A47 Wansford to Sutton Dualling

Scheme Number: TR010039

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Appendix 9.3 – Preliminary Sources Study Report (PSSR)

APFP Regulation 5(2)(a)

Planning Act 2008

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

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Infrastructure Planning

Planning Act 2008

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

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ENVIRONMENTAL STATEMENT APPENDICES
Appendix 9.3 - Preliminary Sources Study Report (PSSR)

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1. Introduction

1.1 General

The Mott MacDonald Sweco Joint Venture (MMS JV) has been commissioned by Highways England to provide design support for proposed re-routing and dualling of the existing A47 carriageway between Wansford and Sutton. This document presents the findings of a Preliminary Sources Study Report (PSSR) and references the previous PSSR carried out by AMEY[5] for the proposed design. It has been produced in accordance with HD22/08 of the Design Manual for Roads and Bridges[1].

1.2 Scope and Objective of the Report

This Preliminary Sources Study Report (PSSR) examines the geotechnical risks associated with the schemes preferred route option, announced on 15th August 2017.

A major risk to the planned works are the ground conditions and as part of the initial civil engineering studies, the available geological, geotechnical, groundwater and environmental information will be collated and summarised in this PSSR.

The report presents the sources consulted in carrying out the study and summarises the pertinent information therein. A preliminary engineering assessment is given, including the identification of the main geotechnical risks and constraints to the chosen route.

At the time of writing, a ground investigation specification has been written, detailing the number and locations of exploratory holes, the sampling requirements and general conditions of the GI. The aim of the GI is to reduce the geotechnical risk and uncertainty of ground conditions outlined in this document. An Annex A document has also been produced.

The scope of this document is limited to geotechnical and contamination aspects of the route. Other aspects of the scheme should be assessed by other parties and as such the design drawings and supporting documents should be consulted to gain a complete understanding of the project.

1.3 Description of Site

The A47 forms part of the strategic road network and provides for a variety of local, medium and long-distance trips between the A1 and the eastern coastline. The corridor connects the cities of Norwich and Peterborough, the towns of Wisbech, Kings Lynn, Dereham, Great Yarmouth and Lowestoft and a succession of villages in what is largely a rural area. The A47 Wansford to Sutton dualling scheme in part of this corridor seeking to improve approximately 2.5km of the existing road located west of Peterborough between the interchange with A1 and the existing roundabout at Sutton.

The existing A47 single carriageway is to be upgraded to dual carriageway standard. It will be constructed slightly to the north of the existing A47 from the A1/A47 interchange for approximately 800m, before crossing the existing A47, where it will be constructed to the south of the existing alignment until it ties into the existing dual carriageway at Sutton Roundabout. The main components of the proposed scheme are:

- The existing roundabout west of Wansford will be modified to incorporate additional entry and exit lanes on each arm, except the southern arm (Old North Road). The northern entry will be further amended to include a segregated left turn from the A1 northbound on to the A47 eastbound carriageway.

- The existing roundabout east of Wansford will have an enlarged circulatory carriageway and will include a new link to the south for access to the Anglian Water pumping station and the BP fuel station. A new underbridge is also to be constructed here under the proposed A47, giving access via this new link to Sacrewell Farm. The existing part-time traffic signals will be removed at this roundabout.

- The existing section on the A1 overbridge, between Wansford west and east roundabouts, will be opened to two lanes in each direction, as permitted within the confines of the existing bridge width.

- To the west of the scheme, a new free flow slip road is to be constructed connecting the existing A1 southbound carriageway to the new A47 eastbound carriageway. The existing diverge lane off A1 southbound is retained as part of this arrangements. This will be used only for movements to A47 westbound carriageway via the existing roundabout east of Wansford village.

- A new bridge will also be constructed, where the proposed A47 alignment crosses over the disused railway line to the west of Sutton Heath Road.

- Current direct accesses to Sutton Heath Road and The Drift will be closed, with alternative arrangements provided for both slightly further east at Sutton Roundabout.

- A larger roundabout is to replace the existing Sutton Roundabout to the east of the scheme. Here, a connection with a retained section of the existing A47 will also be added for access to Sutton Heath Road.

The new A47 will then tie into the existing alignment to the east of Sutton Roundabout, where the existing road is already of dual carriageway standard.

The approximate location of the site is presented in Figure 1 below and the drawing which can be found in Appendix A which details the proposed Design Fix A+ solution.

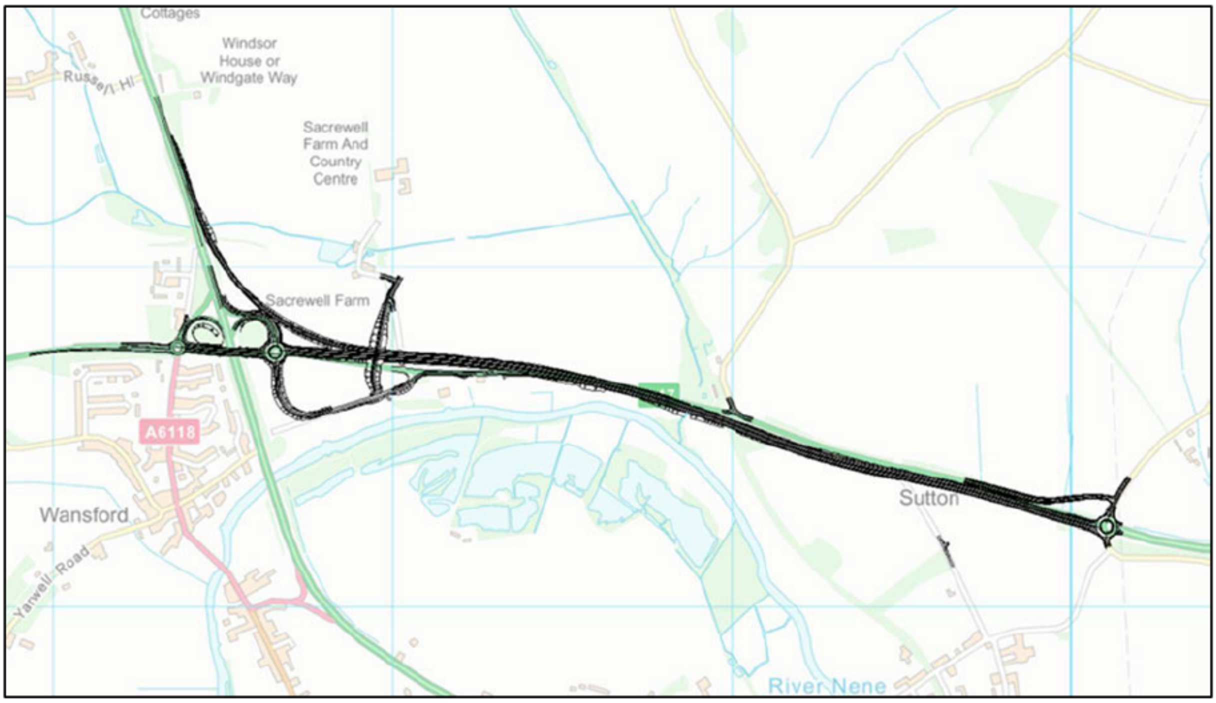

Figure 1: Site Location Plan

Source: Ordnance Survey © Crown Copyright License Number 100022432[2]

Structures to be built along the route and their corresponding chainages according to Design Fix A+ (HE551494-MMSJV-HGN-000-DR-CH-00001) are as follows:

- MC10 Culvert – c. Chainage 120;
- MC80 Underbridge - c. Chainage 290;
- MC00 Overbridge - c. Chainage 290;
- MC00 Culvert - c. Chainage 1210;
- MC00 Railway Underbridge - c. Chainage 1400; and,
- MC00 Culvert - c. Chainage 2360.

It is understood that no topographic survey has been carried out for the preferred route, but one is likely to be commissioned in the near future with LIDAR information currently available.

A site walkover was conducted in a previous PSSR study[5]. Further, on the 7th February 2018 a site walkover was undertaken by MMSJV to help inform the conceptual design works for Design Fix A+. A detailed description of the site is provided in Section 4.

1.4 Description of Project

In 2014 the government published the Roads Investment Strategy (RIS) detailing the investment for 2015 -2020 to improve England's motorways and major A Roads. The RIS includes a package of 6 schemes to improve journeys on the A47 between Great Yarmouth and Peterborough.

Approximately half of the existing A47 is dual carriageway, however the section between Wansford and Sutton is single carriageway. This leads to congestion and causes unreliable and longer journey times.

This report refers to the planned upgrading of the carriageway between Wansford and Sutton to dual carriageway. It will allow for safer, more reliable journeys and supporting economic growth in the region. No previous geotechnical investigations have been undertaken for this scheme, however information from historic investigations is presented in Section 4 of this report.

On the 15th August 2017 HE made a preferred route announcement detailing that the route on the following drawing would be taken forward:

- HE551494-AMY-HGN-WS_STG2-DR-HE-032 Option 2 realigned PRA VARIANT.

This was superseded by Design Fix A completed in December 2017:

- HEWNSFRD-MMSJV-GEN-000-D-CH-00001.

Finally, Design Fix A was superseded by Design Fix A+ in June 2018:

- HE551494-MMSJV-HGN-000-DR-CH-00001.

1.5 Geotechnical Category

It is anticipated that all options under consideration will be

Geotechnical Category 2 in accordance with HD 22/08 of the Design Manual for Roads and Bridges[1].

2. Sources of Information

In addition to the following report produced by AMEY and the references therein:

- Amey, "HAGDMS Report 29538: Geotechnical Preliminary Sources Study Report A47 Wansford to Sutton", April 2017[5].

The below sources of information have been used.

2.1 Topographical Maps

A full discussion of the main features and information illustrated on the topographic maps consulted can be found in Section 4.1.

The following topographical maps were consulted:

- HAGDMS Report 29971, 133467309_1_1 Envirocheck Report - A47 Wansford to Sutton, September 2017[4].
- Google Earth Pro[3]
- Digital Terrain Model (DTM) from HAGDMS[4].

LIDAR data is also available, this has not been consulted as part of this study.

2.2 Geological Maps and Memoirs

A full discussion of the anticipated geology underlying the proposed route based on the geological maps and memoirs referenced below can be found in Section 4.2.

The following geological maps and memoirs were consulted:

- England and Wales Sheet 157 Stamford Solid and Drift Edition, 1:50,000, BGS, 1978[7].
- Memoir for Sheet 158, Peterborough District, 1989[8].
- Classical areas of British geology Sheet 14 Peterborough, Solid and Drift Edition, 1:25,000, BGS, 1972[9].
- England and Wales Sheet TL09NE Solid and Drift Edition, 1:10,000, BGS, 1947[10].
- British Geological Survey, Geology of Britain online viewer[11].
- British Geological Survey, The BGS Lexicon of Names Rock Units[12].
- British Geological Survey, Borehole Scans Database[13].

- HAGDMS Report 29971, 133467309_1_1 Envirocheck Report - A47 Wansford to Sutton, September 2017[4].

2.3 Aerial Photographs

Aerial photography was reviewed from Google Earth Pro[3] and HAGDMS[4].

A discussion of the development of the proposed site and geography based on aerial photography sources listed below can be found in Section 4.1.

2.4 Records of Mines and Minerals Deposits

Full information regarding the mine and mineral records associated with the proposed site referenced below can be found in Section 4.7.

The following sources were consulted:

- HAGDMS Report 29971, 133467309_1_1 Envirocheck Report - A47 Wansford to Sutton, September 2017[4].

2.5 Land Use and Soil Survey Information

Full details of the proposed site's current and historic land use can be found in Sections 4.1, 4.4 and 4.5. A discussion of the potential risks and contamination associated with the described land uses can be found in Section 5 and Section 0.

The following land use sources were consulted:

- HAGDMS Report 29971, 133467309_1_1 Envirocheck Report - A47 Wansford to Sutton, September 2017[4].

2.6 Archaeological and Historical Investigations

No further information in addition to that referenced in the AMEY report[5] relating to archaeological constraints is currently available for the preferred route. The following drawing summarises the known constraints:

- HE551494-AMY-HGN-WS_STG2-DR-HE-032 Option 2 realigned PRA VARIANT

This has also been produced by AMEY and is currently shown as having a status of work in progress. It can be found in Appendix A. It is recommended that the AMEY report[5] is consulted together with the EIA Scoping report to be produced for Phase 3 which will be based on the preferred route.

2.7 Existing Ground Investigations

A full discussion of previous ground investigations conducted within the proposed site footprint and the immediate surrounding area based on the records referenced below can be found in Section 4.2 and Section 6.

The following borehole record sources were consulted:

- British Geological Survey, Borehole Scans Database[13].
- HA GDMS[4].

2.8 Consultation with Statutory Bodies and Agencies

A full discussion of the site's utilities can be found in Section 3.2.

It is understood that the AMEY highways team are compiling service information and drawings but these are yet to be released. The following drawings indicating services likely to be present and their approximate positions are currently available:

- HE551494-AMY-HGN-WS_STG2-DR-HE-004 Existing Utilities - SHEET 1.
- HE551494-AMY-HGN-WS_STG2-DR-HE-005 Existing Utilities - SHEET 2.
- HE551494-AMY-HGN-WS_STG2-DR-HE-002 Existing Features - SHEET 1.
- HE551494-AMY-HGN-WS_STG2-DR-HE-003 Existing Features - SHEET 2.

These have been produced by AMEY and are also currently shown as having a status of work in progress. These can be found in Appendix A.4 and A.5.

2.9 Flood records

A full discussion of the flood records and associated risks based on the references below can be found in Sections 4.3 and 0.

The following flood record source was consulted:

- HAGDMS Report 29971, 133467309_1_1 Envirocheck Report - A47 Wansford to Sutton, September 2017[4].
- Government Flood Risk Maps[14].

2.10 Contaminated Land

A Preliminary Contamination Assessment based on the information listed below can be found in Section 5. Additional information about contaminated land and the associated risks is discussed in Sections 4.7 and 0.

The following report was consulted to assess the potential for contaminated land:

- HAGDMS Report 29971, 133467309_1_1 Envirocheck Report - A47 Wansford to Sutton, September 2017[4].

2.11 Hydrology and Hydrogeology

A full discussion of the site's hydrology and hydrogeology based on the sources of information listed below can be found in Section 4.3.

The following sources were consulted:

- HAGDMS Report 29971, 133467309_1_1 Envirocheck Report - A47 Wansford to Sutton, September 2017[4].

2.12 Ecologically Protected Sites

A full discussion of the site's associated ecological sites is presented within Section 4.8. Ecological constraints are also presented within Section 7.14 and Section 0.

The following source was consulted:

- HAGDMS Report 29971, 133467309_1_1 Envirocheck Report - A47 Wansford to Sutton, September 2017[4].

3. Field Studies

3.1 Site walkover

A site walkover was carried out on 6th March by AMEY, details of which can be found in Section 3.1 of the PSSR carried out by AMEY[5].

On the 7th February 2018 a site walkover was undertaken by MMSJV to help inform the conceptual design works for Design Fix A+. During the visit, several features were observed, including both potential solution features and potential historical landslides which were not identified during desk top assessment. Note that the coordinates stated for observations are approximate and should not be relied upon.

Potential solution features were observed in three locations. The first depression was observed approximately 250m south of the A1 southbound/A47 junction (NGR 507724, 300052). The depression was fenced off and the sound of running water could be heard. It is unclear whether there is an underground channel present. The location of the depression is the mapped location of the boundary between the Lincolnshire Limestone and the Grantham Formation.

Within a wooded area 60m southeast of the intersection between the disused railway and the A47 (NGR 509023, 299517 and NGR 509035, 299498), a series of shallow depressions were identified which did not appear to be manmade in origin. At these localities, only a thin horizon of River Terrace Deposits overlies the Lincolnshire Limestone. Further, there is a property called “Deep Springs” around 100m to the east of the locality.

The third observed depression was seen towards the far eastern extent of the scheme, around 100m west of the Sutton roundabout (NGR 509979, 299247). Despite being labelled a pond, the depression was observed to be steep sided, 5-6m deep and dry at its base. Historical mapping from c.1900 labels the feature as a worked gravel pit, however maps prior to this show the ground to be marshy. The location of the depression would place it within the River Terrace Deposits, with its base at a similar to the level of the boundary between the Lincolnshire Formation and the overlying Rutland Formation.

For all three locations, there is reasonable evidence to suggest that a potential solution feature or underground cavity is present at each of these locations.

An unidentified area of potential historical landslip was also observed during the site walkover. Mass movement was identified by the observation of uneven sloping ground with a depression behind the slope crest and a bulge at the toe. The Design Fix A+ cross sections between approximate Chainages 700m to 900m on MC00 illustrate this profile.

In addition, a further historical landslide, previously identified by Chandler (1979) and shown on BGS 1:50k mapping can be observed to the immediate west.

Further evidence for the likelihood of mass movement in the area shown are:

- A cuspate depression in the field to the north of the existing A47 northeast of the fuel station
- A row of wooden electricity pylons constructed along the possible landslip feature, some of which have rotated from the vertical to lean down slope
- Potential linear areas of seepage along the slope, defined by areas of coarse grass

The observations stated above and further observations made during the site visit are summarised in Appendix B, as well as on the A47 Schemes Wansford to Sutton Dualling Site Walkover Plan Sheet 1 to 3 (HE551494-MMSJV-HGT-000-DR-CE-0005 to HE551494-MMSJV-HGT-000-DR-CE-0007) in Appendix C.

3.2 Access and constraints

Due to the high traffic volume along sections of the proposed route, it was not possible to observe certain sections of the route during the walkover carried out by AMEY detailed in Section 3.1 above. Further, for the site walkover on the 7th February 2018, portions of the proposed scheme could not be accessed due to lacking the permission of landowners and for security reasons

Some sections of the proposed route were noted as having very soft compressible ground during the initial AMEY walkover[5], this may present problems for vehicle access. Please refer to the original report for details.

It is understood that the AMEY highways team are compiling service information and drawings but these are yet to be released. The following drawings indicating services likely to be present and their approximate positions are currently available (See Appendix A).

- HE551494-AMY-HGN-WS_STG2-DR-HE-004 Existing Utilities - SHEET 1
- HE551494-AMY-HGN-WS_STG2-DR-HE-005 Existing Utilities - SHEET 2
- HE551494-AMY-HGN-WS_STG2-DR-HE-002 Existing Features - SHEET 1
- HE551494-AMY-HGN-WS_STG2-DR-HE-003 Existing Features - SHEET 2

The site constraints shown on the drawing listed below summarises the approximate location of utilities and the locations at which they cross the proposed A47 route:

- 384161-MMD-00-LG2-DR-A-0001 A47 Schemes, Wansford to Sutton, A47 Dualling

The following summarises the location of utilities and locations at which they cross the proposed A47 carriageway, however reference to the utilities plans should be made when assessing possible constraints for the route.

An underground high voltage cable runs below the existing southbound A1 slip road and along the existing section of the A47. The cable then splits at the existing junction with the Sacrewell Farm and Country Centre. The separate cables terminate near the fuel station and at a small structure at the southern end of the Sacrewell Farm and Country Centre access road respectively.

At the location of the fuel station, a pair of water mains orientated approximately north-south transect both the existing and proposed A47 routes. These are thought to be pumped mains associated with the pumping station to the east of the fuel station. There is also a pair of water mains indicated as cutting the existing and proposed A47 routes between the junction of The Drift and the Old Peterborough Road in a southeast to northwest orientation.

Underground Vodaphone cables, underground BT cables and a water main are shown to run below the existing A47 from the Sacrewell Farm and Country Centre access road junction. An underground Interoute cable is also shown, however this spurs off to run northeast below Sutton Heath Road.

High voltage overhead powerlines are present on the south side of the existing A47 from the approximate location of the fuel station to the point where the A47 crosses the dismantled railway. Here, they split and the overhead lines then follow the dismantled railway both southeast and northwest. Another set of high voltage lines also pass just to the east of the proposed scheme, orientated approximately north- south.

Further consultation with the statutory undertaker will be required to determine whether the aforementioned utilities would be affected by the future works.

3.3 Geomorphological mapping

No mapping projects have been conducted specifically for the scheme. The condition data stored within the geotechnical asset database of HAGDMS[4] has been reviewed and is summarised within Section 4.5.

3.4 Previous Investigations

The following reports have also been consulted:

- HAGDMS Report 16333, A1/A47 junction improvements, Parkman, November 1998[4].
- HAGDMS Report 16334, A1/A47 junction improvements, Parkman, November 1998[4].
- HAGDMS Report 28097, A1/A47 Wansford Pinch Point Programme Scheme, Amey, October 2014[4].
- HAGDMS Report 339, A1 (M) Peterborough to Stamford Geotechnical Procedural Statement, Carl Bro Group March 1995[4].
- HAGDMS Report 7619, A1 Fletton Parkway to Stamford Geotechnical Desk Study, Kirkpatrick & Partners, December 1992[4].
- HAGDMS Report 8315, A47 Sutton West of A1 Improvement Geotechnical Desk Study, Stirling Maynard & Partners, July 1992[4].
- HAGDMS Report 21822, Area 6 - Geotechnical Asset Management Plan, Atkins, July 2007[4].

- HAGDMS Report 22327, Area 6 - A47 Wansford to Norwich Geotechnical Principal Inspection Report, Atkins, October 2007[4].
- HAGDMS Report 22883, A Late Roman Cemetery beside the A1 near Durobrivae (Water Newton): Archaeological Recording, Cambridgeshire County Council, November 1999[4].
- HAGDMS Report 25865, Area 6 - A47 Wansford to Kings Lynn Geotechnical Principal Inspection Report, Atkins, May 2010[4].
- HAGDMS Report 23928, Area 7 - Geotechnical Principal Inspection Report: A1, A M Scott, December 2009[4].
- HAGDMS Report 26576, Area 7 - A1(M) J17 to A43 Wothorpe Interchange Geotechnical Principal Inspection Report, Atkins, October 2011[4].

4. Site Description

4.1 Geography and Topography

The preferred route option is located adjacent to the existing A47 single carriageway and will run between the A47/A1 junction north of Wansford and the A47/Castor/Upton roundabout north of Sutton. It will comprise approximately 2.55km of new dual carriageway. The approximate location of the site is presented in the Design Fix A+ drawing which can be found in Appendix A:

- HE551494-MMSJV-HGN-000-DR-CH-00001

The western extent of the proposed route is at the junction of the A1 and A47, north of Wansford on Black Swan Hill at approximately 33m Above Ordnance Datum (AOD). It is proposed for a free flow slip road to join the south bound A1 and east bound A47 carriageways. The slip road leaves the A1 (22m AOD), passing over the flank of Black Swan Hill where it achieves its greatest height (31m AOD), before dropping to meet the A47 (28m AOD).

The main route runs to the north of the River Nene gently losing elevation until crossing the White Water Brook and dismantled railway at 13m AOD. At this point, the route climbs the eastern side of the White Water Brook Valley to approximately 21m AOD, before gradually falling to join the existing A47 dual carriageway at the A47 Castor/Upton junction in the eastern extent of the route at an approximate level of 17m AOD[2&4].

The proposed freeflow slip and the western portion of the carriageway up to c.Ch650 lie to the north of the existing carriageway within 350m of its current footprint. The remainder of the carriageway to the east, lies to the south of the existing carriage way within 15m of the existing footprint.

The majority of the route passes through agricultural with a few isolated areas of woodland. OS mapping[2] only indicates woodland in the immediate surrounds of the crossing of the disused railway in the White Water Valley. However aerial photographs of the route[3,4&6], show additional areas of woodland at c.Ch 150, c.Ch 350 and c.Ch 2200.

A fuel station is noted just to the south of the proposed route at c.Ch 600 with a pumping station labelled adjacent to its eastern boundary and a mobile phone aerial to its west. A residential dwelling is also shown at Ch 1600 within the proposed route, this is labelled Deep Springs. The remainder of the route to the east of Deep Springs is also labelled as a Roman Road.

The River Nene flows west to east approximately parallel to the proposed route between c.Ch 0 to c.Ch 1300 before turning to flow approximately southeast. A series of lakes are located to the south of the river. White Water Brook dissects the route flowing in a northwest to southeast orientation at between c.Ch 1175 and c.Ch 1225. A small waterbody also lies within this area. The proposed route also crosses two other minor watercourses at c.Ch 2125 and c.Ch 2350, which are joined by another watercourse that runs parallel to the southern boundary of the existing A47. Another small waterbody is also present at c.Ch 2350 and appears to join to these suspected drainage ditches.

4.2 Geology

British Geological Survey and memoir

The published geology for the area has been reviewed by reference to the 1:50,000 scale British Geological Survey (BGS) maps for the area; Sheet 157 Stamford[7], Peterborough District Memoir for Sheet 158[8] and TL09NE, Solid and Drift[10], the BGS online digital geological map viewer[11] and Lexicon[12].

Summary geological maps are also presented within HAGDMS Report 29971[4]. Reference should also be made to Sections 4.2, 6 and the following drawings in Appendix A created by AMEY[5].

- HE551494-AMY-HGT-Z1-DR-GE-00002 Geotechnical Hazard Plan
- HE551494-AMY-HGT-Z1-DR-GE-00005 Geological Long Section

These drawings reflect several route options, the current preferred route option is similar to Option 8, but passes closer to the existing A47 in the eastern portion of the route.

Artificial ground

The geological maps do not show artificial ground beneath the footprint of the site, however several historic boreholes show varying depths of Made Ground in isolated locations. The BGS maps do not show Made Ground unless the thickness exceeds 2.5m, however the development of infrastructure in the local area suggests artificial ground is likely to be encountered beneath the existing carriageway and adjacent roads.

An area of ground denoted Landslip is present on BGS sheet 157[7] between Ch 250 and Ch 550. This is associated with the area of Wansford Pumping Station. The landslip is thought to be associated with a periglacial slip plane reactivated by the construction of the Wansford pumping station in 1980's.

Superficial Deposits

Three main types of superficial deposit are present along the route with two areas of the route mapped with no superficial deposits. Figure 2 shows the distribution of the superficial deposits along the proposed route.

The majority of the superficial deposits along the proposed route are River Terrace Gravels described as forming 3 million years ago during the Quaternary period in an environment dominated by rivers.

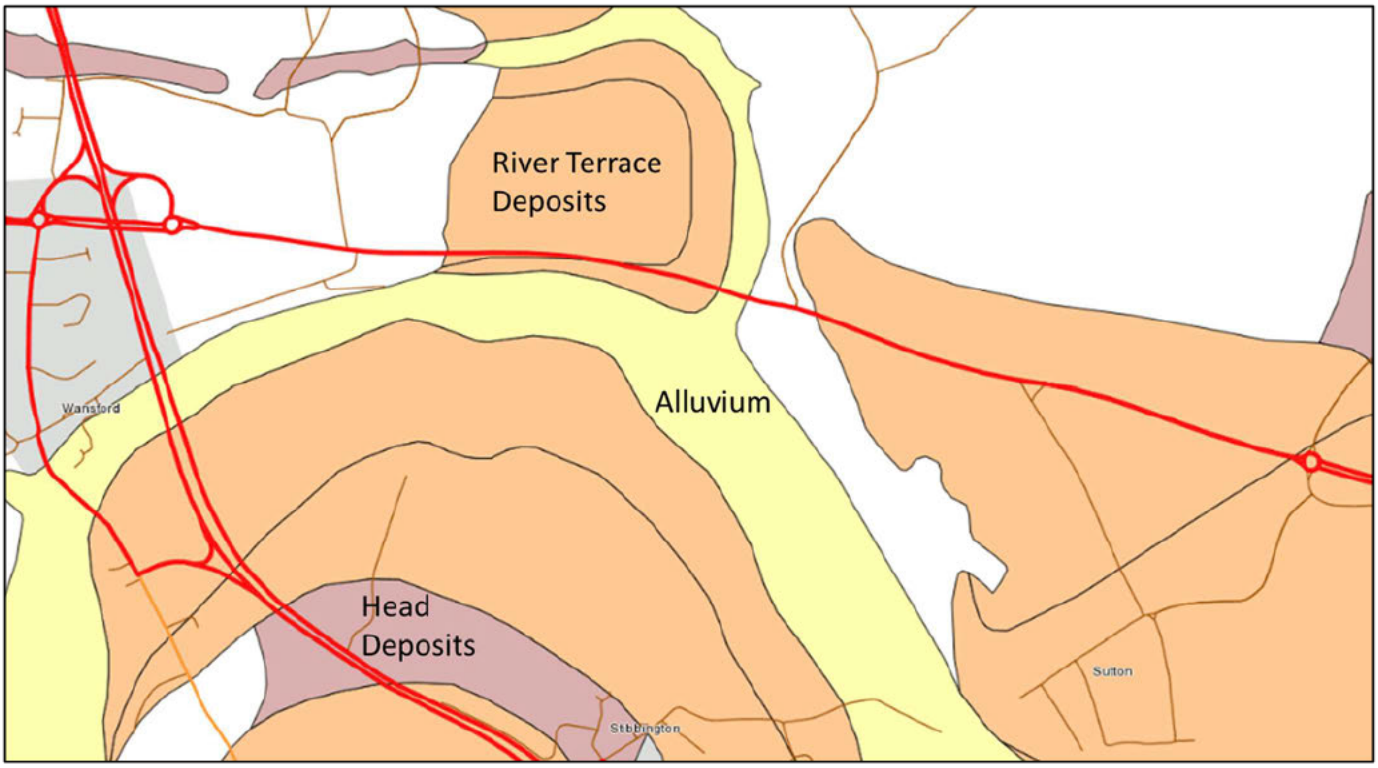

Figure 2: Superficial Deposits

Source: HAGDMS[4]

A thin strip of Alluvium is noted crossing the route in the base of the White Water Brook Valley, Alluvium is also present as a strip between c.30m and c.50m wide following the existing Nene River Valley. The alluvial deposits are described as having formed 2 million years ago in the Quaternary period in an environment dominated by rivers and are found in close proximity to present day watercourses. Excavations may encounter Alluvium where the route impinges onto the River Nene Valley, and also in the vicinity of the White Water Valley.

