
BH A1741	0.9	1.26	0.36
BH1001	17	19	2
BH1012R	22.7	25.2	2.5
BH1023R	8	9	1
BH1031	24.7	26.5	1.8
BH1038	22	23	1
BH1046	14	15	1

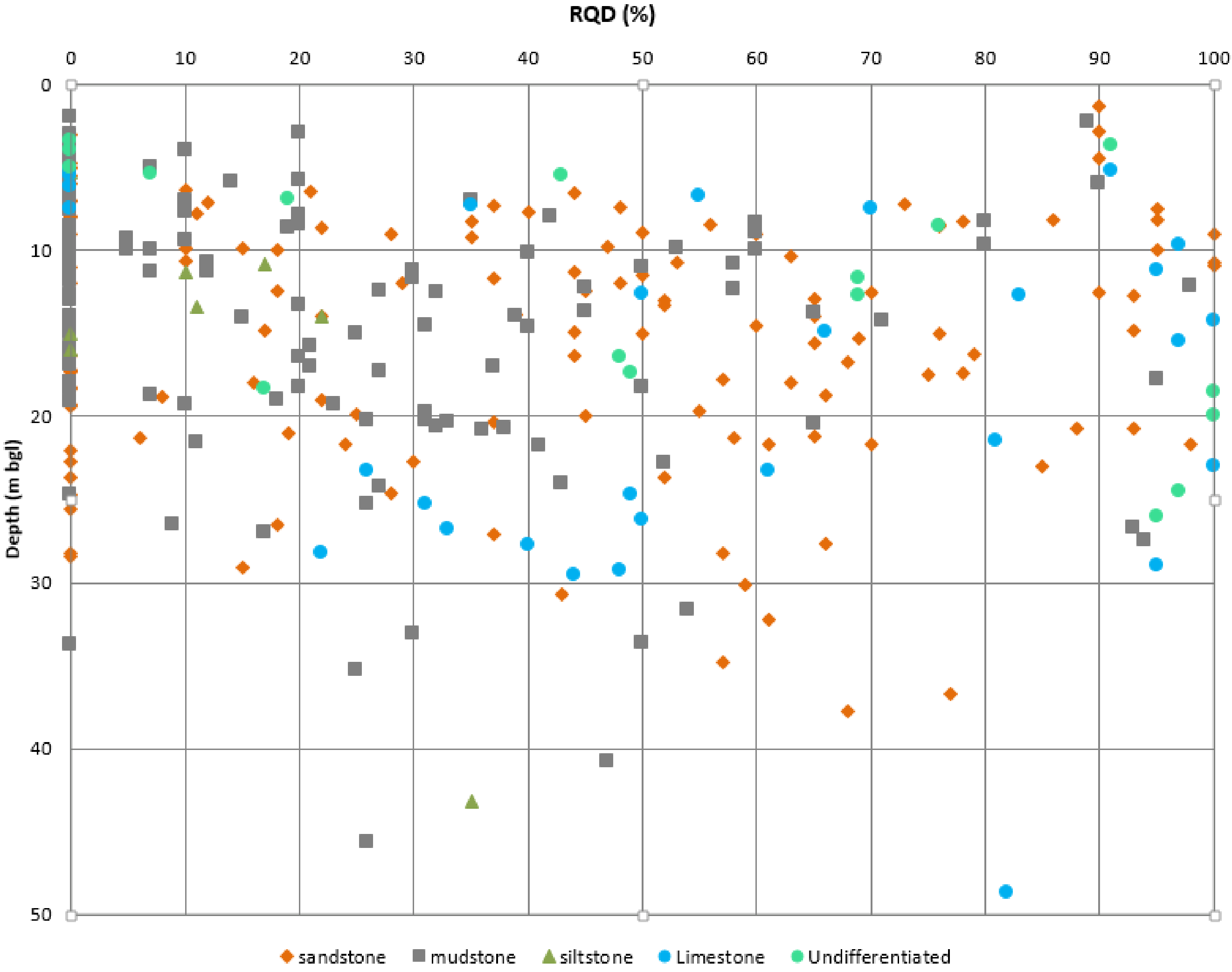


Figure 29 - RQD vs Depth for the Intact Rock

Rock Quality Designation (RQD) values within the rock range between 0% and 100% and the large variability is indicative of the nature of the rock and the number of results that have been obtained across the scheme. Figure 29 shows the RQD values verses depth for the various rock types encountered. It should be noted that frequently the measurement of RQD traverses a stratum boundary and therefore only the values specific to a single rock type have been displayed graphically. The Limestone and Undifferentiated material gave the highest mean RQD values of 52%. RQD values for the Sandstone were marginally lower at 42%. RQD values for both the Mudstone and Siltstone appear to marginally increase with depth, with mean values of 22% and 12% respectively. RQD values are plotted on to the relevant boreholes on the long sections contained within Appendix F.

DISCONTINUITY DATA

Discontinuity descriptions taken from the recent borehole logs are generally described as follows;

- Discontinuity Set 1: subvertical very close to medium spacing, predominantly smooth planar to rough undulating but occasionally smooth stepped, generally clean with occasional gravel infill and orangish brown or dark grey staining.

- Discontinuity Set 2: subhorizontal very closely to medium spacing, occasionally widely spaced, predominantly smooth planar to rough undulating but occasionally smooth stepped, and generally clean with occasional gravel infill and orangish brown and / or dark grey staining.

Data acquired from the televiewer surveys undertaken within BHA1741 and BH1036 located on the north and south of the River coquet valley has assisted in confirming the in situ structure of the rock mass. A Stereonet combining the results from both boreholes is displayed in Figure 30 and confirm the vast majority of discontinuities are subhoriozontal to horizontal as illustrated by the dense fisher concentration within the centre of the stereonet. The vast majority of these are likely to be attributed to bedding planes within the rock structure.

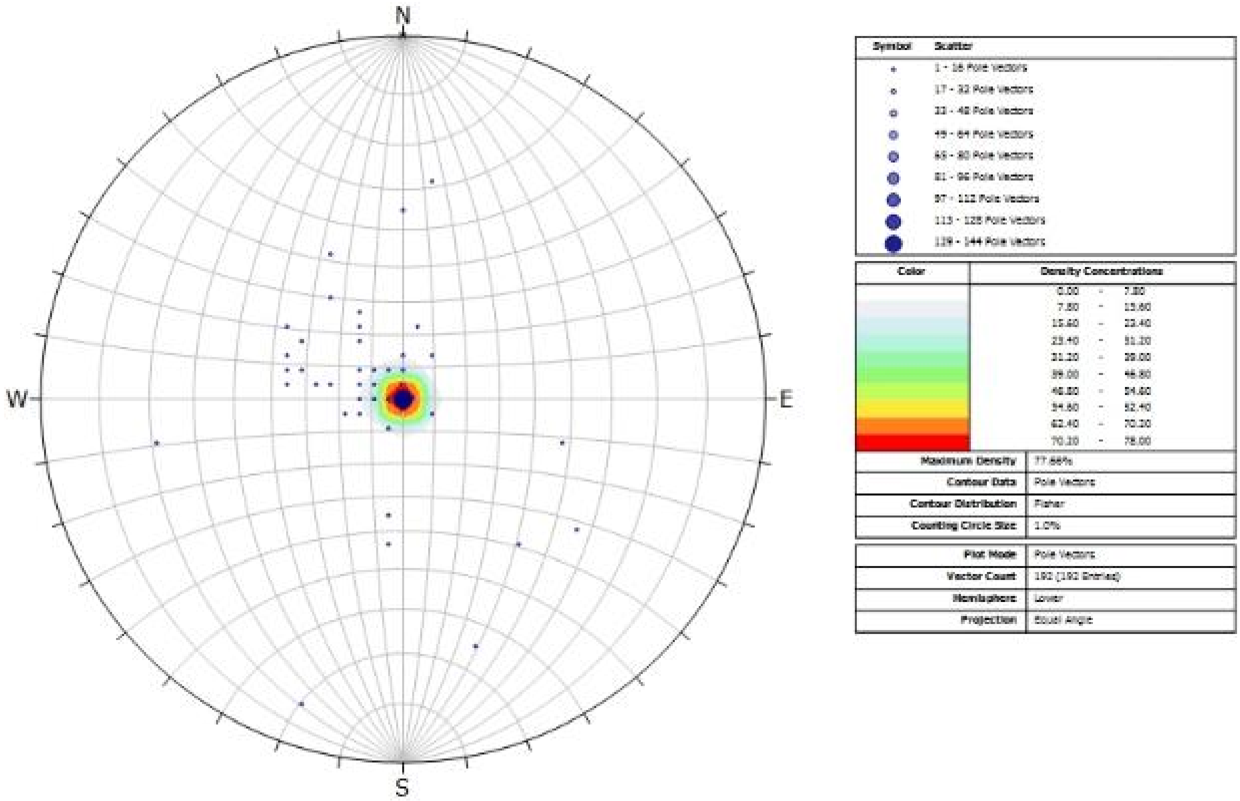


Figure 30 – BHA1741 and BH1036 Televiewer Survey

STRENGTH TESTS

Point load testing was undertaken on samples of the Stainmore Formation in order to provide additional data on the rock strength in the absence of sufficient suitably sized samples being recovered and available for Unconfined Compressive Strength (UCS) tests. The size corrected point load (IS_{50}) results for each material are graphically displayed in Figure 31. A breakdown for each material is summarised in Table 19.

Assessment of the point load values have been undertaken. The axial tests gave results between 0.15MPa and 5.19MPa (average 1.6MP, indicative of a strong material) which were on the whole greater than the diametric results 0.03 MPa to 0.99MPa (average 0.25, indicative of an extremely weak to weak material) indicating that the strength is greater in the vertical direction. The lump tests which are taken from randomly oriented core indicated a broader range of results between 0.08MPa and 4.78MPa (average 1.2, indicative of a strong material) although for the Mudstone and

Undifferentiated material these tests wielded several test results considered too large for a true point load test and therefore discounted.

Based on the results, the Mudstone appears to be the stronger material with an overall IS_{50} average of 1.4MPa, closely followed by the undifferentiated material (average 1.15MPa). This is contrary to the log descriptions and therefore the anticipated results. The intact Sandstone appears to be marginally weaker with an overall average of 0.63 MPa, although when addressing only the axial tests, which are more representative of the in-situ stresses the results are somewhat similar, with average axial IS_{50} of 1.22MPa (Sandstone), 1.4 MPa (Mudstone) and 1.42MPa (Undifferentiated). Fewer tests were undertaken on the Limestone material which gave the lowest results with an average IS_{50} of 0.49MPa. The total number of tests on each material type undertaken relative to the sample area are considered to be 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.

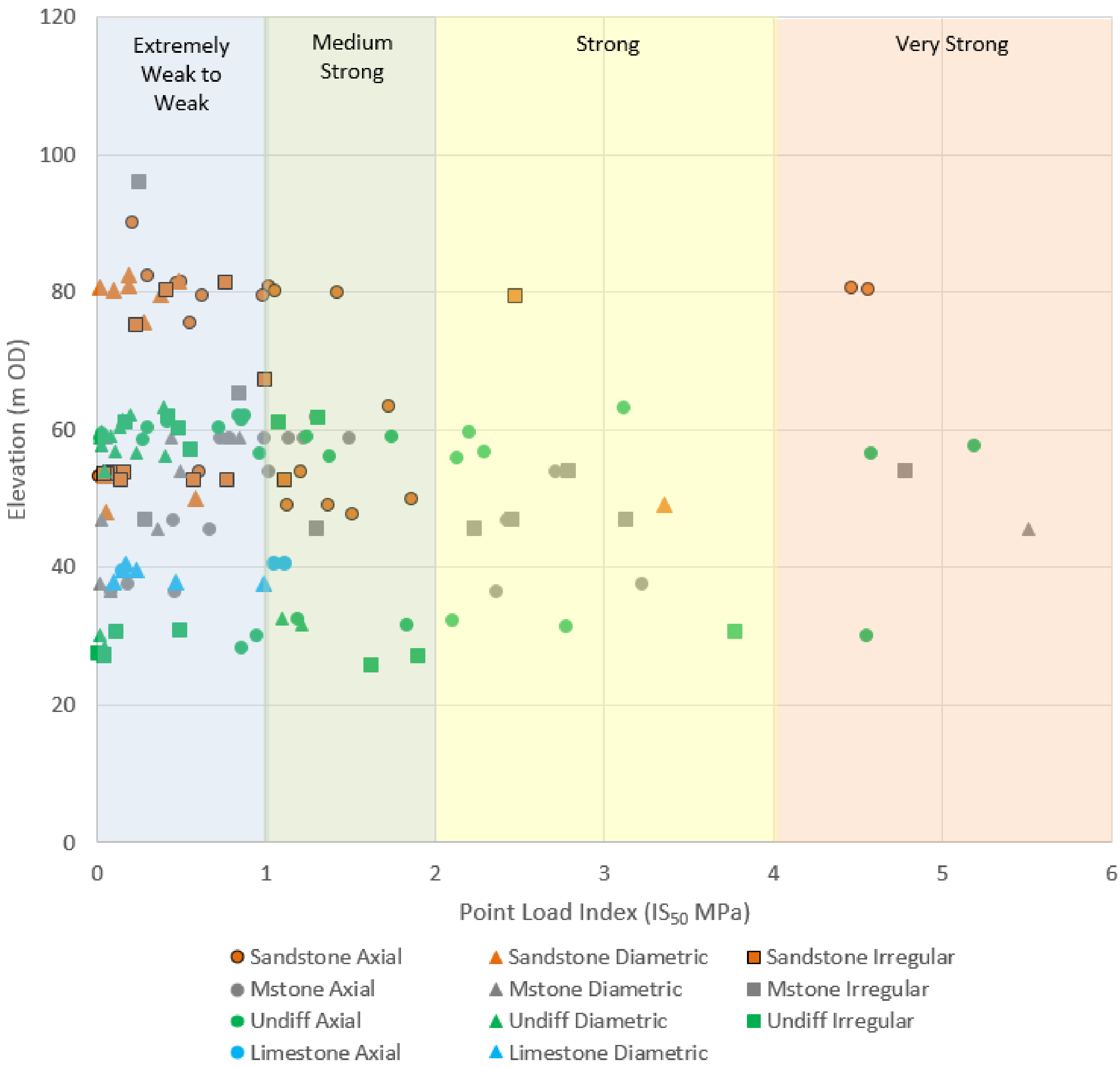


Figure 31 - Point Load Index (IS_{50}) vs Elevation

Six UCS tests were performed on the intact rock with values ranging from 5.2MPa, for a material described as a very weak, locally de-structured Mudstone, to 52MPa for a material described as moderately strong to moderately weak argillaceous Limestone with thin beds of calcareous mudstone. Three of the tests were performed on Sandstone cores and gave values of 16.7MPa to 19.4MPa, indicative of a weak material (after Table 5 of EN ISO 14689−1:2003). This appears marginally stronger but within a similar order of magnitude to the majority of the point load tests. The relatively limited results of the UCS strength testing plotted against elevation are shown on Figure 32.

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 i.e. the abundance of undifferentiated strata thinly interbedded, it was not possible to refine this correlation factor across the various bedrock classifications. Figure 32 shows the derived UCS values alongside the direct UCS results. The graph shows a large scatter in the derived UCS values, ranging between 0.23MPa and 127MPa, indicative of extremely weak to very strong rock. The largest variance occurs between derived values for the Limestone verses the single direct UCS result.

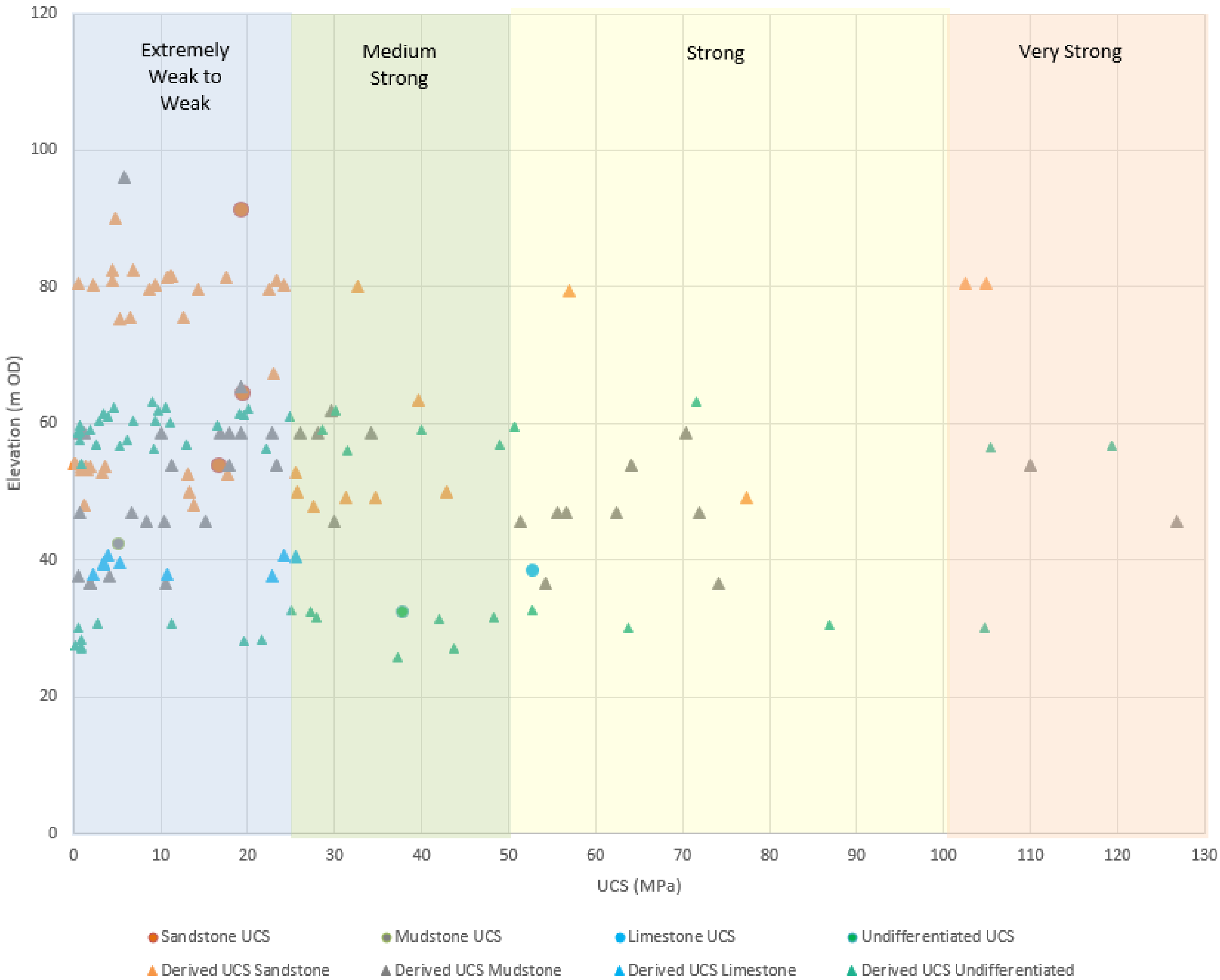


Figure 32 - UCS vs Elevation for the Intact Rock

FRICTIONAL ANGLE ALONG DISCONTINUITIES

In the areas of proposed or existing rock cuttings the stability of the slope will be controlled by a range of factors. This would include the number of discontinuities, the number and intersection of release planes, whether these daylight on the slope, the friction angle, the angle between the plane azimuth, the slope face azimuth and also any groundwater pressures being exerted. No direct shear box tests were undertaken on samples of rock obtained during the GI. Published angles of basic sliding friction are given in Tomlinson (2001) (ref 20). For the rocks encountered in the Stainmore Formation, angles of basic siding friction of between 27° and 34° are advised for a clean discontinuity, the actual friction angle being controlled by the shape, roughness, thickness, type of infill and the presence of water.

BEARING CAPACITY

The effect of fracture frequency on bearing capacity can be estimated from the RQD and material UCS (ref 19);

- Where RQD > 90% there is no reduction in bearing pressure.

- Where 90 to 50% RQD is recorded in 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

Table 19 – Summary of Geotechnical Parameters for Intact Bedrock

Sandstone Properties	Min	Max	Mean	No of Tests	Suggested Global Design Parameter*
Moisture Content (%)	1.8	6.0	4	4	
Bulk Density (Mg/m^3)	-	-	24	1	24
Sandstone Point Load IS_{50} (MPa)	0.06	1.72	0.63	35	1 to 10
Sandstone Laboratory UCS (MPa)	17	19	19	3	
Friction Angle (˚)	-	-	-	-	27-34#
Mudstone Properties	**Min**	**Max**	**Mean**	**No of Tests**	
Moisture Content (%)	-	-	6.2	1	
Bulk Density (Mg/m^3)	-	-	24	1	24
Mudstone Point Load IS_{50} (MPa)	0.08	4.78	1.4	33	1 to 5
Mudstone Laboratory UCS (MPa)	-	-	5.23	1	
Friction Angle (˚)	-	-	-	-	20 to 27#
Limestone Properties	**Min**	**Max**	**Mean**	**No of Tests**	
Moisture Content (%)	-	-	1.6	1	
Bulk Density (Mg/m^3)	-	-	28	1	28

Limestone Point Load IS_{50} (MPa)	0.1	1.11	0.49	9	1 to 10
Limestone Laboratory UCS (MPa)	-	-	53	1	
Friction Angle (˚)	-	-	-	-	34 to 40
Undifferentiated Properties	**Min**	**Max**	**Mean**	**No of Tests**	
Moisture Content (%)	-	-	2.6	1	
Bulk Density (Mg/m^3)	-	-	25	1	25
Undifferentiated Point Load IS_{50} (MPa)	0.03	5.19	1.15	52	1 to 10
Undifferentiated Laboratory UCS (MPa)	-	-	38	1	
Friction Angle (˚)	-	-	-	-	20 to 30

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

Note: compressive strength of the rock is extremely variable, global parameters are unlikely to be appropriate for detailed foundation design.

Based on values given in Ref. 20 Table 2.2

6.9. 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.

Monitoring instrumentation was installed in a total of 61 exploratory holes during the 2006 GI and these included;

- Gas monitoring standpipes installed in 11 exploratory holes;
- 19mm diameter standpipe piezometers installed in 46 of the exploratory holes; and
- Eight vibrating wire piezometers installed in 4 of the exploratory holes (two instruments per hole).

Installation details for these exploratory holes along with the groundwater monitoring results are summarized in Appendix A of the Preliminary Geotechnical Report (ref 1).

Groundwater monitoring equipment was installed in sixteen of the holes formed as part of the recent investigation with response zones targeting the groundwater strikes, areas of mine workings or anticipated pile depths. The exploratory holes were subsequently monitored for 3 months following completion of the works.

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.

The 2006 report (ref 1) reports that during the monitoring period, following a period of stabilisation, groundwater levels rarely varied by more than approximately 0.5m within each exploratory hole. The recent installations corroborate with these results and a general rule local to the notable watercourse that dissect the route, the groundwater levels are fairly stable between 0.5 and 1.0m bgl. Piezometers and standpipes installed within the Glacial Deposits recorded groundwater generally at depths of between 1.5 and 2.5m bgl.

Historically larger fluctuations of between 1.28m to 4.40m were recorded in three exploratory holes (BH1011, BH1018 and, BH1034) and this was thought to be due to the piezometer tip being located either within a granular horizon or at the soil-rock interface, where preferential flow paths may have established.

It is noted that the groundwater level is locally lower than general around CH17800 to CH1800. The Glacial Till is thinner than general in this area and it is possible that the underlying sandstone is providing some underdrainage in this section.

The piezometer installed in BH1044 responding at a depth of 15m within the existing embankment fill recorded groundwater at a depth of 11.36m or a level of 40.93m OD. This corresponds to the approximate level of the water course passing beneath the embankment at this location.

Piezometers installed within the bedrock at depth typically recorded ground water levels at a lower level than instruments responding at shallower depth within the drift material. This suggests perched water conditions within the drift that is also under drained by the bedrock. Within the vicinity of the River Coquet, a large number of springs have been observed to be issuing within the river valley which is also an indication of perched water.

GROUNDWATER IMPACT

To date the historic 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.

6.10. GROUNDWATER CHEMISTRY / CONTAMINATED LAND

GROUND AND GROUNDWATER CHEMISTRY

Testing was undertaken on samples of the soil to ascertain the aggressivity of the ground to buried concrete as set out in BRE Special Digest 1 (ref 21). The results of the testing are summarised in Table 20.

It is anticipated that most of the site would be considered to be Natural Ground without pyrite with mobile groundwater although the areas of Made Ground may be considered Brownfield dependant on the source and nature of the Made Ground.

Table 20 - Summary of Chemical Analysis Results for Concrete Classification

Strata	Chemical Test	Value			ACEC Class
		Minimum	Maximum	No. of tests	
Made Ground	pH	5.3	7.4	20	AC-1
	Total Sulphur (%)	0.01	0.31	16	
Glacial Till	pH	6.7	9.0	51	AC-1
	Soluble Sulphate (mg/l)	0.02	0.11	2	
	Total Sulphate (%)	25.1	219.5	11	
	Total Sulphur (%)	0.01	0.53	30	
Glaciolacustrine	pH	7.0	8.2	5	AC-1
	Soluble Sulphate (mg/l)	110.6	295.6	3	
	Total Sulphur (%)	<0.01	0.04	2	
Alluvium	pH	5.9	8.1	4	AC-1
	Soluble Sulphate (mg/l)	30.8	30.8	1	
	Total Sulphur (%)	0.02	0.39	3	

CONTAMINATED LAND

Non-Aggressive Ground Soils Chemistry

Combining the laboratory results from both the 2006 and 2017 ground investigation a total of 56No. soil samples were submitted for chemical analysis.

Legislation and guidance on the assessment of potentially contaminated sites acknowledges the need for a proportionate and consequently tiered risk based approach. The following assessment represents a Generic Quantitative Risk Assessment (GQRA), being a comparison of reported site contaminant levels against Generic Assessment Criteria (GAC). The GAC used in this assessment have been developed by WSP and have been calculated using the Environment Agency's Contaminated Land Exposure Assessment (CLEA) Workbook v1.071 to assess potential health risks associated with contaminants in soil. The soils results have been assessed against GAC derived for a commercial end use, using GAC for 1% Soil Organic Matter (SOM). Given the proposed scheme, comprises the upgrade of the existing highway it is noted that the use of GAC for a commercial end use provides a conservative assessment.

There were no exceedances of GAC within the soils dataset from the ground investigation completed in 2017. Table 21 provides a summary of the soils results from the ground investigation completed in 2006 identified to exceed the soils GAC for a commercial end use.

Table 21 - Summary of Soils Results Exceeding GAC for a Commercial End Use

Determinand	Number of samples analysed*	GAC (mg/kg) *(No. of exceedances)*	Min (mg/kg)	Max (mg/kg)	Location of Exceedance
Benzo(a)pyrene	40	38 *(1)*	<0.0012	108.535	TP1278 – 2.3mbgl
TPH C6 – C40	40	1,000# *(1)*	<10	4,492	TP1278 – 2.3mbgl
TPH C6 – C40	40	1,000# *(1)*	<10	3,723	TP1278 – 2.3mbgl

Notes:

* soils results from the 2006 ground investigation

There is no GAC for TPH C6-C40 or TPH C20-C40, for the purposes of this assessment it is considered beneficial to identify TPH concentrations reported above an arbitrary value of 1,000 mg/kg.

Only total chromium was reported in the 2006 results, there is no GAC for total chromium, only chromium VI. When screened against the GAC (24mg/kg) for chromium VI there are 30 No. exceedances (reported concentrations of chromium range between 15mg/kg and 47mg/kg). Given the limited extent of the exceedances they are not listed in this table as it is considered that it represents an overly conservative assessment. Within the 2017 results it is noted that concentrations of chromium VI were all reported to be less than the limit of detection (<1mg/kg) and concentrations of chromium III generally ranged between 10mg/kg and 28mg/kg with one exception of a reported concentration of 130mg/kg. On the basis that chromium III has a much lower toxicity than chromium VI and that there were no exceedances of the GAC for chromium VI within the 2017 dataset chromium is not considered to be a potential contaminant of concern.

Table 21 indicates that all exceedances of the GAC (or with respect to TPH, concentrations of note) were reported in TP1278 completed as part of the 2006 ground investigation. TP1278 was located to the north of the Longdike Burn crossing point, within an area identified as RAF land within the PSSR. The sample taken from TP1278 2.3mbgl comprised Made Ground consisting dark grey/black clayey sand and gravel, a strong hydrocarbon odour was noted.

Leachate Chemistry

There was no leachate analysis completed as part of the 2006 or 2017 ground investigation.

Groundwater Chemistry

There was no groundwater analysis completed as part of the 2017 ground investigation. Two groundwater samples were scheduled for analysis as part of the 2006 ground investigation, samples were taken from BH1004 and BH1024. Given the age of the analytical results they are not considered to be representative of the current groundwater quality, it is however noted that organic contaminants (EPH (DRO C110 -C40)) were identified in both groundwater samples scheduled for analysis, this was interpreted as 'possible petroleum naphthas / unknown pattern'. Elevated concentrations of copper and chromium were reported in BH1004 and elevated concentrations of nickel were reported in BH1024.

Potential sources of Contaminated Land

The route of the Morpeth to Felton section of the A1 passes through predominantly agricultural land, with areas to the east having a significant history of mining. A summary of the potential sources of contamination identified along the length of the proposed upgrade between Morpeth and Felton is provided below.

- Existing road network (A1), embankment fill materials, oils and fuels;
- Agriculture – slurry, pesticides, herbicides, fertilisers;
- WW2 airfield and associated buildings – aviation fuel, gasoline, diesel, antifreeze, radium-226 dials, solvents, fire-fighting agents, PCBs, hydraulic fluid, heavy metals;
- Garage and historical filling station – oils/fuels;
- Infilled ponds and quarries – filled with unknown Made Ground;
- Historical landfills, (Eshott – industrial, commercial, household and liquids/sludge wastes and The Helm, Fetton - inert wastes);
- Foot and mouth burial pits – 70m west of Ch.2150, 418327 589732;
- Tank, located at Ch.920 (1973, 1996);
- Shallow Mine Workings at Causey Park Hagg;
- Mine gases
- General Made Ground

As part of this assessment soils analytical data has been reviewed from two phases of ground investigation. It is noted that the recent GI (2017) was completed to supplement data available from previous GIs and focussed on the primary areas of proposed earthworks including embankments, cuttings and new or modified structures.

Based on the GI data available there are limited sources of contamination along the route, the laboratory results indicated that analytes in all but one of the soil samples analysed meet the conservative assessment criteria for a commercial end use. A potential source of contamination has been identified in an area of former RAF land, to the north of the existing Longdike Burn bridge crossing. Hydrocarbon odours were noted in the Made Ground encountered and laboratory results reported exceedances of the GAC in relation to benzo(a)pyrene. Although not exceeding GAC it is noted that concentrations of TPH were reported above an arbitrary value of 1,000mg/kg indicating that there is a potential source of contamination in this area. Should there be earthworks proposed in this area it is recommended that further investigation is completed to confirm the extent of contamination and further assess the nature of the soils with respect to potential re-use or the requirement for off site disposal.

7. GEOTECHNICAL RISK

7.1. 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 4] 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:

- Unidentified voids associated with shallow underground mine workings and abandoned shafts and adits;
- Presence of unforeseen poor ground; Weak & compressible soils;
- Shallow rock/ hard dig material;
- Presence of aggressive ground conditions;
- Shortfall of quality fill material;
- Insufficient GI data;
- Determinants within soils which pose a risk to human health and to the environment;
- Instability of existing earthwork slopes on the mainline;
- Instability of existing River Coquet abutment earthwork;
- Instability of River Coquet valley;
- Construction work having a destabilising impact on existing River Coquet Foundations;
- High or perched groundwater; and
- Unexploded Ordnance.

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.

7.2. PRELIMINARY REVIEW OF GEOTECHNICAL OPTIONS

INTRODUCTION

WSP has been commissioned to complete works to end of Stage 4 of the CDM 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 the cutting to the immediate south of the River Coquet.

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 26° and c' of 0kPa.

Additional space has been left within the redline boundary for the following options should they be deemed necessary during detailed design:

- The cutting to the immediate south of the River Coquet Bridge (M2FC011 between CH22000 to CH22460) which will be modified has current signs of groundwater seepage and instability. A midslope berm of 5m width should be assumed to intercept surface runoff and groundwater seepages. It may be possible to steepen the cutting where bedrock is encountered.
- The embankment which is being widened between CH23100 and CH23260 (M2FE07) is in area of complex geology (historic landslip deposits) and has defects suggesting subsidence. It is recommended that the red line boundary is extended an additional 30m at the toe once all other considerations are included in case the embankment needs buttressing to keep it stable.
- The northern most cutting (M2FC013) which is to be widened is in an area of laminated clays which may need digging out for stability. It is recommended an additional 10m is added to the red line boundary once all other considerations are included to allow space for any potential temporary works.

All earthworks will have crest and toe drainage.

Where embankments are greater than 1.5m high, it has been assumed from pricing that a starter layer 0.5m thick of 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 in Tables 14 and 16. 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 (design ongoing). This would have the added benefit of utilising some of the surplus fill material.

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 (ref 23 - 30). 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 I. A summary of the foundation options addressed to date is provided in Table 21.

Note, the River Coquet structure is being discussed separately in the next section due to the complexity of the design.

Table 22 – Summary of Foundation Options

Structure Name		Chainage	Scheme Requirements
Scheme Overbridges	Highlaws Junction	12250	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 12 and 25m across the four sites are currently being assessed, with West Moor Junction 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.
	Fenrother Junction	14910	
	Causey Park Overbridge	17060	
	West Moor Junction	21700	
Cotting Burn		10770	No structural options or amendment to the existing culvert.
Warreners House Interchange		10870	No structural options or amendment to the existing bridge.
Shieldhill Burn Culvert		11825	Culvert extension. Foundation options still being assessed.
Paradise Culvert (Floodgate Burn Culvert)		13660	New Precast concrete box culvert extension for Floodgate Burn. The founding depth is yet to be established. It is likely to be founded on the Glacial Till of firm to stiff clay extending from 2.0m bgl, which is the base of the Alluvium, to a depth of at least 19m bgl. An allowance for over-excavation to remove any soft material would be required.
Priest Bridge (Underbridge)		14035	New precast concrete box culvert for the River Lyne. The founding depth is yet to be established. Glacial Till would be a suitable founding strata for precast units if founded in the firm to stiff deposits. Alluvium, comprising a mix of soft or firm clay and sand extending to depths of up to approximately 2m bgl currently under the site. The underlying Glacial Till extended to a depth of at least 19m bgl. An allowance for over-excavation to remove any soft material would be required.
Causey Park Culvert		17060	New precast concrete box culvert. Glacial Till would be a suitable founding strata for precast units at the anticipated founding level, albeit with an allowance for over-excavation should any Alluvium or soft spots be encountered.
Eshott Burn Culvert		18310	New culvert. Foundation options still being assessed.
Burgham Culvert		19500	Culvert extension for Longdike Burn. Foundation options still being assessed.

Structure Name	Chainage	Scheme Requirements
Burgham Underbridge	19500	New junction flat arch Underbridge. Glacial Till of firm to stiff clay extends to a depth of at least 25m bgl under the proposed site. It is currently anticipated that the structure will require a piled foundation but this is subject to foundation loading confirmation.
Bockenfield Culvert	19990	New precast concrete box culvert for Longdike Burn. Glacial Till would be a suitable founding strata for precast units at the anticipated founding level, albeit with an allowance for over-excavation should any Alluvium or soft spots be encountered.
Glenshotton Culvert	21860	Precast Concrete Box Culvert Extension for Thirston Burn. It is currently anticipated that the Glacial Till underlying the embankment material at culvert location would be a suitable founding strata.
River Coquet Bridge	22480 - 22710	New Bridge - Design options still being assessed.
Parkwood Subway	23100	Subway span extension using precast concrete culvert sections. Unmapped landslide deposits shown under the site and beneath the existing embankment. Made Ground of unknown origin comprising stiff gravelly clay was encountered underlying the embankment material. Given the unusual ground the structure will need to be piled.
Parkwood Culvert	23150	Precast Concrete Box Culvert Extension. Made Ground comprising firm to stiff gravelly clay, extending to depths of up to 1.5m bgl underlain by Glacial Till comprising firm to stiff clay underlie the site. The Glacial Till is likely to be a suitable founding layer for the culvert. An assessment of the settlement induced from the overlying embankment load will need to be undertaken once final ground levels are known to check they are within tolerance. Made Ground below founding level should be replaced with Granular Fill. The foundation type and form will be further reviewed as part of preliminary design once the foundation loading is known.

RIVER COQUET BRIDGE

Design of the structure over the River Coquet is ongoing with the following consideration informing the design (see also the Risk Register):

- The need to avoid loading the failed block and area of cracking on the valley slope means the abutments need to be set back compared to the existing bridge.
- Deep foundation solutions are being considered that take the foundation below the anticipated failure surfaces within the slope
- Deep excavations at the new abutment locations are to be minimised as far as is possible to minimise the possibility of impact on the existing bridge foundations.
- Foundations are being designed to resist any lateral loading from movement within the valley slopes.

Deep caisson foundations are considered to be the preferred option both from design considerations (particularly resistance to lateral loading) and buildability and consequently this will be taken forward as the proposed design solution for the purpose of preliminary design for DCO. The current proposal is to provide two caissons connected by a cross head beam to support the north abutment, with both caissons located just to the north of the area of cracking. A single larger diameter caisson is proposed for the north pier.

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 retention 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 is as the required invert levels to avoid inundation by groundwater.

It should be noted that GI specifically specified for the retention basins has not been undertaken as basin locations were not known at time of the most 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. The cohesive material will require some degree of lime conditioning or drying as the optimum moisture content for this material has been assessed in the in the region of 13% with the natural moisture content lying between 15 to 22%.

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.

A preliminary assessment of material suitability for reuse indicates approximately 75% of cohesive material extracted from the top 2.0m of the cuttings will be suitable for reuse, increasing to approximately 90% at greater than 2.0m below ground level. Where the Glaciolacustrine deposits occur, these are deemed unsuitable as Class 2 due to lower average shear strengths. If laminated clays are encountered, insitu shear strength testing is recommended to ensure Cu exceeds 50kPa. It is recommended that use of a Performance Specification for construction to maximise opportunity to use site won fill.

Preliminary assessment of cut/fill balance would indicate an overall surplus of material of roughly 40% to construct the scheme (total excavation of approximately 700,000m^3 with a total fill requirement of approximately 390,000m^3). There is on-going design work on landscape bunds which could utilise this material as Class 4 Fill, the results of this work will be presented in the Design Summary Report.

MINING ISSUES

Voids associated with shallow underground mine workings and abandoned shafts and adits are deemed only to be a risk in the vicinity Causey Park where the road is in cutting and Eshott Airfield. Where the road is at grade. As set out in Section 5.7, the Ground Investigation undertaken along the route has not identified any mining related voids although anecdotal evidence suggests they may be present. Given this, a risk of encountered unexpected voids has been included in the scheme risk register for pricing to allow for grouting of unexpected voids.

No deep and/ or surface mining backfill material has been identified beneath route and therefore this geotechnical risk has been closed.

8. REFERENCES

1. Highways Agency (Laing O'Rourke, White Young Green), A1 Morpeth to Felton Dualling – Preliminary Geotechnical Report, August 2006. HAGDMS No. 20917.
2. Jacobs, 2015, A1 in Northumberland Statement of Intent, Report ref OD-036, HAGDMS No.28835.
3. Jacobs, 2016, A1 in Northumberland – Morpeth to Felton PSSR, Report ref B2104700, HAGDMS No. 29386.
4. Jacobs, 2016, A1 in Northumberland – Morpeth to Felton, Annex A, Report ref B2104700, HAGDMS No. 29387.
5. Bullen Consultants limited, 2004, Preliminary Sources Study Report, A1 Morpeth to Felton Dualling, TPI preferred route announcement. Report ref 104D108/07/01, Darlington. HAGDMS No.19699.
6. BGS, 1966, Solid Geology, Map 9 – Rothbury, 1:63,360 scale.
7. BGS, 2009, Bedrock and Superficial Geology, Map 9 – Rothbury, 1:50,000 scale.
8. BGS, 1935, Memoirs of the Geological Survey England and Wales, Explanation of sheets 9 and 10, The geology of the country around Rothbury, Amble and Ashington, HMSO, London.
9. Allied Exploration & Geotechnics, 1998, A1 Felton Park to Lane Head, Northumberland Ground Investigation HAGDMS No.9366.
10. Allied Exploration & Geotechnics, 1999, A1 Felton Park to Lane Head Southern Extension HAGDMS No.9368
11. Norwest Holst, 2006, Factual Report on Ground Investigation at A1 Morpeth to Felton Dualling, Northumberland, Norwest Holst – Report Reference F14298/F01. HAGDMS No. 20918
12. Ian Farmer Associates Limited, A1 in Northumberland, Morpeth to Felton, Final Report on Ground Investigation, November 2017. HAGDMS No. 30315.
13. Manual of Contract Documents for Highways Works, Volume 5, Section 3 Ground Investigation, 1997.
14. British Standards Institute: BS 10175 'Code of practice for the investigation of potentially contaminated sites', BSI 2011+A1:2013.
15. British Standards Institute: BS 5930 'Code of practice for site investigations', BSi 2015.
16. BS EN 1997, Part 2:2007, 'Eurocode 7 – Ground investigation and testing – Part 2.
17. BS 8002, 2015. Code of practice for Earth retaining structures, BSI.
18. Stroud, M.A. and Butler, F.G., 1975, The Standard Penetration Test and the Engineering Properties of Glacial Materials, Proc. Symp. Engineering Properties of Glacial Materials, Midlands Soil Mechanics and Foundation Society.
19. Peck, R.B., Hanson, W.E. and Thornburn, T.H., 1974, Foundation Engineering, 2nd edition, John Wiley and Sons
20. Tomlinson, M.J., 2001, Foundation Design and Construction, 7th Edition, Pearson
21. BRE Special Digest 1, 2005. Concrete in Aggressive Ground, 3rd Edition, BRE.
22. Socotec Uk Ltd, July 2018, A1in Morpeth To Felton & Alnwick To Ellingham Factual Report On Ground Investigation : Morpeth To Felton – Causey Park, Report No A8013-18/Cp. HAGDMS No. 30564.
23. WSP January 2018, A1 Morpeth To Felton Dualling Scheme Overbridges Structures Options Report. Report no; HE551459-WSP-SBR-M2F-RP-CB-0418
24. WSP December 2017, A1 Morpeth To Felton Dualling Scheme Bockenfield Culvert Structures Options Report. Report no; HE551459-WSP-SBR-M2F-RP-CB-0425

25. WSP December 2017, A1 Morpeth To Felton Dualling Scheme Burgham Underbridge Structures Options Report. Report no; HE551459-WSP-SBR-M2F-RP-CB-0400
26. WSP December 2017, A1 Morpeth To Felton Dualling Scheme Causey Park Culvert Structures Options Report. Report no; HE551459-WSP-SBR-M2F-RP-CB-0421
27. WSP December 2017, A1 Morpeth To Felton Dualling Scheme Parkwood Subway Structures Options Report. Report no; HE551459-WSP-SBR-M2F-RP-CB-0435
28. WSP December 2017, A1 Morpeth To Felton Dualling Scheme Priest Bridge Structures Options Report. Report no; HE551459-WSP-SBR-M2F-RP-CB-0398
29. WSP January 2018, A1 Morpeth To Felton Dualling Scheme River Coquet Bridge Structures Options Report. Report no; HE551459-WSP-SBR-M2F-RP-CP-0440
30. WSP January 2018, A1 Morpeth To Felton Dualling Scheme Glenshotton and Parkwood Culvert Structures Options Report. Report no; HE551459-WSP-SBR-M2F-RP-CB-0437

Appendix A

EARTHWORKS DATASHEETS

Last Update: 17-09-2018
Design Revision: February 2018

Earthwork Details:

MAJOR CUTTING M2FC01		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	
			From	To				
General Details[1]	Northbound	14_A1_42906 At grade	1260	1365	-3.8	-2.0 – -4.0	105 - 109	
	Southbound	14_A1_42905 At grade	1260	1380	<0.5	<0.5	104 - 105	
Earthwork Details	HAGDMS Defects	Current Earthwork Classification	Observation No.		Feature		Class	Location Index
		None Recorded.						
	Preliminary Earthwork Proposals	Widening of the A1 is adjacent to the northbound carriageway only. Proposed soil slope regrade 1:3 recommended in cohesive Glacial Till. Max height is at approximate ch.11320 A filter drain will be required at the toe to draw down the groundwater to below that of the toe of the slope. Crest drainage should be installed in where the surrounding land slopes towards the cutting. Road pavement will be founded on the cohesive Glacial Till.						

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BHA1701	8.0	104.58	-	None	-
TP1202	4.5	103.30	-	None	-
TP1203	4.5	104.97	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 – 0.3	103 - 104.67	0.2 – 0.3	Soft dark brown slightly sandy clayey TOPSOIL with occasional rootlets
Cohesive Glacial Till	>8.0	<96.58	>7.8	Firm becoming very stiff grey brown, occasionally mottled at shallow depths, slightly sandy slightly gravelly CLAY with occasional cobbles and boulders. Gravel is angular to subrounded fine to coarse of Sandstone, Coal, Limestone Siltstone and Mudstone.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Glacial Till	
	No. of tests	Results
Natural Moisture Content (%)	20	6.6 – 29 (A = 21.8)
Liquid Limit (%)	4	41 – 57 (A = 46.5)
Plastic Limit (%)	4	18 – 24 (A = 20)
Plasticity Index (%)	4	22 – 33 (A = 26.5)
SPT 'N' Value	4	17 - >50
c_u (kPa) (Hand shear vane)	21	70 – 130 (A = 103)
Dry Density (Mg/m^3) (2.5kg Compaction)	11	1.5 – 1.84 (A = 1.7)
Bulk Density (Mg/ m^3)	5	1.88 – 1.98 (A = 1.92)
MCV	5	6.6 – 10.5 (A = 8.48)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched Groundwater	Low permeability deposits in the form of Glacial Till may give rise to perched water. No groundwater noted in historical holes.
Hard dig	Occasional cobbles and boulders noted in the Glacial Till

Last Update: 17-09-2018
Design Revision: February 2018

Earthwork Details:

MINOR CUTTING M2FC02		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	
General Details[1]	Northbound	14_A1_42906 At grade	11365	11525	-1.8	-1.0 to -1.8	103.5 – 105	
	Southbound	14_A1_42905 At grade	11365	11480	<1.5	<1.5	103.5 – 105	
Earthwork Details	HAGDMS Defects	Earthwork Classification	Observation No.		Feature		Class	Location Index
		None recorded						
	Preliminary Earthwork Proposals	Proposed soil slope regrade 1:3 recommended in cohesive Glacial Till. Max height is at approximate ch.1390. A filter drain will be required at the toe to draw down the groundwater to below that of the toe of the slope. Crest drainage should be installed in where the surrounding land slopes towards the cutting. Road pavement will be founded on the cohesive Glacial Till.						

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
TP1203	4.5	104.97	-	None	-
*BH1001	21.0	106.81	Standpipe piezometer tip at 4.5 [4 – 5.0]	-	1.12 - 1.83

**10m offset from northern extent of earthwork.*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3	106.51 – 104.67	0.3	TOPSOIL
Cohesive Glacial Till (TP1203 only – BH1001 is rotary drill)	17	89.81	16.7	Very soft to very stiff slightly sandy gravelly CLAY with occasional cobbles and boulders. Gravel is subangular fine to coarse of limestone, mudstone, coal and sandstone. Cobbles and boulders are subangular of sandstone.
Sandstone (BH1001 only)	>21.0	85.81	>2.0	Moderately strong yellow fine to coarse grained SANDSTONE. Discontinuities 0-10 deg; 5-60 deg.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till		Sandstone	
	No. of tests	Results	No. of tests	Results
Moisture Content (%)	18	6.6 – 29 (A = 22.14)		
Liquid Limit (%)	2	45 – 57 (A = 51)		
Plastic Limit (%)	2	19 – 24 (A = 21.5)		
Plasticity Index (%)	2	26 – 33 (A = 29.5)		
c_u (kN/m^2)	12	70 – 130 (A = 102)		
MCV	5	6.6 – 10.5 (A = 8.48)		
Max Dry Density (mg/m^3)	11	1.5 – 1.84 (A = 1.66)		
Bulk Dry Density (mg/m^3)	5	1.88 – 1.98 (A = 1.93)		
UCS (MPa)			1	16.7

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched Groundwater	Due to the low permeability Glacial Till, there is potential for perched groundwater to be

Hazard	Process/ Activity
	encountered.
Hard dig	Glacial Till comprising cobbles and boulders was encountered at relatively shallow depths.

Last Update: 18-09-2018
Design Revision: February 2018

Earthwork Details:

<table>
<tr><th colspan="2" rowspan="2">MINOR CUTTING
M2FC03</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="2">General Details[1]</td><td>Northbound</td><td>14_A1_42904 At grade
14_A1_42906 At grade</td><td>11895</td><td>12290</td><td>-1.65</td><td>-1.0</td><td colspan="2">108.5 - 110</td></tr>
<tr><td>Southbound</td><td>14_A1_42905 At grade
14_A1_42902 At grade</td><td>11900</td><td>12290</td><td><-1.5</td><td>-0.5</td><td colspan="2">108.5 - 110</td></tr>
<tr><td rowspan="3">Earthwork Details</td><td rowspan="2">HAGDMS Defects</td><td>Earthwork Classification</td><td colspan="2">Observation No.</td><td colspan="2">Feature</td><td>Class</td><td>Location Index</td></tr>
<tr><td colspan="7">None Recorded</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="7">• Widening of the A1 predominantly adjacent to the northbound carriageway but some widening of the southbound carriageway adjacent to new Highlaws Junction layout
• Regrade existing soil slope to 1:3 in the cohesive Glacial Till
• A filter drain will be required at the toe to draw down the groundwater to below that of the toe of the slope.
• Road pavement is likely to be founded on cohesive Glacial Till.
• Material reuse; Glacial Till class 2.</td></tr>
</table>

Published Geology

Superficial	**Solid**
Predominantly underlain by Glacial Till-Diamicton.	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (m OD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
TP1205	2.8	110.38	-	None	-
TP1207	4.3	108.45	-	None	-
BH1002	14.55	109.77	Standpipe piezometer installed with tip to 5.0 [4.5 – 5.5]	None	Dry -1.745
BH1002R	30.05	110.27	Standpipe piezometer installed with tip to 21.5 [21 – 22]	Strike at 21.5 (heavy flow)	2.53 – 4.63
TP1208	4.5	110.14	-	None	-
BH1004	6.2	109.89	Slotted Standpipe [2 – 6.2]	Strike at 2.9 (No rise after 20 minutes)	1.94 – 3.0
TPA1701	3.5	110.22	-	None	-
TPA1753_ SOAKAWAY	3.0	109.9	-	None	-
BHA1704	20	110.27	Slotted Standpipe [1.6 – 3] Piezometer tip at 7.7 [6.8 – 8.5]	Strike 1 at 2.5 (Rose to 2.0 after 20 mins) Strike 2 at 6.8 (Rose to 3.8 after 20 mins)	2.5 – 3.6
BHA1703	20	109.35	Piezometer tip at 4.0 [3.0 – 5.5]	None	2.06 – 3.3

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.1 – 0.5	104.83– 110.08	0.1 – 0.5	Topsoil
Cohesive Glacial Till	>2.8 – 17.3	92.97 – 107.58	>2.4 – 16.8	Very soft to stiff brown mottled grey slightly gravelly sandy CLAY/SILT. Gravel is subangular to subrounded fine to coarse of various lithologies including sandstone, mudstone and quartz.
Granular Glacial Till	0.9 – 8.5	105.5 – 108.45	0.2 – 1.8	Medium dense brown to grey clayey subangular to subrounded fine to coarse sandy GRAVEL/ gravelly SAND of various lithologies including mudstone, sandstone, limestone, quartz and

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
				coal.
Sandstone (Interbedded with Mudstone Layers)	18.0 - >30.05	110.27 - <80.22	0.55 – 4.2	Moderately weak to strong dark grey fine to coarse grained thinly to thickly laminated occasionally micaceous SANDSTONE with some thin laminations. Slightly to moderately weathered with discontinuities. Interbedded with weak grey silty MUDSTONE and weak light grey very thinly to thinly bedded SILTSTONE.
SILTSTONE (BHA1703 and BH1704 only)	93.4	15.7-16.9	0.4	Weak very thinly to thinly bedded SILTSTONE. Discontinuities horizontal and sub-horizontal, planar rough. In BHA1703 recovered as non-intact friable gravel-sized fragments.
Mudstone (Interbedded with sandstone layers)	15.3 - 27.9	94.05 – 82.37	0.46 -3.0	Moderately weak to moderately strong thinly laminated dark grey Mudstone with occasional laminations of light grey fine grained sandstone. Partially weathered with discontinuities.
Local Ground Variations	Thinly laminated Clay encountered within the cohesive Glacial Till of BHA1703 (3.0 – 3.6m bgl), BHA1704 (1.3- 3.0m bgl) and TP_A1753 (1.3 – 3.0m bgl) some interlaminations with fine to medium sand. TPA1701- slightly sandy slightly gravelly CLAY interlaminated with gravely fine to coarse SAND. Gravel is fine to coarse subangular to subrounded including sandstone and mudstone.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till		Granular Glacial Till		Mudstone		Sandstone	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	66	7.4 – 28 (A = 16.7)	6	2.8 – 199 (A = 14.1)	-	-	-	-
Liquid Limit (%)	17	31 – 49 (A = 38.6)	1	31	-	-	-	-
Plastic Limit (%)	17	13 – 30 (A = 18.4)	1	30	-	-	-	-
Plasticity Index (%)	17	10 – 29 (A = 20.2)	1	1	-	-	-	-
SPT (N Value)	20	4 – 52 (A = 25.8)	5	10 – 50 (A = 30.8)	-	-	-	-
MV (m2/MN)	22	0.008 – 0.52			-	-	-	-
MCV	1	7.4	5	2.8 – 13.7 (A = 7.6)	-	-	-	-
c_u (kN/m^2)	48	37 – 123 (A = 79.6)	-	-	-	-	-	-
Cu TT (KN/m2)	3	23 – 154 (A = 79.6)	-	-	-	-	-	-
CBR (%)	2	Top 2.2 – 7.6 Bottom 3.1 – 6.2	-	-	-	-	-	-
Max Dry Density (mg/m^3)	15	1.55 – 1.9 (A = 1.71)	-	-	-	-	-	-
Bulk Density (mg/m^3)	29	1.97 - 2.2 (A = 2.17)	5	2.1 – 2.25 (A = 2.17)	-	-	-	-
Point Load IS^{50}	-	-	-	-	1	0.25	1	0.21
UCS (MPa)	-	-	-	-	-	-	1	16.7

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched/ shallow Groundwater	Low permeability glacial till deposits may give rise to perched water. Multiple water strikes in the Till, occasionally at shallow depths (<2.0m bgl). Vigilance during construction should maintained for groundwater. Sump-pumping may be required in more granular glacial material.
Laminated Clays	Laminated Clays were encountered in BHA1703, BHA1704 and TPA1753 at relatively shallow depth (<3.0m bgl). The weak planes within the laminated clays may lead to long term slope instability.

Hazard	Process/ Activity
Hard dig	Glacial Till is encountered at relatively shallow depths- cobbles are encountered within the Glacial Till. The base of the cutting is likely to be within the glacial till.
Surface flooding	Surface Flooding; risk up to 1 in 30 per year noted within an area of localised excavation and backfill to the east if the existing A1 at Ch. 12300.
Potentially Contaminated Land	Possible are of localised excavation and backfill at Ch. 12300. New junction layout requires material to be excavated within and adjacent to the existing side roads around the proposed Highlaws Junction. Approximate location of Foot and Mouth burial Site - Defra Carcass Burial Site east of the proposed Junction at Ch12200.

Last Update: 01-10-2018
Design Revision: Feb 2018

Earthwork Details:

MINOR CUTTING M2FC04		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	Northbound	N/A new earthwork	13795	13960	-1.7	1.0 -1.5	86 - 89
	Southbound	N/A new earthwork	13750	13950	-1.5	0.5 – 1.0	86 - 89
Earthwork Details	Preliminary Earthwork Proposals	Proposed 1:3 soil slope in cohesive Glacial Till. Base of cutting likely to be within cohesive Glacial Till. A filter drain will be required at the toe to draw down the groundwater to below that of the toe of the slope. Road pavement is likely to be founded on cohesive Glacial Till. Material reuse; Glacial Till class 2.					

Published Geology

Superficial	Solid
Glacial Till.	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
TP1219	4.2	86.54	-	None	-
BH1008	10	87.81	Standpipe piezometer tip to 5.0 [4.0 – 6.0]	None	Dry – 3.39

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3 – 0.5	85.04 – 87.51	0.3 – 0.5	Topsoil
Cohesive Glacial Till	>4.2 - >10	<82.34 – <77.81	>3.7 - >7.7	Firm to stiff slightly sandy gravelly CLAY with occasional cobbles. Gravel is fine to coarse subangular of various lithologies including sandstone, limestone and mudstone. Cobbles are subangular of sandstone.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till	
	No. of tests	Results
Moisture Content (%)	22	6.6 – 27.9 (A = 18)
Liquid Limit (%)	5	32 – 45 (A = 335.8)
Plastic Limit (%)	5	12 – 20 (A = 15.8)
Plasticity Index (%)	5	18 – 25 (A = 20)
SPT 'N' Value	5	11 – 36 (A = 21.8)
c_u (kPa) Hand Shear Vane	18	60 – 130 (A = 102.7)
c_u (kPa) - Triaxial	3	97 – 157 (A = 119.7)
MCV	2	6.6 – 8.4
Max Dry Density (mg/m^3)	8	1.51 – 1.84 (A = 1.69)
Bulk Density (mg/m^3)	5	1.88 – 2.26 (A = 2.06)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched Groundwater	Potential for perched water in granular water bearing strata due to low permeability Glacial Till deposits.
Hard dig	Glacial Till, containing cobbles is encountered at relatively shallow depth

Last Update: 1-10-2018
Design Revision: February 2018

Earthwork Details:

MINOR CUTTING M2FC05		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	**Northbound**	N/A – new earthwork	14130	14400	-2.4	-1.0 to -2.0	84.5 - 88
	Southbound	N/A – new earthwork	14120	14400	-2.4	-1.0 to -2.0	84.5 - 88
Earthwork Details	**Preliminary Earthwork Proposals**	Proposed soil slope 1:3 in cohesive Glacial Till recommended. Base of cutting likely to be within cohesive Glacial Till A filter drain may be required at the toe to draw down the groundwater to below that of the toe of the slope. Road pavement is likely to be founded on cohesive Glacial Till. Material reuse; Glacial Till class 2.					

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
*TP1225	4.3	85.40	-	None	-
TP1226	4.5	88.54	-	None	-
TP1227	4.5	87.61	-	None	-

**offset from the southern extent of the earthwork by approximately 30m*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3	87 - 88	0.3	Topsoil
Cohesive Glacial Till	>4.5	<81	>4.2	Firm to very stiff brown to dark grey slightly sandy slightly gravelly CLAY with cobbles and boulders. Gravel is fine to coarse subangular of various lithologies including limestone sandstone, coal and mudstone. Cobbles and boulders are subangular of sandstone.
Local Ground Variations	Granular Glacial Till was encountered at the base of TP1227, comprising grey sandy angular to subangular fine to coarse GRAVEL of sandstone, mudstone and limestone.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till	
	No. of tests	Results
Moisture Content (%)	19	6.6 – 29.4 (A = 21.8)
Liquid Limit (%)	5	40 – 60 (A = 50.4)
Plastic Limit (%)	5	21 – 25 (A = 22.5)
Plasticity Index (%)	5	24 – 35 (A = 29.5)
c_u (kN/m^2) Hand Shear Vane	39	64 – 130 (A = 103)
CBR (%)	2	Top 3.8 – 8.3 Bottom 4.4 – 8.8
MCV	2	6.6 – 8.4
Max Dry Density (mg/m^3)	11	1.49 – 1.91 (1.68)
Bulk Density (mg/m^3)	2	1.88 – 1.94

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched Groundwater	Potential for perched groundwater due to the low permeability cohesive Glacial Till
Hard dig	Glacial Till is encountered at shallow depths, comprising cobbles and boulders.
Slope Stability	Relatively high plasticity index for Glacial Till encountered within the proposed cutting material.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

MINOR CUTTING M2FC06		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	**Northbound**	N/A – new earthwork	14400	15020	-1.9	1.0 – 1.5	88.5 - 90
	Southbound	N/A – new earthwork	14400	15020	-1.9	1.0 – 1.5	88.5 - 90
Earthwork Details	**Preliminary Earthwork Proposals**	Proposed soil slope 1:3 in cohesive Glacial Till recommended. Base of cutting likely to be within cohesive Glacial Till A filter drain may be required at the toe to draw down the groundwater to below that of the toe of the slope. Road pavement is likely to be founded on cohesive Glacial Till. Material reuse; Glacial Till class 2.					

Published Geology

Superficial	**Solid**
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH1011	8	88.88	Standpipe piezometer tip at 3.0 [2.5 – 3.5]	Strike 1 at 3.6 Strike 2 at 7.1	Dry – 3.2
BH1012	7.1	90.08	-	None	-
BH1012R	25.2	90.27	Standpipe piezometer tip at 5.5 [5.0 – 6.0]	None	1.5 – 4.92
TP1228	4.5	88.96	-	None	-
TP1229	4.3	89.02	-	None	-
TP1230	4.5	88.70	-	None	-
TP1232	4.5	89.71	-	None	-
TP1233	4.5	89.88	-	None	-
TP1234	4.5	89.97	-	None	-
BHA1707	20	89.29	Standpipe piezometer tip at 8.0 [7.0 – 9.0]	9.0	Dry – 7.76

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 – 0.4	88.4 – 90.07	0.2 – 0.4	Dark brown slightly sandy clay TOPSOIL.
Glacial Till	>4.0 - >8.0	<80.9 - 85.5	>3.7 - >7.7	Firm to very stiff, occasionally soft brown slightly sandy slightly gravelly CLAY with occasional cobbles and boulders. Gravel is subangular to subrounded of various lithologies, including sandstone, limestone, mudstone and coal. Cobbles and boulders are subrounded of sandstone. Occasionally interbedded with medium dense to dense dark grey/ brown very clayey fine to coarse gravelly SAND/ sandy GRAVEL generally 0.3 – 0.8m thick.
Sandstone (BH1012, BH1012R and BH1707)	>17.63 - >22.7	<67.57 - < 71.66	layer thickness 0.4 – 6.08	Weak to moderately strong light grey thickly laminated to thinly bedded fine to medium grained SANDSTONE with extremely closely to closely spaced thin laminations to thin beds of dark grey mudstone. Slightly to moderately weathered, occasionally destructured with discontinuities.
Mudstone (BH1012, BH1012R and BH1707)	18.7 – 20.0	89.29 – 90.27	Layer thickness 0.53 – 2.33	Weak to moderately strong dark grey MUDSTONE. Partially to distinctly weathered with discontinuities. Medium spaced to very closely-spaced thin laminations of black coal or medium grained sandstone.

Local Ground Variations	**Bedrock** encountered around 83.4m OD. **Made Ground** - encountered in BH1012 between 0.3m – 1.4m bgl described as dark grey slightly sandy clayey fine to coarse gravel with occasional cobble sized fragments. **Glaciolacustrine** deposits encountered in TP1233 and TP1234 between 1.7 and 2.7m bgl and described as firm to stiff thinly laminated grey/brown slightly sandy slightly gravelly CLAY. **Coal** encountered in BH1012R at 18.7m bgl with a thickness of 0.1m described as very weak, black vitreous Coal. In BH1012R, interbedded Sandstone and Siltstone is encountered from 7.7m to terminal depth.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Glacial Till		Glaciolacustrine		Sandstone/ Undifferentiated	
	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	57	6.9 – 28(A = 17.9)	3	27 – 30 (A = 28.3)		
Liquid Limit (%)	22	22 - 63 (A=41.5)	3	54 – 57 (A = 55.7)		
Plastic Limit (%)	22	13 – 25 (A = 18.3)	3	23 – 26 (A = 24)		
Plasticity Index (%)	22	12 – 38 (A = 23.2)	3	31 – 33 (A = 31.6)		
SPT 'N' Value	9	25 – 50 (A = 39)	-	-	1	50
c_u (kPa) Hand Shear Vane	88	36 – 130 (A = 94.2)	6	114 – 130 (A = 121)		
c_u TT (kPa) Triaxial	5	53 – 150 (A = 112)				
MCV	5	6.9 – 12.3 (A = 9.6)				
CBR (%)	1	Top 7.1 Bottom 8.8				
Max Dry Density (mg/m^3)	11	1.68–1.94 (A = 1.80)				
Bulk Density (mg/m^3)	22	1.92–2.26 (A=2.12)				
UCS	-	-				
PL IS_{50}	-	-			17	0.02 – 4.56 (A = 1.03)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Mine workings (deep)	The area lies within an area of deep coal. Coal was also encountered in BH1012R at 18.8m bgl.
Perched/ high Groundwater	Multiple water strikes were encountered in the Glacial Till of BH1011, some at very shallow depth. The low permeability of the Glacial Till deposits may give rise to perched groundwater. Cutting crosses Fenrother Burn at Ch14960 – possible culvert required.
Hard dig	Glacial Till, comprising cobbles and boulders was encountered at relatively shallow depth.
Slope stability	Up to 1.0m thick laminated clays encountered at northern extents of proposed earthwork.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

MINOR CUTTING M2FC07		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
General Details[1]	**Northbound**	N/A – new earthwork	15525	15910	-2.2	-1.0 -1.5	95.5 - 99
	Southbound	N/A – new earthwork	15525	15920	-2.2	-1.0 -1.5	95.5 - 99
Earthwork Details	**Preliminary Earthwork Proposals**	Proposed soil slope of 1:3 recommended. The base of the cutting is likely to be within the cohesive Glacial Till. A filter drain may be required at the toe to draw down the groundwater to below that of the toe of the slope. Road pavement is likely to be founded on cohesive Glacial Till. Material reuse; Glacial Till class 2.					

Published Geology

Superficial	**Solid**
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
*TP1237	3.3	91.64	-	None	-
TP1238	2.6	98.91	-	None	-
BH1013	3.2	97.59	Standpipe piezometer tip at 3.0 [2.2 – 3.2]	None	0.98 – 2.64
TPA1707	3.5	95.94	-	None	-

** Approximately 30m offset from southern extent of earthwork*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3	98.6 – 91.6	0.3	TOPSOIL
Cohesive Glacial Till	1.9 – 2.7	89.0 – 96.9	1.6 – 2.7	Firm to stiff mottled brown grey sandy gravelly CLAY. Gravel is subangular fine to medium of various lithologies including sandstone, mudstone, limestone and coal.
Weathered Bedrock	>2.6 – >3.3	<89.04 - <96.71	0.4 - 1.1	Dense very clayey fine to coarse gravelly SAND/ sandy GRAVEL. Gravel is subangular to subrounded of sandstone. Described as SANDSTONE recovered as slightly clayey sand in BH1013 and Grey clayey sandy angular and tabular fine to coarse GRAVEL of mudstone in TP1237.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till		Weathered Bedrock; weathered Sandstone/ Mudstone	
	No. of tests	Results	No. of tests	Results
Moisture Content (%)	24	7.7 – 28 (A = 17.8)		
Liquid Limit (%)	7	35 – 48 (A = 42.9)		
Plastic Limit (%)	7	18 – 26 (A = 20.7)		
Plasticity Index (%)	7	16 – 25 (A = 22.1)		
SPT ‘N’ Value	-	-	4	24 – 50 (A = 43.5)
c_u (kPa) Hand Shear Vane	32	45 – 136 (A = 91.3)		
Max Dry Density	16	1.52 –1.91 (A = 1.7)		
Bulk Density	2	1.88 –1.94 (A = 1.76)		

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched/ high Groundwater	There is potential for perched groundwater due to the low permeability Glacial Till deposits in the area. Shallow groundwater was encountered in BH1013 and there is evidence of a risk of surface flooding in the vicinity of the proposed cutting.
Hard dig	Glacial till, comprising cobbles and boulders was encountered at the locality at relatively shallow depth. Weathered rock head appears to be shallow (~3.0m).

