<u>Important Notice</u> – This document represents a supporting appendix to the *Network Rail East West Rail Central Section – Phase 2f Report (Dated 29th March 2019)*. This document must be read in conjunction with that report and be used exclusively for the same purposes as that report. Please refer to the notice contained in the Preface of the report for more information.

East West Rail

Central Section - Phase 2e

Technical Memo

Geotechnical Sensitivity Assessment

Document reference: NR_IP_EN_IDG_TM_145674_EWRCS-P2E_010

Document History

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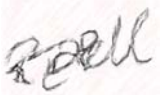
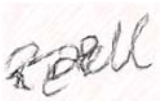
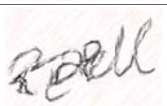
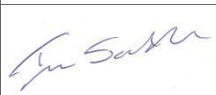
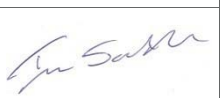
22/11/18	03	Amended following further client comments			
13/11/18	02	Amended following CEM/DPE review			
15/10/18	01	First Issue			
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Contents

Executive Summary

Three East West Rail Central Section Phase 2 routes were chosen by the Infrastructure Projects Scotland and North East (IP SNE) Network Rail Project Team for the purpose of undertaking an early stage geotechnical earthwork assessment. These routes are referenced as A(D)1, C(D)3 and C(D)3 Cambourne.

Four main changes have been made as part of this assessment (and in the following estimate production by others): -

- Cut slope angles have been based on geology type.
- Nett minimum approach used derive a vertical earthwork profile, as opposed to a balanced profile.
- An inclusion for site strip has been made to show potential impact on overall volumes.
- Estimators have factored in potential re-use of cut material, as opposed to cut material disposal and fill material import.

The range of reduction observed in overall route earthwork volumes, due to geology based slope angles, is ~2.5 – 3.6% stemming from cut reduction. However, as cut volume has reduced this volume must be sourced. When including for deficit, this benefit reduces to <1%. This suggests the simplified 1v:4h cutting earthwork slope angles previously applied was a reasonable initial estimate for the region.

Greater route earthwork volume change was achieved through the net minimum approach compared to producing an earthwork balance. A summary of the impact is presented below and comparison made to a balanced earthworks approach: -

Route	Balanced excl. site strip	Net minimum excl. site strip	Net minimum incl. site strip
	Earthwork volume m^3		
A(D)1	3,405,716	2,965,702	5,491,082
C(D)3	13,844,548	13,207,106	17,365,590
C(D)3 Cambourne	12,918,084	9,719,972	13,701,124

An inclusion for site strip of 1m deep has been made at this stage to highlight the potential impact and earthwork risk. This is an assumed average depth; where actual depth may vary throughout a routes length.

Potential sources of embankment construction fill material from quarries has been identified in the region, and predominantly consists of river and glacial sands and gravels. Some quarrying of chalk and limestone is still being undertaken, clay extraction is thought to have ceased due to brick work closures. The possibility of opening new quarries for the sole purpose of generating fill material could be considered, or quarrying cuttings where material is suitable and can be transported along the corridor for deposition. A mineral extraction plan is provided produced showing quarry sites relative to route alignments.

A high-level assessment of civil infrastructure requirements and route impact has been undertaken based on a revised ‘net minimum’ vertical profile. At this level of assessment, the impact on estimated bridge infrastructure is minimal, as crossings are still to be provided and accommodation of floodplains and road crossings remain necessary regardless of profile. Length of track infrastructure and signalling provision is unchanged due to horizontal route alignment remaining unchanged, and changes in the vertical profile having negligible impact on overall route lengths.

Further work

- Cost benefit comparison of material re-use (double handling, storage etc) against imported material.
- Further iteration of the vertical alignment could be undertaken to further reduce total earthwork requirements but at this stage is of diminishing returns for route comparisons.
- The economy of importing locally sourced material identified in this report would need to be explored against a further option of ‘mining’ cuttings where suitable material exists to supply embankment construction.
- Cost-benefit of importing granular fill material and resulting steeper embankment slope angles and resulting reduction in cost of footprint and volume.
- Assessment of earthwork construction, such as simultaneous cutting and adjacent embankment construction to minimise earthwork storage requirements.

1. Introduction

Network Rail Design Delivery (NRDD) has been commissioned by Infrastructure Projects Scotland and North East (IP SNE) to provide a GRIP 2 geotechnical sensitivity assessment as part of the East West Rail Central Section (Figure 1.1).