Head deposits are noted near the planned free flow slip road, running east west across the planned route, in the base of an un-named valley. They are described as being deposited 3 million years ago in the Quaternary period in an environment dominated by subaerial slopes and are formed by processes of solifluction, soil wash and soil creep. The deposits are generally poorly sorted and comprise clay, silt, sand and gravel with occasional peat inclusions.

Solid Geology

The bedrock of the local area is generally flat lying with a shallow dip towards the south east. The units present are recorded as Rutland Formation, Upper and Lower Lincolnshire Limestone, Grantham formation and Whitby Mudstone Formation. The underlying units are generally seen only in the valleys of the primary watercourses. Figure 3 shows the distribution of the solid geology.

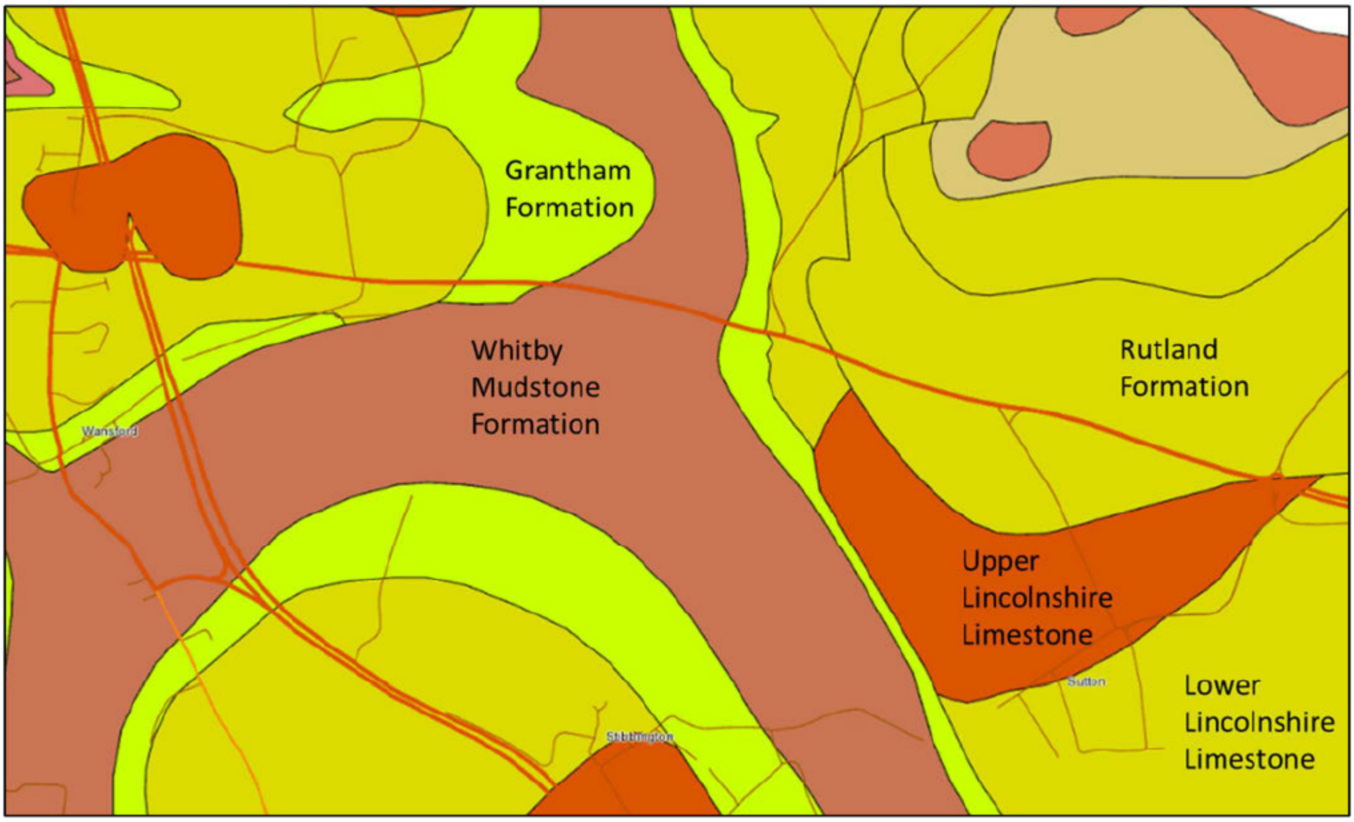

Figure 3: Solid Geology

Source: HAGDMS[4]

The oldest unit likely to be encountered on site is the Whitby Mudstone Formation, part of the Lias Group. It is a sedimentary bedrock formed approximately 176 to 183 million years ago during the Jurassic Period in an environment dominated by shallow seas. The sediments are mainly siliciclastic, deposited as clay, silt, sand and gravel. The BGS Lexicon[12] suggests the unit will be composed of grey mudstones and shales with bands of phosphatic and limestone nodules.

The Grantham Formation overlies the Whitby Mudstone Formation and is a sedimentary bedrock formed approximately 172 to 176 million years ago during the Jurassic Period in an environment dominated by shallow seas. The materials are likely to comprise white and grey leached silts and sands and dark grey clays, commonly containing rootlets and lignitic debris.

Overlying the Grantham Formation are the Lower and Upper Lincolnshire Limestones. These formed following a marine transgression and are thought to have accumulated in warm shallow current agitated seas approximately 168 to 172 million years ago in the Jurassic Period. The Lower Lincolnshire Limestone is composed of flat bedded oolitic limestones with marl partings. The Upper Lincolnshire Limestone comprises coarse grained oolites thought to fill channels in the older limestone.

The upper-most solid geology unit likely to be encountered along the route is the Rutland Formation. This is a sedimentary bedrock formed approximately 165 to 172 million years ago during the Jurassic Period in an environment of freshwater coastal marshes. The sediments are mainly siliciclastic, deposited as sandstones, siltstones and fireclays, occasionally containing rootlets.

Structural

A fault is observed[7] 250m to the north of the proposed route at approximately Ch 1300. The fault is orientated north east, south west but does not extend across the scheme.

Landslide Risks

The 1:50,000 BGS map of the area shows an area of landslip at c.Ch 350 to c.Ch 600. This landslip was recognised during works to upgrade the Wansford Pumping Station in 1972, when excavation caused mass movement of the landslide downslope towards the works. Movement was documented upslope of the excavations, and cracking was noted in agricultural fields c. 20m to the north of the A47 carriageway. The report by Chandler (1979)[31] describes the events that occurred. Please also refer to the observations made during the site visit by MMSJV in Section 3.1.

Chandler (1979)[31] proposed that the movements occurred on a pre-existing shear surface that was formed during past mass movement. The original surface is thought to have formed due to the brecciation of the Whitby Mudstone Formation through the process of valley bulging and cryoturbation. This is based on the observation of numerous valley bulging derived shear surfaces within the Whitby Mudstone Formation at Empingham Dam (approximately 16km northwest of the site), along with a disturbed fabric. The original slip occurred during a time of erosion by the River Nene, when the Alluvium had yet to be deposited. This was followed by subsequent minor slips taking place after Alluvium had been deposited.

Using back calculation, Chandler (1979) [31] found that a simple single failure mechanism returned parameters that were too low for intact Whitby Mudstone Formation. This suggested that the slope that had been subjected to either a previous failure or progressive failure. Therefore, by using residual parameters for the planar base of the shear surface (the purported pre-existing shear surface) parameters were attained which which were closer to unsheared Whitby Mudstone Formation.

It was therefore concluded by Chandler (1979)[31] that the mass movement induced by excavation utilised, in part, a pre-existing shear surface which formed during valley bulging, cambering and cryoturbation. It was also suggested that the pre-existing shear surface extended further into the slope. The movement occurred due to the removal of the toe weight during excavation.

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Figure 4 taken from Ballantyne et al (1994)[32], illustrates the processes of valley bulging and cambering.

Erosion of a river valley through competent cap rock removes the lateral support from the cap rock and the horizontal confining stress are reduced in the softer clays. As a result, the softer underlying rock will begin to bulge upwards into the base of the valley removing support from the cap rock which will consequently drape in towards the valley base. The cap rock will show normal faulting and blocks will show surface dips greater than the surrounding valley slope.

Gulls may be associated with the normal faulting of the cap rock as steeply inclined fissures or joints that have been partially or wholly infilled with overlying material. Where cambered blocks move downslope gulls may be widened.

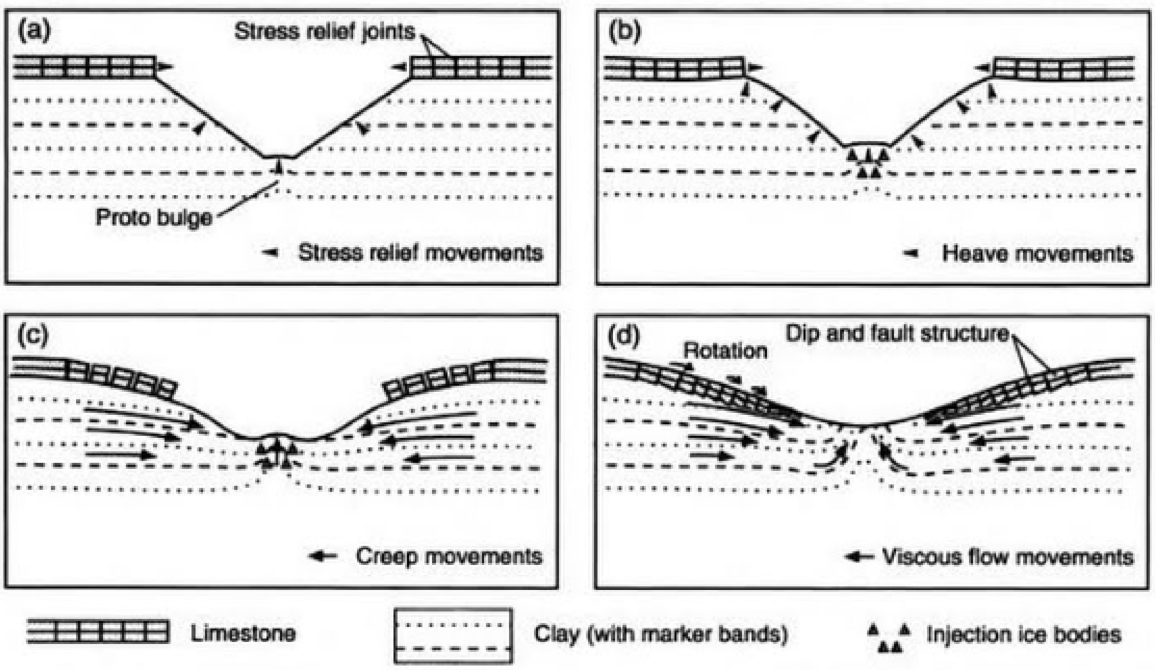

Figure 4: Cambering and Valley Bulging

Source: Ballantyne et al (1994)

It is thought that these processes occurred concurrently with brecciation of the exposed mudstone by cryoturbation. Brecciation of the mudstone was noted in the Whitby Mudstone in excavations related to the formation of Empingham Reservoir and was shown to penetrate up to 20m into the clay.

The processes of Valley Bulging, Cambering and brecciation are shown to occur in areas where the competent cap rock is cut by erosion to reveal the underlying mudstone. Several such areas exist within the footprint of the proposed route and as such these areas may be at risk of landslip.

Figure 5 highlights the areas considered at risk along the proposed route due to the similar geological conditions present.

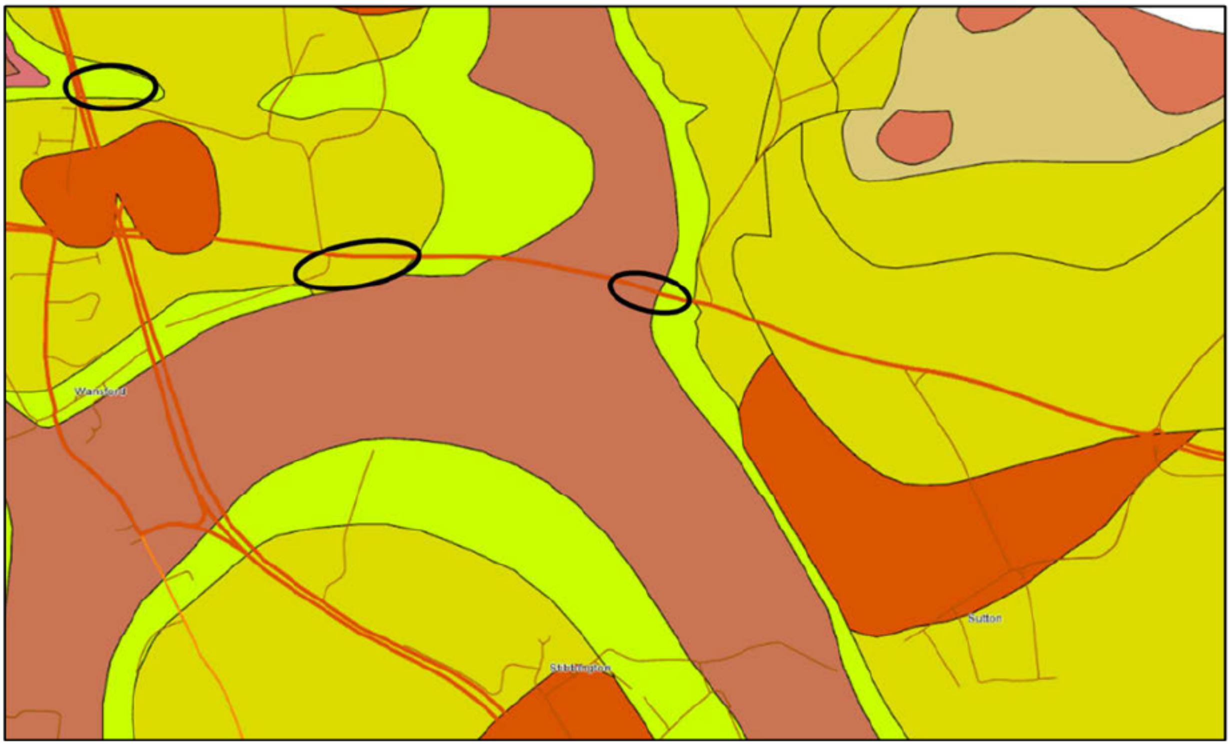

Figure 5: Areas at risk of cambering and valley bulging

Source: HAGDMS[4]

Brecciation will increase the permeability of the Whitby Mudstone Formation and thus decrease its strength by softening. Gulls may also represent localised areas of lower strength within the Lincolnshire Limestone.

<u>Dissolution Risks</u>

As stated by BGS GeoSure[33], in areas where groundwater flows through soluble rocks such as rock-salt and limestone, there is the potential for dissolution to occur. Dissolution is the process whereby the mineral forming elements such as calcium and potassium are taken into solution by the groundwater (of acidic pH), thus breaking down the minerals and hence breaking down the rock.

Rock-salt has a high propensity to dissolve, with any near surface deposits being quickly removed due to dissolution. However, rock-salt is not found in the A47 Wansford to Sutton scheme area. Limestone however can be found within the scheme boundary, primarily within the Upper and Lower Lincolnshire Limestone Formations. Limestone is less easily dissolved than rock-salt, however significant cavities such as caves and underground rivers can be formed within it, leading to what is known as a karst landscape.

A karst landscape can lead to potential geotechnical hazards. These include:

- Near surface cavities
- Subsidence and sinkhole formation
- Uneven rock head

Over time, it is possible for dissolution derived cavities to collapse, due to the reduce strength of the rock mass, leading to the subsidence of the overlying ground. Further, changes in groundwater flow can lead to the removal of sediment deposited in the cavities, causing collapse and subsidence. In both cases the subsidence is expressed as either a conical or cylindrical depression at the surface, forming what are commonly known as sinkholes.

Areas of depression were observed during the site walkover undertaken by MSSJV representatives, where in one instance, running water was audible. This observation could infer the presence of an underground river and therefore could indicate that a karst landscape is present at the site. What's more, limestone is recorded as being close to ground surface at all of the observation locations. Therefore, it could be suggested that dissolution cavities may be present wherever limestone is recorded as being close to surface. For more information on these observations, please consult Section 3.1.

British Geological Survey and HAGDMS Borehole Scans

There are 6 British Geological Survey (BGS) registered boreholes[13] recorded on the proposed route, and 10 further usable logs within a 250m buffer zone, as shown in Figure 6. Borehole scans can be found in Appendix D.

Figure 6: BGS borehole logs near the proposed route

Source: BGS GeoIndex[34]

Tables 1 to 4 summarise the groups of similar strata likely to be encountered, together with the thicknesses and general descriptions of the units encountered in the excavations noted.

Table 1: Summary of Boreholes TL09NE86, TL09NE52 *, TL09NE48 and TL09NE41

Strata	Thickness (m bgl)	Depth to top of stratum(m bgl)	Bottom Depth (m bgl)
Topsoil** Brown loam with abundant limestone fragments	0.25 - 0.5	0	0.25 - 0.5
Upper and lower Lincolnshire Limestone Interbedded firm sandy clay and moderately weak limestone layers over Moderately weak rubbly oolitic LIMESTONE with traces of brown sandy clay. Medium grained to fine grained. Well to poorly sorted.	2.44 - >4.7	0 - 0.5	2.4 - 5.0 (maximum value is unproven)
Grantham Formation Clay and silt.	3.4 - 4.5	2.4 - 4.0	5.8 - 8.5
Whitby Mudstone Blue CLAY.	>13.1	5.8 - 8.5	>21.3 (unproven)

*Units are inferred from geological descriptions.

** Topsoil was not present in TL09NE52.

The boreholes reviewed in Table 2 are at different ground levels to the site and may not reflect the wider conditions, but are included to give a description of the Alluvium conditions that may be encountered in the River Nene valley.

Table 2: Summary of Boreholes TL09NE78* and TL09NE79

Strata	Thickness (m bgl)	Depth to top of stratum (m bgl)	Bottom Depth (m bgl)
Topsoil	0.2	0	0.2
Alluvium Medium brown very clayey SAND. Occasionally the fine flint and limestone pebbles	0.1** - 1.6	0.2 - 4.4**	1.8 - 4.5
River Terrace Sandy, in places clayey fine angular and sub angular GRAVEL. Sand is fine to coarse.	3.5	4.5	8.0

Occasionally over a fine to cobble size GRAVEL with a fine to medium silty sand matrix.			
Whitby Mudstone Stiff blue grey/dark grey silty CLAY	>2.1 (Unproven)	1.8 - 8.0	>10.1 (unproven)

* 4.4m of Made Ground was noted in TL09NE78 from surface. However, this is not thought to be indicative of the wider conditions.

** the deeper upper surface of the Alluvium corresponds to the Made ground encountered at this location and is not thought to be indicative of the wider conditions.

Table 3: Summary of Boreholes TL09NE77, TL09NE88*, TL09NE82, TL09NE345*, TL09NE346*, TL09NE312, TL09NE313, TL09NE314 and TL09NE347*

Strata	Thickness (m bgl)	Depth to top of stratum (m bgl)	Bottom Depth (m bgl)
Topsoil Dark brown silty sand	0.2 - 0.5	0	0.2 - 0.5
Made Ground** Hard brown sandy clay with occasional gravel, traces of ash	0.8	0.2	1.0
Head*** Firm brown silty and sandy CLAY with occasional gravel. Occasionally present as a stiff clayey sandy SILT	0.4 - 1.4	0.2 - 0.5	0.9 - 1.6
River Terrace Medium dense clayey silty SAND with some gravel, with areas of compact very clayey sandy fine to coarse GRAVEL and stiff to hard grey silty CLAY.	1.6 - 5.9	0.2 - 1.6	2.6 - 6.3
Rutland Formation Hard brown silty CLAY with occasional gravel and cobbles	1.1 - 1.6	1.0 - 3.2	2.1 - 4.8
Upper and lower Lincolnshire Limestone Moderately strong rubbly oolitic LIMESTONE with some stiff brown sandy clay in upper levels	1.2 - 4.1 unproven	2.1 - 6.3	5.0 - 9.4 (unproven)
Grantham Formation	Unproven	6.0	7.9 (unproven)

Compact grey silty SAND			

* Units are inferred from geological descriptions.

** Made Ground was only encountered in TL09NE88 and this may be associated with the A47 carriageway which it is adjacent to.

***Head deposits were only encountered in TL09NE314 and TL09NE345.

Borehole TL09NE87 (proximal to the BP Fuel Station) is shown separately in Table 4, as there is a possibility that the logged Made Ground, is either historically disturbed by some form of mass movement, or possible embankment fill.

Table 4: Summary of Boreholes TL09NE87*

Strata	Thickness (m bgl)	Depth to top of stratum (m bgl)	Bottom Depth (m bgl)
Topsoil	0.2-0.5	0	0.2-0.5
Made Ground** Moderately weak rubbly oolitic LIMESTONE with some firm sandy clay	3.3	0.2	3.5
Whitby Mudstone Clay Stiff blue-grey	2.1 (Unproven)	3.5	5.6 (unproven)

*Units are inferred from geological descriptions.

**In TL09NE87 this unit is described similarly to the Lincolnshire Limestone in other areas, but is described as possible Made Ground in this log.

4.3 Hydrology and Hydrogeology

Hydrogeology

Superficial Deposits

The Head Deposits are designated as a Secondary Undifferentiated Aquifer; meaning it has not been possible to assign either category A or B to the deposit due to its variable characteristics.

The Alluvium and River Terrace Deposits are designated as a Secondary A Aquifers; meaning they are deposits with permeable layers capable of supporting water supplies at a local rather than strategic scale.

Solid Geology

The Rutland Formation is designated as a Secondary B Aquifer; meaning the deposits are predominantly lower permeability and may be able to store and yield limited amounts of groundwater.

The Upper and Lower Lincolnshire Limestone Formations are designated as Principal Aquifers; meaning the geology has a high intergranular permeability, usually providing a high level of water storage and may support water supplies on a strategic scale. This also means that soils could possibly transmit a wide range of pollutants.

Grantham Formation is designated as a Secondary Undifferentiated Aquifer; meaning it has not been possible to assign either category A or B to the deposit due to its variable characteristics.

The Whitby Mudstone is designated as an Unproductive Strata; meaning they are deposits with a low permeability that have negligible significance for water supply.

No source protection zones are noted on site, or within 500m of the site boundary. The site is designated as being a nitrate vulnerable zone.

Hydrology

Six inland rivers traverse or adjoin the site, generally crossing from north to south, with the exception of the waterway flowing to Sacrewell Farm in the north west of the site, which flows from west to east.

A further seventy four surface water features are identified within 250 metres of the site comprising inland rivers and lakes such as the River Nene, however this high number reflects the large number of tributaries in the watercourses.

The areas bounding White Water Brook and the stream crossing the proposed free-flow slip road are designated as a Zone 2 floodplain, with small areas to either side designated as a Zone 3 floodplain. Zone 2 floodplains estimate that the annual probability of flooding is between 1 in 1000 (0.1%) and 1 in 100 (1%) from rivers, whilst Zone 3 floodplains see the annual probability as 1 in 100 (1%) or greater.

The risk of flooding from surface waters is rated as high in several areas along the proposed route. A high rating indicates that there is a 1 in 30 (or greater) chance within a given year of flooding from surface water. High risk areas are associated with watercourses crossing the route together with an area north of the junction with The Drift.

BGS records indicate that most of the site to the east of Ch 550 is susceptible to groundwater flooding of properties situated below ground level. In addition, several areas are susceptible to groundwater flooding at surface, generally coincident with the location of watercourses.

4.4 Historical Development

The history of the site's land use and development has been reviewed referencing the historic maps presented in the HAGDMS Report 29971[4]. A brief summary of the historic map and development within approximately 500m of the site are detailed in Table 5, highlighting the major changes observed in the historic maps

Table 5: Summary of site history

Year of Publication	Scale	Features on or within 100m of the site	Features >500m from the site
1885	1:2,500 and 1:10,560	• The majority of the site and surrounds are given over to agricultural use. • A small stream with associated embankment and track cross the route of the proposed free flow slip road in the north of the site. • The Old North road is shown running north south immediately adjacent to the west side of the site. • A road linking Wansford and Peterborough is shown running east/west within the south of the site, named Peterborough road. To the eastern side of the site, this road forms the route of the proposed road. • Several mile stones are noted along the Peterborough road. • The River Nene and associated flood plain are noted to the south of the site, within 100m at the closest point. • In the western half of the scheme the areas adjacent to the River Nene are noted as "Liable to Floods". • A Weir with associated stanchion is shown on the River Nene approximately 100m south of the site. • The Stamford and Wansford Railway crosses the proposed route at close to its midpoint. A Rail station with associated buildings named "Wansford Road Station" is shown 50m to north of the site. • A Towing path is noted running along the north bank of the River Nene in the east of the site. The river is within the footprint of the proposed route in the vicinity of the rail crossing. • Two streams are noted in the vicinity of the scheme to the immediate west of the railway crossing. Only one is shown as crossing the proposed site area. • Flaxton Ford is named on the River Nene at the approximate centre point of the route. • Sutton Toll is noted to the east of the rail crossing approximately 25m north of the site. • A small area of mixed woodland is noted within the site boundary immediately east of the rail crossing.	• Multiple small roads and tracks cross the proposed route and a local area. • Approximately 400m south west of the site the settlement of Wansford is shown, including St Mary's Church and Wansford Bridge. • Thornlaugh Corn Mill with associated Mill Pond is shown approximately 125m to the north of the site. • Approximately 300m north of the site isolated buildings are shown to the north of Thornlaugh Mill. • Isolated buildings are noted together with a marked Mile post approximately 200m west of the site along the Old North road. • Approximately 300m west of the site an area of woodland named "The Plantation "is shown. • Approximately 500m south east of the site the settlement of Sutton is shown, including St Michael' Church and Wansford Bridge. • Sutton pits are noted approximately 250m of the south east of the site, these appear to be sand and gravel pits. • Ermine Street, an old Roman route is shown 250m to the east of the site with a north west, south east trend. • A large area to the north east of the site is named Sutton Heath and noted as Rough Pasture with two pits at approximately 250m and 400m north of the site. • Two small ponds are noted within the pasture area. • Upton Lodge buildings are present 250m to the north east along Ermine street, noted as the route of a Roman Road. • Approximately 600m north west of the site the settlement of Thornlaugh is shown, including St Andrew's Church, a Rectory, School and Smithy.
1886	1:2,500	No significant changes noted	• Southern side of the River Nene is not shown on the map.
1887	1:2,500 and 1:10,560	• The north side of the River Nene is not shown on the 1:2,500 maps.	• The settlement of Wansford is shown as extended to the south of the River Nene, approximately 500m south of the site including a site of antiquities named "Roman Houses". • The settlement of Stibbington is shown 750m to • The land to the south of the River Nene is shown as agricultural land.