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

MINOR CUTTING M2FC08		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	**Northbound**	N/A – new earthwork	16310	16810	-1.95	-1.0 – 1.5	92.5 – 99.5
	Southbound	N/A – new earthwork	16300	16810	-1.95	-1.0 – 1.5	92.5 – 99.5
Earthwork Details	**Preliminary Earthwork Proposals**	Proposed soil slope 1:3 in cohesive Glacial Till recommended. Base of cutting likely to be within cohesive Glacial Till A filter drain may be required at the toe to draw down the groundwater to below that of the toe of the slope. Road pavement is likely to be founded on cohesive Glacial Till. Material reuse; Glacial Till class 2.					

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
TP1240	3.9	99.46	-	None	-
TP1241	4.2	96.87	-	None	-
TP1242	4.5	98.34	-	None	-
TP1243	4.5	96.82	-	None	-
TP1244	4.5	94.60	-	None	-
TP1245	4.5	93.09	-	None	-
BH1014	23.2	96.13	Standpipe piezometer tip at 3.0 [2.2 – 3.2]	None	0.75 – 1.44
*TPA1713	3.5	88.72	-	None	-

**offset 20m north of the northern extent of the earthwork*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 – 0.3	92.79 – 99.16	0.2 - 0.3	TOPSOIL
Glacial Till	>3.9 – 7.8	88.33 - <95.56	>3.6 – 7.5	Predominantly firm to stiff slightly silty slightly gravelly CLAY with occasional cobbles and boulders. Gravel is subangular to subrounded fine to coarse sandstone, limestone, mudstone, coal and quartz. Cobbles and boulders are subangular of sandstone and limestone. Occasionally interbedded with sandy subangular fine to coarse GRAVEL with some cobbles. Cobbles are subangular of sandstone/ Clayey fine to medium SAND.
Sandstone Layer 1 Layer 2 Layer 3 Layer 4 (BH1014 only)	11.81 14.97 20.85 >23.2	84.32 81.16 75.28 <72.93	4.0 1.27 4.15 >1.16	Light yellow fine medium and coarse grained SANDSTONE. Recovered as fine medium and coarse gravel sized fragments overlying moderately weak to moderately strong grey with orange brown staining fine to medium grained SANDSTONE. Moderately weathered with discontinuities, occasionally interbedded with mudstone.
Mudstone Layer 1 Layer 2 (BH1014 only)	13.7 16.7	82.43 79.43	1.7 1.9	Very weak to moderately weak dark grey MUDSTONE with localised orange staining. Partially to distinctly weathered with discontinuities.
Siltstone (BH1014 only)	22.04	74.09	1.19	Moderately weak to moderately strong SILTSTONE. Partially weathered with extremely closely spaced thin laminations fine to medium grained sandstone with discontinuities.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till		Sandstone	
	No. of tests	Results	No. of tests	Results
Moisture Content (%)	53	7.5 – 27 (A = 16.4)		
Liquid Limit (%)	22	29 – 53 (A = 39.2)		
Plastic Limit (%)	22	12 – 23 (A = 17.7)		
Plasticity Index (%)	22	14 – 32 (A = 21.5)		
SPT 'N' Value	4	30 – 40 (A=35.3)	2	50
c_u (kPa) Hand Shear Vane	80	40 – 130 (A = 90.6)		
Cu TT (kN/m^2) Traxial	1	81		
MCV	5	7.5 – 13.4 (A = 9.96)		
Max Dry Density (mg/m^3)	23	1.71 – 1.98 (A = 1.83)		
Bulk Dry Density (mg/m^3)	6	2.01 – 2.18 (A = 2.11)		

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched/ High Groundwater	Potential for perched groundwater due to the low permeability material of the Glacial Till. Groundwater was not encountered in the majority of exploratory holes. However, shallow groundwater was encountered in BH1014.
Hard dig	Glacial Till comprising cobbles and boulders was encountered at relatively shallow depths.

Last Update: 02-10-2018
Design Revision: February 2018

Earthwork Details:

MAJOR CUTTING M2FC09		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
General Details[1]	Northbound	N/A – new earthwork	17490	18020	-3.0	2.5 – 3.0	78 - 86
	Southbound	N/A – new earthwork	17400	18035	-3.5	2.5 – 3.0	78 - 86
	Preliminary Earthwork Proposals	1:3 proposed soil slope recommended within the cohesive Glacial Till. A filter Drain will be required at the cutting toe to draw down the groundwater to below that of the toe of the slope. Crest drainage should be installed in where the surrounding land slopes towards the cutting. The existing field drains which will be cut by the earthwork should be intercepted by collector drains. Road pavement will be founded on the cohesive Glacial Till.					

Published Geology

Superficial	Solid
Glacial Till	Predominantly underlain by the Stainmore Formation – Mudstone, Siltstone and Sandstone at the southern extent of the earthwork. The Causey Park Dyke of Quartz-Microgabbro bisects the route in a southwest-northeast direction between Ch17810 to Ch17850. Peninne Lower Coal Measures Formation – Mudstone, Siltstone and Sandstone Ch17850 to Ch17970.

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BHA1722	6.8	78.49	-	1.6 rose to 1.2 after 20 mins	4.2 – 4.52
BHA1723	10.5	85.48	-	15.2 rose to 13.10 after 20 mins	Dry – 2.77
TPA1716	3.5	80.75	-	None	-
BHA1743	3.5	81.85	-	None	-
BH1017	28.10	84.40	Standpipe Piezometer tip at 4.5 [4 - 5]	Strike at 3.00 (rising to 2.2 after 20 mins)	1.81 – 3.45
BH1018	4.5	83.96	Slotted Standpipe [2.3 – 4.4]	None	2.76 – 4.4
BH1019	24.54	85.13	Slotted Standpipe [9.5 – 24.5]	Strike at 4.70 (rising to 4.3 after 20 mins)	7.1 – 8.11
BH1020	21.30	83.08	Standpipe Piezometer tip at 14.5 [14 - 15]	Strike at 7.30 (rising to 4.8 after 20 mins)	11.72 – 13.32
BH1021	27.4	83.36	Slotted Standpipe [2 – 5]	None	1.48 – 3.44
BH1046	17.00	85.04	-	None	-
BH1047	21.0	82.0	-	None	-
TP1252	4.0	83.17	-	None	-
TP1253	4.50	84.29	-	None	-
TP1256	2.60	85.04	-	None	-
TP1258	4.50	84.96	-	None	-
TP1259	4.40	84.10	-	None	-
TP1261	4.00	84.10	-	None	-
TP1263	4.4	82.44	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.1 – 0.6	78.39 – 85.08	0.1 – 0.6	Topsoil.
Glacial Till	>2.6 – 17.25	68.23 – <82.44	>2.0 – 16.85	Predominantly firm to very stiff brown mottled grey slightly sandy slightly gravelly CLAY with occasional cobbles and boulders. Gravel is subangular fine to coarse of sandstone, quartz, quartzite and limestone. Occasionally described as brown slightly clayey gravelly fine to coarse SAND or medium dense dark brown clayey

				very sandy subangular to subrounded fine to coarse GRAVEL
Weathered rockhead	3.5 – 18.15	78.49 – 85.48	0.2 – 3.3	Weathered zone over intact bedrock; described as either very weak to weak thinly laminated dark greyish brown MUDSTONE. recovered as stiff to very stiff CLAY or fractured rock recovered angular tabular GRAVEL of mudstone or sandstone.
Mudstone	8.2 – 26.83 (may represent more than one layer)	57.6 – 71.8	0.21 – 5.35	Very weak to moderately strong dark grey MUDSTONE. Partially weathered in places, closely to very closely spaced 0-10 degrees planar and smooth discontinuities.
Siltstone	13.1 – 27.4	55.96 – 70.93	0.2 – 2.31	Very weak to strong dark grey SILTSTONE. Weathered in places with orange staining. Discontinuities: 0 – 60 degree fractures very closely to closely spaced planar and smooth.
Sandstone	8.0 – 28.1	56.3 – 75.13	>0.1 – 7.13	Weak to very strong light grey fine to medium grained SANDSTONE. With think to thick laminations or dark grey MUDSTONE. Fresh to slightly weathered. Discontinuities: 0 – 15 degrees very closely to closely spaced planar to undulating smooth with occasional orange staining.
Local Ground Variations	**Bedrock –** encountered at 16.1m bgl at southern extent of the earthwork, rising to 8.3m bgl before falling away to 13.0m bgl at the northern extent. **Made Ground** – Soft dark brown slightly gravelly organic CLAY. Gravel sized fragments are subangular to subrounded fine to coarse of various materials. Identified at the surface in BH1017. **Possible Alluvium -** Soft light grey brown, locally mottled orange brown, slightly fine sandy CLAY with occasional rootlets with occasional pockets of sand and sand partings encountered between 0.1 – 1.5 mbgl in BHA1722 associated with an apparent land drain adjacent to Causey Park Overbridge. **Laminated clay** – Firm to stiff thinly laminated dark brown mottled grey slightly sandy slightly gravelly CLAY. Gravel is subangular to subrounded fine to medium of various lithologies including charcoal sandstone and quartz. – identified in BH1017 to a maximum depth of 3.0m bgl. **Coal** – Weak to moderately weak dense black vitreous COAL. Identified in BH1020 between 13.7 – 13.95m bgl and BH1021 between 16.8 – 17.3m bgl. **Possible Fault Gorge -** Very weak thinly laminated dark grey black carbonaceous MUDSTONE. Destructured. (Recovered as very stiff clay) encountered between 16.25 – 16.8 in BH1046. Zone of no recovery between 14.0 – 15.0m bgl in BH1046.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Alluvium		Glacial Till		Weathered Mudstone/ Sandstone		Mudstone		Sandstone	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	1	23.2	148	7- 32 (A = 17.3)	1	9.5	-	-	-	-
Liquid Limit (%)	1	NP	33	NP – 61 (A = 42)	-	-	-	-	-	-
Plastic Limit (%)	1	NP	33	NP – 29 (A = 19.5)	-	-	-	-	-	-
Plasticity Index (%)	1	NP	33	NP – 38 (A = 23)	-	-	-	-	-	-
SPT 'N' Value	1	21	35	4 – 50 (A = 33.1)	12	50	1	50	-	-
c_u (kPa) (hand vane)			104	45 – 134 (= 100)	-	-	-	-	-	-
c_u (kPa) (triaxial)			11	52 – 231 (A = 107)	-	-	-	-	-	-
CBR (%)			1	Top 8.2 Base 7.2	-	-	-	-	-	-

Test	Alluvium		Glacial Till		Weathered Mudstone/ Sandstone		Mudstone		Sandstone	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Max Dry Density (Mg/m^3) (2.5kg Compaction)	-	-	67	1.6 – 2.02 (A = 1.8)	-	-	-	-	-	-
Bulk Density (Mg/ m^3)	-	-	53	1.91 – 2.25 (A = 2.08)	-	-	-	-	-	-
MCV	-	-	7	7.1 – 13.3 (A = 10.2)	-	-	-	-	-	-
P/L IS_{50} (MN/m^2)	-	-	-	-	-	-	2	0.84 – 1.29	2	1.0 – 1.72
UCS (MPa)	-	-	-	-	-	-	-	-	1	19.4

Summary of Geotechnical Risks

Hazard	Process / Activity
Mine workings	Coal measures strata subcrop beneath the route at Causey Park Hagg. An Inferred coal seam underlying the route at ch17930 a 0.35m thick coal seam overlying 1.52m of ‘Seggar’ or coarse fireclay. Aerial photographs of the Causey Park area show surface depressions associated with collapsed mine roadways in the fields either side of the route alignment. It is estimated that mine working voids in excess of 2.0m may be encountered at this location. It is anticipated that the preferred road alignment will cross the zone of influence of mine workings between Ch17800 and Ch18000. Treatment of these former mine workings by grouting will be required at this location.
Laminated clays	Possible weak planes in material leading to long term slope instability/lateral sliding of foundations – BH1017, thickness of 2.9m between depths of 0.1 – 3m bgl.
High/ Perched Groundwater	Multiple water strikes in the Till, occasionally at shallow depths. Vigilance during construction should maintained for groundwater. Sump-pumping may be required in more granular glacial material.
Surface Water Flooding	Site is adjacent to an area exposed to a surface flood risk of 1 in 30. Land drains are present to existing side roads to draw down the groundwater table.
Hard dig	Till is relatively shallow in places. Cobbles and boulders are frequently encountered within the Glacial Till at elevations below 80m OD which could impact on excavation.
Potentially Contaminated Land	Location of deep coal mining underneath the proposed route – Victoria seam Opencast mining of Causey Park Dyke underneath the proposed route. Causey park brick and tile yard located 250m east of the proposed route.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

MAJOR CUTTING M2FC10		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	**Northbound**	N/A – new earthwork	18430	18775	-4.5	2.0 – 4.0	74 - 85
	Southbound	N/A – new earthwork	18410	18780	-5.4	3.0 – 5.0	74 - 85
Earthwork Details	**Preliminary Earthwork Proposals**	1:3 proposed soil slope recommended. Base of cutting likely to be in rock therefore a steeper slope may be achievable dependant on the discontinuity distribution and weathered rock horizon. A berm may be required at the drift/ berm interface. A filter Drain will be required at the toe to draw down the groundwater to below that of the toe of the slope. Crest drainage should be installed where the surrounding land slopes towards the cutting. Road pavement is likely to be founded on rock.					

Published Geology

Superficial	Solid
Glacial Till	Predominantly underlain by Pennine Lower Coal Measures- Mudstone, Siltstone and Sandstone. Stainmore Formation – Mudstone, Siltstone and Sandstone at the northern and southern extents of the earthwork.

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH1023	6.2	85.39	Standpipe piezometer to 5.5 [3.9 – 5.9]	Strike at 8.5 (no flow details recorded)	3.71 – 5.17
BH1023R	12	85.23	-	Strike at 8.1 (no flow details recorded)	-
TP1266	4.5	77.45	-	None	-
TP1265	4.5	81.66	-	None	-
TPA1722	3.5	76.86	-	None	-
BHA1729	10.0	83.41	Standpipe piezometer tip at 8.0 [7.0 – 9.0] Slotted standpipe [4.0 – 5.0]	Strike 1 at 4.3, rose to 3.7 after 20 mins Strike 2 at 8.0,	4.3 – 4.51
TPA1720	3.5	79.52	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 - 0.3	<72.95 – 80.89	0.2 - 0.3	TOPSOIL.
Glacial Till	>3.5 – 5.0	80.5 - <72.95	>3.3 – 5.0	Firm to very stiff, occasionally described as soft a shallow depths, brown or mottled brown/ grey slightly sandy slightly gravelly CLAY with occasional cobbles. Gravel is subangular fine to coarse of various lithologies including sandstone, mudstone, limestone, coal and quartz. Cobbles are subangular of sandstone and limestone. Described as Boulder Clay in BH1023R at shallow depths (DD).
Weathered bedrock	6.0 – 6.44	76.97 – 79.39	1.5 – 2.44	Firm to very stiff grey/ brown sometimes dark green, sandy silty micaceous gravelly CLAY with occasional lithorelicts of mudstone and laminations/ partings of coal OR light brown sandy GRAVEL. Gravel is angular and subangular sandstone.
Sandstone	>10 - >12	<73.23 – <73.41	>7	Very weak to moderately strong orange brown fine to coarse grained SANDSTONE occasionally interbedded with very thinly interbedded with very weak green grey MUDSTONE. Moderately weathered. Two sets of discontinuities observed 1) 0-10 deg closely spaced 2) 70-80

				deg medium spaced.
Local Ground Variations	**Bedrock –** encountered between 4.0 – 5.0m bgl.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Glacial Till		Weathered Mudstone/ Sandstone		Weathered Mudstone	
	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	54	5.9 – 23.4 (A = 15.2)	6	6.6 – 21.2 (A = 12.8)	-	-
Liquid Limit (%)	13	32 – 47 (A = 38.4)	1	53	-	-
Plastic Limit (%)	13	14 – 23 (A = 18.4)	1	29	-	-
Plasticity Index (%)	13	16 – 24 (A = 20.2)	1	14	-	-
SPT 'N' Value	4	18 – 38 (A = 30)	5	31 – 50 (A = 37.2)	-	-
c_u (kPa) Hand Shear Vane	42	50 -120 (A = 89.5)	-	-	-	-
CBR	2	Top 2.2 – 8.8 Base 2.0 – 10.0	-	-	-	-
P/L IS_{50} (MN/m^2)	-	-	-	-	5	0.24-0.71 (A=0.88)
MCV	5	7.8 – 10 (A = 9.1)	-	-	-	-
Max Dry Density (mg/m^3)	29	1.66 – 2.03 (A = 1.83)	-	-	-	-
Bulk Density (mg/m^3)	11	1.74 – 2.03 (A = 2.09)	-	-	-	-

Summary of Geotechnical Risks

Hazard	Process/ Activity
Mine workings (deep)	In an area of deep coal (between 50m and 1200m deep) Area may be affected by historic coal mining; Risk of non-coal mining is considered to be low.
Hard dig	Glacial till is encountered at relatively shallow depths – cobbles are encountered within the glacial till. Superficial material reuse class 2C. Base of cutting likely to be in rock which is likely to be considered hard digging but the severity is dependent on the weathered nature of the rock and in situ fracture spacing. Bedrock material reuse Class 6A.
High/ Perched Groundwater	Several water strikes in the Glacial Till, occasionally at shallow depths. Vigilance during construction should maintained for groundwater. Sump-pumping may be required in more granular glacial material. A minor watercourse runs parallel to the proposed route approximately 150m west of the site.

Last Update: 02/10/2018
Design Revision: February 2018

Earthwork Details:

MAJOR CUTTING M2FC11		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	**Northbound**	14_A1_42929	21850	22460	-10.8	-3.0 to -9.0	106.0 – 110.0
	Southbound	14_A1_42928	21880	22460	> -10.5	-3.0 to -9.0	106.0 – 108.0

Earthwork Details – HAGDMS Defects

Earthwork Classification	Observation No.	Feature	Class	Location Index
Cutting (Northbound)	14_A1_42929_520487	Small slip at crest of lower slope.	1D	C
Cutting (Northbound)	14_A1_42929_520486	Erosion feature near crest. Extends to boundary fence.	1D	C
Cutting (Southbound)	14_A1_42929_520490	Animal burrows sandy gravel of coal excavated.	Minor observation	
Cutting (Southbound)	14_A1_42928_520479	Possible slight settlement at toe of lower slope due to burrows beneath gorse.	Minor observation	
Cutting (Southbound)	14_A1_42928_520480	Animal burrows beneath gorse in toe of lower slope.	1D	C
Cutting (Southbound)	14_A1_42928_520471	Animal burrows beneath gorse.	Minor observation	
Cutting (Southbound)	14_A1_42928_520472	Slip at toe of upper slope 13m long, 0.15m deep. Slight seepage at south end. Slip at crest of upper slope 19.7m long 0.2m deep. Slope soft under foot.	1D	C
Cutting (Southbound)	14_A1_42928_520473	Small slip in upper slope 4m long 2.5m upslope from bench. Small slip to north 0.9m long 0.2m high.	1D	C
Cutting (Southbound)	14_A1_42928_520475	Toe of upper slope wet and soft underfoot.	1D	C

Earthwork Details – Preliminary Earthwork Proposals

- Widening of the A1 is adjacent to the southbound carriageway only.
- Regrade existing soil slope to 1:3. Base of cutting likely to be in rock therefore a steeper slope may be achievable dependant on the discontinuity distribution and weathered rock horizon. A 5.0m berm will be required at the drift/ rock interface to intercept any drainage requirements.
- A filter Drain will be required at the toe to draw down the groundwater to below that of the toe of the slope. Crest drainage should be installed in where the surrounding land slopes towards the cutting.
- Road pavement is likely to be founded on rock.

Published Geology

Superficial	Solid
Predominantly underlain by Glaciofluvial sands and gravels. Glacial Till at northern and southern extents.	Stainmore formation- Mudstone, siltstone and sandstone.

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
*BHA1738	15.2	60.61	Slotted standpipe [2.0 – 5.0]	None	4.92 - 4.98
*BHA1739	38.25	63.93	-	None	-
BH10	10.0	66.40	-	Strike at 3.70 rose to 3.90	-
*BH1032	5.0	66.71	Standpipe Piezometer [tip at 4.5, response zone between 4 - 5]	None	3.6 – 4.86
*BH1033	20	66.75	Standpipe Piezometer [tip at 8.0, response zone between 7.5 -8.5]	Strike at 16.50, no rise after 20 mins	3.6 - 9.46
*BH1034	5.0	68.34	Standpipe Piezometer [tip at 4.5, response zone between 4 - 5]	None	1.35 – 4.24
*BH1035	20.50	68.41	Standpipe Piezometer [tip	Strike at 17.0, no rise after 20	12.89 – 15.8

Hole reference	Final Depth (m)	Ground Level	Installation Details [Response Zone]	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring
			at 17.0, response zone between 16.5 - 17.5]	mins	
*BH1036	50.0	63.67	-	None	
BH11	11.0	67.63	-	Strike at 2.70	-
BH12	13.0	68.69	-	Strike at 3.0	-
BH13	13.0	67.61	-	Strike at 3.20	-
BH14	4.95	65.19	-	None	-
BH14A	15.0	64.4	-	None	-
BH7	3.45	60.64	-	None	-
BH8	4.35	63.32	-	None	-
BH9	4.70	65.36	-	Strike at 3.70	-
*BHA/98	3.0	65.16	Slotted standpipe [3.0 – 8.0]	None	4.96 – 7.11
*BHB/98	4.0	66.41	-	None	-
*BHC/98	4.60	67.74	Slotted standpipe [8.0 – 11.0]	None	9.28 – 9.38
*BHD/98	3.0	68.34	-	None	-
*BHE/98	4.0	66.76	Slotted standpipe [7.0 – 10.0]	None	7.14 – 7.83
*TP1297	4.50	63.09	-	None	-
*TP1298	4.20	67.74	-	None	-
*TP1299	3.20	68.53	-	None	-
*TPA	3.50	61.16	-	None	-
*TPB	3.60	63.01	-	None	-
*TPC	3.50	65.96	-	None	-
*TPD	0.80	61.36	-	None	-
*TPE	3.50	67.52	-	None	-
*TPF	1.50	62.91	-	None	-
*TPG	3.50	67.90	-	Strike at 2.80	-
*TPH	1.40	62.73	-	None	-
*TPI	3.60	68.07	-	None	-
*TPJ	1.10	60.37	-	None	-
*TPK	3.0	66.50	-	None	-
WS1518	2.0	61.87	-	Strike at 1.20	-

**undertaken at the proposed widening location i.e. at the crest or in the field adjacent to the existing cutting*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.15-0.5	66.25 – 68.04	0.15-0.5	TOPSOIL. Occasionally described as sandy.
Cohesive Glacial Till	0.4 - 5.7	57.97 – 64.84	1.45 – 4.5	Predominantly firm to stiff, occasionally described as soft at shallow depths, brown and grey sandy gravelly occasionally silty CLAY with infrequent cobbles and boulders. Gravel is fine to coarse subangular to subrounded of sandstone, mudstone limestone and quartz.
Weathered Mudstone	0.6-4.6	59.49 – 65.33	0.3 – 2.1	Grey to dark grey completely weathered MUDSTONE very weak. Generally recovered as clayey sandy gravel or sandy gravelly clay.
Coal: Layer 1 Layer 2 Layer 3 Layer 4	 0.9 – 3.6 4.5 – 7.0 16.08 – 19.08 34.8	 62.01 – 64.47 56.67 – 59.78 47.67 – 52.33 28.87	0.16 – 2.1	Very weak to weak black vitreous COAL occasionally non intact and recovered as tabular fine to medium gravel or interbedded with weathered sometimes organic mudstone.

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Mudstone	>0.8 – 47.25	16.42 – 63.34	>0.2 – 7.81	Very weak to moderately weak dark grey/ black MUDSTONE slightly to distinctly weathered with thin laminations of sandstone and coal. Discontinuities: 1) 0-15 deg very closely to closely spaced planar smooth or undulating stepped 2) 40-60 deg medium spaced undulating stepped 3) 70-90 deg closely to widely spaced planar smooth.
Weathered sandstone	2.0 – 4.2	62.75 – 66.53	0.5 – 1.6	Yellow brown/ grey fine to coarse grained SANDSTONE recovered as fine to coarse sand or sandy subangular to subrounded fine to coarse gravel and overlying the intact sandstone.
Sandstone	2.5 – 46.22	63.67 – 68.41	0.47 – 6.82	Moderately strong to strong grey/ yellow fine to coarse grained SANDSTONE. Slightly to moderately weathered. With occasional closely to medium spaced thin laminations of dark grey mudstone. Discontinuities: 1) 0-10 deg extremely closely to medium spaced planar smooth or rough.
Siltstone	17.2 (BH1035) – 45.75 (BH1036)	17.92 – 57.55	1.12 – 2.55	Very weak to moderately strong grey to black SILTSTONE with occasional thin laminations of fine to medium grained sandstone. Discontinuities: 1) 0-20 deg closely to medium spaced undulating stepped or planar smooth 2) 80-90 deg closely to medium spaced planar rough.
Undifferentiated Mudstone and Sandstone	3.2 – 20.0	46.75 – 64.7	0.25 – 4.46	Moderately weak to moderately strong thinly interlaminated dark grey MUDSTONE and light grey SANDSTONE. Slightly to moderately weathered. 1) 0-10 deg very closely to closely spaced planar smooth with brown staining. 2) 80-90 deg closely spaced undulating smooth or planar stepped.
Limestone layer 1 layer 2 (BH1036 only)	31.61 >50	32.06 <13.67	8.78 >2.75	Weak becoming strong dark grey fine to medium grained LIMESTONE. Slightly to highly weathered. Discontinuities: 1) extremely closely to closely spaced randomly orientated undulating rough 2) 0-10 deg closely to medium spaced planar rough. 3) 40-60 deg closely to widely spaced planar smooth with localised orange brown staining.
Local Ground Variations	**Bedrock** - The drift material generally increases with depth from north to south along the cutting with bedrock at the surface at the northern extent to around 5 – 6.0m bgl at the southern extents. A thin layer of Made Ground was encountered in TPJ between 0.1m bgl and 1.10m bgl and excavated at the crest of the existing southbound cutting. The material is described as 'loose clayey sandy gravel with many cobbles and boulders'.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till		Weathered Mudstone		Mudstone		Weathered Sandstone		Sandstone		Undifferentiated Mudstone / Sandstone	
	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 (%)	52	4.8 - 22 (A = 15.5)	1	20	-	-	11	6 – 19.2 (A = 13)	-	-	-	-
Liquid Limit (%)	9	26 - 45 (A = 33.8)	1	36	-	-	-	-	-	-	-	-
Plastic Limit (%)	9	14 – 23 (A = 17.9)	1	19	-	-	-	-	-	-	-	-
Plasticity Index (%)	9	12 – 22 (A = 17.1)	1	17	-	-	-	-	-	-	-	-
SPT 'N' Value	6	12 – 27	4	50	3	87 - 107	9	11 - >50 (A	4	>50	-	-

Test	Cohesive Glacial Till		Weathered Mudstone		Mudstone		Weathered Sandstone		Sandstone		Undifferentiated Mudstone / Sandstone	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
		(A = 17.1)						= 39)				
c_u (kN/m^2) Hand Shear Vane	51	20 – 134 (A = 89.1)	-	-	-	-	2	130	-	-	-	-
c_u(kN/m^2) TT	2	168 - 177	-	-	-	-	-	-	-	-	-	-
Bulk Density (mg/m^3)	10	2 – 2.21 (A = 1.82)	-	-	-	-	-	-	-	-	-	-
Max Dry Density (mg/m^3)	32	1.64 – 1.96 (A = 1.8)	-	-	-	-	10	1.7 – 1.97 (A = 1.84)	-	-	-	-
MCV	8	4.8 – 10.8 (A = 7.98)	-	-	-	-	-	-	-	-	-	-
P/L IS_{50} (MN/m^2)	-	-	-	-	19	0.03 – 62.6 (A = 5.84)	-	-	9	0.05 – 3.36 (A = 1.29)	43	0.02 – 71.3 (A = 5.34)
UCS (MPa)	-	-	-	-	-	-	-	-	1	16.7	-	-

Summary of Geotechnical Risks

Hazard	Process/ Activity
Hard Dig	Glacial Till is encountered to relatively shallow depths – cobbles and boulders are anticipated within the Superficial material. The majority of the cutting will be in rock which is likely to be considered hard digging but the severity is dependent on the weathered nature of the rock and in situ fracture spacing.
Ground instability	A number of 1D defects relating to minor slips and groundwater seepages have been identified within the existing earthwork which is currently at a 1 in 2 gradient with an apparent berm with lower and upper slope. The majority of the defects on the southbound slope appear to be within the upper slope section and relate to seepages or animal burrows. 2006 Geotechnical report extract; To the south of the Coquet Valley the cutting has been excavated through glacial till into the underlying mudstones and sandstones. This cutting has a single mid height bench formed at the approximate level of the base of the cohesive till with slopes of approximately 1v:2h.
High/ Perched Groundwater	Several water strikes in the Glacial Till and bedrock are recorded at shallow depths. Vigilance during construction should maintained for groundwater. Extensive water bearing strata in the cutting will require an appropriate drainage design.

Last Update: 02/10/2018
Design Revision: February 2018

Earthwork Details:

<table>
<tr><td colspan="2" rowspan="2">MAJOR CUTTING M2FC12</td><td rowspan="2">HAGDMS Reference</td><td colspan="2">Chainage</td><td rowspan="2">Max Slope Height (m)</td><td rowspan="2">Typical Slope Height (m)</td><td colspan="2" rowspan="2">Elevation Range (m OD)</td></tr>
<tr><td>From</td><td>To</td></tr>
<tr><td rowspan="2">General Details[1]</td><td>Northbound</td><td>14_A1_429826</td><td>22690</td><td>23080</td><td>-8.0</td><td>- 5.0 to -8.0</td><td colspan="2">111.0 – 102.0</td></tr>
<tr><td>Southbound</td><td>14_A1_42985</td><td>22690</td><td>23070</td><td>>-8.0</td><td>-5.0 to -6.0</td><td colspan="2">112.0 – 102.0</td></tr>
<tr><td rowspan="9">Earthwork Details</td><td rowspan="8">HAGDMS Defects</td><td>Earthwork Classification</td><td colspan="2">Observation No.</td><td colspan="2">Feature</td><td>Class</td><td>Location Index</td></tr>
<tr><td>Cutting</td><td colspan="2">520379</td><td colspan="2">Slip, subsidence</td><td>1D</td><td>C</td></tr>
<tr><td>Cutting</td><td colspan="2">520382</td><td colspan="2">Slope bulge, animal burrowing.</td><td>1D</td><td>C</td></tr>
<tr><td>Cutting</td><td colspan="2">520384</td><td colspan="2">Animal burrowing</td><td>-</td><td>-</td></tr>
<tr><td>Cutting</td><td colspan="2">520386</td><td colspan="2">Slip</td><td>1D</td><td>C</td></tr>
<tr><td>*Embankment</td><td colspan="2">578468</td><td colspan="2">Tension cracks.</td><td>1D</td><td>C</td></tr>
<tr><td>*Embankment</td><td colspan="2">279883</td><td colspan="2">Slope, slope bulge, tension cracks, dislocated trees, terracing, dislocated fence.</td><td>1A</td><td>C</td></tr>
<tr><td>*Embankment</td><td colspan="2">437808</td><td colspan="2">Slip, tension cracks.</td><td>1A</td><td>C</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="7">Widening of the A1 is adjacent to the southbound carriageway only.
Regrade existing soil slope to 1:3. If base of cutting is likely to be in rock, a steeper slope may be achievable dependant on the discontinuity distribution and weathered rock horizon. A 5.0m berm may be required at the drift/ rock interface to intercept any drainage requirements.
A filter drain will be required at the toe to draw down the groundwater to below that of the toe of the slope. Crest drainage should be installed in where the surrounding land slopes towards the cutting.
Road pavement is likely to be cohesive Glacial Till.</td></tr>
</table>

*** Embankment defects included as there is known instability adjacent to the southern extent of existing cutting towards the River Coquet which appears to be migrating north.**

Published Geology

Superficial	**Solid**
Glaciofluvial- sand and gravel	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
WSA135	0.62	57.5	-	None	-
WSA135A	0.55	57.55	-	None	-
WSA135B	3.45	57.5		Seepage at 3.45	-
WSA136	2.45	53.8	-	None	-
BH1038	30	55.61	Standpipe piezometer [tip at 29.9, response zone 29 – 30]	Strike at 2.0m, slow inflow	19.57 – 22.56
BH1039	3.65	61.69	-	None	-
BH1039A	15.5	61.69	Vibrating wire piezometers; 1) tip at 5.0 [4.5 – 5.5] and 2) tip at 13.0 [12.5 – 13.5]	Strike 1; 12.7m, no rise after 20 minutes. Strike 2; 12.7m, no rise after 20 minutes. Water rise at 13.95m, no rise after 20 minutes	1) -0.57 – 4.66 2) 9.04 – 15.87
BH1040	15.54	62.02	Vibrating wire piezometers; 1) tip at 5 [4.5 – 5.5] and 2) tip at 14.1 [13.6 – 14.6]	Strike at 14.1, fast inflow. No rise after 20 minutes	1) 3.92 – 4.95 2) 8.17 – 12.34
BH1041	15	61.85	Vibrating wire piezometers; 1) tip at 5.0 [4.5 – 5.5] and 2) tip at 12.2 [11.7 – 12.7]	-	1) 8.17 – 12.34 2) 9.36 – 15.21
BH1042	18	63.29	Vibrating wire piezometers; 1) tip at 5.0 [4.5 – 5.5] and 2) tip at 15.0 [14.5 – 15.5]	-	1) 2.79 – 4.7 2) 11.82 – 16.12
BH27B	15	55.54	-	None	-
BH28	8.65	61.82	-	None	-
BH29	8	62.31	-	None	-
BH30	9	62.38	-	None	-

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH31	9.25	61.81	-	None	-
BH32	12	57.19	-	None	-
TP1300	4.5	62	-	None	-
TP1301	4.5	63.75	-	None	-
WS1524	1	55.31	Standpipe piezometer Tip at 0.9 [0.5 – 1]	None	Dry

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.1-0.3	55.16 – 63.45	0.1 – 0.3	TOPSOIL
Made Ground (recent window samples undertaken through existing cutting)	0.55 - 0.7	53.4 – 57.18	0.32 - 0.55	Roadstone over dark grey brown slightly sandy slightly gravelly clay with occasional cobble sized fragments. Gravel is angular and subangular fine to coarse limestone.
Glacial Till	2.85 – 12.77	46.04 – 59.75	1.95 – 12.77	Predominantly observed as firm to stiff brown slightly sandy slightly gravelly CLAY with occasional cobbles and boulders. Gravel is subangular to subrounded fine to coarse grained of various lithologies, including sandstone, mudstone, coal and quartz. Cobbles and boulders are subangular of sandstone and mudstone. Granular Till also is also encountered interbedded with the cohesive Till (generally <1.0m) as clayey fine to coarse SAND, occasionally sandy GRAVEL, with frequent pockets of clay and some gravel of various lithologies including sandstone, quartzite, quartz, mudstone and coal.
Weathered Mudstone/Siltstone/ Sandstone (residual soil)	8.0 – 15.23	45.19– 54.31	0.15 – 5.5 – 2.26	Very weak to moderately weak MUDSTONE/SILTSTONE recovered as destructured or non-intact; soft to stiff silty sandy gravelly CLAY. Gravel is of mudstone, siltstone or shale. Weathered sandstone observed as very dense very silty SAND with fragments of sandstone.
Mudstone	5.1 >30.0	55.04 - <25.61	0.25 - 4.8	Weak to moderately strong, locally very weak dark grey occasionally brown stained MUDSTONE Discontinuities: 0-20 deg very closely to closely spaced planar smooth clean locally light brown stained. 2) 70-90 deg closely to medium spaced planar and curviplanar smooth clean locally brown stained.
Siltstone (BH1041 and BH27B Only)	7 - 15	40.54 – 48.54	1.55 - 5	Weak to moderately weak dark grey carbonaceous calcareous SILTSTONE with closely spaced discontinuities.
Limestone (BH1038 and BH27B only)	10 – 16.25	43.51 – 45.54	1.0 – 3.6	Moderately weak to strong thinly bedded limestone with several sets of joints and discontinuities.
Sandstone	8.5 - 22.0	33.61 – 53.19	0.5 – 2.92	Moderately weak to strong grey thinly to thickly laminated fine to medium grained interbedded SANDSTONE. Slightly weathered to highly weathered with numerous discontinuities; 1) 0-10 deg closely spaced planar smooth locally rough clean. 2) 70-90 deg closely to medium spaced planar smooth orange brown stained.
Local Ground Variations	**Bedrock –** encountered between 10.3m bgl at the crest of the southern extent of earthwork to 6.3m bgl at the crest of the northern extent of earthwork. **Weathered bedrock** – weathered bedrock material unrelated to the weathered rock horizon immediately below the drift was encountered in BH1038 interbedded within the intact rock. Thicknesses are recorded as between 0.55 – 1.7m at a maximum depth pf 19.8m bgl. The material is described as weak to moderately weak locally very weak dark grey occasionally brown stained MUDSTONE. Destructured and distinctly weathered. Recovered as non intact core.			

Local Ground Variations	**Cohesive Alluvium-** a 0.2m thick layer of cohesive alluvium was encountered in BH1039A, consisting of 'soft greyish brown sandy CLAY with organic debris (Driller's Description). **Undifferentiated mudstone/siltstone/sandstone-** encountered in BH1038, BH1039A and BH1040 at thickness of 2.2 – 3.7m comprising 'moderately strong to strong locally thinly to thickly laminated grey and light grey fine to medium grained SANDSTONE and grey SILTSTONE/ MUDSTONE. **Coal-** Fresh fissile black COAL encountered in BH1039A (6.65m - 6.8m bgl) and BHE (18.77m – 19.07m bgl). In BH1039A recovered as 'slightly gravelly sand, gravel is subrounded fine to medium grained.'

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Glacial Till		Weathered Mudstone/ Siltstone/ Sandstone		Mudstone		Sandstone		Limestone		Undifferentiated Bedrock	
	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 (%)	63	3.2 – 33 (A = 16.4)										
Liquid Limit (%)	14	32 – 46 (A = 37.4)										
Plastic Limit (%)	14	14 – 25 (A = 17.6)										
Plasticity Index (%)	14	13 – 23 (A = 19.0)										
SPT 'N' Value	22	4 – 50 (A = 29.5)	4	>50								
c_u (kN/m^2) Hand Shear Vane	72	42 – 130 (A = 100)										
c_u(kN/m^2) TT	8	0 – 93 (A = 19)										
P/L IS_{50} (MN/m^2)			20	0.02 – 29.6 (A = 4.5)	6	50	12	0–1.11 (A=0.25)	9	0.1–1.11 (A=0.49)	12	0.02 – 4.55 (A = 1.79)
UCS (MPa)			1	5.23	29	0.0 (A=1.55)	1	16.7	1	52.9	1	37.9
Bulk Density (mg/m^3)	24	1.95 – 2.3 (A = 2.1)										
Max Dry Density (mg/m^3)	21	1.48 – 1.94 (A = 1.8)										
MCV	16	3.2 – 14.5 (A = 9.4)										

Summary of Geotechnical Risks

Hazard	Process/ Activity
Ground instability	A number of 1D defects relating to minor historical slips, tension cracks and slope bulges have

	been identified within the existing earthwork which is currently between a 1 in 2.5 and 1 in 3 gradient. Substantial areas of the slope have undergone granular replacement. Excavations in the Glaciofluvial sand and gravels might be unstable. Sand and silt might be frost susceptible. From the 2006 geotechnical report; The cutting section to the north of the River Coquet has been excavated entirely within Glacial Till and required extensive remedial measures during construction to deal with areas of instability. These areas were stabilised through excavation and replacement with coarse granular fill.
High/ Perched Groundwater	Several water strikes in the Glacial Till and bedrock are recorded at shallow depths which will require dewatering during construction and an appropriate drainage design. Extensive water bearing strata in the cutting will require an appropriate drainage design.
Hard Dig	Glacial Till is encountered to relatively shallow depths – cobbles and boulders are anticipated within the Superficial material.
Potentially Contaminated Land	Located in close proximity to a poorly backfilled old quarry.

Last Update: 02/10/2018
Design Revision: Feb 2018

Earthwork Details:

<table>
<tr><th colspan="2" rowspan="2">MAJOR CUTTING
M2FC13</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="2">General Details[1]</td><td>Northbound</td><td>14_A1_42923</td><td>23290</td><td>23600</td><td>12.0</td><td>12.0 – 10.0</td><td colspan="2">62.0 – 56.0</td></tr>
<tr><td>Southbound</td><td>14_A1_42988</td><td>23290</td><td>23600</td><td>12.0</td><td>10.0</td><td colspan="2">61.0 – 56.0</td></tr>
<tr><td rowspan="5">Earthwork Details</td><td rowspan="4">HAGDMS Defects</td><td>Earthwork Classification</td><td colspan="2">Observation No.</td><td colspan="2">Feature</td><td>Class</td><td>Location Index</td></tr>
<tr><td>Cutting (southbound)</td><td colspan="2">520393</td><td colspan="2">Poorly back filled excavation</td><td colspan="2">Minor Observation</td></tr>
<tr><td>Cutting (southbound)</td><td colspan="2">279895</td><td colspan="2">Slip</td><td>1D</td><td>C</td></tr>
<tr><td>Cutting (northbound)</td><td colspan="2">520448</td><td colspan="2">Animal Burrowing</td><td colspan="2">Minor Observation</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="7">Widening of the A1 is adjacent to the southbound carriageway only.
Regrade existing soil slope to 1:3 as the current slope, which is at approximately 1:2.5, looks to have been unstable. Allow an extra 10m beyond the toe of the proposed slope for possible overdig as the laminated clays may be an issue.
A filter drain will be required at the toe to draw down the groundwater to below that of the toe of the slope. Crest drainage should be installed in where the surrounding land slopes towards the cutting.
Road pavement is likely to be founded on Glaciolacustrine deposits and may require some form of improvement.</td></tr>
</table>

Published Geology

Superficial	**Solid**
Predominantly Glaciofluvial Deposits – sand and gravel Glacial Till underlies the earthwork to the northern and southern extents of the earthwork.	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH01/98	12.0	59.31	Standpipe piezometer [tip at 9.3, response zone 6.5 – 9.5]	None	6.24 – 6.28
*BH02/98	6.0	53.55	Standpipe piezometer [tip at 5.5, response zone 4.0 – 6.0]	None	1.90 – 2.13
BH03/98	12.0	59.22	Standpipe piezometer [tip at 4.0, response zone 2.2 – 4.5]	4.5	Dry – 3.88
*BH04/98	6.0	53.89	-	None	-
BH05/98	12.0	59.13	Standpipe piezometer [tip at 11.5, response zone 10.0 – 12.0]	None	5.0 – 7.33
*BH06/98	6.0	54.24	Standpipe piezometer [tip at 4.8, response zone 2.0 – 5.0]	None	1.10 – 1.30
BH1045	10.0	59.0	Standpipe piezometer [tip at 5.30, response zone 4.7 – 5.7]	Water Strike 3.70	3.64 – 4.09
BH35	8.0	49.98	-	Water Strike 2.10	-
BH35A	8.0	58.16	-	Water Strike 3.50	-
BH36	11.0	59.40	-	Water Strike 2.70	-
BH37	10.50	58.92	-	Water Strike 2.50	-
BH38	9.50	59.14	-	Water Strike 2.50	-
*TP01	1.60	53.45	-	None	-
*TP02	2.0	53.87	-	Water Strike 1.80	-
TP03	3.60	59.44	-	None	-

Hole reference	Final Depth (m)	Ground Level	Installation Details [Response Zone]	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring
*TP04	3.50	53.78	-	Seepage at 1.5	-
*TP05	3.0	54.01	-	Seepage at 1.1	-
TP06	3.50	59.40	-	None	-
*TP07	1.50	54.08	-	None	-
*TP08	3.50	54.45	-	Seepage at 2.4	-
TP1306	3.50	58.17	-	None	-
TP1307	4.50	58.79	-	None	-
WS1526	1.30	56.12	Standpipe piezometer [tip at 1.30, response zone 0.8 – 1.3]	None	Dry – 1.50
WS1527	1.30	58.19	Standpipe piezometer [tip at 1.30, response zone 0.8 – 1.3]	None	Dry

** Exploratory holes excavated at existing A1 road level*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.10 – 0.70	49.98 – 59.14	0.10 – 0.70	TOPSOIL. Occasionally grass over TOPSOIL.
Granular Made Ground (largely granular replacement in existing cutting)	0.20 – 2.50	51.55 – 59.11	0.20 – 1.90	MADE GROUND: grey to dark grey occasionally clayey and sandy, coarse angular gravel consisting mainly of dolerite with occasional cobbles and boulders.
Glacial Till	1.7 – 12.0	41.98 – 58.16	0.7 – 10.4	Firm to stiff, grey brown slightly sandy, sometimes silty and gravelly CLAY. Occasionally described as a sandy Silt or described as interbedded or with pockets of medium dense fine to coarse sand/ gravel. Gravel is fine to coarse subangular to subrounded and consists of sandstone, mudstone, limestone and quartz. Cobbles are subangular of sandstone. The clay is described as low to intermediate plasticity.
Glaciolacustrine	>2.6 – 9.5	42.98 - <55.9	>1.1 – 8.8	Soft to firm, sometimes stiff, grey to dark brown thinly to thickly laminated slightly sandy gravelly SILT or CLAY of low to intermediate plasticity. Gravel is subrounded and consists of sandstone, mudstone, dolerite and coal. Frequently interbedded with loose yellow/ brown thinly to thickly laminated silty gravelly fine to medium SAND. Gravel is subrounded of predominantly sandstone.
Possible weathered Sandstone (BH36 Only)	>11.0	<48.4	0.2	Dense brown SAND.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Granular Made Ground		Cohesive Made Ground		Cohesive Glacial Till		Granular Glacial Till		Glaciolacustrine	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	2	2.7 – 8.6	3	20 – 25 (A=23)	54	4.1 – 39 (A=18.7)	-	-	37	0 – 35.9 (A=23.7)
Liquid Limit (%)	-	-	3	30 – 39 (A=35.7)	15	29 – 53 (A=38.)	-	-	13	26 – 48 (A=34.8)
Plastic Limit (%)	-	-	3	17 – 20 (A=18.3)	15	15 – 23 (A=18.6)	-	-	13	17 – 28 (A=21.5)
Plasticity Index (%)	-	-	3	12 – 21 (A=17.3)	15	13 – 32 (A=19.3)	-	-	13	9 – 20 (A=13.3)
SPT 'N' Value	3	0 – 8 (A=5.3)	-	-	7	6 – 25 (A=12.9)	6	5 – 14 (A=8.6)	20	1 – 20 (A=7.3)
c_u (kPa) (hand	-	-	-	-	49	46 – 176 (A=98)	-	-	48	11 – 166 (A=46.7)

Test	Granular Made Ground		Cohesive Made Ground		Cohesive Glacial Till		Granular Glacial Till		Glaciolacustrine	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
vane)										
cu (kPa) (Triaxial)	-	-	-	-	14	17 – 105 (A=76.9)	-	-	6	16 – 72 (A=30)
Φ (Triaxial) (degrees)	-	-	-	-	1	28	-	-	1	32
CBR (%)	-	-	-	-	-	-	-	-	9	Top 0.2-4.6 Bottom 0.2-7.4
MCV	-	-	-	-	12	4.1 – 13.3 (A=8.5)	-	-	2	4.4 – 14.6
Bulk Density (mg/m³)	-	-	-	-	26	1.51 – 2.22 (A=1.9)	-	-	-	-
Max Dry Density (mg/m³)	-	-	-	-	22	1.51 – 2.02 (A=1.8)	-	-	3	1.78 – 1.94 (A=1.9)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Soft ground	Cutting and base of cutting to be predominantly formed and founded through Soft/ loose Glaciolacustrine deposits which may require ground improvement.
Laminated clays	Possible weak planes in material leading to long term slope instability in the deposits. Relatively low material shear strengths may give rise to long term slope stability issues.
Perched/ high groundwater	Several water strikes in the Glacial Till/ Glaciolacustrine deposits are recorded over the proposed location and depth of cutting formation which will require dewatering during construction and an appropriate drainage design.
Existing Slope instability	The existing cutting has been excavated entirely within Glacial Till and Glaciolacustrine deposits and has required extensive remedial measures during construction to deal with known areas of instability. These areas were stabilised through excavation and replacement with coarse granular fill.

Last Update: 17-09-2018
Design Revision: February 2018

Earthwork Details:

<table>
<tr><th colspan="2" rowspan="2">MAJOR EMBANKMENT M2FE01</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="2">General Details[1]</td><td>Northbound</td><td>14_A1_42906</td><td>11680</td><td>11900</td><td>3.4</td><td>2.0 - 3.0</td><td colspan="2">107 - 111</td></tr>
<tr><td>Southbound</td><td>14_A1_42905</td><td>11730</td><td>11900</td><td><1.5</td><td><1.5</td><td colspan="2">106 - 107</td></tr>
<tr><td rowspan="3">Earthwork Details</td><td rowspan="2">HAGDMS Defects</td><td>Earthwork Classification</td><td colspan="2">Observation No.</td><td colspan="2">Feature</td><td>Class</td><td>Location Index</td></tr>
<tr><td colspan="7">No defects noted.</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="7">Widening is adjacent to the northbound carriageway only. Proposed 1:3 soil slope recommended. Max embankment height is at Ch11840Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer.
Minor consolidation is likely to occur in the over consolidated glacial clays.
A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off.
There is an existing Culvert under the A1 at approximate ch11840associated with Shieldhill Burn</td></tr>
</table>

Published Geology

Superficial	Solid
Glacial Till to the southern an northern extents of the earthwork Alluvium – Gravel, Sand and Silt between approximate ch1800 and ch1870	Stainmore Formation– Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BHA1702	0.6	104.93	-	None	-
BHA1702A	0.6	104.9	-	None	-
BHA1702B	8.0	104.9	-	None	-
TP1204	4.5	106.96	-	None	-
WS1502	1.7	105.13	-	None	-
WS1502A	1.6	105.12	Standpipe Piezometer [tip at 1.3, response zone 1 – 1.6]	None	0.39 – 0.99

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3	104.6 – 106.66	0.3	Brown slightly sandy clayey TOPSOIL.
Cohesive Made Ground	0.5 - 0.6	104.3 - 104.62 -	0.3+ - 0.5+	Orange brown mottled grey slightly sandy slightly gravelly CLAY with occasional rootlets. Gravel sized fragments are subangular to subrounded fine to coarse of various lithologies including sandstone, mudstone and quartz. Described as reworked natural ground in BH1702A.
Glacial Till	>1.6 - >8.0	<96.9 – <103.52	>1.1 - >7.7	Firm to stiff grey mottled brown slightly sandy gravelly CLAY with occasional cobbles and boulders. Gravel is subangular to subrounded fine to coarse of sandstone, quartz, limestone, mudstone and occasional coal. Occasional subangular cobbles and boulders of sandstone noted within the south of the area (TP1204).
Local Ground Variations	Exploratory holes that encountered Cohesive Made Ground appear to be in the vicinity of Shieldhill Burn			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Glacial Till	
	No. of tests	Results
Moisture Content (%)	4	17 – 30 (A = 21.5)
Liquid Limit (%)	4	40 – 50 (A = 44)
Plastic Limit (%)	4	18 – 23 (A = 21)
Plasticity Index (%)	4	19 – 27 (A = 23)
SPT 'N' Value	4	17 – 48 (A = 29)
c_u (kPa) (hand shear vane)	9	60 – 130 (A = 96)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Soft Ground	Potentially thin layers of alluvium associated with Shieldhill Burn may be present leading to localised settlement/ differential settlement during embankment construction. Some consolidation likely to occur during embankment construction over the Glacial Till.
Perched Groundwater	Shallow groundwater levels recorded <1.0m bgl
Surface Flooding	Part of the site is situated within an area with an annual risk of up to 1 in 30 of surface flooding. This is associated with Shieldhill Burn

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

MAJOR EMBANKMENT M2FE02		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
General Details[1]	**Northbound**	14_A1_56185 At grade 14_A1_56184 At grade 14_A1_42907 At grade	3480	3790	3.7	2.0 – 3.0	87 - 91
	Southbound	14_A1_42900 Embankment 14_A1_42901 At grade	3480	3790	<1.5	<1.5	86 - 90
Earthwork Details	**HAGDMS Defects**	None recorded					
	Preliminary Earthwork Proposals	• Widening predominantly to the northbound carriageway. The northern extent of the proposed earthwork forms part of the new offline section. • 1:3 proposed soil slope recommended. Dig out and replace any soft spots • Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer. May need granular shoulders for flood protection. • Minor consolidation is likely to occur in the over consolidated glacial clays. • A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off. • There is an existing Culvert under the A1 at approximate ch3660 associated with Floodgate Burn.					

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH1007	10	85.38	Piezometer [tip at 5.0 response zone 4.5 – 5.5]	None	dry – 4.8
TP1219	4.2	86.54	-	None	-
WS1503	1.9	90.63	Piezometer [tip at 1.40 response zone 0.9 – 1.9]	None	dry – 1.10
WS1504	1.5	86.76	Piezometer [tip at 1.50 response zone 0.5 – 1.5]	None	0.08 – 1.04
WS1505	1.8	85.72	-	None	-
WS1506	1.4	85.18	Piezometer [tip at 0.8 response zone 0.4 – 0.9]	0.50	0.44 – 0.81

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.0 – 0.5	85.18 – 90.63	0.2 – 0.5	TOPSOIL
Cohesive Glacial Till	>1.5 - >10.0	<75.38 - <88.73	>1- >9.8	Firm to stiff brown occasionally mottles orange or grey, slightly sandy gravelly CLAY with occasional cobbles. Gravel is subangular to subrounded fine to medium of various lithologies including sandstone, mudstone and occasional limestone and quartz.
Local Ground Variations	**Granular Alluvium;** confined to the exploratory holes excavated in the vicinity of Floodgate Burn: WS1506 from the base of the topsoil to 1.4m bgl described as Brown grey slightly gravelly very clayey fine to coarse SAND with occasional rootlets. Gravel is subangular fine of sandstone.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till	
	No. of tests	Results
Moisture Content (%)	21	6.6 – 27.9 (A = 18.3)
Liquid Limit (%)	7	28 – 36 (A = 31.9)
Plastic Limit (%)	7	14 – 18 (A = 27.1)

Test	Cohesive Glacial Till	
	No. of tests	Results
Plasticity Index (%)	7	9 – 19 (A = 15.5)
SPT 'N' Value	7	12 – 50 (A = 27)
c_u (kPa) (hand shear vane)	18	30 – 130 (A = 101)
c_u (kPa) (Traixial total stess)	1	72
Max Dry Density (Mg/m^3) (2.5kg Compaction)	8	1.51 – 1.84 (A = 1.7)
Bulk Density (Mg/ m^3)	3	1.88 – 2.21 (A = 2.0)
MCV	2	6.6 – 8.4 (A = 7.5)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Hard dig	Occasional cobbles reported in Glacial Till.
Soft Ground	Potentially thin layers of alluvium associated with Floodgate Burn may be present leading to localised settlement/ differential settlement during embankment construction. Potentially loose sand recorded in close proximity to watercourse. Some consolidation likely to occur during embankment construction over the Glacial Till.
Perched Groundwater	Shallow groundwater levels recorded <1.0m bgl
Surface flooding	Part of the site is situated within an area with an annual risk of up to 1 in 30 of surface flooding. This is associated with Floodgate Burn.
Potentially Contaminated Land	Outbuilding historically located under the route at ch3750 – ch3760, route goes over field access track.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

MAJOR EMBANKMENT M2FE03		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	Northbound	N/A – new earthwork	13950	14130	6.7	4.0 – 6.0	80 - 87
	Southbound	N/A – new earthwork	13930	14120	6.7	4.0 – 6.0	80 - 87
	Preliminary Earthwork Proposals	1:3 proposed soil slope recommended within new embankments. Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer. Minor consolidation is likely to occur in the over consolidated glacial clays. More significant settlement will occur where embankment is constructed over alluvium unless this material is removed prior to construction. A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off. There is an existing Culvert under the A1 at approximate ch4040 associated with the River Lyne.					

Published Geology

Superficial	Solid
Glacial Till to the southern and northern extents of the earthwork. Alluvium – Gravel, Sand and Silt between approximate ch4000 and ch4080.	Stainmore Formation– Mudstone, Siltstone and Sandstone.

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BHA1705	9.6	80.01	Standpipe piezometer tip at 8.7 [7 – 9]	8.0m (rising to 2.5 after 20 mins)	0.82 – 2.39
TPA1751 SOAKAWAY	3.5	85.86	-	None	-
BH1009	22.35	80.33	Standpipe piezometer tip at 6.5 [6 – 7]	Strike 1 at 6.8 (rising to 2.5 after 20 mins fast flow noted) Strike 2 at 19.35m (heavy flow noted)	0.67 – 2.73
BH1010	8.8	80.32	Standpipe piezometer tip at 7.5 [7.25 – 8.25]	7.5 (rising to 4.85 after 20 mins fast flow noted)	1.15 – 1.98
TP1220	3.2	85.54	-	None	-
TP1221	4.5	81.05	-	None	-
TP1222	4.5	80.55	-	None	-
TP1225	4.3	85.40	-	None	-
WS1507	2.6	80.27	-	None	-
WS1508	1.3	80.20	Standpipe piezometer tip at 1.2 [0.7 – 1.3]	1.2 (no flow details recorded)	0.76 – 1.23
WS1531	1.3	80.50	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.1 – 0.5	79.83 – 85.14	0.1 – 0.5	Brown slightly sandy clayey TOPSOIL
Alluvium	0.4 - 2	78.32 – 80.65	0.4 – 1.6	Soft to firm brown occasionally dark green occasionally gravelly sandy CLAY with frequent rootlets. Gravel is subangular fine to medium of coal, limestone and sandstone. Occasionally the material is described as a sand or with pockets of fine to medium sands.
Glacial Till	9.5 - 19.35	60.98 – 70.51.	>5.75 - 18.85	Predominantly described as firm to stiff, occasionally very stiff, brownish grey slightly sandy slightly gravelly occasionally very gravelly CLAY with occasional cobbles. The material is occasionally interbedded with thin (0.1m - <0.8m thick) dense to very dense clayey, gravelly sand or sandy gravel. Gravel is subangular to subrounded fine to coarse of coal, limestone, sandstone and quartz with occasional cobbles. Cobbles are subangular to subrounded of limestone, mudstone and

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
				sandstone.
Sandstone (BH1009 and BHA1705 only)	>9.6 - 20.85	59.48 - <70.41	>0.1 - 1.5	Weak to moderately strong light grey fine to medium grained SANDSTONE. Moderately weathered. With extremely closely to closely spaced thin laminations of dark grey mudstone. Discontinuities: 0 – 10 degrees extremely closely to closely space planar smooth with localised orange staining. Recovered as very weak and weak gravel size fragments with occasional sand In BHA1705),
Mudstone (BH1009 only)	>22.35	<57.98	>1.5	Moderately weak to moderately strong dark grey MUDSTONE with very closely to closely spaced thin laminations of light grey fine to medium grained sandstone. Distinctly locally partially weathered.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Alluvium		Glacial Till		Sandstone	
	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	3	27 – 31 (A = 29)	45	11 – 38 (A = 21)	-	-
Liquid Limit (%)	1	33	15	25 – 52 (A = 41)	-	-
Plastic Limit (%)	1	21	15	12 – 27 (A = 18)	-	-
Plasticity Index (%)	1	12	15	12 – 31 (A = 22.7)	-	-
SPT 'N' Value	-	-	14	6 – 50 (A = 24.1)	1	>50
c_u (kPa)	1 (TT)	9	55 (hand shear vane) 5 (TT)	50 – 130 (A = 93.3) 24 – 103 (A = 65.2)	-	-
Bulk Density (mg/m^3)	1	1.85	20	1.93 – 2.7 (A = 2.2)		

Summary of Geotechnical Risks

Hazard	Process/ Activity
Soft ground	Thin layers of alluvium up to 1.5m thick and associated with River Lyne are highly likely be present underlying the proposed route leading to potentially localised settlement during embankment construction and long term differential settlement. The ground is likely to be compressible in this area unless the material is removed prior to construction, Some consolidation likely to occur during embankment construction over the Glacial Till.
Surface Flooding	Part of the embankment is situated within an area with an annual risk of up to 1 in 30 of surface flooding. This is associated with River Lyne. Hydrophilic vegetation is apparent between ch14010 and ch14080.
Perched Groundwater	Perched groundwater may be present within granular lenses within the Glacial Till or at the base of the granular material above the Glacial Till. Shallow groundwater levels have been recorded <1.0m bgl.
Existing Slope instability	Hummocky ground and a slope bulge indicating potentially unstable ground has been detected between the existing A1 alignment and the proposed route – HAGDMS observation: 14_A1_43021_520434. A slope bulge was noted in the field where the embankment is to be constructed.
Hard dig	Evidence of cobbles of strong material encountered during ground investigations.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

MAJOR EMBANKMENT M2FE04		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	**Northbound**	N/A – new earthwork	16810	17300	4.2	2.5 – 3.5	79 - 89
	Southbound	N/A – new earthwork	16810	17290	3.2	2.5 – 3.0	79 - 89
	Preliminary Earthwork Proposals	1:3 proposed soil slope recommended within new embankments. Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer. Minor consolidation is likely to occur in the over consolidated glacial clays. More significant settlement will occur where embankment is constructed over alluvium unless this material is removed prior to construction. A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off. There is an existing Culvert under the A1 at approximate ch16980 associated with the Earsdon Burn.					

Published Geology

Superficial	Solid
Predominantly Glacial Till - Part of the site is drift free	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH1015	20	78.37	Piezometer [1.5 – 4.0, tip at 3.0]	Strike at 1.5, slow rise to 1.4 after 20 mins	0.9 – 1.27
BHA1718	7.0	78.09	Slotted standpipe [0.6 – 1.5]	None	0.84 – 1.17
TPA1713	3.5	88.73	-	None	-
TP1246	3.6	87.22	-	3.6	-
TP1247	3.5	78.36	-	None	-
TP1248	4.5	79.96	-	None	-
TP1249	2.3	79.45	-	None	-
TP1250	4.5	78.31	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 – 0.5	87.77	0.2 – 0.5	-
Alluvium	0.9 – 1.2	77.17 – 77.46	0.6 – 0.8	Soft brown and grey, occasionally mottled or firable slightly sandy gravelly CLAY with occasional rootlets. Gravel is angular to subangular fine to coarse of sandstone, mudstone, coal and quartz. Occasional subangular medium gravel sized fragments of wood. Occasionally interbedded with thin beds of silty fine to coarse SAND containing pockets of clay.
Glacial Till	>2.3 – 14.0	64.37 – <85.23	>1.9 – 12.8	Predominantly firm to stiff light brown and grey mottled slightly sandy slightly gravelly CLAY with occasional cobbles. Occasionally described as thinly laminated or interbedded with brown clayey slightly gravelly fine to coarse SAND. Gravel is angular to subangular fine to coarse of mudstone, sandstone, coal, limestone and quartz.
Sandstone (BH1015 only)	14.97	63.4	0.97	Moderately strong greenish brown fine to medium grained SANDSTONE. Slightly to moderately weathered. With extremely to closely spaced thin laminations of dark grey mudstone. Discontinuities: 1) 0-10 deg extremely closely to very closely spaced planar smooth with localised orange brown staining.
Weathered Mudstone (BH1015 only)	17.0	61.37	2.03	Very weak brown MUDSTONE. Destructured. (Recovered as stiff gravelly clay).
Siltstone (BH1015 only)	17.53	60.84	0.53	Moderately strong to strong dark grey SILTSTONE. Slightly weathered. Discontinuities: 1) 0-10 deg extremely to closely spaced planar smooth.

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Sandstone (BH1015 only)	>20	<58.37	>2.47	Moderately strong greenish grey locally stained orange brown fine to medium grained SANDSTONE. Moderately weathered. With extremely closely to closely spaced thin laminations of dark grey mudstone. Discontinuities: 1) extremely closely to closely spaced planar smooth. 2) 80-90 deg closely to medium spaced planar smooth.
Local Ground Variations	Alluvium is confined to the exploratory holes excavated in the vicinity of Earsdon Burn: BH1015, BHA1718 and TP1247. Bedrock is only encountered in BH1015 due to the relativity shallow excavated depths of the remaining holes.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Alluvium		Glacial Till	
	No. of tests	Results	No. of tests	Results
Moisture Content (%)	1	29	24	10.5 - 48 (A= 19.2)
Liquid Limit (%)	1	42	14	28 - 57 (A = 40.5)
Plastic Limit (%)	1	20	14	14 – 23 (A = 18.9)
Plasticity Index (%)	1	22	14	9 – 34 (A = 21.6)
SPT 'N' Value	6 (from granular alluvium only)	30 – 46 (A =39)	7	7 – 50 (A = 25)
c_u (kPa) (hand shear vane)	3	64 - 62 (A = 57)	40	30 – 130 (A = 79.7)
c_u (kPa) (Traixial)	-	-	2	48 – 56 (A = 52)
Max Dry Density (Mg/m^3) (2.5kg Compaction)	-	-		
Bulk Density (Mg/m^3)	-	-	8	2.22 – 2.36 (A = 2.24)
MCV	-	-		
P/L IS_{50} (MN/m^2)	-	-	-	-
UCS (MPa)	-	-	-	-

Summary of Geotechnical Risks

Hazard	Process/ Activity
Soft ground	Thin layers of predominantly cohesive alluvium between 0.5m - 1.5m thick associated with the Earsdon Burn are shown to be present underlying the proposed route (~ch 17050) leading to potentially localised settlement during embankment construction and long term differential settlement. The ground is likely to be compressible in this area unless the material is removed prior to construction. Some consolidation likely to occur during embankment construction over the Glacial Till.
Surface Flooding	Part of the proposed embankment is situated within an area with an annual risk of up to 1 in 30 of surface flooding. This is associated with Earsdon Burn. Groundwater levels are shallow adjacent to the watercourse.
Hard dig	Evidence of cobbles of strong material encountered during ground investigations.