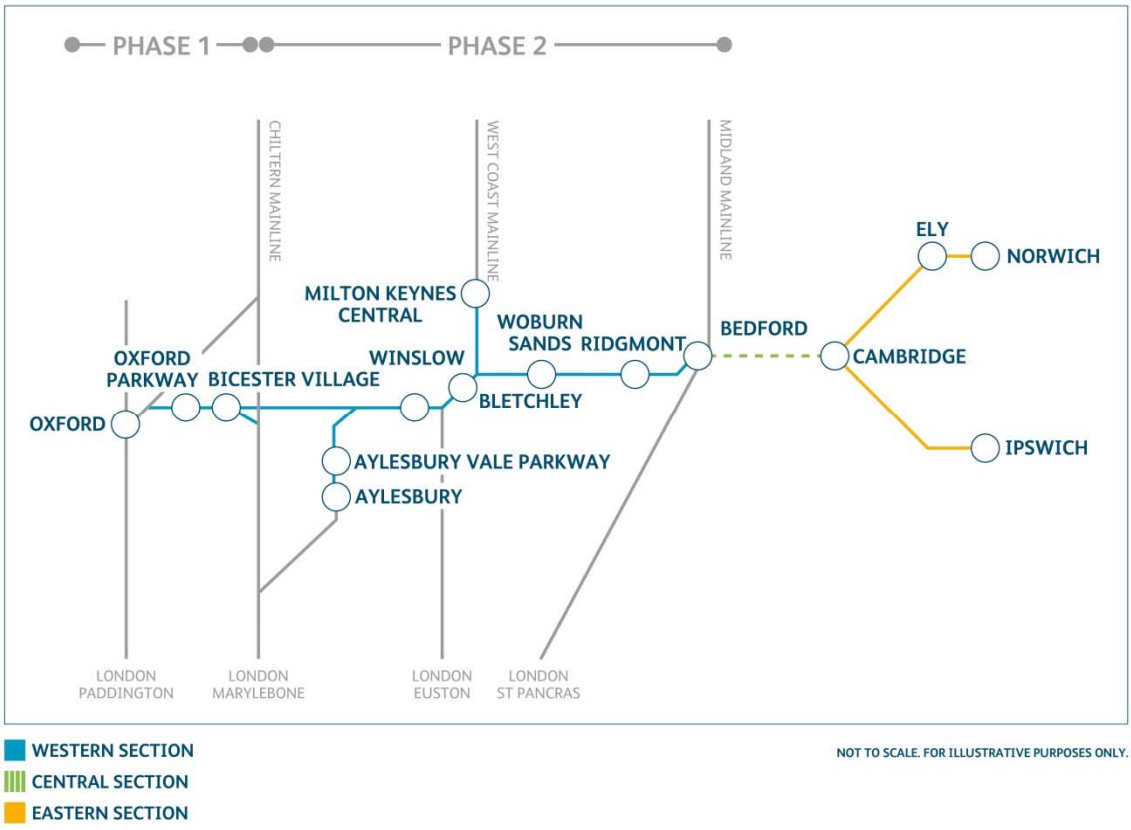

Figure 1.1 East West Rail Scheme Schematic

1.2 Studies Objectives

The following assessment has been carried out in accordance with the following agreed Geotechnical Sensitivity activity objectives: -

Geotechnical Sensitivity

- *Establish appropriate generic cut angles*
- *Establish whether cut materials can be economically reused, and suitable angles of repose*
- *Establish sources of suitable materials for fill*
- *Consider interface with existing infrastructure, flooding and sensitive areas*
- *Consider appropriateness of material transportation (distance, material quality)*
- *Consider proximity to existing quarries*
- *Propose one new vertical alignment per route (three in total) each showing revised / minimised earthworks volumes*
- *Calculate new volumes for each of the three routes in a format that allows the cost planners to readily update the Stage 2e cost plans*

2. Desk Study

2.1 Location

The study area encompasses new cross-country route options A(D)1, C(D)3 and C(D)3 – Cambourne, as shown in Figure 2.1 below.

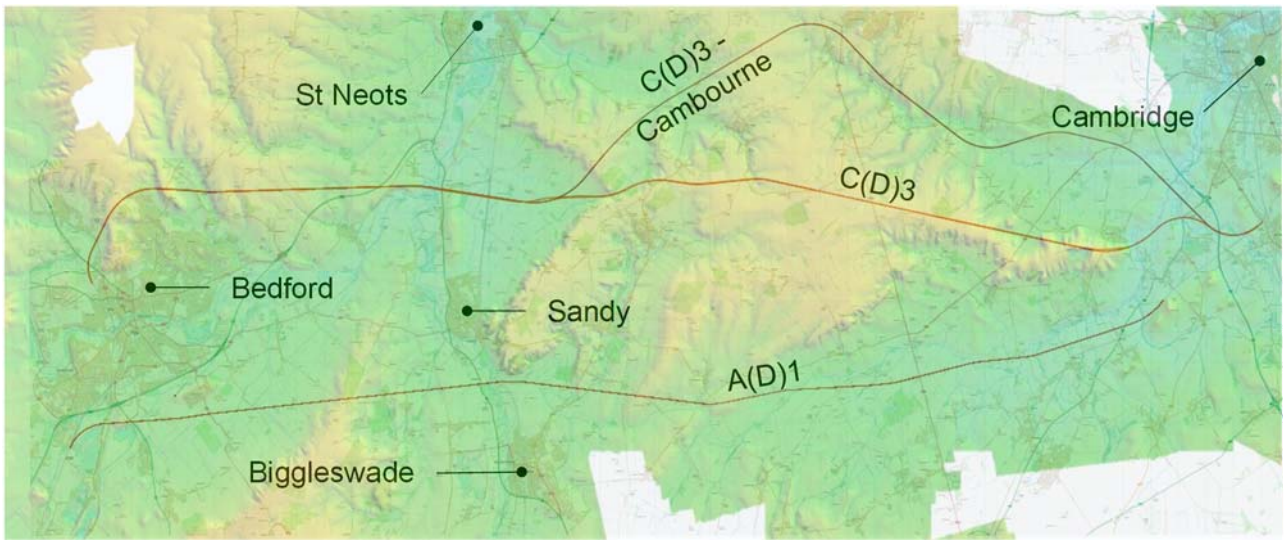

Figure 2.1 Study Area and Route Options

The area overlaps three county areas of East Anglia, but predominantly Bedfordshire and Cambridgeshire. The C(D)3 - Cambourne route would also pass through a small area of Huntingdonshire to the west of Cambourne.

2.2 Site Description

As a function of constraint avoidance, proposed routes run predominantly through open fields bypassing major conurbations.

Topographically, elevated ground north of Bedford and the Sandy Hills (east of Sandy and St Neots) is divided by major river courses, the River Great Ouse (Marston Vale) and the River Ivel. Between the Sandy Hills and Cambridge is the River Cam. Ground level generally lies between 15m and 85m. Routes are split between those running south of the Sandy Hills (A(D)1) avoiding high ground and northerly route options passing over and through the Hills (C(D)3 & C(D)3 – Cambourne. As shown in Figure 2.1 .