Year of Publication	Scale	Features on or within 100m of the site	Features >500m from the site
1889	1:2,500	• Area north of the site is not shown on the map	• Area immediately south of the River Nene is noted as Liable to Flood.
1900	1:2,500	• The buildings formerly shown as Thornlaugh Corn Mill are shown as Si k Fishery. Associated Fish Ponds are shown approximately 100m to the north of the site. • A Sluice is shown on White Water Brook immediately adjoining the north of the site. • Sheep and Cattle pens are noted alongside the Wansford Road Station.	• The isolated buildings shown north of Thornlaugh Hall are named as Sacrewell Farm. • Approximately 300m north west of site a small pond is shown. • The two small ponds in the rough pasture area are shown draining to the south into White Water Brook.
1900 - 1901	1:2,500	• An old gravel pit is noted immediately adjoining eastern extent of the site at Ch 2350.	• No significant changes noted
1901	1:2,500 and 1:10,560	• A foot bridge shown at location of the weir across the River Nene. • A footpath is shown crossing the west of the site from Si k Fishery to the west of Wansford. • An old Quarry is noted 400m north west of the site in the vicinity of Thornlaugh. • Areas north of the site are only partially shown on the 1:2,500 map.	• Area to the west of the site, in the vicinity of the Mile post, is named Black Swan Hill. • The Sutton Pits are noted as containing a crane. They are shown as rough pasture in places. • Two small areas of woodland named "Top Field Spinney" and "Hell Corner" are noted to the north of the site at 500m and 750m.
1902	1:2,50 and 1:10,560	• The north side of the River Nene is not shown on the 1:2,500 map.	• No significant changes noted
1928	1:10,560	• The area of the site is not shown on the map.	• No significant changes noted
1952	1:2,500 and 1:10,560	• Areas north of the site are only partially shown on the 1:2,500 map.	• Land immediately to the south of the River Nene comprises several new bodies of water. • A Public House is noted approximately 150m west of the site to the north of Wansford.
1952 -1953	1:10,000	• To the west of the site a new road is shown along the footprint of the current A1. • The small area of woodland within the site is extended to adjoin the railway. • An isolated building is noted alongside the road and within the footprint of the proposed route approximately 150m to the east of the rail line.	• A Tow path is mapped running along the southern bank of the River Nene. • The Railway is no longer continuous to the north, and noted as disused.
1958	1:2,500 and 1:10,000	• A site of "Roman buildings" is noted to the immediate south of the site in the vicinity of the planned underpass. • The route of the A47 as shown is noted as the course of a Roman Road.	• No significant changes noted
1964-1965	1:10,000	• A new road is noted as being under construction in the current footprint of the A47, with a junction with the A1 noted. • A telephone call box is noted approximately 100m to the south west of the site.	• No significant changes noted
1965	1:2,500	• No significant changes noted	• No significant changes noted
1969	1:10,000	• The extreme north of the proposed slip road route is not shown on map. • Changes are shown to the A1/A47 junction.	• No significant changes noted

Year of Publication	Scale	Features on or within 100m of the site	Features >500m from the site
1970	1:2,500 and 1:10,000	• Only extreme north of the proposed slip road route is shown on the map. • A building with enclosing fence line is noted east of the rail line, named Deep Springs. • A Pylon line is noted as crossing the site at Ch 2550. • A new pond with surrounding woodland is shown immediately adjoining the south east of the site in location of a former quarry. • Two drainage lines feeding a pond, one coming directly south, one from the west. The drains cross under the A47 from the north side in separate locations. • Two small ponds are noted in an area of woodland to the west of the former Wansford Rail station.	• Sutton Pits are no longer shown as Quarries, instead area is shown as Coniferous and non-Coniferous woodland. • Approximately 250m south west of the site a new building named Willowhayne House is noted along The Drift road. • A building shown 175m north of the railway crossing formerly associated with the Wansford Road Station is named Heath House. • Small areas of Marsh are shown adjoining the dismantled railway.
1970 - 1979	1:10,000	• No significant changes noted	• No significant changes noted
1970-1976	1:2,500	• New developments are shown alongside the south boundary of site comprising a Filling station Ch 500 and Filter tank Ch 300. • A new access road is shown for the Sacrewell Farm and Mill buildings.	• Old Mill pond is shown as marsh rather than open water
1970-1990	1:2,500	• Only the area south of 300,000 Northing is shown on the map. • Area of old Mill/Fishery labelled as Sacrewell Farm.	• No significant changes noted
1975-1976	1:2,500	• No significant changes noted	• A small area of residential development is shown immediately to west of the site across the A1. • Telephone call post is noted along the route of the A1 north of the site.
1976	1:2,500	• Weir and footbridge are no longer noted along River Nene. The stanchion is still noted. • A public convenience is noted along route of old road cut by the new road.	• Development of Wansford beyond original boundaries. • A flood gauging station is noted on the north bank of the Nene.
1980	1:2,500	• No significant changes noted	• Quarry 400m north west of site is shown as disused.
1980-1983	1:10,000	• Pumping station is noted approximately 25m to the south of the site, with large embankments also shown in the vicinity. • A Mast is noted approximately 25m south of the site in the vicinity of the Pumping Station. • Workings are noted 25m to the south of the site, no area is denoted.	• Further development of the settlement of Wansford to the west of the A1. • Glasshouses noted approximately 175m west of the site named Wanhill Nurseries. • A subway is noted 200m west of the site, to the west of the A1 and 300m to the south of the site under the A1. • Bungalow noted 500m south of the site, on the south side of the River Nene.
1980- 1984	1:10,000	• A New track is noted running from Top Field Spinney south towards the site area.	• Railway shown as Dismantled Railway • Quarries shown 250m and 400m north of the railway crossing are no longer shown. •
1991	1:10,000	• Most of site area not shown on map	• To the eastern extent of the proposed route a track is shown following the footprint of the present day A47.
1992	1:2,500	• A new road alignment is shown joining the roundabout at the eastern end of the route.	• To the eastern extent of the proposed route a new dual carriageway is shown following the footprint of the present day A47.

Year of Publication	Scale	Features on or within 100m of the site	Features >500m from the site
		• A strip of non-coniferous woodland is noted along the north side of the route of the A47.	
1994	1:2,500	• Sluice is shown adjacent to the pumping station along the north bank of the River Nene.	• No significant changes noted
1996	1:2,500 and 1:10,000	• Only the area north of 300,000 Northing is shown on the 1:2,500 map. • Only the extreme eastern extent of the route is shown on the 1:10,000 map. • New pond is shown to west of A1 approximately 25m from the planned slip road.	• No significant changes noted
1999	Aerial Photograph	• Site area is shown as agricultural land. • Both filling station and pumping station are shown adjacent to the site boundary. • New pond to west of A1 is visible as partially filled. • Mill Pond visible as open water. • The area named Deep Springs is vis ble as buildings with an enclosed garden, inferred to be a residential dwelling.	• Area immediately to the south of the site is pasture adjoining the river Nene. The A1 road runs north south on the western boundary of the site. • The area south of the River Nene is a body of water.
1999-2000	1:10,000	• Disused workings are shown 25m to the south of the site.	• Pump house is shown approximately 200m south west of the site. • A Pavilion is noted approximately 350m south west of the site.
2006	1:10,000	• Sacrewell Farm named Sacrewell Farm and Country Centre. • New vehicle tracks are noted in the entryway to Sacrewell Farm	• No significant changes noted
2017	1:2,500 and 1:10,000	No significant changes noted	• A Roman Building site is shown approximately 375m to the north east of the free flow slip road.

4.5 Man-Made Features

The following man-made features are present within the proposed route footprint.

Major road infrastructure:

- A47 Single carriageway trending east west.
- A1 carriageway trending north south immediately adjacent to the western end of the scheme.

Minor road infrastructure:

- Access track for Sacrewell Farm on the north side of the existing carriageway at Ch 350.
- Side road junction and electricity substation on the south side of the existing carriageway at Ch 400.
- Sutton Heath road junction on the north side of the existing carriageway at Ch 1350.

- The Drift road junction on the south side of the existing carriageway at Ch 1900.
- Existing roundabout with side roads joining form the north and south of the carriageway at Ch 2500.

Other infrastructure:

- Wansford Pumping Station on the south side of the existing carriageway at Ch 500, thought to be associated with two pumping tunnels passing under the carriageway in a north west south-east orientation.
- Filter Tank noted at Ch 300 to the immediate south of the site.
- Mast in the vicinity of Wansford Pumping Station at Ch 500.
- Active Fuel Station with access slip roads on the south side of the existing carriageway at Ch 600.
- Inferred culverts passing north south under the carriageway carrying the White water Brook at Ch 1200.
- Disused railway cutting crossing under the proposed route at Ch 1300.
- Residential settlement beneath the proposed carriageway at Ch1500.
- Inferred culverts passing north to south under the carriageway carrying surface water features at Ch 2100 and 2350.
- High voltage overhead cables at Ch 2550.

<u>Earthworks associated with the existing A1 and A47 roads</u>

The majority of the A1 and A47 are either at grade or on embankment along the proposed route. Table 6 to Table 9 summarise the type of earthworks along the existing A1 and A47 routes.

Table 6: Summary of A1 southbound earthworks

PIF	Earthwork Type	Earthwork ID	Chainage on Proposed Route	Maximum Height	Maximum Slope Angle
1309	Embankment	6_A1_48699	Ch 0 to 75 - Free Flow slip	4.6m	34.0º
815	At Grade	6_A1_17727	Ch 75 to 100 - Free Flow slip	-	-

Table 7: Summary of A1 northbound earthworks

PIF	Earthwork Type	Earthwork ID	Chainage on Proposed Route	Maximum Height	Maximum Slope Angle
1320	Embankment	6_A1_49456	Ch 0 to 75 - Free Flow slip	3.7m	23.0º
512	At Grade	6_A1_17886	Ch 75 to 100 - Free Flow slip	-	-

The existing junction of the A1 and A47 lies to the south west of the proposed route, the current junction is mainly at grade with a small area of cutting.

Table 8: Summary of A47 eastbound earthworks

PIF	Earthwork Type	Earthwork ID	Chainage on Proposed Route	Maximum Height	Maximum Slope Angle
801	At Grade	6_A47_38912	Ch 50 to 350	-	-
815	At Grade	6_A47_20922	Ch 350 to 1100	-	-
816	Embankment	6_A47_20923	Ch 1100 to 1375	1.4m	20.0º
899	At Grade	6_A47_28006	Ch 1375 to 1450	-	-
1000	At Grade	6_A47_29006	Ch 1450 to 2500	-	-

Table 9: Summary of A47 westbound earthworks

PIF	Earthwork Type	Earthwork ID	Chainage on Proposed Route	Maximum Height	Maximum Slope Angle
813	At Grade	6_A47_30403	Ch 50 to 350	-	-
814	At Grade	6_A47_20921	Ch 350 to 550	-	-
819	At Grade	6_A47_27903	Ch 550 to 1100	-	-
817	Embankment	6_A47_27900	Ch 1100 to 1375	2.0m	24.0º
894	At Grade	6_A47_28001	Ch 1375 to 1650	-	-
895	At Grade	6_A47_28002	Ch 1650 to 1900	-	-
896	At Grade	6_A47_28003	Ch 1900 to 2125	-	-
897	At Grade	6_A47_28004	Ch 2125 to 2350	-	-
898	At Grade	6_A47_29001	Ch 2350 to 2500	-	-

Table 10 to Table 12 summarise the information relating to recorded defects relating to the earthworks associated with the A1 and A47 sections.

Table 10: Summary of A1 southbound earthwork defects

Location	Coordinates	Observation ID	Date	Chainage on Proposed Route	Observation Class	Details
6_A1_48699_451506	507406,200208 to 507414,300186	451506	19/05/2010	Ch 0	1D	Dislocated Trees
6_A1_48699_451502	507433,300150	390646	19/05/2010	Ch 50	-	Minor historic slip, no longer visible
6_A1_48699_451503	507433,300132	390609	19/05/2010	Ch 65	1D	Terracing in embankment
6_A1_48699_451505	507434,300117	451505	19/05/2010	Ch 70	1D	Erosion of gully outfall
6_A1_48699_451504	507439,300108	451504	19/05/2010	Ch 80	1D	Erosion from outfall

Table 11: Summary of A1 northbound earthwork defects

Location	Coordinates	Observation ID	Date	Chainage on Proposed Route	Observation Class	Details
6_A1_49456_393388	507396,300173	393388	19/05/2010	Ch 10	1D	Rabbit Burrows
6_A1_49456_451516	507401,300121	393387	19/05/2010	Ch 65	1D	Dislocated trees

Table 12: Summary of A47 eastbound earthwork defects

Location	Coordinates	Observation ID	Date	Chainage on Proposed Route	Observation Class	Details
6_A47_29006_211722	509374,299438 to 509608,299396	211722	08/05/2009	Ch 1900	-	Badgers and rabbits in side of roadway
6_A47_29006_211730	509780,299345 to 509892,299305	211730	08/05/2009	Ch 2200	-	Badgers in side of roadway

No defects are noted in the A47 westbound carriageway earthworks.

4.6 Archaeological Features

The historic maps within HAGDMS Report 29971[4] show four sites of antiquity near the route. Ermine Street to the west of the site is noted as a Roman Road, as is the course of the original A47 route, as shown on the 1958 map edition. Roman buildings are noted at approximately Ch 300 near the planned underpass. A Roman building is also noted 375m to the north east of the free flow slip road.

The Amey PSSR[5] carried out for the route notes an area immediately to the north of the route that is designated a scheduled monument due to the presence of Bronze age crop marks. However, MML is unable to reference this data due to regulatory constraints.

In addition, HAGDMS reports 23928 and 22883[4] identify a site approximately 3.2km south east of the eastern extent of the proposed route where ancient human remains were uncovered during maintenance work on the A1.

Advice should be sought from an archaeologist to obtain further explanation and understanding prior to development. Reference should also be made to any archaeological surveys that are going to be conducted for this project.

4.7 Environmental Records

Soil Geochemistry

The maximum estimated concentration values of chemicals within the soils at the site are presented below. For further information on how this data is calculated and the limitations upon its use, please see HAGDMS Report 29971[4] for further details.

HAGDMS Report 29971[4] identified the estimated maximum soil chemistry values for the site as:

- Estimated Arsenic concentration: <15 mg/kg generally, with small areas up to 25-35 mg/kg associated with low lying ground and water courses.
- Estimated Cadmium concentration: <1.8 mg/kg
- Estimated Chromium concentration: Generally 60-90 mg/kg with 120-180 mg/kg in the vicinity of the River Nene valley.
- Estimated Lead concentration: <100 mg/kg
- Estimated Nickel concentration: 15-30 mg/kg

Water abstractions

There is one abstraction noted on site:

- B H Bradshaw & Son, (A16SW) 0m NE, (NGR 507800, 299700), Spray Irrigation, River Nene, 2448000m^3 p.a. Start and end date not supplied.

A further 27 licensed abstractions are noted within 250m of the site boundary:

- J P & M Sharpley & Son, (B9NE) 20m W, (NGR508900,288500), Spray Irrigation, River Nene, Annual rate not supplied, end date not supplied.
- J P & M Sharpley & Son, (B9NE) 20m W, (NGR508900,288500), Spray Irrigation, River Nene, 2000000m^3 p.a, end date not supplied.
- Messrs J P & M Sharpley, (A15NW) 32m N, (507405, 300105), Spray Irrigation, Tributary of River Nene, 818300m^3 p.a. In Perpetuity.

- Messrs J P & M Sharpley, (A15NW) 37m N, (50740, 300105), Spray Irrigation, River Nene, 818300m^3 p.a., in perpetuity.
- Messrs J P & M Sharpley, (A15NW) 38m N, (507400, 300100), Spray Irrigation, Tributary of River Nene, Annual rate not supplied, end date not supplied.
- William Scott Abbott Trust, (A15NW) 38m N, (507400, 300100), Spray Irrigation, Stream at Sacrewell, Annual rate not supplied, end date not supplied.
- Mr T B Jones, (A11NE) 54m E, (507700, 299500), Spray Irrigation, Well and Borehole, 32000m^3 p.a., end date not supplied.
- J H Seed, (A15SW) 73m N, (507400, 300001), Spray Irrigation, Watercourse at Thornlaugh, Annual rate not supplied, end date not supplied.
- William Scott Abbott Trust, (B13SE) 102m NW, (508900, 2997000), Spray Irrigation, Sacrewell, 1363830m^3 p.a, end date not supplied.
- B H Bradshaw & Son, (A12NW) 104m E, (NGR 507890, 299482), Spray Irrigation, River Nene, Annual rate not supplied, end date not supplied.
- William Scott Abbott Trust, (A16SW) 104m NE, (507900, 300000), Spray Irrigation, Thornlaugh Beck, Annual rate not supplied, in perpetuity.
- Anglian Water Services Limited, (A12NE) 107m E, (508160, 299580), Transfer between sources, River Nene, Annual rate not supplied, end date not supplied.
- Anglian Water Services Limited, (A12NE) 107m E, (508160, 299580), Transfer between sources, River Nene, Annual rate not supplied, end date not supplied.
- Anglian Water Services Limited, (A12NE) 107m E, (508160, 299580), Transfer between sources, River Nene, Annual rate not supplied, end date not supplied.
- Anglian Water Services Limited, (A12NE) 107m E, (508160, 299580), Transfer between sources, River Nene, Annual rate not supplied, end date not supplied.
- Anglian Water Services Limited, (A12NE) 107m E, (508160, 299580), Transfer between sources, River Nene, Annual rate not supplied, end date not supplied.
- Anglian Water Services Limited, (A12NE) 107m E, (508160, 299580), Transfer between sources, River Nene, Annual rate not supplied, end date not supplied.
- Anglian Water Services Limited, (A12NE) 107m E, (508160, 299580), Transfer between sources, River Nene, Annual rate not supplied, end date not supplied.
- B H Bradshaw & Son, (A12NW) 181m E, (NGR 507900, 299400), Spray Irrigation, River Nene, Annual rate not supplied, end date not supplied.
- Anglian Water Services Limited, (A12NW) 193m E, (508100, 299500), Transfer between sources, River Nene, Annual rate not supplied, end date not supplied.

- Anglian Water Services Limited, (A12NE) 193m E, (508100, 299500), unspecified, source unknown, 763000000m^3 p.a, end date not supplied.
- Anglian Water Services Limited, (A12NW) 198m E, (508105, 299495), Transfer between sources, Stream, 763000000m^3 p.a, end date not supplied.
- B H Bradshaw & Son, (B9SE) 217m W, (NGR 509020, 299261), Spray Irrigation, River Nene, Annual rate not supplied, end date not supplied.
- J B Bradshaw, (A15NW) 220m NW, (NGR 507200, 300195), Impounding, Thornlaugh brook, 2000000m^3 p.a., end date not supplied.
- J B Bradshaw, (A15NW) 221m NW, (NGR 507200, 300200), Spray Irrigation, Thornlaugh brook, 2000000m^3 p.a., end date not supplied.
- William Scott Abbott Trust, (A16NW) 240m NE, (NGR 507800, 300095), Impounding, Thornlaugh Beck, 1309280m^3 p.a, in perpetuity.
- William Scott Abbott Trust, (A16NW) 243m NE, (NGR 507800, 300100), Spray Irrigation, Thornlaugh Brook, 1309280m^3 p.a, end date not supplied.

Discharge consents

There are no discharge consents on site and 10 discharge consents within 250m of the site boundary, detailed below:

- Anglian Water Services Limited, (A15NW) 38m N, (NGR 507400, 300100), Storm Sewage overflow, River Nene.
- Anglian Water Services Limited, (A15NW) 38m N, (NGR 507400, 300100), Storm Sewage overflow, River Nene.
- Anglian Water Services Limited, (A15NW) 46m N, (NGR 507399, 300080), Sewage discharges, pumping station, River Nene tributary.
- Anglian Water Services Limited, (A15NW) 67m N, (NGR 507360, 300130), Emergency Sewage Discharge, Receiving water not supplied.
- Anglian Water Services Limited, (A15NW) 67m N, (NGR 507360, 300130), Storm Sewage overflow, River Nene tributary.
- Hauxton Fishery Services Ltd, (A16NW) 135m NE, (NGR 507950, 300100), Discharge of other matter, Wittering Brook.
- Anglian Water Services Limited, (A11NE) 189m S, (NGR 507600, 299400), Storm Sewage overflow, River Nene.
- Anglian Water Services Limited, (A11NE) 189m S, (NGR 507600, 299400), Storm Sewage overflow, River Nene.
- Anglian Water Services Limited, (A11NE) 206m S, (NGR 507600, 299380), Storm Sewage overflow, River Nene tributary.

- Anglian Water Services Limited, (A11NE) 220m S, (NGR 507610, 29936), Storm Sewage overflow, River Nene.

Enforcement and prohibition notices

There are no enforcement and prohibition notices for locations within 250m of the site.

Pollution incidents

Three pollution incidents have been recorded within 250m of the site's boundary, detailed below:

- Incident Ref 1813, (A15SW) 138m NW, (NGR 507400, 299800), Oils – Other Oil, incident date 1st October 1993, Category C - minor incident.

- Incident Ref 1374223, (A16SW) 3m E, (NGR 508110, 299690), Organic Chemicals/Products: Pesticides and biocides, incident date 18th September 2015, Category 2 - Significant incident.

- Incident Ref 1292778, (A12NW) 190m E, (NGR 508103, 299503), Chemicals/Products: Pesticides and biocides, incident date 7th November 2014, Category 2 - Significant incident.

Mineral sites

There are three BGS recorded mineral sites within 250m of the site boundary as listed below:

- Sutton Gravel Pit, (B11SW) 8m E, (NGR 509981,299251), River Terrace deposits, Ceased.

- Stibbington, (B9NW) 248m W, (NGR 508525, 299370), River Terrace deposits, Ceased.

- Sutton Pits, (B10SW) 250m W, (NGR 509270, 299155), Upper Lincolnshire Limestone, Ceased.

In addition, two further sites of General Quarrying or Sand, Clay or Gravel pits are noted as past land uses:

- General Quarrying, (B10SW) 209m SW, NGR 509326, 299141.

- Quarrying of Sand and Clay, Operation of Sand and Gravel pits, (B11SW) 19m E, NGR 509985, 299239.

HAGDMS Report 29971[4] shows no evidence of Coal Mining affected areas, Man Made mining cavities, Mining instability, Natural cavities, Non-coal mining areas or potential mining areas within 250m of the site boundary.

Waste activities

No BGS recorded, active or historical landfill sites have been identified within 250m of the route plan.

Registered radioactive substances

There are no records of registered radioactive substances within 250m of the site.

Control of major accident sites

There are no records of major accident hazards sites within 250m of the site.

Planning hazardous substances consents

There are no records of planning hazardous substance consents and enforcements within 250m of the site.

Potentially contaminative industrial uses

There are two active potentially contaminative industrial sites within 250m of the site's boundary, detailed below:

- BP - Rss Wansford, (A12NE), 9m E (NGR 508264, 299668), Petrol Station, Open.
- Rss Wansford, (A12NE), 9m E (NGR 508264, 299668), Vehicle Cleaning Services, Open

4.8 Ecological Designation of Land and other protected Land Uses

There is one Site of Special Scientific Interest recorded within 250m of the site boundary, detailed below:

- Sutton Heath and Bog, (B13SE) 48m NW, (NGR 509029, 299804).

There are no records of Areas of Outstanding Natural Beauty, Designated Ancient Woodlands, National Nature Reserves (NNR), Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Ramsar sites, Local Nature Reserves (LNR), World Heritage Sites, National or Forest Parks, or Environmentally Sensitive Areas within 1km of the site.

The site is located within a Nitrate Vulnerable Zone and there are no Source Protection Zones located within 250m of the site boundary.

Further information regarding statutory and non-statutory constraints was identified in Section 4.11 of the AMEY PSSR[5], however, MML is not able to include these due to regulatory constraints.

4.9 Radon

The highest classification on site for Radon is an intermediate radon probability area; meaning that between 5-10% of homes are above the action level. As such, basic radon protective measures are necessary for the construction of new dwellings or extensions.

4.10 Geotechnical Risks

HAGDMS Report 29971[4] lists the risks of compressible ground along the route as negligible aside from areas where Alluvium is mapped, where the risk is moderate. The risk of collapsible ground along the route are stated as very low.

A small area of moderate risk of landslip is located over the area of landslide noted in the BGS Geological map, corresponding to the Wansford Pumping Station. In addition, a small area of low risk is present to the south of the site, along the northern bank of the River Nene extending west from the Wansford Pumping Station. The risk of landslide across the remainder of the site is noted as very low.

The potential for ground dissolution hazards is generally associated with the incidence of the Lincolnshire Limestone Formation. It is noted as very low or less across the majority of the site, with small areas of low risk associated with limestone to the west end of the scheme and the railway cutting in White Water Valley.

The risks of running sand are shown as very low and if an issue, are associated with the occurrence of the River Terrace Deposits.

The risks of shrinking and swelling clay ground stability hazards are associated with the distribution of the Alluvium deposits and shown as low in those areas.

The presence of Alluvium on site suggests there may also be risks of ground gas generated by organic constituents.

The potential risk of landslide due to pre-existing slip plains as noted in Section 4.2 is thought to be present in the vicinity of the north of the proposed free flow slip from the A1 to the A47, the vicinity of Wansford Pumping Station and the east side of the White Water Brook valley.

4.11 Unexploded Ordnance (UXO) Risk

The preliminary Unexploded Ordnance (UXO) Risk Assessment conducted by 6 Alpha Associates for the scheme (HAGDMS Report 29972[4]) reported a low probability of encountering UXO on site. In accordance with CIRIA C681[15], no further action is required to address the UXO risk.

4.12 Motion Monitoring

HAGDMS Report 29971[4] lists two monitoring points located on site, showing less than 1.5mm movement annually, as such they are designated stable.

A further 15 points lie within 250m of the route, all are designated stable, showing movements of less than 1.5mm p.a.

Two of the above stations are located within Wansford Pumping Station; showing between 0.4 and 1.1mm movement p.a. This value is designated stable, but is slightly higher than the values in the immediate surroundings, these are within the vicinity of the slip recorded on the BGS Maps.

5. Preliminary Contamination Assessment

5.1 Environmental Protection Act 1990, Part 11A

The primary legislative regime under which historic contaminated land is managed in the UK is Part IIA of the Environmental Protection Act (EPA), 1990. The framework for the assessment of potential land contamination adopted in this report is based on current guidance documents regarding the implementation of Part IIA of the EPA and the assessment of potentially contaminated land, with particular reference to:

- Department of the Environment Food and Rural Affairs (DEFRA) (2012): "Environmental Protection Act 1990: Part 2A, Contaminated Land Statutory Guidance", April 2012[16].

- Environment Agency (2008): "Human Health Toxicological Assessment of Contaminants in Soil", Science Report – SC050021/SR2[17].

- Environment Agency (2008): "Updated Technical Background to the CLEA Model", Science Report - SC050021/SR3[18].

- Construction Industry Research and Information Association (2001): "Contaminated land risk assessment: A guide to good Practice", CIRIA C552[19].

- British Standard Institution (2002): "Characterisation of waste. Leaching. Compliance test for leaching of granular waste materials and sludges. One stage batch test at a liquid to solid ratio of 10 l/kg for materials with particle size below 4 mm (without or with size reduction)", ref. BS EN 12457-2:2002[20].

- British Standard (BS) 10175:2011, "Investigation of Potentially Contaminated Sites[21].

- Department for Communities and Local Government (2012): "National Planning Policy Framework"[22].

Part IIA principally deals with sites where individual historic contamination linkages present a "Significant Possibility of Significant Harm" (SPOSH) or a Significant Possibility of Significant Pollution to Controlled Waters (SPOSPCOW) representing an unacceptable level of contamination risk for each linkage. The Part IIA clean-up is the minimum which can be done on a cost basis to make and keep the site in a "just safe" condition for an existing or planned change of use.