Last Update: 02-10-2018
Design Revision: February 2018

Earthwork Details:

<table>
<tr><th colspan="2" rowspan="2">MAJOR EMBANKMENT M2FE05</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 rowspan="2">Elevation Range (m OD)</th></tr>
<tr><th>From</th><th>To</th></tr>
<tr><td rowspan="3">General Details[1]</td><td>Northbound</td><td>N/A – new earthwork</td><td>18100</td><td>18430</td><td>3.0</td><td>1.0 – 2.5</td><td>78 - 83</td></tr>
<tr><td>Southbound</td><td>N/A – new earthwork</td><td>18100</td><td>18400</td><td>2.4</td><td>1.0 – 2.0</td><td>78 - 83</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="6">1:3 proposed soil slope recommended within new embankments.
Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer. Minor consolidation is likely to occur in the over consolidated glacial clays.
A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off.</td></tr>
</table>

Published Geology

Superficial	Solid
Glacial Till	Pennine Lower Coal Measures Formation – Mudstone, Siltstone and Sandstone to the northern extent of the earthwork. Stainmore Formation – Mudstone, Siltstone and Sandstone.

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH1022	8	78.56	Slotted standpipe [4 – 6]	-	Dry – 1.36
TPA1720	3.5	79.52	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3	78.26	0.3	TOPSOIL
Granular Glacial Till (TPA1720 Only)	0.9	78.62	0.6	Orangish brown very clayey slightly gravelly fine to coarse SAND. Gravel is fine to medium subangular to subrounded of sandstone, coal, mudstone and slate.
Cohesive Glacial Till	>8.0	<70.56	>7.7	Firm to stiff, becoming very stiff below 4.0m bgl dark brown mottled grey slightly sandy slightly gravelly CLAY. Gravel is subangular to subrounded fine to coarse of various lithologies including sandstone, mudstone and quartz. Cobbles are noted beneath 1.9m bgl and subangular of sandstone.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till	
	No. of tests	Results
Moisture Content (%)	9	6 – 27.9 (A = 11.8)
Liquid Limit (%)	3	30 – 40 (A = 34)
Plastic Limit (%)	3	13 - 17 (A = 15.3)
Plasticity Index (%)	3	16 – 23 (A = 18.6)
SPT 'N' Value	2	13 - 50
c_u (kPa) (hand shear vane)	18	50 – 130 (A = 98.2)
c_u (kPa) (Triaxial)	1	110

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched Groundwater	Shallow groundwater recorded < 1.5m bgl.
Surface Flooding	Annual risk of up to 1 in 1000 from surface water.

Last Update: 02-10-2018
Design Revision: February 2018

Earthwork Details:

MAJOR EMBANKMENT M2FE06		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details	**Northbound**	N/A – new earthwork and 14_A1_43001	19130	20050	5.9	2.0 – 4.0	54 - 64
	Southbound	N/A – new earthwork and 14_A1_43000	19220	19730	5.5	2.0 – 4.0	54 - 64
Earthwork Details	**Preliminary Earthwork Proposals**	The southern extent of the proposed earthwork forms part of the new offline section. Widening predominantly to the northbound carriageway where the earthwork merges with the existing A1. 1:3 proposed soil slope recommended. Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer. Minor consolidation is likely to occur in the over consolidated glacial clays. More significant settlement will occur where embankment is constructed over alluvium unless this material is removed prior to construction. A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off. An overbridge is proposed at 19500, embankment and a Culvert extension at 19980.					

Published Geology

Superficial	Solid
Glacial Till with Alluvium – Gravel, Sand and Silt between approximate ch19920and ch20020	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BHA1733	20	63.18	-	Strike 1 at 2.6 (rose to 2.5 after 20 mins) Strike2 at 4.6 (rose to 3.4 after 20 mins)	-
BHA1735	8.0	53.6	Standpipe piezometer tip at 2.2 [1.5 – 2.6]	2.2	0.47 – 0.9
BH1026	5	66.7	Slotted Standpipe [3 – 4.5]	None	3.5 - 4.15
BH1027	25	64.01	Standpipe piezometer tip to 9.7m [8.5 – 10.5]	None	2.5 – 2.76
BH1028	20	56.75	Standpipe piezometer tip at 10.7 [10.2 – 11.2]	Strike at 6.00 (slow, no rise) Strike at 9.50 (slow, no rise)	0.59 - 4.31
TPA1723	3.5	68.27	-	None	-
TPA1724	3.5	64.21	-	None	-
TPA1726	3.5	61.21	-	None	-
TPA1732 Soakaway	3.5	63.89	-	None	-
TPA1733	3.5	63.18	-	None	-
TP1268	4.5	66.79	-	None	-
TP1269	4.5	67.39	-	None	-
TP1270	4.3	65.67	-	None	-
TP1271	4.5	65.38	-	None	-
TP1272	4.5	65.59	-	None	-
TP1273	3	62.51	-	None	-
TP1274	3	61.55	-	None	-
TP1275	3.4	60.18	-	None	-
TP1276	3	58.85	-	None	-
TP1277	2.5	57.4	-	None	-
TP1278	3.1	56.85	-	None	-
WS1512	2.6	54.17	-	None	-
WS1513	1.8	55.15	-	Strike at 0.2	-

Hole reference	Final Depth (m)	Ground Level	Installation Details [Response Zone]	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring
WS1514	2	53.81	Standpipe piezometer tip at 1.5 [1.0 – 1.5]	None	0.82 – 1.5
WS1515	2.5	52.35	Standpipe piezometer tip at 2.5 [1.0 – 2.5]	None	0.82 – 1.49
WS1528	2	54.11	-	Strike at 1.20	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.1 – 0.4	60.91 – 67.09	0.1 – 0.4	TOPSOIL
Made Ground (BH1028, TP1277 and TP1278 only)	0.20 – 3.9	52.85 – 57.2	0.2 – 3.7	Brown slightly sandy slightly gravelly CLAY/ clayey SAND and GRAVEL. Gravel sized fragments are subangular to subrounded fine to medium of various lithologies including ash, coal, pottery and asphalt/ tar. Occasional strong hydrocarbon odour.
Alluvium	0.7 – 5.6	50.05 – 54.45	0.7 – 2.4	Very soft to soft grey brown sandy, occasionally gravelly, sometimes organic CLAY with occasional rootlets or plant matter interbedded with orange brown clayey gravelly SAND. Gravel is subangular to subrounded fine to coarse of predominantly sandstone.
Glaciolacustrine Deposits	2.50 – 10.10	46. 65 – 62.39	>0.2 – 6.8	Soft to stiff occasionally sandy thinly laminated CLAY found within discrete layers within the Glacial Till. Largest thickness found in BH1028 between 5.6 and 10.1m bgl.
Glacial Till	>1.8 - >20.0	<36.75 - <56.78	>1.1 – >9.9	Firm to stiff grey brown slightly sandy slightly gravelly CLAY with occasional cobbles. Gravel is subangular to subrounded fine to coarse of various lithologies including sandstone, mudstone and quartz. Frequently described as medium dense brown clayey sandy angular to subrounded fine to coarse GRAVEL or fine to coarse clayey SAND of between 0.2 – 2.4m thickness.
Local Ground Variations	Coal at the base of TP1278 – described as dense black COAL with beds of weak weathered mudstone. (Possible Made Ground)			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Made Ground		Alluvium		Glacial Till		Glaciolacustrine Deposits	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	3	21 – 28 (A=24)	8	17 – 32 (A=23.6)	56	11 – 33 (A = 20)	18	19.1 – 28 (A = 24)
Liquid Limit (%)	3	39 – 44 (A = 41	6	29 – 55 (A = 41)	19	23 – 62 (A = 39)	4	30 – 46 (A = 40.8)
Plastic Limit (%)	3	18 – 21 (A = 20)	6	15 – 22 (A = 15)	19	14 – 24 (A = 18.4)	4	15 – 27(A = 20.5)
Plasticity Index (%)	3	18 – 23 (A = 21)	6	NP – 33 (A = 17)	19	NP – 39 (A = 19)	4	15 – 22 (A = 18.5)
SPT 'N' Value	2	9 - 50	2	1 - 7	15	13 – 64 (A = 37)	3	7 – 21(A = 14.5)
c_u (kPa) Hand Shear Vane	21	30 – 110 (A=70.9)	-	-	101	32 – 130 (A = 72)	9	40 – 104 (A= 64)
c_u TT (kPa) Traxial	1	21	-	-	5	38 – 116 (A = 75.6)	2	27 - 39
CBR (%)			-	-	1	Top 3.2 Base 3.5	-	-
Bulk Dry Density (mg/m^3)	1	1.97	-	-	31	1.92 – 2.33 (A = 2.1)	6	2.03 – 2.19 (A = 2.15)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Mine workings (deep)	The earthwork is located within an area of deep coal. The northern section of the earthwork

Hazard	Process/ Activity
	(Chainage 19600+) is an area covered by a coal mining report, available from the Coal Authority.
Laminated clays – soft ground	Glaciolacustrine deposits were observed within numerous exploratory holes in the mid-section of the earthwork (approximate Chainage 19400), generally comprising soft to stiff laminated clays. This may lead to minor settlement where embankments are constructed on this material unless it is removed prior to construction.
Perched Groundwater	Shallow groundwater levels recorded <1.0m bgl.
Hard dig	Glacial Till, comprising cobbles and boulders were encountered in exploratory holes at relatively shallow depth. Impenetrable ground noted in TP1273 at 3.0m (cobbles and boulders) Unsuitable for hand vanes in clay at some locations due to gravel/ cobble content of ground.
Slope stability	Pit sides noted to be unstable in several of the trial pits.
Flooding	1 in 100 chance of annual flooding from surface water directly underlying the route associated with the floodplain of Longdike Burn.
Potentially Contaminated Land	Fine to coarse gravel sized fragments of ash and Gravel sized fragments are fine to coarse angular to subangular of sandstone, coal, pottery and asphalt/tar. Strong hydrocarbon odour. Recorded in the Made Ground indicated to be up to ~4.0m bgl adjacent to the northern extent of the earthwork.

Last Update: 02/10/2018
Design Revision: February 2018

Earthwork Details:

<table>
<tr><th colspan="2" rowspan="2">MAJOR EMBANKMENT M2FE07</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="2">General Details[1]</td><td>Northbound</td><td>14_A1_42924 Embankment</td><td>23070</td><td>23250</td><td>13.0</td><td>5.0 – 10.0</td><td colspan="2">106.0 – 110.0</td></tr>
<tr><td>Southbound</td><td>14_A1_42987 Embankment</td><td>23070</td><td>23270</td><td>8.0</td><td>2.0 – 5.0</td><td colspan="2">106.0 – 110.0</td></tr>
<tr><td rowspan="4">Earthwork Details</td><td rowspan="3">HAGDMS Defects</td><td>Earthwork Classification</td><td colspan="2">Observation No.</td><td colspan="2">Feature</td><td>Class</td><td>Location Index</td></tr>
<tr><td>Embankment</td><td colspan="2"></td><td colspan="2">Subsidence; possible slight settlement at crest with over steep uneven slope and possible bulge at toe. Trees are vertical so probably natural geometry or settlement post construction. Very slight rotation of barrier in places.</td><td>1D</td><td>C</td></tr>
<tr><td>14_A1_42987 Embankment</td><td colspan="2"></td><td colspan="2">Slight settlement at crest with slope bulge below.</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="7">Widening is adjacent to the southbound carriageway only. Proposed 1:3 soil slope is recommended with an extra 20m beyond the toe of the embankment to allow for any issues associated with the underlying mass movement deposits, irregular topography and traversing culvert.
Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer.
A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off.
There is a subway (structure ID 1408) under the A1 at approximate ch13090 and an existing culvert (100m) at ch13145 associated with an unnamed watercourse.</td></tr>
</table>

Published Geology

Superficial	Solid
Predominantly underlain by unmapped landslide deposits (Debris slides of rock and soil, including mud flows) with Glacial Till underlying the northern extents of the earthwork and Glaciofluvial sands and gravels at the southern extent.	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BHA1742	7.0	49.24	Slotted standpipe [2.5 – 3.5]	Strike at 3.2 rose to 3.0 after 20 minutes	2.68 – 3.0
BH1043	3.1	47.24	Standpipe installed to 2.9 [2.4 – 3.1]	Strike at 2.5. No rise after 20 minutes	0 – 1.88
BH1044	16.9	53.55	Standpipe installed to 15 [14.5 – 15.5]	Strike at 16.5. No rise after 20 minutes	11.43 – 13.29
*BH33	4.8	43.18	-	-	-
*BH33A	5	38.2	-	-	-
*BH34	8	41	-	-	-
*BH35	8	49.98	-	-	-
*BH35A	8	58.16	-	-	-
TP1302	3	41.51	-	-	-
TP1303	2.5	40.91	-	-	-
TP1304	3.5	46.63	-	-	-
TP1305	4.5	49.12	-	-	-
WS1526	1.3	56.12	Standpipe Piezometer tip at 1.30 [0.8 – 1.3]	-	-
WS1529	1.3	39.74	-	-	-

** Excavated prior to road construction*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.1-0.4	40.1 – 57.76	0.1 – 0.4	Topsoil
Cohesive Made Ground	0.4 – 16.2	37.05 – 48.72	0.4 – 16.2	Dark brown/ grey sandy slightly gravelly clay. Gravel sized fragments are subangular to subrounded fine to coarse of various lithologies including sandstone, mudstone and quartz. Cobble sized fragments are subrounded of sandstone.
Granular Made Ground (BH1043 Only)	3.1	44.14	0.95 - 1.7	Dark grey/ brown slightly sandy very clayey fine to coarse gravel sized fragments of mudstone, sandstone, clinker and ash with occasional cobble sized fragments. Cobble sized fragments are subangular of sandstone.
[1]Glaciolacustrine deposits	3.1 – 7.0	34.5–51.36	1.5 – 6.9	Soft to firm occasionally laminated sandy clayey SILT/ silty CLAY with some fine to medium gravel. Occasionally described as loose silty organic SAND.
Glacial Till	2 – 8.0	33.5 – 54.56	1.0 – 4.1	Generally observed as firm to stiff silty sandy CLAY with some fine to medium gravel and occasional cobbles. Gravel is subangular fine to medium of sandstone, mudstone and coal. Cobbles are subangular of sandstone. Pockets of peat were noted. Some granular material was encountered comprising clayey gravelly fine to coarse SAND/clayey very sandy GRAVEL. Gravel of various lithologies including sandstone, mudstone and quartzite.
Weathered siltstone/ Sandstone	2.0 – 3.0 (emb toe) 16.9 (emb crest)	35.2 - 36.65	0.4 - 3.0	Very dense brown fine to medium silty clayey SAND.
Sandstone	>3.0 - >8.0	<33 – <40.18	>0.5	Weak light brown fine to coarse grained SANDSTONE. Sometimes recovered as slightly gravelly sand.
Local Ground Variations	Maximum embankment height recorded as ~13.0m. BH1044 indicates Made Ground up to 16.2m bgl. No other recent holes go through the full thickness of embankment material. Made ground only encountered in some of the recent exploratory holes excavated after the Felton bypass was constructed. Granular Made Ground only encountered in BH1043 excavated directly adjacent to Parkwood Subway. [1]Glaciolacustrine deposits only found in some of the exploratory holes excavated prior to the embankment construction.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Made Ground		Granular Made Ground		Glacial Till		Glaciolacustrine deposits		Sandstone	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	28	11 – 29 (A = 17.3)	1	15	26	4.1 – 39 (A = 20.2)	-	-	-	-
Liquid Limit (%)	10	25 – 42 (A = 35.2)	1	35	8	26 – 48 (37)	-	-	-	-
Plastic Limit (%)	10	NP – 23 (A = 14.2)	1	15	8	15 – 24 (A = 20)	-	-	-	-
Plasticity Index (%)	10	NP – 22 (A = 15.8)	1	20	8	9 – 125 (A = 17.0)	-	-	-	-
SPT 'N' Value	6	10 – 50 (A = 34.6)	3	7 – 50 (A = 35.6)	4	5 – 11 (A = 7.5)	1	4	2	50 - 62
c_u (kPa) Hand Shear Vane	16	20 – 130 (A = 65.6)	-	-	36	60 – 130 (A = 97)	-	-	-	-
Cu (kPa) TT	4	0 – 160 (A = 50)	-	-	-	-	-	-	-	-

Test	Cohesive Made Ground		Granular Made Ground		Glacial Till		Glaciolacustrine deposits		Sandstone	
	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results	No. of tests	Results
UCS (MPa)	-	-	-	-	-	-	-	-	1	16.7
MCV	-	-	-	-	5	4.1 – 10 (A = 6.76)	-	-	-	-
Max Dry Density (mg/m^3)	-	-	-	-	12	1.51 – 1.84 (A = 1.7)	-	-	-	-
Bulk Density (mg/m^3)	13	2.06 – 2.19 (A - = 2.12)	-	-	5	1.95 – 2.07 (A = 2.0)	-	-	-	-

Summary of Geotechnical Risks

Hazard	Process/ Activity
Soft ground	Soft Glaciolacustrine deposits encountered in BH34 and BH35 although none encountered in the recent exploratory holes. Minor consolidation is likely to occur in the over consolidated glacial clays and possibly in the underlying mass movement deposits which are likely to highly variable.
Existing Slope instability	Evidence of historical slips and subsidence observed at the existing embankment during past earthwork inspections and the embankment itself is founded on potential landslide deposits. Notes from historical reports as follows; At the extreme north of the proposed scheme lies the existing A1 crosses the park wood valley on a 13m high embankment. The side slopes of this embankment are constructed at 1(v):3(h) and show only minor signs of shallow instability to the north east of the park wood subway. BH1044 located at the crest of the existing a1 embankment to the north of Parkwood subway proved the embankment to be constructed from reworked cohesive till with sandstone cobbles and boulders. Possible sandstone bedrock was encountered at 16.9m depth (36.65m AOD). TP's 1302 and 1303 were thought to have terminated on bedrock at an approximate level of 38.5m AOD although the draft logs do not indicate this. Bedrock was proven approximately 100m to the south of the subway in BH's 1041 and 1042 at a level of approximately 50.5m AOD.

Last Update: 18/04/2018
Design Revision: February 2018

Earthwork Details:

<table>
<tr><td colspan="2">At GRADE M2FG01</td><td>HAGDMS Reference</td><td colspan="2">Chainage</td><td>Max Slope Height (m)</td><td>Typical Slope Height (m)</td><td colspan="2">Elevation Range (m OD)</td></tr>
<tr><td colspan="2"></td><td></td><td>From</td><td>To</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="2">General Details[1]</td><td>Northbound</td><td>14_A1_14488 Cutting
14_A1_14569 Cutting
14_A1_42906 At grade</td><td>10800</td><td>11080</td><td>-</td><td>-</td><td colspan="2">89 – 98.5</td></tr>
<tr><td>Southbound</td><td>14_A1_14573 Embankment
14_A1_56203 At grade
14_A1_42905 At grade</td><td>10800</td><td>11110</td><td>-</td><td>-</td><td colspan="2">89 - 93</td></tr>
<tr><td rowspan="4">Earthwork Details</td><td rowspan="3">HAGDMS Defects</td><td>Earthwork Classification</td><td colspan="2">Observation No.</td><td colspan="2">Feature</td><td>Class</td><td>Location Index</td></tr>
<tr><td>Cutting</td><td colspan="2">14_A1_14488_574141</td><td colspan="2">Small creep next to bridge abutment at toe. Burrow at end. Slight slope bulge at toe.</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Embankment</td><td colspan="2">14_A1_14573_574143</td><td colspan="2">Slight bulge at toe.</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="7">Proposed 1:3 soil slope recommended where applicable. Earthworks will largely be unaltered.
Warrens House Overbridge is located at Ch. 10870 (structure ID 56305)
Possible regrade to existing cutting at Ch10900 (north of warrens house overbridge). Max height 5.7m.</td></tr>
</table>

Published Geology

Superficial	**Solid**
Made Ground	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH11A (W1)	6.1	92.32	-	Strike at 5.65	-
BH11B (W2)	6.1	92.2	-	Strike 1 at 0.9 Strike 2 at 5.5	-
BH11C (W3)	7.62	91.17	-	Strike at 6.5	-
BH11D (W4)	6.4	91.47	-	None	-
TP1201	4.4	95.63	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.4 - 0.90	90.56 – 95.23	0.4 - 0.90	Topsoil.
Cohesive Glacial Till	> 4.4 - 5.94	91.17 – <95.63	4.0 – 4.88	Firm to stiff dark brown slightly sandy slightly gravelly CLAY/ Boulder CLAY.
Weathered Mudstone	>6.1 - >7.62	<91.17 - <92.32	>0.46 - >1.68	Stiff grey silty clay and SHALE.
Local Ground Variations	**Made Ground**: encountered between 0.0 – 1.1m bgl in BH11C			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till	
	No. of tests	Results
Moisture Content (%)	18	5.3 – 21 (A = 16.4)
Liquid Limit (%)	2	46 – 48
Plastic Limit (%)	2	19
Plasticity Index (%)	2	27 – 29
c_u (kPa)	9	70 – 130 (A = 102)

Test	Cohesive Glacial Till	
	No. of tests	Results
Hand Vane		
CBR (%)	1	Top 2.6 Base 4.7
MCV	5	5.3 – 9.9 (A = 7.6)
Max Dry Density (mg/m3)	11	1.7 – 1.9 (A = 1.79)
Bulk Density (mg/m3)	5	1.94 – 2.08 (A = 2.0)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched/ high Groundwater	Water strikes recorded within 1.0m of ground level during the historical GI.
Existing Slope instability	Existing known defects recorded adjacent to Warrens House Overbridge potentially exacerbated by earthwork modifications. Possible historic slip features across embankment adjacent to A697 southbound slip over ~10m length.
Hard dig	Cobbles and boulders noted in the Glacial Till.

Last Update: 17-09-2018
Design Revision: February 2018

Earthwork Details:

<table>
<tr><th colspan="2" rowspan="2">AT GRADE
M2FG02</th><th rowspan="2">HAGDMS Reference</th><th colspan="2">Chainage</th><th rowspan="2" colspan="2">Max Slope Height (m)</th><th rowspan="2">Typical Slope Height (m)</th><th rowspan="2" colspan="2">Elevation Range (m OD)</th></tr>
<tr><th>From</th><th>To</th></tr>
<tr><td rowspan="2">General Details[1]</td><td>Northbound</td><td>14_A1_42906
At grade</td><td>11100</td><td>11260</td><td colspan="2">-</td><td>-</td><td colspan="2">95 - 97</td></tr>
<tr><td>Southbound</td><td>14_A1_42905
At grade</td><td>11105</td><td>11260</td><td colspan="2">-</td><td>-</td><td colspan="2">96 -97</td></tr>
<tr><td rowspan="3">Earthwork Details</td><td rowspan="2">HAGDMS Defects</td><td>Earthwork Classification</td><td colspan="2">Observation No.</td><td colspan="3">Feature</td><td>Class</td><td>Location Index</td></tr>
<tr><td colspan="8">None Recorded.</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="8">Widening is adjacent to the northbound carriageway only. Proposed 1:3 soil slope recommended.
Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer.
Minor consolidation is likely to occur in the over consolidated glacial clays.
A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off.</td></tr>
</table>

Published Geology

Superficial	**Solid**
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
WS1501	1.8	97.8	-	None	-
TP1201	4.4	95.6	-	None	
*TP1202	4.5	103.3	-	None	-
TPA1749_SOAKAWAY	3.5	97.01	-	None	-
TPA1748_SOAKAWAY	3.5	95.91	-	None	-

** off set 25m north of northern extent of earthwork*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 – 0.4	95.63 – 103.3	0.2 – 0.4	Dark brown slightly sandy clayey TOPSOIL.
Cohesive Glacial Till	>1.8 - >4.5	<91.23 - <98.8	1.4 – 4.2	Firm to very stiff grey brown slightly sandy gravelly CLAY with occasional cobbles and boulders. Gravel is angular to subrounded fine to coarse sandstone, siltstone mudstone, limestone, quartz and coal. Cobbles and boulders are subangular of sandstone.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till	
	No. of tests	Results
Moisture Content (%)	20	5.3 – 21 (A = 16.6)
Liquid Limit (%)	4	41 – 48 (A = 44.5)
Plastic Limit (%)	4	18 – 19 (A = 18.8)
Plasticity Index (%)	4	22 – 29 (A = 25.8)
Peak c_u (kN/m^2) hand shear vane	18	70 – 120 (A = 102.6)
CBR (%)	1	Top 2.6 Bottom 4.7
MCV	5	6.6 – 8.4 (A = 7.62)
Max Dry Density (mg/m^3)	11	1.7 – 1.93 (A = 1.79)
Bulk Dry Density (mg/m^3)	5	1.94 – 2.08 (A = 2.0

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched Groundwater	Potential for perched groundwater due to the low permeability of the Glacial Till. No groundwater encountered within the exploratory holes.
Hard dig	Glacial Till comprising cobbles and boulders was encountered at relatively shallow depth.

Last Update: 17-09-2018
Design Revision: February 2018

Earthwork Details:

AT GRADE M2FG03		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
General Details[1]	**Northbound**	14_A1_42906 At grade	11555	11670	-	-	107 - 108
	Southbound	14_A1_42905 At grade	11555	11670	-	-	107 - 108
Earthwork Details	**HAGDMS Defects**	Earthwork Classification	Observation No.		Feature		Class / Location Index
		None Recorded					
	Preliminary Earthwork Proposals	• Widening of the A1 is adjacent to the northbound carriageway only. • North bound and southbound carriageways separated by 1 in 2 slope up to 1.0m high • Proposed soil slope regrade 1:3 recommended in cohesive Glacial Till. • A filter drain may be required to draw down the groundwater to below that of the toe of the slope. • Road pavement will be founded on the cohesive Glacial Till. • Material reuse; Glacial Till class 2					

Published Geology

Superficial	**Solid**
Glacial Till-Diamicton	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH1001	21	106.81	Standpipe piezometer installed with tip at 4.5 [4 – 5]	None	1.12 – 1.83
TP1204 (~15m offset of northern extent)	4.5	106.96	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3	106.51	0.3	Topsoil
Cohesive Glacial Till	17	89.81	14	Very soft to very firm dark brown to mottled grey slightly sandy slightly gravelly CLAY with occasional cobbles. Gravel is of subangular fine to coarse sandstone, limestone and mudstone. Cobbles are of sandstone.
Sandstone	>21	<85.81	>2	Moderately strong fine to coarse grained SANDSTONE. Slightly to moderately weathered with discontinuities.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till		Sandstone	
	No. of tests	Results	No. of tests	Results
Moisture Content (%)	19	6.6 – 30 (A = 19.7		
Liquid Limit (%)	2	40 – 50		
Plastic Limit (%)	2	19 – 23		
Plasticity Index (%)	2	21 – 27		
MCV	2	6.6 – 8.4		
c_u (kPa) Hand Shear Vane	9	9 – 130 (A = 96)		
Max Dry Density (mg/m^3)	15	1.55 – 1.91 (A = 1.7)		

Test	Cohesive Glacial Till		Sandstone	
	No. of tests	Results	No. of tests	Results
Bulk Density (mg/m^3)	2	1.88 – 1.94		
UCS (MPa)			1	16.7

Summary of Geotechnical Risks

Hazard	Process/ Activity
Hard dig	Glacial Till is encountered at relatively shallow depths- cobbles are encountered within the glacial till. Base of cutting will be within the Glacial Till.
Perched/ shallow Groundwater	Low permeability glacial till deposits may give rise to perched water. Water recorded in the Till at 1.12m bgl which may require dewatering during construction and an appropriate drainage design.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

<table>
<tr><th colspan="2" rowspan="2">AT GRADE
M2FG04</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[1]</td><td>Northbound</td><td>14_A1_42904
At grade</td><td>12290</td><td>13270</td><td>-</td><td>-</td><td colspan="2">109 - 111</td></tr>
<tr><td rowspan="2">Southbound</td><td>14_A1_42902
At grade</td><td rowspan="2">12290</td><td rowspan="2">13220</td><td rowspan="2">-</td><td rowspan="2">-</td><td colspan="2" rowspan="2">110 - 112</td></tr>
<tr><td>14_A1_42903
At grade</td></tr>
<tr><td rowspan="3">Earthwork Details</td><td rowspan="2">HAGDMS Defects</td><td>Earthwork Classification</td><td colspan="2">Observation No.</td><td colspan="2">Feature</td><td>Class</td><td>Location Index</td></tr>
<tr><td colspan="7">None Recorded</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="7">Proposed 1:3 soil slope recommended where applicable. Earthworks adjacent to the southbound carriageway will largely be unaltered. Widening is primarily adjacent to the northbound carriageway which is predominantly on embankment.
Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer.
Minor consolidation is likely to occur in the over consolidated glacial clays.
A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off.</td></tr>
</table>

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
TP1215	1.6	106.85	-	None	-
TP1216	3.2	101.93	-	None	
BH1005	3.1	109.24	Slotted Standpipe [3.1 – 1.5]	None	1.95 – 3.1
BH1005A	2.9	109.22	-	None	-
BH1006	5.0	97.77	Standpipe piezometer tip at 4.5 [4.0 – 5.0]	None	1.06 – dry
TP1214	2.8	110.63	-	None	-
TP1213	4.0	110.64	-	None	-
TP1212	4.3	109.6	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3 - 0.4	97.47 – 110.34	0.3 - 0.4	TOPSOIL
Cohesive Glacial Till	1.4 – >5.0	92.77 – 107.93	1 – >4.7	Firm to stiff brown mottled grey slightly sandy, slightly gravelly CLAY with occasional cobbles and boulders. Gravel is subangular fine to medium of sandstone, mudstone, coal and limestone.
Sandstone/ Weathered Sandstone	>1.6 - >4.3	<98.73 - <107.83	>0.4	Yellow/ brown fine to coarse SANDSTONE. Recovered as subangular to tabular fine to coarse gravel or cobbles.
Local Ground Variations	**Bedrock** generally encountered between 105.5m OD and 108m OD at the southern extent and less than 93.0M OD at the northern extent.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till		Sandstone	
	No. of tests	Results	No. of tests	Results
Moisture Content (%)	60	8 - 31 (A = 18.4)		
Liquid Limit (%)	14	25 – 55 (A = 39.4)		
Plastic Limit (%)	14	16 – 27 (A = 18.9)		

Test	Cohesive Glacial Till		Sandstone	
	No. of tests	Results	No. of tests	Results
Plasticity Index (%)	9	7 – 33 (A = 20.6)		
SPT 'N' Value	3	10 – 50 (A = 36.7)	2	50
CBR (%)	2	Top 0.2 – 5.4 Bottom 0.23 – 0.74		
MV (m^2/MN)	4	0.12 – 0.19		
c_u (kPa) Hand shear vane	63	30 – 130 (A = 92.5)		
c_u (kPa) Triaxial	3	58 – 117 (A = 84.3)		
MCV	7	0 – 11.4 (A = 5.27)		
Max Dry Density (mg/m^3)	24	1.64 – 2.01 (A = 1.82)		
Bulk Density (mg/m^3)	13	1.99 – 2.18 (A = 2.05)		

Summary of Geotechnical Risks

Hazard	Process/ Activity
Soft ground	0.5m thick alluvial deposits were encountered in BH1005A consisting of sandy CLAY.
Perched/ high groundwater	There is potential for perched groundwater within the low permeability material of the Glacial Till. Multiple strikes of groundwater within some exploratory holes and groundwater recorded within 1.0m of ground level. Some parts of the route are recorded as within an area with an annual risk of up to 1 in 30 of surface flooding.
Hard dig	Cobbles encountered within the granular Glacial Till in TP1215 between 1.4m and 1.6m bgl may impact on works.
Potentially Contaminated Land	Open cast sandstone mining recorded 120m east of the proposed route at Ch.12800 within the red line boundary.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

AT GRADE M2FG05		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
General Details[1]	Northbound	14_A1_42904 At grade 14_A1_56185 At grade	13270	13485	-	-	110 -111
	Southbound	14_A1_42903 At grade 14_A1_42900 Embankment	13270	13485	-	-	110 -111
Earthwork Details	HAGDMS Defects	Earthwork Classification	Observation No.		Feature	Class	Location Index
		None Recorded					
	Preliminary Earthwork Proposals	Widening of the A1 is predominantly adjacent to the northbound carriageway. Regrade existing soil slope to 1:3 in the cohesive Glacial Till. A filter drain may be required at the toe to draw down the groundwater to below that of the toe of the slope. Road pavement is likely to be founded on cohesive Glacial Till. Material reuse; Glacial Till class 2					

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
*BH1006	5	97.77	Standpipe Piezometer installed with tip to 4.5m	None	Dry – 3.98
TP1217	4	92.76	-	None	-
WS1503	1.9	90.63	Standpipe piezometer installed with tip to 1.4m	None	Dry – 1.1

**off set 40m south of southern extent of earthwork*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 – 0.4	90.2-97.5	0.2 – 0.4	Topsoil
Cohesive Glacial Till	>5	<88.73	>4.7	Firm to stiff brown grey slightly sandy slightly gravelly CLAY with occasional cobbles and boulders. Gravel is subangular to subrounded of sandstone, mudstone, coal and limestone. Cobbles and boulders are subangular of sandstone.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till	
	No. of tests	Results
Moisture Content (%)	23	6.6 – 31 (A = 20.7)
Liquid Limit (%)	5	30 – 56 (A = 40)
Plastic Limit (%)	5	15 – 23 (A = 18.8)
Plasticity Index (%)	5	13 – 33 (A = 21)
MV (m2/MN)	4	0.11 – 0.19
SPT 'N' Value	2	50
c_u (kN/m^2)	21	30 – 130 (A=102)
c_u TT (kN/M^2)	2	58 – 117
MCV	2	6.6 – 8.4
Max Dry Density (mg/m^3)	8	1.51 – 1.84 (A = 1.69)
Bulk Density (mg/m^3)	9	1.88 – 2.25 (A = 2.03)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Hard dig	Glacial Till encountered at relatively shallow depths. Cobbles and boulders encountered within the Glacial Till
Potentially Contaminated Land	Material to be excavated within and adjacent to an existing side road and spoil heap at ch13290.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

At Grade M2FG06		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	**Northbound**	N/A – new earthwork	15050	15420	-	-	89.5 - 91
	Southbound	N/A – new earthwork	15050	15440	-	-	89.5 - 91
Earthwork Details	**Preliminary Earthwork Proposals**	Proposed 1:3 soil slope recommended. A filter drain will be required at the earthwork toe to draw down the groundwater to below that of the toe of the slope. Crest drainage should be installed in where the surrounding land slopes towards the cutting. The existing field drain associated with Fenrother Burn will be cut by the earthwork and should therefore be intercepted by collector drains. Road pavement will be founded on the cohesive Glacial Till.					

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
TP1235	2	90.09	-	2.0 (rapid inflow)	-
TP1236	2	90.41	-	2.0 (rapid inflow)	-
WS1509	1.8	91.20	Standpipe Piezometer tip at 1.5. [0.9 – 1.8]	1.2 (no flow details recorded)	Dry – 0.48
BHA1710	6.0	90.34	Standpipe [3.5 – 5.5]	5.4 (no rise after 20 mins)	1.5 – 1.87
TPA1737	3.3	90.49	-	None	-
TPA1705	3.5	91.01	-	2.1 (no flow details recorded)	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 – 0.35	89.89 – 91.0	0.2 – 0.35	TOPSOIL
Alluvium	0.3 – 1.4	89.14 – 90.71	0.85 – 1.2	Soft to firm brown slightly sandy slightly gravelly CLAY with occasional pockets of fine to medium sand. Gravel is subangular to subrounded fine to medium sandstone. Occasionally described as dark brown clayey fine to coarse SAND.
Glaciolacustrine deposits (only BHA1710)	2.20	88.14	0.70	Firm brown thinly laminated CLAY.
Glacial Till	>1.80 - >6.0	<89.4 - <84.34	>0.4 - >4.8	Firm to to stiff, occasionally soft slightly sandy slightly gravelly CLAY with occasional cobbles and boulders. Gravel is fine to coarse of various lithologies, including sandstone, mudstone quartz and occasional coal. Cobbles and boulders are of sandstone and mudstone. Occasionally described as grey clayey sandy subangular to subrounded fine to coarse GRAVEL of various lithologies or brown slightly silty fine and medium SAND of strata 0.1 – 0.5m thickness.
Local Ground Variations	**Made Ground** - encountered within TPA1737 between 0.0 – 0.3m bgl described as soft dark brown sandy slightly gravelly CLAY. Gravel is fine to coarse subangular to subrounded including sandstone and coal, with fragments of glass, ceramics and brick.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Alluvium		Glaciolacustrine		Cohesive Glacial Till	
	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	1	24	2	14.2 – 25.5	20	5 – 31 (A = 18.4)
Liquid Limit (%)	1	32	1	59	14	29 – 55 (A = 38.7)
Plastic Limit (%)	1	16	1	27	14	14 – 26 (A = 19.9)
Plasticity Index (%)	1	16	1	32	14	10 – 30 (A = 18.8)
SPT 'N' Value	-	-	-	-	3	12 – 13 (A = 12.7)
c_u (kPa) Hand shear vane	-	-	-	-	9	53 – 130 (A = 84.9)
c_u (kPa) Triaxial	-	-	1	52	1	65
CBR (%)	1	Top 0.34 Base 0.34	-	-	3	Top 1.3 – 4.3 Base 1.3 – 5.1
Max Dry Density (Mg/m^3)	-	-	-	-	5	1.73 – 1.87 (A = 1.81)
Bulk Density (Mg/m^3)	-	-	1	2.12	1	2.03

Summary of Geotechnical Risks

Hazard	Process/ Activity
Soft ground	Cohesive alluvial and glaciolacustrine deposits generally described as soft were encountered within BHA1710 between 0.35m and 2.2m bgl. These localised deposits associated with the tributary of Fenrother burn, which runs parallel to the east of the proposed alignment, may give rise to differential settlement.
Perched/ high Groundwater	The low permeability deposits may give rise to potential perched groundwater, which may cause issues for construction. Groundwater is shown to be relatively shallow.
Flooding	1 in 30 chance of annual flooding from surface water directly underlying the route between Ch15190 – Ch15310. Rapid inflow of water in to trial pits at relatively shallow depths. A land drain was encountered at 0.7m bgl in TP1235.
Hard dig	Cobbles and boulders were encountered within the Glacial Till of the exploratory holes between depths of 1.4m and in excess of 6m bgl. This hard dig may cause issues for plant during excavation.
Slope stability	Collapse of trial pit sides during excavation noted on the exploratory logs, particularly when groundwater is encountered. Laminated clays encountered between 1.5m and 2.2m bgl within BHA1710. Comprising Firm brown thinly laminated CLAY.
Potentially Contaminated Land	Fragments of glass, ceramics and brick encountered in TPA1737 as shallow depths.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

At Grade M2FG07		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
General Details[1]	**Northbound**	N/A – new earthwork	15400	15525	-	-	90.5 - 92
	Southbound	N/A – new earthwork	15400	15525	-	-	90.5 - 92
Earthwork Details	**Preliminary Earthwork Proposals**	1:3 proposed soil slope recommended within new embankments. Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer. Minor consolidation is likely to occur in the over consolidated glacial clays. More significant settlement will occur where embankment is constructed over alluvium unless this material is removed prior to construction. A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off. There is an existing land drain associated with Fenrother Burn at the southern extent of the earthwork.					

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
WS1509	1.8	91.2	Standpipe piezometer installed to 1.5m bgl. [0.9 – 1.8]	Strike at 1.2m bgl	Dry – 0.48
TP1237	3.3	91.64	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 - 0.3	91 – 91.34	0.2 – 0.3	TOPSOIL.
Possible Alluvium (WS1509 only)	1.4	89.8	1.2	Dark brown mottled grey clayey fine to coarse SAND.
Glacial Till	1.8 - >2.6	89.04 – 89.4	0.4 - >2.3	Firm to stiff mottled dark brown/ grey sandy gravelly CLAY. Gravel is subangular fine to medium of limestone, mudstone, coal and sandstone.
Possible weathered Mudstone (WS1509 only)	>3.3	<88.34	>0.7	Grey clayey sandy angular and tabular fine to coarse GRAVEL of mudstone with occasional subangular cobbles and boulders of mudstone.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Glacial Till	
	No. of tests	Results
Moisture Content (%)	3	24 – 31 (A = 27.7)
Liquid Limit (%)	3	35 – 48 (A = 41.3)
Plastic Limit (%)	3	19 – 26 (A= 22)
Plasticity Index (%)	3	16 – 22 (A = 19.3)
c_u (kPa) Hand shear Vane	9	45 – 92 (75.1)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Soft ground	Alluvial deposits associated with the tributary of Fenrother burn which runs parallel to the east of the proposed alignment, may give rise to differential settlement.
Perched/ high Groundwater	The low permeability deposits may give rise to potential perched groundwater, which may cause issues for construction. Groundwater is shown to be relatively shallow.
Flooding	1 in 30 chance of annual flooding from surface water directly underlying the route. Exploratory holes to the south indicated rapid inflow of water in to trial pits at relatively shallow depths. The

Hazard	Process/ Activity
	earthworks fall within a topographic depression which is likely to affected by flooding from tributaries of Fernother Burn.
Hard dig	Cobbles and boulders were encountered within the Glacial Till of the exploratory holes between depths of 1.4m and in excess of 6m bgl. This hard dig may cause issues for plant during excavation.
Slope stability	Collapse of trial pit sides during excavation noted on the exploratory logs, particularly when groundwater is encountered.

Last Update: 01-10-2018
Design Revision: February 2018

Earthwork Details:

At Grade M2FG08		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	**Northbound**	N/A- new earthwork	15910	16310	-	-	98 - 100
	Southbound	N/A- new earthwork	15920	16300	-	-	98 - 100
Earthwork Details	**Preliminary Earthwork Proposals**	1:3 proposed soil slope recommended within new embankments. Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer. Minor consolidation is likely to occur in the over consolidated glacial clays. More significant settlement will occur where embankment is constructed over alluvium unless this material is removed prior to construction. A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off.					

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
*TP1238	2.6	98.91	-	None	-
WS1510	1.8	98.8	-	None	-
TP1239	4.5	98.85	-	None	-
TP1240	3.9	99.46	-	None	-
TPA1710	3.5	99.63	-	None	-

** offset 50m from the southern extent of the earthwork.*

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 - 0.3	98.6 – 99.16	0.2 - 0.3	TOPSOIL
Glacial Till	>1.8 - >4.5	94.35 – 97.0	>1.6 – >4.2	Soft to stiff slightly clayey slightly sandy slightly gravelly CLAY with low cobble content. Gravel is subrounded to subangular fine to coarse of sandstone, quartz, coal, limestone and mudstone. Occasionally described as light brown sandy subangular fine to coarse GRAVEL with some cobbles.
Weathered Sandstone (TP1238 only)	2.6	96.31	>0.6	Brown yellow sandy clayey subangular fine to coarse GRAVEL of sandstone.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till	
	No. of tests	Results
Moisture Content (%)	32	9.3 – 27 (A = 16.2)
Liquid Limit (%)	7	32 – 47 (A = 41.4)
Plastic Limit (%)	7	15 – 20 (A = 18.4)
Plasticity Index (%)	7	17 – 27 (A = 23)
c_u (kPa) Hand Shear Vane	45	30 – 136 (A = 86.4)
Max Dry Density (mg/m^3)	24	1.65 – 1.97 (A = 1.8)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Perched Groundwater	Due to the low permeability of the Glacial Till, there may be potential for perched groundwater at the site of the earthwork although no groundwater was encountered during the GI.
Hard dig	Cobbles and boulders were encountered within the Glacial Till at relatively shallow depths which may affect the works.

Last Update: 02-10-2018
Design Revision: February 2018

Earthwork Details:

At Grade M2FG09		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
			From	To			
General Details[1]	**Northbound**	N/A – new earthwork	17300	17490	-	-	78 - 80
	Southbound	N/A – new earthwork	17300	17490	-	-	78 - 80
Earthwork Details	**Preliminary Earthwork Proposals**	Proposed 1:3 soil slope recommended. A filter drain will be required at the earthwork toe to draw down the groundwater to below that of the toe of the slope. Crest drainage should be installed in where the surrounding land slopes towards the cutting. The existing field drain associated with Earsdon Burn will be cut by the earthwork and should therefore be intercepted by collector drains. Road pavement will be founded on the cohesive Glacial Till.					

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
TP1251	3.5	79.46	-	None	-
BH1016	19.8	79.39	Standpipe piezometer tip to 3.0m [2.5 – 3.5]	3.0 (fast flow, no rise after 20 mins)	0.98 – 1.7
TPA1716	3.5	80.75	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3 – 0.5	78.89 – 7916	0.3 – 0.5	TOPSOIL
Glacial Till	>3.5 - 9.80	<80.75 - < 79.39	>3.2 - 9.3	Soft to very stiff generally firm, occasionally mottled or friable slightly sandy slightly gravelly CLAY with low cobble content. Gravel is subangular to subrounded of various lithologies including sandstone, mudstone and quartz. Interbedded with brown clayey gravelly fine to coarse SAND of 0.4 – 0.5m thick.
Interbedded Sandstone/ Mudstone and Siltstone (BH1016 Only)	19.8	<59.59	>10	Moderately weak to moderately strong, occasionally very weak thinly interlaminated light grey fine to medium grained SANDSTONE and dark grey MUDSTONE. Slightly to highly weathered. Discontinuities 1) 0-10 deg very closely spaced planar smooth. Interbedded with moderately strong dark grey black SILTSTONE (0.5 – 1.9m thick).
Local Ground Variations	Bedrock encountered at ~10m bgl.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till		Sandstone	
	No. of tests	Results	No. of tests	Results
Moisture Content (%)	16	9.6 – 32 (A = 20.1)	-	-
Liquid Limit (%)	3	26 – 31 (A = 13)	-	-
Plastic Limit (%)	3	12 – 24 (A = 1)	-	-
Plasticity Index (%)	3	13 – 17 (A = 15.7)	-	-

Test	Cohesive Glacial Till		Sandstone	
	No. of tests	Results	No. of tests	Results
SPT 'N' Value	5	7 – 50 (A = 23.8)	1	50
MV (m^2/MN)	5	0.071 – 0.4	-	-
c_u (kPa) Hane Shear Vane	18	21 – 110 (A = 73.6)	-	-
c_u TT (kPa) Triaxial	2	41 – 62	-	-
Bulk Density (mg/m^3)	7	2.2 – 2.37 (A =2.33)	-	-
Max Dry Density (mg/m^3)	3	1.92 – 2.03 (A = 1.97)	-	-

Summary of Geotechnical Risks

Hazard	Process/ Activity
Mine workings (shallow and deep)	The proposed earthwork is located within an area noted to have deep coal (with depths of 50 – 1200m bgl). Shallow coal was encountered approx. 300m east of the Site. No seams were encountered in the exploratory holes.
Perched Groundwater	Low permeability deposits may give rise to perched groundwater which may impact works.
Hard dig	Cobbles and boulders were encountered within the Glacial Till of the exploratory holes.
Flooding	There is a land drain located along field boundary underneath the proposed route which appears to be a tributary of Earsdon Burn. There is a 1 in 30 chance of annual flooding from surface water directly underlying the route.

Last Update: 02-10-2018
Design Revision: February 2018

Earthwork Details:

AT GRADE M2FG10		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
General Details[1]	**Northbound**	N/A – new earthwork	18780	19130	-	-	67.5 – 77.5
	Southbound	N/A – new earthwork	18790	19130	-	-	67.5 – 77.5
Earthwork Details	**Preliminary Earthwork Proposals**	1:3 proposed soil slope recommended within new embankments. Embankment is to be founded on cohesive sub grade and therefore requires a granular starter layer. Minor consolidation is likely to occur in the over consolidated glacial clays. More significant settlement will occur where embankment is constructed over alluvium unless this material is removed prior to construction. A drainage ditch is required at least 2.0m beyond the toe of the embankment to control run off.					

Published Geology

Superficial	Solid
Glacial Till	Predominantly underlain by the Stainmore Formation – Mudstone, Siltstone and Sandstone. The Pennine Lower Coal Measures Formation underlies the southern extent of the earthwork.

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
TP1266	4.5	77.45	-	None	-
WS1511	1.7	71.37	-	Strike at 1.0 (no flow details)	-
TP1267	4.5	67.53	-	None	-
TP_A1722	3.5	76.86	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.3	77.15 – 67.23	0.3	TOPSOIL
Cohesive Glacial Till	>4.5	<63.03	>4.2	Firm to stiff slightly sandy slightly gravelly CLAY with occasional cobbles and boulders. Gravel is subangular to subrounded fine to medium of sandstone, mudstone, coal, limestone, and quartzite. Cobbles and boulders are subangular of sandstone.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Cohesive Glacial Till: No. of tests	Cohesive Glacial Till: Results
Moisture Content (%)	24	5.9 – 22 (A = 14.4)
Liquid Limit (%)	10	33 – 50 (A = 39.1)
Plastic Limit (%)	10	16 – 28 (A = 19.1)
Plasticity Index (%)	10	16 – 22 (A = 20)
c_u (kPa) Hand Shear Vane	27	40 – 120 (A = 83.5)
MCV	1	10
Max Dry Density (mg/m^3)	13	1.74 – 2.03 (A = 1.87)
Bulk Dry Density (mg/m^3)	1	2.16
CBR (%)	1	Top 8.3 Base 10

Summary of Geotechnical Risks

Hazard	Process/ Activity
Mine workings (shallow and deep)	The earthwork is located within an area of deep coal. The southern extent of the site is within bedrock of the Lower Pennine Coal Measures Formation, which outcrops <300m to the east of the earthwork. However, the area is not located in a coal mining reporting area (Coal Authority).
Perched Groundwater	There is potential for perched groundwater within the low permeability material of the Glacial Till.
Hard dig	Cobbles and boulders were encountered at relatively shallow depth within the exploratory holes which may cause problems for works.
Flooding	1 in 30 chance of annual flooding from surface water directly underlying the northern extent of the earthwork.

Last Update: 02/10/2018
Design Revision: February 2018

Earthwork Details:

AT GRADE M2FG11		HAGDMS Reference	Chainage From	Chainage To	Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)
General Details[1]	**Northbound**	14_A1_43001 At Grade	20050	20600	-	-	61.0 – 55.0
	Southbound	14_A1_42998 At Grade 14_A1_42897 At Grade	20000	20600	-	-	61.0 – 55.0

		Earthwork Classification	Observation No.	Feature	Class	Location Index
Earthwork Details	**HAGDMS Defects**	None Recorded				
	Preliminary Earthwork Proposals	Proposed 1:3 soil slope recommended where applicable. Widening is primarily adjacent to the northbound carriageway up to Ch.20200 at which point widening then includes both carriageways. Minor embankment/ cuttings is to be founded on/ within cohesive sub grade and therefore requires a granular starter layer. Minor consolidation is likely to occur in the over consolidated glacial clays.				

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH1029	35.1	61.85	Standpipe Piezometer tip at 28.25 [27.25 – 29.28]	Strike at 24.5 (no flow details recorded) Strike at 28.2(no flow details recorded)	0.5 – 4.05
TP A1728	3.5	61.45	-	None	-
TP A1729	3.6	62.16	-	None	-
TP A1744	1.7	62.64	-	None	-
TP A1743	2.0	58.13	-	None	-
TP1279	4	59.52	-	None	-
TP1280	4.4	60.97	-	None	-
TP1281	4.5	62.46	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 – 0.3	59.32 – 61.55	0.2 – 0.3	Topsoil
Made Ground (associated with made up ground adjacent to airfield)	0.4 – 1.7	60.94 – 61.76	0.4 – 1.7	Dark brown clayey slightly gravelly fine to coarse SAND/ sandy GRAVEL with generally low cobble content or dark grey slightly sandy gravelly CLAY with occasional cobbles. Cobble sized fragments are subangular of sandstone, brick, concrete, cinder and burnt shale.
Glaciolacustrine	3.6 – 8.6	53.25 – 58.56	0.1 – 1.2	Found as discrete layers in the Glacial Till and described as; Firm to stiff thinly laminated dark brown grey slightly sandy slightly gravelly CLAY occasionally interlaminated with fine to coarse SAND.
Glacial Till	>2.0 – 25.25	36.3 - <58.66	> 2.0 – 25.25	Firm to stiff, occasionally soft, grey brown sometimes mottled slightly sandy slightly gravelly CLAY. Gavel is fine to medium subangular to subrounded of sandstone, mudstone, coal and limestone. Occasionally interbedded with layers of clayey very gravelly fine to coarse SAND.
Interbedded Sandstone, Mudstone and Siltstone. (BH1029 Only)	>35.10	<26.75	>9.55	Moderately weak to moderately strong fine to coarse grained moderately weathered Sandstone/ Siltstone interbedded with very weak to weak dark grey to black Mudstone occasionally described as Distinctly weathered to destructured.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Glaciolacustrine		Glacial Till	
	No. of tests	Results	No. of tests	Results
Moisture Content (%)	1	27	13	7.6 -36 (A = 19.4)
Liquid Limit (%)	1	52	8	30 – 69 (A = 42.3)
Plastic Limit (%)	1	22	8	14 – 26 (A = 19.1)
Plasticity Index (%)	1	30	8	14 – 43 (A = 23.1)
SPT 'N' Value			6	22 – 50 (A = 33.5)
c_u (kPa) Hand Shear Vane	4	60 – 74 (A = 66.8)	44	50 – 130 (A = 93.7)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Mining	Mine shaft noted on the historical maps ~150m to the east of the proposed upgrade and underlying the airfield. Shallow and deep mining possible beneath the route.
Hard dig	Occasional cobbles reported in Glacial Till.
Slope stability.	Presence of discrete layers of laminated clay with the Glacial Tills at moderate depth to a maximum thickness of 1.2m.
Perched Groundwater	Shallow groundwater levels recorded <1.0m bgl
Surface flooding	Part of the site is situated within an area with an annual risk of up to 1 in 30 of surface flooding. This is associated with Longdike Burn

Last Update: 02/10/2018
Design Revision: February 2018

Earthwork Details:

AT GRADE M2FG12		HAGDMS Reference	Chainage		Max Slope Height (m)	Typical Slope Height (m)	Elevation Range (m OD)	
			From	To				
General Details[1]	**Northbound**	14_A1_43001 At Grade	20600	21020	-	-	62.0 – 63.0	
	Southbound	14_A1_42998 At Grade 14_A1_42897 At Grade	20600	21020	-	-	62.0 – 63.0	
Earthwork Details	**HAGDMS Defects**	Earthwork Classification	Observation No.		Feature		Class	Location Index
		None Recorded						
	Preliminary Earthwork Proposals	Proposed 1:3 soil slope recommended where applicable. Widening is primarily adjacent to the northbound carriageway up to Ch.20200, at which point widening then includes both carriageways. Minor embankment/ cuttings is to be founded on/ within cohesive sub grade and therefore requires a granular starter layer. Minor consolidation is likely to occur in the over consolidated glacial clays.						

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH1029	35.1	61.85	Standpipe Piezometer tip at 28.25 [27.25 – 29.28]	Strike at 24.5 (no flow details recorded) Strike at 28.2(no flow details recorded)	0.5 – 4.05
TP A1728	3.5	61.45	-	None	-
TP A1729	3.6	62.16	-	None	-
TP A1744	1.7	62.64	-	None	-
TP A1743	2.0	58.13	-	None	-
TP1279	4	59.52	-	None	-
TP1280	4.4	60.97	-	None	-
TP1281	4.5	62.46	-	None	-

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
Topsoil	0.2 – 0.3	59.32 – 96.52	0.2 – 0.3	Topsoil
Made Ground (associated with made up ground adjacent to airfield).	0.4 – 1.7	60.94 – 61.76	0.4 – 1.7	Dark brown clayey slightly gravelly fine to coarse SAND/ sandy GRAVEL with generally low cobble content or dark grey slightly sandy gravelly CLAY with occasional cobbles. Cobble sized fragments are subangular of sandstone, brick, concrete, cinder and burnt shale.
Glaciolacustrine	3.6 – 8.6	53.25 – 58.56	0.1 – 1.2	Found as discrete layers in the Glacial Till and described as; Firm to stiff thinly laminated dark brown grey slightly sandy slightly gravelly CLAY occasionally interlaminated with fine to coarse SAND.
Glacial Till	>2.0 – 25.25	36.3 - <58.66	> 2.0 – 25.25	Firm to stiff, occasionally soft, grey brown sometimes mottled slightly sandy slightly gravelly CLAY. Gavel is fine to medium subangular to subrounded of sandstone, mudstone, coal and limestone. Occasionally interbedded with layers of clayey very gravelly fine to coarse SAND.
Interbedded Sandstone, Mudstone and Siltstone. (BH1029 Only)	>35.10	<26.75	>9.55	Moderately weak to moderately strong fine to coarse grained moderately weathered Sandstone/ Siltstone interbedded with very weak to weak dark grey to black Mudstone occasionally described as Distinctly weathered to destructured.

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Glaciolacustrine		Glacial Till	
	No. of tests	Results	No. of tests	Results
Moisture Content (%)	1	27	13	7.6 -36 (A = 19.4)
Liquid Limit (%)	1	52	8	30 – 69 (A = 42.3)
Plastic Limit (%)	1	22	8	14 – 26 (A = 19.1)
Plasticity Index (%)	1	30	8	14 – 43 (A = 23.1)
SPT 'N' Value			6	22 – 50 (A = 33.5)
c_u (kPa) Hand Shear Vane	4	60 – 74 (A = 66.8)	44	50 – 130 (A = 93.7)

Summary of Geotechnical Risks

Hazard	Process/ Activity
Mining	Mine shaft noted on the historical maps ~150m to the east of the proposed upgrade and underlying the airfield. Shallow and deep mining possible beneath the route.
Hard dig	Occasional cobbles reported in Glacial Till.
Slope stability.	Presence of discrete layers of laminated clay with the Glacial Tills at moderate depth to a maximum thickness of 1.2m.
Perched Groundwater	Shallow groundwater levels recorded <1.0m bgl.
Surface flooding	Part of the site is situated within an area with an annual risk of up to 1 in 30 of surface flooding. This is associated with Longdike Burn.

Last Update: 02/10/2018
Design Revision: February 2018

Earthwork Details:

<table>
<tr><th colspan="2">AT GRADE
M2FG13</th><th>HAGDMS Reference</th><th colspan="2">Chainage
From / To</th><th>Max Slope Height (m)</th><th colspan="2">Typical Slope Height (m)</th><th>Elevation Range (m OD)</th></tr>
<tr><td rowspan="2">General Details[1]</td><td>Northbound</td><td>14_A1_42898 At Grade
14_A1_42930 At Grade</td><td>21020</td><td>21880</td><td>-</td><td colspan="2">-</td><td>63.0 – 61.0</td></tr>
<tr><td>Southbound</td><td>14_A1_42897 At Grade
14_A1_42931 At Grade</td><td>21020</td><td>21880</td><td>-</td><td colspan="2">-</td><td>62.0 – 61.0</td></tr>
<tr><td rowspan="3">Earthwork Details</td><td rowspan="2">HAGDMS Defects</td><td>Earthwork Classification</td><td colspan="2">Observation No.</td><td colspan="2">Feature</td><td>Class</td><td>Location Index</td></tr>
<tr><td colspan="8">None Recorded</td></tr>
<tr><td>Preliminary Earthwork Proposals</td><td colspan="8">Proposed 1:3 soil slope recommended where applicable. Widening is primarily adjacent to the Southbound carriageway.
Minor embankment/ cuttings is to be founded on/ within cohesive sub grade and therefore requires a granular starter layer.
Minor consolidation is likely to occur in the over consolidated glacial clays.
West Moor Junction is located at Ch21560 with an unnamed culvert at Ch21850.</td></tr>
</table>

Published Geology

Superficial	Solid
Glacial Till	Stainmore Formation – Mudstone, Siltstone and Sandstone

Summary of Relevant Exploratory Holes

Hole reference	Final Depth (m)	Ground Level (mOD)	Installation Details [Response Zone] (m bgl)	Depth of Water Recorded During GI (m bgl)	Post GI Monitoring (m bgl)
BH A1736	23.3	60.45	Install A Slotted Standpipe [2 - 4] Install B Standpipe Piezometer tip at 7.5 [6.5 – 8.5] Install C Slotted Standpipe [19.0 – 21.0]	Strike at 3.2 rose to 2.7 after 20 mins Strike at 7.2 rose to 4.6 after 20 mins	Install A 2.2 – 2.45 Install B 2.0 – 2.38 Install C 6.0 – 6.34
BH A1737	21.75	60.53	Slotted Standpipe [5.6 – 9.7]	Strike at 5.4 rose to 3.7 after 20 mins	2.49 – 2.54
BH1	3.45	60.98	-	Strike at 2.6	-
BH1031	33.5	61.02	Standpipe Piezometer tip at 4.0 [3.5 – 4.5]	Strike at 3.7	0 – 2.1
BH2	3.45	60.38	-	Strike at 2.4	-
BH3	3.45	60.66	-	Strike at 2.1	-
BH4	3.45	60.03	-	Strike at 2.0	-
BH5	3.45	59.7	-	None	
BH6	4.25	59.61	-	None	
TP A1730	1.4	61.6	-	None	
TP A1730A	3.5	61.6	-	None	
TP A1731 Soakaway	3.5	60.2	-	None	
TP A1747	3.7	61.45	-	None	
TP1285	4.5	61.65	-	None	
TP1286	4	62.14	-	None	
TP1294	4.5	60.33	-	None	
TP1296	4.5	59.71	-	None	
WS1517	1.4	61.4	-	Strike at 1.3	

Summary of Ground Conditions

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thicknes s (m)	Typical Description
Topsoil	0.1 – 0.4	59.3 –	0.2 – 0.3	Topsoil.

Stratum	Depth to base (m bgl)	Level of base (mOD)	Stratum thickness (m)	Typical Description
		61.35		
Made Ground	0.2 – 1.5	58.21 – 60.74	0.2 – 1.5	Grey slightly sandy gravelly CLAY gravel sized fragments are angular to subangular fine to coarse of dolerite road stone, sandstone, limestone, coal, ash and tarmac.
Glaciolacustrine	3.2 – 10.8	49.73 – 57.82	0.3 – 2.3	Found as discrete layers in the Glacial Till and described as; Firm to stiff thinly laminated dark brown grey slightly sandy slightly gravelly CLAY occasionally interlaminated with fine to coarse sand partings.
Glacial Till	>2.8 – 19.25	41.77 - <58.14	>2.6 – 19.25	Firm to very stiff, occasionally soft, grey brown sometimes mottled slightly sandy slightly gravelly CLAY. Gavel is fine to medium subangular to subrounded of sandstone, mudstone, coal and limestone. Occasionally interbedded with layers of clayey very gravelly fine to coarse SAND (typically 1.0m thick) or slightly gravelly sandy SILT (typically 0.5 – 1.5m thick).
Interbedded Sandstone, Mudstone (BHA1736, BHA1737 and BH1031 only)	>21.75 – 33.5	<27.52 - <38.78	>5.15 – >14.25	Moderately weak to moderately strong fine to coarse grained moderately weathered laminated Sandstone interbedded/ laminated with very weak to weak dark grey to black Mudstone.
Coal (BHA1736, BHA1737 and BH1031 only)	19.73 – 21.32	39.21 – 41.29	0.1 – 0.37	Weak black vitreous COAL.
Local Ground Variations	**Bedrock** encountered between 16.3 – 19.25m bgl BH1031 – **zone of no recovery** between 24.7 – 26.5m bgl **Granular Glacial Till** – only encountered in the northern section of the earthwork and junction.			

Summary of Laboratory and In-situ Geotechnical Test Results

Test	Made Ground		Glaciolacustrine		Glacial Till	
	No. of tests	Results	No. of tests	Results	No. of tests	Results
Moisture Content (%)	18	6.4 – 25 (A = 14.4)	23	18.7 - 34 (A = 26.7)	56	6 - 32 (A = 21.3)
Liquid Limit (%)	6	38 – 47 (A = 43.3)	6	37 – 55 (A = 44.7)	25	30 – 59 (A = 43)
Plastic Limit (%)	6	19 – 27 (A = 22.2)	6	17 – 29 (21.5)	25	14 - 27 (A = 19.7)
Plasticity Index (%)	6	18 – 26 (A = 21.2)	6	20 – 31 (A = 23.2)	25	11 - 38 (A = 23.3)
SPT 'N' Value		24	3	12 - 29 (A = 18)	24	10 – 50 (A = 20.75)
c_u (kPa) Hand Shear Vane	9	50 – 130 (A = 90.7)	9	38 - 130 (A = 63)	50	50 – 130 (A = 95.6)
c_u (kPa) Triaxial	-	-	2	25 - 27	7	41 – 147 (A = 82.7)
Triaxial Φ (˚)					3	10 - 12
Bulk Density (mg/m^3)	-	-	17	1.95 – 2.17 (A = 2.1)	27	1.82 – 2.23 (A = 2.04)
Max Dry Density (mg/m^3)	12	1.75 – 1.98 (A = 1.86)	-	-	-	-
Particle density (mg/m^3)	-	-	1	2.73	-	-
CBR (%)	-	-	-	-	2	Top 2.2 – 4.9 Base 2.2 – 6.1

Summary of Geotechnical Risks

Hazard	Process/ Activity
Hard dig	Occasional cobbles reported in Glacial Till.
Coal Mine workings (deep)	The earthwork is in the vicinity of an area of deep coal, a coal mining report of the area can be obtained from the Coal Authority. Coal was also encountered within the exploratory holes at significant depths. However, no surface depressions were observed in the vicinity and due to the depth at which coal is observed, it is considered to be unlikely that historic mine workings will impact the proposed earthwork.
Slope stability	Presence of discrete layers of laminated clay within the Glacial Till within BHA1736, BHA1737, TP1294 and BH1031.

Hazard	Process/ Activity
Perched Groundwater	Shallow groundwater levels recorded <1.0m bgl
Surface flooding	Part of the site is situated within an area with an annual risk of up to 1 in 30 of surface flooding. This is associated with two filed drains the route appears to dissect.
Potentially Contaminated Land	Re-use of cutting material? Waste classification Sandy gravelly CLAY gravel sized fragments are angular to subangular fine to coarse of dolerite road stone, sandstone, limestone, coal, ash and tarmac. Associated with made ground of existing A1. At approximate chainage of 21300 the northbound carriageway is in close proximity to the site of an old clay pit, the extents and back fill materials are unknown.