2.1 Geology

2.1.1 British Geological Survey 1:50,000 Geological Mapping

2.1.1.1 Solid and Superficial Geology

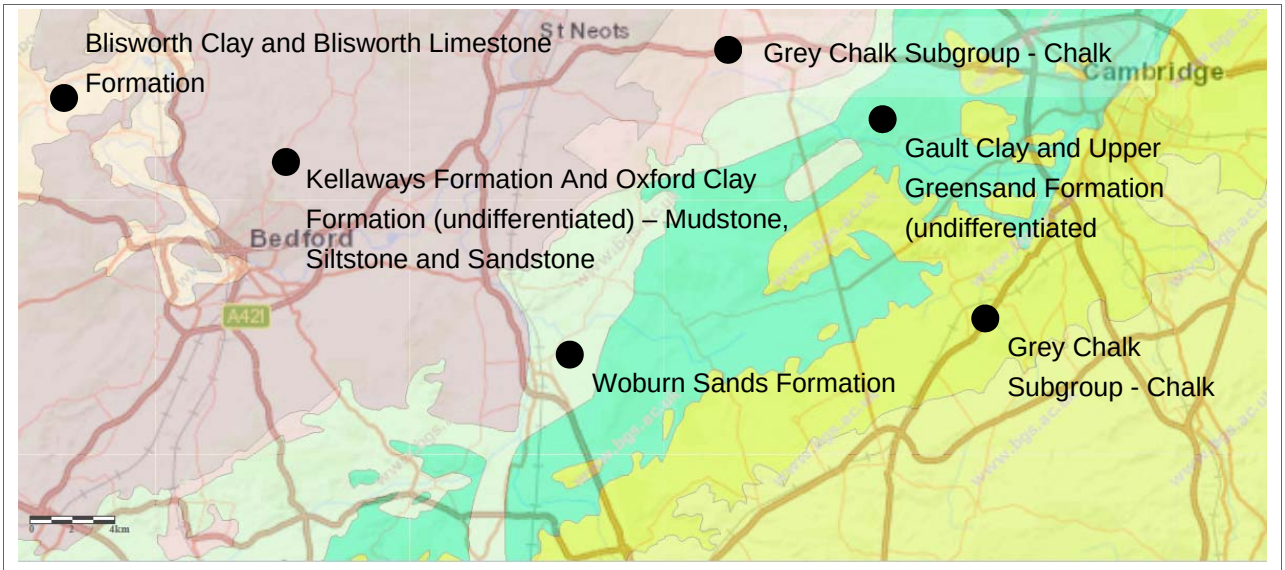

Figure 2.2 Route Solid Geology (British Geological Survey Online Viewer, 2018)

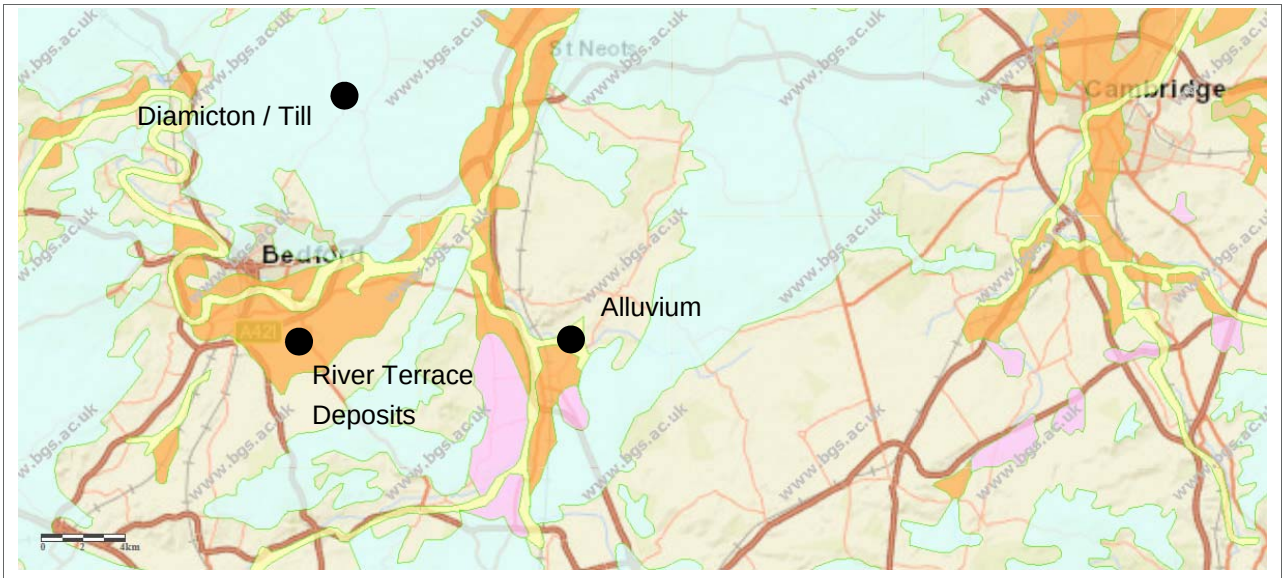

Figure 2.3 Route Solid Geology (British Geological Survey Online Viewer, 2018)

2.1.2 Geological Setting

Regional geology is dominated by sedimentary rocks laid down during the Middle to Upper Jurassic, and Cretaceous Periods (BGS, 2010). Rock dip angle is generally to the south east, although dip angle is very shallow and indicated to be < 1° based on inspection of geological mapping (stated dip angles) and borehole triangulation.

Glacial and alluvial superficial deposits are present in the region, associated with Quaternary glaciation, fluvial river channel deposition. Glacial Till deposits, or boulder clay, was laid down during the Quaternary Period, and is present over the high ground between Bedford and Cambridge and lies unconformably over the solid geology.

The lower lying areas have either no superficial deposits present or Alluvium, River Terrace Deposits or Head Deposits. Alluvium along river channels will be unconsolidated and may contain, silt clay, sand and gravel. There is a risk of settlement (immediate and consolidation) from being loaded.

To the periphery of river channels and floodplains may be River Terrance Deposits, which are again unconsolidated and likely to be poorly graded (single sized) and have some level of rounding / reduced angularity. This will provide a shear strength compared to a well graded and angular granular material. Head Deposits consisting of downslope (soluflucted) debris are localised where present. This material can look similar to glacial till (Waltham, 2009) and may be well sheared with a low residual shear strength.

British Geological Survey (BGS) 1:50,000 online geology viewer, and geological maps listed below indicate the following tabulated solid geology to be present: -

Table 2.1 Applicable Solid Geology

Geology		*Anticipated material
Formation	**Member / Unit**	
Kellaways Formation	Kellaways Sand	Clay, sands, silts / weak rock / sandstone
	Kellaways Clay	Clay / weak rock
Oxford Clay Formation	Peterborough Member	Clay / weak rock
Lower Greensand Group	Woburn Sands Formation	Sand / Cemented Sand / weak rock
Selborne	Gault Formation	Clay / Weak rock
Lower Chalk Formation	West Marly Melbury Chalk Formation	Weak rock / moderately strong rock
	Totternhoe Stone Member	Weak rock / moderately strong rock

2.2 Geotechnical Hazards

The following hazards may be present and should be considered further when devising a site investigation to inform the design: -

- Soft and compressible soils associated with rivers and floodplains – soft alluvial clay and silt, peat / organic soils
- Soft ground conditions relating to weathering i.e. soft / putty chalk
- High plasticity Gault Clay soils (high smectite content) and risk of long term settlement issues following placement
- Relict shear planes in formed cuttings (clays)
- Running sands
- Presence of water and artesian and sub-artesian ground water conditions
- Variability of boulder clay (glacial till)
- Head deposits with low residual shear strength

3. Earthwork Design

A Design Decision Log and Hazard log is provided in **Appendix A** and **Appendix B**, respectively.