Elimination of liability under Part IIA is not always achievable largely because of the inherent risk basis of the statutory regime, the technical difficulty in establishing levels of contamination that are likely to represent SPOSH, and the variable distribution of contamination at many sites. Statutory guidance on Part IIA (DEFRA, 2012) recognises that sites require prioritisation by Local Authorities under the statutory Part IIA site inspection programme to ensure that only those sites likely to present the greatest risks are identified. However, it should be recognised that considerable investigation is often required to establish whether sites are likely to meet the definition of contaminated land under Part IIA. Such investigation may be beyond the scope of project budgets for nominally “low risk sites” necessitating judgement on an acceptable level of investigation, and the likelihood of meeting SPOSH / SPOSPCOW criteria based on incomplete data. Since the designation of Contaminated Land is the responsibility of the local authority, it is advised that consensus is sought on any recommendations regarding the significance of contaminated land risks and remedial measures through consultation with the Regulator(s).

5.2 Planning Policy Context

The EPA is designed to ensure that risks are considered only in relation to the current use of the site. There are no obligations placed by the EPA for management or mitigation of risks relating to future uses, which would require a change in planning permission. Planning policy guidance is available at the national and strategic levels. The relevant policies are considered below:

National Planning Policy Guidance

The National Planning Policy Framework (Department for Communities and Local Government, 2012) includes the following policies in relation to contaminated land:

Policy 109:
“The planning system should contribute to and enhance the natural and local environment by:

- Preventing both new and existing development from contributing to or being put at unacceptable risk from,
- Or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability; and
- Remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate”.

Policy 120:

“To prevent unacceptable risks from pollution and land instability, planning policies and decisions should ensure that new development is appropriate for its location. The effects (including cumulative effects) of pollution on health, the natural environment or general amenity, and the potential sensitivity of the area or proposed development to adverse effects from pollution, should be taken into account. Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.”

Policy 121:

“Planning policies and decisions should also ensure that:

- The site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation;

- After remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and
- Adequate site investigation information, prepared by a competent person, is presented".

The glossary states the following relation to "site investigation information":

"Site investigation information: Includes a risk assessment of land potentially affected by contamination, or ground stability and slope stability reports, as appropriate. All investigations of land potentially affected by contamination should be carried out in accordance with established procedures [such as BS10175 (2011) Code of Practice for the Investigation of Potentially Contaminated Sites]. The minimum information that should be provided by an applicant is the report of a desk study and site reconnaissance".

<u>Qualitative Risk Assessment Framework</u>

Contamination and environmental considerations are studied by developing a conceptual model of the site that describes the environmental features of the site together with the expected interaction of potential contamination sources and the wider environment. The Generic Quantitative Risk Assessment considers site contamination data against generic risk based thresholds for the contamination linkages identified in the conceptual model.

Where quantitative risk assessment is not possible, a qualitative risk assessment in accordance with CIRIA C552 (2001) has been undertaken. This is described below:

5.3 Conceptual Model

A key element of an environmental risk assessment is the development of a conceptual model which is done by undertaking a Source –Pathway – Receptor analysis of the Site:

- Sources (S) are potential or known contaminant sources e.g. a former land use;
- Pathways (P) are environmental systems thorough which a contaminant could migrate e.g. air, groundwater;
- Receptors (R) are sensitive environmental receptors that could be adversely affected by a contaminant. E.g., Site occupiers, groundwater resources.

Where a source, relevant pathway and receptor are present, a pollutant linkage is considered to exist whereby there is a circumstance through which environmental harm could occur and a potential environmental liability is considered to exist. The sources, pathways and receptors expected on the site are summarised in this section.

Sources

Onsite Sources

S1: Large areas of the site and surroundings are currently designated as agricultural fields and agricultural pesticides and sewage sludge may have been applied to the ground within the site footprint.

S2: Agricultural machinery and associated fuel spillages within site footprint. Some of the site functions as arable farmland may result in contamination, with the possibility of fuel spillages from farm machinery.

S3: The current A47 carriageway and associated side roads are likely to result in contamination associated with vehicle fuels, chemicals, brake and exhaust by products. The potential Made Ground anticipated being present within the carriageway foundations could also be a potential source of contamination.

Offsite Sources

S4: The fuel station located at Ch 600 could be a potential source of hydrocarbons (e.g. via fuel and/or oil leaks) and airborne particulates, with the possibility of fuel spillages.

S5: The potential Made Ground anticipated to be present within the foundations of existing buildings and pylon foundations alongside the proposed route could be a potential source of contamination.

S6: The Wansford Pumping station with associated tunnels located at approximately Ch 400 may result in contamination associated with chemicals associated with water purification. There is also likely to be Made Ground associated with previous construction activities on site.

S7: Traffic using the A1 could be a potential source of hydrocarbons (e.g. via fuel and/or oil leaks) and airborne particulates.

S8: The majority of the surrounding area is agricultural land to which pesticides may have been applied.

S9: Agricultural machinery and associated fuel spillages on agricultural land surrounding the site footprint. The land surrounding the site functions as arable farmland, with the possibility of fuel spillages from farm machinery.

S10: The disused rail line crossing the site could be a potential source of hydrocarbons (e.g. via fuel and/or oil leaks) however, it has not been in active use for a long period of time so risks are thought to be minimal.

S11: Buildings associated with the disused railway station, including cattle pens and a man-made pond are present approximately 85m north of the route at Ch 1250.

S12: An electricity substation and a mast are located approximately 80m south of the proposed carriageway. A further mast is located approximately 80m north of the site. Both are at approximately Ch 300.

S13: Historical sand and gravel pits surrounding the site boundary at varying distances.

S14: A sewage pumping station is located on the west side of the A1 at Ch100 of the freeflow sliproad.

Pathways

Areas of the site are underlain by superficial alluvium and gravel deposits which have been designated as 'Secondary A Aquifer'. These are defined as 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers'. Small areas of Head deposits are also shown but are designated undifferentiated aquifers.

The majority of the site is further underlain by the Upper and Lower Lincolnshire Limestone Formations which are classified as Principal Aquifers. These are defined as permeable layers capable of supporting water supplies at a local scale. This is classified as 'layers of rock or drift deposits that have high inter-granular and/or fracture permeability'. In addition, the Rutland and Grantham Formations are designated as Secondary B and Secondary Undifferentiated Aquifers. The Whitby Mudstone Formation is designated Unproductive Strata and as such is unlikely to form a pathway for pollutants.

P1: Horizontal and vertical migration of leachate through potentially permeable soils and geological formations;

P2: Migration of contaminants along engineered preferential pathways, e.g. Underground services, pipes, tunnels and drainage pathways both surface and culverted;

P3: Surface runoff along roads, pavements, cutting faces etc.;

P4: Root uptake.

P5: Human uptake pathways for a commercial / industrial land use which is considered to be broadly applicable to the proposed development, based on Environment Agency (2008) CLEA UK Framework:

- Inhalation
- Ingestion
- Dermal contact

P6: Vertical and lateral migration of volatile vapours and ground gases.

Receptors

R1: Groundwater

R2: Surface water features

R3: Subsurface structures;

R4: Flora and fauna;

R5: Construction and Maintenance workers;

R6: Final end users.

5.4 Preliminary Qualitative Risk Assessment

For each possible pollution linkage (source-pathway-receptor) identified, the potential risk can be evaluated based on the following principle:

Contamination risk = Probability of event occurring x Consequence of event occurring

This relationship can be represented graphically as a matrix (Table 13), which is adapted from the CIRIA 552[19] guidance.

The result of this assessment is presented in Table 14 and should be subject to refinement following receipt of more detailed data

Table 13: Overall contamination risk matrix

		Consequence			
		Severe	Medium	Mild	Minor
Probability	High likelihood	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Moderate/low risk	Low risk
	Low likelihood	Moderate risk	Moderate/low risk	Low risk	Very low risk
	Unlikely	Moderate/low risk	Low risk	Very low risk	Very low risk

The methodology for the assessment is presented in Appendix E.

Table 14: Preliminary qualitative risk assessment

Source	Receptor	Pathway	Consequence	Probability	Risk	Comments
Onsite **S1**: Large areas of the site are currently designated as agricultural field and agricultural pesticides and sewage sludge may have been applied to the ground within the site footprint. **S2:** Agricultural machinery and associated fuel spillages within site footprint. **S3:** The current A47 carriageway and associated side roads are likely to result in contamination associated with vehicle fuels, chemicals, brake and exhaust by products. Made Ground within the carriageway foundations could also be a potential source of contamination. **Offsite** **S4:** The fuel station could be a potential source of hydrocarbons (e.g. via fuel and/or oil leaks) and airborne particulates, with the possibility of fuel spillages. **S5**: Made Ground anticipated being present within the foundations of existing buildings and pylon	**R1:** Groundwater	**P1:** Horizontal and vertical migration of leachate through potentially permeable soils and geological formations	Medium	Low Likelihood	Low /Moderate	The Upper and Lower Lincolnshire Limestone Formations are classified as Principal Aquifers with high vulnerability, the Alluvium and River Terrace Gravels are designated as Secondary A Aquifers with intermediate to high vulnerability. The remaining geological units are intermediate vulnerability. The overall risk to groundwater is therefore considered to be LOW/MODERATE.
	R2: Surface Water	**P1:** Horizontal and vertical migration of leachate through potentially permeable soils and geological formations	Medium	Low Likelihood	Low /Moderate	There are multiple surface water features, pumping stations and watercourses associated with the Nene River within and immediately surrounding the site. Due to the distance of potential receptors the risk to surface water is considered LOW/MODERATE.
	R3: Subsurface Structures	**P1**: Horizontal and vertical migration of leachate through potentially permeable soils and geological formations **P2**: Migration of contaminants along engineered preferential pathways, e.g. Underground services, pipes, tunnels and drainage pathways both surface and culverted **P6:** Vertical and lateral migration of volatile vapours and ground gases	Medium	Unlikely	Low	It is possible that the underlying drift and solid geology may exhibit concentrations of sulphates that are corrosive to sub-surface concrete structures. Therefore the risk to buried concrete is considered to be LOW subject to confirmation from receipt of site chemical data.

Source	Receptor	Pathway	Consequence	Probability	Risk	Comments
foundations alongside the proposed route could also be a potential source of contamination. **S6**: The Wansford Pumping station with associated tunnels may result in chemical contamination. Made Ground associated with previous construction activities on site could also be a potential source of contamination. **S7:** Traffic using the A1 could be a potential source of hydrocarbons (e.g. via fuel and/or oil leaks) and airborne particulates. **S8**: The majority of the surrounding area is agricultural land to which pesticides may have been applied. **S9:** Agricultural machinery and associated fuel spillages on agricultural land surrounding the site footprint. The land surrounding the site functions as arable farmland, with the possibility of fuel spillages from farm machinery. **S10:** The disused rail line crossing the site could be a potential source of hydrocarbons (e.g. via fuel and/or oil leaks)	**R4**: Flora and Fauna	**P1**: Horizontal and vertical migration of leachate through potentially permeable soils and geological formations **P2:** Migration of contaminants along engineered preferential pathways, e.g. Underground services, pipes, tunnels and drainage pathways both surface and culverted; **P3:** Surface runoff along roads, pavements, cutting faces etc **P4:** Root uptake. **P5**: Human uptake pathways **P6**: Vertical and lateral migration of volatile vapours and ground gases.	Mild	Low Likelihood	Low	Proposed landscaping within the site is to be confirmed. The risk to flora and fauna is therefore considered to be LOW.
	R5: Construction and Maintenance workers	**P5:** Human uptake pathways **P6**: Vertical and lateral migration of volatile vapours and ground gases.	Mild	Low Likelihood	Low	It is standard practice for all members of the construction and maintenance teams to wear suitable Personal Protective Equipment (PPE). It is possible that construction workers will come into contact with soils and ground gas during site works and until further information on the contamination status of the site has been obtained the risk should be considered to be LOW

Source	Receptor	Pathway	Consequence	Probability	Risk	Comments
S11: Buildings associated with the disused railway station, including cattle pens and a man-made pond. **S12:** An electricity substation and a mast are located approximately 80m south of the proposed carriageway. A further mast is located approximately 80m north of the site. **S13:** Historical sand and gravel pits surrounding the site boundary at varying distances. **S14:** A sewage pumping station is located on the west side of the A1 at Ch100 of the freeflow sliproad.	**R6**: Final End Users	**P5**: Human uptake pathways **P6:** Vertical and lateral migration of volatile vapours and ground gases.	Mild	Unlikely	Very Low	Following development, end users are unlikely to come into contact with the soils at site. Ground gas monitoring may be required to ascertain the presence of hazardous ground gases. Assuming that any remedial works are undertaken prior to development, the risks to the final end users should be considered to be VERY LOW.

6. Ground Conditions

6.1 General

The following section discusses the soils anticipated at the site and includes engineering properties where known. BGS mapping indicates that the site is underlain by three main superficial deposits; Head Deposits, Alluvium and River Terrace Gravel Deposits, with some areas of the site indicated to have no superficial cover. The site is indicated to encounter several different solid geology units comprising; The Rutland Formation, The Upper and Lower Lincolnshire Limestones, the Grantham Formation and the Whitby Mudstone Formation. It is also anticipated that embankment fill (Made Ground) will be encountered along the proposed route, particularly in areas currently forming embankments. In addition, backfilled quarries and sand and gravel pits were identified in proximity to the route, suggesting that Made Ground associated with historical land use may also be encountered.

6.2 Artificial Ground

It is considered likely that artificial ground in the form of made or worked ground will be encountered along the proposed route particularly in areas where the route crosses the existing carriageway or man-made embankments alongside it. The method of placing the material underlying such features is not known and the degree of engineering input into the placement in unknown. There are no materials testing parameters available for the made ground and the descriptions provided in the logs available are highly varied; from hard sandy clay with occasional gravel and ash to moderately weak rubbly oolitic limestone with some firm sandy clay. As such it is not possible to provide predicted engineering properties for this material and an appropriate GI will be required to determine the nature and properties of the varied materials along the proposed route.

6.3 Anticipated Superficial Deposits

<u>Topsoil</u>

Topsoil was encountered in most BGS registered boreholes within the site boundary, with its thickness indicated to be between 0.2 and 0.5m. In most exploratory hole logs no description was provided for the topsoil, however where given it was described as dark brown silty sand with abundant limestone fragments in places.

<u>Head Deposits</u>

The BGS maps indicate Head deposits to be present mainly in the river valleys crossing the free flow slip road from the A1 and an area to the north east of the route. The BGS logs showed Head deposits in two locations at the east end of the route. They were described as firm brown silty sandy clay with occasional gravel. However, in the eastern most location they were logged as stiff clayey sandy silt. The head deposits show a thickness of between 0.4m and 1.4m.

Alluvium Deposits

The BGS maps indicate Alluvial deposits to be present proximal to the River Nene and the White Water Brook valleys. These deposits were not identified in the boreholes along the proposed route, but were present in two boreholes to the south of the River Nene. They were described as medium brown very clayey sand with occasional fine pebbles and showed a thickness of up to 1.6m. The thickness of the Alluvium is likely to vary across the floodplain of the River Nene valley.

River Terrace Gravels

The BGS maps indicate River Terrace Gravel deposits to be present on the majority of the eastern part of the proposed route from west of White Water Brook Valley to the A47/Castor/Upton roundabout. They were described as sandy and clayey fine gravel occasionally coarsening with depth. The deposits show a thickness of between1.6m and 5.9m.

6.4 Anticipated Solid Geology

Rutland Formation

The Rutland Formation forms the upper bedrock unit in the east of the site. It is generally described as a hard brown silty clay with occasional gravel and cobbles with the BGS registered borehole within the site boundary showing a thickness of 1.1m.

Upper and Lower Lincolnshire Limestone

The Upper and Lower Lincolnshire Limestone bedrock unit is present beneath the majority of the route aside from the river valleys. It is generally described as moderately weak to moderately strong light brown rubbly oolitic Limestone with traces of brown sandy clay. The thickness of this unit was between 2.2 and 3.5m thick where proven but was noted up to 4.7m thick and unproven in Borehole TL09NE 86 on the eastern end of the route.

Grantham Formation

The Grantham Formation bedrock underlies the Upper and Lower Lincolnshire Limestone units and its distribution largely mimics that of the limestone. It shows a variable composition described variously as compact grey silty sand and stiff sandy clay with some gravel. The thickness of this unit was not proven in the BGS registered boreholes examined however it did showing a thickness of at least1.9m.

Whitby Mudstone Formation

The Whitby Mudstone Formation is indicated to form the basal bedrock across the site, directly underlying superficial deposits in the river valleys. It is generally described as stiff blue-grey/dark grey silty clay. The thickness of this unit was not proven at site, with the BGS registered boreholes indicating a thickness of greater than 13.1m to the east of the site.

6.5 Preliminary Parameters

The parameters given in this section are based on parameters published within BS8004:2015[23], Clay Materials Used In Construction[24], Barnes (2010)[25] and HAGDMS report 8315[4]. The parameters presented should be treated with extreme caution and are for indicative design only. These parameters shall not to be used for detailed design without confirmation through further ground investigation. When undertaking the indicative design, it is recommended that the most conservative value of any range is used. Revision of the parameters will be carried out on completion of the project specific ground investigation for the proposed site and associated works.

Table 15 to Table 17 provide a summary of the preliminary parameters suitable for indicative design, for the strata likely to be encountered across the site. In some cases, it was not possible to provide preliminary parameters as these are not provided within readily available published literature.

It is assumed that Topsoil will be removed prior to construction; therefore this has not been considered further.

Table 15: Preliminary geotechnical parameters for superficial deposits

Parameter	Head Deposits	Alluvium Deposits	River Terrace Deposits
Unit Weight (bulk density)	15-18 kN/m^3 [A]	10 - 20 kN/m^3 [A]	15-19 kN/m^3 [C]
Plasticity Index, Ip	21[B]	11-170 [A]	-
Effective Angle of Shearing Resistance, ϕ	24-27[C]	0-9[A*]	30 [A]
Effective cohesion, c'	0 [C]	0[A]	0 [C]
Undrained Shear Strength, cu	20-100[B]	20-180[A]	-

[A] Values taken from HAGDMS report 8315[4]
[B] No site specific information available for deposits.
[C] From BS 8004:2015
* The range of values for this parameter is unrealistic and hence must be used with caution.

Table 16: Preliminary geotechnical parameters for the solid geology

Parameter	Rutland Formation	Grantham Formation	Whitby Mudstone Formation
Unit Weight (bulk density)	15-23 kN/m^3 [A]	17-19 kN/m^3 [A]	19-25 KN/m^3 [A]
Plasticity Index, Ip	6-60[A]	29[A]	16-23[A]
Effective Angle of Shearing Resistance, ϕ	0-34[A*]	0-35[A*]	0-31[A*]
Effective cohesion, c'	0	0	0-25[A]
Undrained Shear Strength, cu	5-625 kPa[A*]	40-80 kPa[A]	5-275kPa[A*]
Elastic Modulus	>20 MPa[B]	10-20 MPa[B]	10-20 MPa[B]

[A] Values taken from HAGDMS report 8315[4]. Parameters derived from quick undrained triaxial tests using 38mm diameter specimens from less than 10 samples. Parameters may therefore not be representative and must be used with caution.
[B] Soil Mechanics[25]
* The lower bound values of these parameters are unrealistic and hence must be used with caution.

Table 17: Preliminary geotechnical parameters for the Lincolnshire Limestone Formation

Parameter	Lincolnshire Limestone Formation
Unit Weight (bulk density)	20 kN/m^3 [A]
Uniaxial Compressive Strength	5-12.5 MN/m^2 [B]
Elastic Modulus	>20 MPa[A]

[A] To be confirmed with BGS Memoir[8] values if shown.

[B] Values inferred from Foundation construction and design[26].

6.6 Groundwater Conditions

Where encountered, groundwater was recorded as being between 2.7m and 4.5m below ground level. However, the majority of the BGS logs either did not record the groundwater level or recorded a dry borehole. It is suggested that the change in ground level across the proposed route is likely to lead to varying groundwater levels.

For preliminary design, it is recommended that groundwater is assumed as being 1m below ground level, except for areas identified as at risk from flooding. In these locations, like the River Nene valley, groundwater should be assumed to be at ground level.

7. Preliminary Engineering Assessment

7.1 General

This section provides an overview of the site and proposed development based on data currently available.

Mott MacDonald Sweco Joint Venture has independently assessed and reviewed the engineering geology and the geotechnical consideration of the proposed scheme based on the available geotechnical information where relevant. Drawing No. HE551494-MMSJV-HGN-000-DR-CH-00001 provides the only engineering earthworks/structures design for the route. Detailed specifications for the proposed earthworks should be obtained for a more in-depth technical assessment and, hence, this assessment will need to be reviewed and developed when further design has been carried out.

The existing earthworks along the route are discussed within Sections 4.5, and the proposed earthworks in Sections 7.3 and 7.4. HA Departmental Standard HD41/15 [9] defines earthworks below 2.5m in height for their entire length and at-grade sections as 'minor earthworks'. From the topographical section provided in Drawing No. HE551494-MMSJV-HGN-000-DR-CH-00001, the preliminary proposed formation levels are likely to be categorised as 'minor earthworks' although this is subject to review at detailed design stage, as detailed in Table 18 and Table 19.

The proposed structures at the site are discussed in Section 7.5.

The preliminary engineering assessment considers anticipated ground conditions based on previous site investigation work within the area of the site. The anticipated geology is discussed in Section 6 of this report.

7.2 Geological Constraints

The following section broadly summarises the main engineering considerations of each stratum likely to be encountered during the lifetime of the project and should be read in conjunction with the interpreted geology. It is assumed that Topsoil will be removed prior to any site works commencing, it has therefore been excluded from this section.

<u>Head Deposits</u>

These deposits consist of clayey sandy silt with occasional gravel and roots. The following constraints and engineering considerations have been identified for these soils:

- Deposits are likely to have high dilatancy and tend to be sensitive to moisture content variations.
- Low bearing capacities.
- Liable to be a compressible unit.
- Excavations within this unit are likely to demonstrate instability and may collapse.

- Head deposits are an unsuitable founding material for shallow foundations due to variability, low strength, and high compressibility.
- Head deposits are likely to be an inappropriate material for earthworks without modification or sorting due to: the variable nature of the materials, low strength and sensitivity to moisture content variation expected in the materials on site.
- There is a potential risk for concrete to be attacked by aggressive ground.

Alluvium Deposits

These deposits consist of very clayey sand. The following constraints and engineering considerations have been identified for these soils:

- Deposits are likely to have high dilatancy and tend to be sensitive to moisture content variations.
- Low bearing capacities.
- Variable founding and settlement conditions (potential for differential settlement) due to the variable nature of the deposit.
- Liable to be a compressible unit.
- Excavations within this unit are likely to demonstrate instability and may collapse.
- Alluvium is an unsuitable founding material for shallow foundations due to variability, low strength, and high compressibility.
- Alluvium is likely to be an inappropriate material for earthworks due to the variable nature of the materials including areas of low strength and high compressibility and sensitivity to moisture content variation expected in the materials on site.
- There is a potential risk for concrete to be attacked by aggressive ground.
- It is possible that ground gas will be encountered within Alluvium deposits.

River Terrace Gravels

These deposits consist of slightly silty fine to medium sand over fine to medium sand and sub-rounded gravel. The following constraints and engineering considerations have been identified for these soils:

- Perched groundwater within beds of silty sand and very fine-grained sand layers may be encountered.
- Silty layers may have high dilatancy and tend to be sensitive to moisture content variations.
- Excavations within this unit are likely to demonstrate instability and may collapse without support.

Rutland Formation

These deposits consist of hard brown silty clay with occasional gravel and cobbles. The following constraints and engineering considerations have been identified for these soils:

- Deposits are likely to be sensitive to moisture content variations, silt horizons are likely to show a marked dilatancy.
- Bearing capacities may be variable depending on moisture content.
- Rutland Formation may show some variability, so strength and compressibility may vary correspondingly.
- There is a potential risk for concrete to be attacked by aggressive ground.
- The unit is logged as a transitional in composition between a rock and a soil which may make excavation difficult.
- It is possible that the Rutland Formation may demonstrate a variable weathering profile.

Upper and Lower Lincolnshire Limestone Formation

These deposits consist of moderately weak light brown rubbly oolitic limestone with traces of brown sandy clay. The following constraints and engineering considerations have been identified for these soils:

- Deposits are formed of soluble material, so there is potential risk of collapsing ground.
- The unit forms the principal aquifer so measures may be required to protect this.
- The unit is comprised of hard ground and may make excavation difficult.
- The unit has potential as a founding material, but may not be of sufficient thickness in all localities.
- Interbedded soil and rock deposits may make the unit difficult to model.
- It is possible that there may be some instability within temporary excavations in the more sand dominated layers.

Grantham Formation

These deposits consist of stiff brown sandy clay with some flint and limestone gravel. The following constraints and engineering considerations have been identified for these soils:

- Deposits are likely to be sensitive to moisture content variations, silt horizons are likely to show a marked dilatancy.
- Bearing capacities may be variable depending on moisture content.

- Grantham Formation may show some variability, so strength and compressibility may vary correspondingly.
- BGS Lexicon[12] suggests some organic material may be present, as such Grantham Formation may not be suitable for earthworks material and may be a compressible unit.
- There is a potential risk for concrete to be attacked by aggressive ground.
- The unit is logged as stiff which may make excavation difficult.
- It is possible that the Grantham Formation may demonstrate a variable weathering profile.

Whitby Mudstone Formation

These deposits consist of stiff, blue-grey clay. The following constraints and engineering considerations have been identified for these soils:

- The Whitby Mudstone Formation is likely to be over-consolidated and may be susceptible to drainage issues.
- There is a potential risk for concrete to be attacked by aggressive ground
- It is possible that the Whitby Mudstone Formation may demonstrate a variable weathering profile.
- It is possible that some horizons may include limestone nodules within the Whitby Mudstone Formation
- It may exhibit swelling or shrinking behaviour – the potential removal of stress and reduction in overburden pressure during excavation could induce swelling.
- The Whitby Mudstone Formation may be moisture sensitive. Therefore, there is a risk that ground conditions on site may deteriorate if the material becomes wet.
- The strength and compressibility of the Whitby Mudstone Formation may vary with depth, be affected by the presence of fissures and penetration of water during construction.

7.3 Cuttings

The locations and details of the proposed cuttings along the planned route, and the underlying geology, are summarised in Table 18 by reference to chainage. The proposed cuttings are located at the western end and centre of the route, as detailed in drawing HE551494-MMSJV-HGN-000-DR-CH-00001.

The published geology determined for the area has been reviewed by reference to the 1:50,000 scale British Geological Survey (BGS) maps for the area. Summary geological maps are also presented within HAGDMS Report 29971[4]. The proposed cutting slope gradient across each route option is anticipated to vary according to the location, underlying geology, groundwater conditions and geometry of individual slopes. No information is available on HAGDMS regarding existing cutting slope angles along the A47 in the vicinity of the proposed route.

The proposed cuttings are likely to occur in the River Terrace Gravels. For cutting slopes in the River Terrace Gravels, it is recommended at this stage, and in the absence of specific site geotechnical data, slope angles of a minimum of 1 in 2.5 are considered conservative and should be used for preliminary design.

Some cuttings may occur within the Lower Lincolnshire Limestone. Slope angles of 1 in 3 are considered conservative for this formation, and should be used in preliminary design.

It is possible that Grantham Formation may be revealed in the base of the cutting for the local road accessing Sacrewell Farm. Slope angles of 1 in 3 are considered conservative for this formation, and should be used in preliminary design.

It is anticipated that conventional plant should be suitable for excavation and no ripping or blasting is required. Cut is expected within either the River Terrace Gravels or Lower Lincolnshire Limestone, however historical borehole logs suggest the top 5m of the Lower Lincolnshire Limestone is highly weathered.

The management of the generated cut material and their re-use criteria are discussed in Section 7.6. It is likely that there will be a proportion of topsoil and soft weathered residual soil material that cannot be reused.

Groundwater is likely to be encountered close to the natural ground levels of the site. Groundwater flow is likely to be principally towards the south and the River Nene, together with other surface water bodies. Groundwater levels should be considered in the slope stability analyses during the detailed design stage.

Table 18: Proposed cuttings

Earthwork Type	Maximum Height (m)	WB/EB	Approximate Chainage		Estimated Length (m)	Expected Strata in Cutting
			From	To		
Cutting	5.6	MC80 Local Road	340	700	350	5m Lower Lincolnshire Limestone Underlain by Grantham Formation
Cutting	0.45	EB	725	790	65	River Terrace Gravels
Cutting	0.15	EB	1100	1160	60	River Terrace Gravels
Cutting	1.1	EB	1410	1730	320	River Terrace Gravels
Cutting	0.76	EB	1860	1890	30	River Terrace Gravels
Cutting	1.2m	EB	2380	2440	60	River Terrace Gravels

Notes
1. Chainages not covered in Table 18 are at grade.