Appendix B

GEOLOGICAL MAPPING AND EXPLORATORY HOLE LOCATION PLAN

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BHA17*XX*, TPA17*XX*, WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/ 98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0046 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

wsp

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98*, *TPA - TPK*,

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

WSP

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/ 98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes: - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0648 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

wsp

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/* 98, *TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0846 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98*, *TPA - TPK*,

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/ 98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

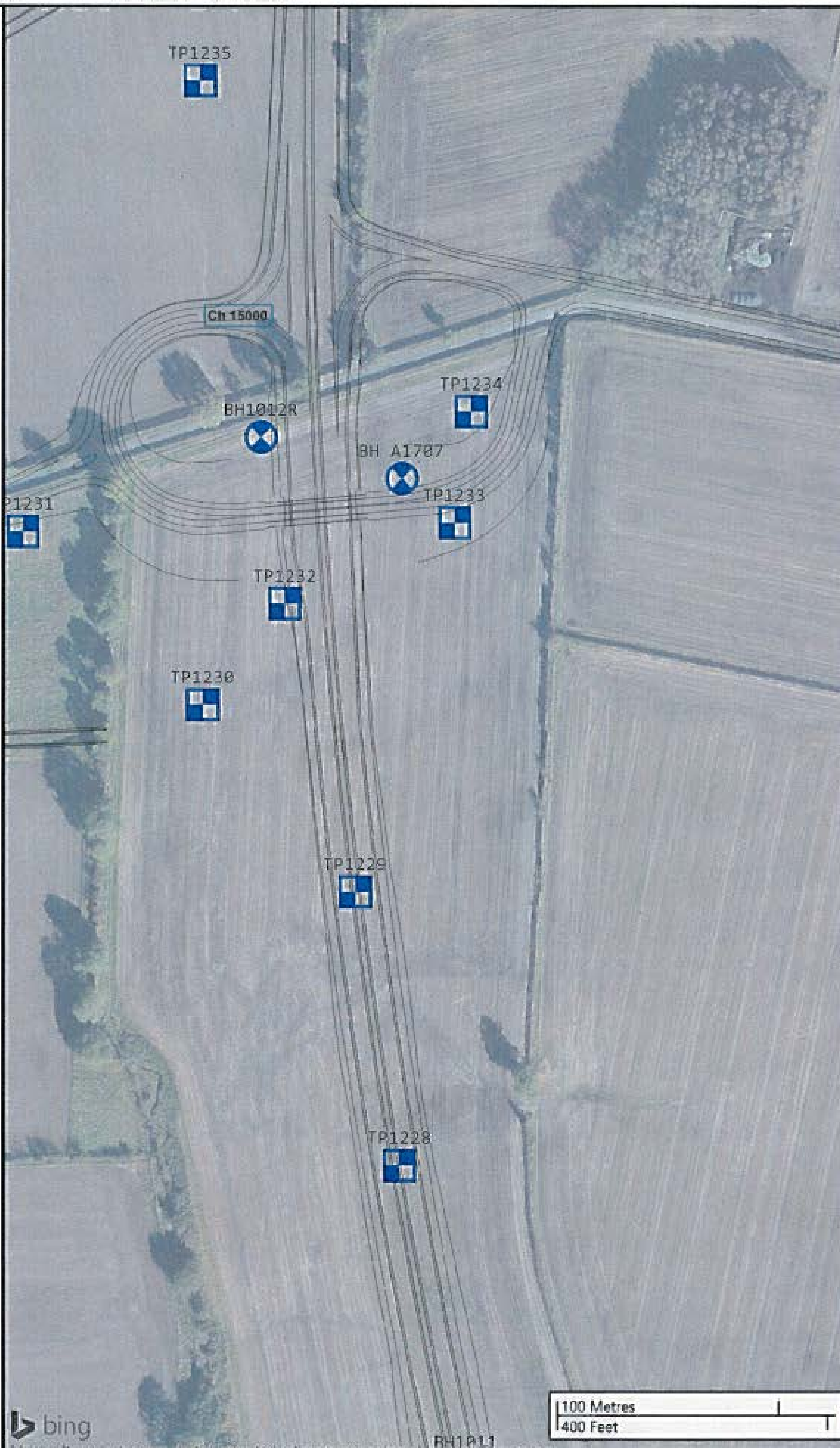
2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault



Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/ 98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551439-WSP-HGN-M2F-M2-CH-0046 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/* 98, *TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0046 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

wsp

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98*, *TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

wsp

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

wsp

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

- Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0846 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

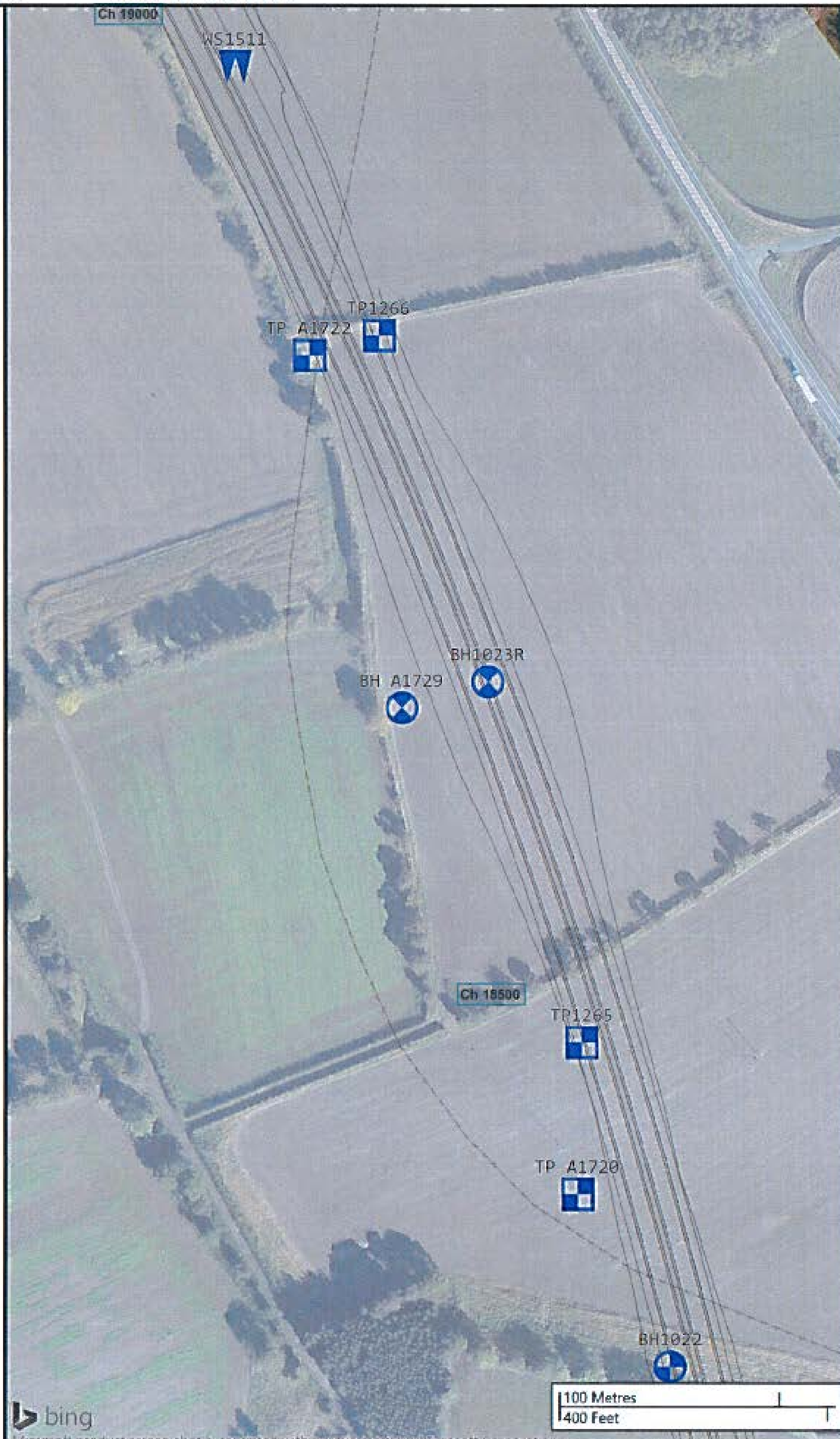
2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0846 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault



Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

WSP

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

wsp

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/* 98, *TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

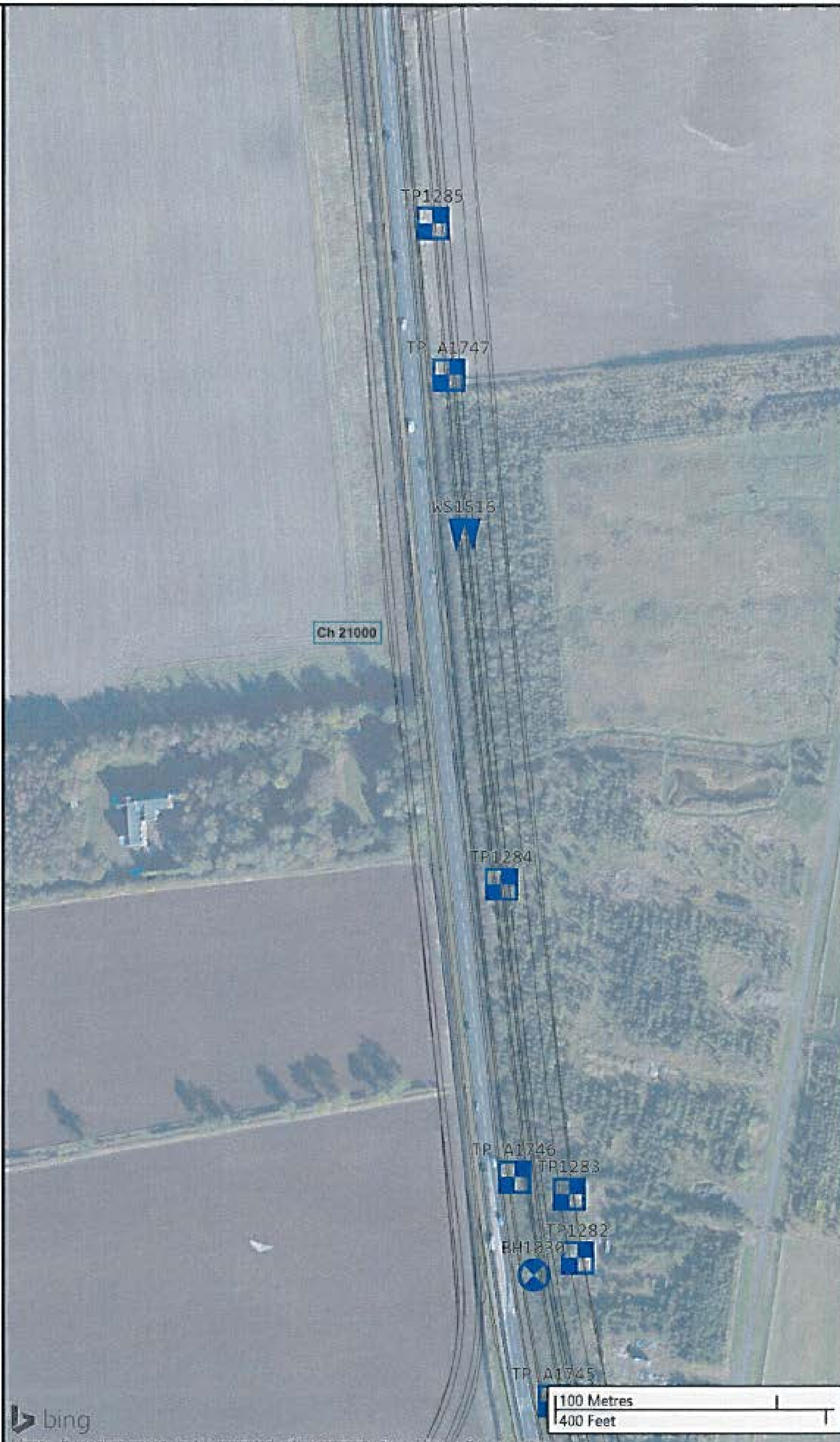
2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault



Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/* 98, *TPA - TPK,*

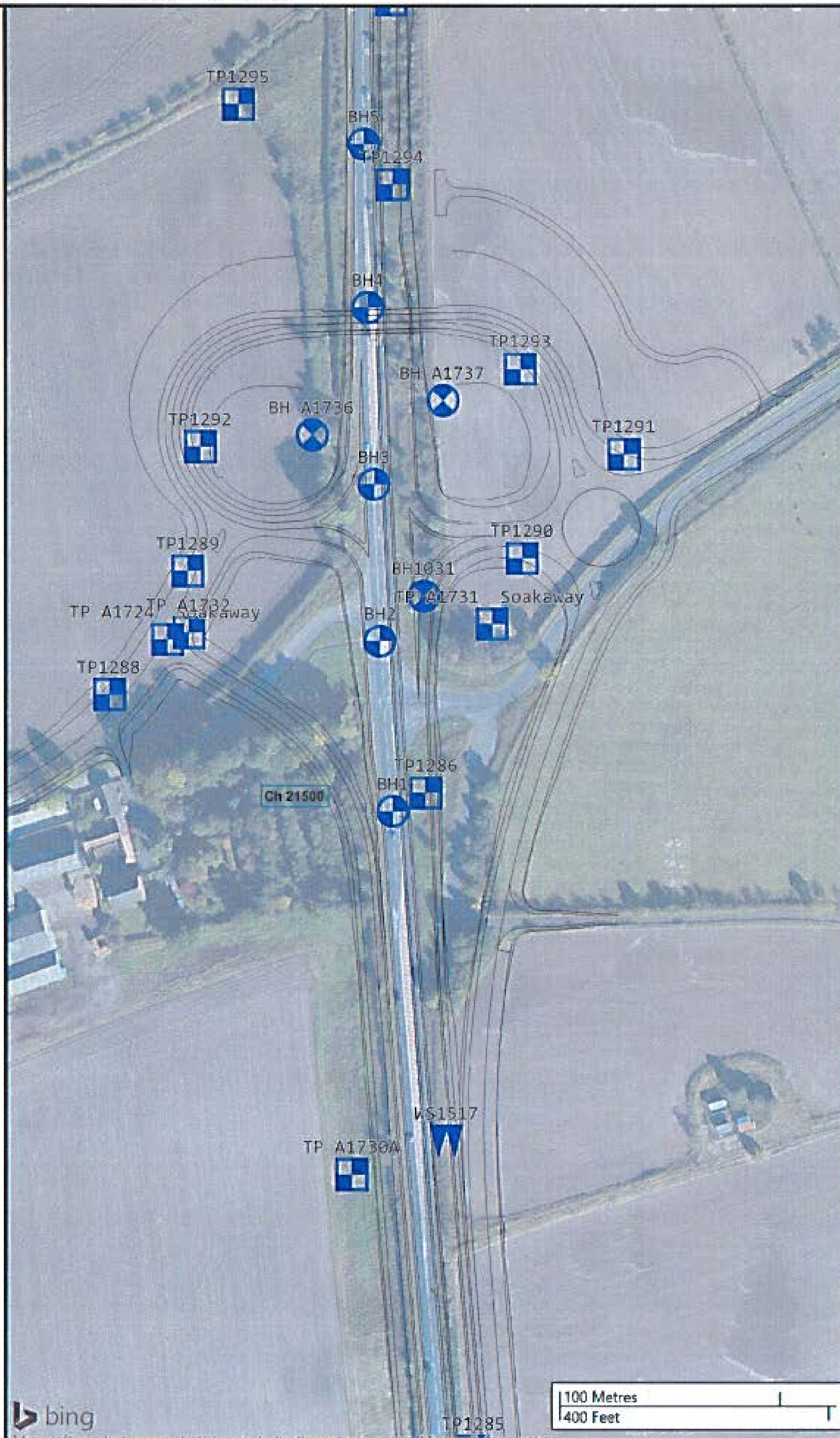
2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

- Alluvium
- Glaciofluvial Sands and Gravels
- Glacial Till
- Drift Free
- Marine Band
- Coal Seam
- Fault



Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98, TPA - TPK,*

2006 Exploratory Holes; *BH10XX, TP12XX, WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0846 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault

Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2500
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98*, *TPA - TPK*,

2006 Exploratory Holes; *BH10XX*, *TP12XX*, *WS15XX*

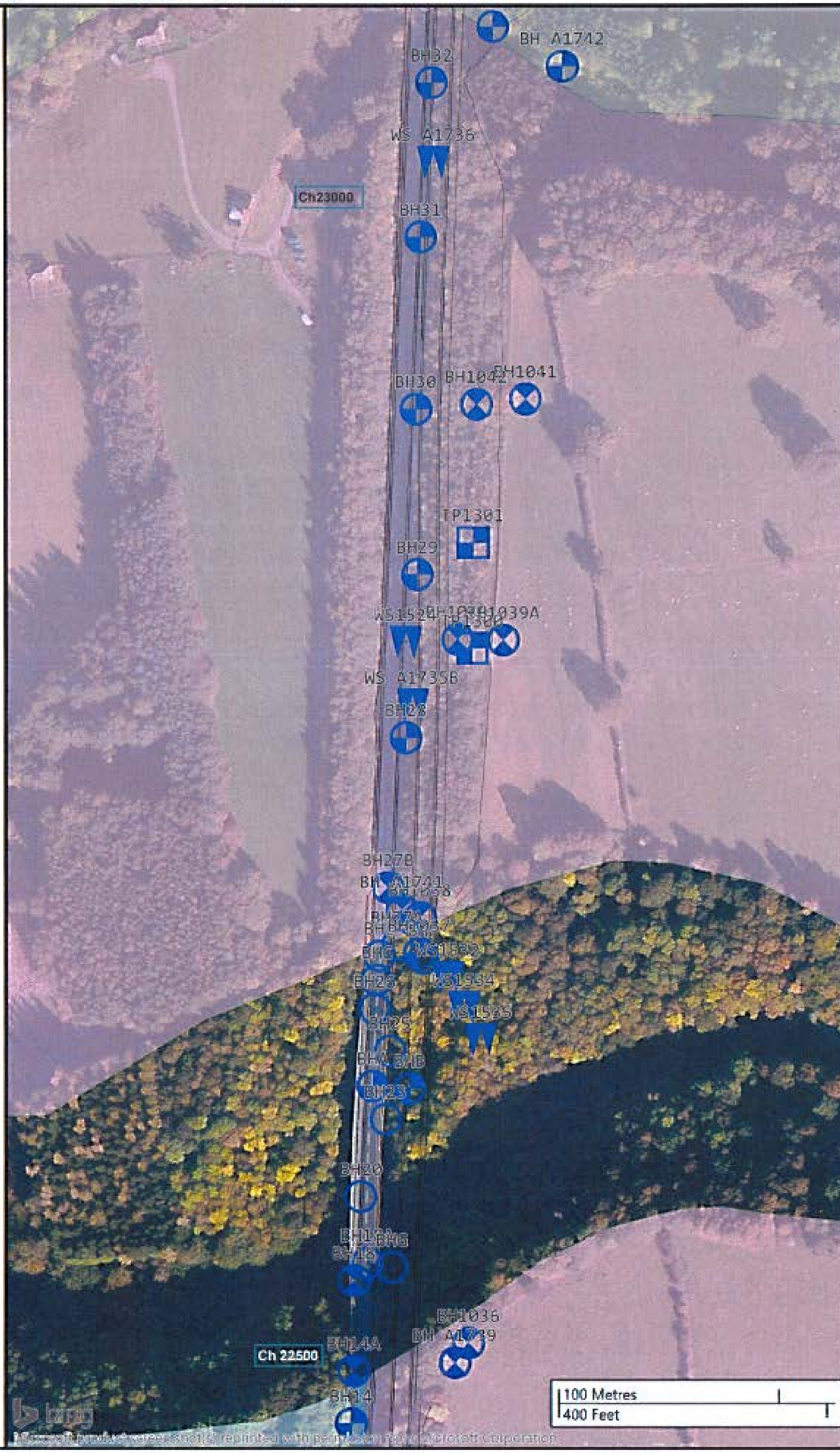
2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault



Project Id:	1078852 – 219 – GEO	Title:	Exploratory Hole Locations and 1:50K Drift Geology
Project Title:	A1	Scale:	1:2000
Location:	A1 Morpeth to Felton	Engineer:	WSP
Client:	Highways England	Contractor:	Ian Farmers

wsp

Legend Key

- Sections - Section line 1
- Locations By Type - Empty
- Locations By Type - CC
- Locations By Type - CP
- Locations By Type - CP+RC
- Locations By Type - DP
- Locations By Type - RC
- Locations By Type - RO
- Locations By Type - TP
- Locations By Type - WS

GI Phases BH prefixes;

Pre 1974 Exploratory Holes; *BHXX* and *TPXX*

1998 Exploratory Holes; *XX/98*, *TPA - TPK*,

2006 Exploratory Holes; *BH10XX*, *TP12XX*, *WS15XX*

2017 Exploratory Holes; - BH/ A17*XX* TPA17*XX* WSA17*XX*

— Highways Alignment: HE551459-WSP-HGN-M2F-M2-CH-0646 - ACAD ALL 2D P04.5 NG

Geology

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

- Marine Band
- Coal Seam
- Fault

Appendix C

GEOHAZARD PLANS

DO NOT SCALE

Millimetres

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION
Status: S2

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 1 OF 18

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume
HE551459	WSP	HGT

Section	Type	ID	Direction	Type	Role	Number
			M2F	DR	GE	0722

Revision

PW Stage Code

DO NOT SCALE

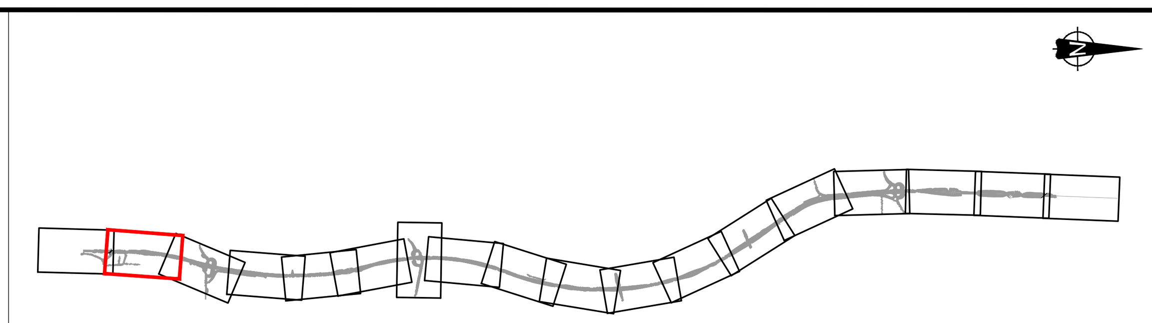
Millimetres 0 10 100

MAINLINE
CH10+850m - CH11+700m

ONLINE - NB WIDENING

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas



Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION
Status: S2

Queen Street
Manchester
M2 5JB, UK

T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 2 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume	Revision
HE551459	WSP	HGT	

Section	Type	ID	Direction	Type	Role	Number	PW Stage Code
			M2F	DR	GE	0723	

DO NOT SCALE

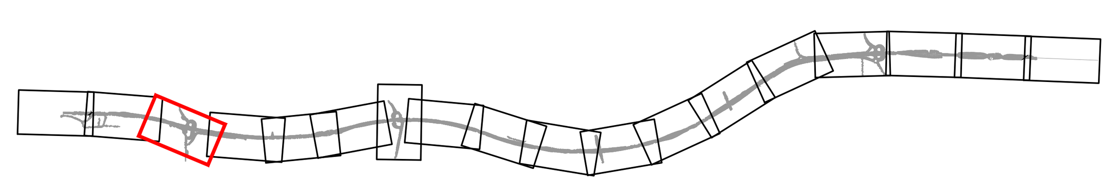
Millimetres 0 10 100

MAINLINE
CH11+700m - CH12+500m

ONLINE - NB WIDENING

KEY:

Symbol	Description
	Proposed Alignment
	Over/Underbridge
	Culvert
	Drainage Pond
	Storage Swale
	Maintenance Hardstanding
	Known existing ground instability (HAGDMS and site observations)
	Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
	Areas underlain by soft alluvial deposits
	Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
	Area underlain by laminated glaciolacrustrine deposits
	Contaminated land / Area of known Made Ground
	Hard Dig / Shallow rock head
	Area of SSSI / Ancient woodland
	Areas underlain by mass movement deposits
	Inferred fault
	Hard Dig - Causey Park Dyke
	Coal Seam
	Void Risk Areas



Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION
Status: S2

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 3 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume	Section	Type	ID	Direction	Type	Role	Number	Revision
HE551459	WSP	HGT				M2F	DR	GE	0724	

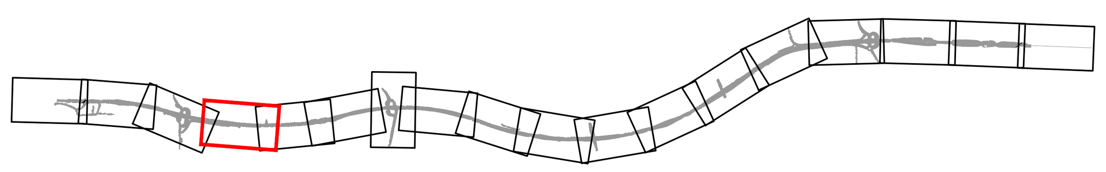
PW Stage Code

DO NOT SCALE

Millimetres 0 10 100

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas



Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION
Status: S2

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 4 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume
HE551459	WSP	HGT

Section	Type	ID	Direction	Type	Role	Number
			M2F	DR	GE	0725

Revision

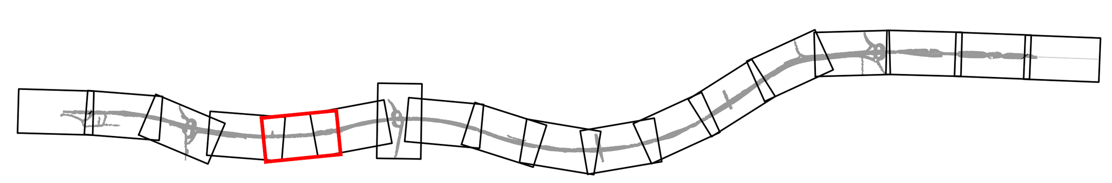
PW Stage Code

DO NOT SCALE

Millimetres 0 10 100

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas



Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability	FOR INFORMATION
Status	S2
Address	Queen Street, Manchester, M2 5JB, UK; T+ 44 (0) 161 832 4542; wsp.com
Client	highways england
Project Title	A1 IN NORTHUMBERLAND MORPETH TO FELTON
Drawing Title	GEOHAZARD PLANS SHEET 5 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	**Date**	**Date**	**Date**	**Date**
A1	14/03/2018	15/03/2018	--	--

Drawing Number: Project	Originator	Volume	Section	Type	ID	Direction	Type	Role	Number	Revision	PW Stage Code
HE551459	WSP	HGT				M2F	DR	GE	0726		

DO NOT SCALE

KEY:

Symbol	Description
	Proposed Alignment
	Over/Underbridge
	Culvert
	Drainage Pond
	Storage Swale
	Maintenance Hardstanding
	Known existing ground instability (HAGDMS and site observations)
	Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
	Areas underlain by soft alluvial deposits
	Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
	Area underlain by laminated glaciolacrustrine deposits
	Contaminated land / Area of known Made Ground
	Hard Dig / Shallow rock head
	Area of SSSI / Ancient woodland
	Areas underlain by mass movement deposits
	Inferred fault
	Hard Dig - Causey Park Dyke
	Coal Seam
	Void Risk Areas

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION
Status: S2

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 6 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume	Section	Type	ID	Direction	Type	Role	Number	Revision	PW Stage Code
HE551459	WSP	HGT				M2F	DR	GE	0727		

DO NOT SCALE

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION | Status: S2

Queen Street
Manchester
M2 5JB, UK

T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 7 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	**Date**	**Date**	**Date**	**Date**
A1	14/03/2018	15/03/2018	--	--

Drawing Number: Project HE551459 | Originator WSP | Volume HGT | Section | Type | ID | Direction M2F | Type DR | Role GE | Number 0728

Revision:

PW Stage Code:

DO NOT SCALE

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION | Status: S2

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 8 OF 18

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	**Date**	**Date**	**Date**	**Date**
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume
HE551459	WSP	HGT

Section	Type	ID	Direction	Type	Role	Number
			M2F	DR	GE	0729

Revision

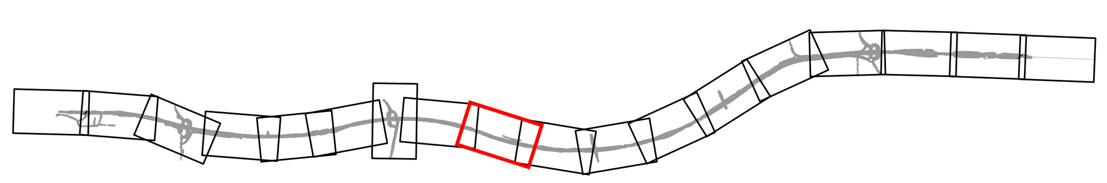
PW Stage Code

DO NOT SCALE

Millimetres 0 10 100

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas



Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION | Status: S2

Queen Street
Manchester
M2 5JB, UK

T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 9 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume	Section	Type	ID	Direction	Type	Role	Number
HE551459	WSP	HGT				M2F	DR	GE	0730

Revision

PW Stage Code

DO NOT SCALE

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION
Status: S2

Queen Street
Manchester
M2 5JB, UK

T+ 44 (0) 161 832 4542
wsp.com

© WSP UK Ltd

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 10 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size: A1	Date: 14/03/2018	Date: 15/03/2018	Date: --	Date: --

Drawing Number

Project	Originator	Volume	Section	Type	ID	Direction	Type	Role	Number
HE551459	WSP	HGT				M2F	DR	GE	0731

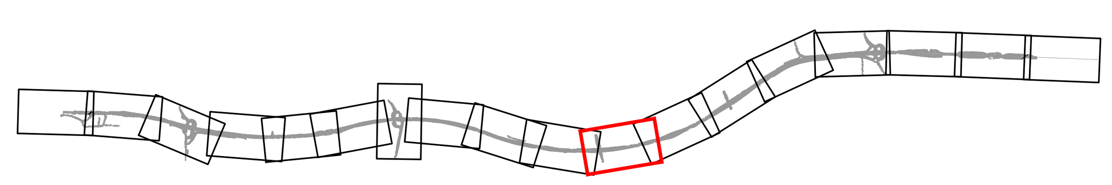
Revision:
PW Stage Code:

DO NOT SCALE

Millimetres 0 10 100

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas



Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION
Status: S2

Queen Street
Manchester
M2 5JB, UK

T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 11 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

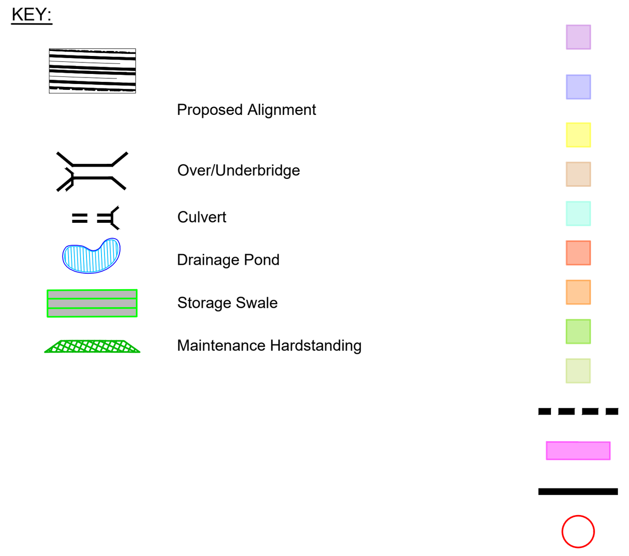
Project	Originator	Volume
HE551459	WSP	HGT

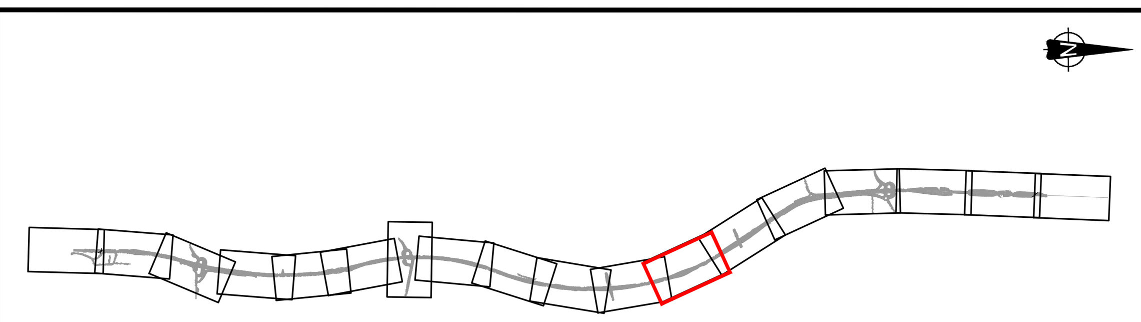
Section	Type	ID	Direction	Type	Role	Number
			M2F	DR	GE	0732

Revision

PW Stage Code

KEY:





Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION	Status: S2	Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON
Queen Street Manchester M2 5JB, UK T+ 44 (0) 161 832 4542 wsp.com © WSP UK Ltd		Drawing Title: GEOHAZARD PLANS SHEET 12 OF 18
Client: highways england		

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume	Revision
HE551459	WSP	HGT	

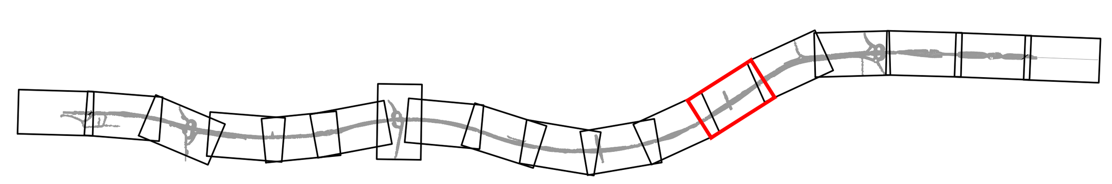
Section	Type	ID	Direction	Type	Role	Number	PW Stage Code
			M2F	DR	GE	0733	

DO NOT SCALE

Millimetres 0 10 100

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas



Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION | Status: S2

WSP
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 13 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume	Direction	Type	Role	Number
HE551459	WSP	HGT	M2F	DR	GE	0734

Section | Type | ID

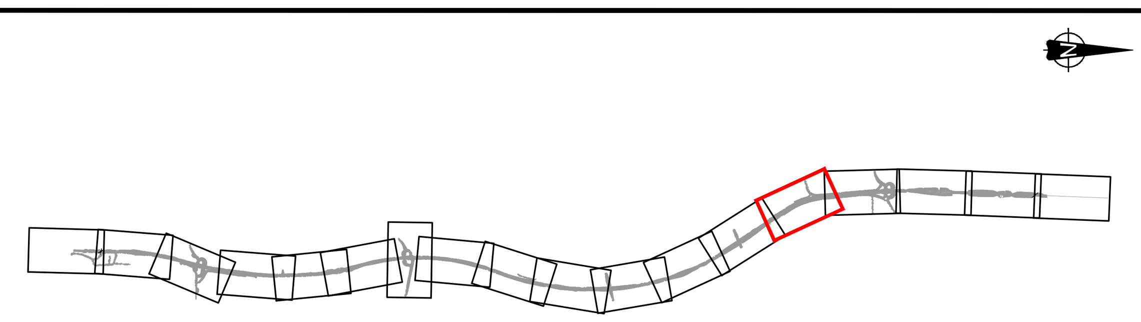
Revision

PW Stage Code

DO NOT SCALE

KEY:

Symbol	Description
	Proposed Alignment
	Over/Underbridge
	Culvert
	Drainage Pond
	Storage Swale
	Maintenance Hardstanding
	Known existing ground instability (HAGDMS and site observations)
	Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
	Areas underlain by soft alluvial deposits
	Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
	Area underlain by laminated glaciolacrustrine deposits
	Contaminated land / Area of known Made Ground
	Hard Dig / Shallow rock head
	Area of SSSI / Ancient woodland
	Areas underlain by mass movement deposits
	Inferred fault
	Hard Dig - Causey Park Dyke
	Coal Seam
	Void Risk Areas



Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION
Status: S2

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 14 OF 18

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	**Date**	**Date**	**Date**	**Date**
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume	Section	Type	ID	Direction	Type	Role	Number	Revision
HE551459	WSP	HGT				M2F	DR	GE	0735	

PW Stage Code

DO NOT SCALE

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION
Status: S2

Queen Street
Manchester
M2 5JB, UK

T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 15 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number: Project HE551459 | Originator WSP | Volume HGT | Section | Type | ID | Direction M2F | Type DR | Role GE | Number 0736

Revision

PW Stage Code

DO NOT SCALE

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION — Status: S2

WSP
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 16 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number: Project HE551459 | Originator WSP | Volume HGT | Section | Type | ID | Direction M2F | Type DR | Role GE | Number 0737

Revision | PW Stage Code

DO NOT SCALE

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability: FOR INFORMATION | Status: S2

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Project Title: A1 IN NORTHUMBERLAND MORPETH TO FELTON

Drawing Title: GEOHAZARD PLANS SHEET 17 OF 18

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume	Section	Type	ID	Direction	Type	Role	Number	Revision
HE551459	WSP	HGT				M2F	DR	GE	0738	

PW Stage Code

DO NOT SCALE

KEY:

- Proposed Alignment
- Over/Underbridge
- Culvert
- Drainage Pond
- Storage Swale
- Maintenance Hardstanding
- Known existing ground instability (HAGDMS and site observations)
- Areas at risk of flooding from rivers or surface flooding following excessive rainfall (up to 1 in 30 annual risk)
- Areas underlain by soft alluvial deposits
- Area underlain by contaminated land/ unknown ground conditions/ backfilled ground
- Area underlain by laminated glaciolacrustrine deposits
- Contaminated land / Area of known Made Ground
- Hard Dig / Shallow rock head
- Area of SSSI / Ancient woodland
- Areas underlain by mass movement deposits
- Inferred fault
- Hard Dig - Causey Park Dyke
- Coal Seam
- Void Risk Areas

Rev.	Date	Description	By	Eng' Ch'k	Disc' Ch'k	App'd

Suitability	FOR INFORMATION
Status	S2
Project Title	A1 IN NORTHUMBERLAND MORPETH TO FELTON
Drawing Title	GEOHAZARD PLANS SHEET 18 OF 18

Queen Street
Manchester
M2 5JB, UK

T+ 44 (0) 161 832 4542
wsp.com

Client: highways england

Scale	Drawn	Eng. Check	Approved	Authorised
1:1250	SA	MH	--	--
Original Size	Date	Date	Date	Date
A1	14/03/2018	15/03/2018	--	--

Drawing Number

Project	Originator	Volume	Direction	Type	Role	Number
HE551459	WSP	HGT	M2F	DR	GE	0739

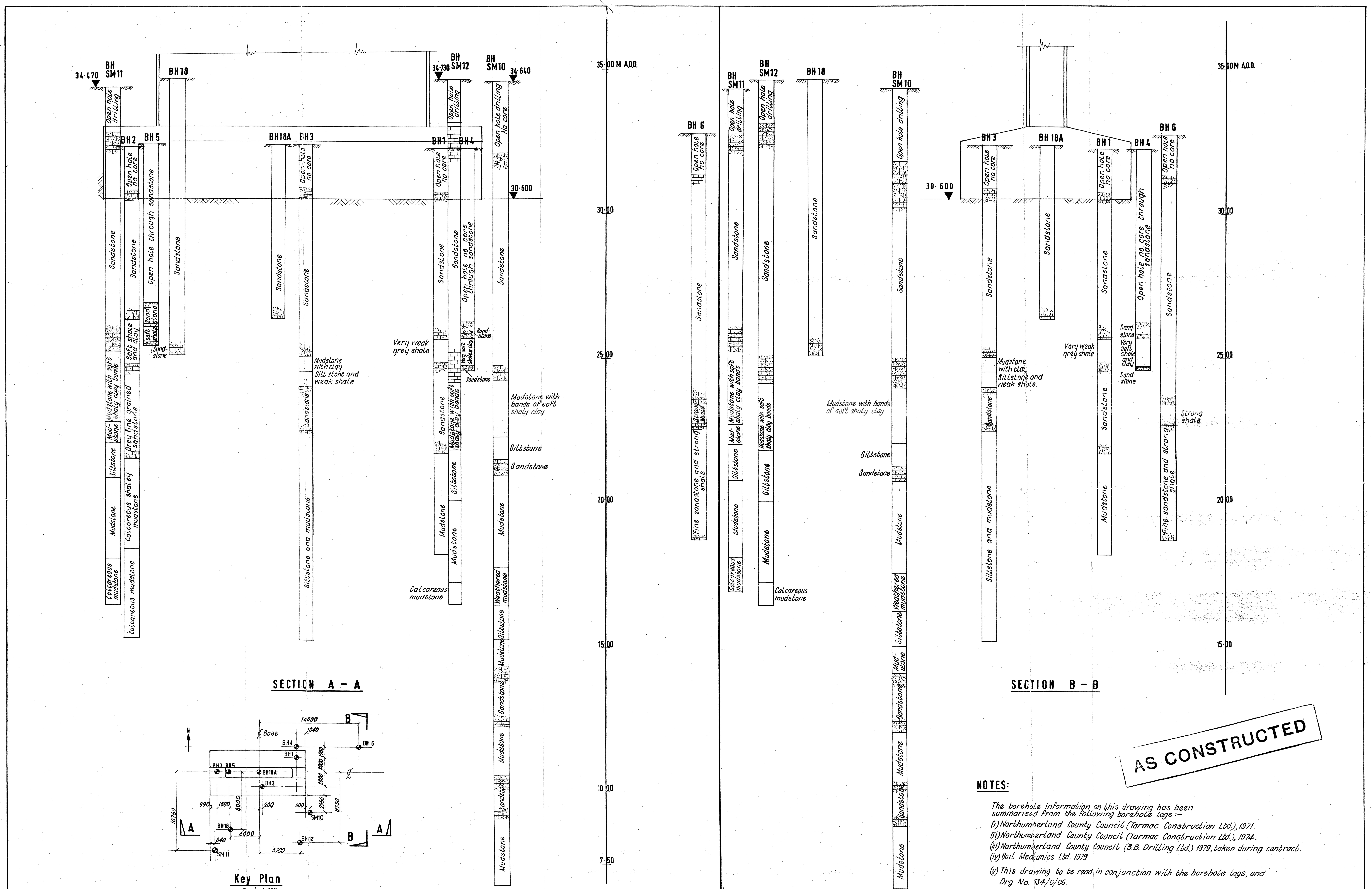
Section | Type | ID

Revision

PW Stage Code

Appendix D

AS BUILTS



NOTES:

The borehole information on this drawing has been summarised from the following borehole logs:-

(i) Northumberland County Council (Tarmac Construction Ltd.), 1971.
(ii) Northumberland County Council (Tarmac Construction Ltd.), 1974.
(iii) Northumberland County Council (B.B. Drilling Ltd.) 1979, taken during contract.
(iv) Soil Mechanics Ltd. 1979
(v) This drawing to be read in conjunction with the borehole logs, and Drg. No. 534/C/05.

Harris & Sutherland
Consulting Civil and Structural Engineers 38-42 Whitfield Street, London W1P 5RF 01-580 9052

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV	DATE	AMENDMENTS	CHK'D
Z	Nov'81	As constructed.	

LONDON – EDINBURGH – THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA

RIVER COQUET BRIDGE

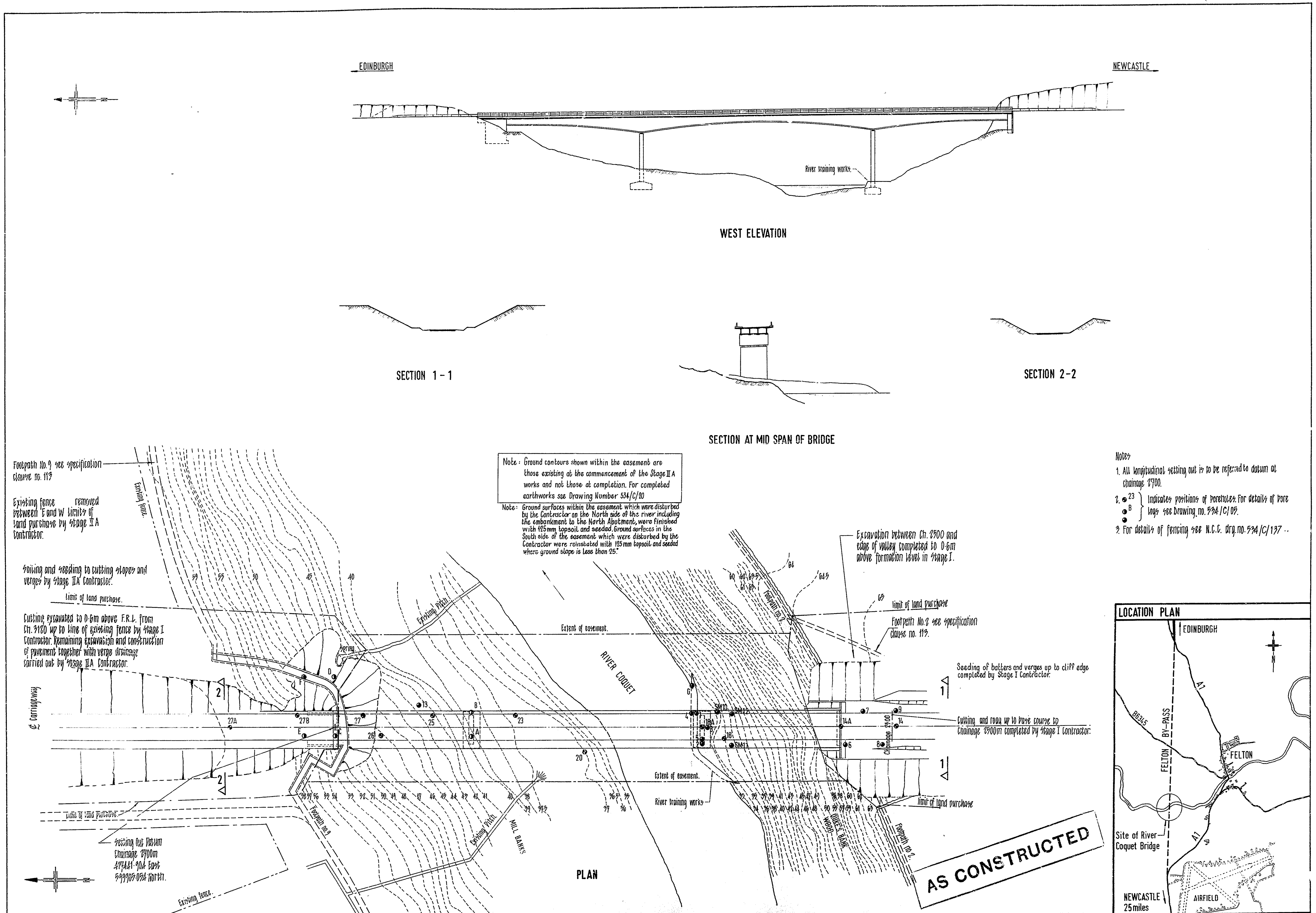
SOUTH PIER BOREHOLES

ORIGINAL DRG. SIZE (B1)	DRAWN I.S.	DATE Nov. '79	SCALE 1:50
	TRACED M.T.S.	Nov. '79	DRAWING No.
	CHECKED		534/CS/201Z
	APPROVED		

ARMSTRONG MICROFILMING LTD. DATE 22.3.84 ROLL № Roll 110

SCALE IN INCHES SCALE IN CENTIMETRES

30× 26× 21·2× 15× 12× 12× 15× 21·2× 26× 30×



Harris & Sutherland
Consulting Civil and Structural Engineers 38-42 Whitfield Street, London W1P 5RF 01-580 9052

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV.	DATE	AMENDMENT	CHK'D.
Z	Nov'81	As constructed.	

LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA.

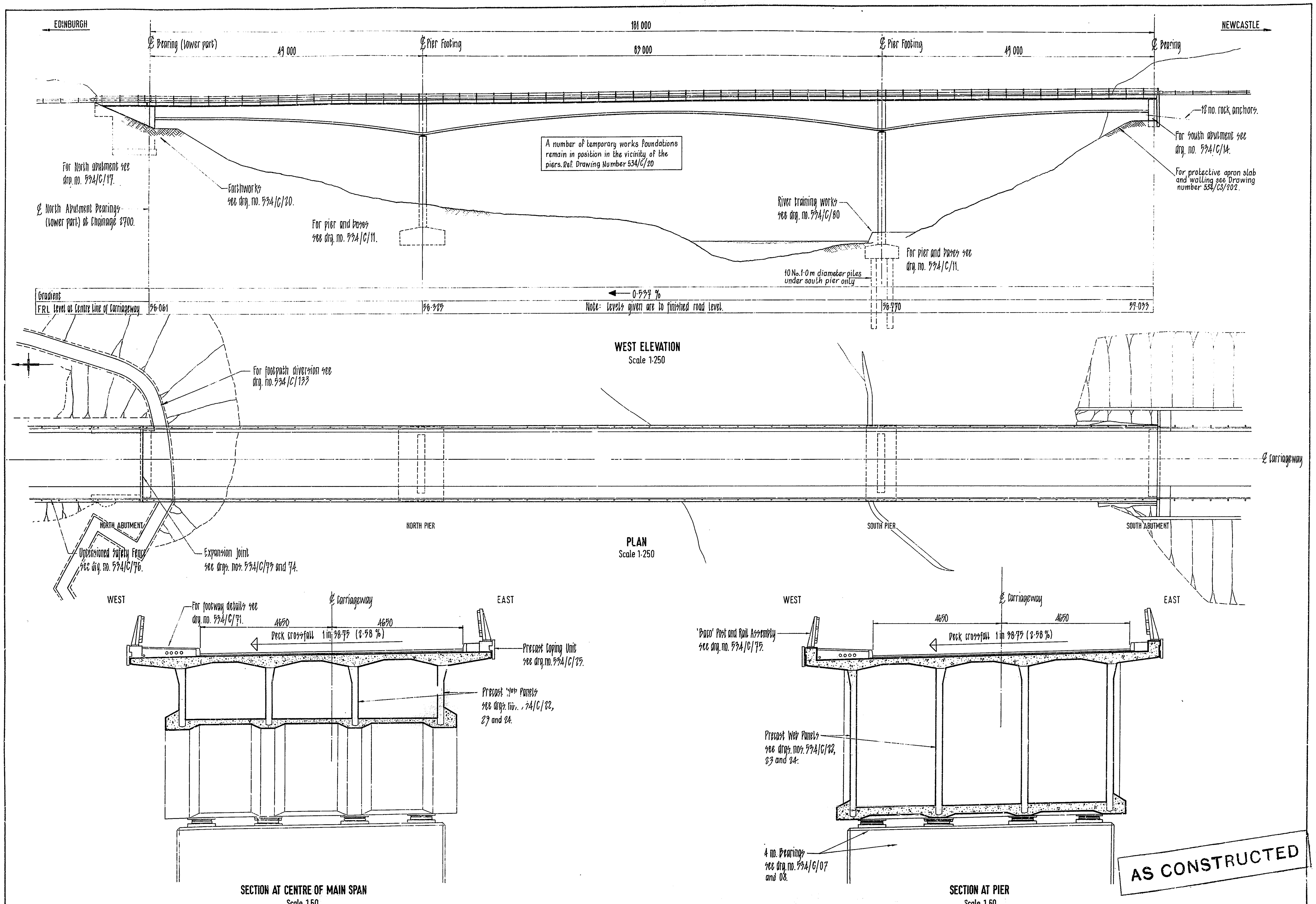
RIVER COQUET BRIDGE

LOCATION AND SITE PLAN

ORIGINAL DRG. SIZE (B1)

		DATE	
DRAWN	GP	Jan. '78	SCALE 1:500
TRACED			DRAWING No.
CHECKED	N.P.B.	Sept. 78	534/C/01Z
APPROVED			

REDUCED DRAWING 0 10 20 30 40 50 50mm ON ORIGINAL



Harris & Sutherland
Consulting Civil and Structural Engineers 55-65 Winfield Street, London 01-580 9052

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV.	DATE	AMENDMENT	CHK'D
ZA	Jan.84	East side pavement modified.	
Z	Nov.81	As constructed.	

LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA

RIVER COQUET BRIDGE

GENERAL ARRANGEMENT

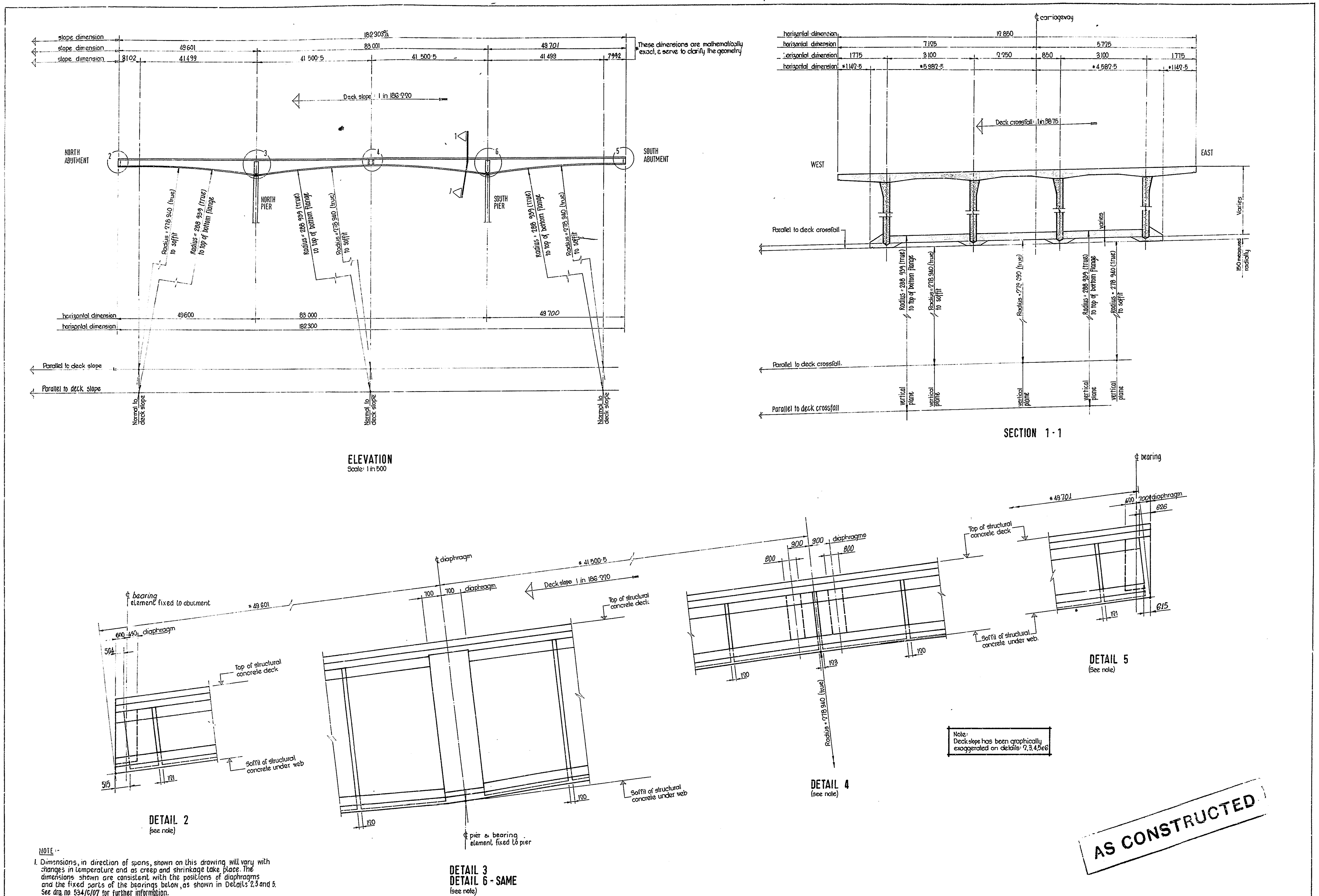
ORIGINAL DRG. SIZE (B1)

		DATE	
DRAWN		Jan.'78	SCALE As noted.
TRACED			DRAWING No.
CHECKED	N.P.B.	Sept. '78	534/C/02 ZA
APPROVED		Oct. '78	

REDUCED DRAWING 0 10 20 30 40 50 50mm ON ORIGINAL

ARMSTRONG MICROFILMING LTD. DATE ROLL № Roll 110 22.3.84

SCALE IN INCHES SCALE IN CENTIMETRES



NOTE :-

1. Dimensions, in direction of spans, shown on this drawing will vary with changes in temperature and as creep and shrinkage take place. The dimensions shown are consistent with the positions of diaphragms and the fixed parts of the bearings below, as shown in Details 2,3 and 5. See drg. no. 534/C/07 for further information.
2. For locations and dimensions of post-tensioning tendon anchorage ribs in bottom flange see drg. no. 534/C/62.

Harris & Sutherland
Consulting Civil and Structural Engineers 38-42 Whitfield Street, London W1P 5RF 01-580 9052

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV	DATE	AMENDMENT	CHK'D
Z	Nov.'81	As constructed.	

LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE II A

RIVER COQUET BRIDGE

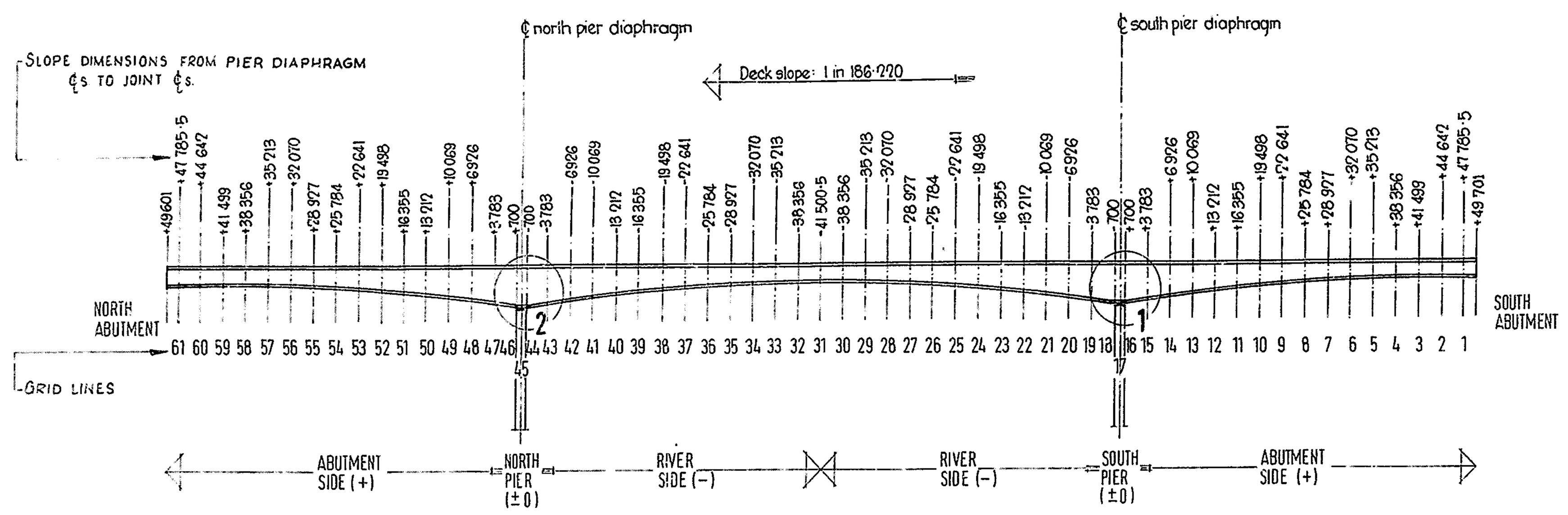
BOX GIRDER GEOMETRY SHEET 1

ORIGINAL DRG. SIZE (B1)	DRAWN T.M.P.	DATE Jan.'78
	TRACED	
	CHECKED N.P.B.	Sept.'78
	APPROVED B.M.F.	Oct.'78

SCALE 1 in 600; 1 in 50

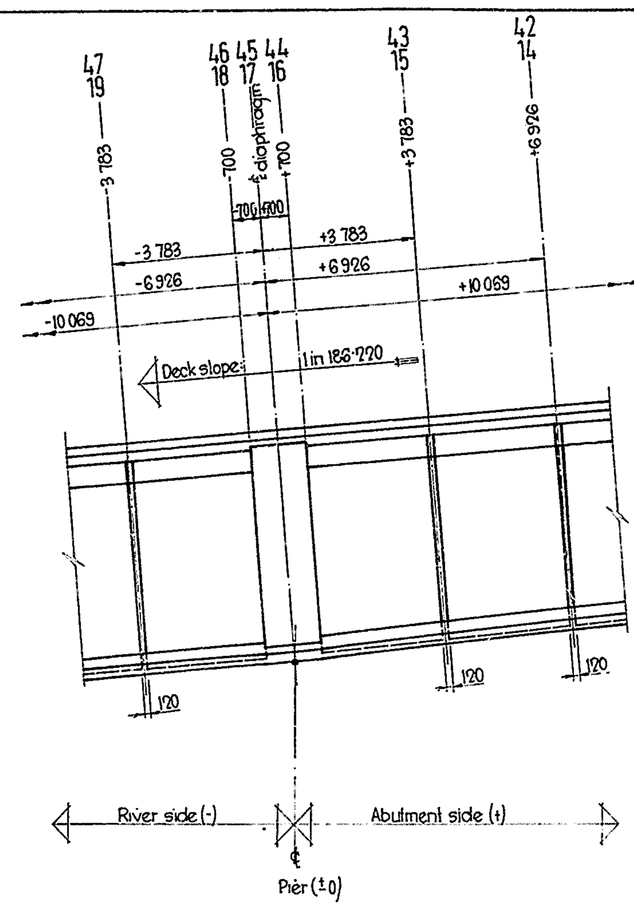
DRAWING No. 534/C/03Z

REDUCED DRAWING 0 10 20 30 40 50 50mm ON ORIGINAL



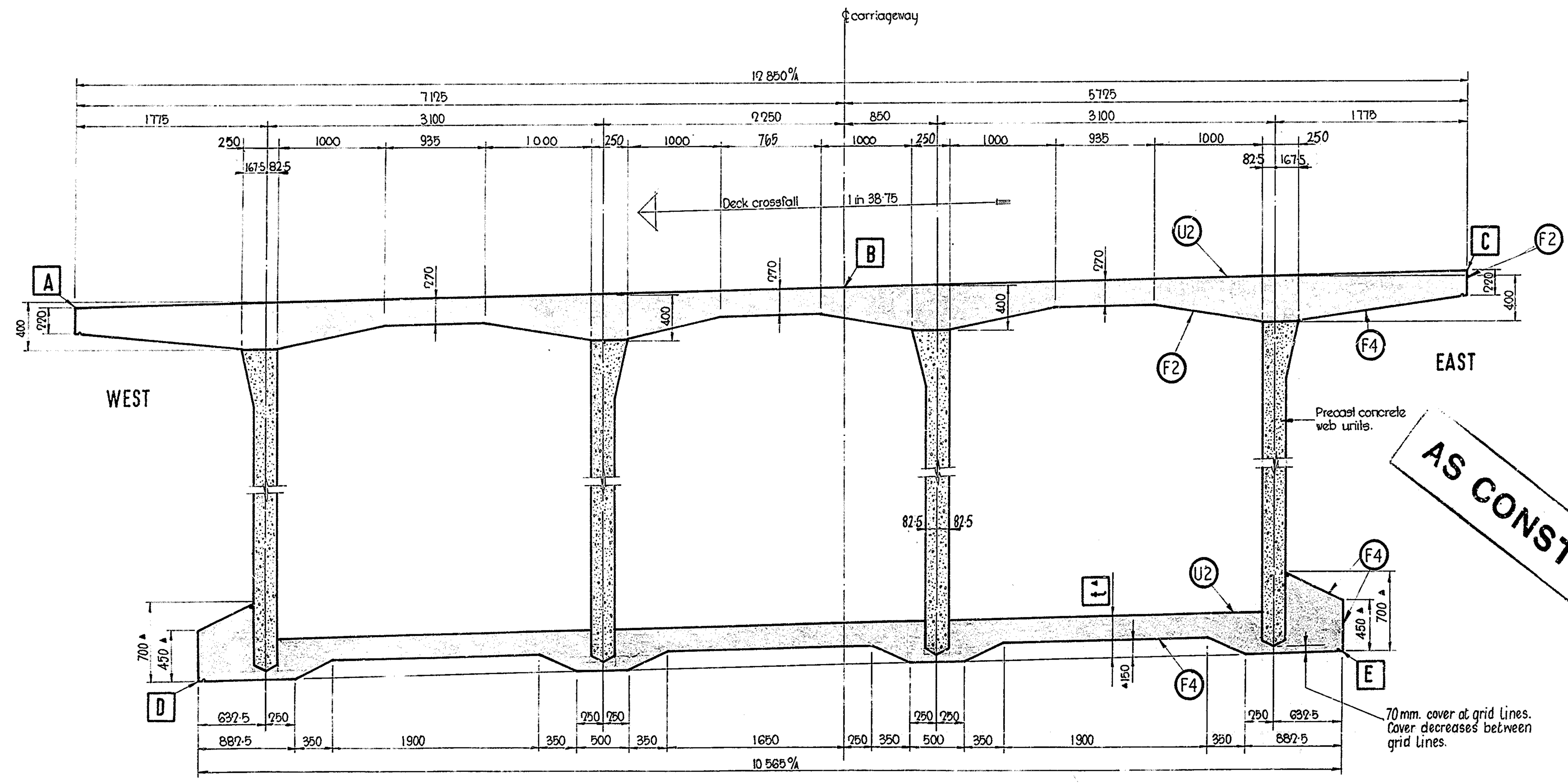
ELEVATION (Scale: 1 in 500)

Note:
1. Dimensions shown are mathematically exact & serve to clarify the geometry.
2. ¦ denotes construction joint ℄ between precast web units (see details 1 & 2)
3. soffit line between grid lines formed as a straight line.



DETAIL 1
DETAIL 2 - SAME (Scale: 1 in 100)
Note:
Deck slope has been graphically exaggerated.

These levels define theoretical finished deck levels and not as constructed finished deck levels.



TYPICAL CROSS - SECTION (Scale: 1 in 25)
Note:
1. For levels at points A, B, C, D, E & dimension 't' see tables this sheet & elevation above.
2. ▲ denotes that the dimension is perpendicular to the soffit - all other dimensions are either horizontal or vertical.