3.1 Imported and Site Won Material Suitability

3.1.1 Mineral Extraction

Bedfordshire and Cambridgeshire are known for extraction of the following minerals: -

- Quaternary glacial sands and gravels
- River Terrace Deposits,
- Cretaceous chalk
- Cretaceous and Jurassic (Gault and Lower Oxford) Clay (Cameron, 1995).

Refer to **Appendix C** for locations of mineral extraction sites. All quarrying sites are understood to be open cast.

3.1.1.1 Aggregates (Sand and Gravel)

The presence of large watercourses and (Quaternary) historic glacial events have produced sand and gravel depositions quarried at multiple locations in the Bedfordshire and Cambridgeshire region. From a review of mineral resource information, the following locations are a potential source of construction material: -

- Willington, Bedfordshire (multiple operators/sites)
- Broom, Biggleswade, Bedfordshire (multiple operators/sites)
- Sawston (near Great Shelford), Cambridgeshire

Further away, sand and gravel is quarried near Luton and Dunstable in Bedfordshire and around Chatteris, Ely and Peterborough in Cambridgeshire.

3.1.1.2 Clay

The Kempston Hardwick and Stewartby area of south of Bedford was renowned for brick making and extraction of Oxford Clay and specifically ‘Knotts’, a fossiliferous clay, beneficial for the production of bricks due to its shale content. No extraction is currently being undertaken at these sites and in recent times the former pits have been utilised for landfill deposition.

Through review of BGS Mineral Extraction sites information (BGS Directory of Mines, (Cameron et al, 2014)) and BGS Mineral Extraction mapping (Cameron & Highly, 1995) no clay extraction sites are thought to be active, and for the purposes of provided earthwork fill pits would have to be re-opened.

3.1.1.3 Chalk

The remnants of open cast chalk quarries remain near Cambridge; Cherry Hinton and Barrington but are thought to be non-operational currently. From 2014 BGS Mineral Extraction information, one chalk pit remains near Dunstable, some 20miles/32km south of Bedford. Chalk aggregate would be suitable as general fill although the distance may be prohibitive.

3.1.1.4 Limestone

Two limestone sites exist, the first near Dunstable, 20miles/32km south of Bedford, and a further 8.4miles/13.5km north-east of Cambridge. Limestone aggregate would be suitable as general fill although the distance may be prohibitive.

3.1.2 Imported Fill Suitability

In the absence of ground investigation (and slope stability assessment), TRRL research (Perry, 1989) has been reviewed where existing road earthwork failures have been observed and recorded to establish the failure rate depending on geology. The following table provides an indication of anticipated class each source may provide (in terms of general fill for earthworks), together with anticipated achievable embankment slope angles: -

Table 3.1 Imported Fill Types and Embankment Slope Angles

Mineral Extraction	Material Class for General Fill MCHW	[1]Embankment Slope Angle (1 v: - h)		
		< 2.5m	2.5 – 5.0m	> 5.0m
Sand and Gravel				
River Gravel	1A – 1C	2	2	2
Glacial Gravel		1.75	1.75	1.75
Recycled Aggregate	1A – 1C	2	2	2
Clay (Oxford Clay)	2A – 2D	3	3.5	3.5
Chalk	3	2	2	2
Limestone (crushed rock / non-argillaceous)	1A – 1C	2	2	2

[1]Slope angles presented are based on Perry (1989) TRRL research.

3.1.3 Site Won Material

Table 3.2 Site Won Material Types and Embankment Slope Angles

Cutting Material	Material Class for General Fill MCHW	[1]Embankment Slope Angle (1 v: - h)		
		< 2.5m	2.5 – 5.0m	> 5.0m
Sand and Gravel				
River Gravel	1A – 1C	2	2	2
Glacial Gravel		1.75	1.75	1.75
Oxford Clay (Stewarby & Peterborough Members)	2A – 2D	3	3.5	3.5
West Melbury Marly and Zig Zag Chalk Formation	3	2	2	2
Boulder Clay (Glacial Till)	2A – 2D	2.0	3.0	3.0

[1]Slope angles presented are based on Perry (1989) TRRL research.

3.2 Earthwork Volume Calculation

3.2.1 Introduction

To achieve an efficient profile and reduce overall earthwork volume (and footprint), a net minimum approach is to be used to earthwork design to compare to the balanced approach previously applied. Each routes' vertical profile is to be adjusted to follow the ground profile closely and find efficiencies between cuttings and embankments.

The following (non-balanced) volumes are to be calculated: -

- Route cut, fill and surplus/deficit
- Site strip, and
- Trackbed

Geological data from mapping, borehole data and the application of cut slope angles from Section 3.0 of this report, is to be used to calculate revised earthwork volumes.

In the absence of soils testing and based on TRRL research (Perry, 1989), indicating potential re-use of cut material at various slope angles, materials have been classified in line with MCHW Series 600 Earthworks (Table 3.3).

Table 3.3 Earthwork Types

Material Origin	MHCW Classification		Assumed Re-use (%)
Site Won			
Cutting excavation	1 – 2, 3	General fill	100%
Site strip removal	4 & 5	Fill to landscape / Top soil	100%
Imported Material			
General Fill	1, 2, 3, 6	General fill (based on locally quarried material)	-
Ballast / trackbed	Unclassified in MCHW		N/A

Site strip is to be calculated based on earthwork width and assumed to be re-used locally for general landscaping and topsoil.

3.2.2 Calculation Methodology

3.2.2.1 General Procedure and Software

A digital topographical terrain model was developed using a combination of Ordnance Survey Terrain 5 data and the Environment Agency Digital Terrain Model (DTM) 2.0m data set, to provide sufficient coverage over the area of interest.

For the geotechnical sensitivity, Autodesk Civils 3D was utilised with the Geotechnical Module. DTM data was used in combination with geotechnical information for 'safe' slope angles. Geology

dependant cutting earthwork profiles were produced in Civils 3D and applied to designated lengths of route cuttings where particular geological units were identified.