7.4 Embankments

The locations and details of the proposed embankments along the planned route, and the underlying geology, are summarised in Table 19 by reference to chainage. The majority of the proposed embankments are located along the western end of the route, with one towards the far eastern end.

The published geology determined for the area has been reviewed by reference to the 1:50,000 scale British Geological Survey (BGS) maps for the area. Summary geological maps are also presented within HAGDMS Report 29971[4].

The proposed embankments are likely to be founded on the River Terrace Gravels. As the majority of the proposed cutting on the scheme is likely to encounter the River Terrace Gravels, it is likely any cut material will be considered for re-use to form these embankments, and in the absence of site specific geotechnical data, slope angles of 1 in 2.5 are considered conservative and should be used for preliminary design.

Some embankments may be founded on Alluvium; the Lower Lincolnshire Limestone Formation; the Upper Lincolnshire Limestone Formation, the Rutland Formation; the Grantham Formation; and the Whitby Mudstone Formation.

Alluvium and Head Deposits are considered unsuitable for use as embankment fill due to low strength, composition, and compressible nature without specific site geotechnical data and assessment.

Where present, weak compressible ground may require either improvement or excavation and replacement below the formation.

Table 19: Proposed embankments

Earthwork Type	Maximum Height (m)	WB/EB	Approximate Chainage		Estimated Length (m)	Expected Strata beneath embankment
			From	To		
Embankment	2.0	MC10 Slip Road	0	754	754	Upper and Lower Lincolnshire Limestone.
Embankment	3.5	MC20 Local Road	0	260	260	Lower Lincolnshire Limestone, Grantham Formation from approximately Ch 200 to Ch 400.
Embankment	2.0	WB	0	725	725	Upper and Lower Lincolnshire Limestone, from approximately Ch 550; River Terrace Gravels overlying Grantham Formation.
Embankment	4.1	WB	725	1350	625	From approximately Ch 725 to 1350 River Terrace Gravels overlying Whitby Mudstone Formation. From approximately Ch 1150 to Ch1200; Alluvium overlying Whitby Mudstone Formation. From approximately Ch 1200 to Ch1350, Grantham Formation generally overlain by Made Ground.

Earthwork Type	Maximum Height (m)	WB/EB	Approximate Chainage		Estimated Length (m)	Expected Strata beneath embankment
			From	To		
Embankment	0.9	WB	1350	2100	1050	From approximately Ch 1350 to Ch 1600, River Terrace Gravels overlying Lower Lincolnshire Limestone. From approximately Ch 1600 to Ch2100, River Terrace Gravels overlying Rutland Formation.

Notes
1. Chainages not covered in Table 19 are at grade.

7.5 Structures

The proposed structures along the route, as detailed in drawing HE551494-MMSJV-HGN-000-DR-CH-00001, are summarised in Table 20 by chainage. The published geology determined for the area has been reviewed by reference to the 1:50,000 scale British Geological Survey (BGS) maps for the area. Summary geological maps are also presented within HAGDMS Report 29971[4].

It is recommended a site-specific ground investigation is undertaken along the proposed route.

Table 20: Proposed structures

Structure Name	Approximate Chainage	Structure Description	Solid Geology	Superficial Deposits
MC20 Local Road	0	New road structures leading to roundabout	Upper Lincolnshire Limestone, Lower Lincolnshire Limestone and Grantham Formation	No Superficial Deposits Recorded
Underbridge	290	Underbridge for new road under A47	Lower Lincolnshire Limestone	No Superficial Deposits Recorded
MC10 Slip Road	720	New road structures leading to roundabout	Upper Lincolnshire Limestone, Lower Lincolnshire Limestone and Grantham Formation	Head Deposits
Culvert	1210	For existing stream running to River Nene	Grantham Formation and Whitby Mudstone Formation	River Terrace Gravels
Underbridge	1400	Underbridge for disused railway line under A47	Grantham Formation and Whitby Mudstone Formation	River Terrace Gravels

Structure Name	Approximate Chainage	Structure Description	Solid Geology	Superficial Deposits
New Road	2050	New road connecting local roads to Sutton Roundabout	Rutland Formation	River Terrace Gravels
Culvert	2360	For existing flowing stream into pond	Upper Lincolnshire Limestone and Rutland Formation	River Terrace Gravels

7.6 Fill Material and Earthworks Acceptability

The key to successful earthworks is to have a clear understanding of the sequence of strata, the geometry of the vertical alignment and the engineering properties of the soils encountered. The scale of excavation will have a bearing on the potential acceptability for re-use.

Where soils are silty, clayey or have the potential for uniformly graded characteristics, it should be recognised that these deposits are sensitive for use in difficult or marginally acceptable weather conditions. Wet weather can cause rapid deterioration in their properties and it can be difficult to achieve adequate compaction when in excess of the optimum moisture content. In these circumstances, the selection of an appropriate programme with construction in dry months is appropriate to maximise the re-use of available materials.

The vertical alignment of the proposed development should be designed to optimise the earthworks balance, recognising that the sandy materials, such as the River Terrace Gravels, are more likely to be acceptable for re-use within earthworks, whereas silts and soft clays, such as Alluvium, are likely to be unacceptable for re-use.

Depending on the programme and season for the proposed construction works, it may be possible to improve the workability of the materials by soil modification or stabilisation. Where fill contains wet cohesive deposits, and is unacceptable for compaction, the addition of lime may improve acceptability for compaction.

Sandy materials may benefit from the addition of cement, to improve sub formation strength, either on embankments using on site sandy material or in at grade sections where in-situ CBR for loose soils may be low or marginal. Soil stabilisation in this manner may alleviate the need for imported granular capping material if haul distances are significant, however further testing, laboratory tests and site trials to validate the approach are required to develop such proposals.

Unacceptable materials, such as topsoil, silt, soft clays and very loose sands, will have to be treated or removed in order to provide a satisfactory formation for the road. Importing of granular capping material would be required to address low California Bearing Ratio (CBR) strength conditions, or alternatively, as discussed above soil stabilisation could be considered subject to specialist contractor testing, laboratory tests and site trials at construction stage being successful in demonstrating its viability.

Table 21 summarises the strata available for use; the location of the strata; and its use on site as a fill material; as well as any geotechnical considerations.

Table 21: Recommended use of material won on site

Stratum	Approximate Location	Recommended use as a Fill Material	Notes
Head Deposits	Thin band in the north west of the site	Class 4 Landscape Fill	Likely to be inappropriate material for earthworks without treatment. Likely to have low bearing capacities, liable to compression and unstable.
Alluvium	Thin band cutting across the centre of the site in a north-south direction	Class 4 Landscape Fill	Likely to be an inappropriate material for earthworks due to low strength, high compressibility.
River Terrace Gravels	Towards the centre and east of the site	Class 1 General Granular Fill	Consists of slightly silty sand to gravel. Potential to encounter perched groundwater. Excavations likely to demonstrate instability.
Rutland Formation	Towards the east of the site	Class 2 General Cohesive Fill	Formation is highly variable in terms of strength, compressibility and bearing capacities.
Upper and Lower Lincolnshire Limestone	Towards the west of the site, and small band in the centre	Testing is required to determine Class	Deposits of soluble material, so risk of collapsing ground. May be required to protect the principal aquifer.
Grantham Formation	Two bands in the centre of the site in a north-south direction	Class 2 General Cohesive Fill	Deposits are likely to be sensitive to moisture content variations. Variable bearing capacity, strength, and compressibility. Potential to encounter organic material.
Whitby Mudstone Formation	Towards the centre of the site	Class 2 General Cohesive Fill	Formation is likely to be over consolidated and be susceptible to drainage issues. May exhibit swelling or shrinking behaviour, with varying strength and compressibility.

The balance of cut and fill use is not likely to be even, with a large portion of the proposed route on embankment. However, material taken from the cutting made in forming the proposed underpass to access the Sacrewell Farm and Country Centre could be considered for reuse in forming new earthworks.

7.7 Foundations

The geology and ground conditions vary both laterally and vertically and it is, therefore, anticipated that the bearing capacity and settlement characteristics will similarly vary.

Foundations will be required for the following structure types:
- New highway bridges,
- New or modified water course crossings, and
- Minor structures (lighting, signs, technology, barriers).

The location and purpose of individual structures will influence the type of foundation design required for the structure. Table 22 details characteristics of shallow and deep foundations.

Any foundation solution has the potential to be subject to differential settlement when they abut existing or new embankments or other structures. Loading soft ground can create lateral forces within the ground which can add additional load to structure foundations (for example, adding in additional lateral loads to piles). Settlement attenuation solutions will be required. The use of load transfer platforms or ground improvement techniques in proximity to the structure can be considered to minimise differential settlement in the vicinity of the structure.

Table 22: Foundation solution options

Solution	Foundation Types	Uses
Shallow Foundations	• Strip Foundations • Pad Foundations	• Minor structures • Large loads on strong, stable ground • Bridging problematic ground
Deep Foundations	• Driven Piles • Cast in-situ piles (e.g. bored concrete pile)	• Minor structures with significant moments • Large loads • Transferring load to stable ground at depth • Transferring load into soil via skin friction

At present, not enough information is known regarding parameters of the soils underlying the site. Due to the combination of cross slope foundations and the presence of alluvium in the vicinity of large embankments particular caution will need to be taken if structures are to be founded within the superficial deposits, due to their variable lithology and anticipated low bearing capacity.

7.8 Subgrade

During the design of future GI for the scheme and geotechnical design phase, the following issues require consideration:
- The frost susceptibility of the subgrade,
- The susceptibility of the subgrade to heave in cohesive ground,
- CBR values for subgrade beneath the existing A47, and
- The nature of artificial ground beneath the existing A47.

For information on the sub-grade required, please consult HE551494-MMSJV-HPV-000-RP-CH-00001.

7.9 Contaminated Land and Soil Chemistry

From historical boreholes available from the BGS and a review of the site's history it is likely that Made Ground associated with both embankment fill and the infilling of historical features (such as sand and gravel pits) will be encountered on site. If areas of Made Ground associated with features other than the existing earthworks are encountered, then they should be focused on for potential contamination testing.

As the site occupies part of the route of the A47, a particular focus on potential contaminated ground due to its proximity to multiple potential sources of pollution will be required.

There is the potential that isolated pockets of contamination and/or asbestos may be encountered within the site, as previously these have been identified on other Highways England projects situated within rural areas.

The natural geochemistry of the following strata may lead to conditions aggressive to buried concrete where they are encountered along the proposed route; Head Deposits, Alluvium, Rutland Formation, Grantham Formation and Whitby Mudstone Formation.

For further details relating to potential contamination at the site reference should be made to Section 5.

7.10 Drainage

New earthworks will be required along the proposed route; as such it is likely that surface water drainage will be required in areas of new earthworks. Drainage may need to be altered in areas of existing earthworks, as part of this project.

7.11 Existing Geotechnical Problems

The existing geotechnical problems for the site are outlined in this section.

<u>Slope Instability</u>

The site is located in an area of gently sloping topography and with the exception of the area around Wansford Pumping station, the instability of natural slopes is considered a low risk issue.

The construction of Wansford Pumping Station is thought to have reactivated a periglacial slip surface and such the risk in this area is higher and will require further assessment.

Existing earthworks associated with the A1 and A47 are detailed within Section 4.5, with any documented defects summarised within Table 10 to Table 12. Prior to construction works it will be necessary to review the stability of existing earthworks in more detail.

Assessment of stability of new embankments should allow for removal of compressible topsoil or near surface soft layers of silt and clays within natural deposits or Made Ground. The potential for critical deep-seated failure mechanisms passing through underlying deposits of lower shear strength should be given particular consideration. Slope angles would have to be selected to accommodate variation in the ground and groundwater conditions.

Temporary Excavations

Consideration should be given to the stability of temporary excavations constructed within soils of variable profile including silts, sands and clay layers. These soils have potential for collapse unless measures are taken for battering excavations back at stable slopes or for incorporating support measures.

Any temporary works would need to take into account the presence of groundwater, which could act to further destabilise these soils, increase pressures on temporary support or introduce a requirement for dewatering.

General consideration to groundwater control should be given when designing excavations or forming slopes of any kind.

In areas of alluvial sediments, consideration should also be given to ground release within excavations, with appropriate measures being taken to limit risks to personnel.

Compressible Soils and Soils of Low Bearing Capacity

Near surface soils including topsoil, silt layers, soft clay or very loose of loose sand have the potential to be of low bearing capacity and high compressibility. Compressible soils often suffer from significant and variable long-term settlements if some form of engineering remediation is not carried out. These soils of low bearing capacity are generally expected to be unsuitable as founding layers for both shallow and deep foundations.

7.12 Site History and Man-Made Obstacles

The proposed route mainly passes directly along the existing route of the A47 and comprises dualling of the existing road, including construction of new roundabouts, slip roads and bridge structures.

The construction of proposed new slip roads along the route encompasses works on previously undeveloped land.

Two culverts are proposed to be constructed along the route under the existing A47 allowing flow of current streams to the River Nene and a small pond in the east.

Underbridges are proposed in the western end of the scheme related to the new slip road, in the centre of the scheme to accommodate the disused railway line.

Utilities drawings indicate service structures have the potential to provide significant constraints to the proposed development. A comprehensive assessment of local and strategic services infrastructure in the region should be completed.

Service Diversions

The following drawings indicating services likely to be present and their approximate positions are currently available (See Appendix A).

- HE551494-AMY-HGN-WS_STG2-DR-HE-004 Existing Utilities - SHEET 1
- HE551494-AMY-HGN-WS_STG2-DR-HE-005 Existing Utilities - SHEET 2
- HE551494-AMY-HGN-WS_STG2-DR-HE-002 Existing Features - SHEET 1
- HE551494-AMY-HGN-WS_STG2-DR-HE-003 Existing Features - SHEET 2

These utilities have the potential to provide significant constraints to the proposed development or potentially economic cost for the division.

Of note are the underground high voltage cable that terminates at a small structure at the southern end of the Sacrewell Farm and Country Centre access road, which is in vicinity of the deep area of cut.

Also of note are the pair of water mains orientated approximately north-south that transect the proposed A47 route just to the east of the fuel station, these are thought to be pumped mains associated with the pump station. There is also a pair of water mains indicated as cutting the proposed A47 route between the junction of The Drift and the Old Peterborough Road in a southeast to northwest orientation. These could require protection or bridging over dependant on the requirements of the owner.

Further review will be required prior to construction for all potentially affected services.

7.13 Physical Constraints

Groundwater

Groundwater is likely to be encountered close to the natural ground level of the site.

Groundwater flow is likely to be principally towards the south and the River Nene together with other surface water bodies. This may lead to inflows at particular horizons in any excavations. Preferential pathways for groundwater flow may also lead to softening of adjacent cohesive layers.

Significant changes to the present earthworks will be required, therefore changes to earthworks drainage are likely to be required.

Flooding

Several areas of the site are shown to lie in an area of potential flooding caused by rivers. Groundwater is likely to be encountered close to the natural ground level of the site and as such may present a risk, particularly where there is a proposed underpass. Ground investigation data will need to be assessed to further understand ground and groundwater conditions.

The area bounding the White Water Brook and the stream crossing the proposed free flow slip are designated as a Zone 3 floodplain. Further investigation of any potential flooding risk and the effect of development upon this should be conducted prior to construction.

Groundwater Chemistry

Potentially adverse groundwater chemistry is identified as follows, from review of past site uses and that of adjacent land:

- Pesticides, herbicides and fertilisers etc. from past farming activities.
- Potentially contaminated leachate generated from soil used to construct the roads at the site.
- The sources singly or in combination require an assessment of impact upon:
    - Construction materials (e.g. metal work and concrete etc.)
    - Human health (e.g. construction operatives and end-users)
    - The environment (e.g. abstraction, discharge to controlled waters etc.)

7.14 Environmental Constraints

The site is located within a Nitrate Vulnerable Zone.

No source protection zones affect the site, or can be found within 500m of the site boundary.

BGS records indicate that the site is susceptible to flooding from surface water in several areas associated with existing watercourses. In addition, most of the site to the east of Ch 550 is susceptible to groundwater flooding both below and at ground level.

The Whitby Mudstone Formation is designated as Unproductive Strata. The Head Deposits and Grantham Formation are designated as Secondary Undifferentiated Aquifers meaning it has not been possible to assign either category A or B to the deposit due to the variable characteristics of the deposit.

The Alluvium and River Terrace Deposits are both designated as a Secondary A Aquifer; meaning they are deposits with permeable layers capable of supporting water supplies at a local rather than strategic scale.

The Rutland Formation is designated Secondary B Aquifer; predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering.

The Upper and Lower Lincolnshire Limestone Formations are designated as a principal aquifer; meaning the geology has a high intergranular permeability, usually providing a high level of water storage and may support water supplies on a strategic scale.

Groundwater vulnerability is designated as high to intermediate for all of the identified aquifers on site.

There is one Site of Special Scientific Interest (SSSI) recorded within close proximity to the site, 48m to the north, named Sutton Heath and Bog.

Earthworks could affect archaeological features. Advice should be sought from a specialist in these fields to offer further explanation and understanding prior to development. Reference should be made to any archaeological surveys that may be conducted for this project.

7.15 Additional Considerations

In-Situ Soil Stabilisation

It is possible that some of the earthworks required as part of the construction of the embankments may require stabilisation, particularly where Alluvium is likely to be present, such as at the toe of the embankments to be constructed on side long ground adjacent to the river. The viability of this will be dependent on the thickness and physical properties of this unit. Additionally, if widening of earthworks is required, it may be possible to reuse materials from cuttings associated with the scheme to form new earthworks. In that case in-situ soil stabilisation may be necessary.

The natural material could be stabilised by adding cement (Portland cement), lime (hydrated lime or quick lime) or the incorporation of fibres (fibre reinforced soil). It should be noted that fibres are likely to require import from the USA and their availability is a risk, however they may be considered an option where the Whitby Mudstone Formation will be directly exposed; for example in cuttings, such as in the vicinity of Sacrewell Farm.

The aim is to minimise importing material to the site and to make use of the existing soil. Due to the variability of the soils and the large scale of this site, there will be inherent risks involved with employing an in-situ soil stabilised foundation. Therefore, early testing is required to establish the feasibility of this technique. If it transpires that in-situ soil stabilisation will be required as part of these works a suitable sampling and testing regime will be specified.

Gaseous Ground Constraints

Ground gas may potentially be present within the site area due to the presence of Alluvium and possibly backfilled historical quarries. If ground gas is present, certain structures would require protection measures to be put in place and there would be a need to assess impact of new earthworks or structures on migration of hazardous gases.

Geotechnical Risk Register

Table 27 details the Geotechnical Risk Register. The risks associated with other aspects of the scheme, such as procedures, highway design and contractual and strategic issues are not dealt with here and the scheme risk register should be consulted for information on these elements.

The methodology is based on advice given in the document Managing Geotechnical Risk. The Geotechnical Risk Register should be considered as a live document and updated throughout the course of the scheme. It is incumbent on all parties involved in the scheme to advise the other members when the risks change.

Various threats are identified and the potential consequences of these occurring are described. The risk assessment is qualitative and the various threat are assessed using the following criteria:

- Cost;
- Programme;
- Health and Safety; and,
- Environment.

The risk is derived by considering the impact and likelihood for each threat and opportunity. Both the impact and likelihood have been assessed using a scale of 1 to 5, corresponding to "very low" to "very high" for impact and "negligible / improbable" to "very likely / almost certain" for likelihood. These ratings are summarised in Table 23 and Table 24.

Table 23: Hazard impact table

Impact			Cost	Programme	Health and Safety	Environment
1	Very Low	Negligible	Negligible	Negligible effect on programme	Negligible	Negligible
2	Low	Significant	1% Budget	5% effect on programme	Minor injury	Minor environmental incident
3	Medium	Serious	10% Budget	12% effect on programme	Major injury	Environmental incident requiring management input
4	High	Threat to future work and Client relations	20% Budget	25% effect on programme	Fatality	Environmental incident leading to prosecution or protestor action
5	Very High	Threat to business survival and credibility	50% Budget	50% effect on programme	Multiple fatalities	Major environmental incident with irreversible effects and threat to public health or protected natural resource

Table 24: Hazard likelihood index

Likelihood		Probability
1	Negligible / Improbable	< 1%
2	Unlikely / Remote	> 1%
3	Likely / Possible	> 10%
4	Probable	> 50%
5	Very Likely / Almost Certain	> 90%

The risk score is calculated by multiplying the impact score by the likelihood score, giving the scores shown in Table 25. The actions required depending on the risk score are shown in Table 26.

Table 25 Risk level matrix

		Impact				
		1	2	3	4	5
Likelihood	1	N	N	N	N	A
	2	N	N	A	A	H
	3	N	A	A	H	S
	4	N	A	H	S	S
	5	A	H	S	S	S

Table 26: Designer actions

Risk Product (I x L)	Risk Level	Description	Action by Designer
1 to 4	N	Negligible	None
5 to 9	A	Acceptable	Check that risks cannot be further reduced by simple design changes
10 to 12	H	High	Amend design to reduce risk, or seek alternative Option. Only accept Option if justifiable on other grounds.
15 to 25	S	Severe	

Ground investigation can help to mitigate ground and groundwater risks; however these risks cannot be eliminated. Ground investigations by their nature can only investigate and monitor a small part of the sub-surface conditions for a limited duration. Conditions on site identified during construction could reveal ground conditions that could not have been taken into account from the results of the ground investigation.

It is recommended that adequate and appropriate supervision must be provided during construction to assess the ground conditions encountered and interpret the results of the site testing. When appropriate this supervision during construction should be undertaken by a suitably experienced and qualified Engineering Geologist / Geotechnical Engineer.

Table 27 highlights the potential hazards that could be encountered during the site investigation and/or construction. The consequence of the hazard is outlined and a score is given for the impact and likelihood for this hazard, giving an overall risk, which is categorised as either a cost, time environment or health and safety. From this potential control measures are stated to alleviate hazard, leading to a rescoring of the impact and likelihood, resulting in a residual risk.

Table 27: Geotechnical risk register

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
1. Head Deposits	Variable lithologies of poor engineering quality. Soft, compressible soils (in places), variable thickness. Stability issues in excavations. Potential pathways for contamination migration. In places, secondary aquifer.	4	3	H	C,T,H&S,E.	Detailed ground investigation and associated geotechnical laboratory testing to allow a detailed ground model and set of parameters be determined for use within design.	3	2	A
2. Alluvium Deposits	Variable lithologies of poor engineering quality. Soft, compressible soils of variable thickness. Stability issues in excavations. Potential pathways for contamination migration. Secondary aquifer.	4	3	H	C,T,H&S,E.	Detailed ground investigation and associated geotechnical laboratory testing to allow a detailed ground model and set of parameters be determined for use within design.	3	2	A

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
3. River Terrace Deposits	Variable lithologies and thickness. Stability issues in excavations. Potential pathways for contamination migration. Secondary aquifer.	3	3	A	C,T,H&S,E.	Detailed ground investigation and associated geotechnical laboratory testing to allow a detailed ground model and set of parameters be determined for use within design.	3	2	A
4. Rutland Formation	Variable layered lithologies. Potential for bands of hard material. Potential pathways for contamination migration. Secondary aquifer.	3	3	A	C,T,H&S,E.	Detailed ground investigation and associated geotechnical laboratory testing to allow a detailed ground model and set of parameters be determined for use within design.	3	2	A

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
5. Upper & Lower Lincolnshire Limestone	Variable lithologies and unit thickness. Soluble material. Interbedded soil and rock deposits - difficult to model material accurately and therefore potentially conservative design. Principal aquifer. Excavatability of material. Variable weathering and strength profile.	4	3	H	C,T,H&S,E.	Detailed ground investigation and associated geotechnical laboratory testing to allow a detailed ground model and set of parameters be determined for use within design.	3	2	A
6. Grantham Formation	Variable layered lithologies. Potential for Shirinking/swelling or softening of clay bands with addition/removal of water. Potential pathways for contamination migration. Secondary aquifer.	4	3	H	C,T,H&S,E.	Detailed ground investigation and associated geotechnical laboratory testing to allow a detailed ground model and set of parameters be determined for use within design.	3	2	A

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
7. Whitby Mudstone Formation	May contain silt sand or gravel layers. Potential for Shirinking/swelling or softening of material with addition/removal of water, Fissuring may present pathways for contamination migration and variable strength profile. Pyrite content may present risks for subsurface concrete	4	3	H	C,T,H&S,E.	Detailed ground investigation and associated geotechnical laboratory testing to allow a detailed ground model and set of parameters be determined for use within design.	3	2	A
8. Topsoil	Damage / loss of a reusable commodity.	4	3	H	C,T,H&S,E.	Conduct an agricultural land classification and soil resource survey prior to commencing works.	3	2	A
9. Inadequate ground investigation.	Unforeseen ground conditions, inappropriate design parameters	4	4	S	C,T,H&S,E.	Conduct a full ground investigation based on a detailed desk study and to the latest standard.	2	1	N

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
10. Reactivation of periglacial slip at Wansford Pumping Station	Planned embankment loading a historical slip plane. Failure of embankment before, during or after construction. Damage to road surface.	5	4	S	C,T,H&S	Conduct a full ground investigation based on a detailed desk study and to the latest standard. Include monitoring instruments to monitor movement in the vicinity before during and after installation.	3	3	A
11. Unsuitable Embankment Fill associated with existing A47 route	Variable lithologies of unknown engineering quality. Pathways for contamination migration could be opened.	4	3	H	C,T,H&S,E.	Conduct a full ground investigation based on a detailed desk study and to the latest standard.	3	3	A
12. Route alignment along top of erosional slope of Nene Valley. Steep slopes across carriageway	Erosion and drainage issues due to surface water runoff. Differential settlement across carriageway	4	3	H	C,T,H&S	Conduct a full ground investigation based on a detailed desk study and to the latest standard. Specify drainage design to mitigate residual risks	3	2	A

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
13. Faulting present 250m to north of proposed route	If fault extends further south than mapping suggests, areas of weakness in the underlying rock may affect the proposed foundation solutions in this area.	3	2	A	C,T,H&S	Conduct a full ground investigation based on a detailed desk study and to the latest standard.	3	2	A
14. Disused sand and gravel pits and quarries adjacent to the route	Characterisation of any backfill regarding contamination. Differential settlement of backfill	3	3	A	C,T,H&S,E.	Conduct a full ground investigation based on a detailed desk study and to the latest standard, including contamination testing in the vicinity of any areas of interest.	2	2	N
15. Changes in the groundwater table.	Detrimental effect on earthworks stability and formation trafficability.	3	1	N	C,T.	Monitoring of groundwater levels during and after ground investigation.	3	1	N

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
16. Flooding of site; including surface or groundwater flooding	Damage to equipment, delay of works, requirement for review of design to mitigate against future flooding events. Toe erosion of embankments alongside River Nene. Flooding of underpass.	3	4	H	C,T,E.	Conduct a detailed assessment of flooding risk prior to construction works and include any appropriate mitigation within the design.	2	1	N
17. Diversion of existing watercourses.	If these are infilled with an unsuitable material this may result in differential settlement. Temporary open-cut diversion of streams may be required in several locations along the route.	3	2	A	C,T,H&S.	Ensure appropriate fill is used	2	1	N
18. Drainage issues where impermeable strata are exposed at surface	Pooling of water in lowlying areas, e.g. underpass, with associated softening of clay materials at outcrop.	3	3	A	C,T,H&S,E.	Conduct a detailed assessment of flooding risk prior to construction works and include any appropriate mitigation within the design.	2	1	N

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
19. Characterisation of "Deep Springs" site.	Does the name of this residential dwelling refer to a surface/ underground water feature.	3	3	A	C,T,E	Conduct an assessment to characterise the location	2	1	N
20. Potentially contaminated ground conditions, including asbestos	Contamination risks to construction workers who may come into contact with contaminated material during the works and to the environment. Increased levels of hydrocarbons present within soils, groundwater and surface water. Pathways could be opened up that may lead to the contamination of groundwater.	4	3	H	C,T,H&S,E.	As part of any ground investigation works contamination testing should be undertaken to assess whether any contamination is present within the soils and / or groundwater at site. Areas with signs of pollution should be focused on. Prior to construction an asbestos risk assessment should be undertaken	3	2	A