LEVELS OF NORTH PIER CANTILEVERS

	SLOPE DIMENSION FROM ℄ NORTH PIER DIAPHRAGM	GRID LINE	A	B	C	D	E	t mm.
ABUTMENT SIDE (+)	+0	45	56·033	56·217	56·365	50·563	50·835	——
	+700	46	56·029	56·213	56·361	50·559	50·831	see drg. 534/C/31
	+3783	47	56·012	56·196	56·344	50·980	51·252	435
	+6926	48	55·995	56·179	56·327	51·374	51·646	422
	+10 069	49	55·978	56·162	56·310	51·732	52·004	409
	+13 212	50	55·961	56·145	56·293	52·053	52·325	398
	+16 355	51	55·944	56·128	56·276	52·338	52·610	388
	+19 498	52	55·928	56·112	56·260	52·589	52·861	379
	+22 641	53	55·911	56·095	56·243	52·803	53·075	371
	+25 784	54	55·894	56·078	56·226	52·981	53·253	365
	+28 927	55	55·877	56·061	56·209	53·123	53·395	359
	+32 070	56	55·860	56·044	56·192	53·231	53·503	355
	+35 213	57	55·843	56·027	56·175	53·302	53·574	352
	+38 356	58	55·826	56·010	56·158	53·338	53·610	351
	+41 499	59	55·809	55·993	56·141	53·339	53·611	350
	+44 642	60	55·793	55·977	56·125	53·323	53·595	350
	+47 785·5	61	55·776	55·960	56·108	53·306	53·578	350
	+49 601	——	55·766	55·950	56·098	53·296	53·568	——
RIVER SIDE (−)	−0	45	56·033	56·217	56·365	50·563	50·835	——
	−700	44	56·037	56·221	56·369	50·567	50·839	see drg. 534/C/31
	−3783	43	56·053	56·237	56·385	51·021	51·293	435
	−6926	42	56·070	56·254	56·402	51·449	51·721	422
	−10 069	41	56·087	56·271	56·419	51·841	52·113	409
	−13 212	40	56·104	56·288	56·436	52·196	52·468	398
	−16 355	39	56·121	56·305	56·453	52·515	52·787	388
	−19 498	38	56·138	56·322	56·470	52·799	53·071	379
	−22 641	37	56·155	56·339	56·487	53·047	53·319	371
	−25 784	36	56·172	56·356	56·504	53·259	53·531	365
	−28 927	35	56·188	56·372	56·520	53·434	53·706	359
	−32 070	34	56·205	56·389	56·537	53·576	53·848	355
	−35 213	33	56·222	56·406	56·554	53·681	53·953	352
	−38 356	32	56·239	56·423	56·571	53·751	54·023	351
	−41 500·5	31	56·256	56·440	56·588	53·786	54·058	350

LEVELS OF SOUTH PIER CANTILEVERS

	SLOPE DIMENSION FROM ℄ SOUTH PIER DIAPHRAGM	GRID LINE	A	B	C	D	E	t mm.
ABUTMENT SIDE (+)	+0	17	56·479	56·663	56·811	51·009	51·281	——
	+700	16	56·483	56·667	56·815	51·013	51·285	see drg. 534/C/31
	+3783	15	56·499	56·683	56·831	51·467	51·739	435
	+6926	14	56·515	56·699	56·847	51·894	52·166	422
	+10 069	13	56·533	56·717	56·865	52·286	52·559	409
	+13 212	12	56·550	56·734	56·882	52·642	52·914	398
	+16 355	11	56·567	56·751	56·899	52·961	53·233	388
	+19 498	10	56·583	56·767	56·915	53·244	53·516	379
	+22 641	9	56·600	56·784	56·932	53·492	53·764	371
	+25 784	8	56·617	56·801	56·949	53·704	53·976	365
	+28 927	7	56·634	56·818	56·966	53·880	54·152	359
	+32 070	6	56·651	56·835	56·983	54·022	54·294	355
	+35 213	5	56·668	56·852	57·000	54·127	54·399	352
	+38 356	4	56·685	56·869	57·017	54·197	54·469	351
	+41 499	3	56·702	56·886	57·034	54·232	54·504	350
	+44 642	2	56·718	56·902	57·050	54·248	54·520	350
	+47 785·5	1	56·735	56·919	57·067	54·265	54·537	350
	+49 701	——	56·745	56·929	57·077	54·275	54·547	——
RIVER SIDE (−)	−0	17	56·479	56·663	56·811	51·009	51·281	——
	−700	18	56·475	56·659	56·807	51·005	51·277	see drg. 534/C/31
	−3783	19	56·458	56·642	56·790	51·426	51·698	435
	−6926	20	56·442	56·626	56·774	51·820	52·092	422
	−10 069	21	56·425	56·609	56·757	52·179	52·451	409
	−13 212	22	56·408	56·592	56·740	52·500	52·772	398
	−16 355	23	56·391	56·575	56·723	52·785	53·057	388
	−19 498	24	56·374	56·558	56·706	53·035	53·307	379
	−22 641	25	56·357	56·541	56·689	53·249	53·521	371
	−25 784	26	56·340	56·524	56·672	53·427	53·699	365
	−28 927	27	56·323	56·507	56·655	53·569	53·841	359
	−32 070	28	56·307	56·491	56·639	53·678	53·950	355
	−35 213	29	56·290	56·474	56·622	53·749	54·021	352
	−38 356	30	56·273	56·457	56·605	53·785	54·057	351
	−41 500·5	31	56·256	56·440	56·588	53·786	54·058	350

Note:
Levels at points A, B, C, D & E are given in metres; slope dimension & dimension 't' are given in mm.
Levels given in these tables are final levels after all creep & shrinkage has taken place & at a theoretical mean temperature of 10°C. They are not setting out levels. See Specification Clause 2904.

GENERAL NOTES:-

1. Dimensions, in direction of spans, shown on this drawing will vary with changes in temperature and as creep and shrinkage take place. The dimensions shown are consistent with the positions of diaphragms and the fixed parts of the bearings below, as shown in Details 2, 3 and 5 on Drg. No. 534/C/03.
2. Local changes in thickness of bottom flange for tendon anchorages are not shown on this drawing. This information is given on drg. 534/C/62.

GENERAL NOTES cont'd.

3. For details of drip grooves see Drg. 534/C/71
4. For details of seal at interface of web and bottom nib see Drg. 534/C/71.
5. Levels given are to structural concrete.
6. (F2) : Denotes type of finish.

GENERAL NOTES cont'd

7. Tolerances : Thicknesses of top and bottom flanges shall be within −3 mm and +6 mm of the dimensions stated on the drawings.

Harris & Sutherland
Consulting Civil and Structural Engineers 35-42 Whitfield Street, London W1P 5RJ 01-580 9052

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV.	DATE	AMENDMENT	CHK'D
Z	Nov.'81	As constructed.	

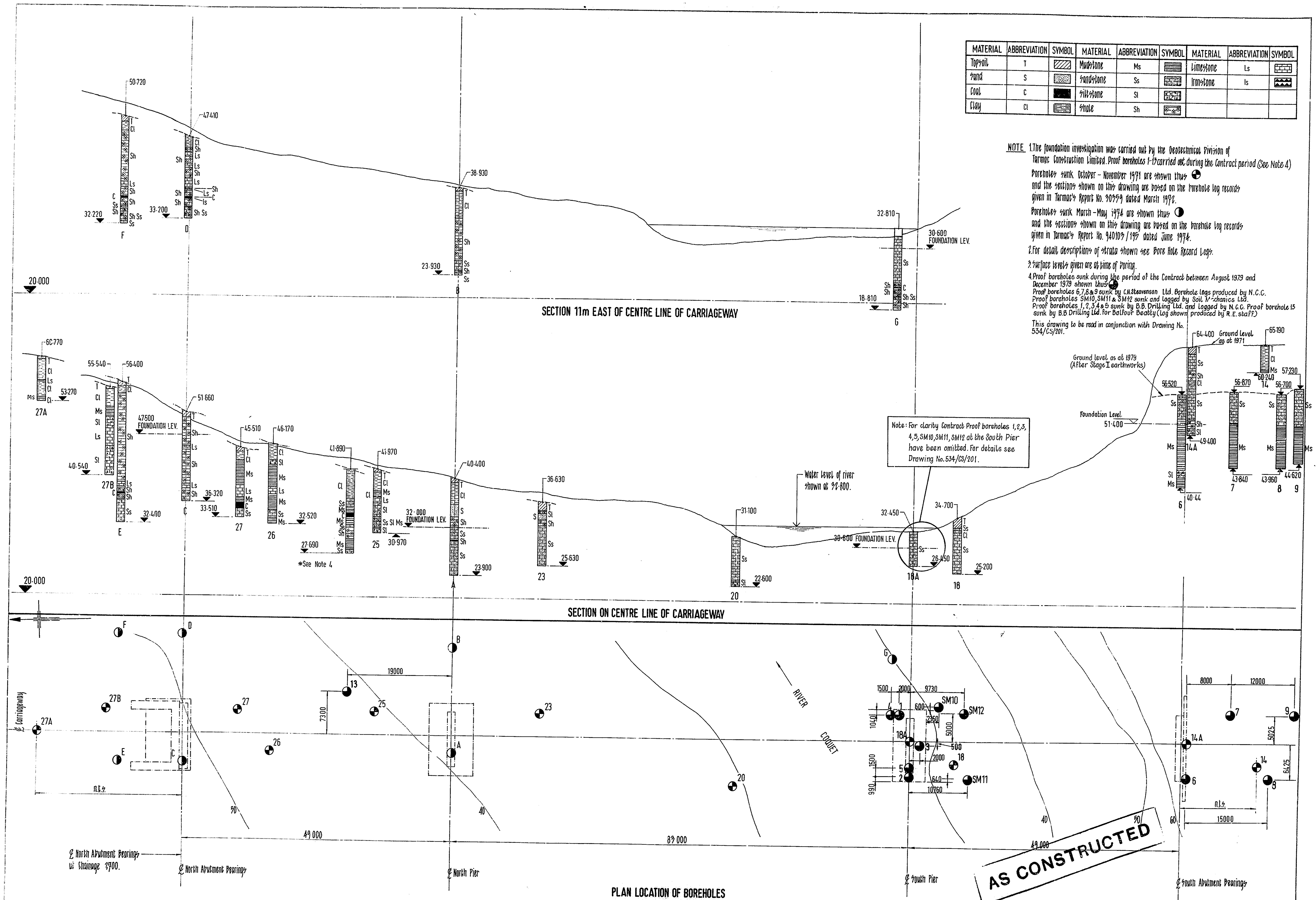
LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA

RIVER COQUET BRIDGE

BOX GIRDER GEOMETRY SHEET 2

ORIGINAL DRG. SIZE (B1)		DATE	
DRAWN	T.M.P.	Jan. '78	SCALE: As shown
TRACED			DRAWING No.
CHECKED N.P.B.		Sept. '78	534 / C / 04 Z
APPROVED B.M.F.			

REDUCED DRAWING
0 10 20 30 40 50
50mm ON ORIGINAL



MATERIAL	ABBREVIATION	SYMBOL	MATERIAL	ABBREVIATION	SYMBOL	MATERIAL	ABBREVIATION	SYMBOL
Topsoil	T		Mudstone	Ms		Limestone	Ls	
Sand	S		Sandstone	Ss		Ironstone	Is	
Coal	C		Siltstone	Sl				
Clay	Cl		Shale	Sh				

NOTE 1. The foundation investigation was carried out by the Geotechnical Division of Tarmac Construction Limited. Proof boreholes 1-13 carried out during the Contract period (See Note 4)
Boreholes sunk October - November 1971 are shown thus ⊕
and the sections shown on this drawing are based on the borehole log records given in Tarmac's Report No. 30359 dated March 1972.
Boreholes sunk March - May 1974 are shown thus ◑
and the sections shown on this drawing are based on the borehole log records given in Tarmac's Report No. 940103/195 dated June 1974.
2. For detail descriptions of strata shown see Bore Hole Record Logs.
3. Surface levels given are at time of boring.
4. Proof boreholes sunk during the period of the Contract between August 1979 and December 1979 shown thus ●
Proof boreholes 6,7,8 & 9 sunk by C.H.Steavenson Ltd. Borehole logs produced by N.C.C.
Proof boreholes SM10, SM11 & SM12 sunk and logged by Soil Mechanics Ltd.
Proof boreholes 1,2,3,4 & 5 sunk by B.B. Drilling Ltd. and logged by N.C.C. Proof borehole 13 sunk by B.B Drilling Ltd. for Balfour Beatty (Log shown produced by R.E. staff)
This drawing to be read in conjunction with Drawing No. 534/CS/201.

Harris & Sutherland
Consulting Civil and Structural Engineers

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV.	DATE	AMENDMENT	CHK'D
Z	Nov.'81	As constructed.	

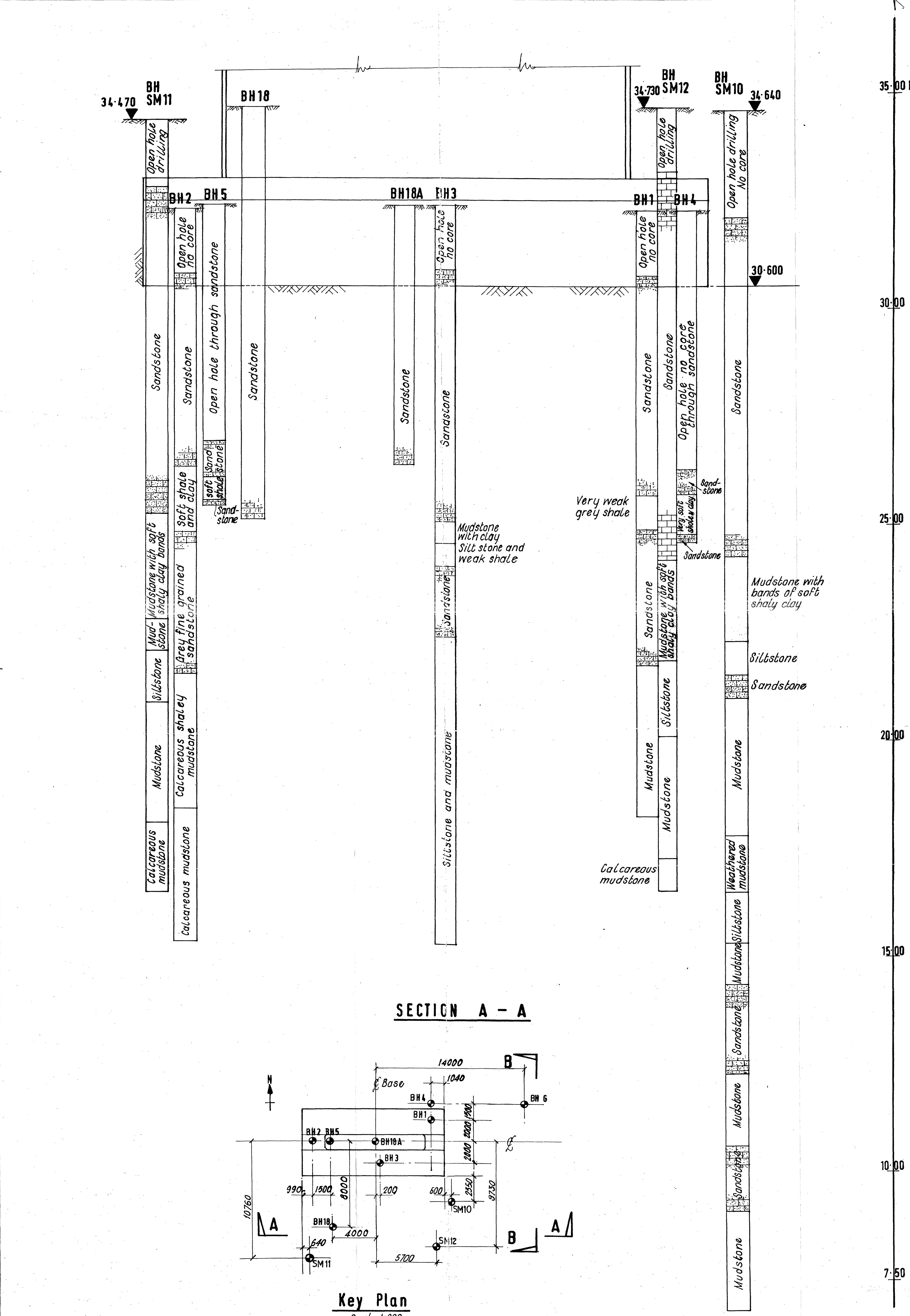
LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA

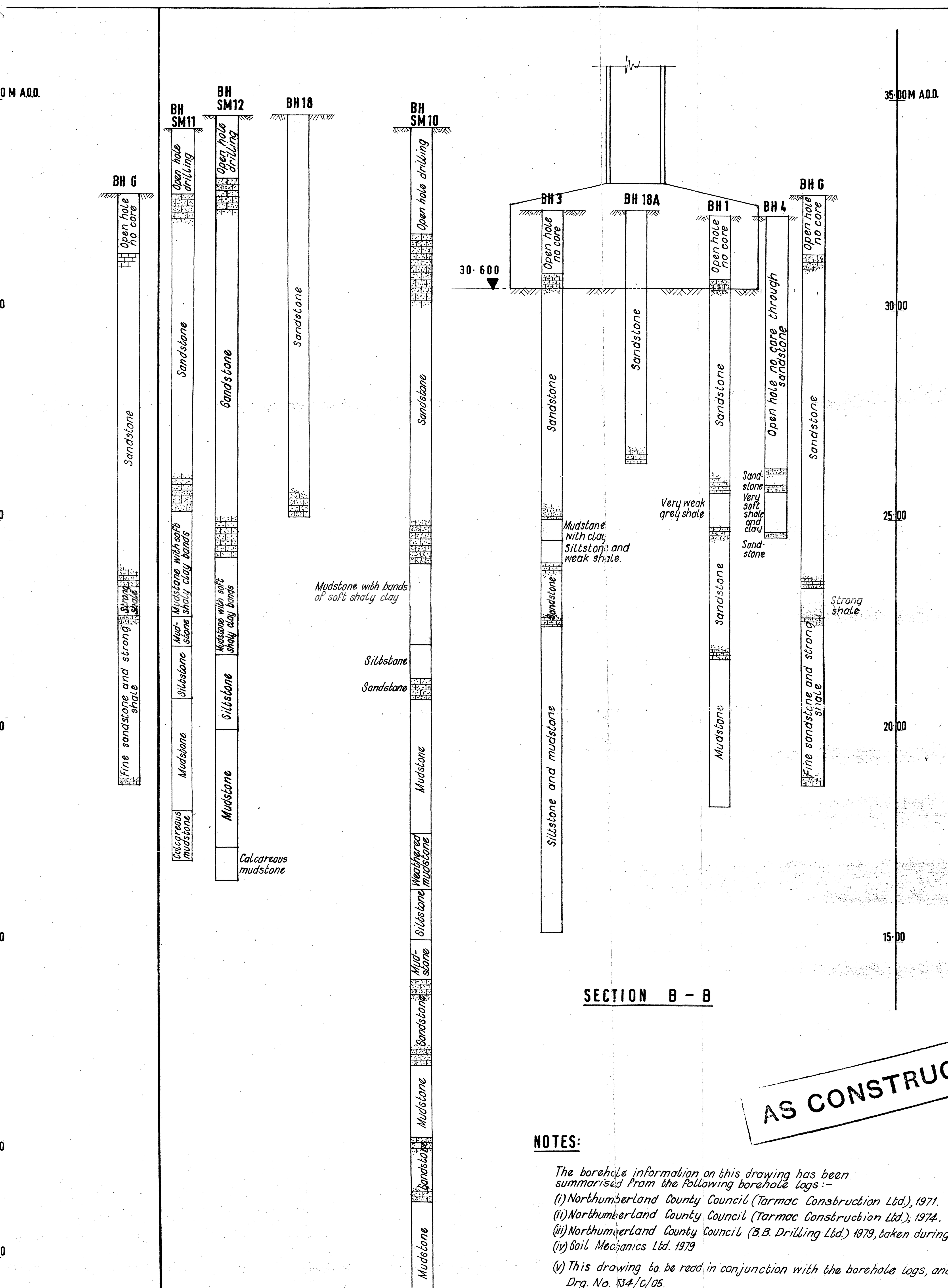
RIVER COQUET BRIDGE

SITE INVESTIGATION

ORIGINAL DRG. SIZE (B1)			
DRAWN		DATE Jan.'78	SCALE 1:25
TRACED			DRAWING No.
CHECKED N.P.B.	Sept.'78		534 / C / 05 Z
APPROVED B.M.F.	Oct.'78		

REDUCED DRAWING 0 10 20 30 40 50 50mm ON ORIGINAL





AS CONSTRUCTED

NOTES:

The borehole information on this drawing has been summarised from the following borehole logs:–

(i) Northumberland County Council (Tarmac Construction Ltd.), 1971.
(ii) Northumberland County Council (Tarmac Construction Ltd.), 1974.
(iii) Northumberland County Council (B.B. Drilling Ltd.) 1979, taken during contract.
(iv) Soil Mechanics Ltd. 1979
(v) This drawing to be read in conjunction with the borehole logs, and Drg. No. 534/C/05.

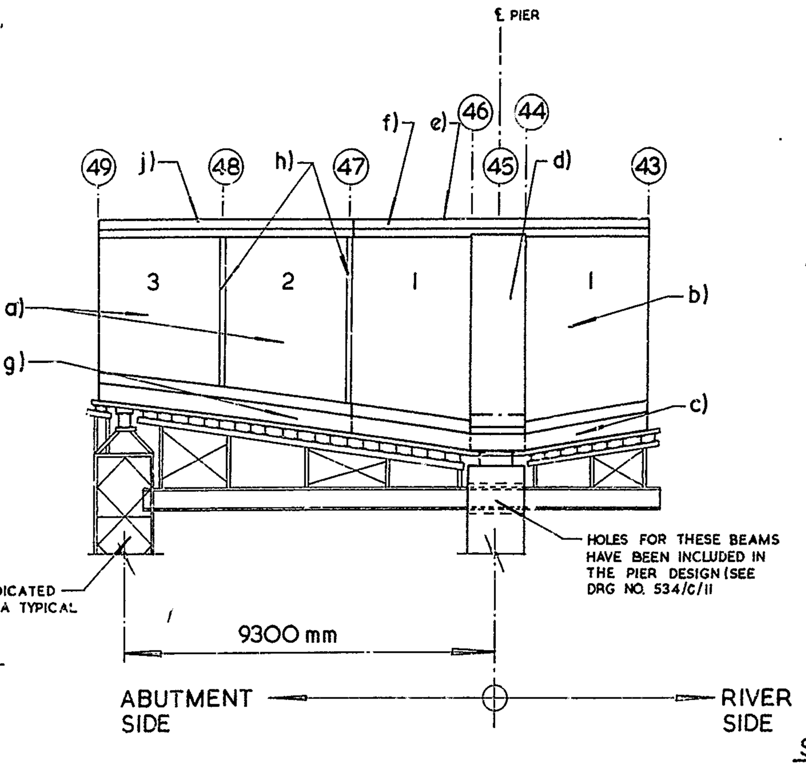
Harris & Sutherland Consulting Civil and Structural Engineers 38-42 Whitfield Street, London W1P 5RF 01-580 9052	Z Nov '81 As constructed.	LONDON – EDINBURGH – THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA	ORIGINAL DRG. SIZE (B1)
DEPARTMENT OF TRANSPORT NORTHERN REGIONAL OFFICE NEWCASTLE UPON TYNE	REV DATE AMENDMENTS CHK'D	RIVER COQUET BRIDGE **SOUTH PIER BOREHOLES**	DRAWN I.S. DATE Nov. '79 TRACED M.T.S. Nov. '79 CHECKED APPROVED
			SCALE 1:50 DRAWING No. 534/CS/201Z

c.j. = construction joint

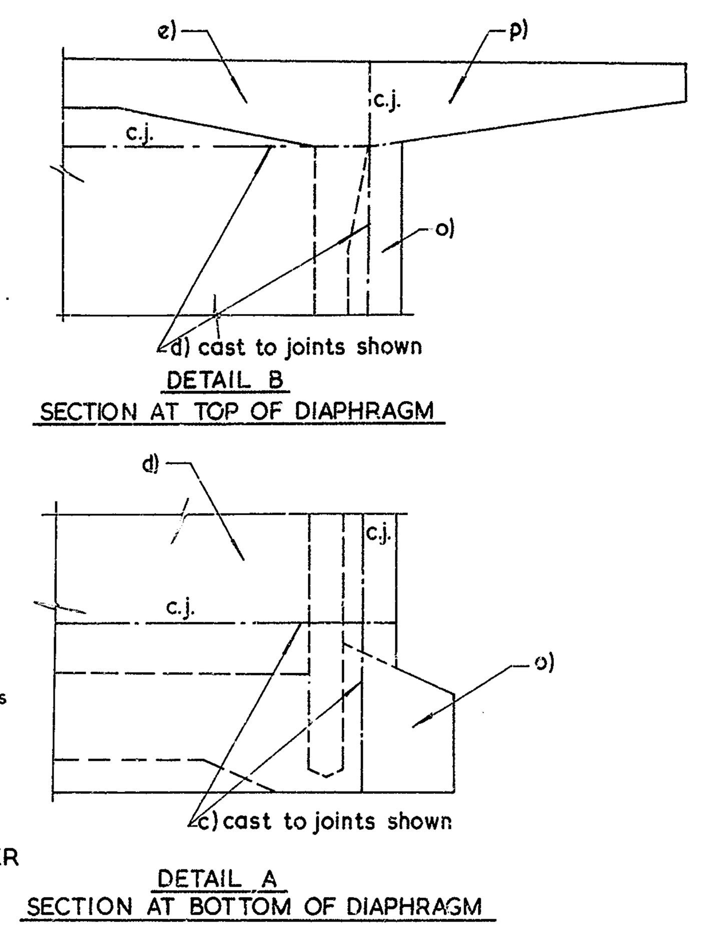
STAGE 1

(a) Erect the 12 web panels on the abutment side.
(b) Erect the 4 web panels on the river side.
(c) Cast bottom flange for segments 1 and diaphragm kicker, but excluding nibs over width of pier diaphragm, see Detail A.
(d) Cast diaphragm, but see Details A & B.
(e) Cast top flange for segments 1 and over the diaphragm, but excluding cantilevers over width of pier diaphragm.
(f) Post-tension bars no. 16, 18, 17, 85, 87 & 86 between grid lines 45 & 47 (see drawing 534/C/50- Section adjacent to ℄ 47).
(g) Cast bottom flange for segments 2 & 3 on the abutment side
(h) Cast web joints between segments 1, 2, and 3 on the abutment side.
(j) Cast top flange for segments 2 and 3 on the abutment side.
(k) Post-tension bars no. 43, 45, 44, 58, 60 59, 19, 21, 20 82, 84, 83, 13, 15, 14, 88, 90, 89 @ ℄ 45.
(l) Post-tension bars no. 106, 105, 107, 104, 108, 112, 113, 111, 114, 110, 115 @ ℄ 49.
(m) Post-tension the transverse diaphragm tendons see drawing 534/C/34
(n) Couple bars no. 103 and 109.
(o) Cast bottom flange nibs at the diaphragm and the ends of the diaphragm (see Details A & B).
(p) Cast top flange cantilevers at the diaphragm.
(q) Post-tension bars no. 7, 8, 9, 94, 96 and 95.
(r) Post-tension bars no. 103 & 109.

Note: Construction Stage 27 completed in the following order:- 27(a) to 27(c) 27(g), 27(d), 27(h), 27(e), 27(j), 27(k) to 27(r). Stage 27(f) omitted [See Drg. 534/C/41]



CONSTRUCTION STAGE 1 (HAMMERHEAD)
CONSTRUCTION STAGE 27 (Similar but handed)



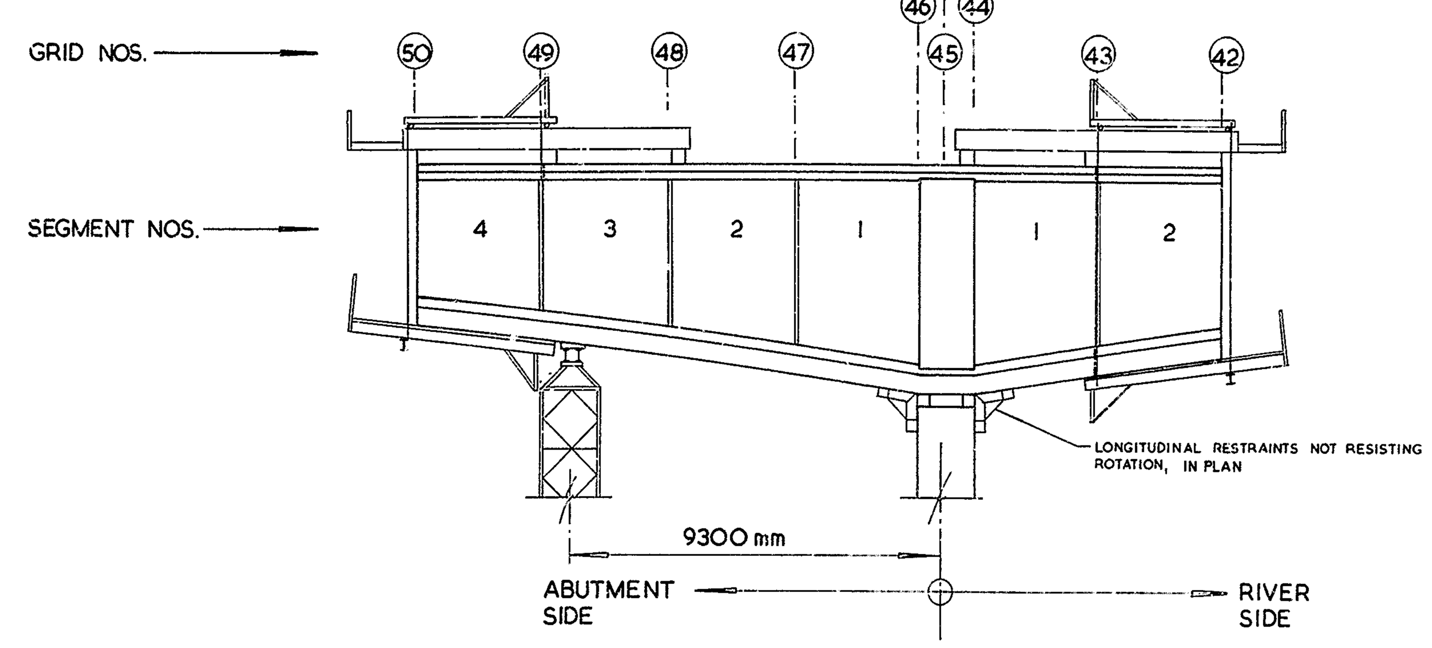
STAGE 2 (Abutment side)

(a) Complete erection of cantilever carriage.
(b) Erect web panels for segment 4.
(c) Cast bottom flange, web joints and top flange.

STAGE 3 (River side)

(a) As for Stage 2.
(b) Erect web panels for segment 2.
(c) As for Stage 2.

NOTE: The hammerhead soffit falsework may be removed after completion of the hammerhead. When this is done temporary longitudinal restraints must be provided e.g. as shown here.



CONSTRUCTION STAGES 2 AND 3 (COMMENCE CANTILEVER CONSTRUCTION)
CONSTRUCTION STAGES 28 AND 29 (Similar but handed)

STAGE 4 (Abutment side)

(a) Post tension at end of segment 4
(b) Move cantilever carriage forward
(c) Erect segment 5 web panels and cast bottom flange web joints and top flange.

STAGES 5 - 24 (Alternately river side - abutment side - river side)

Each segment constructed similarly to segment 4.

At any time there are either 2 or 3 more segments cast on the abutment side of the pier than on the river side.

STAGE 25 (River side)

(a) Post-tension at end of segment 12
(b) Move cantilever carriage forward
(c) Erect the four segment 13 web panels. Cast bottom flange up to diaphragm and diaphragm kicker. Cast diaphragm. Cast top flange up to and including the diaphragm and web joints.

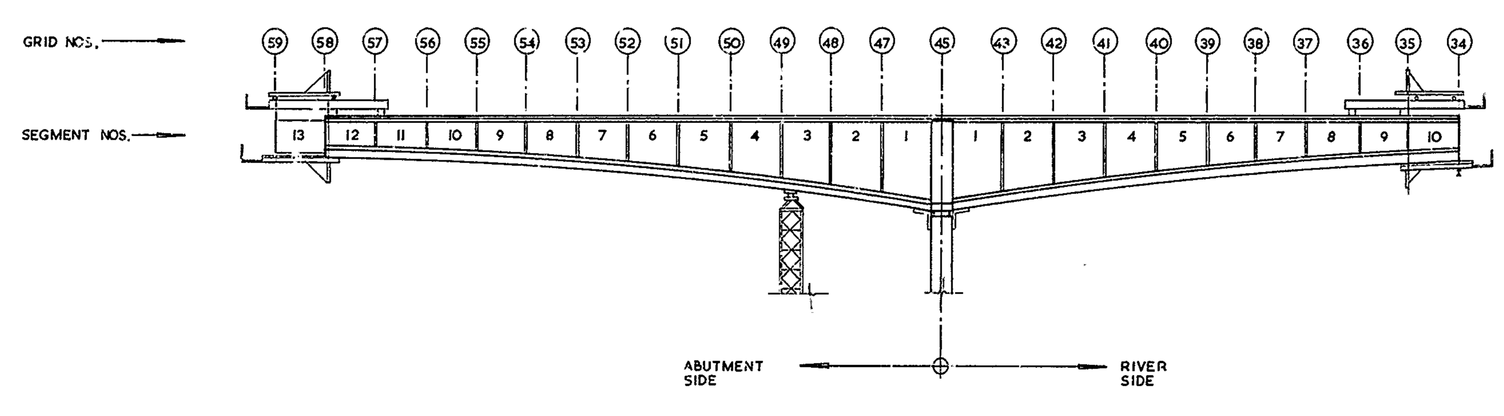
NOTE:

The centre joining steelwork must be cast into the diaphragm at this stage.

STAGE 26 (Abutment side and river side)

Post-tension at the end of segment 15 on the abutment side and segment 13 on the river side.

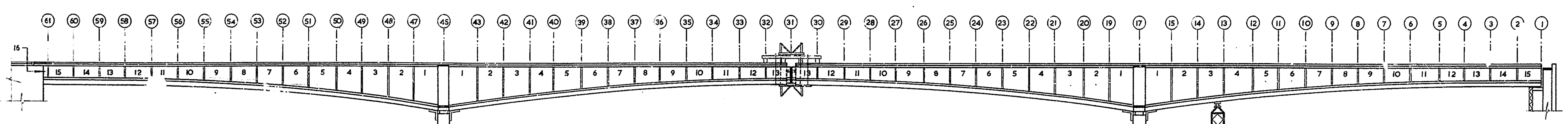
Stage 26 completes cantilever construction for the north half. The cantilever carriages may be removed in any order.



CONSTRUCTION STAGES 4 - 26
CONSTRUCTION STAGES 30 - 52 (Similar but handed)

GENERAL NOTES

(i) The term 'cast' implies that all steel reinforcement, ducts, etc., have previously been correctly positioned.
(ii) The superstructure construction sequence is identical for construction from the north pier or from the south pier until segment 15 on the abutment side and segment 13 on the river side have been post-tensioned. This phase of construction is therefore described for the north half only (construction stages 1-25) either half may be built first or both simultaneously.
(iii) A travelling point load of 250 kN has been allowed for at any position during any phase of cantilever construction.
(iv) The temporary prop shall have sufficient compressive and tensile resistance to meet the requirements of section 2900 of the Specification.
The rigidity of the prop, both laterally and vertically, shall be adequate for the Contractor's erection proposals. In addition, the following limits shall apply:
Laterally ± 5mm. for max. working loads.
Vertically ± 3mm. for max. wind loading.
(v) The temporary prop should at all times be located as shown under construction Stage 1.
(vi) Some variation is possible during the later construction stages depending on which half is built first. An acceptable sequence is shown here assuming that the north half is constructed first.
Construction Stages 27-52 are concerned with the construction of the south half up to segment 15, abutment side and segment 13, river side.
(vii) Stages 53 and 54 may be completed before Stage 27 etc. (If this is done only one main prop is required.)
(viii) The rigidity of the cantilever carriage structure and the placing sequence of the insitu concrete elements of a segment shall be such that cracking (particularly between the precast element and the joint infill) shall be avoided.



CONSTRUCTION STAGES 53-58

STAGE 53

(a) Prevent vertical deflection of tip of abutment arm using props and ties at segment 15 - north abutment end of cantilever.
(b) Set abutment bearings and erect formwork for segment 16 (this formwork and the top of the bearings should be rigidly fixed to segment 15 to ensure that segment 16 moves longitudinally with the rest of the north half while curing.
(c) Erect the two segment 16 web panels and cast segment 16.

STAGE 54

(a). Post-tension bottom tendons and remaining top tendons at end of segment 16 (curtain wall not to be cast until after centre joint complete).
(b). Remove segment 16 formwork, and main prop at segment 3 (longitudinal restraints at pier should remain in position at this stage). Prop/tie at segment 15 to remain in position until completion of construction Stage 58. Any preload in the tie is to be removed prior to commencement of Stage 58.

STAGE 57

(For details of centre joint steelwork see drawing no. 534/C/35. For special requirements dependent on temperature conditions see Specification).
(a). Position cantilever carriage centrally over joint.
(b). Jack the north half away from or towards the south half as required. The longitudinal restraints at the north pier should be removed.
(c) Remove any differential deflection at centre using centre joint steelwork. Bolt joint (Access through centre diaphragm) Refer to Drg 534/C/36 for limitation on vertical alignment jacking forces.
(d) Cast centre joint.

STAGE 58

(a) Post tension the first six strand tendons across the centre joint.
(b) Disconnect the bolts in the centre joint steelwork.
(c) Post tension the next nine strand tendons.
(d) Post tension the six Macalloy tendons in the top flange.
(e) Post tension the remaining 15 strand tendons.

STAGE 55

(a) Prevent vertical deflection of tip of abutment arm using prop and ties at segment 15 - South Abutment end of Cantilever.
This restraint shall remain in place until completion of Stage 58. Any preload in the tie is to be removed prior to commencement of Stage 58.
(b) Temporarily anchor segment 15 longitudinally to the solid rock behind the South Abutment, adjusting the position of the South half of the bridge, if necessary, such that the end of segment 15 (bottom) is 1276 mm from bearing centre line as shown on Section G-G on drawing 534/C/31.
The maximum forces to be resisted are approximately +/- 200 KN (exact forces depend on temperature when segment 16 is cast).
(c) Erect the two segment 16 web panels and cast segment 16.

STAGE 56

(a) Post tension bottom tendons and remaining top tendons at end of segment 16.
(b) Remove segment 16 formwork, the main prop at segment 3 and the longitudinal restraint at the South pier.

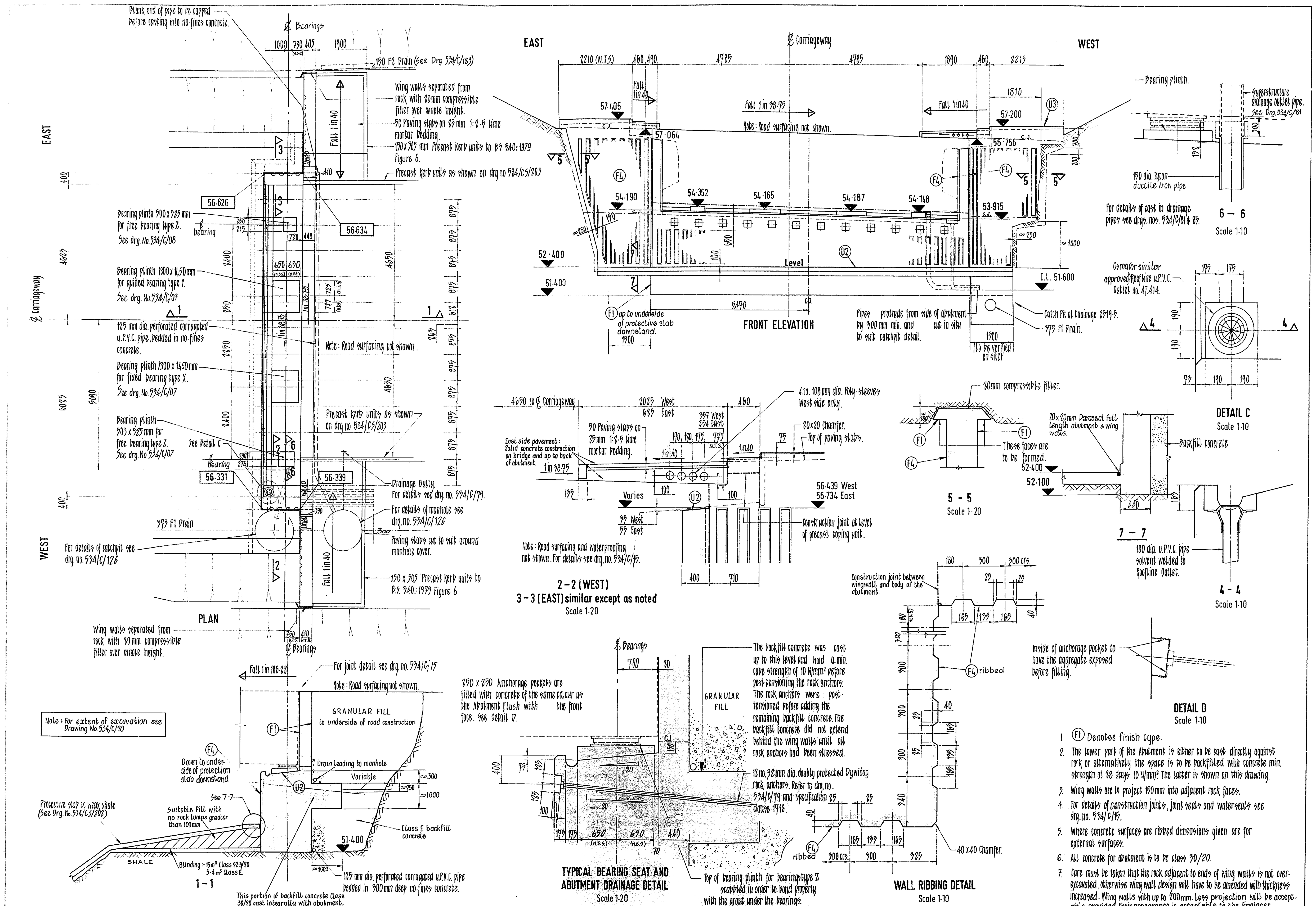
AS CONSTRUCTED

Harris & Sutherland Consulting Civil and Structural Engineers 38-42 Whitfield Street London W1P 5RF 01-580 9052 DEPARTMENT OF TRANSPORT NORTHERN REGIONAL OFFICE NEWCASTLE UPON TYNE	REV. Z / DATE Nov.'81 / AMENDMENT As constructed. / CHK'D	LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA RIVER COQUET BRIDGE SUPERSTRUCTURE CONSTRUCTION SEQUENCE (CONSISTENT WITH DESIGN)	ORIGINAL DRG. SIZE (B1)
DRAWN L.M.S.	DATE Jan.'78	SCALE	
TRACED		DRAWING No. 534/C/06 Z	
CHECKED N.P.B.	Sept.'78		
APPROVED B.M.F.	Oct.'78		

REDUCED DRAWING 0 10 20 30 40 50 50mm ON ORIGINAL

ARMSTRONG MICROFILMING LTD. DATE ROLL Nº Roll 110 22.3.84

SCALE IN INCHES SCALE IN CENTIMETRES



Harris & Sutherland

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV	DATE	AMENDMENT
A	10-1-80	Rock anchors revised.
ZA	Jan.84	East side pavement modified.
Z	Apr.83	As constructed.

LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA

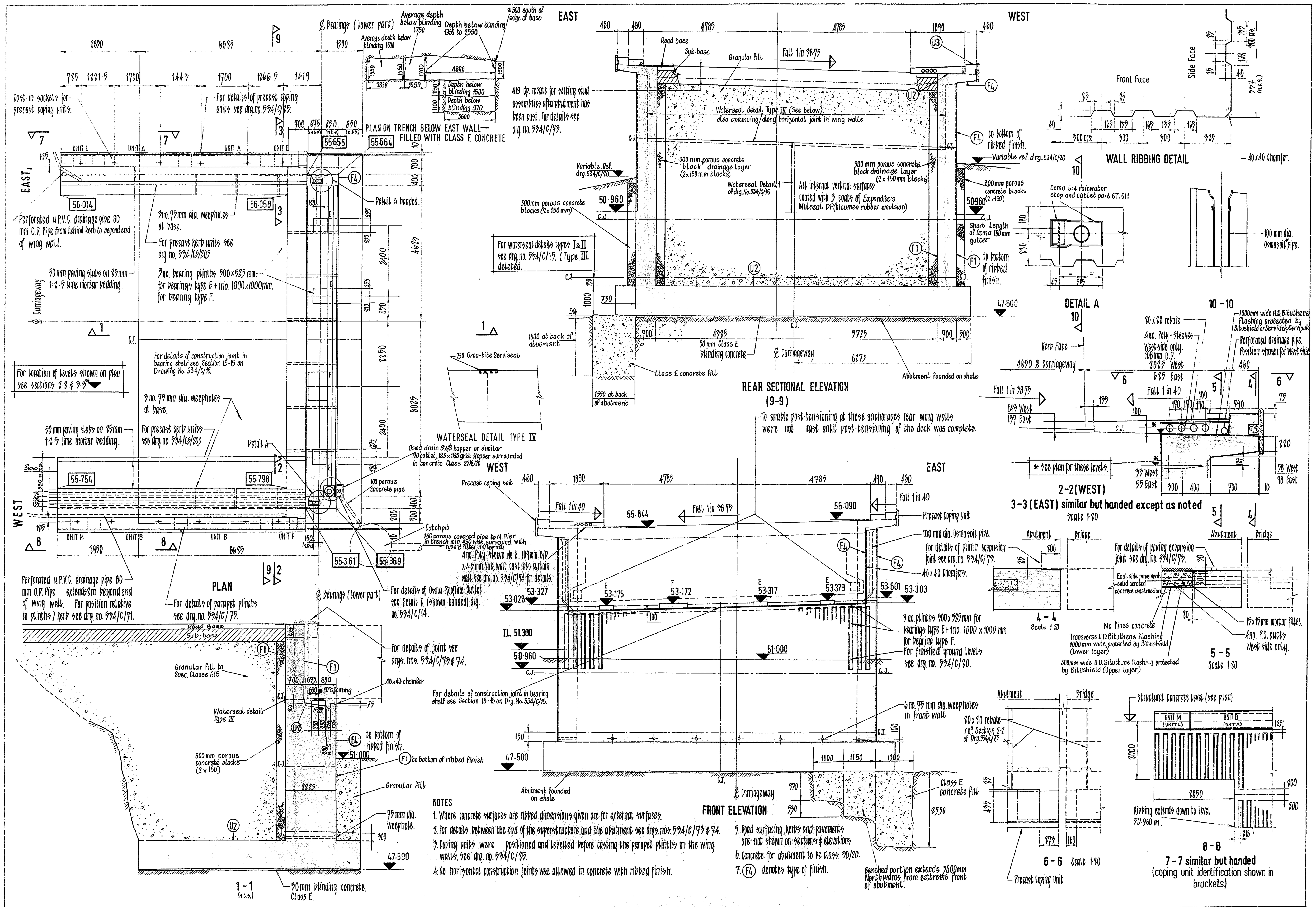
RIVER COQUET BRIDGE

SOUTH ABUTMENT GENERAL ARRANGEMENT

AS CONSTRUCTED

ORIGINAL DRG. SIZE (B1)	DRAWN	DATE Jan. '78	SCALE 1:50 unless noted otherwise
	TRACED		DRAWING No.
	CHECKED N.P.B.	Sept. '78	534/C/14ZA
	APPROVED B.M.F.	Oct. '78	

REDUCED DRAWING — 0 10 20 30 40 50 — 50mm ON ORIGINAL



Harris & Sutherland

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV.	DATE	AMENDMENT
ZA	Jan '84	East side pavement modified.
Z	April '81	As constructed.

LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA

RIVER COQUET BRIDGE

NORTH ABUTMENT GENERAL ARRANGEMENT

AS CONSTRUCTED

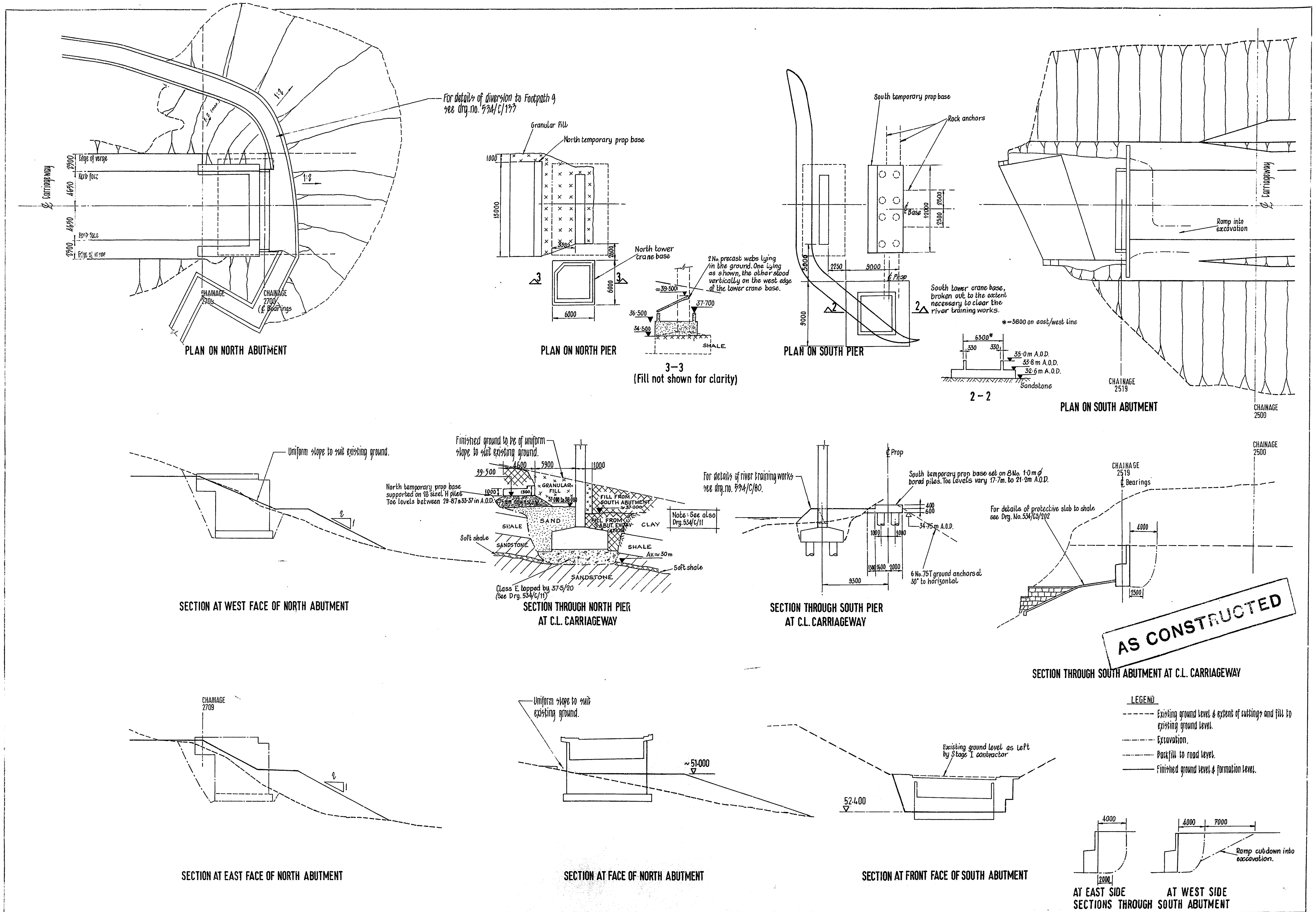
ORIGINAL DRG. SIZE (B1)

DRAWN: GB — DATE: Jan. '78
TRACED
CHECKED: RPB — Sept '78
APPROVED: SHF — Oct '78

SCALE: 1:50 unless noted otherwise

DRAWING No. 534/C/17ZA

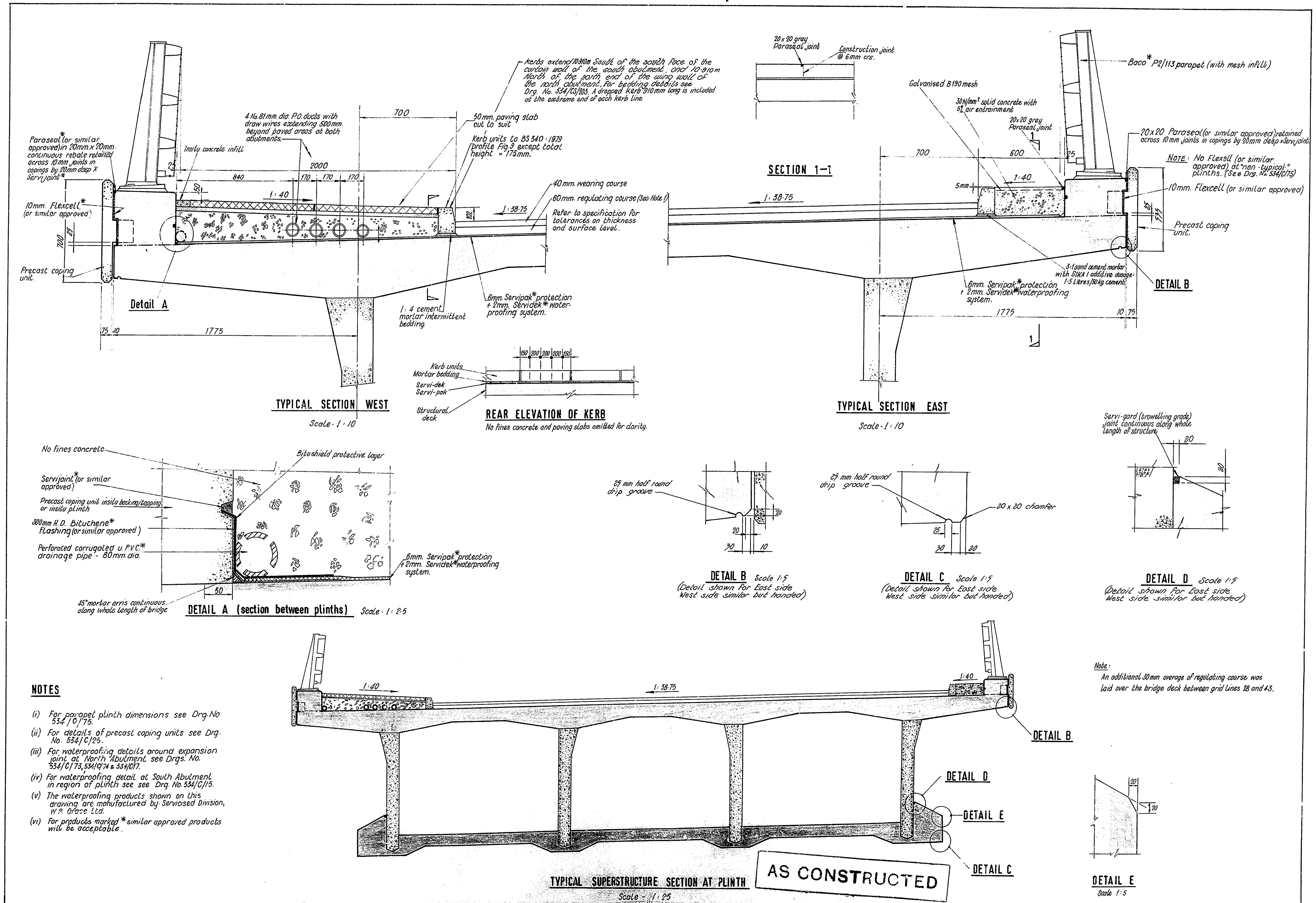
REDUCED DRAWING — 0 10 20 30 40 50 — 50mm ON ORIGINAL



Harris & Sutherland, Consulting Civil and Structural Engineers	LONDON – EDINBURGH – THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE II A	ORIGINAL DRG. SIZE (B1)
DEPARTMENT OF TRANSPORT NORTHERN REGIONAL OFFICE NEWCASTLE UPON TYNE	RIVER COQUET BRIDGE	
Z April '80 As constructed. (REV. DATE AMENDMENT CHK'D)	EARTHWORKS DETAILS TO PIERS AND ABUTMENTS	

DRAWN		DATE Jan. '78	SCALE 1:200
TRACED			DRAWING No.
CHECKED	N.P.B.	Sept. '78	534/C/20 Z
APPROVED	B.M.F.	Oct. '78	

REDUCED DRAWING — 0 10 20 30 40 50 — 50mm ON ORIGINAL



ZA	Jan '84	East side pavement modified. West kerb relaid on intermittent bedding.	
Z	Feb '82	As constructed.	
REV	DATE	AMENDMENT	CHKD

Harris & Sutherland
Consulting Civil and Structural Engineers

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

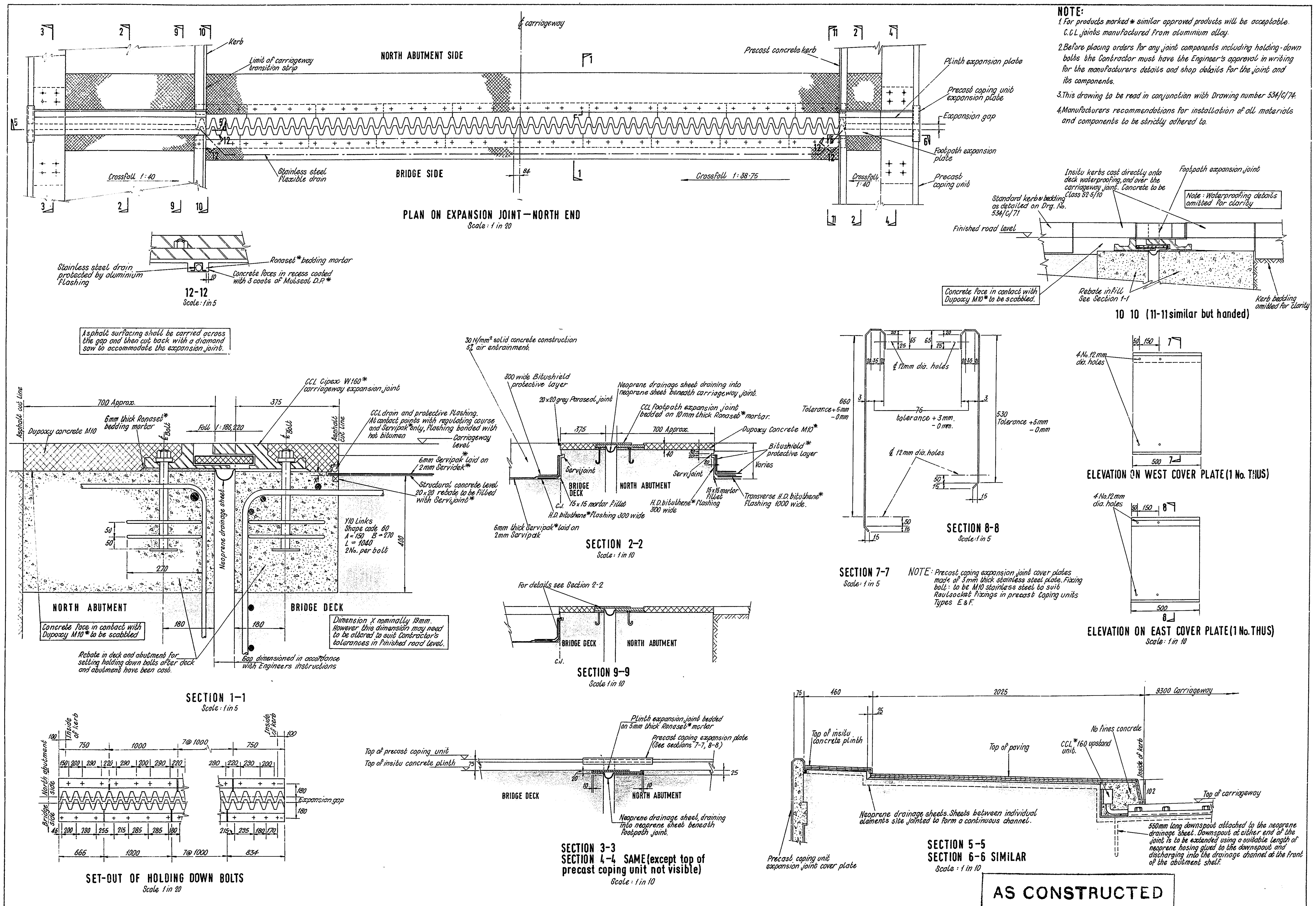
LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE II A

RIVER COQUET BRIDGE

FOOTWAY AND DECK WATERPROOFING DETAILS AND DRIP GROOVE DETAIL

ORIGINAL DRG. SIZE (B1)	DRAWN	DATE Jan. '78	SCALE As shown
	TRACED		DRAWING No.
	CHECKED N.P.B.	Sept. '78	534/C/71ZA
	APPROVED B.M.F.	Oct. '78	

REDUCED DRAWING — 0 10 20 30 40 50 — 50mm ON ORIGINAL



NOTE:
1. For products marked * similar approved products will be acceptable. C.C.L. joints manufactured from aluminium alloy.
2. Before placing orders for any joint components including holding-down bolts the Contractor must have the Engineer's approval in writing for the manufacturers details and shop details for the joint and its components.
3. This drawing to be read in conjunction with Drawing number 534/C/74.
4. Manufacturers recommendations for installation of all materials and components to be strictly adhered to.

AS CONSTRUCTED

Harris & Sutherland
Consulting Civil and Structural Engineers

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

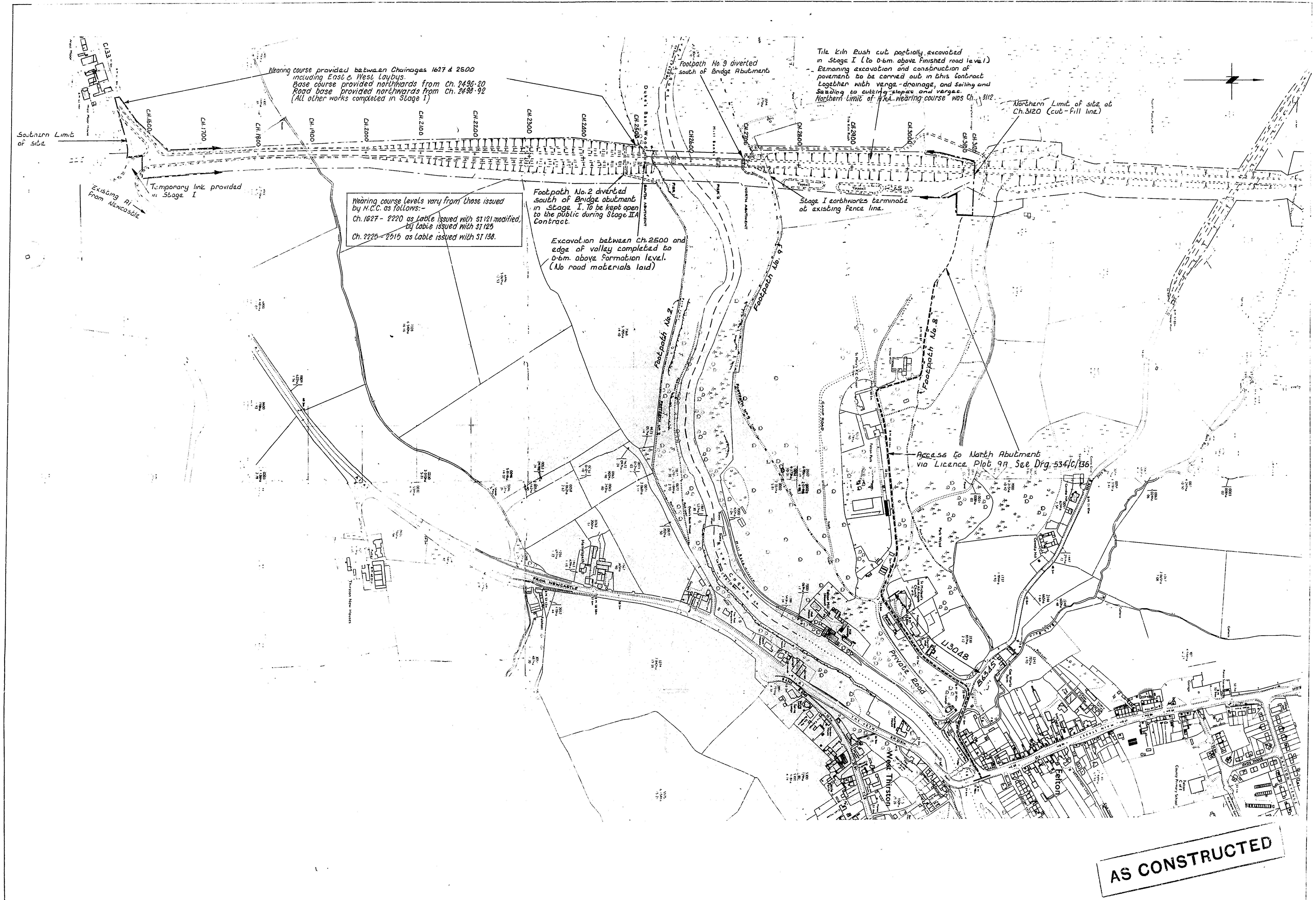
REV	DATE	AMENDMENTS
	Jan.'81	Drawing re-drawn. Joint changed to CCL from PSC at Contractor's request.
A	Jan.'81	CCL plinth joint added. 10-10, 11-11 and 12-12 added.
Z	Nov.'81	As constructed.
ZA	Jan.'84	East side pavement modified.

LONDON – EDINBURGH – THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE II

RIVER COQUET BRIDGE
EXPANSION JOINT SHEET 1

ORIGINAL DRG. SIZE	DRAWN	DATE	SCALE
(B1)	K.D.	Jan.'81	As noted
	TRACED M.G.C.	Oct.'81	DRAWING No.
	CHECKED		534/C/73ZA
	APPROVED		

REDUCED DRAWING 0 10 20 30 40 50 50mm ON ORIGINAL



Harris & Sutherland	LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA	DRG. SIZE (B1)
DEPARTMENT OF TRANSPORT NORTHERN REGIONAL OFFICE NEWCASTLE UPON TYNE	RIVER COQUET BRIDGE GENERAL ARRANGEMENT	

REV.	DATE	AMENDMENTS	CHK'D.
Z	APRIL'80	AS CONSTRUCTED.	

	Name	DATE
DRAWN	H.C.C.	Jan. '78
TRACED		
CHECKED	D.A.M.	Sept. '78
APPROVED	B.M.F.	Oct. '78

SCALE 1:2500

DRAWING No. 534/C/121Z

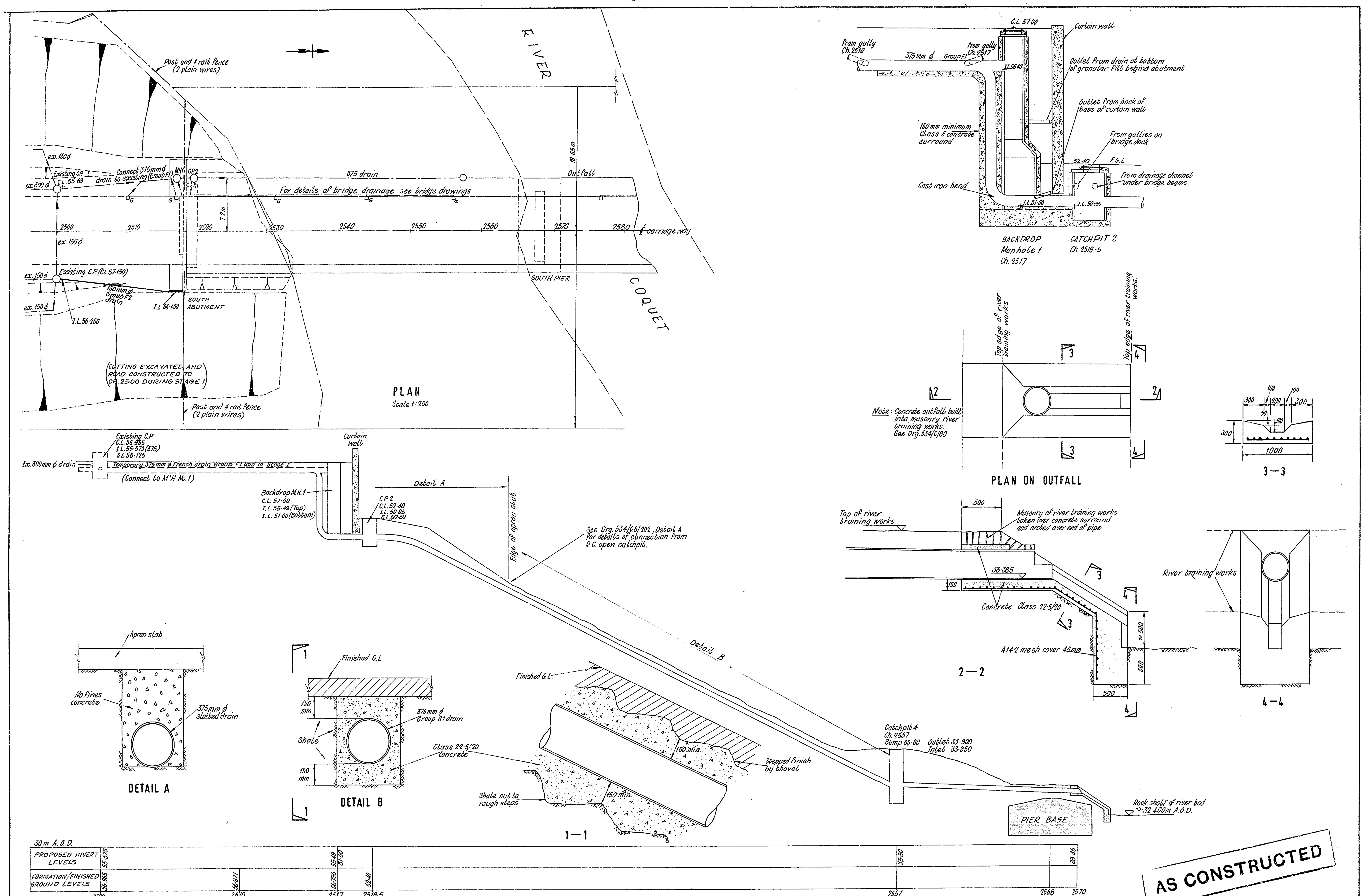
REDUCED DRAWING — 0 10 20 30 40 50 — 50mm ON ORIGINAL

ARMSTRONG MICROFILMING LTD. DATE ROLL №

Roll 110

22.3.84

SCALE IN INCHES SCALE IN CENTIMETRES



LONGITUDINAL SECTION
375mm DIA. DRAIN GROUP S4 — OUTFALL TO RIVER COQUET
Scale 1:100 natural

Harris & Sutherland
Consulting Civil and Structural Engineers

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV	DATE	AMENDMENTS	CHK'D
Z	April '80	As constructed.	