Determination of applicable geology for each cutting was determined predominantly from the following BGS 1:50,000 plan geological maps for Bedford (BGS, 2010), Biggleswade (BGS, 2001) and Saffron Walden (BGS 2002), but also through historic BGS borehole information to triangulate strata layers in Civils 3D using the Geotechnical Module. Interpolation of data was applied due to the density of available data together with map interpretation.

3.2.2.2 Cutting, Embankment and Site Strip Volume Calculation

A twin track railway suitable for a maximum line speed of 125mph has been applied in accordance with NR/SP/OHS/069, as shown in Figure 3.1 below.

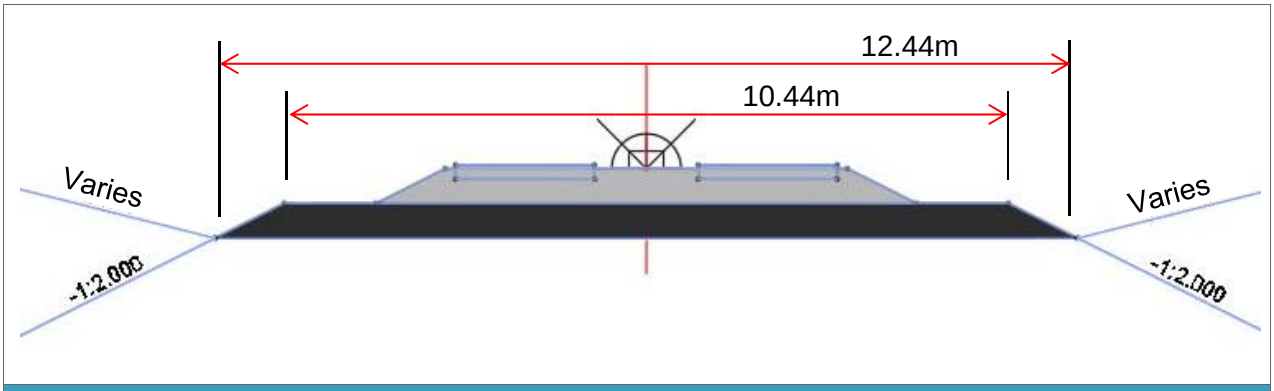

Figure 3.1 Embankment and Cutting Assembly Profile (>100mph)

Using the method set out above, initial volumes were obtained for cut, fill and resulting surplus/deficit. Refer to **Appendix D** for derived route earthwork slope geometry. A summary of applied cutting slope angles is provided in Table 3.4 below.

Table 3.4 Cutting Slope Geometry

Formation / Deposits	[1]Cutting Slope Angle (Angle (1 v: - h) 0 - 2.5	2.5 - 5.0	>5.0	Comments
Oxford Clay	2.5	3	3.5	<1% failure rate within 25 years of construction. *1: 3:5 result determined by author through data extrapolation.
Gault Clay	3.5	4	5	<1% failure rate within 22 years of construction. *1:5 result determined by author through data extrapolation.
Lower Chalk	1.5	2	2	<1% failure rate within 22 years of construction.
Woburn (Lower Greensand)	2	2	2	<1% failure rate within 25 years of construction.
Boulder Clay	1.75	3.5	3.5	<1% failure rate within 25 years of construction.

	[1]Cutting Slope Angle (Angle (1 v: - h)			Comments
Formation / Deposits	**0 - 2.5**	**2.5 - 5.0**	**>5.0**	
(Glacial Till)				

[1]Slope angles presented are based on Perry (1989) TRRL research.

Embankment slope geometry throughout remains at 1v:2h.

Further adjustment of the cut and fill figures was undertaken to account for site strip (Figure 3.2) and calculate re-use volume of Highways Class 4 & 5 (Anon, 2006) material for landscaping, noise, visual barriers etc, and top soil.

Site strip volume estimation was calculated based on Civils 3D produced alignment geometry data at 20m intervals, commensurate with route volume calculation intervals.

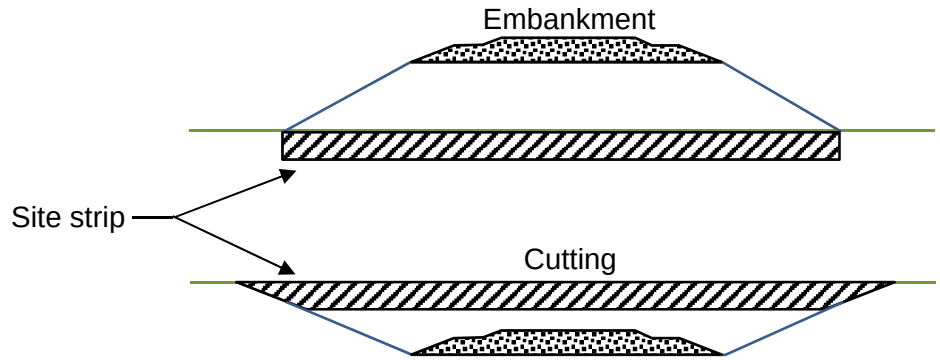

Figure 3.2 Site Strip Calculation

Ballast/trackbed volume is calculated based on linear length of new route new.

3.2.2.3 Assumptions and limitations

- All cut (assumed Class 1 & 2) and Class 4 & 5 site strip material can be re-used.
  - Cut material (excluding site strip) utilised in embankment construction
  - Site strip material utilised for landscaping and topsoil locally
- An average 1.0m deep strip has been assumed at this stage of design, likely favouring northerly routes where more competent ground may be present at shallower depths.
- Modelling of cutting slope angles has considered a single slope angle and has not considered two or more layers (compound slopes). Therefore, the worst-case slope profile depending on geology anticipated has been taken where two strata may be present.

- Properties and performance of the same sedimentary soil strata and superficial deposits in the same proposed cutting will vary as a result of constituents, matrix, deposition and previous loading conditions. Therefore, slope angles suggested are a guide for further exploration and confirmation through site investigation and geotechnical testing.

3.2.3 Sensitivity Earthwork Result Comparison

A comparison of earthwork volumes, based on the following changes in earthwork calculation, is presented below in Table 3.2.3.1.

1. [1]Balanced earthwork vertical profile and application of 1v:2h, embankments and 1v:4h cuttings.
2. Nett minimum vertical profile, with variable (geology based) embankment and cutting slopes.
3. Nett minimum vertical profile, with variable (geology based) embankment and cutting slopes, and inclusion for site strip.