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
21. Potential of aggressive ground conditions on site.	High levels of sulphates could be present within the ground / groundwater, leading to aggressive ground and so the degradation of the concrete strength and quality.	3	2	A	C,T,H&S,E.	Ensure appropriate testing is conducted as part of the ground investigation.	3	1	N
22. Presence of ground gas	Risk to construction workers health, design changes to structures e.g. underpass	4	2	A	C,T,H&S,E.	Ground investigation incorporating gas monitoring and subsequent gas protection measures, if required.	3	1	N
23. Access difficulties during ground investigation works and construction.	Plant becoming bogged down during ground investigation work and construction. Difficulty accessing areas of site due to current A47 carriageway.	2	3	A	C,T,E.	Planning of ground investigation to avoid work during wettest times of the year. Advise Contractor of site constraints prior to beginning work. Use of appropriate plant for site.	1	1	N

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
24. Service / structure strike e.g. Wansford Pumping Tunnels. Structures, associated, high voltage cables.	Delays to construction, changes to alignment, severe financial and political repercussions.	5	2	H	C,T,H&S,E.	Thorough review of detailed service search (including geophysical survey) prior to conducting intrusive works. Careful marking out of exploratory holes and construction excavation, including conducting CAT scans prior to works at any locations.	3	1	N
25. Major engineering features.	Bridges, bridge culverts, underpasses etc are likely to be on a critical path for delivery, delays in design will risk the scheme falling behind the currently specified timescale.	3	3	A	C,T.	Early discussions between designers and those conducting the GI. Continual feedback of constraints noted to optimise the time.	2	2	N

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
26. Lack of suitable material for earthworks on site.	Excessive import of acceptable materials and / or disposal of unacceptable onsite materials.	3	4	H	C,T,H&S,E.	Schedule appropriate earthworks acceptability testing as part of the ground investigation. Programme earthworks into a season with favourable weather. Consider improvement of onsite soils. Monitoring and testing of soils throughout earthworks.	2	2	N
27. Requirement for vegetation or woodland clearance and/or crop destruction to enable ground investigation.	Compensation for lost crops, loss of natural habitat, possible disruption to contractor's programme, environmental objections.	4	5	S	C,T,E.	Conduct a site visit to view exploratory hole locations with an environmental scientist and landowners agent. Close supervision of Contractor during ground investigation works. Allow time within the programme for clearance, if required.	2	5	H

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
28. Ecological / environmental constraints.	Damage to ecologically important habitats, eg. SSSI - Sutton Heath and Bog	3	2	A	C,T,E.	At present these are unknown. Review of ecological surveys should be conducted prior to any works on site.	2	2	A
29. Archaeological constraints.	Damage to areas of archaeological importance. Discovery of new archaeological sites.	3	1	N	C,T.	Archaeological risks are noted in in the wider area. Further review of the available archaeological surveys should be conducted prior to any works on site.	2	1	N
30. Lime Stabilisation.	Formations found to be sulphate bearing will be unsuitable for normal lime/cement stabilisation due to expansion and heave once treated.	3	2	A	C,T,H&S,E.	Ensure appropriate testing is conducted as part of the ground investigation. Develop mitigation methods if high levels of sulphates are encountered to minimise delays.	3	1	N

Hazard	Consequences	Impact	Likelihood	Current Risk	Risk Type	Potential Control measures	Impact	Likelihood	Residual Risk
31. Fibre reinforced soil.	Obtaining suitable fibres may require import from the USA	3	3	A	C, T.	Identify at an early stage whether this presents a viable soil stabilisation solution and establish the time frame required to obtain the necessary fibres.	3	2	A
33. Unexploded Ordnance.	Potential serious injury to construction workers, damage to plant and / or structures.	5	2	A	C,T,H&S.	Maintain vigilance and adopt best practice during construction.	3	1	N
34. Wildlife burrows	May lead to erosion of existing earthworks/ newly constructed earthworks	3	2	A	C, T, H&S.	Consider prevention methods including selection of fill which is not a good habitat for wildlife burrows.	3	1	N

C – Cost

T – Time

E – Environment

H&S – Health and Safety

8. Recommendation for Further Investigation

8.1 Introduction

This section is intended to give an overview of the key objectives for further ground investigation. This will be required prior to development of the site and a full ground investigation specification document will be produced prior to the commencement of any works.

8.2 Objectives

A site investigation will be necessary in order to determine the ground conditions across the site. The objectives of the ground investigation should allow the following tasks to be undertaken:

- Assessment of the deposits as a bearing stratum and establishing geotechnical parameters for design purposes
- Assessment of the suitability of the deposits for reuse on site, in accordance with Series 600;
- Assessment of the extent and nature of any relict solifluction surfaces including the identified historical slip surface to enable this to factored into the design of cuttings and embankments.
- Assessment of the groundwater levels below the site and the effect this may have on proposed development;
- Assessment for the potential for sulphate attack on buried concrete from existing ground and groundwater conditions;
- Assessment of the risk from contaminated land, groundwater and ground gases to human and environmental receptors;
- Assessment for the potential for soakaway drainage; and,
- Assessment of the applicability of soils to be stabilised with cement or lime.

Please see Annex A for further details.

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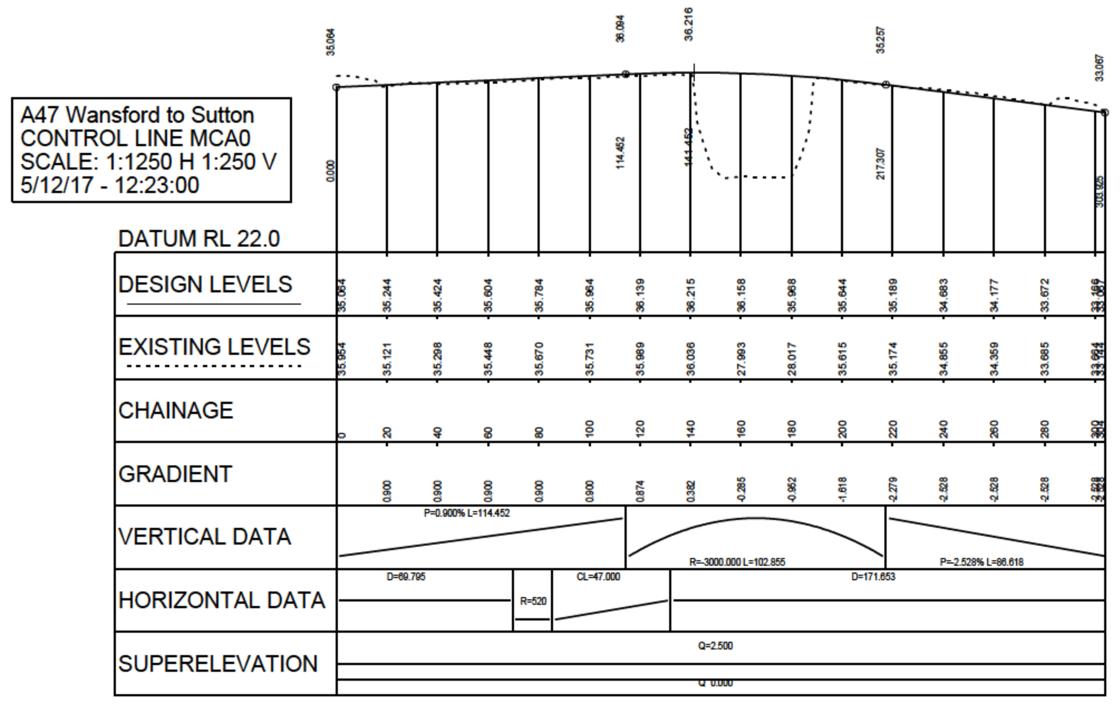
Appendix A. Drawings

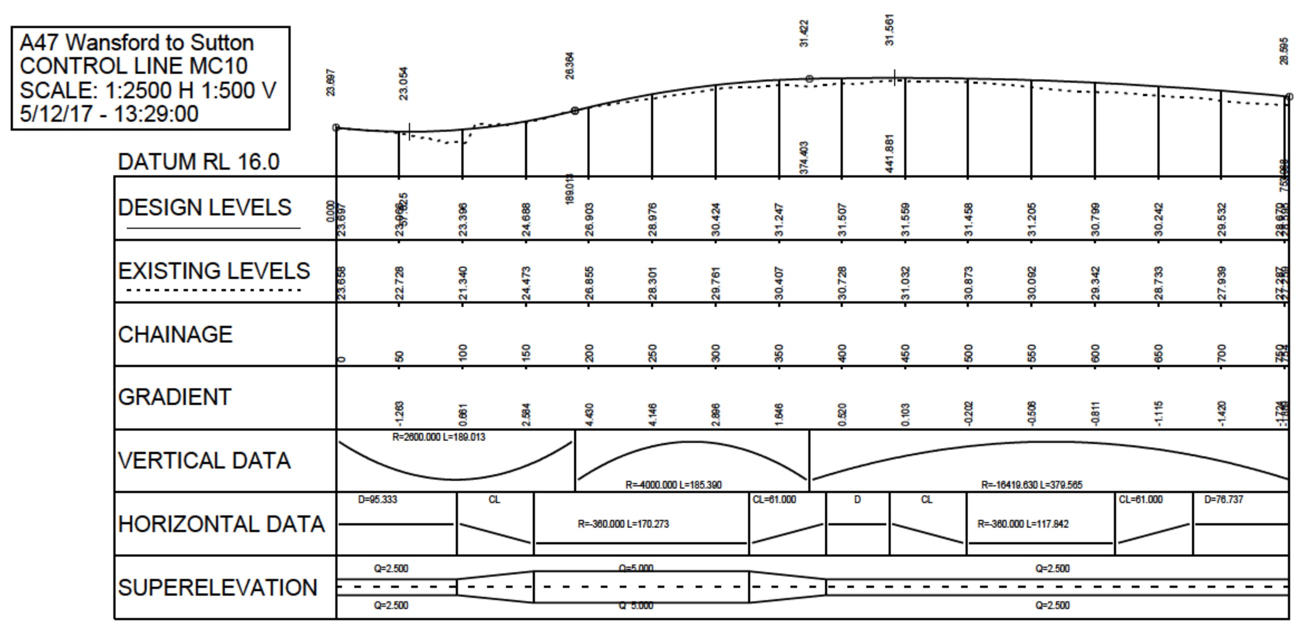
A.1 Design Fix A+

Notes

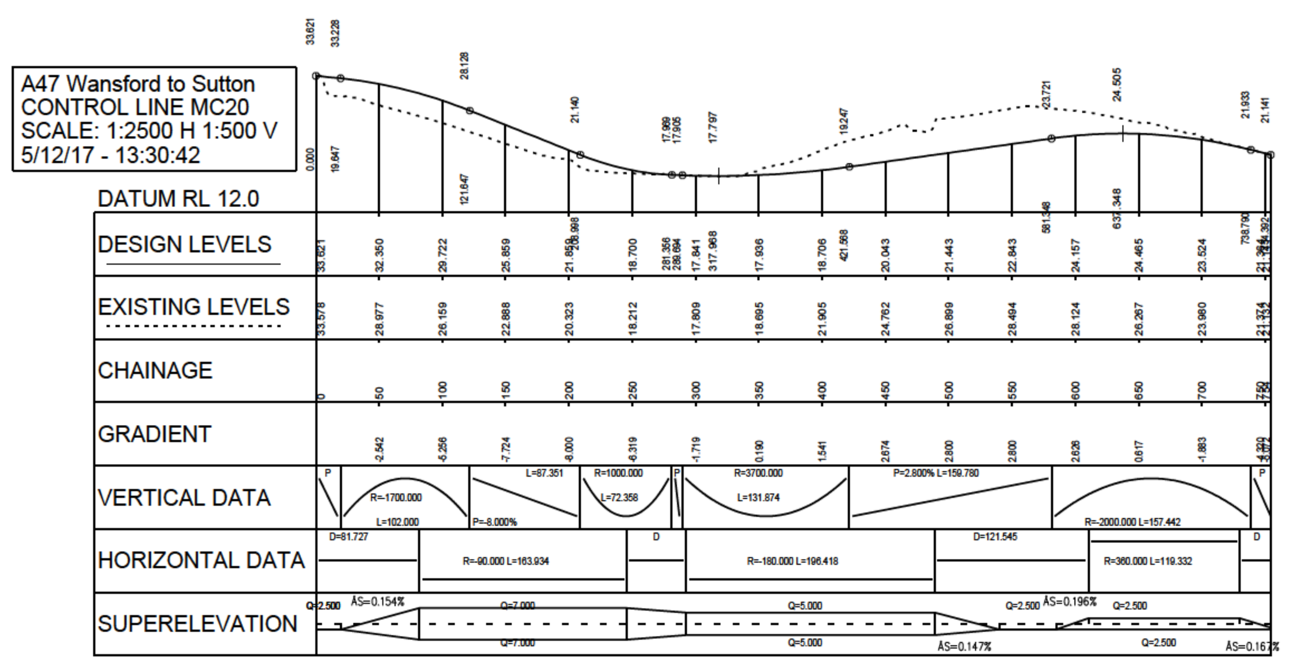
1. Street lighting to cover the same extents as existing lighting locations (based on a TA49 assessment).
2. It is assumed that all junctions operate adequately without traffic signals. Therefore, signals will not be included at this design fix.
3. The geometry of the existing A6118 roundabout will be retained with two circulatory lanes provided.
4. The bus stop on the SB A1 has been removed from the design as initial discussions with key stakeholders have not identified a use.
5. No laybys are shown in the design. It is assumed that the other nearby service areas are adequate.
6. The geometry of the existing A1 SB on-slip will be retained. The existing A1 SB off slip will be removed. (See item 16)
7. Sacrewell Farm and the Wansford Picnic Area will no longer have direct access to the A47. Access will now be provided via a new local road (MC20)
8. The fuel station will only be accessible via the WB A47 using new dedicated slips.
9. The Drift will no longer have direct access to the A47. Access will be retained via Nene Way. Emergency access might be provided onto the new carriageway. A turning head is also envisaged for The Drift, but not shown).
10. The existing A47 carriageway to the east of this location is retained as a local road to provide access to Sutton Heath Road and other properties. Connection between the old A47 and the new alignment is provided by a new arrangement at the eastern roundabout.
11. The existing railway bridge is to be retained. A new structure matching its dimensions is to be provided for the new carriageway.
12. To the west of this location the new dual carriageway follows the existing A47 alignment and therefore the existing carriageway is not retained.
13. Connection between the SB A1 and EB A47 is provided via a new free flow connector road. This is classed as a slip road and is designed to a 70kph geometry allowing a 120kph design speed as per TD22/06 Table 4/1.
14. The new A1 connector road splits, providing access to the roundabout. It is assumed that no separation is required between the opposing flows of this off-slip and the A1 SB on-slip.
15. A dual carriageway is provided over the A1 structure. It is assumed that the structure is able to accommodate this alignment without the need for any geometric departures or reduction in speed limit.
16. It is assumed that having a posted national speed limit on the connector road from the A1 SB will not require separation of the A47 EB on-slip from the A47 WB and local traffic.
17. Flood compensation areas are likely but not shown at this stage, as these will be subject to consultation with the Environment Agency.
18. The need for anti-dazzle fencing or similar between the new A47 EB and old (A47) carriageway has not been included.



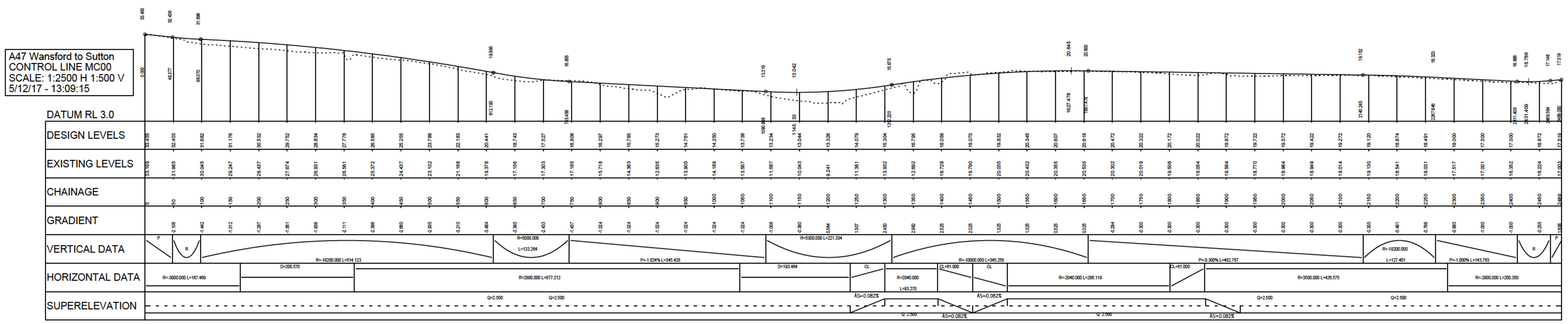
CONTROL LINE MCA0 - DESIGN SPEED 70 KPH



CONTROL LINE MC10 - DESIGN SPEED 70 KPH



CONTROL LINE MC20 - DESIGN SPEED 70 KPH



CONTROL LINE MC00 - DESIGN SPEED 120 KPH

1:5000 | 0 | 250m | 500m

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	11/01/18	First Issue	JO	ML	MG

Mott MacDonald Sweco

Client: highways england

Drawing Status	FOR INFORMATION
Suitability	S2
Project Title	A47 WANSFORD TO SUTTON
Drawing Title	DESIGN FIX A

Scale	Designed	Drawn	Checked	Approved
1:5000	Rajaraman, Chandar	OConnor, James	Levy, Matthew	Gordon, Malcolm
Original Size A1	Date 05/10/17	Date 11/01/18	Date 11/01/18	Date 11/01/18

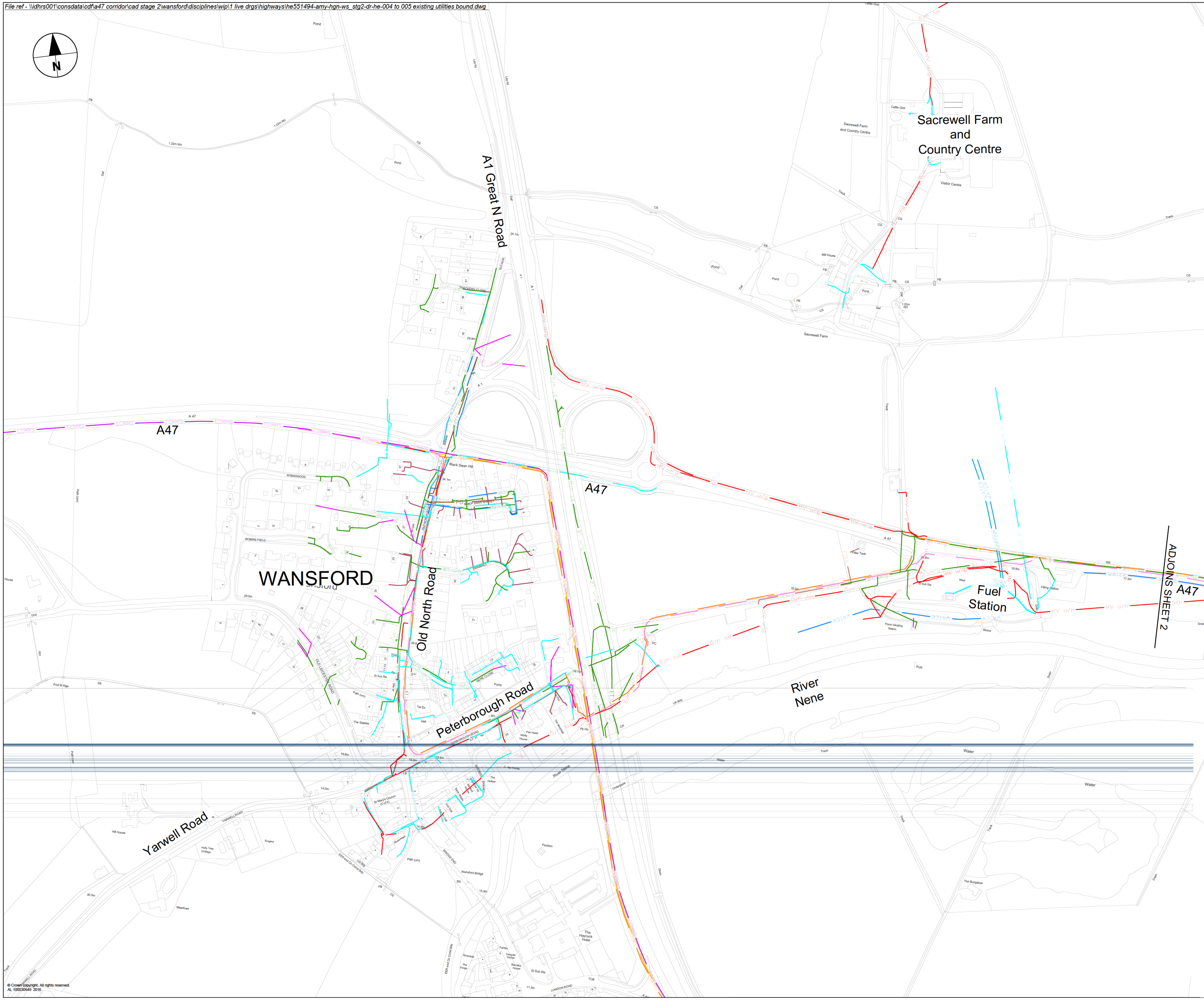
Drawing Number: HE PIN | Originator | Volume — HEWNSFRD- MMSJV - GEN - 000 - D - CH - 00001 — Location | Type | Role | Number

Project Ref. No.: HEWNSFRD

Revision: P01

A.2 Existing Utilities

File ref - \\dhrs001\consdata\cdf\a47 corridor\cad stage 2\wansford\disciplines\wip\1 live drgs\highways\he551494-amy-hgn-ws_stg2-dr-he-004 to 005 existing utilities bound.dwg



NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION.
2. DO NOT SCALE FROM THIS DRAWING, USE ONLY PRINTED DIMENSIONS.
3. ALL DIMENSIONS, CHAINAGES, LEVELS AND COORDINATES ARE IN METRES UNLESS DEFINED OTHERWISE.
4. THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT.

LEGEND

- BT UNDERGROUND CABLES
- BT OVERHEAD CABLES
- HIGH VOLTAGE OVERHEAD CABLES
- WESTERN POWER HIGH VOLTAGE UNDERGROUND
- LOW VOLTAGE OVERHEAD CABLES
- WESTERN POWER LOW VOLTAGE UNDERGROUND
- WESTERN POWER SERVICE LINE
- UK POWER NETWORK
- ANGLIAN CLEAN WATER STANDARD PIPES
- ANGLIAN DECOMMISSIONED WATER PIPES
- ANGLIAN WASTE WATER STANDARD PIPES
- NATIONAL GRID HP GAS MAIN
- VIRGIN MEDIA CABLES
- INTEROUTE CABLES
- INSTALCOM CABLES
- VODAFONE CABLES

IMPORTANT WARNING

The information concerning the location of the public utility apparatus is furnished as a general guide only and no warranty as their correctness is given or implied.

This drawing should not be relied upon in the event of excavations or other works made near to the apparatus, which may exist at various depths and may deviate from the marked route.

It should be noted that a line shown on the plan may indicate the presence of more than one cable.

DRAFT

Rev	Revision details	Drwn	Chkd	Appd	Date
-	-	-	-	-	-

Designed:	GC	Date:	-
Drawn:	MV	Date:	-
Checked:	JOC	Date:	-
Approved:	DH	Date:	-

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Client
Highways England
Woodlands
Manton Lane
Bedford
MK41 7LW

Working on behalf of highways england

Project Name
A47 CORRIDOR - STAGE 2

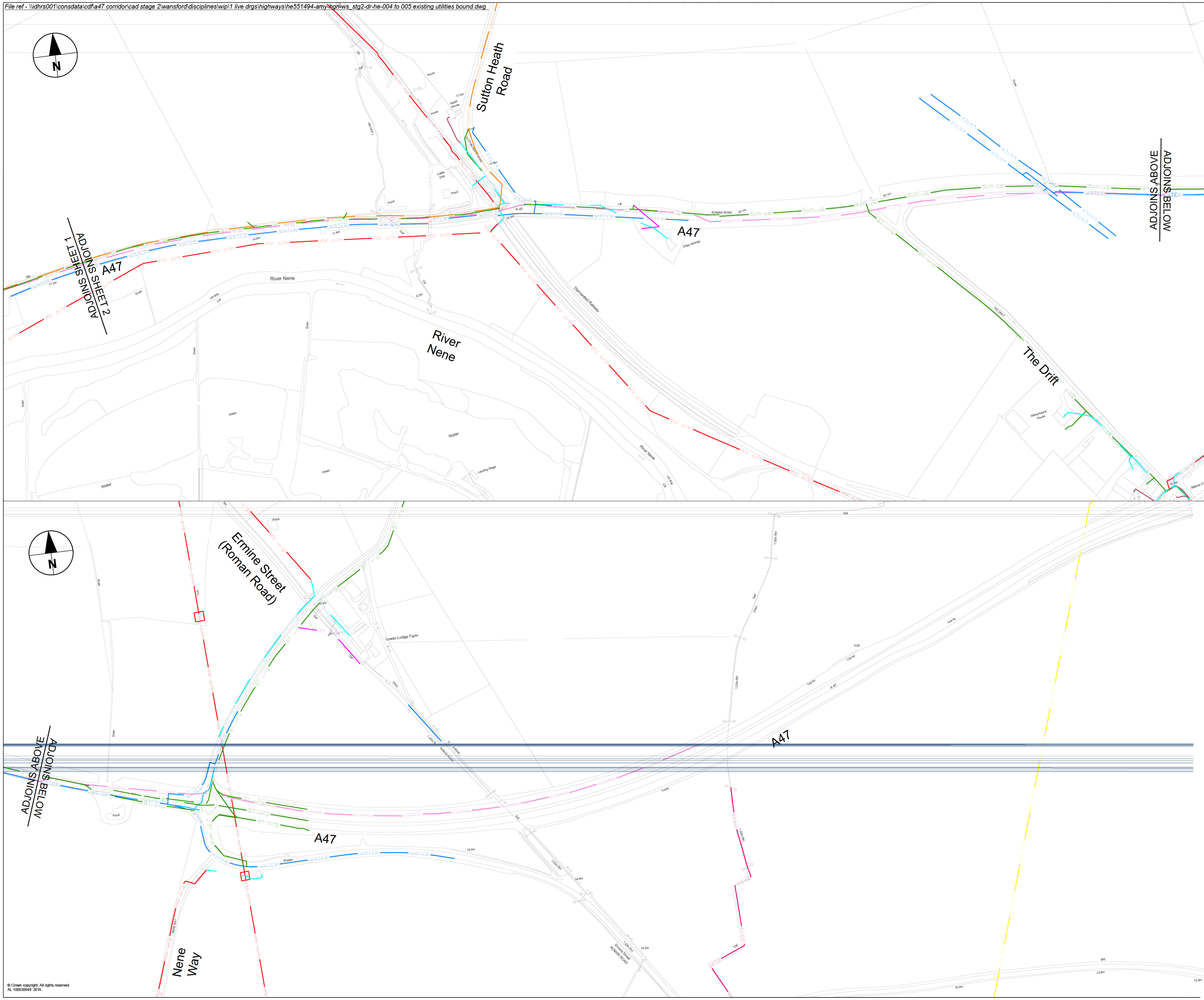
Drawing Title
A47 SCHEMES
WANSFORD TO SUTTON
EXISTING UTILITIES
SHEET 1 OF 2

Original Drawing Size : A1 | Scale : 1:2500
Dimensions : -

Drawing Status: WORK IN PROGRESS | Suitability: S0

Drawing No: HE551494-AMY-HGN-WS_STG2-DR-HE-004 | Rev: -

File ref - \\dhrs001\consdata\cdf\a47 corridor\cad stage 2\wansford\disciplines\wip\1 live drgs\highways\he551494-amy-hgn-ws_stg2-dr-he-004 to 005 existing utilities bound.dwg



NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION.
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3. ALL DIMENSIONS, CHAINAGES, LEVELS AND COORDINATES ARE IN METRES UNLESS DEFINED OTHERWISE.
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LEGEND

- BT UNDERGROUND CABLES
- BT OVERHEAD CABLES
- HIGH VOLTAGE OVERHEAD CABLES
- WESTERN POWER HIGH VOLTAGE UNDERGROUND
- LOW VOLTAGE OVERHEAD CABLES
- WESTERN POWER LOW VOLTAGE UNDERGROUND
- WESTERN POWER SERVICE LINE
- UK POWER NETWORK
- ANGLIAN CLEAN WATER STANDARD PIPES
- ANGLIAN DECOMMISSIONED WATER PIPES
- ANGLIAN WASTE WATER STANDARD PIPES
- NATIONAL GRID HP GAS MAIN
- VIRGIN MEDIA CABLES
- INTEROUTE CABLES
- INSTALCOM CABLES
- VODAFONE CABLES

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This drawing should not be relied upon in the event of excavations or other works made near to the apparatus, which may exist at various depths and may deviate from the marked route.