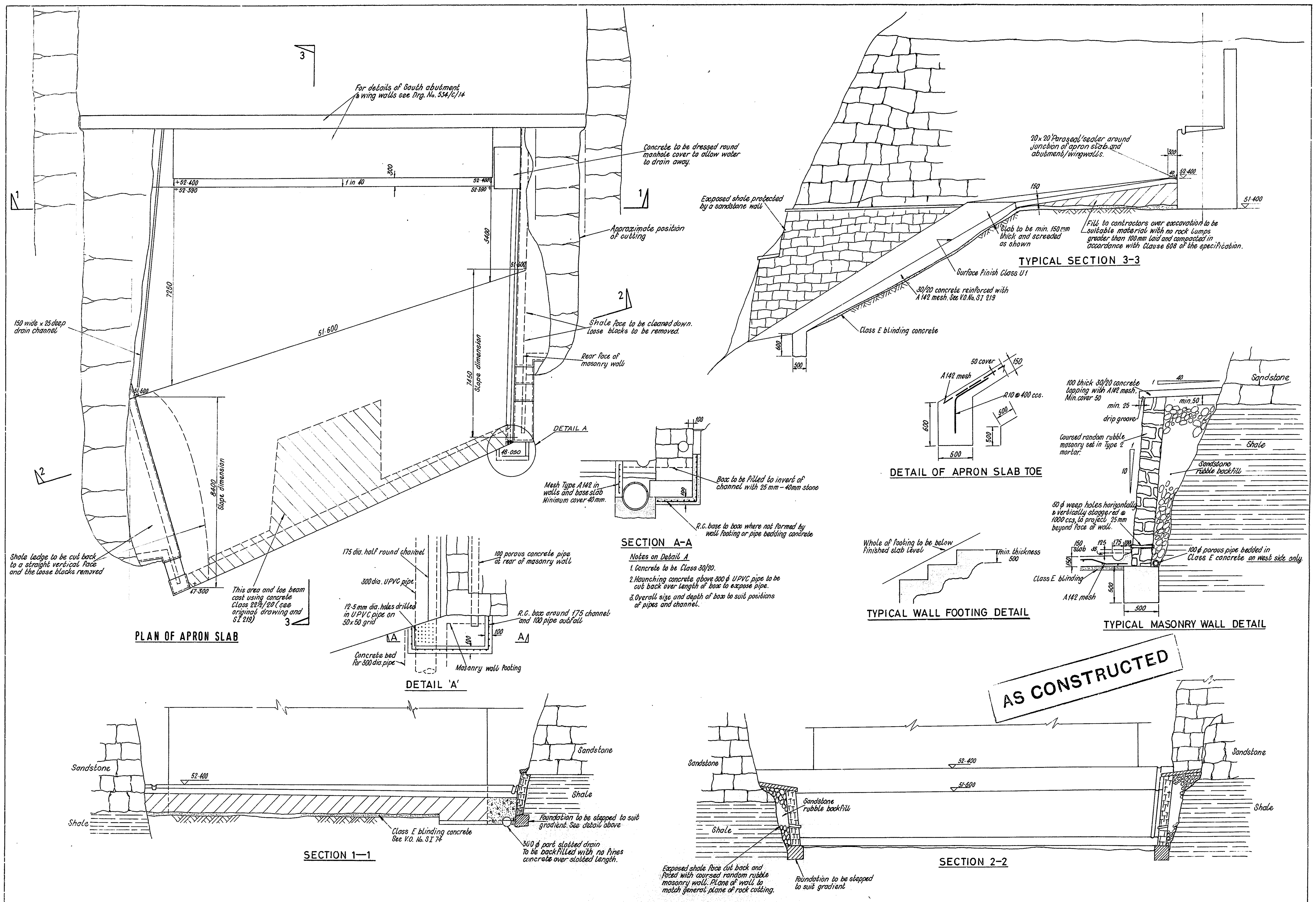
LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS. STAGE IIA

RIVER COQUET BRIDGE

DRAINAGE OUTFALL ON SOUTH BANK OF RIVER COQUET

ORIGINAL DRG. SIZE (B1)		DATE	
DRAWN	H.C.C.	Jan. '78	SCALE: As shown
TRACED	M.G.C.		DRAWING No. 534/C/123Z
CHECKED	D.A.M.	Sept. '78	
APPROVED	B.M.F.	Oct. '78	

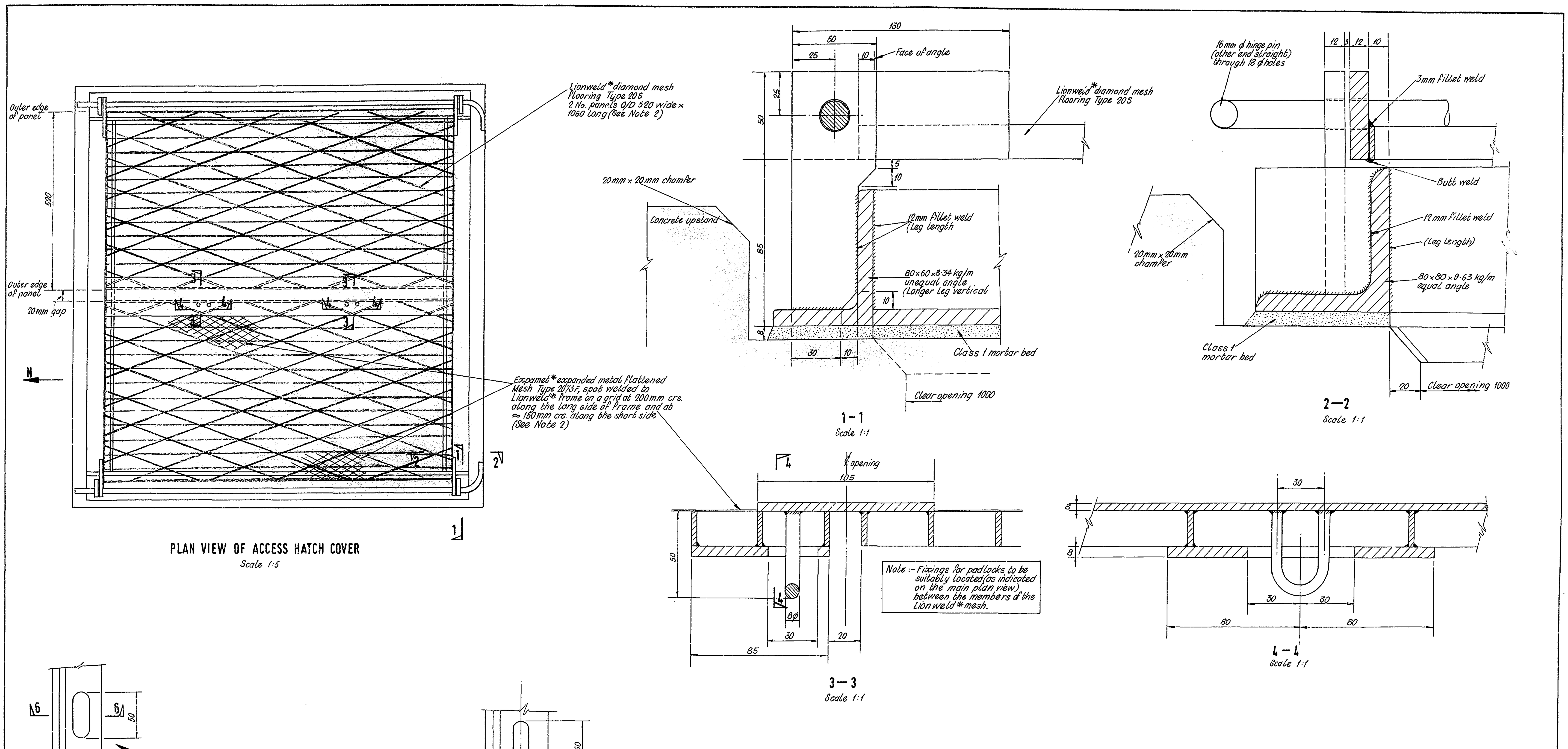
REDUCED DRAWING — 0 10 20 30 40 50 — 50mm ON ORIGINAL

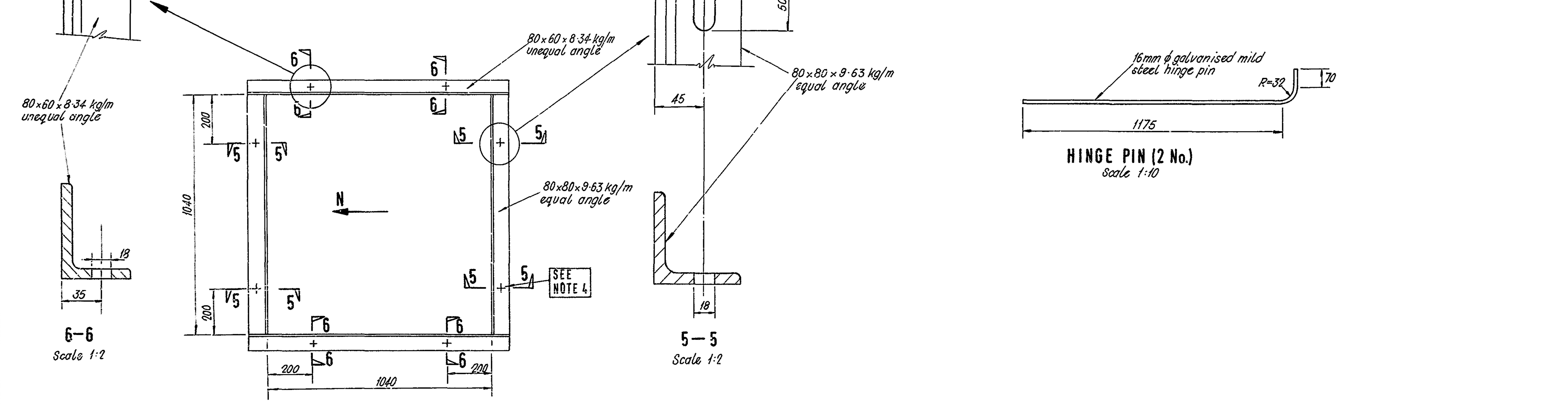


Harris & Sutherland Consulting Civil and Structural Engineers 38-42 Whitfield Street, London W1P 5RF 01-580 9053	A 23-6-81 Drawing redrawn to suit details on site. Z Nov'81 As constructed. AMENDMENTS	LONDON – EDINBURGH – THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE II
DEPARTMENT OF TRANSPORT NORTHERN REGIONAL OFFICE NEWCASTLE UPON TYNE		RIVER COQUET BRIDGE **SOUTH ABUTMENT APRON SLAB**

ORIGINAL DRG. SIZE	DRAWN	DATE	SCALE
(B1)	K.D.	JUNE '81	1:50, 1:20.
	TRACED M.G.C.	JUNE '81	DRAWING No. 534/CS/202Z
	CHECKED		
	APPROVED		

REDUCED DRAWING 0 10 20 30 40 50 50mm ON ORIGINAL





Notes:

1. For products marked *, similar approved will be acceptable. Dimensions may require amendment if Contractor proposes to use an acceptable alternative product.
2. All items to be galvanised mild steel, except where noted. Galvanising to be carried out after fabrication of covers is completed. Galvanizing to be in accordance with B.S. 729 : 1971 at the rate of 610 gm/m²
3. For clear size of openings through soffit slab see Drawings 534/C/45 and 534/C/63.
4. Fixings for hatch at each end of deck are 8 No. 16mm dia. stainless steel drill-in fixings.
5. Each frame is provided with two number Chubb 1K42* open shackled padlocks. (i.e. 4 No. total). Each of the 4 locks is capable of being opened by one key. 8 No. identical keys are provided.
6. Working drawing was numbered 534/RE/2A.

AS CONSTRUCTED

Harris & Sutherland
Consulting Civil and Structural Engineers 38-42 Whitfield Street, London W1P 5RF 01-580 9052

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV.	DATE	AMENDMENT	CHK'D.
A	April '81	Details of covers for both openings made the same. Drg. 534/RE/3 now redundant. Additional fixing for padlock added.	
Z	March '83	As constructed.	

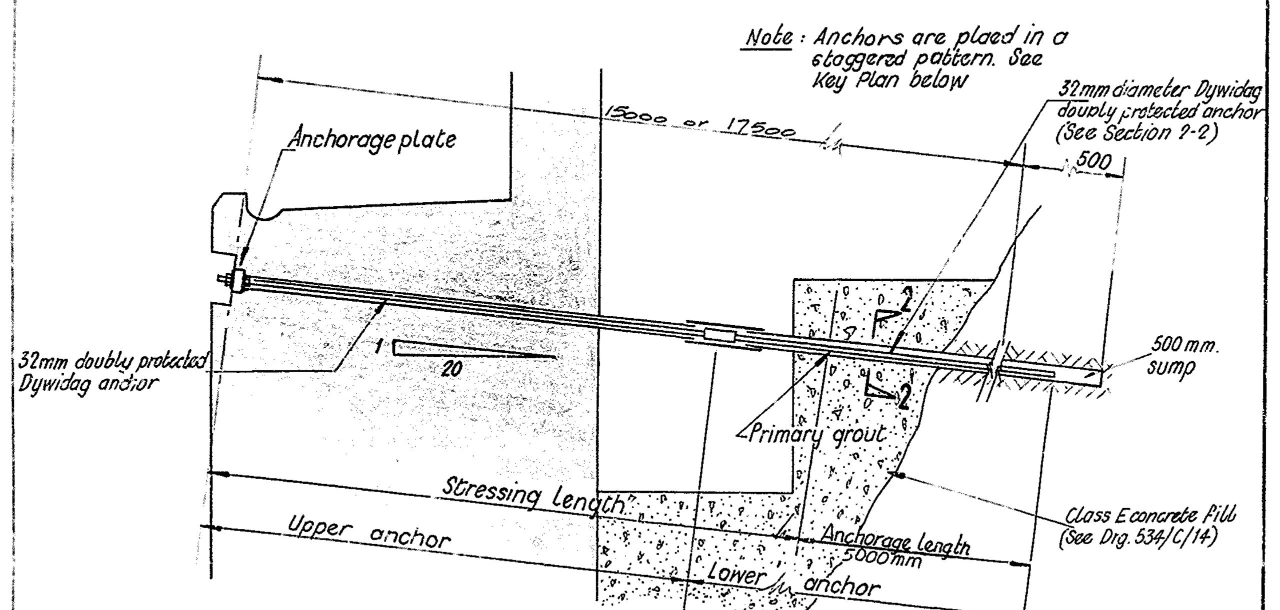
LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE II

RIVER COQUET BRIDGE

DETAILS OF COVER TO ACCESS HOLES THROUGH SOFFIT OF DECK (2 No. THUS)

ORIGINAL DRG. SIZE (B1)	DRAWN K.D.	DATE Feb. '81	SCALE
	TRACED M.G.C.	Mar. '82	DRAWING No. 534/CS/204Z
	CHECKED		
	APPROVED		

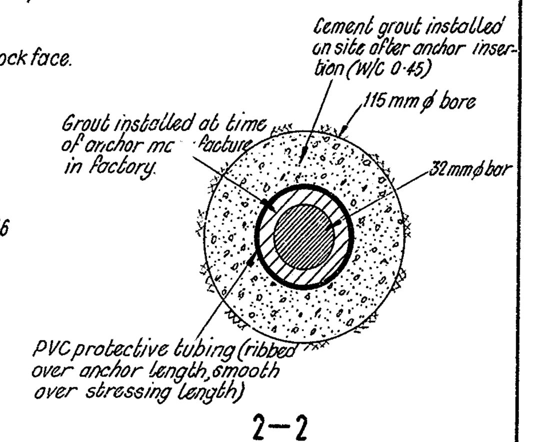
REDUCED DRAWING — 0 10 20 30 40 50 — 50mm ON ORIGINAL



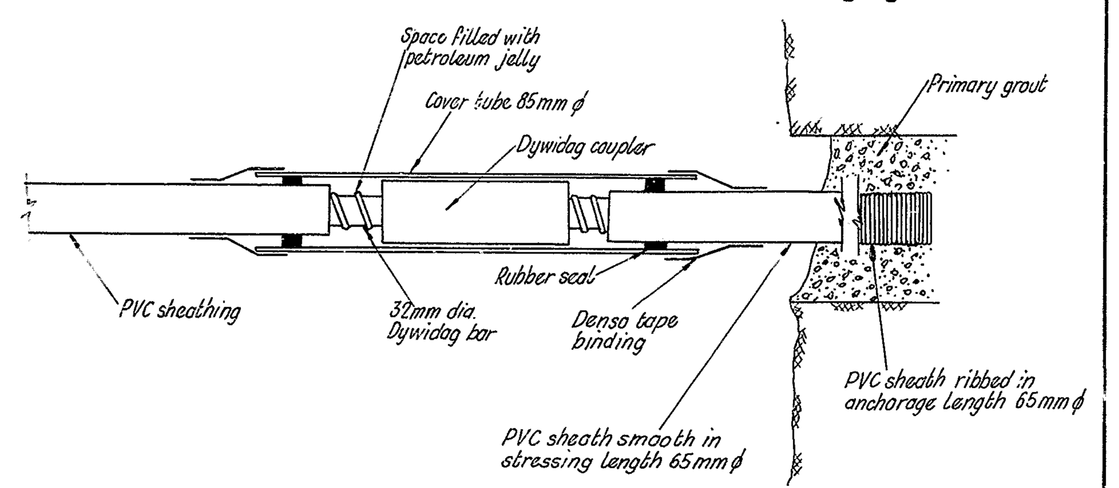
Scale 1:20

Notes

1. The tolerances on the position and alignment of the drilled hole were position 25mm. in any direction at the rock face. line 1:50
2. The tolerance on the position of the anchorage plate were ± 40 vertically ± 40 horizontally
3. Proof Loadings referred to in Specification Clause 1716 were as follows: Lower section 560kN Upper section 560 kN
4. Working load 440 KN

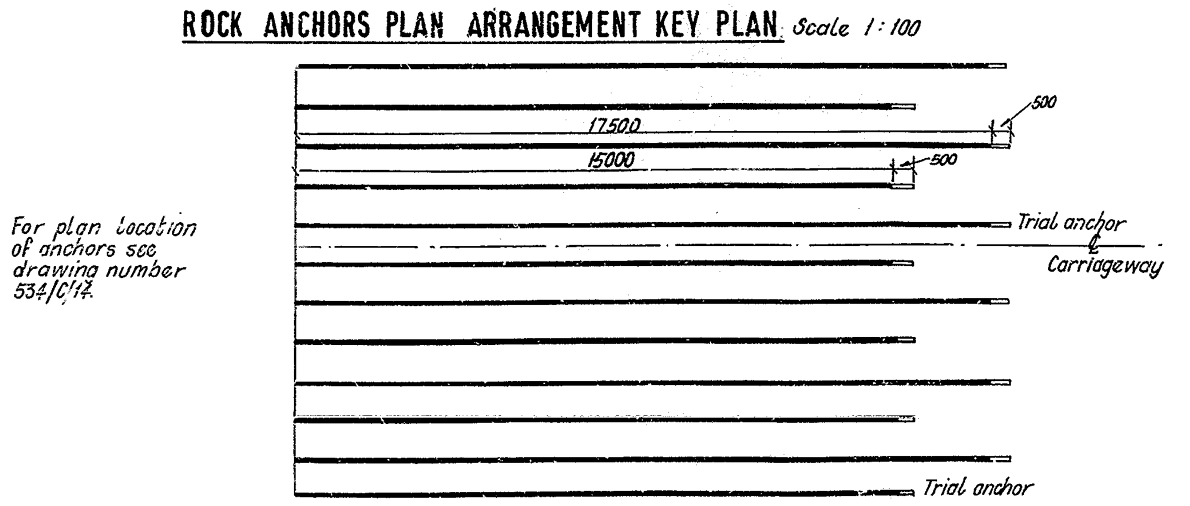


2—2

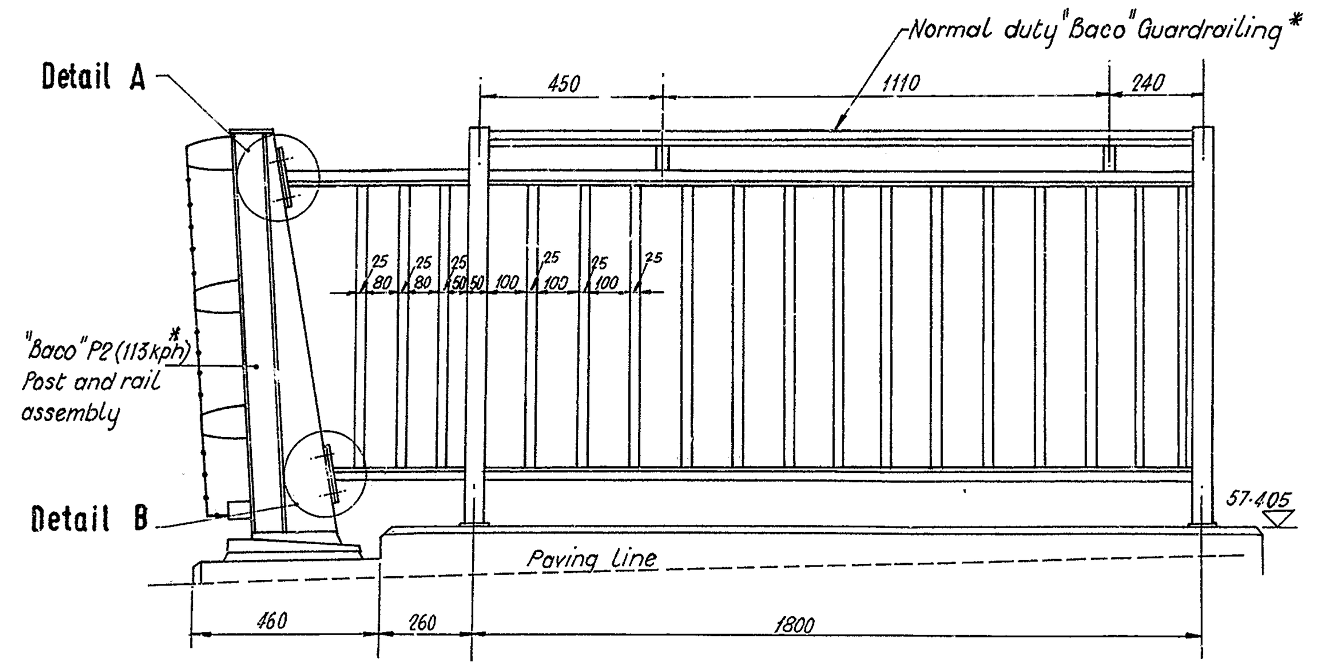


COUPLER DETAIL (N.T.S)

ROCK ANCHORS PLAN ARRANGEMENT KEY PLAN Scale 1:100



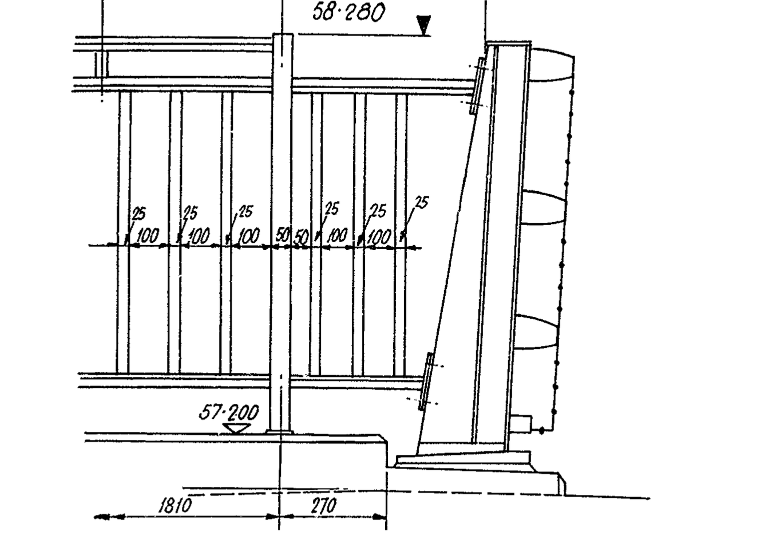
ROCK ANCHORS



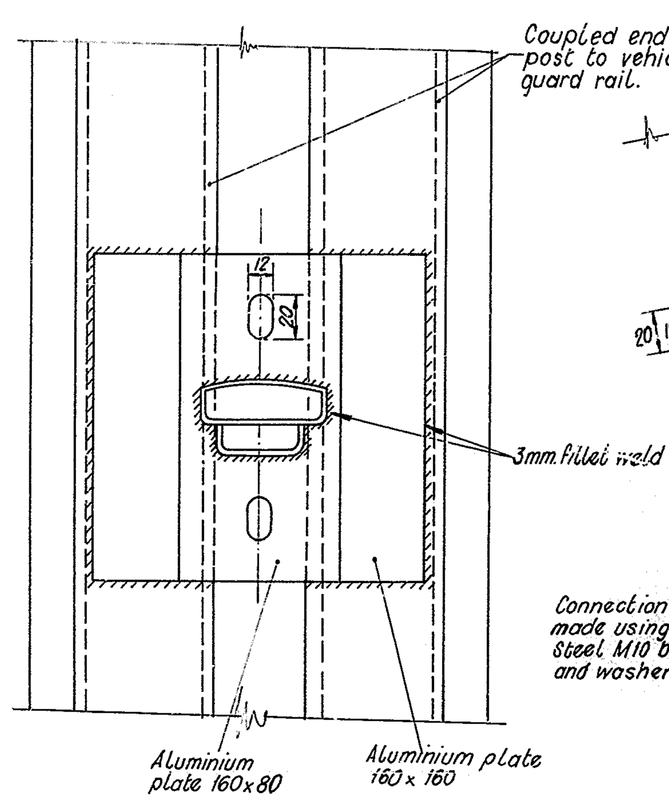
EAST CURTAIN WALL

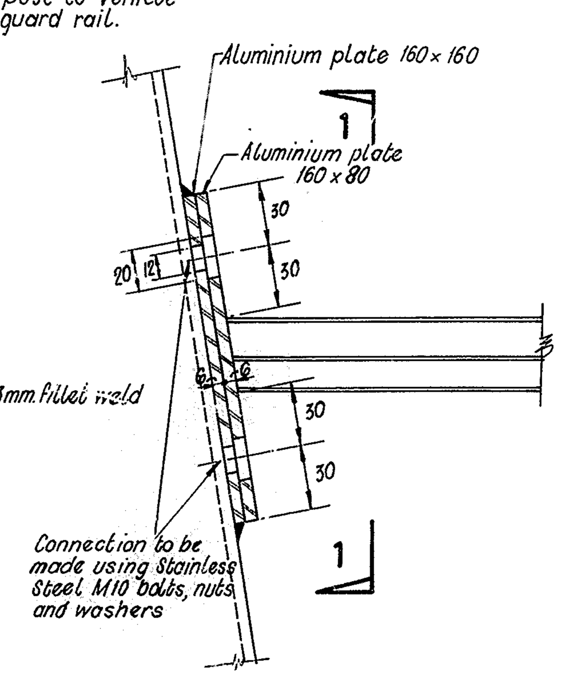
Scale 1:10

Note:- For products marked thus *, similar approved products will be acceptable.



WEST CURTAIN WALL

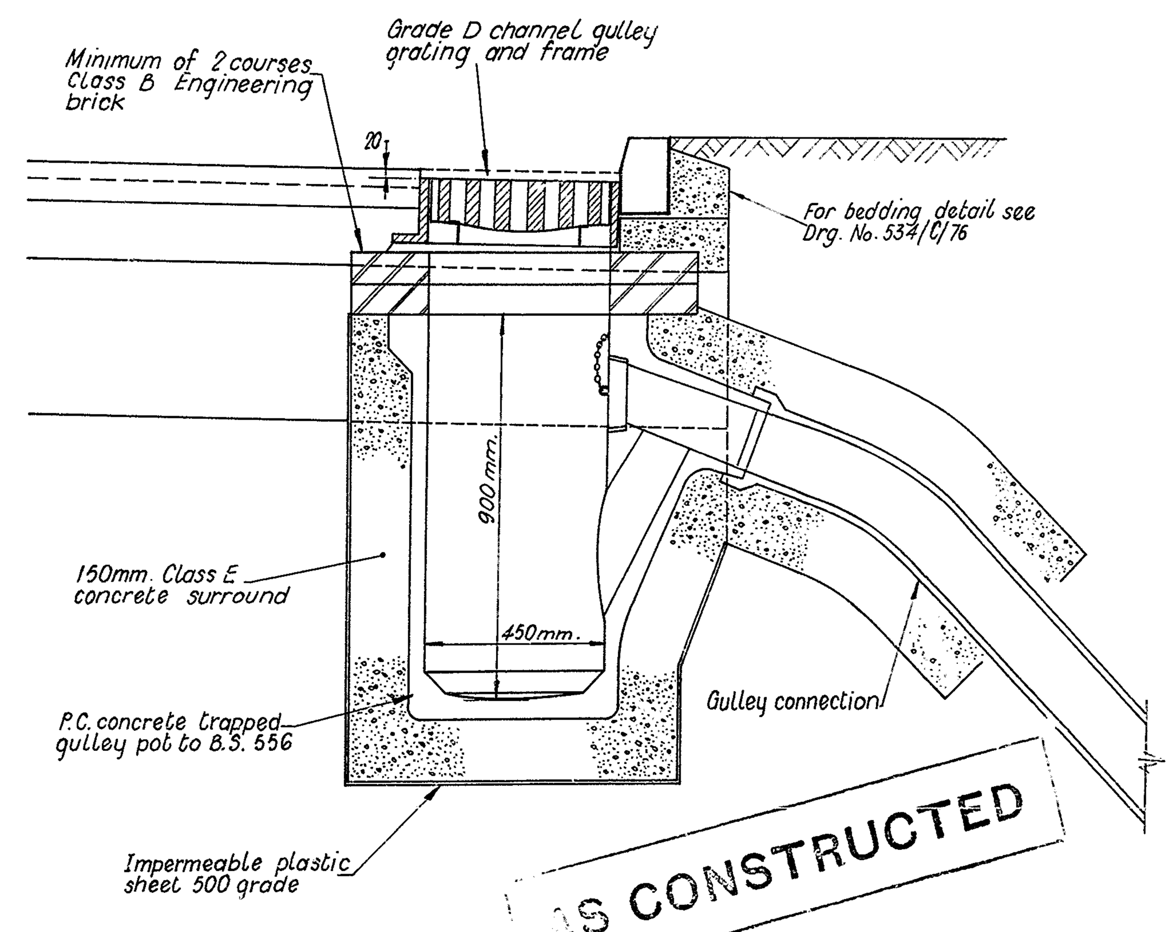




SECTION 1-1
Scale 1:2

DETAIL A
DETAIL B Similar

PEDESTRIAN GUARDRAIL (SOUTH ABUTMENT)



GULLEY POT AT SOUTH ABUTMENT

Scale 1:10

A	10.1.80	Rock anchors revised.
Z	April 81	As constructed.
REV	DATE	AMENDMENT

Harris & Sutherland

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

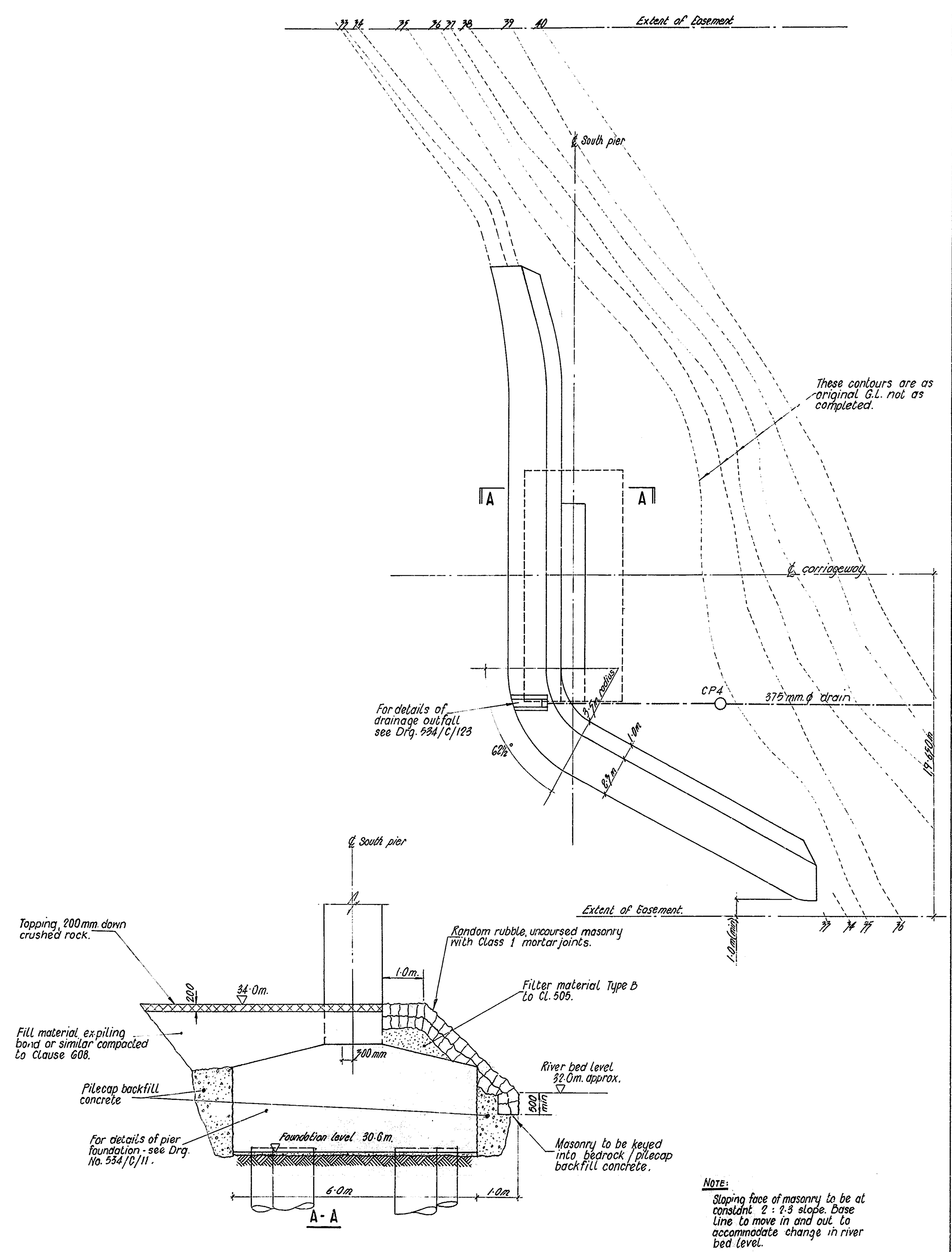
LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE IIA

RIVER COQUET BRIDGE

SOUTH ABUTMENT: ROCK ANCHORS, PEDESTRIAN GUARDRAIL and GULLEY POT

ORIGINAL DRG. SIZE (B1)		
DRAWN K.C.D.	DATE Jan. '78	SCALE As shown
TRACED M.T.S.		DRAWING No.
CHECKED N.P.B.	Sept. '78	534/C/79Z
APPROVED B.M.F.	Oct. '78	

REDUCED DRAWING 0 10 20 30 40 50 50mm ON ORIGINAL



Note:
Sloping face of masonry to be at constant 2 : 2.3 slope. Base line to move in and out to accommodate change in river bed level.

RIVER TRAINING WORKS

AS CONSTRUCTED

Harris & Sutherland
Consulting Civil and Structural Engineers

DEPARTMENT OF TRANSPORT
NORTHERN REGIONAL OFFICE
NEWCASTLE UPON TYNE

REV.	DATE	AMENDMENT	CHK'D
Z	Apr '88	AS CONSTRUCTED.	

LONDON - EDINBURGH - THURSO TRUNK ROAD A1 FELTON BY-PASS STAGE II A

RIVER COQUET BRIDGE
DETAILS OF RIVER TRAINING WORKS

ORIGINAL DRG. SIZE (B1)		
DRAWN	LMS	Jan. '78
TRACED		
CHECKED	N.P.B.	Sept. 78
APPROVED	B.M.F.	Oct. '78

SCALE 1:125 1:50 1:10
DRAWING No. 534/C/80 Z

REDUCED DRAWING
0 10 20 30 40 50
50mm ON ORIGINAL


PIONEER

Appendix E

GEOMORPHOLOGICAL MAPPING MEMO

MEMO

TO	M Howard / J Vickers	**FROM**	J Astbury
DATE	**20 February 2018**	**CONFIDENTIALITY**	**Internal**
SUBJECT	**A1 in Northumberland Morpeth to Felton Dualling – River Coquet Bridge – Geomorphological Mapping Site visit**		

OBJECTIVES OF EXCURSION:

The following was confirmed to be the scope of the excursion:

Objective	Completion Status	Deliverables	Date
Geomorphological mapping (With the aim of observing changes within the site's geomorphology and recording evidence of deterioration or movement of slopes)	✓	2x Geomorphological Maps (Figures 5 and 6)	15/02/2018
Measurement and location of tension cracks and other indicators of failure	✓	Detailed plan of TCs nearby to steps (Figure 3)	16/02/2018
Making visual observations of the rock faces on the southern side of the River Coquet adjacent to the existing bridge	✓	Rock mass descriptions	14/02/2018
Production of a photographic record of the site	✓	GPS positioned photographs	16/02/2018
Familiarisation of staff with the site	✓	N/A	16/02/2018

1. GEOMORPHOLOGICAL ASSESSMENT OF THE NORTH OF THE RIVER COQUET SITE

Introduction

WSP undertook geomorphological mapping of the northern side of the River Coquet valley at the location of the existing A1 River Coquet overbridge. The mapping focused on the river bank to the east of the existing A1 road bridge where former studies; (Laing O' Rourke / White Young Green, 2006; Halcrow Group Limited, 2008; WYG Engineering Geospatial, 2015 and CH2MHill, 2014) and a previous site walkover by WSP staff in October 2017 had identified the potential for active slope instability.

The most recent report made the following recommendations for the continued monitoring of the site (CH2MHill, 2014):

- Walkover surveys of the site every 6 months,
- Continued monitoring of permanent ground markers and tiltmeters on the bridge abutment,
- Monitoring of the propagation and rate of widening of the tension cracking observed on the site via the installation and monitoring of permanent ground markers and crack meters.
- Shallow ground investigation to determine the depth of the failure plane and the nature of the failed materials.

The purpose of the mapping exercise was to confirm the findings of the former studies and to identify any changes in geomorphology since the site was last mapped (on the 13th and 26th February 2014). This action was in-line with the recommendation of CH2MHill's Report to undertake regular walkover surveys of the site (CH2MHill, 2014). This section of the Coquet Valley was targeted for mapping as it is understood to be the preferred location for a proposed new River Coquet bridge as part of the upgrade to dual carriageway to this section of the A1

During the site visit, the following additional objectives were completed:

- Visual inspection of the rock faces on the southern side of the River Coquet,
- Production of a photographic record of the site.

Access

The southern side of the River Coquet valley and bridge was entered via an access ladder on the eastern side of the existing bridge (Figure 1). The ladder was opened by a Highways England Structures Steward. From below the bridge it was possible to descend to the river-side with caution.

The northern side of the River Coquet was accessed via a public footpath through Felton Park from West Thirston.

Method

A team of two engineers completed the geomorphological mapping between 13 – 16th February 2018. The vegetation was much lower at this time of the year, improving visibility of surficial features. The conditions were cold and dry and this weather generally persisted throughout the field excursion with the exception of intermittent snow and rain showers.

Prior to undertaking the mapping, 'bare earth' LiDAR imagery of the site was used to give an insight into the expected ground surface conditions. This LiDAR data had been obtained from data.gov.uk (Environment Agency) through the Open Government Licence (Environment Agency, 2017).

The geomorphological mapping was accomplished at a scale of 1:500, in accordance with the previous report in order to make the results comparable (CH2MHill, 2014). Changes in slope were recorded along with any evidence of water at the surface (e.g. ponding, springs and hydrophilic vegetation). Mapping symbols were again in agreement with CH2MHill's mapping exercise. Distances within the field were assessed using a laser distance measurement hand-held device. Angles were determined using a compass clinometer.

Field descriptions of materials (within exposed faces and fallen blocks) were taken whilst in the field, according to BS 5930 (British Standards Institution, 2015). It is notable, that examination of the cut faces beneath the bridge deck on the south of the river, along with cliffs of bedrock on the north of the river allowed for consideration of the rock mass within three dimensions.

Findings (South)

On the southern side of the River Coquet, visual inspections of the exposed rock cuttings were carried out and photographs taken.

The geomorphology of the southern side of the River Coquet (to the east of the existing A1 bridge) valley was found to comprise the following from crest to floor:

1. A sub-vertical escarpment formed of sandstone. There was limited visual evidence of a significant depth of superficial material overlying this bedrock. The rock cliff face appears to achieve greater relief and more prominent towards the east (Photograph 1),
2. Sub horizontal natural benches within the sandstone at the base of the cliffs (Photograph 1),
3. A mid-slope geomorphic unit, with a gradient of approx. 28º. This slope unit terminates to the south of the pier of the existing bridge where the gradient levels off to 2 – 4º. The presence of trees with bent trunks on this unit *may imply* that the unlithified ‘superficial’ material overlying the mudstones *may* have undergone at least creep rates of movement during their lifetime (i.e. the tree trunks may have grown into a curved shape in order to maintain an ‘upright’ position as the ground surface moved Photograph 2).
4. Fallen blocks are noted at the base of this slope.
5. Elevation decreases, until the Coquet channel is reached, through a steep slope unit which upon visual inspection appears to be formed of boulders within a clay matrix. This region of the slope was associated with the presence of hydrophilic vegetation. It is possible that this material is colluvium, sourced from the upper slopes and has formed a river bluff (Photograph 3).
6. Bedrock, which appeared to be sandstone, was noted within the channel of the River Coquet, occasionally forming natural weirs; potentially indicating that this unit is controlling the basal elevation of the valley (Photograph 4).

It was noted that fallen blocks, thought to have originated from the cliff face at the top of the slope, had been caught by tree trunks; providing evidence that these failures most likely occurred within the recent past. (Photograph 5).

Evidence of scour around the base of the southern pier was observed (Photograph 6).

Eastern Extent of Southern Abutment

The cutting face presented in Photograph 7 shows the exposed rock face adjacent to the southern abutment. No scanline assessment of the rockmass was undertaken (Photograph 7 – eastern exposure). Within the more massive sandstone units, occasional thin interbeds of siltstone were noted (e.g. Photograph 8). From visual observation, the rock was predominantly described as (Photograph 9 – hand sample):

‘Medium strong medium to thickly bedded light orangish brown fine SANDSTONE with thin interbeds of thickly laminated siltstones. Weathers to brownish red at surface. [Stainmore Formation]

Three potential discontinuity sets were observed;

Possible bedding: close to medium spacing, 160/18 E (dip direction / dip), terminating outside of exposure, straight, planar, smooth, very tight, no infilling.

Joint set 1: widely to very widely spaced 308/80 W (dip direction / dip), terminating outside of exposure, wavy, stepped, very tight to open, surface staining where open.

Joint set 2: 155/88 W (dip direction / dip), planar, closed, clean.

Some seepage was noted corresponding to the location of wider joints. Wider joints commonly contained moss, ferns and small trees at the surface

The Sandstone strata was approximated to be 5m thick within the cutting exposure. This sandstone was found to overlie a shale unit:

'Very weak to weak thinly laminated dark grey SHALE. Weathers to orangish brown. [Stainmore Formation]'

This material was covered at the surface by dark brownish grey sandy clayey GRAVEL with occasional cobbles of sandstone. An assessment of the material's thickness was not made due to the gradient of the slope, however it is likely to be relatively thin in this location. This material was devoid of vegetation. It is proposed that this material may be colluvium/residual soil and extends to the base of at least the middle slope unit.

It was not possible to walk across the mid slopes (see point 3. in the list on the previous page) due to their gradient.

Western Extent of Southern Abutment

On the western side of the existing bridge an area of possible active movement was noted. This feature (and its likely recent movement) was evidenced by exposed soil within the backscarp. It was not possible to access this feature due to the steep terrain (slope gradient estimated to be greater than 1 in 2) but the feature appeared to represent a shallow translational movement within superficial materials (Photograph 10).

It was not within the scope of this site visit to undertake an assessment of this area.

Findings (North)

Geomorphological mapping was undertaken, on the northern bank of the River Coquet adjacent to the bank seat of the existing A1 overbridge structure, in order to check for indicators of geomorphological change since the previous study in 2014 (CH2MHill, 2014).

It was confirmed, that to the east of the existing bridge there appears to be a sequence of retrogressive rotational failures, demonstrated at the surface by shallowly forward tilting or back-tilting fault blocks separated by backscarps (Photograph 11). In addition, it was also noted that the apparently discrete fault blocks commonly contained tension cracks and depressions within themselves, suggesting that these blocks may be, or may have been, unstable. (Photograph 12). The lower gradient river terrace structure, separated from the river by a bluff and the alluvial deposition plains were also confirmed (Photograph 13 and Figure 2). As the findings of the mapping exercise were largely in good agreement with the previous studies it is considered superfluous to restate them here, however to summarise:

- Evidence of deep-seated rotational failure within natural materials is evident on the northern slopes, the activity state of this failure complex is unknown but block detachment is discernible,
- There is evidence of relatively recent movement *at least* within the Made Ground (but possibly within the natural deposits as well). This movement has led to the formation of extensive tension cracking,
- A series of monitoring points have been installed adjacent to the public footpath and the eastern side of the northern abutment, however regular monitoring does not appear to have taken place, these instruments appear to have identified movement between 2008 and 2015 (WYG Engineering Geospatial, 2015) (Halcrow Group Limited, 2008),
- Further monitoring and ground investigation to determine the depth of the failure was proposed (CH2MHill, 2014).

A more detailed assessment of the tension cracking, within the previous report's zone of current detachment (CH2MHill, 2014), to the east of the northern abutment was undertaken (location shown in Figure 2). A total of nine tension cracks were noted, measurements taken of these tension cracks are provided within Table 1 (Figure 3).

Table 1 Measurements of tension cracks adjacent to footpath on eastern side of existing bridge. The approximate location at which these measurements were taken is shown within Figure 3.

Tension Crack	Maximum Aperture (measured at the ground surface)[1] (m)	Maximum Depth (m)
1	0.251	0.222
2	0.911	0.327
3	2.600	2.000
4	1.303	0.808
5	0.366	0.311
6	0.587	0.478
7	0.602	0.425
8	0.209	0.202
9	0.305	0.238

[1]These measurements are horizontal distances across the top of the tension crack. No measurement of vertical displacement across the tension cracks were made (see Figure 4 for clarification).

From these measurements, it seems that the scale of the tension cracks, particularly tension crack number 3 may have been underestimated in previous reports or else it may have increased (CH2MHill, 2014) (Laing O'Rourke / White Young Green, 2006). Table 1 shall serve as a baseline for future measurements.

At the location of the footpath steps to the east of the existing A1 descriptions were taken of the Made Ground exposed within the scarp of tension crack 3 (Photograph 14):

Made Ground: Light cream clayey sandy GRAVEL. Gravel is subrounded to subangular, fine to coarse of sandstone. (Approximate thickness of 20cm)

Below this material, the following was described, it was not possible to determine the thickness of this material (Photograph 15):

Made Ground: Light brown silty sandy GRAVEL. Gravel is fine to coarse, subrounded to angular of limestone, sandstone, concrete, brick and clinker. The clinker is extremely strong, remaining intact despite firm hammer blows.

To the east of the site, an exposure of the bedrock succession was seen within a presumed failure plane approximately 200m to the east of the existing bridge (Photograph 16). The material at this location appeared to correlate reasonably well with the observations of the bedrock made on the south of the river. However, an additional joint set's orientation to those already observed was noted within the sandstone here:

JS3: 055 / 75W

It was possible to observe a stratum of coal or carbonaceous shale within the exposure face and this has been annotated on Photograph 17. This material appeared to be black and thickly laminated and from a visual estimate at the foot of the slope, approximately 0.3m thick.

It was found that Made Ground was present at the top of the main back scarp at two locations (Photograph 17 and 18). Apparent corrugated metal sheets were discovered within the back scarp of one of the failures (NZ 17545 99955, indicative location shown on Figure 2 and Figure 7). Some loose sheets of this material were also seen lower down the slope at the surface. This material was observed at a depth of at least 1.5m below ground level (though the material which was above it was not seen due to topsoil and vegetation). The base was not seen nor was the material seen at surface (the footpath at the top of the slope). The lateral extents and origin of this material is uncertain.

Suspected colliery spoil was found to be present at ground surface at the top of the backscarp forming the eastern promontory feature of the backscarp (NZ 17570 99959) (Photograph 18). The eastern extent of the material is marked by the appearance of mosses and rhododendra, whilst the west extent is approx. at the fence junction to the north of the footpath. The area of this material is approx. 14m wide (E-W) and 8.8m N-S (Figure 2 and 7). The exact origin of this material is uncertain and it may have been end-tipped. This material was described in the field as:

'Made Ground; Dark brown very silty slightly sandy GRAVEL with cobble and boulder sized fragments. Cobbles are of slate / shale, brick, clinker, concrete and ceramic. Boulders are of slate, brick and metal wire. Gravel is fine to coarse and of slate and slag and is subrounded.'

The LiDAR data enabled a far greater delineation of the failure attributes and extents of the failure to the west of the existing bridge. It is understood that this is the feature reported within HAGDMS defect record: 14_A1_42927_520468. It is noted that the plantation of pines to the west approximately correlates with the western boundary of a zone of instability (Photograph 19). The location of this area of instability is demonstrated within Figure 6.This western failure has a much more clearly defined foot and lateral flank than the features to the east of the bridge (Photograph 20).

Discussion

As has been discussed previously, the findings of the WSP mapping excursion were largely in agreement with those of the former studies (Figures 5 and 6). Generally speaking, differences within the mapping are minor and relate to the size and geometries of mapped geomorphological units. These differences may relate to the use of an electronic distance measuring device and different reference points having been chosen. However, crucially, most geomorphological units are captured within each mapping excursion.

Notable differences within the mapping occur within the east of the site where the low angle feature, which is suggested to be the top of a fault block was found to be more substantial than is shown within the previous studies (Figure 2 and Photograph 21). This bench was found to occur immediately at the base of the steep backscarp. However, this feature is not within the currently proposed footprint of the new River Coquet Bridge. The WSP survey did not find evidence of the lower gradient, uppermost, slope unit which made up the backscarp as suggested by the previous authors.

It was confirmed that the proposed main backscarp structure becomes steeper and more prominent to the east. This is possibly due to the failures towards the east being more active. The location of these failures corresponds with the apex of the meander and may therefore represent more recent failure scarps, presently being subjected to greater erosion at their foot. This observation could also be in part related in part to a greater proportion of the slope being formed of competent sandstone as opposed to shale as would be expected to be present to the east (owing to the eastwards dip of the bedrock, Photograph 16 showing the culmination of this).

It is interesting to note that deposition of alluvium appears to have taken place at the base of the bluff on the north of the River Coquet downslope of the proposed area of current detachment (Photograph 13). This may imply that erosion at the foot of the slopes is not currently a significant driver of the instability within this area.

Following from this mapping exercise and a previous walk-over of the study area, the locations of the springs were re-mapped using a GPS and waypoint averaging. This has provided more precise locations of the springs to be obtained. For example, the spring to the east of the northern pier has now been found to be located approximately 10m to the west (Figure 7).

There was limited evidence of superficial materials being present within the study area with the exception of topsoil. Due to the presence of extremely strong cobbles of clinker being found within the backscarp of tension crack 3 it is proposed that the material within the 'area of current detachment' is indeed Made Ground as proposed by the CH2M Hill report. In 2006, BH1037 encountered 10.2m thickness of Made Ground (the basal elevation of this material was not confirmed), however this borehole was undertaken approximately 25m north of where the material descriptions of the Made Ground presented within this Appendix were undertaken.

The reassessment of the zone of tension cracking, to the east of the existing River Coquet's northern embankment, has provided a greater understanding of these forms. The orientation of these features are, generally speaking, southwest to northeast indicating likely movement out of the slope which is towards the south and east. Those features which trend closer to an east-west alignment are fairly consistent with the orientation of the backscarps of the deeper seated movements (tension crack 1, 3, 5 and 6). Those features demonstrating closer to a north-south orientation may provide an indication of the movement exploiting the unrestrained boundary to the east as the ground surface elevation drops away steeply in this direction. Further in-situ monitoring of these features would help to confirm if they are active and if so: the direction, rate and scale of these movements.

Historic HAGDMS Observations

A total of four historical defects are noted on HAGDMS along the alignment of the current A1 route and existing River Coquet bridge. As has been discussed previously, observation 14_A1_42927_520468 appears to relate to the failure complex mapped to the west of the existing A1 bridge.

HAGDMS Defect Reference	HAGDMS Characteristics	Correlation with February 2018 Site Visit
14_A1_42984_520375	Slip and tension crack	It is uncertain which tension cracks are photographed and described but this observation appears to be the area summarised in Figure 3 (see Figure 2 for site context).
14_A1_42984_564468	Slip, slope bulge, terracing and tension cracks Described as deeper than last observation. Annual inspection recommended.	Area summarised within Figure 3.
14_A1_42984_578468	Tension crack – Annual inspection recommended	This observation may also relate to the area summarised in Figure 3, most likely TC 2 and 5 – 9 of this survey.

The instability indicated by these observations could affect the construction process of the proposed bridge. These observations remain valid.

The area to the north, at the location of HAGDMS defect inspection: 14_A1_42985_520379 was not mapped as a part of this investigation.

Conclusion

It does not appear that there has been a significant change to the area since the former mapping campaign in February 2014 (CH2MHill, 2014) with many of the features previously identified still distinguishable. Any changes in magnitude to these features is however more difficult to detect, The measurements of the tension cracks within the area of suspected Made Ground appear to be greater in the case of tension crack 3, however this is difficult to determine because not all of the tension cracks were previously measured.

Recommendations

Bearing in mind the findings of this site visit and above discussion there is scope for further works to be undertaken at the site of the proposed River Coquet Bridge in order to gain a better understanding of the ground conditions within the area and so inform design. In future, when the proposed location of the bridge has been finalised the study area could be reduced, this would allow more detailed assessment to take place.

Recommendations for future works are as follows:

i. On the southern side of the valley it would be useful for a tactile scanline survey to be undertaken of the sandstone rock mass. This work, likely to necessitate rope access, would provide a better understanding of the strength of the sandstone and the degree of significance of the siltstone layers. The data collected from the scanline survey could then be compared to televiewer data (e.g. BH1036) for greater understanding and determine changes within the rockmass (e.g. determine GSI).

ii. It is agreed that tension crack monitoring should be continued within the area in order to obtain a rate of movement of the mass. This monitoring could take the form of inclinometers to evaluate the depth of the slip surface. Extensometers and fixed ground survey points could also be worthwhile to provide an indication of whether movement is ongoing and may provide an indication of rate of movement. Monitoring was recommended within previous reports but it would be crucial to ensure that data is captured regularly in order to build a more accurate picture of the movement on the site. The status of the existing inclinometer should be determined and this could be used as a further data source if operational.

iii. Measurement of the vertical displacement across the tension cracks in the area illustrated in Figure 3, as shown in Figure 4 would provide a better understanding of the magnitudes of the movements associated with these features.

iv. It would be beneficial to investigate the extents of Made Ground (both in terms of its thickness and area) and the nature of the material in order to better understand it's properties (including geoenvironmental implications). This would likely be achieved through further intrusive ground investigation.

v. Undertaking of an up-to-date topographical survey would assist in ensuring the correct ground elevations are used during design. This data could also be correlated with the geomorphological mapping.

vi. Long-term groundwater monitoring shall be useful on this site due to the large distances between foundation locations and relief within the valley. The effects of the large relief between the tops of the valley slopes (presumed abutment locations) and the base of the valley (presumed pier locations) may lead to large changes in groundwater across the site.

2. REFERENCES

British Standards Institution. (2015). *Code of Practice for Ground Investigations.* Milton Keynes: British Standards Institute.

CH2MHill. (2014). *Geomorphological Assessment - A1 River Coquet Crossing (DRAFT).* Stockton-on-Tees: CH2MHill.

Environment Agency. (2017). *LiDAR Composite DSM - 1m*. Retrieved from Licensed under Open Government Licence (http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/): https://data.gov.uk/dataset/lidar-composite-dsm-1m1

Google Earth. (2009). Access to River Coquet Site.

Halcrow Group Limited. (2008). *A-one Integrated Highway Services - A1 River Coquet Bridge Landslip Monitoring Options Feasibility Report.* Stockton-on-Tees: Halcrow Group Limited.

Laing O'Rourke / White Young Green. (2006). *A1 Morpeth to Felton Dualling - Preliminary Geotechnical Report.* Leeds: White Young Green .

WYG Engineering Geospatial. (2015). *River Coquet Bridge Monitoring Survey.* WYG Engineering.

3. FIGURES

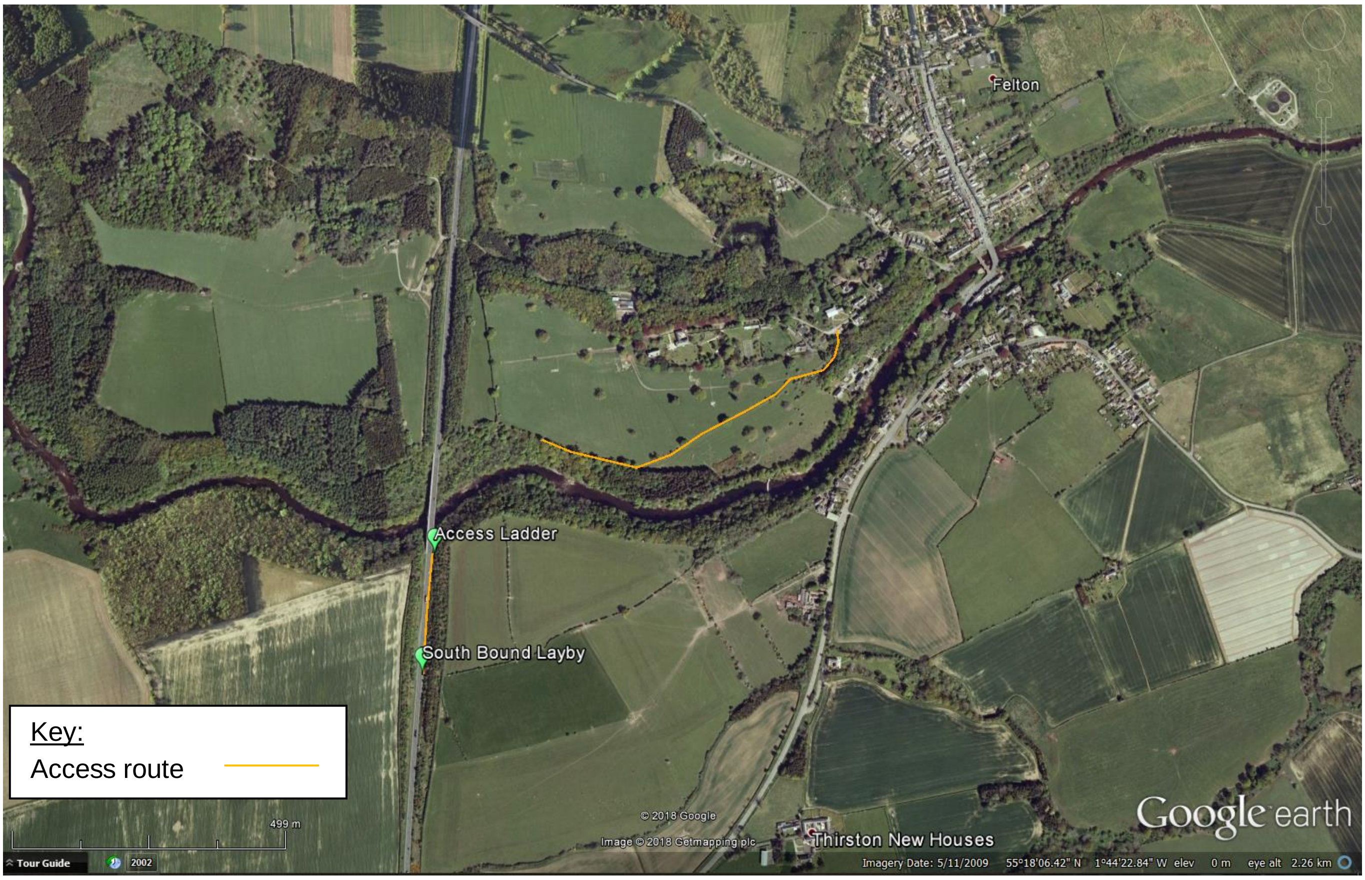
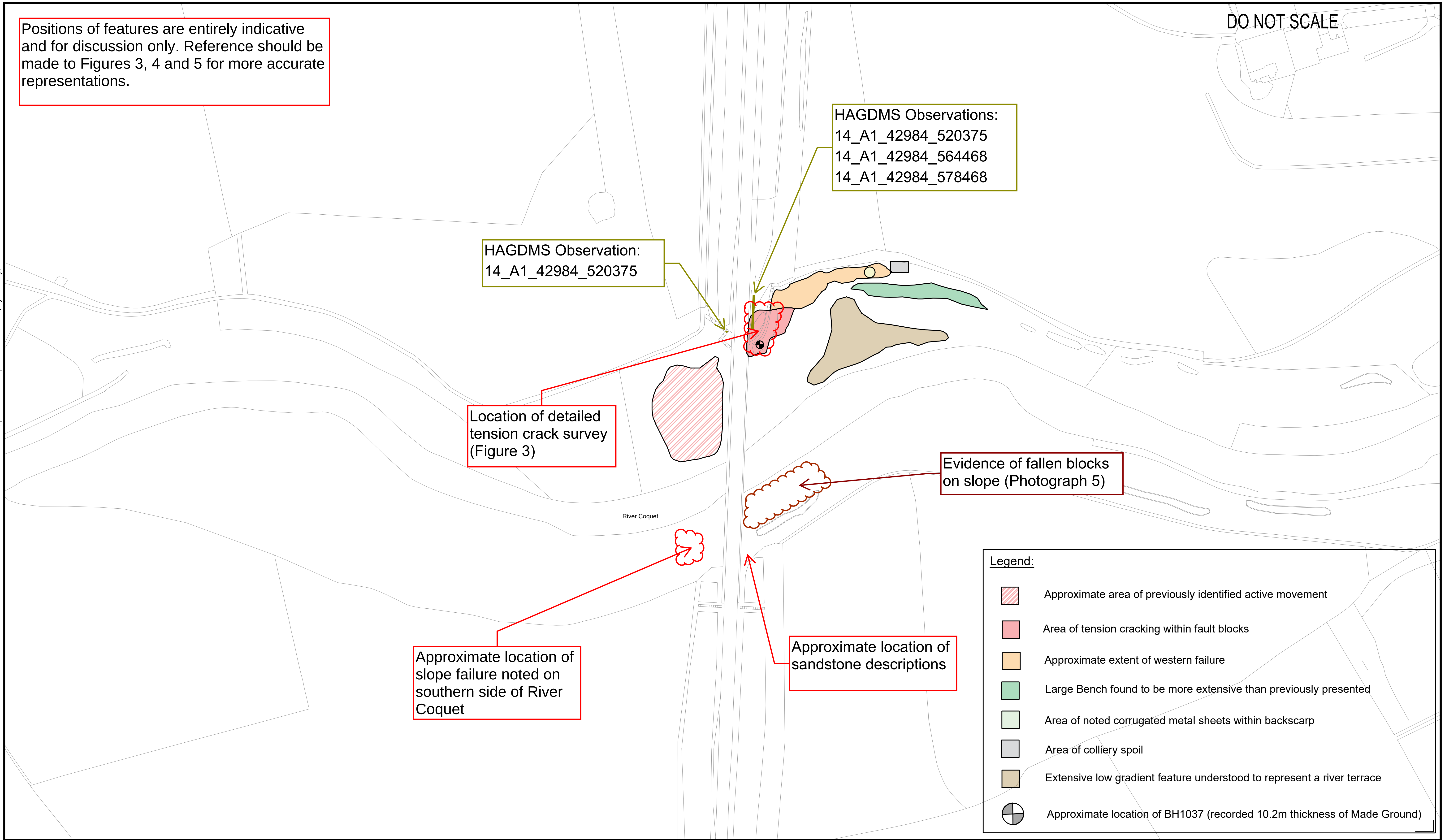


Figure 1 – Access to the site. The northern side of the River Coquet was accessed via a public footpath from West Thirston. The south side of the site was accessed via a ladder. The car was parked in the south-bound layby and the ladder was reached on-foot by walking on the verge. Imagery from Google Earth (Google Earth, 2009).

Figure 2 – Please see overleaf.