[Note: Geology based earthwork profiles has only minor impact on overall earthwork volumes].

Refer to **Appendix E** for route drawings showing vertical profile changes for nett minimum approach.

3.2.3.1 Earthwork Volume Results

Route		Earthwork Assessment Change		
		1	2	3
A(D)1	Cut (m³)	1,200,731	1,135,277	950,073
	Fill (m³)	1,702,858	1,482,851	2,252,132
	Surplus/Deficit (m³)	- 502,127	-347,574	-1,305,059
	Site strip (m³)			983,818
	Total Earthwork (m³)	**3,405,716**	**2,965,702**	**5,491,082**
C(D)3	Cut (m³)	6,909,877	3,351,859	2,768,964
	Fill (m³)	6,922,274	6,603,553	7,779,125
	Surplus/Deficit (m³)	-12,397	-3,251,694	-5,010,161
	Site strip (m³)			1,807,340
	Total Earthwork (m³)	**13,844,548**	**13,207,106**	**17,365,590**
C(D)3 - Cambourne	Cut (m³)	6,459,042	2,092,793	1,957,573
	Fill (m³)	4,320,968	4,859,986	6,055,741
	Surplus/Deficit (m³)	+2,138,074	-2,767,193	-4,098,168
	Site strip (m³)			1,589,642
	Total Earthwork (m³)	**12,918,084**	**9,719,972**	**13,701,124**

Notes

1. Site strip has the impact of increasing earthwork fill volume requirements whilst also creating additional material for landscaping, top soiling, or disposal which has been included in the Column 3 totals.
2. CD3 Cambourne was not balanced initially and provided only a very rough indication of earthwork volumes.

4. Geotechnical Sensitivity Comparison

4.1 Route A(D)1

	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
Buildings and Civils			
Route Length Comparison (km)			
[1]Route length from ELR:BBM divergence to ELR:SBR connection	41.0	40.7	40.7
Route Plan Areas (m²)			
Plan area / footprint of alignment corridor to extent of earthworks	981,845	944,175	991,984
Maintenance track (3.65m wide) full route length	150,745	148,555	148,555
[2,3,4]Route Earthworks (m³)			
Earthwork cut	1,186,659	1,012,552	950,073
Earthwork fill	1,993,056	1,724,885	2,252,132
Deficit (-) / surplus (+)	-806,466	-712,333	-1,305,059
Earthwork strip volume (all earthworks)	-	-	983,818
Imported Ballast / trackbed	-	-	346,764
Other Earthworks			
[5]Volume of landfill material to be relocated from the Elstow authorised landfill site/former pit to facilitate embankment construction	919,908	919,908	919,908
Private Building Demolition/Purchase/Relocation (no.) (Refer to *Appendix F* for breakdown of buildings impacted)			
Buildings directly impacted	20	20	20
Road, Rail and Watercourse Bridge Infrastructure Requirements, and Related Earthworks (Refer to *Appendix F* for breakdown of bridge types required)			
[6]Railway Viaducts (no.)	**1**	**1**	**1**
Total length (m)	860	860	860
Total bridge area (m²)	9,632	9,632	9,632
Road - Rail bridges (no.)	**21**	**20**	**20**
Overbridges (no.)	13	13	11
Underbridges (no.)	8	7	9
Road Bridge Earthworks (m³)			
Road bridge construction cut volume	58,518	58,518	139,317
Road bridge construction fill volume	317,055	317,055	242,100
Deficit (-) / surplus (+)	-258,537	-258,537	-102783
Total new road construction length (m²)	**5,523**	**5,523**	**5,223**
Total new road construction area (m²)	**65,744**	**65,744**	**62,054**
Watercourse Channel Underbridges	**7**	**7**	**7**
Track and Footpath Bridges			

	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
Track bridges (no.)	**18**	**18**	**18**
Overbridges	10	10	11
Underbridges	8	8	7
Additional vehicular track bridges *(for land access - min. 1 per 1600m) (no.)*	**10**	**10**	**10**
Overbridge (no.)	4	4	4
Underbridges (no.)	6	6	6
Track Earthwork (m³)			
Track bridge construction cut volume	292,590	292,590	263,331
Track bridge construction fill volume	253,860	253,860	296,170
Deficit (-) / surplus (+)	+38,730	+38,730	-32,839
Footbridges (no.)	**18**	**18**	**18**
Overbridges	11	11	11
Underbridges	7	7	7
Track			
SGVs 21-18.5-15-13 Double Junction	1	1	1
HVs 32.365-28-21.829-18.5 Double Junction (nr)	1	1	1
Length of twin track plain line (km)	40.7	40.7	40.7
3no SGVs 28 Emergency Crossovers	3	3	3
3no EVs 21 Emergency Crossovers	-	-	-
Signalling			
Total SEUs (3-aspect or ETCS)	58	58	58
Electrification & Plant			
Principal Supply Points (PSPs)	6	6	6

Notes

1. Route lengths provided are in plan and do not account for length due to vertical change.
2. Phase 2e Geotech earthwork cut and fill volumes have been adjusted for site strip to derive a surplus / deficit figure based on theoretically re-usable material. Site strip material has been reported separately.
3. Volumes provided exclude those related to rail grade separated junctions.
4. No allowance has been made for earthwork cover i.e. seeded or stone facing.
5. The Elstow Landfill volume approximation presented above is based on Environment Agency Landfill shapefile area data together with Environment Agency LiDAR DTM information and Ordnance Survey Terrain 5. The volume includes removal of a corridor with 1:8 slopes assumed through the landfill site to enable embankment construction. Ground improvement may be required prior to embankment construction. No inclusion has been made for any below ground / infilled pit excavation.
6. Viaduct area is based on 11.2m wide corridor width multiplied by plan bridge structure length.