It should be noted that a line shown on the plan may indicate the presence of more than one cable.

DRAFT

Rev	Revision details	Drwn	Chkd	Appd	Date
-	-	-	-	-	-

Designed:	GC	Date:	-
Drawn:	MV	Date:	-
Checked:	JOC	Date:	-
Approved:	DH	Date:	-

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Project Name
A47 CORRIDOR - STAGE 2

Drawing Title
A47 SCHEMES
WANSFORD TO SUTTON
EXISTING UTILITIES
SHEET 2 OF 2

Original Drawing Size : A1 | Scale : 1:2500
Dimensions : -

Drawing Status: WORK IN PROGRESS | Suitability: S0

Drawing No: HE551494-AMY-HGN-WS_STG2-DR-HE-005 | Rev: -

A.3 Existing Features

File ref - \\idhrs001\consdata\cdf\a47 corridor\cad stage 2\wansford\disciplines\wip\1 live drgs\highways\he551494-amy-hgn-ws_stg2-dr-he-002 to 003 existing features.dwg

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION.
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3. ALL DIMENSIONS, CHAINAGES, LEVELS AND COORDINATES ARE IN METRES UNLESS DEFINED OTHERWISE.
4. THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT.

LEGEND

JUNCTIONS AND ACCESSES
- In/out junction
- Lay-by

KERBS AND DRAINAGE
- Kerb line

SAFETY BARRIER
- Safety barrier

LIGHTING COLUMNS
- Lighting column

STRUCTURES
- Bridge
- Culvert

OTHER FEATURES
- SP Solar panel pole
- CM CCTV camera mast
- TM Traffic Master (Redundant)
- Traffic Loops
- street lighting feeder pillar and pecu
- Traffic Signal feeder pillar
- x Traffic signal pole

WATER COURSES
- MAJOR RIVER
- DRAINS AND OTHER MINOR COURSES

DRAFT

Rev	Revision details	Drwn	Chkd	Appd	Date
-	-	-	-	-	-

Designed:	GC	Date:	30/06/2016
Drawn:	MV	Date:	30/06/2016
Checked:	JOC	Date:	30/06/2016
Approved:	DH	Date:	30/06/2016

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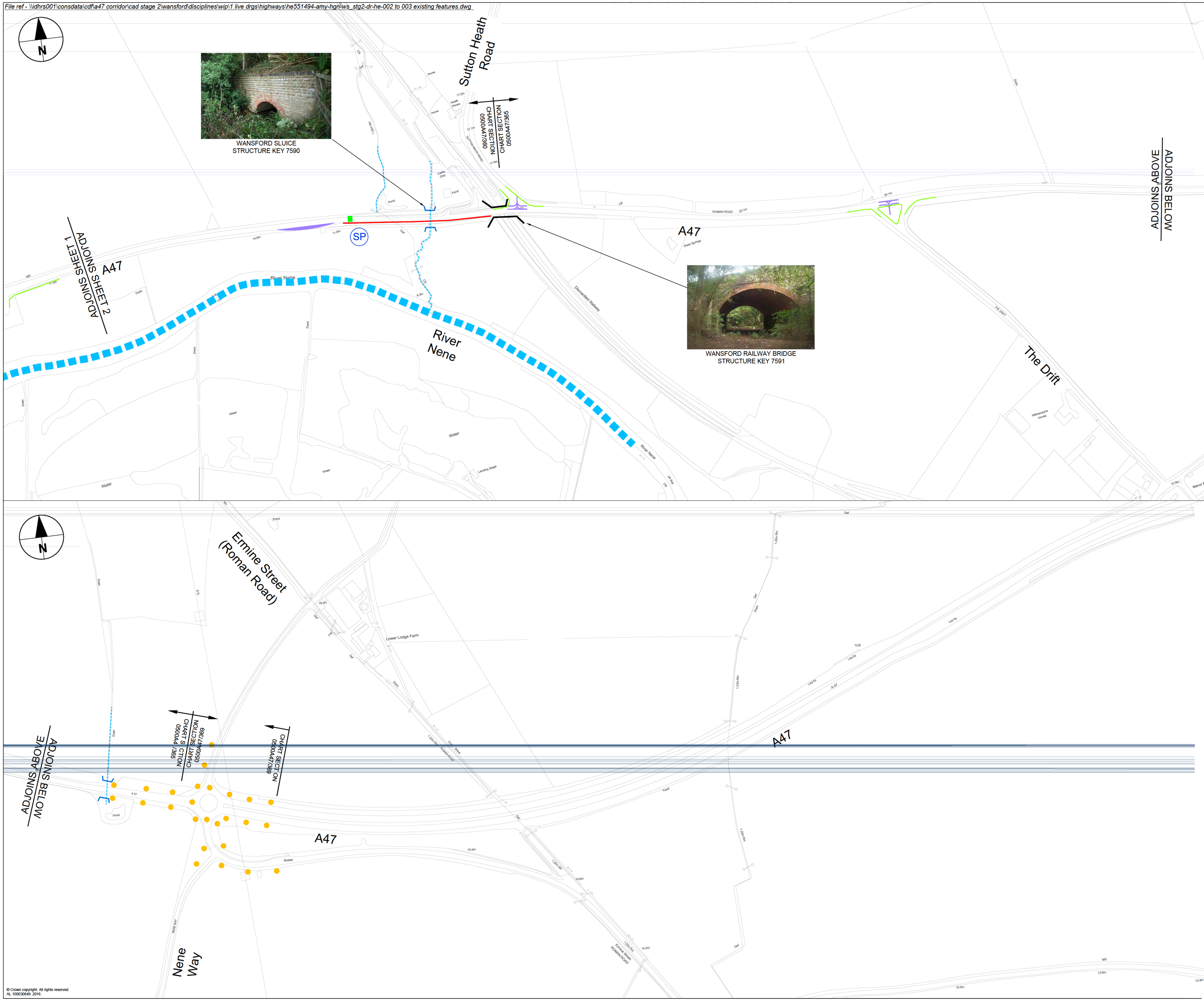
Project Name
A47 CORRIDOR - STAGE 2

Drawing Title
A47 SCHEMES
WANSFORD TO SUTTON
EXISTING FEATURES
SHEET 1 OF 2

Original Drawing Size : A1 | Scale : 1:2500
Dimensions : -

Drawing Status: WORK IN PROGRESS | Suitability: S0

Drawing No: HE551494-AMY-HGN-WS_STG2-DR-HE-002 | Rev: -



NOTES

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4. THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT.

LEGEND

JUNCTIONS AND ACCESSES
- In/out junction
- Lay-by

KERBS AND DRAINAGE
- Kerb line

SAFETY BARRIER
- Safety barrier

LIGHTING COLUMNS
- Lighting column

STRUCTURES
- Bridge
- Culvert

OTHER FEATURES
- SP Solar panel pole
- CM CCTV camera mast
- TM Traffic Master (Redundant)
- Traffic Loops
- street lighting feeder pillar and pecu
- Traffic Signal feeder pillar
- X Traffic signal pole

WATER COURSES
- MAJOR RIVER
- DRAINS AND OTHER MINOR COURSES

DRAFT

Rev	Revision details	Drwn	Chkd	Appd	Date
-	-	-	-	-	-

Designed:	GC	Date:	-
Drawn:	MV	Date:	-
Checked:	JOC	Date:	-
Approved:	DH	Date:	-

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Project Name
A47 CORRIDOR - STAGE 2

Drawing Title
A47 SCHEMES
WANSFORD TO SUTTON
EXISTING FEATURES
SHEET 2 OF 2

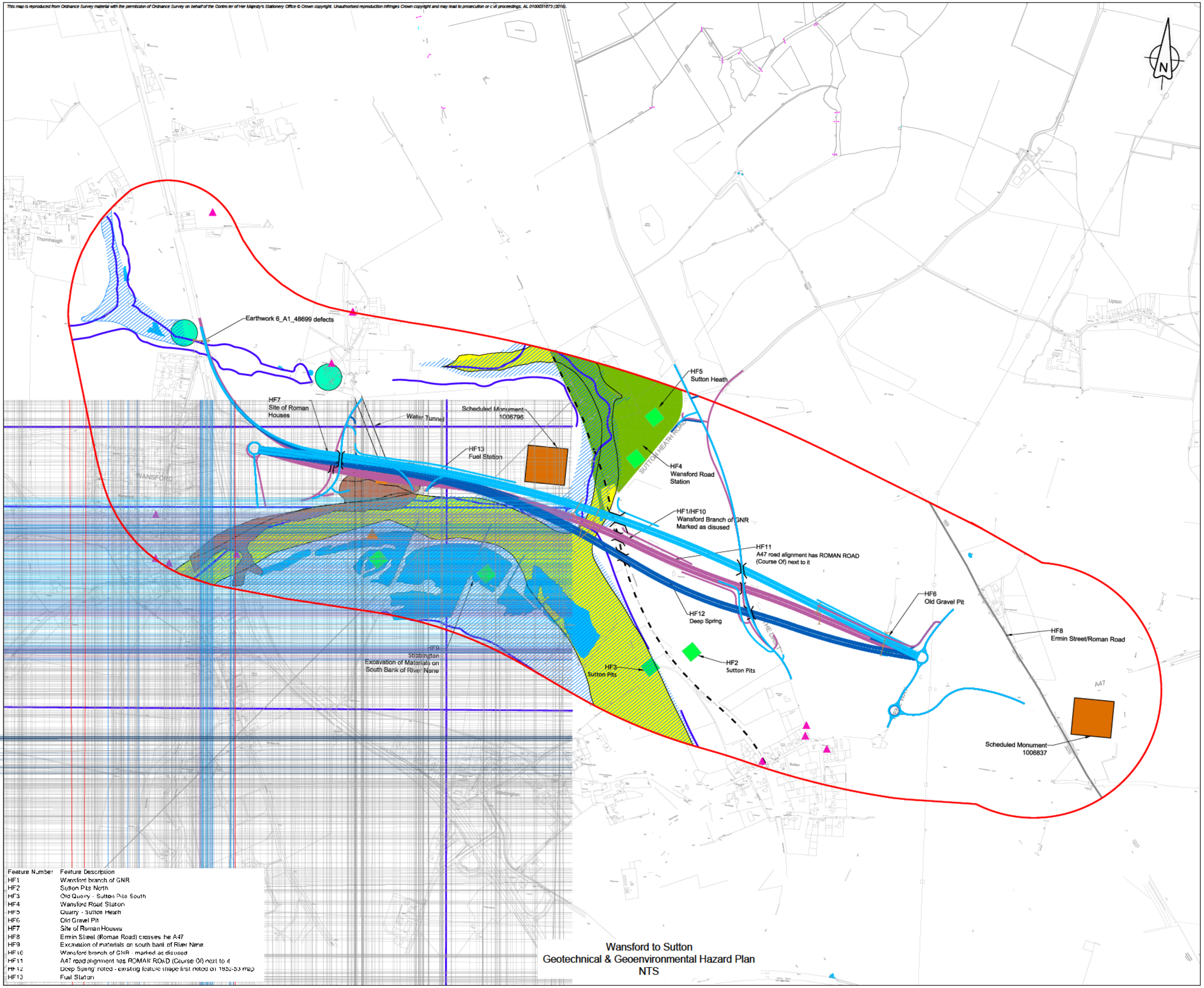
Original Drawing Size : A1 | Scale : 1:2500
Dimensions : -

Drawing Status: WORK IN PROGRESS | Suitability: S0

Drawing No: HE551494-AMY-HGN-WS_STG2-DR-HE-003 | Rev: -

A.4 Geological Hazard Plan

File ref - \\idhrs001\consdata\cdf\a47 corridor\cad stage 2\wansford\disciplines\wip\1 live drgs\geotechnical\he551494-amy-hgt-z1-dr-ge-00002 to 00004.dwg



Feature Number	Feature Description
HF1	Wansford branch of GNR
HF2	Sutton Pits North
HF3	Old Quarry - Sutton Pits South
HF4	Wansford Road Station
HF5	Quarry - Sutton Heath
HF6	Old Gravel Pit
HF7	Site of Roman Houses
HF8	Ermin Street (Roman Road) crosses the A47
HF9	Excavation of materials on south bank of River Nene
HF10	Wansford branch of GNR - marked as disused
HF11	A47 road alignment has ROMAN ROAD (Course Of) next to it
HF12	Deep Spring' noted - existing feature shape first noted on 1952-53 map
HF13	Fuel Station

Wansford to Sutton
Geotechnical & Geoenvironmental Hazard Plan
NTS

LEGEND

Geohazards:

- Defect 6_A1_48699 — Road Defect - Class 1D - Transverse cracks in tar seal
- Landslide - Possibility of slope instability
- Old Road
- Dismantled Railway Track
- Ceased Pits

Geoenvironmental Hazards:

- Sources of Water - Rivers & Ponds
- Water Abstraction from Surface water Sources - Medium size of Abstraction
- River Flood Risk 1:100
- River Flood Risk 1:1000
- Sites of Special Scientific Interest Units (England) - Unfavourable Condition
- Listed Buildings
- Scheduled Monument
- Signficant Pollution Incident, impact on water
- Alluvium Outline

Road Options:

- Option 1
- Option 8
- Option 10

Rev	Revision details	Drwn	Chkd	Appd	Date
P01	First Issue	AB	IT	KI	27.03.17

Designed:	MA	Date:	17.03.2017
Drawn:	AB	Date:	17.03.2017
Checked	IT	Date:	17.03.2017
Approved:	KI	Date:	27.03.2017

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Bedford
MK41 7LW

Working on behalf of highways england

Project Name
A47 Schemes - Wansford to Sutton
Stage 2

Drawing Title
Wansford to Sutton
Geotechnical & Geoenvironmental
Hazard Plan

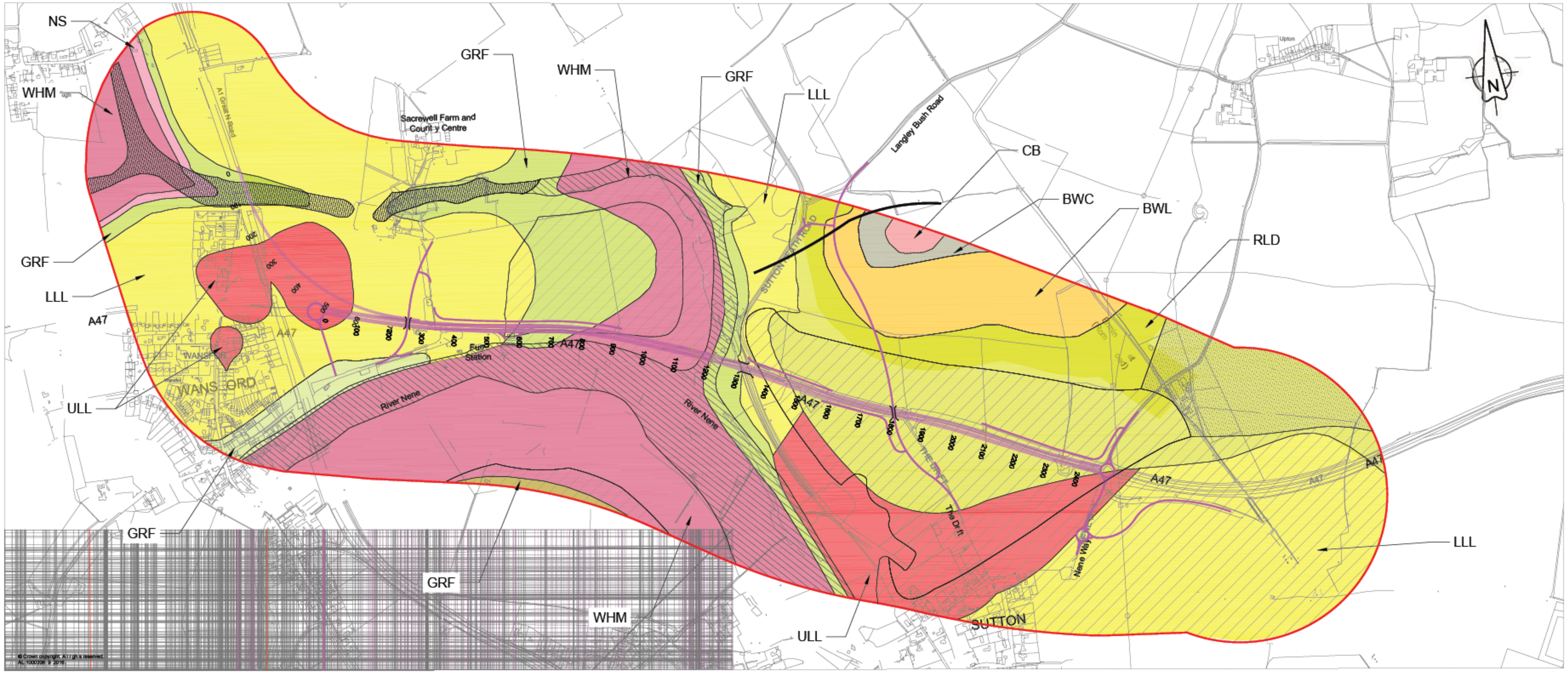
Original Drawing Size : A1 | Scale : NTS
Dimensions : -

Drawing Status: FIT FOR INFORMATION | Suitability: S2

Drawing No: HE551494-AMY-HGT-Z1-DR-GE-00002 | Rev: P01

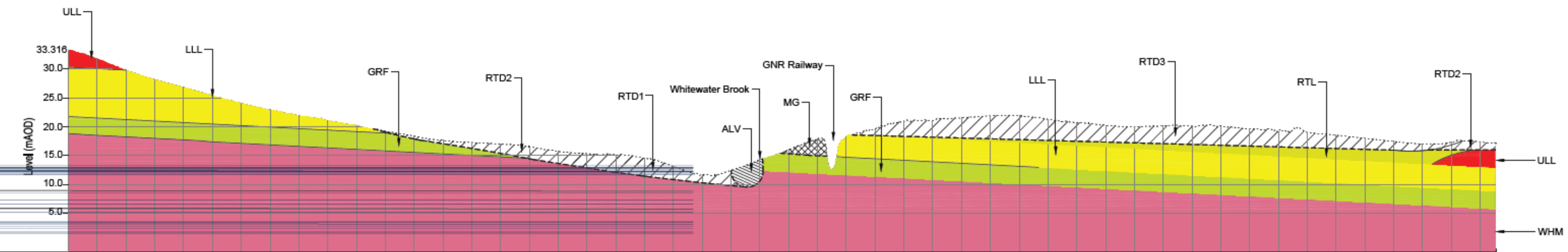
A.5 Geological Long Section

File ref - \\idhrs001\consdata\cdf\a47 corridor\cad stage 2\wansford\disciplines\wip\1 live drgs\geotechnical\he551494-amy-hgt-z1-dr-ge-00005.dwg



PLAN - OPTION 1

NTS



CHAINAGE (m)	EXISTING LEVEL (mAOD)
0.000	33.316
50.000	31.838
100.000	29.805
150.000	28.216
200.000	26.871
250.000	25.460
300.000	24.096
350.000	22.978
400.000	21.969
450.000	21.123
500.000	20.281
550.000	19.300
600.000	18.446
650.000	17.698
700.000	17.344
750.000	17.110
800.000	16.649
850.000	15.792
900.000	15.470
950.000	15.158
1000.000	14.589
1050.000	13.190
1100.000	11.847
1150.000	12.557
1200.000	14.354
1250.000	16.100
1300.000	17.995
1350.000	18.456
1400.000	19.756
1450.000	21.016
1500.000	21.168
1550.000	21.624
1600.000	22.007
1650.000	22.007
1700.000	21.331
1750.000	20.811
1800.000	20.282
1850.000	20.119
1900.000	20.244
1950.000	20.126
2000.000	20.138
2050.000	19.775
2100.000	19.405
2150.000	19.068
2200.000	18.610
2250.000	18.068
2300.000	17.529
2350.000	17.132
2400.000	17.417
2450.000	17.424
2477.453	17.206

Long Section - Option 1

Vertical Scale 1:1000 @ A3, Horizontal Scale 1:10000 @ A3

NOTES

1. This drawing is to be read in conjunction with all other relevant documentation.
2. Do not scale from this drawing, use only printed dimensions.
3. All dimensions, chainages, levels and coordinates are in metres unless defined otherwise.

LEGEND

- Option 1
- Fault Line

Superficial Geology:

- Made Ground
- ALV — Alluvium
- RTD1-3 — River Terrace Deposits (RTD1, RTD2 & RTD3 - Sand and Gravel
- HEAD — Head

Bedrock Geology:

- CB — Cornbrash Limestone Formation
- BWC — Blisworth Clay Formation - Mudstone
- BWL — Blisworth Limestone Formation
- RLD — Rutland Formation - Argillaceous Rocks with Subordinate Sandstone and Limestone
- Lincolnshire Limestone Formation
  - ULL — Upper Member
  - LLL — Lower Member
- GRF — Grantham formation - Sandstone, Siltstone and Mudstone
- NS — Northampton Sand Formation
- WHM — Whitby Mudstone Formation - Mudstone

Rev	Revision details	Drwn	Chkd	Appd	Date
P01	First Issue	AB	IT	KI	27.3.17

Designed:	MA	Date:	27.03.2017
Drawn:	AB	Date:	27.03.2017
Checked:	IT	Date:	27.03.2017
Approved:	KI	Date:	27.03.2017

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Working on behalf of highways england

Project Name

A47 Schemes - Wansford to Sutton Stage 2

Drawing Title

Geological Long Section - A47 Only Option 1

Original Drawing Size : A1 — Scale : As Shown

Dimensions : -

Drawing Status: FOR INFORMATION — Suitability: S0

Drawing No: HE551494-AMY-HGT-Z1-DR-GE-00005 — Rev: P01

Appendix B. Site Walkover Observations

The following table outlines the observations made during the site walkover on the 7th February 2018. The location of the observation and the relevant drawing and photograph references are given.

Observation ID	Observation	Eastings	Northings	Drawing Sheet Number*
1	Existing corrugated steel culvert	507444	300124	1
2	Bund C.0.5m high adjacent to stream. Stream diverted approximately 10-20m to the north from its original course	507491	300132	1
3	Mature trees	507550	300073	1
4	Signs of badgers	507699	300026	1
5	Depression with running water audible underground. Unclear if underground channel	507724	300052	1
6	Soft, boggy ground	507740	300039	1
7	Artificial pond that appears to be associated with the Old Mill House	507805	300052	1
8	Concrete structure with evidence of u ilities	508005	299762	1
9	Access not possible due to security risk	507869	299639	1
10	Fenced off area with warning of deep excava ion	508001	299671	1
11	Rabbit burrows in existing cut of A47	508246	299699	2
12	Fuel station platform	508246	299637	2

Observation ID	Observation	Eastings	Northings	Drawing Sheet Number*
13	Reeds evident within possible historic landslip. May indicate seepage	508318	299672	2
14	Poles of overhead HV cables are not straight	508475	299658	2
15	Possible toe of historic landslip	508527	299643	2
16	Approximate location of steep scarp	508556	299665	2
17	Cuspate shallow depression	508320	299753	2
18	Manhole to the south of A47 and west of stream. Does not correlate with utilities plans	508875	299587	2
19	Brick and stone culvert	508883	299587	2
20	Existing bridge formed of bricks	508980	299575	2
21	Depression	509023	299517	2
22	Overgrown slight depression. Becomes very overgrown towards the rail bridge	509035	299498	2
23	Possible access from the A47 (on embankment)	509065	299527	2
24	Signs of badgers	509004	299485	2
25	Embankments on both sides of the disused railway steep and overgrown	509033	299455	2
26	No access possible	509064	299263	2
27	Outcrop of Limestone	509093	299339	2
28	Intermittent drainage ditch to he south of current A47 alignment	509229	299475	2
29	Evidence of culvert and utilities	509685	299368	3

Observation ID	Observation	Eastings	Northings	Drawing Sheet Number*
30	Drainage ditch to south and current A47 alignment	509838	299312	3
31	Depression of circa 1m that is overgrown	509850	299299	3
32	Very overgrown with mature trees. No water. Approximately 5-6m deep with steep sides. Building waste/ruble around the perimeter.	509979	299247	3

* This refers to which sheet of the A47 Schemes Wansford to Sutton Dualling Site Wa kover Plans the observation is found on.

Appendix C. Site Walkover Plans

Appendix D. Borehole Logs

Figure E1: TL09NE 86

RECORD OF BOREHOLE 1 55E 8172 CASTOR PARKWAY.
TL 09 NE /86
GROUND LEVEL 25.5 m O.D. N.G.R 0781 9972.
1" : 157

BORING: STARTED 6.2.76.
BORING: FINISHED 6.2.76.
HOLE SIZE 0.15 m dia. to 5.0 m depth.

SAMPLE OR TEST DEPTH	TYPE	LEGEND	DEPTH	O.D. LEVEL	CHANGE OF STRATA DESCRIPTION
			0.3	25.2	Topsoil and clay FILL.
			1.5	24.0	Firm brown sandy CLAY and moderately weak brown oolitic LIMESTONE boulder or layers. [redacted]
1.50 - 1.62	C(60)				
2.0 - 2.50	B1				
2.50 - 2.60	C(60)				
3.50	B2				
3.50 - 3.60	C(60)				
4.50	B3				
4.50 - 4.57	C(60)		5.0	20.5	Moderately weak light brown rubbly oolitic LIMESTONE with traces of brown sandy clay. [redacted]
5.0 - 5.07	C(60)				

REMARKS 2 hours spent chiselling in limestone.
The borehole was dry.

KEY: D — DISTURBED SAMPLE
B — BULK DISTURBED SAMPLE
W — WATER SAMPLE
U — UNDISTURBED SAMPLE
S } STANDARD PENETRATION TEST
C } CONE PENETRATION TEST
NO. OF BLOWS FOR 300 mm PENETRATION IN BRACKETS

SOILS ENGINEERING LIMITED PETERBOROUGH

Figure E2: TL09NE 52

INSTITUTE OF GEOLOGICAL SCIENCES

RECORD OF SHAFT OR BOREHOLE

6-in Map Registration No. TL 09 NE/52 A

Name and Number of Shaft or Borehole: 157/1

National Grid Reference: 0754.9943

For whom made

Town or Village WANSFORD County NORTHANTS

1-in New Series Map No.: 157

Enter 'C' if Confidential

Exact site (reference to a fixed point on 1-in map): N of Castor Road, between old main road and New Arterial Road W. of it, 200' from the River Nene

Purpose for which made TRIAL BORING for WATER SUPPLY

Ground Level at shaft/bore relative to O.D. +59.00 feet. If not ground level give O.D. of beginning of shaft/bore

Made by

Date of sinking 1932

Information from Mr. E.L.W. DAVIES

Examined by 16/12/32

SPECIMEN NUMBERS AND ADDITIONAL NOTES

GEOLOGICAL CLASSIFICATION	DESCRIPTION OF STRATA	THICKNESS FT (metres)	THICKNESS IN	DEPTH FT (metres)	DEPTH IN
	Rock	8	0	8	0
		2.44		(2.44)	
	Clay	3	0	11	0
		0.91		(3.35)	
	Sand (a little water here)	8	0	19	0
		2.44		(5.79)	
	Blue Clay (no water)	51	0	70	0
		15.55		(21.34)	
	End of Borehole				

D 7547 Wt. 243081 4,000 9/67 KCN Gp. 807 (5556) (B88)

Figure E3: TL09NE 48

157/244

For Institute use only

GEOLOGICAL CLASSIFICATION	NATURE OF STRATA *If measurements start below ground surface, state how far.*	THICKNESS Feet	THICKNESS Inches	THICKNESS Metres	DEPTH Feet	DEPTH Inches	DEPTH Metres
Lincolnshire Limestone	0 – 0·5 TOP SOIL						
	0·5 – 2M LOOSE LIMESTONE.						
	2 – 4M LIMESTONE.						
Lower Estuarine "Series"	4 – 6·5m CLAY						
	6·5 – 8·5 SILT						
? Upper Lias	8·5 – 12M CLAY						
DP. [redacted] 19/8/82							

Figure E4: TL09NE 41

W.D. Reg. No 157/231

Institute of Geological Sciences

RECORD OF SHAFT OR BOREHOLE

6-in or 1:10 000 Map Registration No. TF 00 SE/ 41

National Grid Reference: 0750 0055

Name and Number of Shaft or Borehole: Empingham Tunnel B1

For whom made: Welland and Nene River Authority

Town or Village: Wansford County: Northants

1-in or 1:50 000 New Series Map No.: 157

Enter 'C' if Confidential:

Exact site (reference to a fixed point on 1-in or 1:50 000 Map):

Purpose for which made: Proving sequence

Ground level at shaft/bore relative to O.D. 35.922 m. If not ground level give O.D. of beginning of shaft/bore ______ m.