File name Z:\GEOTECH\02 PROJECTS\HIGHWAYS AGENCY\A1IN M TO F\10 RIVER COQUET FOUNDATION DESIGN\06. SITE WORKS\SUMMARY DRAWING.DWG, printed on 19 April 2018 11:38:16, by Astbury, James

Figure 2

DRAWING STATUS:
For Discussion Only

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

CLIENT: highways england

PROJECT: A1 in Northumberland - Morpeth to Felton Dualling

TITLE: Summary Drawing

SCALE @ A3: Not To Scale	CHECKED:		APPROVED:
PROJECT No: HE551459	DESIGNED: JA	DRAWN: JA	DATE: April 18
DRAWING No: SUMMARY DRAWING			REV: P01

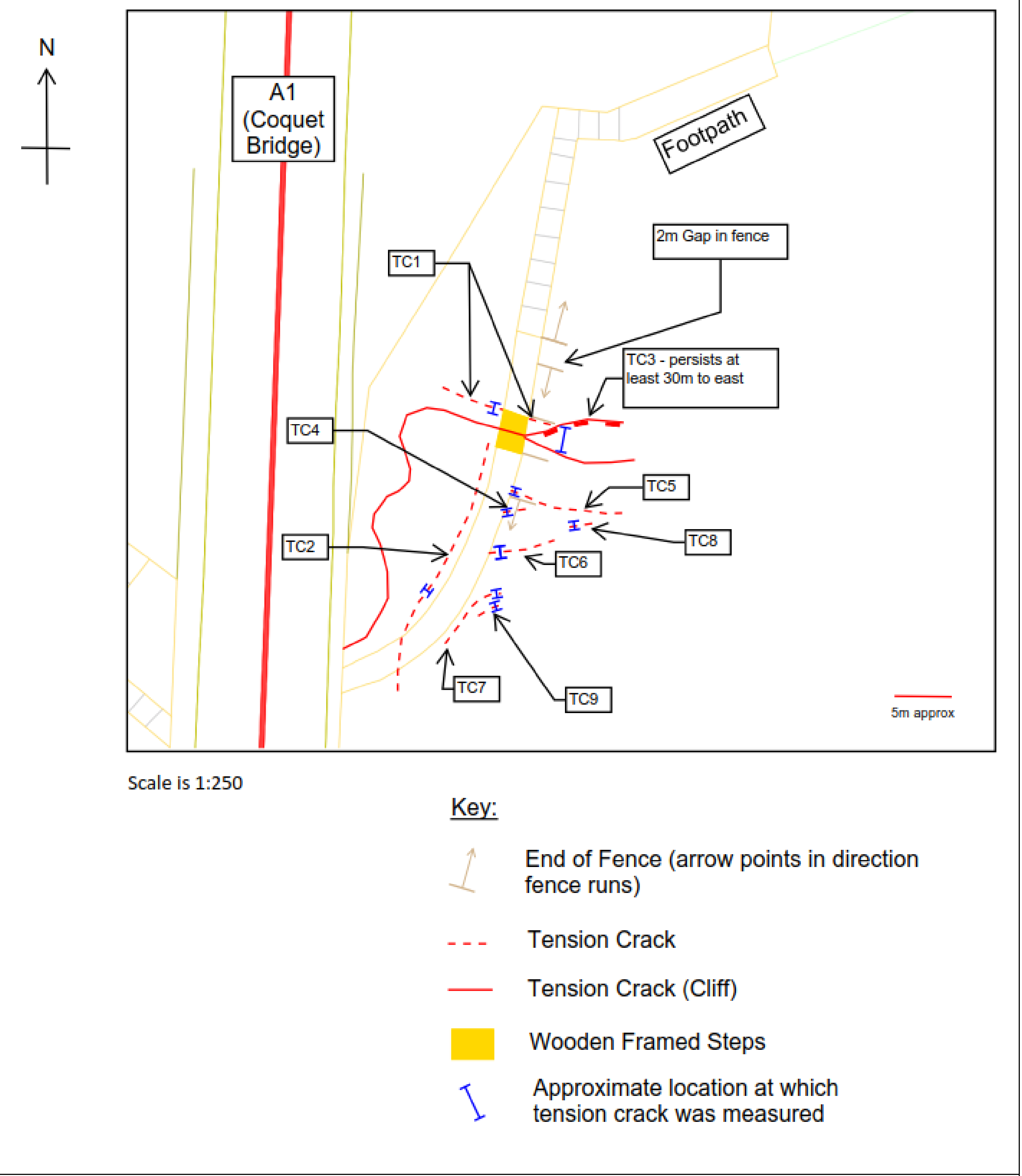


Figure 3 – Detailed plan of the observed tension cracking to the eastern side of the north abutment of the existing bridge.

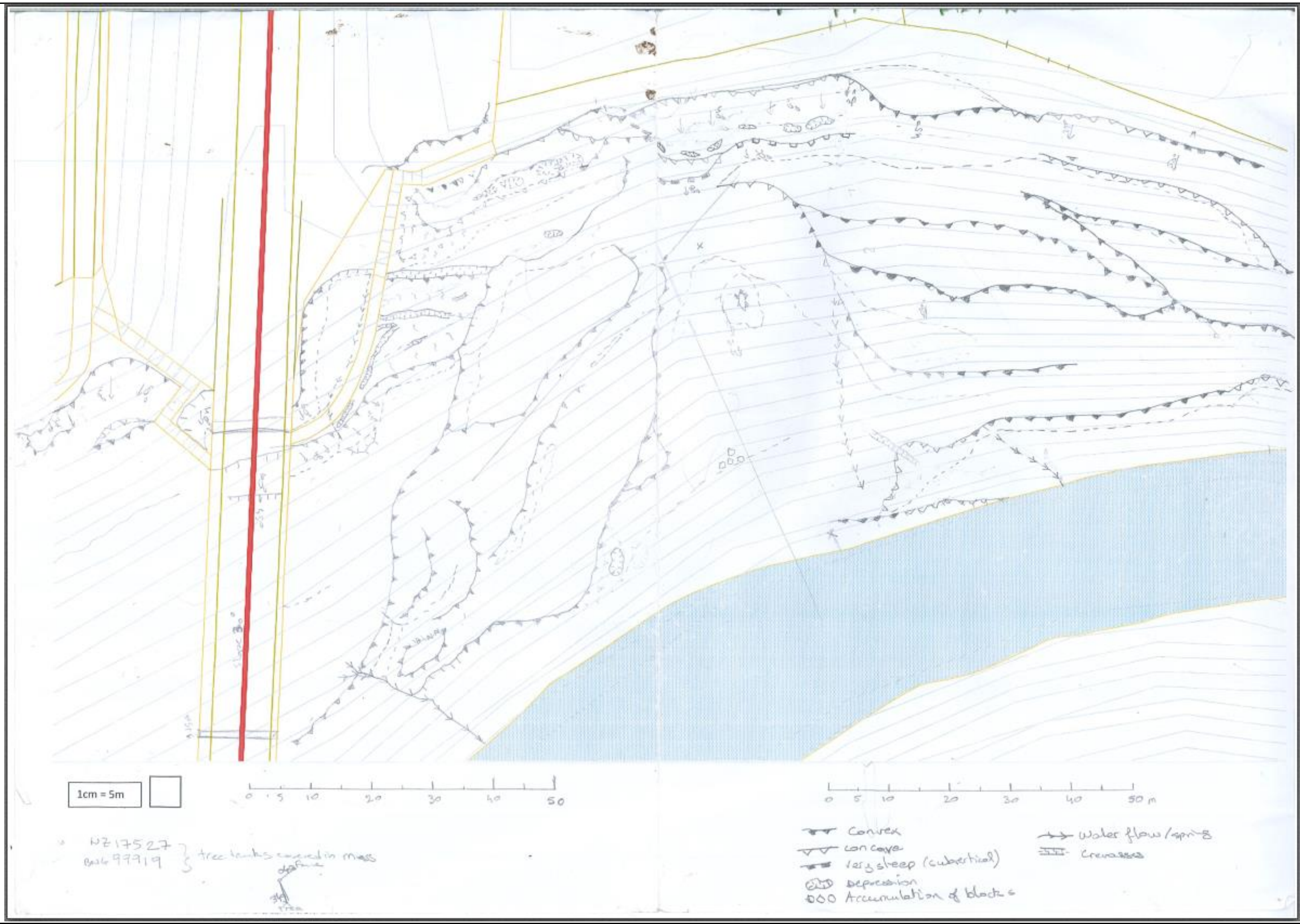


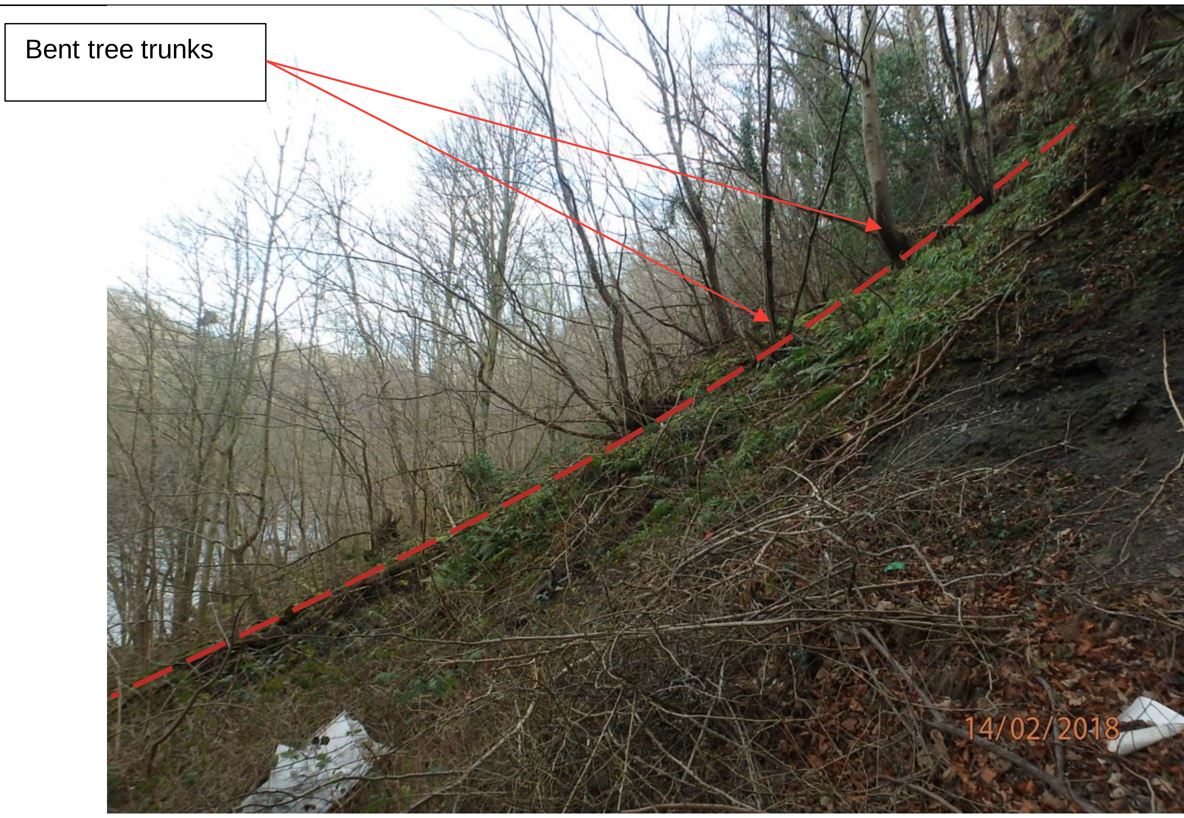
Figure 4 – Geomorphological map of the area to the east of the existing A1 overbridge.

Figure 5 – Geomorphological map of the area to the west of the existing A1 overbridge.

Figure 6 – GPS positions of recorded springs and other points of interest discussed within this memo. GPS points have been obtained through waypoint averaging.

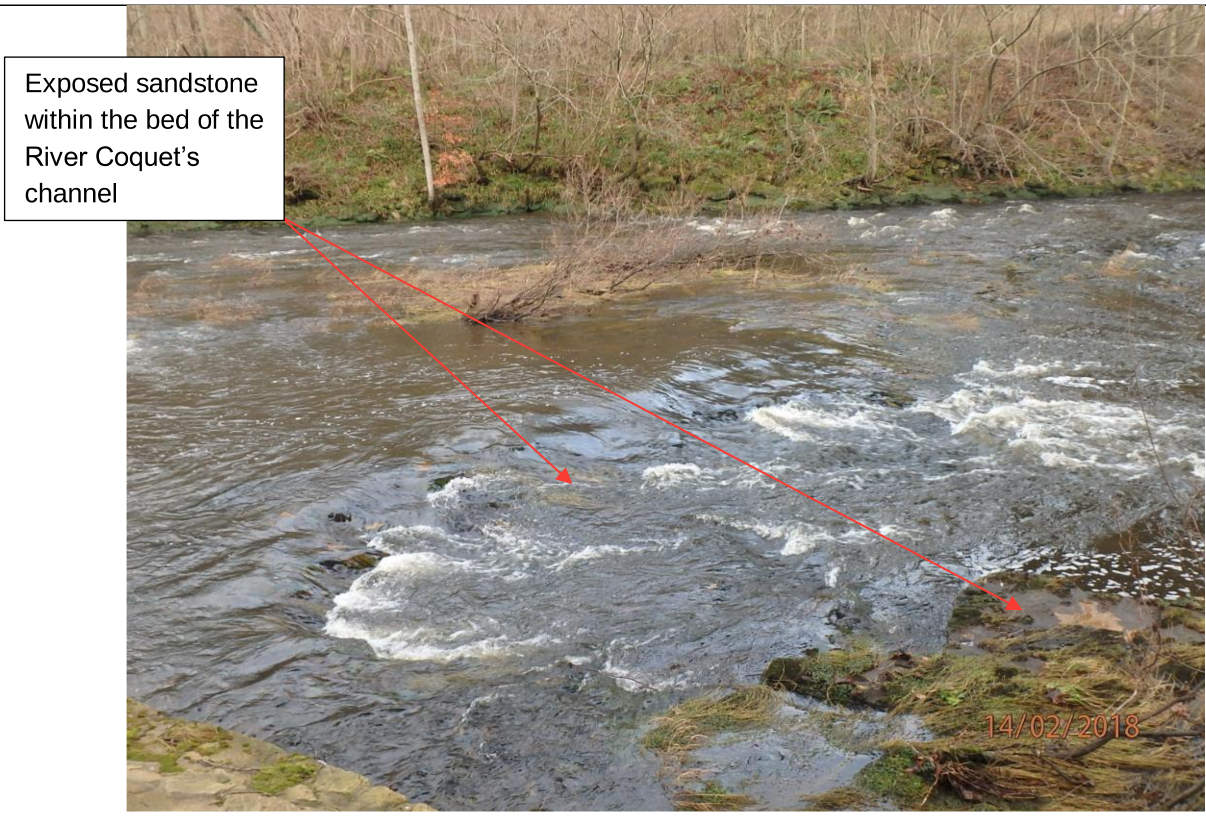
4. PHOTOGRAPHS

Photograph 1 – View south-east to the sandstone escarpment at the top of the slope.



Photograph 2 – view east of the mid-slope, note the curved trunks of mature trees indicating the movement has been occurring for some time.

Photograph 3 – View east from the position of the southern pier of the existing A1 bridge. Note the reducing gradient of the midslope (possible colluvium) and the river cut terrace.



Photograph 4 – Sandstone bedrock exposed within the bed of the River Coquet.

Photograph 5 – Fallen block intercepted by tree trunk. This demonstrates that rock falling has been active within the study area within the recent past.

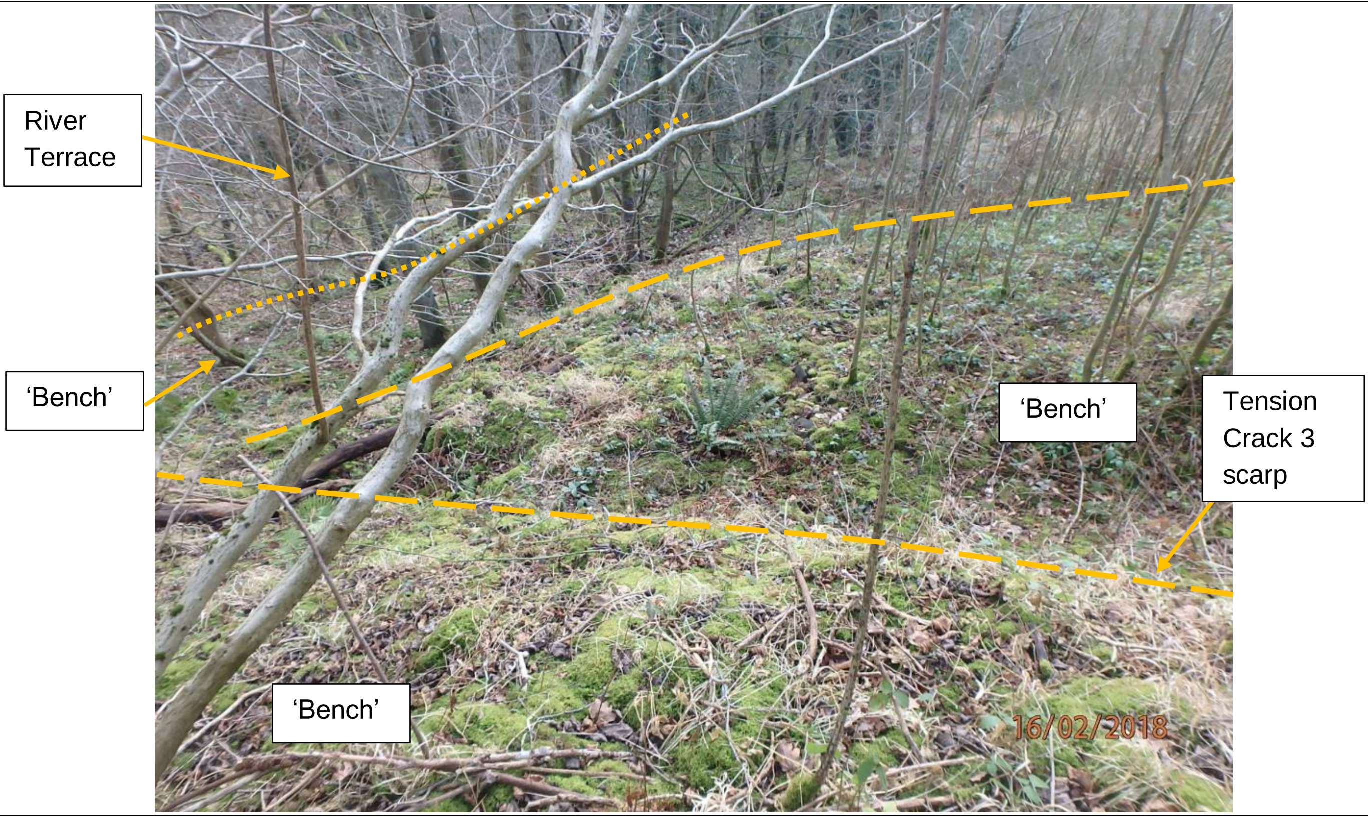
Photograph 6 – Apparent scour around the base and sides of the southern pier of the existing A1 bridge. Note the sandstone blocks which appear to have been intercepted by the structure. The upper divisions on the scale marker are centimetres.

Photograph 7 – Panoramic image mosaic of the exposed western rockface on the southern abutment (looking east).

Photograph 8 – Detailed image of the 'silty' material exposed within the rockface pictured in Photograph 7. The upper divisions on the scale marker are centimetres.

Photograph 9 – Hand sample of the Sandstone material. This material was obtained from a fallen block away from the exposed rock face.

Photograph 10 – Arcuate scarp noted to the west of the southern embankment. This feature appeared to be fairly recent, with exposed soil within the back scarp.



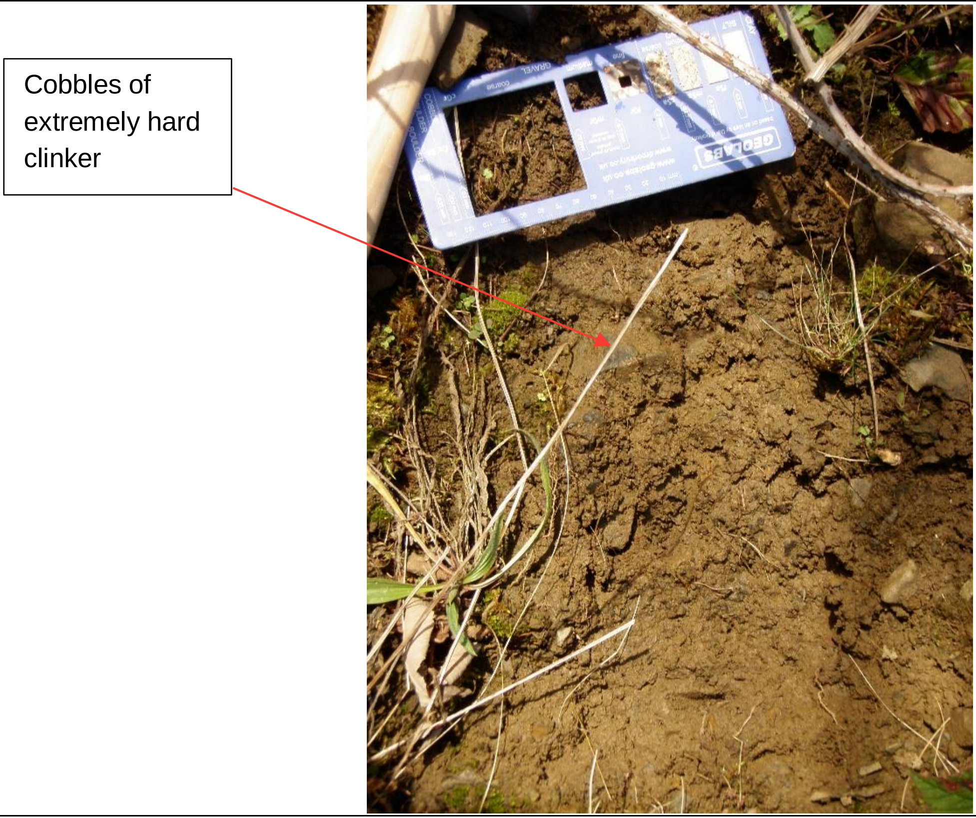
Photograph 11 – View south showing the terrain system of benches and slopes, potentially indicating failure within the area. At this point tension crack 3 has widened into a slope unit. Photograph taken at NZ 17485 99925.

Photograph 12 – View east of a tension crack within a failed block. This structure is located to the south of the public footpath. The clipboard within the photograph is A4 sized.

Photograph 13 – View west along one of the alluvial platform adjacent to the River Coquet. A steep slope unit to the right hand side seperates the river from it's terrace.

Section intentionally blank

Photograph 14 – Made Ground materials described within tension crack 3 adjacent to the footpath steps. The major divisions on the blue card are 1cm wide. The thickness of the upper unit is approximately 20cm.



Photograph 15 – Detail of the lower Made Ground as seen within the scarp of tension crack 3.

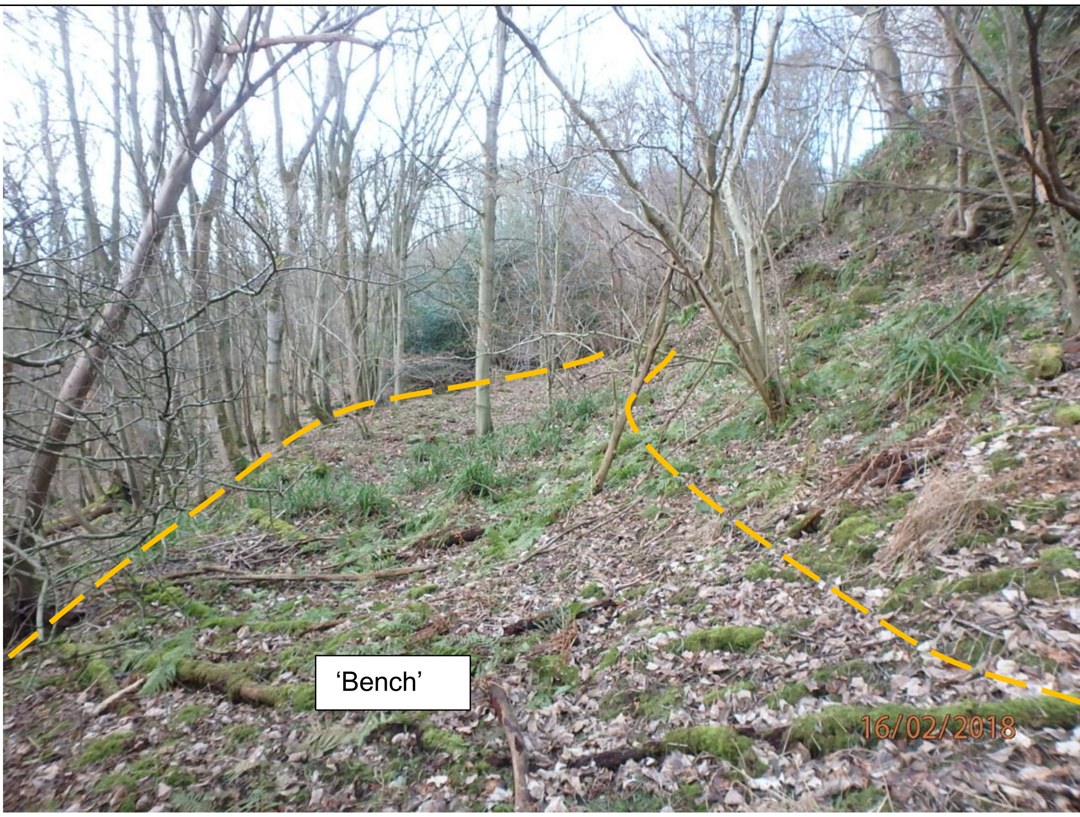
Photograph 16 – Bed rock geological succession observed to the east of the study area (photograph mosaic). This photograph demonstrates the change from the underlying shales to the overlying sandstones which thicken upwards. Photograph taken at NZ 17670 99895, 200m east of the existing bridge (location shown on Figure 5). Thought to represent an exposed failure plane.

Photograph 17 – Exposed corrugated metal sheets, below the level of the footpath, exposed within the backscarp of one of the failed blocks. Photograph taken at NZ 17545 99955. Clipboard is A3 sized.

Photograph 18 – Apparent colliery spoil noted at the surface at NZ 17570 99959. Note the presence of cobble/boulder sized fragments of slate, clinker and brick. Clipboard is A3 sized.

Photograph 19 – Proposed western extent of the zone of instability to the west of the existing A1 bridge northern abutment. Note the change in land use to coniferous forestry to the west.

Photograph 20 – Example of the eastern lateral flank of the zone of instability to the west of the existing A1 bridge (yellow line). The lateral extent is marked by the location of a dry drainage channel (blue line).

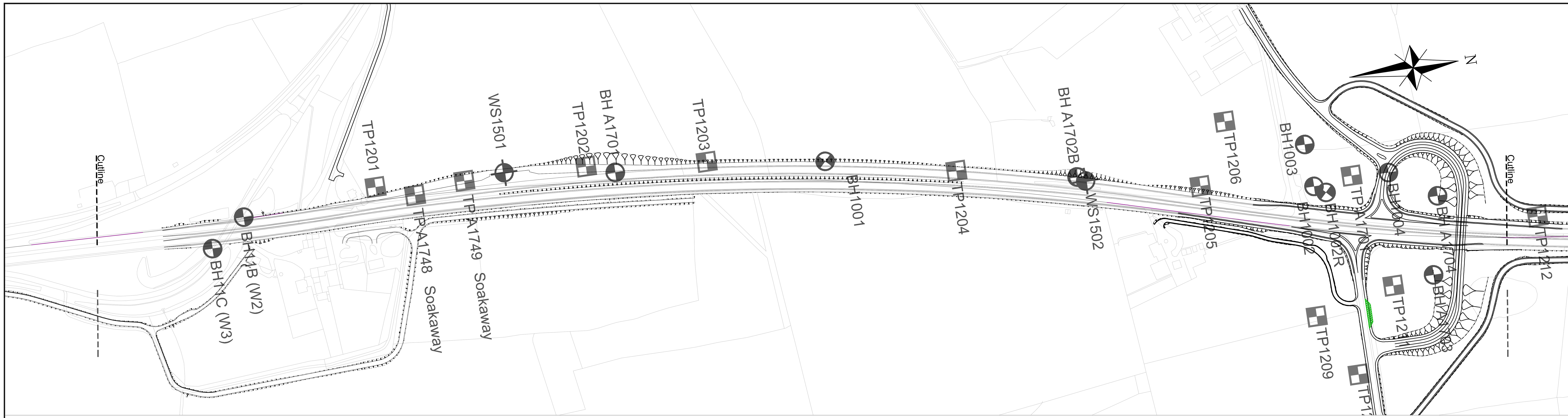


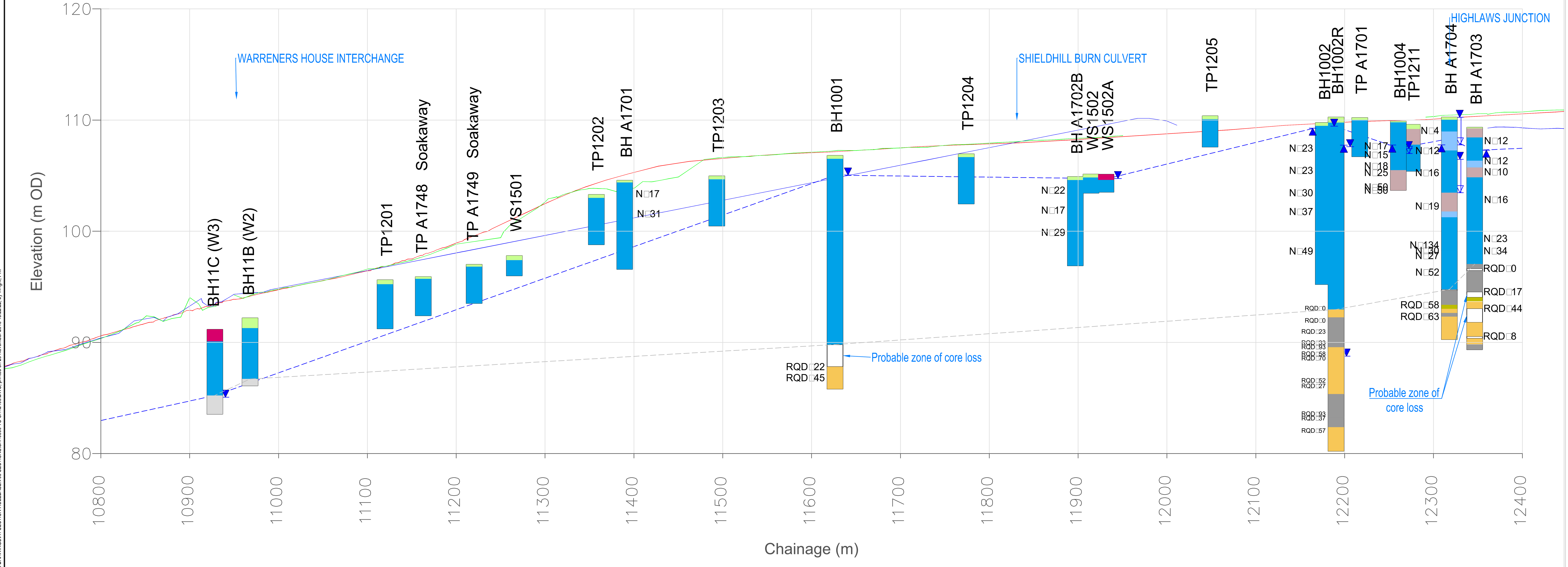
Photograph 21 – View west of the bench structure in the east of the study area. This feature may have been underestimated in scale within previous studies.

Appendix F

GEOLOGICAL LONGSECTIONS

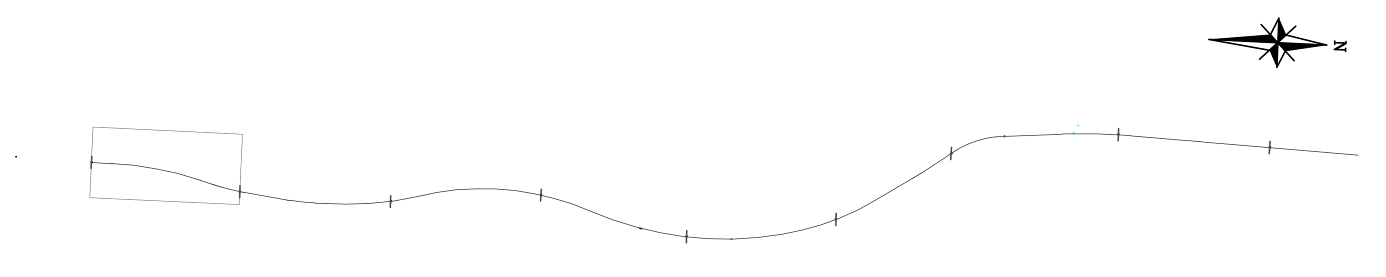
DO NOT SCALE





Key	
	Window Sample
	Borehole
	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
	Inferred base of Made Ground
	Inferred level of bedrock
	Groundwater level
	Groundwater strike
	Maximum recorded groundwater level
N = 12	SPT N value
RQD = 50	Rock Quality Designation

Geology	
Superficial	
	Topsoil
	Made Ground
	Cohesive Made Ground
	Granular Made Ground
	Cohesive Alluvium
	Granular Alluvium
	Glaciolacustrine
	Cohesive Glacial Till
	Granular Glacial Till
	Glaciofluvial Sand and Gravel
	Cohesive River Terrace Deposits
Solid	
	Weathered Mudstone
	Weathered Siltstone
	Weathered Sandstone
	Mudstone
	Siltstone
	Sandstone
	Undiff sst/mst/slst
	Limestone
	Openhole / zone of core loss / void
	Coal



REV	DATE	BY	DESCRIPTION	CHK	APP
P02	05/12/2018	PW	SECOND ISSUE		
P01	03/10/2018	PW	FIRST ISSUE		

DRAWING STATUS: S0 - WORK IN PROGRESS

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

CLIENT: highways england

PROJECT: A1 IN NORTHUMBERLAND MORPETH TO FELTON

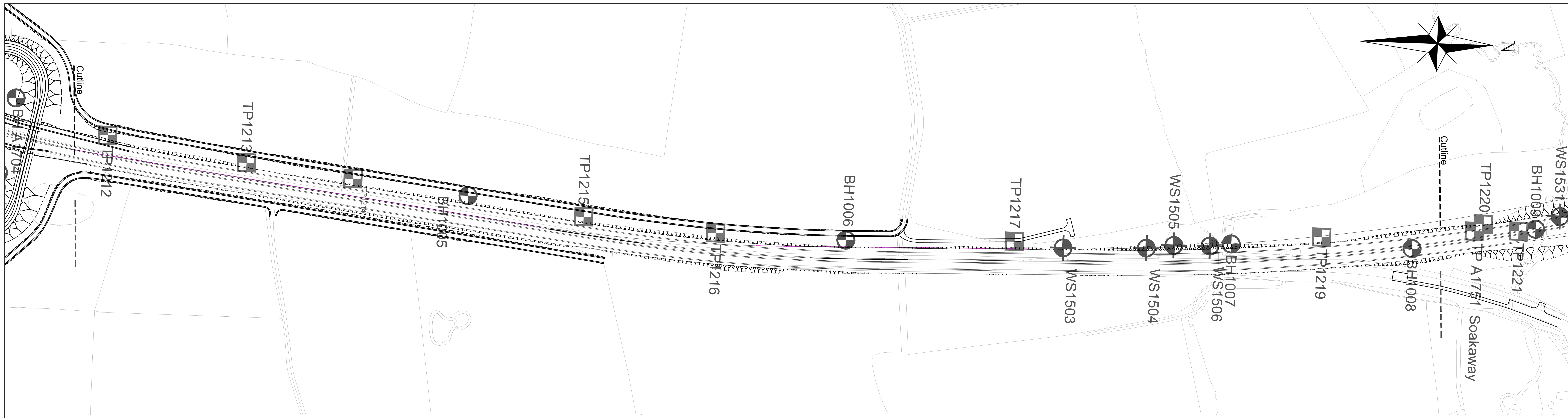
TITLE: GEOLOGICAL LONG SECTION CH10800 TO CH12400 SHEET 1 OF 8

SCALE @ A1:	CHECKED:	APPROVED:
H = 2500 V = 200	JV	BS

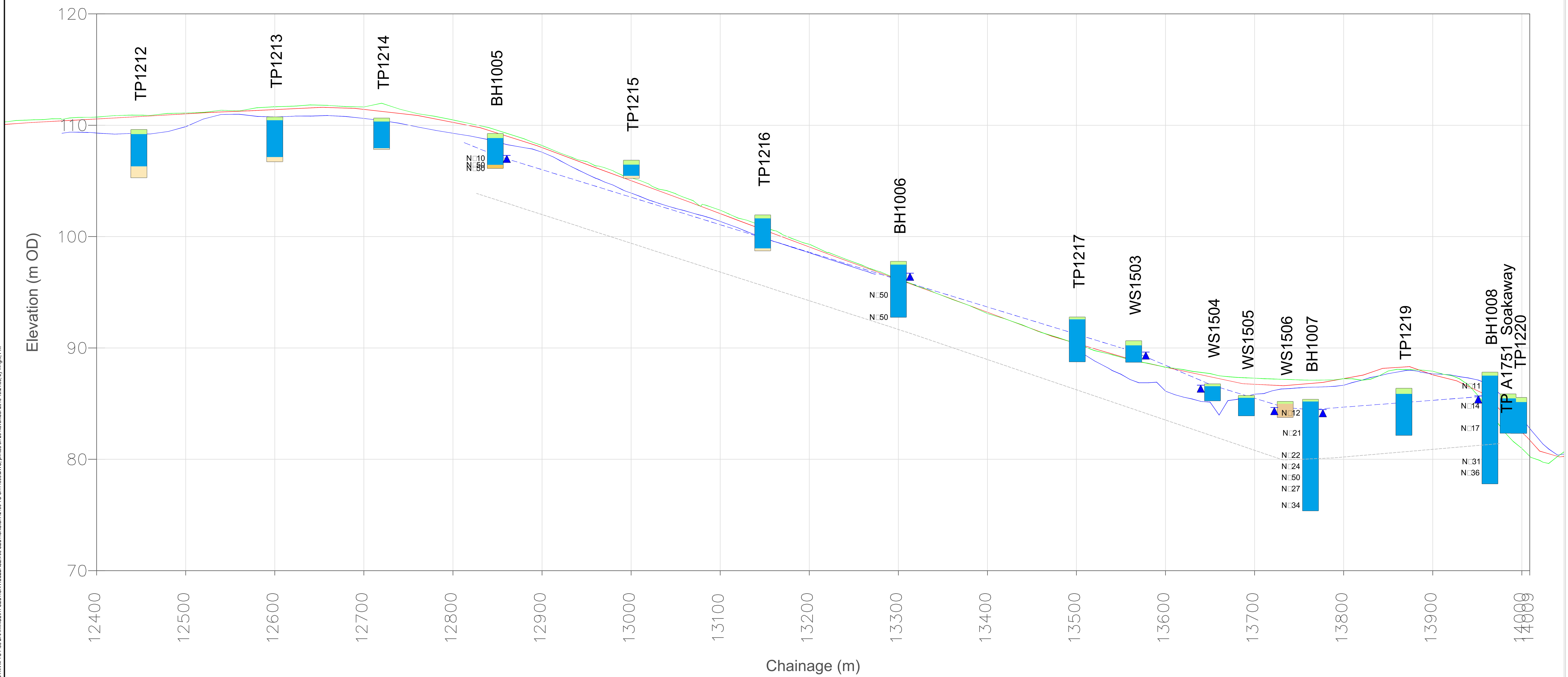
PROJECT No:	DESIGNED:	DRAWN:	DATE:
	PW	PW	November 18

DRAWING No: CH10800 TO CH12400 REV: P02

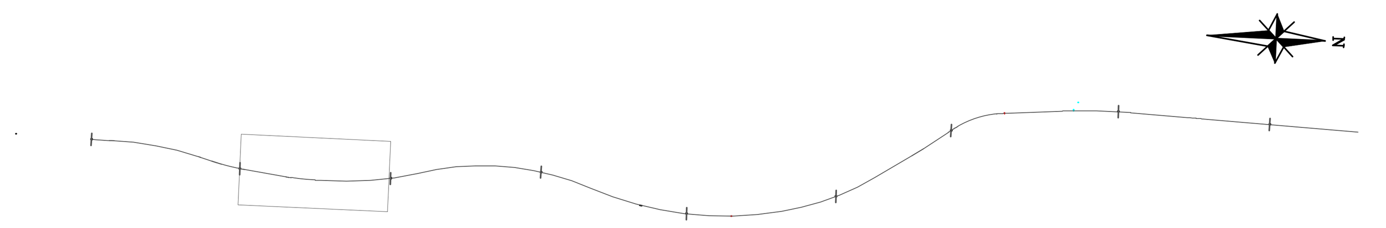
DO NOT SCALE



Key	
◆	Window Sample
⊕	Borehole
▪	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
	Inferred base of Made Ground
	Inferred level of bedrock
▼	Groundwater level
▽	Groundwater strike
▲	Maximum recorded groundwater level
N = 12	SPT N value
RQD = 50	Rock Quality Designation



Geology	
Superficial	
	Topsoil
	Made Ground
	Cohesive Made Ground
	Granular Made Ground
	Cohesive Alluvium
	Granular Alluvium
	Glaciolacustrine
	Cohesive Glacial Till
	Granular Glacial Till
	Glaciofluvial Sand and Gravel
	Cohesive River Terrace Deposits
Solid	
	Weathered Mudstone
	Weathered Siltstone
	Weathered Sandstone
	Mudstone
	Siltstone
	Sandstone
	Undiff sst/mst/slst
	Limestone
	Openhole / zone of core loss / void
	Coal



REV	DATE	BY	DESCRIPTION	CHK	APP
P02	05/12/2018	PW	SECOND ISSUE		
P01	03/10/2018	PW	FIRST ISSUE		

DRAWING STATUS: S0 - WORK IN PROGRESS

wsp

Queen Street
Manchester
M2 5JB, UK

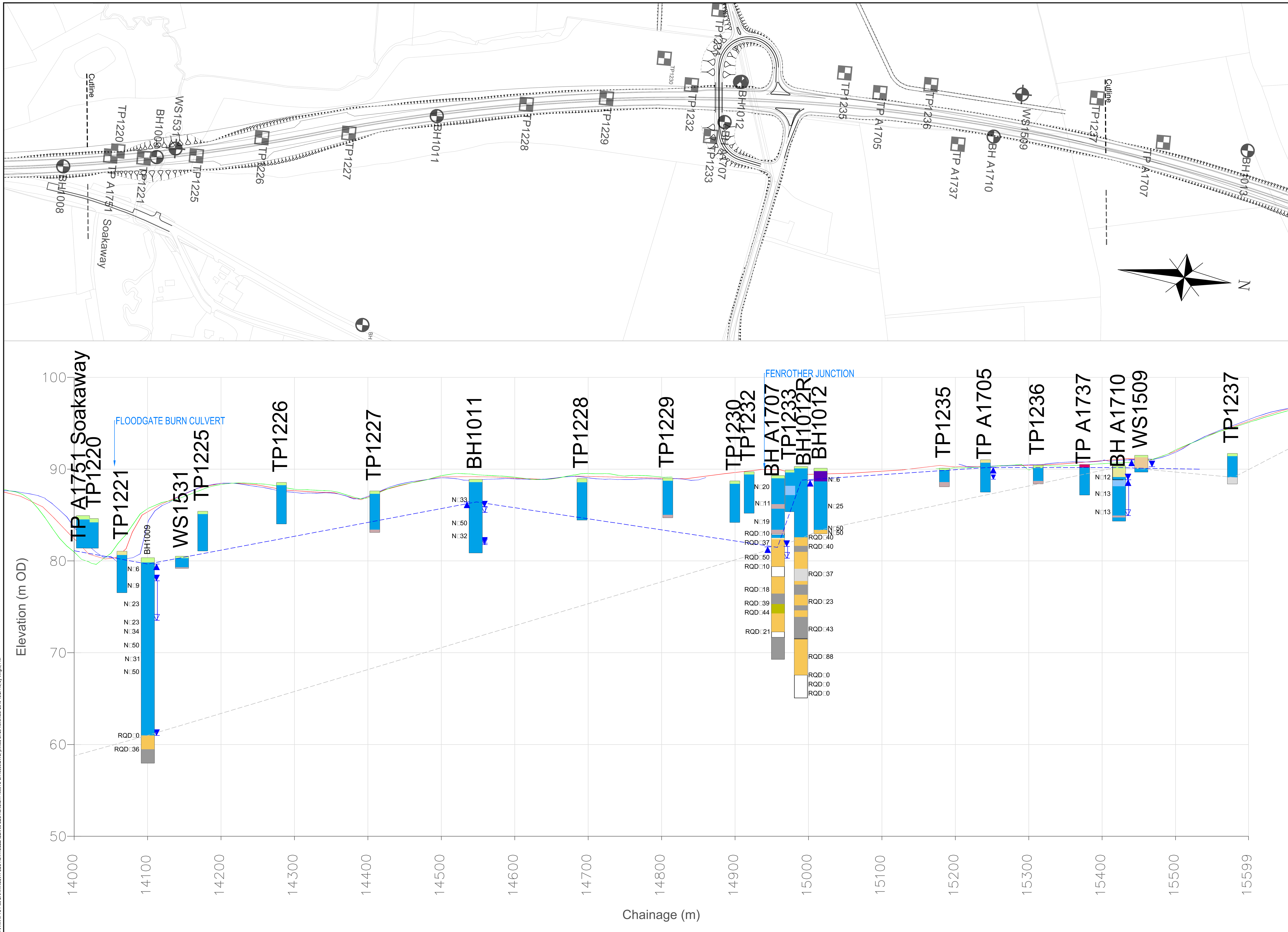
T+ 44 (0) 161 832 4542
wsp.com

CLIENT: highways england

PROJECT: A1 IN NORTHUMBERLAND MORPETH TO FELTON

TITLE: GEOLOGICAL LONG SECTION CH12400 TO CH14000 SHEET 2 OF 8

SCALE @ A1: H = 2500 V = 200	CHECKED: JV	APPROVED: BS
PROJECT No:	DESIGNED: PW / DRAWN: PW	DATE: November 18
DRAWING No: CH12400 TO CH14000		REV: P02



DO NOT SCALE

Key

	Window Sample
	Borehole
	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
	Inferred base of Made Ground
	Inferred level of bedrock
	Groundwater level
	Groundwater strike
	Maximum recorded groundwater level
N = 12	SPT N value
RQD = 50	Rock Quality Designation

Geology

Superficial

- Topsoil
- Made Ground
- Cohesive Made Ground
- Granular Made Ground
- Cohesive Alluvium
- Granular Alluvium
- Glaciolacustrine
- Cohesive Glacial Till
- Granular Glacial Till
- Glaciofluvial Sand and Gravel
- Cohesive River Terrace Deposits

Solid

- Weathered Mudstone
- Weathered Siltstone
- Weathered Sandstone
- Mudstone
- Siltstone
- Sandstone
- Undiff sst/mst/slst
- Limestone
- Openhole / zone of core loss / void
- Coal

REV	DATE	BY	DESCRIPTION	CHK	APP
P02	05/12/2018	PW	SECOND ISSUE		
P01	03/10/2018	PW	FIRST ISSUE		

DRAWING STATUS: S0 - WORK IN PROGRESS

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

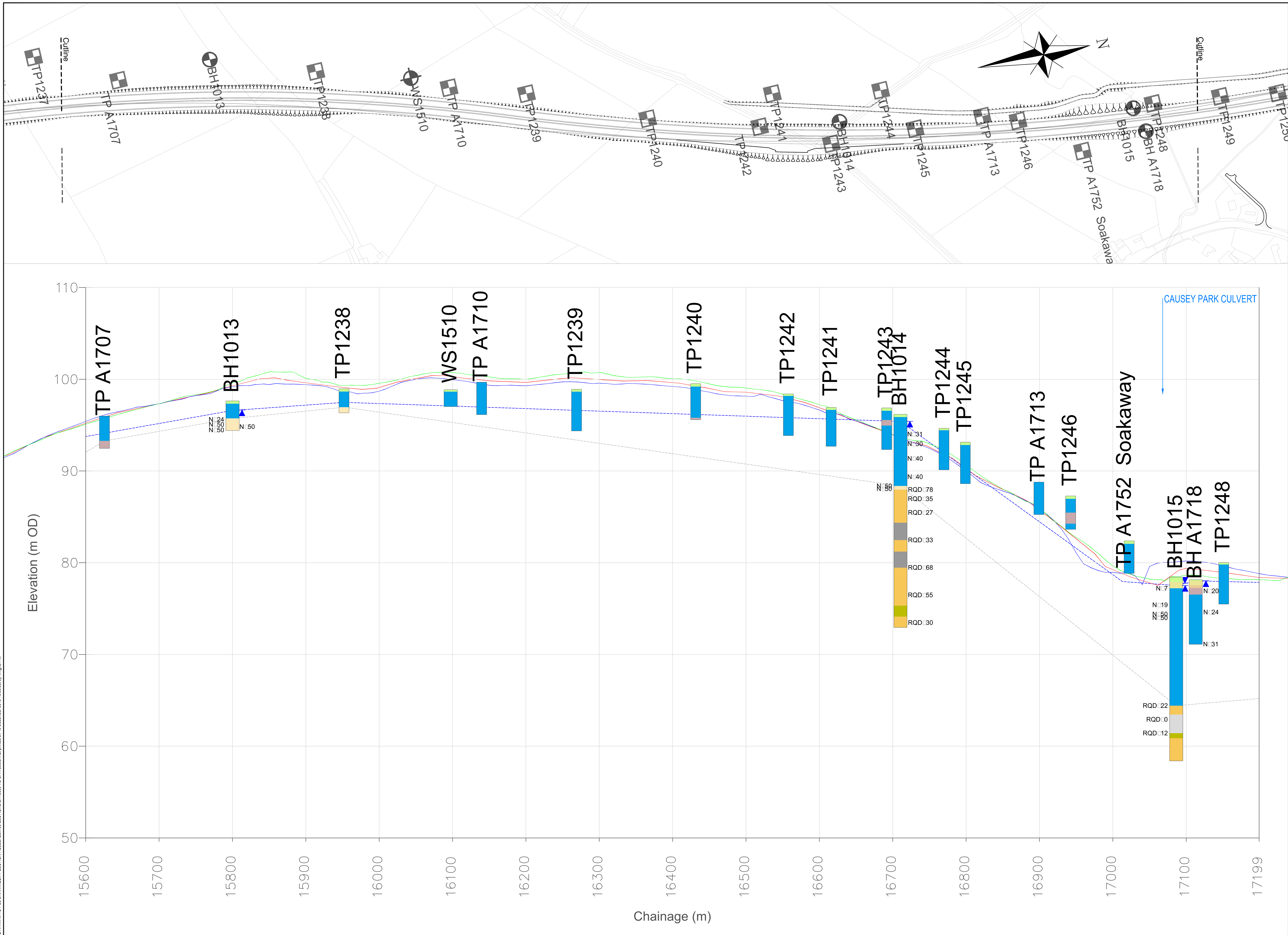
CLIENT: highways england

PROJECT: A1 IN NORTHUMBERLAND MORPETH TO FELTON

TITLE: GEOLOGICAL LONG SECTION CH14000 TO CH15600 SHEET 3 OF 8

SCALE @ A1: H = 2500 V = 200	CHECKED: JV	APPROVED: BS
PROJECT No:	DESIGNED: PW / DRAWN: PW	DATE: November 18
DRAWING No: CH14000TO CH15600		REV: P02

DO NOT SCALE



Key	
	Window Sample
	Borehole
	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
	Inferred base of Made Ground
	Inferred level of bedrock
	Groundwater level
	Groundwater strike
	Maximum recorded groundwater level
N = 12	SPT N value
RQD = 50	Rock Quality Designation

Geology	
Superficial	
	Topsoil
	Made Ground
	Cohesive Made Ground
	Granular Made Ground
	Cohesive Alluvium
	Granular Alluvium
	Glaciolacustrine
	Cohesive Glacial Till
	Granular Glacial Till
	Glaciofluvial Sand and Gravel
	Cohesive River Terrace Deposits
Solid	
	Weathered Mudstone
	Weathered Siltstone
	Weathered Sandstone
	Mudstone
	Siltstone
	Sandstone
	Undiff sst/mst/sist
	Limestone
	Openhole / zone of core loss / void
	Coal

REV	DATE	BY	DESCRIPTION	CHK	APP
P02	05/12/2018	PW	SECOND ISSUE		
P01	03/10/2018	PW	FIRST ISSUE		

DRAWING STATUS: S0 - WORK IN PROGRESS

wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

CLIENT: highways england

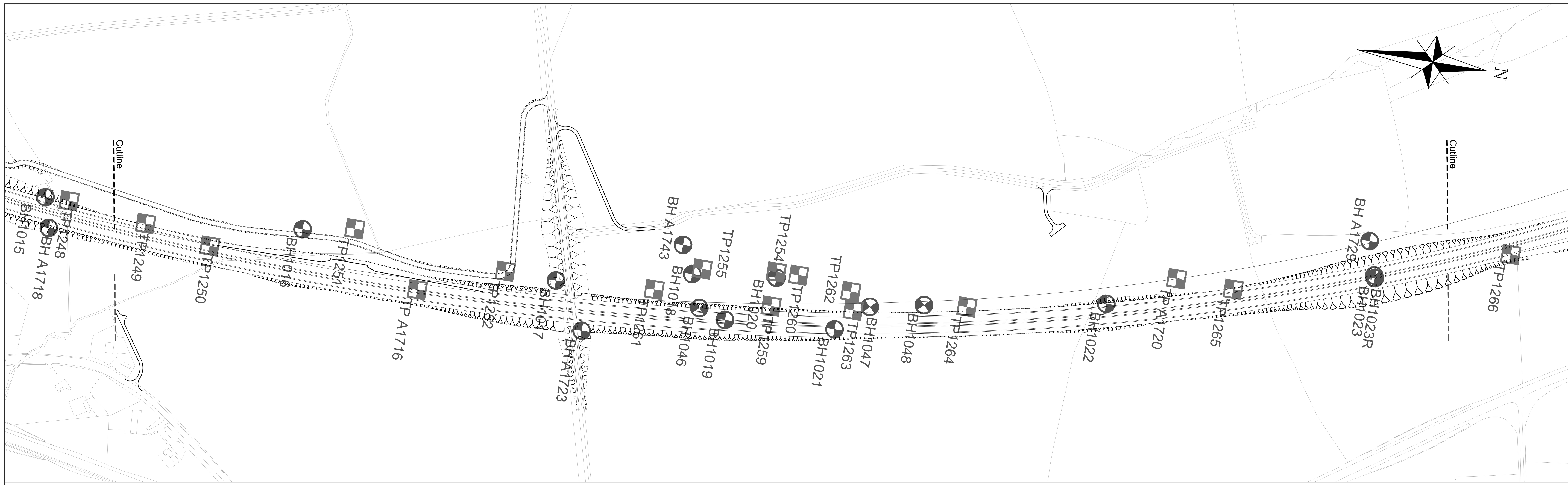
PROJECT: A1 IN NORTHUMBERLAND MORPETH TO FELTON

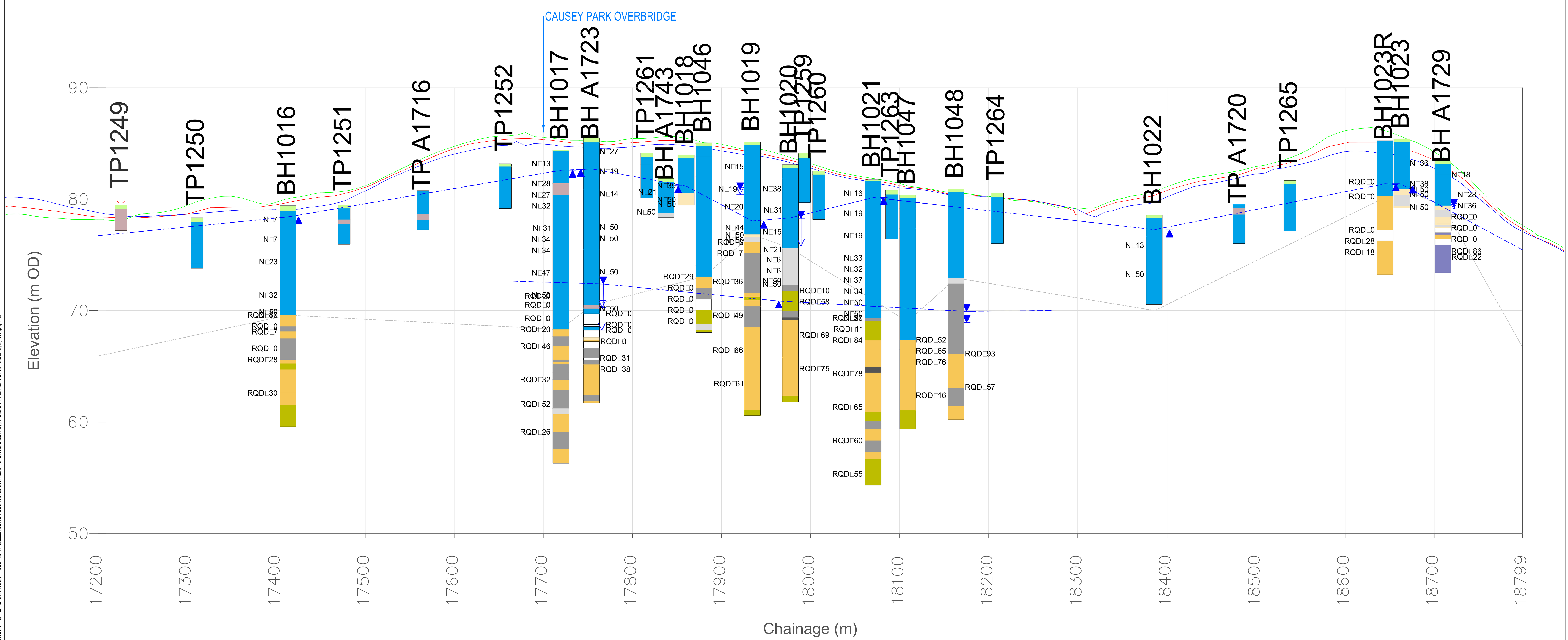
TITLE: GEOLOGICAL LONG SECTION CH15600 TO CH17200 SHEET 4 OF 8

SCALE @ A1: H = 2500 V = 200 | CHECKED: JV | APPROVED: BS

PROJECT No: | DESIGNED: PW | DRAWN: PW | DATE: November 18

DRAWING No: CH15600 TO CH17200 | REV: P02

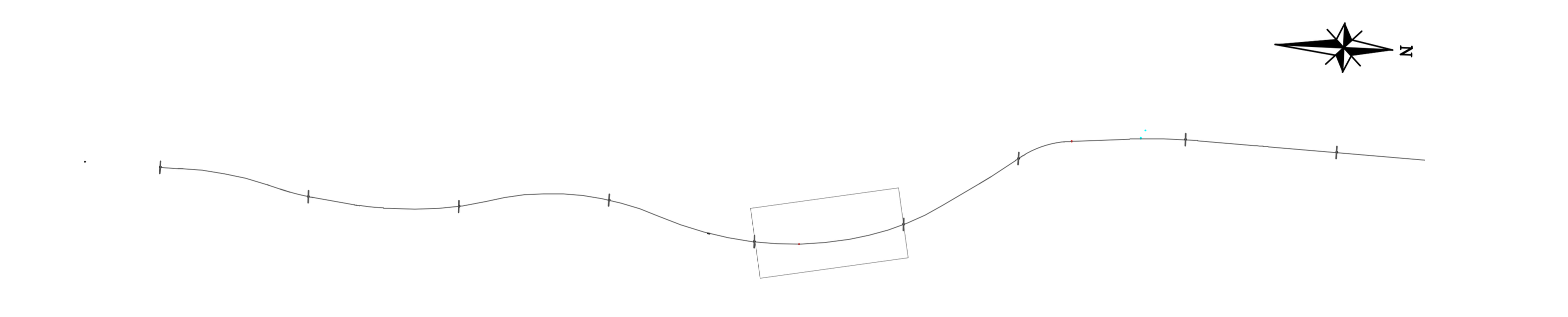




DO NOT SCALE

Key	
	Window Sample
	Borehole
	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
	Inferred base of Made Ground
	Inferred level of bedrock
	Groundwater level
	Groundwater strike
	Maximum recorded groundwater level
N = 12	SPT N value
RQD = 50	Rock Quality Designation

Geology	
Superficial	
	Topsoil
	Made Ground
	Cohesive Made Ground
	Granular Made Ground
	Cohesive Alluvium
	Granular Alluvium
	Glaciolacustrine
	Cohesive Glacial Till
	Granular Glacial Till
	Glaciofluvial Sand and Gravel
	Cohesive River Terrace Deposits
Solid	
	Weathered Mudstone
	Weathered Siltstone
	Weathered Sandstone
	Mudstone
	Siltstone
	Sandstone
	Undiff sst/mst/sist
	Limestone
	Openhole / zone of core loss / void
	Coal



REV	DATE	BY	DESCRIPTION	CHK	APP
P02	05/12/2018	PW	SECOND ISSUE		
P01	03/10/2018	PW	FIRST ISSUE		

DRAWING STATUS: S0 - WORK IN PROGRESS

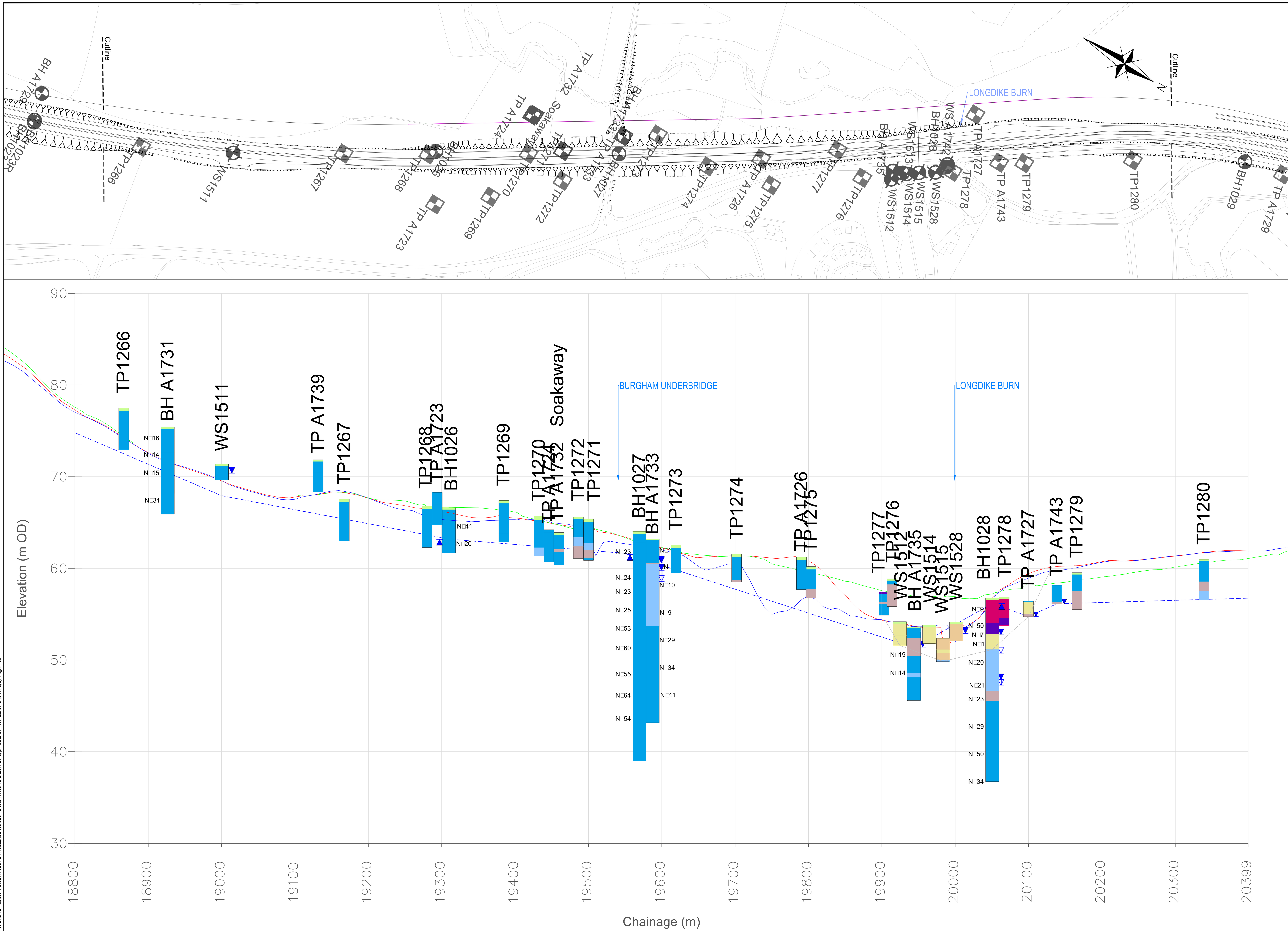
wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

CLIENT: highways england

PROJECT: A1 IN NORTHUMBERLAND MORPETH TO FELTON

TITLE: GEOLOGICAL LONG SECTION CH17200 TO CH18800 SHEET 5 OF 8

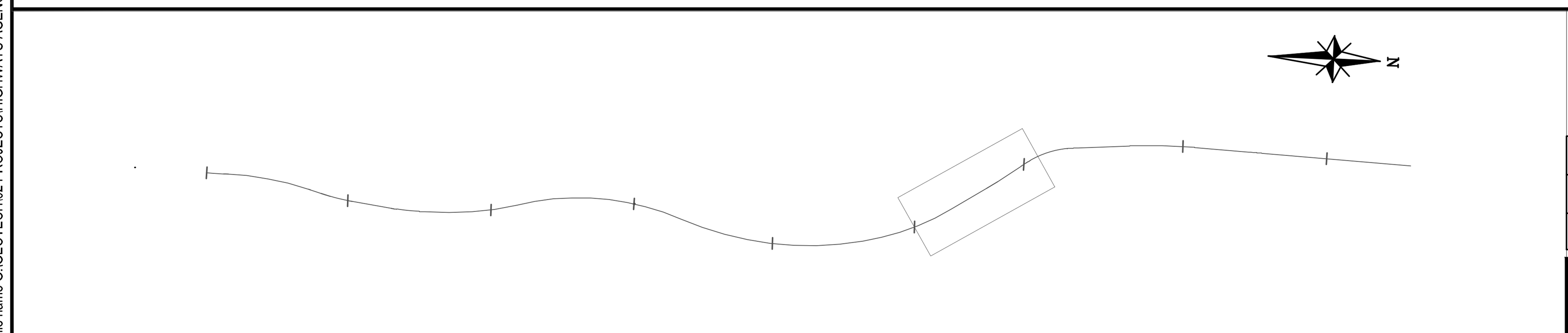
SCALE @ A1: H = 2500 V = 200	CHECKED: JV	APPROVED: BS
PROJECT No:	DESIGNED: PW / DRAWN: PW	DATE: November 18
DRAWING No: CH17200 TO CH18800		REV: P02



DO NOT SCALE

Key	
	Window Sample
	Borehole
	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
	Inferred base of Made Ground
	Inferred level of bedrock
	Groundwater level
	Groundwater strike
	Maximum recorded groundwater level
N = 12	SPT N value
RQD = 50	Rock Quality Designation

Geology	
Superficial	
	Topsoil
	Made Ground
	Cohesive Made Ground
	Granular Made Ground
	Cohesive Alluvium
	Granular Alluvium
	Glaciolacustrine
	Cohesive Glacial Till
	Granular Glacial Till
	Glaciofluvial Sand and Gravel
	Cohesive River Terrace Deposits
Solid	
	Weathered Mudstone
	Weathered Siltstone
	Weathered Sandstone
	Mudstone
	Siltstone
	Sandstone
	Undiff sst/mst/slst
	Limestone
	Openhole / zone of core loss / void
	Coal