4.2 Route C(D)3

	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
Buildings and Civils			
Route Length Comparison (km)			
[1]Route length from ELR:SPC2 divergence to ELR:SBR connection	45.6	45.5	45.5
Route Plan Areas (m²)			
Plan area / footprint of alignment corridor to extent of earthworks	2,205,191	2,106,747	1,835,319
Maintenance track (3.65m wide) full route length	166,440	166,075	166,075
[2,3,4]Route Earthworks (m³)			
Earthwork cut	6,702,458	6,378,589	2,768,964
Earthwork fill	6,887,168	7,013,136	7,779,125
Deficit (-) / surplus (+)	-184,710	-634,546	-5,010,161
Earthwork strip volume (all earthworks)	-	-	1,801,105
Imported Ballast / trackbed			387,660
Private Building Demolition/Purchase/Relocation (no.)			
Refer to *Appendix F* for breakdown of buildings impacted	10	11	11
Road, Rail and Watercourse Bridge Infrastructure Requirements, and Related Earthworks (Refer to *Appendix F* for breakdown of bridge types required)			
Rail Viaducts (no.)	**4**	**4**	**4**
Total length (m)	2,680	2,680	2,680
Total bridge area (m²)	30,016	30,016	30,016
[5]Road Viaducts (no.)	**1**	**1**	**1**
Total length (m)	332	332	332
Total area (m²)	7,968	7,968	7,968
Road - Rail Bridges (no.)	**18**	**18**	**18**
Underbridges (no.)	9	9	10
Overbridges (no.)	9	9	8
Road Bridge Earthworks (m³)			
Road bridge construction cut volume	29,259	29,259	58,518
Road bridge construction fill volume	262,744	262,744	262,744
Deficit (-) / Surplus (+)	-233,485	-233,485	-204,226
Total New Road Construction Length (m²)	**5,629**	**5,629**	**5,826**
Total New Road Construction Area (m²)	**55,559**	**55,559**	**59,213**
Watercourse Channel Underbridges	**2**	**2**	**2**
Track and Footpath Bridges			
Track bridges (no.)	**14**	**14**	**15**
Overbridges	5	5	8
Underbridges	9	9	7

	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
Additional vehicular track bridges (for land access - min. 1 per 1600m) (no.)	**14**	**14**	**14**
Overbridges	9	9	9
Underbridges	5	5	5
Track Earthwork (m³)			
Track bridge construction cut volume (m³)	87,777	87,777	58,518
Track bridge construction fill volume (m³)	190,395	190,395	296,170
Deficit (-) / surplus (+) (m³)	-102,618	-102,618	-237,652
Footbridges (no.)	**18**	**19**	**17**
Overbridges	4	5	7
Underbridges	14	14	10
Track			
FVs 18.5-16-12.75-10.75 Double Junction (no.)	1	1	1
HVs 32.365-28-21.829-18.5 Double Junction (no.)	1	1	1
Length of twin track plain line (km)	45.5	45.5	45.5
SGVs 28 Emergency Crossovers (no.)	3	3	3
EVs 21 Emergency Crossovers (no.)	-	-	-
Signalling			
Total SEUs (3-aspect or ETCS)	62	62	62
Electrification & Plant			
Principal Supply Points (PSPs)	7	7	7

Notes

1. Route lengths provided are in plan and do not account for length due to vertical change.
2. Phase 2e Geotech earthwork cut and fill volumes have been adjusted for site strip to derive a surplus / deficit figure based on theoretically re-usable material. Site strip material has been reported separately.
3. Volumes provided exclude those related to rail grade separated junctions.
4. No allowance has been made for earthwork cover i.e. seeded or stone facing.
5. Viaduct area based on 11.2m wide corridor width multiplied by plan length between abutments. Single A6 (Paula Radcliffe Way) road adjustment EWR/FZ multi-span bridge based on 24m width by 332m long.

4.3 Sensitivity Comparison - Route C(D)3 - Cam

	Phase 2e 125mph Cambourne	Phase 2e 125mph Geotech
Buildings and Civils		
Route Length Comparison (km)		
[1]Route length from (ELR:BBM) divergence to ELR:SBR connection	49.1	49.1
Route Plan Areas (m²)		
Plan area / footprint of alignment corridor to extent of earthworks	2,008,537	1,635,999
[2,3,4]Route Earthworks (m³)		
Earthwork cut	5,644,107	1,957,573
Earthwork fill	4,319,910	6,055,741
Deficit (-) / surplus (+)	+1,324,855	-4,098,168
Earthwork strip volume (all earthworks)	-	1,589,642
Imported Ballast / trackbed	-	418,332
Private Building Demolition/Purchase/Relocation (no.)		
Refer to *Appendix F* for breakdown of buildings impacted	18	18
Road and Rail Bridge Infrastructure Requirements and Related Earthworks (Refer to *Appendix F* for breakdown of bridge types required)		
Rail Viaducts (no.)	**4**	**4**
Total length (m)	2,680	2680
Total bridge area (m²)	30,016	30,016
[5]Road Viaducts (no.)	**1**	**1**
Total length (m)	332	332
Total area (m²)	7,938	7,938
Road - Rail Bridges (no.)	**22**	**22**
Underbridges (no.)	15	12
Overbridges (no.)	7	10
Road/Rail Bridge Earthworks (m³)		
Bridge construction cut volume	29,259	58,518
Bridge construction fill volume	343,444	343,444
Deficit (-) / Surplus (+)	-314,185	-284,926
Total New Road Construction Length (m²)	**5,538**	**5,745**
Total New Road Construction Area (m²)	**61,771**	**64,318**
Watercourse Channel Underbridges	**5**	**5**
Track and Footpath Bridges		
Track bridges (no.)	**24**	**24**
Overbridges	10	10
Underbridges	14	14
Additional vehicular track bridges (for land access -	**10**	**10**

		Phase 2e 125mph Cambourne		Phase 2e 125mph Geotech	
min. 1 per 1600m) (no.)					
	Overbridges	3		2	
	Underbridges	7		8	
Track Earthwork (m³)					
	Bridge construction cut volume (m³)	234,072		234,072	
	Bridge construction fill volume (m³)	211,550		211,550	
	Deficit (-) / surplus (+) (m³)	+22,522		+22,522	
Footbridges (no.)		**20**		**20**	
	Overbridges	9		10	
	Underbridges	11		10	
Track					
FVs 18.5-16-12.75-10.75 Double Junction (no.)		1		1	
HVs 32.365-28-21.829-18.5 Double Junction (no.)		1		1	
Length of twin track plain line (km)		49.1		49.1	
SGVs 28 Emergency Crossovers (no.)		3		3	
EVs 21 Emergency Crossovers (no.)		-		-	
Signalling					
		No.	SEUs	No.	SEUs
Total SEUs (3-aspect or ETCS)			64		64
Electrification & Plant					
Principal Supply Points (PSPs)		7		7	

Notes

1. Route lengths provided are in plan and do not account for length due to vertical change.
2. Phase 2e Geotech earthwork cut and fill volumes have been adjusted for site strip to derive a surplus / deficit figure based on theoretically re-usable material. Site strip material has been reported separately.
3. Volumes provided exclude those related to rail grade separated junctions.
4. No allowance has been made for earthwork cover i.e. seeded or stone facing.
5. Viaduct area based on 11.2m wide corridor width multiplied by plan length between abutments. Single A6 (Paula Radcliffe Way) road adjustment EWR/FZ multi-span bridge based on 24m width by 332m long.