Made by: Soil Mechanics Limited Date of sinking: 1971

Information from: Core by A. Horton and R.J. Wyatt Examined by:

Specimen Numbers and Additional Notes

Geological Classification	Description of Strata	Thickness metres	Depth metres
	Soil brown loam with abundant limestone fragments	0.25	0.25
Lincolnshire Limestone	Limestone, cream oolitic, with shell debris and sparry matrix. Frequentary to 0.60. Medium grained, moderate to poorly sorted oolite below with minor shell debris. Layer of cream to white fine-grained oolith pebbles at 1.50. Bimodal in places.	1.85	2.10
	Limestone, pale cream, fine-grained, very finely oolitic, well-sorted with scattered large ooliths. Spar matrix. 7 cm marl broken band at 2.69 finer grained cross-stratified finely sandy with plant debris on partings. Very finely oolitic throughout. Passing	2.10	4.20

Figure E5: TL09NE 78 and TL09NE 79

* TL09NE/78 - 79

TL 09 NE 78 **0831 9953** **Sibson-cum-Stibbington** **Block D**

Surface level (+13.0 m) +43 ft
Water struck at (+8.5 m)
152 mm percussion
July 1975

Overburden 4.5 m
Mineral 3.5 m
Bedrock 2.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Made ground	4.4	4.4
Alluvium	Sand, medium brown, 'very clayey'	0.1	4.5
River Gravel (First Terrace)	Sandy gravel Gravel: fine angular and subangular, flint, ironstone and limestone, rounded sandstone and quartz Sand: medium ironstone and quartz, coarse ironstone and flint	3.5	8.0
Upper Lias Clay	Clay, stiff, blue-grey	2.1+	10.1

GRADING

Mean for deposit percentages: Fines	Sand	Gravel	Depth below surface (m)	percentages: Fines	Sand		Gravel			
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64
5	53	42	4.5–5.4	3	4	18	26	36	13
			5.4–6.4	5	7	23	23	34	9
			6.4–7.4	5	6	24	29	27	9
			7.4–8.0	No grading data available					
			Mean	5	6	21	26	32	10

TL 09 NE 79 **0814 9916** **Sibson-cum-Stibbington** **Block D**

Surface level (+12.0 m) +40 ft
Water not struck
152 mm percussion
July 1975

Waste 1.8 m
Bedrock 1.4 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.2	0.2
Alluvium	Clay, medium brown, sandy, with fine angular pebbles of flint and rounded of limestone	1.6	1.8
Upper Lias Clay	Clay, blue-grey, silty	1.4+	3.2

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Figure E7: TL09NE 77

TL 09 NE 77 **0857 9986** **Wansford** **Block D**

Surface level (+17.3 m) +57 ft
Groundwater conditions not recorded
152 mm percussion
July 1975

Overburden 0.5 m
Mineral 3.0 m
Bedrock 2.1 m+

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.5	0.5
River Gravel (Second Terrace)	'Clayey' sandy gravel, 'very clayey' in first metre Gravel: fine rounded sandstone, subangular to subrounded limestone, angular flint with ironstone Sand: medium and coarse, quartz, flint, ironstone and limestone	3.0	3.5
Upper Lias Clay	Clay, stiff, blue-grey	2.1+	5.6

GRADING

Mean for deposit *percentages*			Depth below surface (m)	*percentages*					
Fines	Sand	Gravel		Fines	Sand			Gravel	
				$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64
19	51	30	0.5–1.5	22	13	27	18	15	4
			1.5–2.5	19	12	25	20	21	5
			2.5–3.5	15	5	13	19	34	14
			Mean	19	10	22	19	23	7

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Figure E8: TL09NE 88

RECORD OF BOREHOLE 3 TYE 1652 CASTOR PARKWAY
TL 09 NE/88
N.G.R 0916 9952
1" : 157

GROUND LEVEL 20.6 m O.D.

BORING: STARTED 23.1.76.
BORING: FINISHED 23.1.76.
HOLE SIZE 0.15 m dia. to 5.0 m depth.

SAMPLE OR TEST		CHANGE OF STRATA			
DEPTH	TYPE	LEGEND	DEPTH	O.D. LEVEL	DESCRIPTION
			0.2	20.4	TOPSOIL.
0.35	D1				Hard brown sandy clay with occasional gravel, traces of ash (MADE GROUND).
0.45 - 0.90	U(4)1				
0.90	D2		1.0	19.6	
1.05 - 1.35	C(41)				Hard brown silty CLAY with occasional gravel and cobbles.
1.3	D3				
1.75	D4		2.1	18.5	
2.15	D5				Moderately strong light brown rubbly oolitic LIMESTONE with some stiff brown sandy clay.
2.15 - 2.25	C(60)				
2.5 - 3.0	B1				
3.0 - 3.10	C(60)				
3.75	D6				
4.0 - 4.02	C(60)				
4.5	D7		4.8	15.8	
4.5 - 4.55	C(60)		5.0	15.6	Moderately strong light brown rubbly oolitic LIMESTONE.
5.0 - 5.02	C(60)				
5.0	D8				

REMARKS 2½ hours spent chiselling 2.1 to 4.1 m and ½ hour 4.8 to 5 m.
The borehole was dry.

KEY: D — DISTURBED SAMPLE
B — BULK DISTURBED SAMPLE
W — WATER SAMPLE
U — UNDISTURBED SAMPLE
S ( ) STANDARD PENETRATION TEST
C ( ) CONE PENETRATION TEST
NO. OF BLOWS FOR 300 mm PENETRATION IN BRACKETS

SOILS ENGINEERING LIMITED PETERBOROUGH

Figure E9: TL09NE 82

*TL09NE/82-83

TL 09 NE 82 **0963 9912** **Sutton** **Block E**

Surface level (+17.4 m) +57 ft
Groundwater conditions not recorded
152 mm percussion
September 1975

Overburden 0.7 m
Mineral 5.6 m
Bedrock Trace

LOG

Geological classification	Lithology	Thickness m	Depth m
	Soil	0.4	0.4
	Clay, pebbly, sandy	0.3	0.7
River Gravel (Third Terrace)	'Very clayey' sandy gravel Gravel: fine and coarse, limestone and flint with ironstone Sand: medium with fine and coarse, quartz, flint and ironstone with limestone Fines: clay seam between 2.8 m and 3.1 m	5.6	6.3
Lincolnshire Limestone	Limestone, oolitic	Trace	6.3

GRADING

Mean for deposit percentages			Depth below surface (m)	percentages					
				Fines	Sand			Gravel	
Fines	Sand	Gravel		$-\frac{1}{16}$	$+\frac{1}{16}-\frac{1}{4}$	$+\frac{1}{4}-1$	+1–4	+4–16	+16–64
31	38	31	0.7–1.8	25	9	14	11	21	21
			1.8–2.8	36	16	11	8	18	11
			2.8–3.1	100*					
			3.1–4.1	25	11	26	11	8	19
			4.1–5.6	22	8	25	12	22	11
			Mean	31	10	18	10	17	14

* Clay seam not sampled

Figure E10: TL09NE 345

DATION ENGINEERING Ltd.

BOREHOLE LOG

TL19NW 345
10112 99502

LOCATION : Cottam - Wymondley.
BOREHOLE No. : 261
BOREHOLE DIA. : 6"
GROUND LEVEL : -
DATE (Start) : 3rd. May, 1967.
WATER LEVEL : See note.

Description	Thickness	Depth		Sample	Remarks
		0'-0"			
Topsoil.	0' 9"	0' 9"		• 1	
Firm brown silty CLAY.	1' 3"	2' 0"			
Firm red/brown sandy CLAY with occasional Gravel.	3' 6"			I 2	
Medium dense clayey SAND some Gravel.	2' 0"	5' 6"		• 3	
		7' 6"		+ 4	N = 24
Medium dense small/medium GRAVEL and Sand.	3' 0"				
		10' 6"		• 5	
Soft grey/brown silty CLAY.	3' 0"			+ 6	N = 50/2½"
Compact GRAVEL & SAND.	0' 9"	13' 6"			
	1' 9"	14' 3"		+ 7	N = 60/¾"
Hard grey/brown coarse SANDSTONE		16'0"		• 8	
Hard grey/brown LIMESTONE, occasional Gravel.	4' 0"			+ 9	N = 100/1¼"
		20' 0"			
Compact grey silty SAND.	6' 0"			• 10	
		26' 0"		+ 11	N = 120/5".

Note
B.H. making water at 13'6".
B.H. making water from 16'0" to 25'0". Standing W.L. 10'0".

HOLE SCALE : 1"=5' • : DISTURBED SAMPLE I : UNDISTURBED SAMPLE + STANDARD PENETRATION TEST

Figure E11: TL09NE 346

INDATION ENGINEERING Ltd.

BOREHOLE LOG

TL19NW 346
10133 99139

LOCATION : Cottam - Wymondley.
BOREHOLE No. : 262.
BOREHOLE DIA. : 6"
GROUND LEVEL : -
DATE (Start) : 2nd May, 1967.
WATER LEVEL : See note.

Description	Thickness	Depth	Sample	Remarks
Topsoil.	0' 9"	0'-0" 0' 9"	• 1	
Soft to firm brown clayey SAND with occasional Gravel.	5' 3"	6' 0"	+ 2	N = 26
Medium dense brown/yellow SAND	1' 3"	7' 3"	• 3	
Compact brown/yellow small/medium GRAVEL with some Sand occasional thin band of Clay.	10' 3"	17' 6"	+ 4, • 5, + 6	N = 60/5", N = 60/5"
Hard grey/brown broken SANDSTONE with traces of Clay.	2' 3"	19' 9"	• 7, + 8	N = 60/2½"
Stiff black clayey SILT.	0' 9"	20' 6"	• 9	
Compact grey fine silty SAND.	10' 6"	31' 0"	+ 10, + 11	N = 100/5", N = 100/5½"

Note:
B.H. making water at 10'3"

EHOLE SCALE : 1" = 5' • : DISTURBED SAMPLE ▮ : UNDISTURBED SAMPLE + STANDARD PENETRATION TEST

Figure E12: TL09NE 312

TL19NW 312

ENGINEER Stirling Maynard & Partners.	PROJECT Castor and Ailsworth By-Pass.	GROUND LEVEL 16.80 m.O.D.	HOLE NO TP 1
LOGGED BY: Leonard Threadgold. FIELDWORK BY: Exploration Associates Ltd. LAB. TESTING BY:	EXCAVATION METHODS JCB 3CX (With Speedshore Support).	COORDINATES 510125 E 299213 N	FIGURE A
		DATES 6.9.84	SHEET 1 OF 1

Date-Time at Depth	Depth of Casing	Depth of Water	Piez.	STRATA Description	Leg.	Level m.O.D.	Depth m	Sampling/In Situ Testing No	Depth m	Type	Blows	V/Cr/RQD	Lab Testing % <425	W %	PL %	LL %		γ Mg/m³	Cu kN/m²	MCV	Other Tests and Notes
6.9.84				Dark brown silty sand with roots TOPSOIL.		16.80	G.L.														No groundwater observed during excavation. Trial Pit stable.
				Stiff dark orange brown clayey fine sandy SILT with occasional gravel and with roots. HEAD		16.30	0.50	1	0.9	B				14							Particle Size Analysis CBR pH/Sulphate
				Dark orange brown slightly silty fine and medium SAND with pockets of very silty sand sub-horizontal colour banding. RIVER TERRACE		15.60	1.20	2	1.60	B				18							Particle Size Analysis
								3	2.50	B				12							Particle Size Analysis
				Dark orange brown SAND and GRAVEL. Gravel rounded to sub-angular, mostly fine and medium. RIVER TERRACE.		13.90	2.90														
		DRY		Base of Trial Pit.		13.60	3.20	4	3.20	B											

WATER [illegible]

PIEZOMETER: Upper seal; Response length; Lower seal (Installation only, readings elsewhere.)

SAMPLE AND TEST KEY. D Small disturbed sample; B Bulk disturbed sample; W Water sample; U Undisturbed sample; P Piston sample; R Rotary core recovery to scale; V Insitu vane test; S Standard penetration test; C Cone penetration test; K Permeability test; PM Pressuremeter test.

Blows N = N value; 26/150, blows for 150mm, drive after seating; 26*, blows for part or whole of seating drive only; (26) Undisturbed sample blow count.

V Vane strength kN/m² Natural Remould; Cr Core recovery %; RQD Rock quality designation; <425 Sample % passing 425µm sieve.

D. I. EVANS B.Sc, Tech, MSE, FICE, FIHT. Director (Transport) Eastern Regional Office (Transport) 49-51 Goldington Road, Bedford.

SHEET [illegible] FIG. A HOLE NO. TP1

Figure E13: TL09NE 313

TL19NW 313

ENGINEER Stirling Maynard & Partners LOGGED BY: Leonard Threadgold. FIELDWORK BY: Exploration Associates Ltd. LAB. TESTING BY:	PROJECT Castor and Ailsworth By-Pass. EXCAVATION METHODS JCB 3CX (With Speedshore Support).	GROUND LEVEL 16.80 m.O.D. COORDINATES 510233 E 299180 N DATES 6.9.84	HOLE NO TP2 FIGURE A SHEET 1 OF 1

Date/time at depth	Depth of casing	Depth of water	Piez.	Strata: Description	Leg.	Level m.O.D.	Depth m	Sampling/in situ testing: No	Depth m	Type	Blows	V/Cr/RQD	Lab testing: S <425	W %	PL %	LL %		γ Mg/m³	Cu kN/m²	MCV	Other tests and notes
6.9.84						16.80	G.L.														No groundwater observed during excavation. Trial Pit stable.
				Dark brown sandy silt with roots TOPSOIL.		16.30	0.50														
				Dark orange brown silty fine and medium SAND with a little gravel. Patches of very silty sand. RIVER TERRACE.		15.30	1.50	1	0.80	B				9.7							Particle Size Analysis
		DRY		Dark orange brown SAND and GRAVEL. Sand is fine to coarse, gravel is mostly fine and medium, rounded to sub-angular. RIVER TERRACE.		14.20	2.60	2	1.90	B				4.8							Particle Size Analysis
				Base of Trial Pit.																	

WATER: 1 = First water strike; 2 = Subsequent water strikes; ▽ Highest water level in open hole.

PIEZOMETER: Upper seal; Response length; Lower seal (Installation only, readings elsewhere.)

SAMPLE AND TEST KEY: D Small disturbed sample; B Bulk disturbed sample; W Water sample; U Undisturbed sample; P Piston sample; R Rotary core recovery to scale; Y Insitu vane test; S Standard penetration test; C Cone penetration test; K Permeability test; PR Pressuremeter test.

Blows N = N value; 26/150, blows for 150mm drive after seating; 26*, blows for part or whole of seating drive only; (26) Undisturbed sample blow count.

V Vane strength kN/m² Natural / Remould; Cr Core recovery %; RQD Rock quality designation; <425 Sample % passing 425μm sieve.

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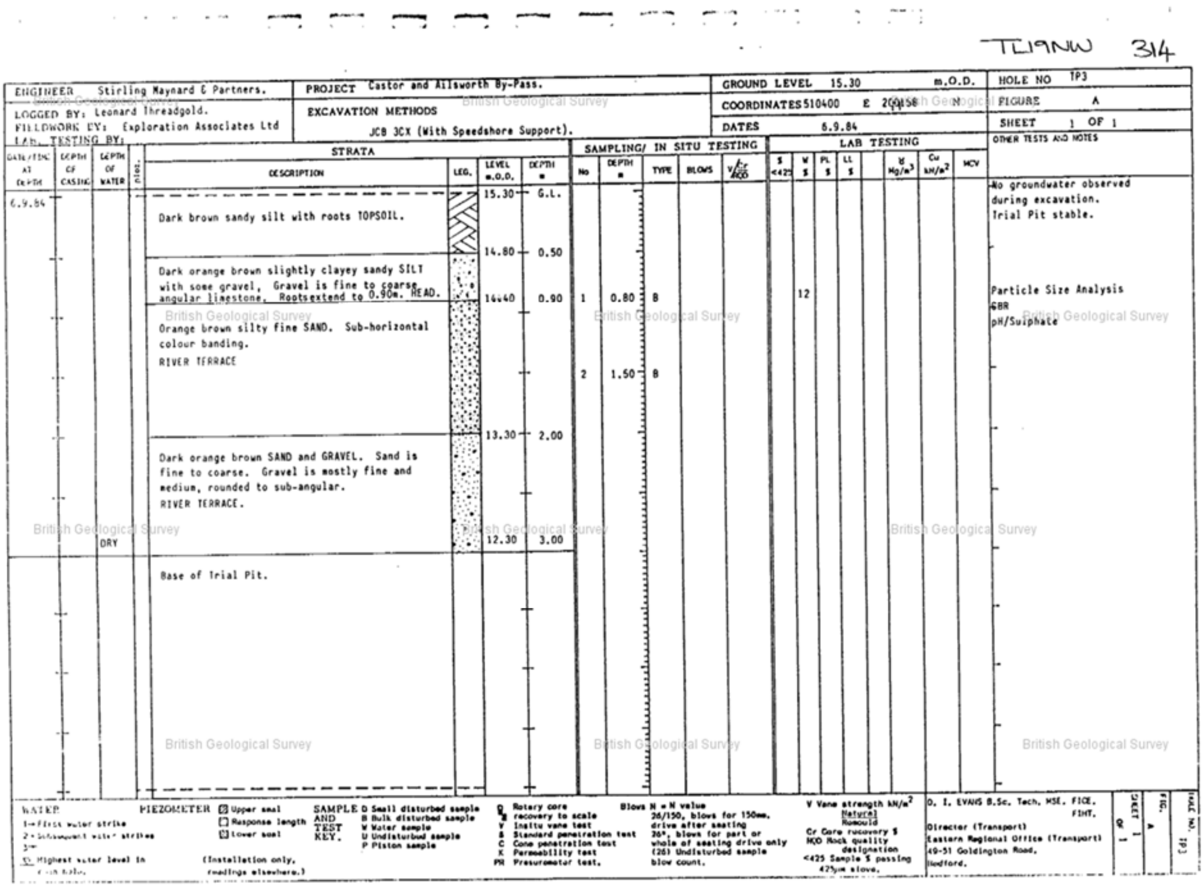
SHEET 1 OF 1 | FIG. A | HOLE NO. TP2

Figure E14: TL09NE 314



TL19NW 314

ENGINEER Stirling Maynard & Partners.
LOGGED BY: Leonard Threadgold.
FIELDWORK BY: Exploration Associates Ltd
LAB. TESTING BY:

PROJECT Castor and Ailsworth By-Pass.
EXCAVATION METHODS JCB 3CX (With Speedshore Support).

GROUND LEVEL 15.30 m.O.D.
COORDINATES 510400 E 299158 N
DATES 6.9.84

HOLE NO TP3
FIGURE A
SHEET 1 OF 1

Date/Time at Depth	Description	Level m.O.D.	Depth m	Sample No	Sample Depth m	Type	W %	Other Tests and Notes
6.9.84		15.30	G.L.					No groundwater observed during excavation. Trial Pit stable.
	Dark brown sandy silt with roots TOPSOIL.	14.80	0.50					
	Dark orange brown slightly clayey sandy SILT with some gravel, Gravel is fine to coarse angular limestone. Rootsextend to 0.90m. HEAD.	14.40	0.90	1	0.80	B	12	Particle Size Analysis CBR pH/Sulphate
	Orange brown silty fine SAND. Sub-horizontal colour banding. RIVER TERRACE			2	1.50	B		
		13.30	2.00					
	Dark orange brown SAND and GRAVEL. Sand is fine to coarse. Gravel is mostly fine and medium, rounded to sub-angular. RIVER TERRACE.	12.30	3.00					
	Base of Trial Pit.							

Depth of water: DRY

WATER 1 = First water strike 2 = Subsequent water strikes 3 = Highest water level in each hole.
PIEZOMETER Upper seal, Response length, Lower seal (Installation only, readings elsewhere.)
SAMPLE AND TEST KEY. D Small disturbed sample B Bulk disturbed sample W Water sample U Undisturbed sample P Piston sample
Q Rotary core recovery to scale V Insitu vane test S Standard penetration test C Cone penetration test K Permeability test PR Presurometer test.
Blows N = N value 26/150, blows for 150mm drive after seating 36*, blows for part or whole of seating drive only (26) Undisturbed sample blow count.
V Vane strength kN/m² Natural Remould Cr Core recovery % RQD Rock quality designation <425 Sample % passing 425μm sieve.
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Figure E15: TL09NE 347

ATION ENGINEERING Ltd.

BOREHOLE LOG

TL19NW 347

10157 98793

LOCATION : Cottam - Wymondley.

BOREHOLE No. : 263

BOREHOLE DIA. : 6"

GROUND LEVEL : -

DATE (Start) : 5th May, 1967.

WATER LEVEL : See note.

Description	Thickness	Depth		Sample	Remarks
		0'-0"			
Topsoil.	0' 9"	0' 9"		• 1	
Firm brown sandy CLAY.	1' 3"	2' 0"		• 2	
Firm brown/yellow clayey SAND and GRAVEL.	2' 6"	4' 6"		+ 3	N = 33
Medium dense brown/yellow small/medium GRAVEL and SAND occasional bands of Clay.	5' 6"	10' 0"		• 4 + 5	N = 61
Compact brown/yellow small/medium GRAVEL and SAND with pieces of Clay.	4' 3"	14' 3"			
Stiff to hard grey silty CLAY with pockets of grey sand.	4' 3"	18' 6"		• 6 I 7 • 8 • 9	
Very hard brown/yellow coarse LIMESTONE.	6' 6"	25' 0"		+ 10 + 11	N = 120/4" N = 150/1"
Note: B.H. making water freely 10'0" to 14'6". B.H. making water from 18'6".					

BORING SCALE : 1" — 5' • : DISTURBED SAMPLE I : UNDISTURBED SAMPLE + STANDARD PENETRATION

Figure E15: TL09NE 87

RECORD OF BOREHOLE 2 19W 2869 CASTOR PARKWAY.
TL 09 NE/87
GROUND LEVEL 18.4 m O.D. N.G.R. 0828 9969
1" : 157

BORING: STARTED 6.2.76.
BORING: FINISHED 6.2.76.
HOLE SIZE 0.15 m dia. to 5.0 m depth.

SAMPLE OR TEST DEPTH	TYPE	LEGEND	CHANGE OF STRATA DEPTH	O.D. LEVEL	DESCRIPTION
			0.2	18.2	TOPSOIL.
1.0 - 2.0	B1				Moderately weak light brown rubbly oolitic LIMESTONE with some firm brown sandy clay (probably MADE GROUND).
1.65 - 1.95	C(18)				
2.25	D1				
2.55 - 2.85	U(4)1				
3.0	D2				
3.15 - 3.45	C(16)		3.5	14.9	
3.50	D3				Stiff brown sandy CLAY with some flint and limestone gravel.
3.55 - 4.0	U(4)2				
4.0	D4				
4.15 - 4.45	C(17)				
4.45	D5				
4.60 - 5.0	U(4)3		5.0	13.4	
5.0	D6				

REMARKS 1 hour spent chiselling in limestone.
The borehole was dry.

KEY: D — DISTURBED SAMPLE
B — BULK DISTURBED SAMPLE
W — WATER SAMPLE
U — UNDISTURBED SAMPLE
S { C { } STANDARD PENETRATION TEST
CONE PENETRATION TEST
NO. OF BLOWS FOR 300 mm
PENETRATION IN BRACKETS

SOILS ENGINEERING LIMITED REFERENCE ...

Appendix E. Qualitative Contamination Assessment

The following Contaminated Land Risk Assessment methodology is based on CIRIA C552 (2001) Contaminated Land Risk Assessment – A Guide to Good Practice[19], in order to quantify potential risk via **risk estimation** and **risk evaluation**, which can be adopted at the Phase I (Desk Study) stage. This will then determine an overall risk category which can be used to identify potential investigation or remedial actions. This methodology uses qualitative descriptors and therefore is a qualitative approach based on desk information. The risk assessment should be refined following receipt of ground investigation data. The methodology requires the classification of:

- the magnitude of the **consequence** (severity) of a risk occurring, and
- the magnitude of the **probability** (likelihood) of a risk occurring.

The potential consequences of contamination risks occurring at this Site are classified in accordance with Table D.1 below, which is adapted from the CIRIA guidance.

Table D.1: Classification of Consequence

Classification	Definition of Consequence
Severe	Short-term (acute) risks to human health likely to result in "significant harm" as defined by the Environmental Protection Act 1990, part IIA. Short-term risk of pollution of sensitive water resource. Catastrophic damage to buildings/property. A short-term risk to a particular ecosystem, or organism forming part of such an ecosystem.
Medium	Chronic damage to Human Health (significant harm as defined in DEFRA, 2012). Pollution of sensitive water resources. A significant change in a particular ecosystem, or organism forming part of such an ecosystem.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ("significant harm" as defined in the DEFRA, 2012) Damage to sensitive buildings/structures/services or the environment
Minor	Harm, though not necessarily significant harm, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc.) Easily repairable effects of damage to buildings, structures and services.

The probability of contamination risks occurring at this Site will be classified in accordance with Table D.2 below from the CIRIA guidance. Note that for each category, it is assumed that a pollution linkage exists. Where a pollution linkage does not exist, the likelihood is zero, as is the risk.

Table D.2: Classification of Probability

Classification	Definition of Probability
High likelihood	There is a pollutant linkage and an event that appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution

Classification	Definition of Probability
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term
Low likelihood	There is a pollutant linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and is less likely in the shorter term
Unlikely	There is a pollutant linkage but circumstances are such that it is improbable that an event would occur even in the very long term

For each possible pollution linkage (source-pathway-receptor) identified, the potential risk can be evaluated based upon the following probability x consequence matrix shown in Table D.3.

Table D.3: Overall Contamination Risk Matrix

		Consequence			
		Severe	Medium	Mild	Minor
Probability	High likelihood	Very High Risk	High Risk	Moderate Risk	Moderate / Low Risk
	Likely	High Risk	Moderate Risk	Moderate / Low Risk	Low Risk
	Low likelihood	Moderate Risk	Moderate / Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate / Low Risk	Low Risk	Very Low Risk	Very Low Risk

Based upon this, CIRIA C552[19] presents definitions of the risk categories, together with the investigatory and remedial actions that are likely to be necessary in each case, as in Table D.4. These risk categories apply to each pollutant linkage, not simply to each hazard or receptor.

Table D.4: Definitions of Risk Categories and Likely Actions Required

Risk Category	Definition and Likely Actions Required
Very High	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability Urgent investigation (if not undertaken already) and remediation are likely to be required.
High	Harm is likely to arise to a designated receptor from an identified hazard Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer term
Moderate	It is possible that harm could arise to a designated receptor from an identified hazard. However, if [it] is relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
Low	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised would at worst be relatively mild.
Very Low	There is a low possibility that harm could rise to a receptor. In the event of such harm being realised it is not likely to be severe.