REV	DATE	BY	DESCRIPTION	CHK	APP
P02	05/12/2018	PW	SECOND ISSUE		
P01	03/10/2018	PW	FIRST ISSUE		

DRAWING STATUS: S0 - WORK IN PROGRESS

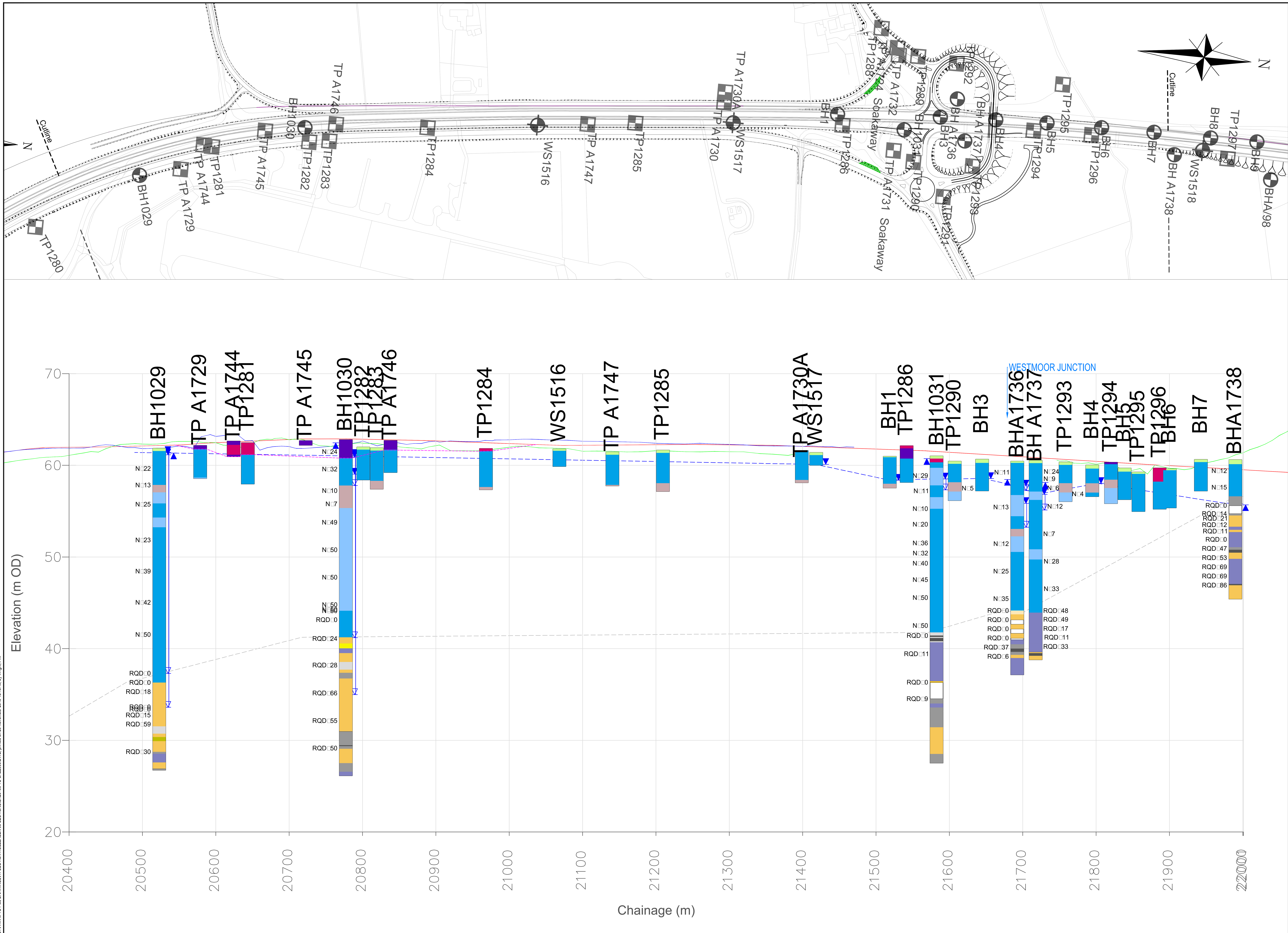
wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

CLIENT: highways england

PROJECT: A1 IN NORTHUMBERLAND MORPETH TO FELTON

TITLE: GEOLOGICAL LONG SECTION CH18800 TO CH20400 SHEET 6 OF 8

SCALE @ A1: H = 2500 V = 200	CHECKED: JV	APPROVED: BS
PROJECT No:	DESIGNED: PW / DRAWN: PW	DATE: November 18
DRAWING No: CH18800 TO CH2040		REV: P02



DO NOT SCALE

Key	
	Window Sample
	Borehole
	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
	Inferred base of Made Ground
	Inferred level of bedrock
	Groundwater level
	Groundwater strike
	Maximum recorded groundwater level
N = 12	SPT N value
RQD = 50	Rock Quality Designation

Geology	
Superficial	
	Topsoil
	Made Ground
	Cohesive Made Ground
	Granular Made Ground
	Cohesive Alluvium
	Granular Alluvium
	Glaciolacustrine
	Cohesive Glacial Till
	Granular Glacial Till
	Glaciofluvial Sand and Gravel
	Cohesive River Terrace Deposits
Solid	
	Weathered Mudstone
	Weathered Siltstone
	Weathered Sandstone
	Mudstone
	Siltstone
	Sandstone
	Undiff sst/mst/sist
	Limestone
	Openhole / zone of core loss / void
	Coal

REV	DATE	BY	DESCRIPTION	CHK	APP
P02	05/12/2018	PW	SECOND ISSUE		
P01	03/10/2018	PW	FIRST ISSUE		

DRAWING STATUS: S0 - WORK IN PROGRESS

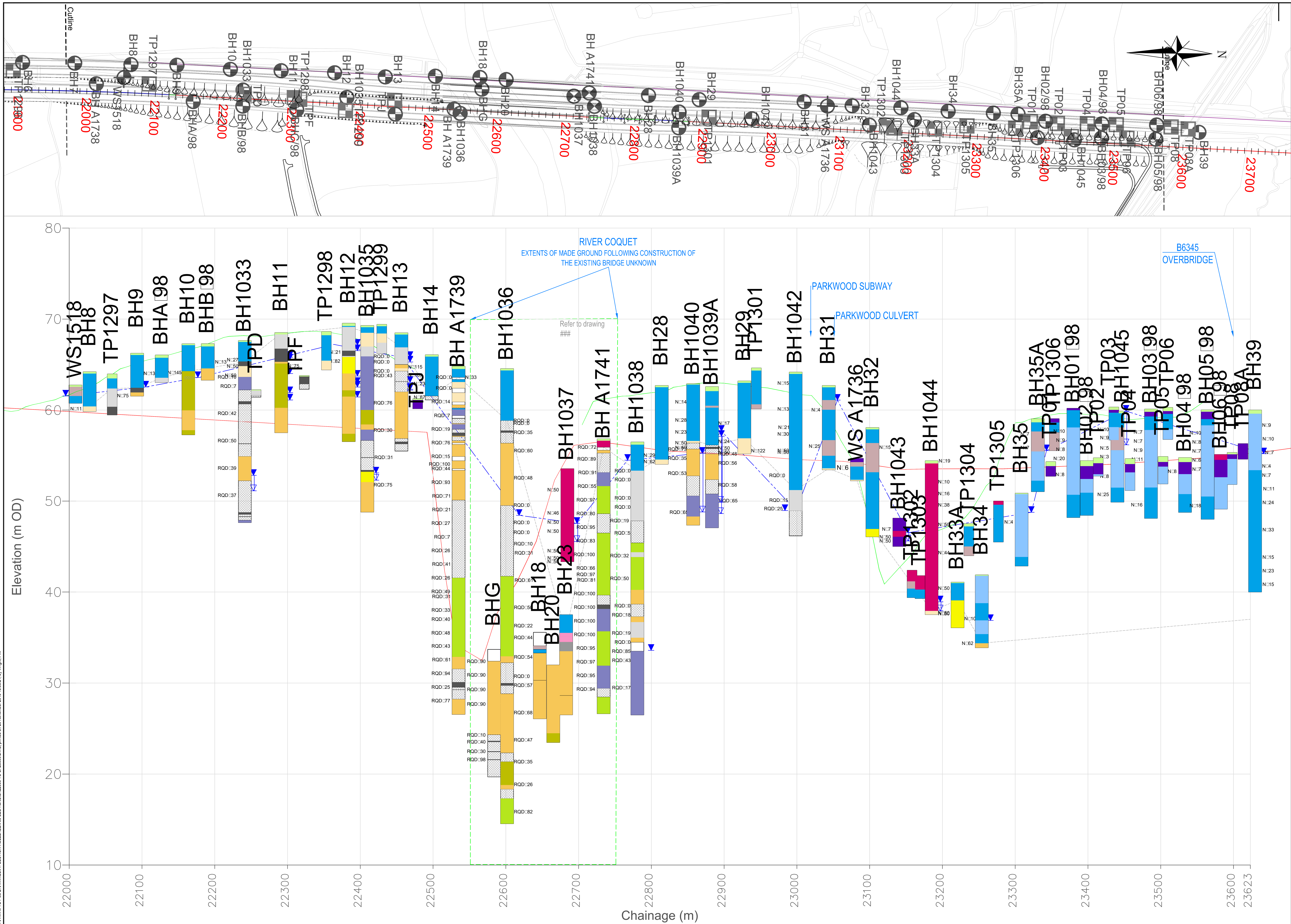
wsp
Queen Street
Manchester
M2 5JB, UK
T+ 44 (0) 161 832 4542
wsp.com

CLIENT: highways england

PROJECT: A1 IN NORTHUMBERLAND MORPETH TO FELTON

TITLE: GEOLOGICAL LONG SECTION CH20400 TO CH22000 SHEET 7 OF 8

SCALE @ A1: H = 2500 V = 200	CHECKED: JV	APPROVED: BS
PROJECT No:	DESIGNED: PW / DRAWN: PW	DATE: MARCH 18
DRAWING No: CH20400 TO CH22000		REV: P02



DO NOT SCALE

Key	
	Window Sample
	Borehole
	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
	Inferred base of Made Ground
	Inferred level of bedrock
	Groundwater level
	Groundwater strike
	Maximum recorded groundwater level
N = 12	SPT N value
RQD = 50	Rock Quality Designation

Geology
Superficial
Topsoil
Made Ground
Cohesive Made Ground
Granular Made Ground
Cohesive Alluvium
Granular Alluvium
Glaciolacustrine
Cohesive Glacial Till
Granular Glacial Till
Glaciofluvial Sand and Gravel
Cohesive River Terrace Deposits
Solid
Weathered Mudstone
Weathered Siltstone
Weathered Sandstone
Mudstone
Siltstone
Sandstone
Undiff sst/mst/slst
Limestone
Openhole / zone of core loss / void
Coal

REV	DATE	BY	DESCRIPTION	CHK	APP
P02	05/12/2018	PW	SECOND ISSUE		
P01	03/10/2018	PW	FIRST ISSUE		

DRAWING STATUS: S0 - WORK IN PROGRESS

wsp
Queen Street
Manchester
M2 5JB, UK

T+ 44 (0) 161 832 4542
wsp.com

CLIENT: highways england

PROJECT: A1 IN NORTHUMBERLAND MORPETH TO FELTON

TITLE: GEOLOGICAL LONG SECTION CH22000 TO CH23600 SHEET 8 OF 8

SCALE @ A1: H = 2500 V = 200	CHECKED: JV	APPROVED: BS
PROJECT No:	DESIGNED: PW / DRAWN: PW	DATE: December 18
DRAWING No: CH22000 TO CH23600		REV: P02

Appendix G

GEOTECHNICAL RISK REGISTER

GEOTECHNICAL RISK EVALUATION MATRIX

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

X

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%

=

		Impact				
		5	**4**	**3**	**2**	**1**
Probability	**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 source.

Name of Project:	A1 in Northumberland Morpeth to Felton Dualling
Date of last update	01-02-2019

Risk Rating (R) = Probability (P) x 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	Voids associated with shallow underground mine workings and abandoned shafts and adits.	Potential for ground failure due to insufficient bearing capacity or excessive settlement of scheme elements during or post-construction. Future instability as a result of rising groundwater causing degradation of underground pillars, floors and roofs as the water table returns to its original level following the cessation of mine dc-watering. Contaminated mine water may enter the drainage systems in the future as groundwater levels rebound following cessation of mine dewatering.	Desk study: Review of all the available information including abandonment plans and historic ground investigation. Walkover with landowner to obtain local knowledge of mining activities and associated effects on ground (subsidence / collapse) Ground investigation specific to address mining risk undertaken.	1	2	2	Allowance for treatment during construction if any unexpected voids encountered. All plans and investigative information to be passed to the Contractor.	1	2	2	Risk only in vicinity Causey Park and Eshott Airfield. It is considered that an effective way to assess and mitigate the risk during construction would be a grid of grouted probe holes in at risk areas.
2	Unforeseen deep and surface mining backfill material.	Construction issues associated with obstructions such as cobbles and boulders within the Made Ground. Presence of voids or loose/ uncompacted materials leading to excessive settlement of scheme elements. Increased drag loads (negative skin friction) on piles due to large amounts of settlement. Inundation of groundwater into fills causing excessive settlement of the backfill and any overlying structural elements.	Desk study - Review all the available information including abandonment plans. Ground investigation for the proposed site extents and structure locations.				None identified beneath route – **Risk Closed**				In vicinity Causey Park, Eshott Airfield. Backfilled open cast pit at Ch.13650 Backfilled open cast pit at Ch.21300

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	
3	Presence weak & compressible soils.	Poor information on the localised Alluvial deposits associated with local watercourses leading to unacceptable settlement of infrastructure such as culvert foundations or embankment extensions, arising from loading of compressible soils. Potentially differential settlement on structures and new and existing pavement causing damage to the existing and new infrastructure. Inadequate CBR of fill/sub-grade requiring increased thickness of sub-base/capping. Increased drag loads on piles. Settlement period of embankments cannot be accommodated within design programme.	Desk study - Review of all the available information including historic GI. Ground investigation for the proposed site extents and structure locations. Preliminary assessment of likely foundation solution provided for Structures Option Reports based on ground investigation.	3	3	9	Detailed design to optimise structure foundation solutions and road pavement foundation. Programme construction of significant embankments early in the programme where feasible. Consider use of sand drains or similar to reduce settlement periods if required.	1	3	3	
4	Presence of laminated clays	Failure of earthwork slopes due zones of reduced shear strength.	Ground investigation undertaken and zones of laminated clays identified and demarcated on geohazard plans. Additional space within redline boundary allowed in areas of laminated clays so slopes can be slackened if required.	2	3	6	Design parameters and calculation to account for such materials during detailed design.	1	3	3	
5	Shallow rock/ hard dig material	Difficulty in excavating material for earthworks or shallow foundations leading to programme delays. Difficulty installing piles through hard strata leading to need to redesign. Extensive cobbles and boulders encountered in the Glacial Till.	Desk study - Review of all the available information including historic GI data. Ground investigation for the proposed site extents and structure locations. Geological longs section and ground models at structure locations produced to identify rock head in relation to levels.	2	3	6	Structural foundations to be optimised during detailed design where shallow rock head is present. Allow for excavation in rock where identified in the construction methodology and programme.	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	
6	Presence of aggressive ground conditions	Pyrite content of coal measures is relatively high and this can oxidise to sulphates which attacks concrete.	Desk study - Review all the available information. Ground investigation where concrete may be used included chemical testing in accordance with relevant standards.	**2**	**4**	**8**	Assign appropriate concrete BRE classes during detailed design.	**1**	**4**	**4**	
7	Shortfall of suitable fill material	Lithologies may not be conducive to the production of high quality fill for re-use as part of the works. The Glacial Till covering much of the route may be too wet to re-use. Degree of suitability of soils for re-use makes it difficult to achieve a cut-fill balance. May need to import fill for construction.	Desk study – Pertinent data within historic ground investigation data reviewed. Ground investigation undertaken. Preliminary assessment of suitability of material for reuse undertaken – indicates most material is wet of optimum Class 2 material.	**2**	**5**	**10**	Detailed assessment for material suitability for re-use on site. Allowance for lime modification of Glacial Till during construction to create Class 2 Fill. Consider use of test embankments prior to main works ascertain compaction properties and performance of site won materials. Consider use of Performance Specification for construction to maximise opportunity to use site won fill.	**1**	**5**	**5**	Preliminary assessment of cut/fill balance would indicate an overall surplus of material of roughly 25% to construct the scheme. There is on-going design work on landscape bunds which could utilise excess material as Class 4 Fill

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	
8	Insufficient GI data	Limited GI available at specific locations of scheme elements. In particular, limited groundwater information with regard to seasonal variations and occasional gaps at structure locations where scheme elements have changed since the site specific ground investigation. Greater risk of encountering unanticipated ground conditions. May result the use of ground models of a reduced accuracy and conservative designs. Extents of Made Ground/ Engineered Fill stemming from the construction of the existing River Coquet Bridge is currently unknown. GI post construction that has proven the full depth of strata at the bridge foundation location is limited. Potential for perched groundwater - difficulty in creating shallow temporary works excavations due to the ingress of water.	Desk study - Review all the available GI information to identify gaps in information. Ground investigation undertaken in Summer/Autumn 2017 in areas where insufficient GI had been identified (largely at locations of proposed structures).	3	3	9	Additional GI scheduled in River Coquet Valley prior to detailed design (GI at this location was not possible during 2017 investigation dur to access constraints). Recommended further GI be undertaken at pond location (pond locations were not known at time of the most recent GI). Recommended that further GI be undertaken at any locations where detailed design identifies need to relocate structures or where localised features such as slope regrades/low retaining walls are required. Further investigation of localised features identified on the Geohazard Plans such as backfilled ponds during construction.	1	3	3	A backfilled pit potentially impinges beneath the route at CH21300
9	Determinants within soils which pose a risk to human health and to the environment.	Material requires disposal to landfill with associated costs. Health and safety risks to site personnel. Variability of made ground means that Investigation / sampling may not reveal full nature of material. Dispersal of contamination across the site. Soil chemistry in made ground areas is at a level that is risk to environment. Pollution of Aquifer or watercourses potentially leading to fines, mitigation and compensation claims.	Desk study - Review all the available information. Ground investigation for the proposed site extents and structure locations. Contamination sampling and laboratory testing to determine the presence and extent of any contamination. Areas of potential contamination identified in scheme environmental reports.	2	3	6	Allowance within construction methodology to dispose of contaminated materials and to prevent contamination being transmitted to sensitive receptors. Appropriate OHS techniques to be employed to minimise exposure to workforce.	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	Instability of existing earthwork slopes - Mainline.	Increased loading and excavations on unstable earthworks during construction affecting isolated cuttings or embankments. Intermittent laminated Glaciolacustrine deposits leading to preferential pathway for failure within shallow slopes. Anisotropic shear strength throughout the material. Potential delays to the scheme due to requirement of slope remedial works prior to construction. Increased risk of plant and rig stability on existing earthwork slopes where defects have been identified.	Desk study - Review all the available information including HA GDMS records to identify location and type of existing defects. Ground investigation undertaken. Allowance within redline boundary for haul routes to be away from any potential areas of instability identified during detailed design.	**2**	**3**	**6**	Design to avoid the requirement of positioning heavy plant near crests of earthworks slopes. Adopt suitable working methodologies for construction. Short and long-term analysis will be carried out by the during detailed design to ensure the slopes will have sufficient design resistance.	**1**	**3**	**3**	Most minor defects in areas of widening will be excavated out during widening.

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	
11	Instability of Embankment M2FE07 and associated structures (Parkwood Culvert and Parkwood Subway)	Settlement of new and existing infrastructure arising from loading of underlying compressible soils. Minor consolidation is likely to occur in the underlying mass movement deposits which are likely to highly variable. Potential delays to the scheme due to requirement of slope remedial works prior to construction. Increased risk of plant instability on existing earthwork slopes where defects have been identified - minor signs of subsidence within M2FE07 to the north of Parkwood Subway and overlying Parkwood Culvert Work to construct culvert and subway extensions destabilises the existing structural foundations.	Desk study - Review all the available information including HA GDMS records to identify location and type of existing defects. Ground investigation undertaken. Review of as built drawings of existing structures. Preliminary assessment of likely foundation solutions provided for Structures Option Reports based on ground investigation.	3	2	6	An inspection of HAGDMS earthwork 14_A1_42924 and 14_A1_42987 should be undertaken prior to the GDR along with two further areas of geotechnical interest identified on the eastern side of Parkwood culvert at ~Ch23100. The two areas of interest are shown on the geohazard plans for the GIR and include 'an area of very wet clay' and 'tension cracks parallel with the slope' at the eastern Parkwood Subway access point. Detailed design to include assessment of new foundations and embankment widening on existing foundations. Monitoring of slopes and existing structures during construction. Design to avoid the requirement of positioning heavy plant near crests of earthworks slopes. Adopt suitable working methodologies for construction. It has been recommended an extra 20m land take allowance beyond the toe of the embankment is assumed so any issues arising from the underlying mass movement deposits, irregular topography and traversing culvert can be addressed. Short and long-term analysis will be carried out by the during detailed design to ensure the slopes will have sufficient design resistance.	1	2	2	Evidence of historical slips and subsidence observed at the existing embankment during past earthwork inspections - slight settlement at crest with over steep, uneven slope and possible bulge at toe. Trees are vertical so probably natural geometry or settlement post construction. Very slight rotation of barrier in places.

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	
12	Instability of existing River Coquet abutment earthwork.	Construction of the new bridge exacerbates existing instability in the earthworks of the existing bridge leading to damage or failure of the existing bridge.	Desk study: Review of existing reports detailing historic monitoring reports and stability assessments.	3	5	15	Further ground investigation to be undertaken through abutment fill to provide further data for detailed design. Detailed design to include assessment of impact of new structure on existing earthwork of existing bridge. It has been proposed that the north abutment will be located behind the back tension crack and so is intended to lie outside the slipping zone. Monitoring of slopes during construction.	1	5	5	It has been instructed by Highways England Project Managers that remediation of the defects of the existing bridge earthworks will not constitute part of the scheme (unless unavoidable). The existing northern abutment does not appear to be suffering movement and comparing OS mapping; this does not indicate any significant regression of the valley over a 140 year or so period.
13	Instability of River Coquet valley	Loading of failed blocks on valley slope from bridge abutment or piers reactivates slope movement causing damage or collapse of the bridge. Creation of access/haul roads down the valley slope reactivates existing failures or destabilises slope and creates new failures.	Desk study and ground investigation undertaken to create preliminary ground model and assess likely failure mechanisms. Geomorphological mapping of valley undertaken to inform assessment of failure mechanisms. Bridge design developed so that abutments are located at the crest of the valley, beyond the failed areas. Bridge spans maximised so that as far as is feasible they are located off the valley slope/failed area.	3	5	15	Further ground investigation to be undertaken to further investigate causes of instability and inform detailed design (to include piezometer and inclinometer installations). Abutment foundations to be designed to avoid destabilising the valley slopes. Pier foundations to be designed to resist any lateral movement from movement within the valley slopes. Stability assessment of any temporary works to create access into valley. Monitoring of slopes during construction.	1	5	5	

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	
14	Existing River Coquet Foundations	Work to construct new bridge destabilise existing bridge foundations (including excavation removing support or damaging associated rock anchors).	Review of as built drawings of existing bridge. Ground investigation undertaken and ground models produced at foundation locations.	2	5	10	Detailed design to include assessment of new foundations on existing foundations. Bridge deck installation method and temporary works to be reviewed to avoid excavations alongside rock anchors on existing south abutment where practicable. Potential additional information on the construction of the bridge has been identified as being held at the National Archives in Kew. Recommended this is obtained as part of detailed design.	1	5	5	Information on the arrangement and working loads of the rock anchors are shown on drawing 534/C/79Z in Appendix D
15	Shallow Bedrock at River Coquet Valley	Inappropriate excavation techniques for deep caisson style foundations required to be formed through rock of varying strength.	Review of historic and recent ground investigation to establish excavations are feasible.	2	2	4	Further ground investigation to be undertaken. Construction technique to be considered as part of detailed design	1	2	2	
16	High or perched groundwater	Detention basins become inundated by groundwater. Excavations for foundations, etc are flooded during excavation.	GI undertaken including groundwater installations and monitoring. Detention basins kept as shallow as possible in areas where shallow groundwater identified.	2	4	8	Detailed design to include allowance for lining of detention ponds and dewatering of excavations where shallow groundwater is identified.	1	4	4	
17	Unexploded Ordnance (UXO)	Construction plant encountering buried ordnance and loading or/ and vibration causing explosion which will be life threatening for construction workers.	Detailed Desk Study undertaken due to historical land use as training location for WWII warplane training.	1	4	4	Detailed desk study confirmed the locations of recorded ordnance and a site risk of low probability. Industry good practice is to raise the awareness of those involved in excavations so that in the unlikely event that a suspect item is discovered, appropriate action is taken. This can be achieved through UXO awareness briefings to site staff.	1	4	4	
18	Buried temporary foundations/footings from construction of existing River Coquet Bridge.	Proposed excavations or piling works for new bridge are obstructed by buried features.	Review of as-built drawings undertaken to identify any features. Features added to Geohazard Plans in relation to proposed new foundations.	2	2	4	These features should be considered for detailed design development and further investigation to locate them should be undertaken if they potentially clash with any construction activity.	1	2	2	Features identified all appear to be beneath or to the west of the existing bridge, away from the areas of the proposed foundations for the new bridge

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	
19	Animal burrowing in granular layers within the Glacial Till exposed in new cuttings	Localised instability of earthwork face. Undermining of highway infrastructure.	Ground investigation undertaken to identify granular horizons	**2**	**2**	**4**	Incorporate rabbit proof netting into the detailed design as appropriate.	**1**	**2**	**2**	

Notes:

1. A ‘Hazard’ is a condition or physical situation with a potential for an undesirable event. This risk register is limited to the management of geotechnical and geoenvironmental hazards. Safety, environment or business hazards are not included.

2. A ‘Risk’ is an uncertain event or set of circumstances that should it occur would have an effect on achieving the projects objectives.

3. The risk management strategy adopted, as included in 'Managing Geotechnical Risk - Improving Productivity in UK Building and Construction' by Clayton CORI, published by DETER and ICE in 2001, is as follows:

    - avoid

    - if unavoidable, transfer

    - if non-transferable, mitigate

    - if unable to mitigate, accept and manage

4. Risk ratings columns are colour shaded according to degree of risk to illustrate those hazards considered to be of greatest risk

Appendix H

MINING WALKOVER AND DESIGN BASIS STATEMENT

MEMO

TO	Matt Howard/ Jim Harbord/ Gary Hugill	**FROM**	Olivia McBarnet
DATE	**29 November 2018**	**CONFIDENTIALITY**	**Confidential**
SUBJECT	**Mining-Causey Park**		

At 1100 Wednesday 18th April Ben Jackson (Osborne) and Olivia McBarnet (WSP) met Mr Hogg, the Landowner, at Causey Park to observe any historic mining features on his land which may impact on works for the A1.

The following memo provides a summary of the meeting and photographs of the area.

1. MINING LOCATIONS

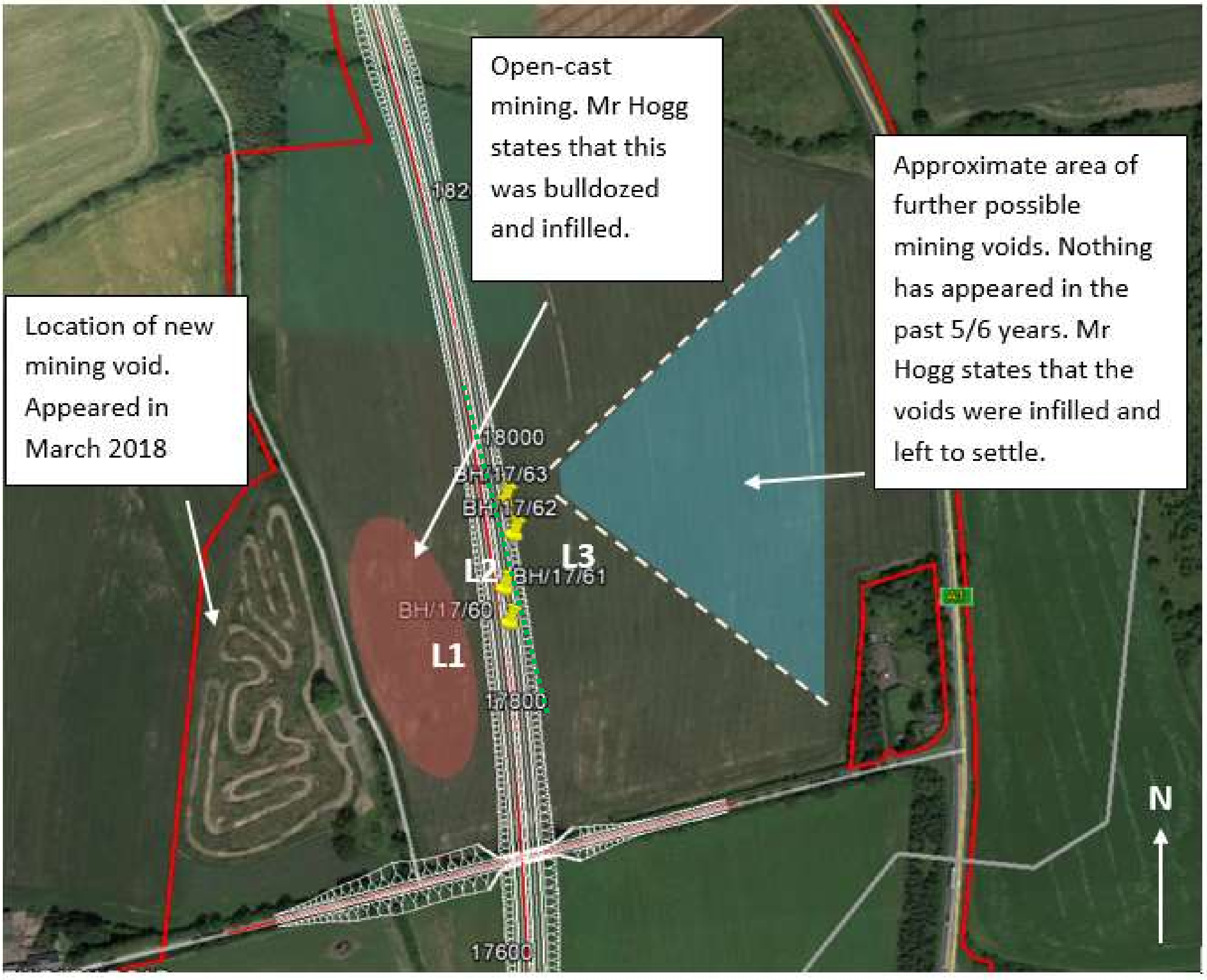


Figure 1-1 Location of historic mine features. Google Earth Imagery 2018

- Opencast mining was located where the concerned field slopes to the west, west of the telegraph poles. Following closure of the works, the area was bull-dozed and infilled. When enquired how the works were infilled Mr Hogg suggested that it was done using excess soil (Figure 1-2;1-3).

- To the west of the proposed boreholes Mr Hogg pointed out undulations in the fields, where previous mining voids have appeared. He indicated that the historic mine works were carried out in a 'diamond shaped geometry', spanning towards the eastern extent of the field.

- These voids have since been infilled or left to settle. The voids which were left have only settled a few inches (from what has been seen), which may indicate that the voids are much deeper in this area. No new voids have appeared in the field for the past 5/6 years (Figure 1-5;1-6).

- To the west of the Site area, Mr Hogg pointed out a large void in the far field. This void opened suddenly in March 2018 (Figure 1-4).

Photographs of the locations of historic mining are located below; the locations of the photos are indicated in Figure 1-1.

Figure 1-2 Looking north from L1. Area of former opencast mining, now infilled.

Figure 1-3 Looking south from L1. Area of former opencast mining, now infilled.

Figure 1-4 Looking West from L2

Figure 1-5 Looking north-east from L3. Undulations in the field may indicate locations of possible historic mining voids.

Figure 1-6 Looking east from L3. Undulations in the field may indicate locations of possible historic mining voids

Figure 1-7 below, highlights the Causey Park dyke and mining voids at Causey Park. Some of the undulations visible on Google Map imagery have been identified on the Geophysical survey below.

Figure 1-7 GeophysicalSurvey. Location of voids. Lang O'Rourke, Preliminary Geotechnical Report. 2006. Google Imagery 2018

A1M2F Phase 1 Design Input Statement

DIS No: G005

Rev No: 01

Design Element

Causey Park Shallow Mine Workings Assessment

Design Input

Coal Authority Mine Abandonment Plan (NC536)
Durham Mining Museum Records
Aerial Photography
Historical Mapping
Stage 1 GI Geophysical Survey Results
Stage 1 GI Exploratory Hole Logs
Stage 1 GI Site Observations

Design Output

Desk Study Information

Prior to commencing the ground investigation, the Coal Authority was contacted for any information regarding past, present and future coal working in the vicinity of the proposed road alignment. Mine workings were identified in the vicinity of Causey Park, with Abandonment Plan NC536 detailing the layout of the workings.

The southern boundary to the Causey Park workings is shown to be the Causey Park Dyke, which trends approximately WSW – ENE. The position of the Dyke is shown both on the 1:50,000 BGS Geological Mapping and the Coal Authority abandonment plan NC536. The indicated alignment of the dyke coincides with the position of a number of quarries identified by historic mapping, which, are understood to have exploited the dolerite which forms the dyke.

The abandonment plan indicates that the materials worked were coal up to 1'2" thick (0.35m) overlying between 3'6" (1.1m) and 5'0" (1.5m) of Seggar (a local term for fireclay), shown to be absent in places. The seggar is indicated to be underlain by Gannister, a fine grained silica rich sandstone or siltsone used in the manufacture of silica bricks.

The northern boundary of the mine workings appears from the abandonment plan to be formed by a fault of unknown throw, indicated to trend approximately E – W. The eastern boundary is formed by the convergence of the above mentioned dyke and fault. The western boundary of the mine workings is indicated to be formed by the outcropping of the strata within the valley side. Accesses to the workings on the eastern side of the valley are shown to be via drifts located at the south-west corner of the eastern workings. The abandonment plan is dated June 1965 indicating this to be the date of its formal closure.

The locations of the drifts coincide with the position of a quarry identified on historical mapping and air photographs. The quarry is not present on the earliest historical mapping examined dating from 1866 and it is not believed that mining had commenced at this time, however it is noted that on this map a brick and tile yard is shown at the present day location of Causey Park Hag Lodge, approximately 400m from the mine workings. The 1898 mapping shows the quarry to be present and potentially mining could have commenced by this date. It is noted that the brick and tile yards are absent on the 1898 map. The 1924, mapping shows no change in from the 1898 mapping. The 1947 mapping identifies the presence of three drifts to the north of the quarry in approximately the same location as the two drifts identified on the

mine abandonment plan indicating mining to be ongoing. The 1957 mapping removes the symbols identifying the locations of drifts but continues to identify their presence at the old quarry. There is no indication of the quarry or drifts on the 1978 mapping indicating mining to have ceased by this date. This agrees with the abandonment plan date of 1965.
Aerial photography dating from 1948 indicates a hedge to present around the boundary of the quarry and possibly a depression at the quarry location. There are no visible indications of mining activity.

Recent air photography believed to date from the 1990's shows the site to be in its current state. Linear features believed to be caused by stressed vegetation are visible trending south- west to north-east in the vicinity of the mine workings. These features are thought to be due to a relic ridge and furrow cultivation pattern.

Records from the Durham Mining Museum indicate that Fireclay was won from the Victoria Coal Seam at Causey Park (NGR NZ185953) between 1955 and 1964 by the Burn Fireclay Company Limited. These dates agree with the aerial photo and historical mapping records.

The mine abandonment plan indicates outcrop of the coal at the floor of the valley at a level of (255' (77.3m AOD) with drift entrance levels of 255' (77.3m AOD) and 258' (78.2m AOD). The levels of the workings are indicated to drop from a level of 244' (73.9m AOD) on the western side to 239' (72.4m AOD) on the eastern side with an indicated dip of 1:50. The hatched area of the abandonment plan is interpreted to indicate areas of worked coal intersected by roadways which are shown to be approximately 2.5m in width. The method of extraction employed in the mine is unclear; the abandonment plan does not show a pillar and stall arrangement or a layout which would typically be associated with long wall working methods. It is considered most likely that a short wall technique was adopted which allowed ground collapse to occur between supported roadways.

The western most section of the workings adjacent to outcrop in the valley floor do not show a network of road ways. It is possible due to the shallow depth (4m below valley floor) that the fireclay was worked by open cast methods in the valley floor. However aerial photo and historical mapping records do not support this hypothesis.

A Walk over Survey identified the presence of a number of depressions possibly relating to crown holes located within the area of workings as indicated by the abandonment plan. The farmer reported that filling of these surface depressions is ongoing.

Non-intrusive Investigation

Northern Archaeological Associates (NAA) carried out a geophysical survey over the area of the Causey Park Mine workings during January 2006. The survey was carried out using a magnetic gradiometer detecting small changes in the magnetic susceptibility of the near surface soils. These changes could be due to the presence of man made ferrous material, variations in the natural moisture content of soils, changes in soil/rock mineralogy or density of natural materials. The results of the survey were processed and presented upon a topographic plan of the area overlaid with the layout of the mine workings from the abandonment plan.

In general surface scatter is low and interpreted to be due to localised ferrous litter. Faint linear features are present trending south-west to north-east spaced at 5-7m intervals and correspond to features discernible on air photography. These features are thought to be due to a relic ridge and furrow cultivation pattern.

A large linear dipolar anomaly was identified crossing the shallow mine workings area orientated and located closely to the indicated position of the Causey Park Dyke identified on the abandonment plan and geological mapping. This anomaly is interpreted to be a result of the variation in magnetic potential of the Causey Park Dyke (Dolerite) when compared to the surrounding Mudstones. The positive section of the anomaly is interpreted to represent the actual position of the dyke and is approximately 20m in width; the negative section of the anomaly is interpreted to be a 'shadow' effect. This agrees well with the Geological Memoir which reports a width of 63' for Causey Park Dyke to the east of Causey Park.

Other smaller roughly circular dipolar anomalies were identified in the area of shallow mine working as shown on the abandonment plan. Due to their location being restricted to the area of shallow mine working these features are interpreted to be associated with the development of crown holes. The walk-over survey identified surface expression of a number of crown holes, however the locations of these do not correspond to the location of magnetic anomalies (taking into account the low level of survey accuracy associated with the had held GPS method of locating the crown holes).

A large dipolar anomaly was identified on the southern side of the dyke at the location of the former quarry and is interpreted to be associated with the backfill to the quarry.

Intrusive Investigation

A total of 7no. boreholes (1018 to 1021, inclusive & 1046 to 1048, inclusive) and 8no. trial pits (1254 to 1255 and 1258 to 1263, inclusive) were completed to investigate and determine the extent of the shallow mine workings.

Working from the south along the alignment of the road the following ground conditions were encountered.

Trial pit 1261 encountered cohesive till to a depth of 4m.

Further north and in the anticipated location of the Causey Park dyke based on the geophysical survey, BH1018 and TP1255 both encountered cohesive till overlying possible bedrock at depths of 3.4m and 3.2m respectively. Both exploratory holes were terminated on a yellow/orange gravel of sandstone (possible weathered sandstone bedrock). The depth of the bedrock in these two exploratory holes is much shallower than nearby holes and may reflect the presence of the dyke, which is formed from more resistant strata. As a result of glacial erosion the dyke remains at a higher elevation than the adjacent mudstone and sandstone strata. Historical sources indicate the dyke to be formed from quartz dolerite which is a dark bluish-grey rock of sufficiently coarse crystalline texture to allow the chief constituents to be identified by eye. It is not thought likely that the gravel of sandstone encountered was mis-identified Dolerite, however, it may be that a band of sandstone is present as a cap on top of the dolerite dyke.

Nearby BH1046 also located in the anticipated location of the dyke encountered cohesive till to a depth of 12m overlying bedrock of sandstone and mudstone. Several zones of core loss were recorded between 12.9m and 16.0m, the largest being between 14.0-15.0m and 15.25-16.0m. It is unclear whether these zones of core loss are associated with mine workings or are a result of highly fractured ground adjacent to the dyke structure. TP1258 encountered cohesive till to a depth of 4.5m.

Immediately to the north of the anticipated location of the Causey Park dyke based on the geophysical survey BH1019 encountered 8.3m of cohesive till overlying interbedded sandstone and mudstone. Between 12.43-12.53m depth (72.7-72.6m AOD) a gravel of coal and mudstone was recovered. This may represent the remnants of the worked coal and fireclay which would have been expected at a level of 72.1m AOD according to the abandonment plan. Core recovery was greater than 97% in all core runs indicating that if ground collapse had occurred then few voids remained in the Coal Measures.

Trial pits 1254, 1259 and 1260 were all located within the area of mine working identified by the abandonment plan; these pits recorded cohesive till to depths of 4.4m, 4.4m and 4.3m respectively. Borehole 1020 located in the same area encountered cohesive till to a depth of 7.5m overlying mudstone, siltstone and sandstone strata. Core recovery was 90% or greater over all core runs. Between 13.71m (69.37m AOD) and 13.95m (69.13m AOD) coal was encountered with a seam thickness of 0.24m. This is approximately 4m lower than the coal level expected from the abandonment plan of 73.1m AOD. The seam thickness of 0.24m is significantly less than the 0.35m indicated by the abandonment plan. There is also no fireclay present beneath the coal suggesting the borehole to have passed through an area of extraction. The sandstone present directly beneath the coal fits the description of Gannister as indicated to underlie the coal and fireclay on the abandonment plan.

Borehole 1021 was located beyond the northern limit of the mine workings as indicated on the abandonment plan and encountered cohesive till to a depth 12.40m underlain by mudstone, siltstone and sandstone strata. Core recovery in excess of 90% was obtained for all core runs. Between 16.8m (66.56m AOD) and 17.29m (66.97m AOD) coal was encountered with a seam thickness of 0.41m. The seam thickness of 0.41m is slightly greater than the 0.35m indicated by the abandonment plan. No fireclay is present beneath the coal, although the abandonment plan does indicate it to be absent in places, but a material meeting the description of Gannister is present immediately beneath the coal. The quality of the core obtained in this hole and the thickness of the coal seam indicate that no working of the coal has been carried out. The level of the coal in BH1021 when compared to that encountered in BH1020 indicates a minimum dip of 1:32 (borehole spacing of 91m with a 2.81m difference in coal level). This dip is steeper than that indicated by the abandonment plan (1:50) and suggests the presence of a fault, as shown on the abandonment plan, between BH1020 and BH1021.

Further north trial pits 1262 and 1263 both encountered cohesive till to the base of the pits (4.3m and 4.4m respectively). Borehole 1047 encountered cohesive till to a depth of 13.0m underlain by sandstone and siltstone strata proved to a depth of 21.0m. Core recovery was generally greater than 90%, however, between 18.0-21.0m depth within a thinly laminated dark grey black siltstone recovery dropped to 57% due to an assumed zone of core loss between 19.32 (62.68m AOD) and 20.62m (61.38m AOD). The zone of core loss is not considered to be due to shallow mine workings as the level of core loss is below the anticipated coal seam and was not underlain by the Gannister material identified in BH 1020 and BH1021. Further investigation will be required to confirm this.

Borehole 1048 to the far north of the workings encountered cohesive till to a depth 8.5m underlain by mudstone and sandstone strata, proved to a depth of 20.7m. Core recovery of 100% was achieved in all core runs and no coal was encountered. It is considered that borehole 1048 represents a definite northern limit to the workings.

Additional Investigation

Based upon the above information it is considered that BH1046 and 1018 are located upon/adjacent to the Dyke. The position of the dyke has been proven using non-intrusive techniques but has not been verified by intrusive techniques. It is proposed to carry out deep trial trenching using a tracked excavator to determine the exact lateral extent of the dyke.

Both BH1019 and BH1020 suggested the presence of collapsed mine workings. Core recovery within this area was generally high and indicates the closed ground. However, the presence of crown holes indicates voids or loosened ground to be present in some areas above the mine workings. It is noted the level of the coal in BH1020 was lower than indicated on the abandonment plan which, may be as a result of minor faulting. An additional borehole is proposed between BH1019 and BH1020 to provide further information on the level of the coal strata and possible presence of workings.

Some uncertainty remains over the northern limit of the workings. It remains likely that no workings are present beyond the mine workings limit identified on the abandonment plan; however, the findings of BH1021 and BH1047 leave a residual risk that workings extend further north and which, requires confirming through further investigation. Borehole 1021 identified coal which appeared to be unworked and down-thrown by the fault shown on the abandonment plan. Further evidence of the coal was, however, not encountered in BH1047 or BH1048 although core loss was encountered at a lower level in BH1047. It is thought that BH1048 represents a definite northern limit to the workings. The reason for the core loss in BH1047 is currently unexplained. Further investigation is required to determine whether it was due to shallow mine workings. It is proposed to carry out three further boreholes to the north of BH1020 to further investigate the extent of the coal seam and presence of possible voids/broken ground.

Proposed Mine Treatment Works

The recommendations for mine treatment presented below are in accordance with the guidance provided in CIRIA Special Publication 32 (1984) Construction over abandoned mine workings.

The on going development of crown holes over the Causey Park mine workings demonstrates the hazard of gradual surface ground settlement and/or sudden ground collapse. This hazard arises from the presence of voided and/or loosened ground above the mine workings. In order to control the risk of the surface movement affecting the completed works it is proposed to carry out a programme of staged grouting to fill voids and consolidate very loose ground.

The southern limit of the workings is reasonably well defined and may be taken as chainage 6,950m for preliminary design purposes. The northern limit of the workings remains unproven with a low risk remaining that the core loss encountered in BH1047 was associated with mine workings. For preliminary design purposes it is recommended that chainage 7,110m is taken as the northern limit of the workings with an allowance made in the risk register for the very low risk (<20%) of treatment being required to chainage 7,200m. It is recommended that grouting should extend a distance of 10m beyond the edge of verge giving a treated width of 41.1m. This results in a total area for treatment of 6,576m^2 with an allowance in the risk register for a further 3,699m^2 of treatment.

The mine workings are expected at depths of 10-15m beneath existing ground level. The proposed road centre line vertical alignment provides for a 3-4m deep cutting through the area of the mine workings thus reducing the depth from road formation to the workings. It is recommended that for preliminary costing purposes grout holes are assumed to extend to an average depth of 15m.

The intrusive investigation did not identify large voids in the mine workings area. However, the small number of exploratory holes means that much of the workings may remain open, especially along the roadways which will have been supported. The ongoing development of crown holes confirms the presence of voided or very loose ground. For preliminary costing purposes it is recommended that a grout take equal to 85% of the seam thickness is used. Assuming a typical coal and fireclay thickness of 0.35m and 1.3m respectively results in a seam thickness for costing purposes of 1.4m. This results in a grout volume of 9,206m^3 and an allowance in the risk register for a further 5,179m^3 of grout.

Grout holes should be drilled using rotary percussive techniques to allow rapid progress through hard strata. Grout holes shall have a minimum diameter of 70mm to allow for the injection of sand and/or pea gravel to fill large cavities. Grout shall have a minimum 28 day crushing strength of 1 MN/m^2.

Primary grout holes shall be spaced at 6m intervals on a square grid equating to a total of 183 grout holes. Grouting shall be carried out in stages from the base of the hole with limit pressures being set to equal the overburden pressure. Termination criteria based on grout take will also be set. Where grout takes are excessive then a secondary grid of holes shall be utilised at 3m centres to ensure complete infilling of voids. For preliminary costing purposes it is recommended that an allowance is made for 25% of the treatment area to require secondary grouting at 3m centres (183 holes).

Testing to confirm the effectiveness of the treatment will comprise a number of additional grout holes with grout take carefully monitored. For preliminary costing purposes it may be assumed that secondary grouting holes perform this function.

Summary of quantities

Item	Quantity	Contingency Allowance
Grout	9,206m^3	5,179m^3
1er Grout holes (15m)	183	103
2er Grout holes (15m)	183	103

LORCE/Designer agreement		
Name (LORCE) :	Signed:	Date:
Name (Designer) :	Signed :	Date:

Appendix I

PRELIMINARY GEOTECHNICAL GROUND MODELS

River Coquet - South Abutment

Ground Model Summary

Parameter	Units	Sandstone	Shale	Limestone	Coal
Elevation	(m AOD)	56.00 - 49.25 27.25 - 25.00	49.25 - 40.75 32.00 - 29.25 28.75 - 27.25	40.75 - 32.00	29.25 - 28.75
γ (Bulk)	kN/m^3	22	22	22	15
γ (Saturated)	kN/m^3	23	22	23	15
C'	kN/m^2	Not required for pile analysis			
UCS	MPa	10	5	10	1
ϕ'	º	34	27	28.5	16
RQD (Average)	%	45	5	35	0
E	MPa	400	150	600	50
ν	N/A	0.2	0.2	0.2	0.2
Assume $E_h = 1.0E_v$					
Groundwater Elevation	(m AOD)	49.5			

Project Number	70038006	Project	A1 in Northumberland Morpeth to Felton

River Coquet - South Pier

Ground Model Summary

Parameter	Units	Glacial Till / Colluvium	Sandstone	Shale	Coal	Interbedded Sandstones and Mudstones
Elevation	(m AOD)	Assumed to have been excavated	31.50 - 25.00	25.00 - 19.00	Not logged in this location	19.00 - 7.50
γ (Bulk)	kN/m^3		22	22		Assume shale parameters
γ (Saturated)	kN/m^3		23	22		
C'	kN/m^2		Not required for pile analysis			
UCS	MPa		10	5		
ϕ'	o		34	27		
RQD (Average)	%		45	5		
E	MPa		400	150		
ν	N/A		0.2	0.2		
Assume $E_h = 1.0E_v$						
Groundwater Elevation	(m AOD)	32				

Project Number	70038006	Project	A1 in Northumberland Morpeth to Felton

River Coquet - North Pier

Ground Model Summary

Parameter	Units	Weathered Mudstone (soil)	Shale (rock)	Sandstone	Coal
Elevation	(m AOD)	38.00 - 33.00	33.00 - 28.00 25.00 - 7.00	28.00 - 25.00	Not logged in this location
γ (Bulk)	kN/m^3	18	22	22	
γ (Saturated)	kN/m^3	19	22	23	
C'	kN/m^2	Not required for pile analysis			
UCS	MPa	N/A	5	10	
ϕ'	°	25	27	34	
RQD (Average)	%	N/A	5	45	
E'	MPa	-	150	400	
E_u	MPa	10			
ν	N/A	0.5	0.2	0.2	
M_C	%	10	N/A	N/A	
P_L	%	36	N/A	N/A	
L_L	%	19	N/A	N/A	
I_P	%	14	N/A	N/A	
C_u	kPa	85	N/A	N/A	
Assume $E_h = 1.0E_v$					
Groundwater Elevation	(m AOD)	33.0			

Project Number	70038006	Project	A1 in Northumberland Morpeth to Felton

River Coquet - North Abutment

Ground Model Summary

Parameter	Units	Cohesive Made Ground	Shale	Sandstone	Coal	Limestone
Elevation	(m AOD)	55.00 - 52.50	52.50 - 45.00 39.00 - 37.50 37.00 - 34.00 31.00 - 25.50	34.00 - 31.00	37.50 - 37.00	45.00 - 39.00
γ (Bulk)	kN/m^3	18	22	24	15	22
γ (Saturated)	kN/m^3	18	23.5	24	15	24
C'	kN/m^2	Not required for pile analysis				
UCS	MPa	N/A	2	10	1	10
ϕ'	o	20	21	32	11	24
RQD (Average)	%	N/A	2	25	0	10
E'	MPa	-	150	400	50	600
E_u	MPa	8				
ν	N/A	0.5	0.2	0.2	0.2	0.2
M_C	%	21	N/A	N/A	N/A	N/A
P_L	%	25	N/A	N/A	N/A	N/A
L_L	%	51	N/A	N/A	N/A	N/A
I_P	%	25	N/A	N/A	N/A	N/A
C_u	kPa	50	N/A	N/A	N/A	N/A
Assume $E_h = 1.0E_v$						
Groundwater Elevation	(m AOD)	53.5				

Project Number	70038006	Project	A1 in Northumberland Morpeth to Felton

Highlaws Junction Overbridge

Ground Model Summary

Parameter	Units	Glacio - lacustrine Deposits	Glacial Till (Granular)	Glacial Till (Firm to Stiff)	Mudstone (assumed)	Sandstone	Coal
Elevation	(m AOD)	109 - 105.5	105.5 - 102	102 - 99.5	95 - 93 < 90	93 - 90	
γ (Dry)	kN/m^3	17	17	18	22.5	24	
γ (Saturated)	kN/m^3	20	19	20	24	24	
C'	kN/m^2	Not required for pile design					
UCS	MPa	N/A			1	5	
ϕ'	°	20	32	25	24	35	
RQD (Average)	%	N/A			5	50	Not logged in this area
E_u	MPa	12	17	25	30	300	
E'	MPa	-		-			
ν	N/A	0.5	0.2	0.2	0.2	0.2	
M_C	%	25	N/A	16	Applicable only to soils		
P_L	%	22	N/A	19			
L_L	%	41	N/A	36			
I_P	%	20	N/A	18			
C_u	kPa	35	N/A	85			
Assume $E_h = 1.0E_v$							
Groundwater Elevation	(m AOD)	108					

Project Number	70038006	Project	A1 in Northumberland Morpeth to Felton

Fenrother Junction Overbridge

Ground Model Summary

Parameter	Units	Glacial Till (Firm to Stiff)	Sandstone	Mudstone (assumed)	Coal
Elevation	(m AOD)	88.5 - 82.5	82.5 - 79.0	79.0 - 69.0	71.57 - 71.47
γ (Dry)	kN/m^3	18	24	22.5	Not considered as separate unit in this ground model
γ (Saturated)	kN/m^3	21	24	23.5	
C'	kN/m^2	Not required for pile design			
UCS	MPa	N/A	7.5	5	
ϕ'	°	25	31.5	24	
RQD (Average)	%	N/A	30	25	
E_u	MPa	20	450	200	
E'	MPa	-			
ν	N/A	0.2	0.2	0.2	
M_C	%	17.0	Applicable only for soils		
P_L	%	19.0			
L_L	%	39.5			
I_P	%	21.0			
C_u	kPa	80			
Assume $E_h = 1.0E_v$					
Groundwater Elevation	(m AOD)	88.5			

Project Number	70038006	Project	A1 in Northumberland Morpeth to Felton

Causey Park Overbridge

Ground Model Summary

Parameter	Units	Glacial Till (Firm)	Glacial Till (Stiff)	Bedrock (undif.)	Coal
Elevation	(m AOD)	83.0 - 75.5	75.5 - 68.0	68.0 - 56.0	Not logged in this location
γ (Bulk)	kN/m^3	18.0		22.5	
γ (Saturated)	kN/m^3	20.0		24.0	
c'	kN/m^2	Not required for pile design			
UCS	MPa	N/A		7.5	
ϕ'	º	25		24	
RQD (Average)	%	N/A		25	
E_u	MPa	20	25	300	
E'	MPa	-	-		
ν	N/A	0.2	0.2	0.2	
M_C	%	17		-	
P_L	%	20		N/A	
L_L	%	40		N/A	
I_P	%	24		N/A	
C_u	kPa	85	150	N/A	
Assume $E_h = 1.0E_v$					
Groundwater Elevation	(m AOD)	83			

Project Number	70038006	Project	A1 in Northumberland Morpeth to Felton

West Moor Junction Overbridge

Ground Model Summary

Parameter	Units	Cohesive Glacial Till (Upper)	Glacial Till (Granular)	Glacio - lacustrine Deposits	Cohesive Glacial Till (Lower)	Sandstone	Mudstone (assumed)	Coal[1]
Elevation[3]	(m AOD)	60.0 - 58.0 54.0 - 52.5	58.0 - 57.0	57.0 - 54.0 52.5 - 50.5	50.5 - 43.5	43.5 - 40.5	40.5 - 40.0 39.5 - 37.0	40 - 39.5
γ (Bulk)	kN/m^3	17.5	15	17	17.5	24	22.5	15
γ (Saturated)	kN/m^3	20	18	20.1	20	24	24	15
C'	kN/m^2	C' not required for pile design						
UCS	MPa	N/A				1	1	1
ϕ'	°	25	30	20	25	30.5	22	15
RQD (Average)	%	N/A				10	10	0
E_u	MPa	17.6	10	10.5	29	60	40	50
E'	MPa	15		10	25			
ν[2]	N/A	0.2						
M_C	%	20.0	-	25.0	20.0	Paramters only applicable to soil		
P_L	%	21.0	N/A	21.5	21.0			
L_L	%	45.0		41.0	45.0			
I_P	%	21.0		19.7	21.0			
C_u	kPa	80		35	133			
Assume $E_h = 1.0E_v$								
Groundwater Elevation	(m AOD)	58						

Project Number	70038006	Project	A1 in Northumberland Morpeth to Felton

Burgham Underbridge

Ground Model Summary

Parameter	Units	Glaciolacustrine Deposits	Glacial Till
Elevation	(m AOD)	59 - 53.0	53.0 - 39.0
γ (Bulk)	kN/m^3	20.0	20.0
γ (Saturated)	kN/m^3	21.0	21.0
C'	kN/m^2	C' not required for pile design	
UCS	MPa	N/A	
ϕ'	o	20	26
RQD (Average)	%	N/A	
E_u	MPa	10.5	48
E'	MPa	9	27
ν	N/A	0.2	
ν_u	N/A	0.49	
M_C	%	25	-
P_L	%	22	-
L_L	%	41	-
I_P	%	20	20
C_u	kPa	35	159
Assume $E_h = 1.0E_v$			
Groundwater Elevation	(m AOD)	57.5	

Parameter	Method of Derivation
Stratigraphy and Groundwater Level	Geological stratigraphy at the site of each of the proposed bridge locations was derived from the .AGS file produced by Ian Farmers Associates supplied alongside the Factual Report issued by same organisation [1]. Geological cross sections and long sections were generated from the borehole description information using HoleBASE's quick log feature. Boreholes nearby to the considered structure were chosen as these were assumed to be the most representative of the ground conditions at each of the proposed foundation locations. A cautious interpretation of the stratigraphy was then made. Where there was conflicting evidence as to what type or consistency of material was present at a given elevation the more onerous case was taken forwards for the purposes of preliminary design.
Characteristic SPT 'N' Value	SPT 'N' values for each of the materials were obtained from the .AGS file provided with the Factual Report produced by Ian Farmer Associates [1]. For each bridge location, local data was plotted against elevation and representative values chosen for each of the materials. **RISK:** in non-conformance with the guidance of CIRIA 143 the SPT N values **were not** corrected for the purposes of material derivation [3].
Bulk Weight Density	If it was considered that sufficient density testing results were available for a given material then this derived value was occasionally taken forwards. Frequently however, bulk density of geological material was assigned based upon the guidance provided in BS 8004:2015 (Figure 1 and Figure 2 in the case of bulk and saturated weights respectively) [4]. For cohesive materials, weight density was derived according to the material's undrained shear strength. For the case of granular materials, bulk density was assigned according to the material's relative density (as defined by BS 5930:2015) was used [3]. Consideration was also given to material testing undertaken as part of the 2017 ground investigation undertaken by Ian Farmers Associates [1]. In the case of Glacial Till, a comparison of the Dry Density was also made to the figure presented with CIRIA 504 [4].
Atterberg Limits	For each proposed bridge location, a range of data values was presented for each of the Atterberg Limit parameter, both local and global datasets (M_c, L_L, P_L and I_p). Lab testing data had been taken from the .AGS file produced by Ian Farmers Associates supplied alongside the Factual Report issued by same organisation [1]. I_P data was plotted against elevation and representative design values chosen. In the case of Glacial Till, a comparison of the Atterberg Limits were also made to the ranges of values presented with CIRIA 504 (Table 4.4) [4]. In the case of mudstone
Particle Size Distribution	Particle size distributions were generated for the granular deposits using the sieving data extracted from the .AGS file accompanying the Factual Report produced by Ian Farmers Associates [1]. The results were plotted on a standard PSD chart template. These charts were then used to classify the grading of coarse materials.
Undrained Shear Strength	The following data was extracted from the .AGS file produced by Ian Farmer Associates which accompanied the scheme Factual Report [1]: → Hand Shear Vane Testing (including residual tests – **Note:** not used in preliminary design),

	→ Triaxial Testing (Unconsolidated Undrained Triaxial Testing and Consolidated Undrained Triaxial Testing), → Undrained shear strength correlated from SPT 'N' values according to the Stroud correlation by the method presented within CIRIA 143 [5] (or CIRIA 504 in the case of cohesive Glacial Till – i.e. where fine particles control the behaviour of the Glacial Till [5]). Values of f_1 were based on the plasticity index of the material as per Figure 31 of CIRIA 143. The above data was plotted against elevation and a cautious value selected for each material.
Angle of shearing resistance – constant volume (coarse materials)	The $\varphi'_{cv;k}$ value for coarse materials was based on: ➢ Values taken from Peck et al.'s (1974) charts as presented with CIRIA 143 [5], ➢ Values calculated according to the method provided by BS8004:2015: $\varphi'_{cv;k} = 30^o + \varphi'_{ang} + \varphi'_{PSD}$. A cautious value was then selected.
Angle of shearing resistance – constant volume (fine materials)	The value of $\varphi'_{cv;k}$ was taken from consideration of the following data: ➢ Drained triaxial testing (cohesive materials), ➢ The relationship presented by BS 8004: 2015 relating $\varphi'_{cv;k}$ to the material's Plasticity Index (I_P): $\varphi'_{cv;k} = (42^o – 12.4\log_{10}I_P)$. A cautious value was then adopted.
c'	Conservatively assumed to be 0kPa in all cases.
Young's Modulus (E_u and E')	**<u>Fine Grained Materials</u>** Values for firm and stiff clay were considered from Look (2007) for comparison to the values calculated. E': Derived from SPT 'N' values according the method proposed by CIRIA 143 (E'/N). E_u: Derived from the plasticitiy and undrained cohesion of the material by the method of Stroud (1975): $E_u = KC_u$ where K is a constant whose value is defined by the material's Plasticity Index. **<u>Coarse Grained Materials</u>** E': Derived from SPT N_{60} data according to the equation presented in CIRIA 143: E'/N_{60} = 1 MPa [5].
Poisson's Ration (v)	The following values were assumed (Tomlinson, 2001, [6]): → Undrained Soils: 0.5, → Drained Soils: 0.2, → Rock (undifferentiated): 0.2.
Rock Material Parameters[1]	
Unconfined Compressive Strength (q_{uc})	The q_{uc} value of bedrock at bridge locations was attributed based on the following sources of information: → A small number of direct q_{uc} tests were undertaken (as presented with the .AGS file accompanying the Factual Report produced by Ian Farmer Associates [1]),

	→ UCS was correlated from Point Load Test results according to the formula: $$UCS = 23 * I_{S(50)}$$ A coefficient of 23 had been chosen due to insufficient data having been provided to establish a graphical relationship [7] – this correlation is as was adopted by the scheme GIR [8]. **RISK:** Point load testing was not undertaken in accordance with ISRM procedure and therefore full test sample material descriptions did not accompany the results of the testing. → Consideration was also given to the strength of the rock as indicated by the borehole log descriptions. The approximate q_{uc} values as set out by BS 5930:2015 could then be considered. The above data was then plotted (or the plot presented with the scheme GIR was considered) and a cautious value of q_{uc} was chosen for preliminary design.
Core Recovery (TCR, SCR and RQD)	The core recovery details for each rock type, in each proposed bridge location was taken from the local borehole logs [1]. This data was graphed and cautious values selected to be used for preliminary design.
Young's Modulus **(Rock)**	In the absence of plate load or pressure meter testing, E_m (Young's Modulus of the rock mass) was determined according to the equation presented by Tomlinson [6]: $E_m = jM_rq_{uc}$. Where: j is a constant whose value is determined by the RQD of the rockmass, M_r is a constant whose value is dictated by lithology, q_{uc} is the unconfined compressive strength.
Angle of shearing resistance – Rock	No direct testing was undertaken to determine φ' as part of the scheme therefore, Roclab 1.0 was used to obtain an estimated value. In order to make this estimation, Roclab required the following inputs: ➢ q_{uc}, ➢ $JCond_{89}$ –whose value is determined by the condition of discontinuities within the rockmass [9]. ➢ Geological Strength Index (GSI): calculated with the equation provided by Hoek et al. (2013); GSI = 2*(Jcond76)+(RQD/2) [10]. ➢ M_i is an intact rock mass strength factor governed by lithology and the texture of rock (values taken from Wyllie and Mah, [11]). ➢ D – the disruption factor [11]. ➢ E_i the intact Young's Modulus which was conservatively taken to be equal to E_m.
Cohesive Strength	As was the case with the angle of shearing resistance, the cohesive strength was not tested for directly during the ground investigation. Again, Roclab 1.0 was used to estimate the cohesive strength. This was undertaken using the same inputs as per the above for the angle of shearing resistance.

[1]**[Applicable only to River Coquet Sites for which full preliminary design was not undertaken]** In the absence of testing, preliminary, guideline material parameters for coal were taken from Barton (1974) [14].

5 REFERENCES

[1] British Standards Institution, "BS EN 1997-1:2004+A1:2013 - Eurocode 7: Geotechnical Design - Part 1: General Rules," British Standards Institution, London, 2013.

[2] Ian Farmer Associates, "Final Report on Ground Conditions," Ian Farmer Associates, Washington, 2017.

[3] C. R. I. Clayton, "CIRIA 143: The Standard Penetration Test (SPT): Methods and Use," CIRIA, London, 1995.

[4] British Standards Institution, "BS8004: Code of Practice for Foundations," British Standards Institution, London, 2015.

[5] British Standards Institution, "BS5930:2015 Code of Practice for Ground Investigations," British Standards Institute, London, 2015.

[6] CIRIA, "C504 - Engineering in Glacial Tills," CIRIA, London, 1999.

[7] M. J. Tomlinson, Foundation Design and Construction. 7th Edition., Harlow: Pearson Education Ltd, 2001.

[8] I. Farmer, Engineering Behaviour of Rock. 2nd Edition, London: Chapman and Hall, 1983.

[9] WSP, "A1 in Northumberland: Morpeth to Felton Scheme Ground Investigation Report. Doc Ref: HE551459-WSP-HGT-M2F-RP-CE-518," WSP, Manchester, 2018.

[10] Z. T. Bieniawski, Engineering Rock Mass Classification, New York: Wiley Interscience, 1989.

[11] E. Hoek, T. G. Carter and M. S. Diedeichs, "Quantification of the Geological Strength Index Chart," in *47th US Rock Mechanics/Geomechanics Symposium*, San Francisco, 2013.

[12] D. C. Wyllie and C. W. Mah, Rock Slope Engineering. 4th Edition, London: Spon Press, 2005.

[13] E. Hoek, "Blast Damage Factor D Technical Note for RocNews," 02 February 2012. [Online].

[14] N. R. Barton, A review of the shear strength of filled discontinuities in rock, Oslo: Norweigan Geotechnical Institution, 1974.

No 8 First Street
Manchester
M15 4RP

wsp.com

GEOTECHNICAL CERTIFICATE

Scheme Title: A1 in Northumberland Morpeth to Felton

Report Title: A1 in Northumberland: Morpeth to Felton Ground Investigation Report

Project Title: A1 Morpeth to Ellingham dualling

(*-Delete as appropriate)

Certificate Seq. No.
WSP 2

HAGDMS No: 30125

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 Morpeth to Felton

Report Title: A1 in Northumberland: Morpeth to Felton Ground Investigation Report

HA GDMS Report Number: 30125

3. DEPARTURES FROM STANDARDS

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.

Signed: [redacted]

Designer (Designers Geotechnical Advisor)

Name: ... [redacted]

Date: .... [redacted]

On behalf of

......................WSP..........

*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: A B S Wheeler

Date: 12th March 2019

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.

This document is also available on our website at www.gov.uk /highways

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

*Calls to 03 numbers cost no more than a national rate call to an 01 or 02 number and must count towards any inclusive minutes in the same way as 01 and 02 calls.
These rules apply to calls from any type of line including mobile, BT, other fixed line or payphone. Calls may be recorded or monitored.

Registered office Bridge House, 1 Walnut Tree Close, Guildford GU1 4LZ
Highways England Company Limited registered in England and Wales number 09346363