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Appendix A - Design Decision Log

Design Decision Log

Job Ref:	Project	Rev	Prepared By	Date:	Checked By:	Date:	Approved By:	Date:
145674	East West Rail Central Section - Phase 2e: Geotechnical Sensitivity	01	R. Bell	12/10/18	I.Samworth	13/11/18	I.Samworth	13/11/18

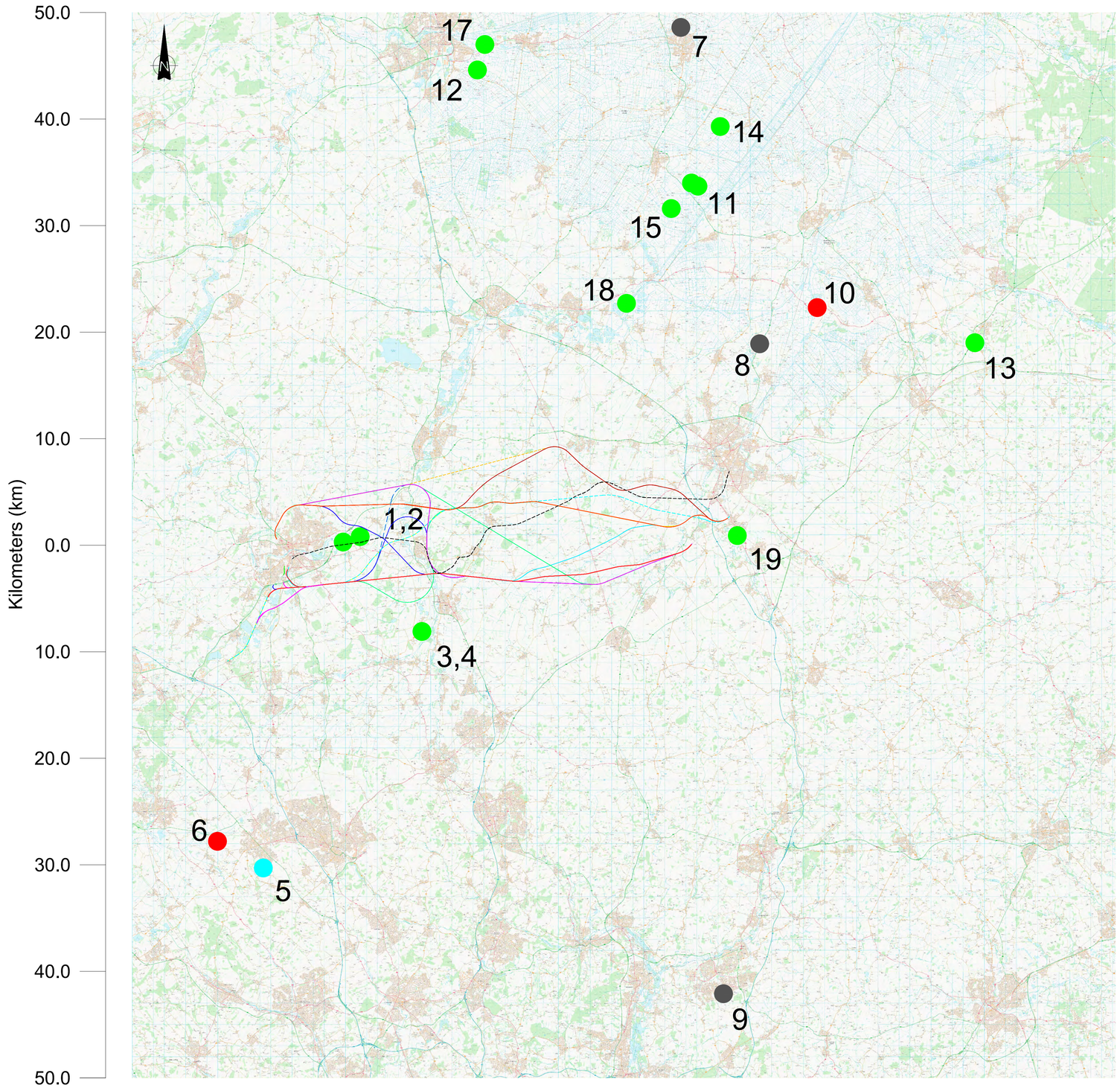
Ref	By	Date	Design Decision	Decision Effect *(Impact on cost, programme, risks etc)*	Designer's Risk Ref
DD01	Team (IP SNE + NRDD)	08/08/18	Routes C(D)3, C(D)3 Cambourne and A(D)1 to be basis of earthwork reassessment (IS, RC, DA, FF, RN, RB present)	• Another route may be chosen for further development which has not been assessed.	
DD02	NRDD	08/08/18	As part of sensitivity, a 'balanced' earthwork strategy will not be applied. Vertical alignment will be based on ground profile fit and efficiency consideration between cutting and embankment size/width.	• The routes are likely have a deficit of material requiring imported fill or locally larger cuttings through widening to provide material (if suitable). • Further assessment of potential sources of suitable general fill will be required. As only type is known for the area but not volume.	
DD03	NRDD	08/08/18	Track elevated 2m above Flood Zone areas crossed.	• Potentially overstated embankment earthwork volume - a lower clearance may be acceptable.	
DD04	NRDD	06/09/18	Calculation of site strip based in 1m deep strip (and infill) for embankments based on corridor width. Cuttings based on removal of 1m deep strip from cutting volume.	• Risk that a greater depth of strip is required when ground investigation is undertaken.	
DD05	NRDD	06/09/18	Applied MCHW Series 600 for assumed re-use soil types as general earthwork fill and re-use of cut material.	• Risk that ground investigation soils testing indicates further soils 'modification' required to make cut soils suitable. E.g. lime addition/stabiliation, drying etc. • 100% re-use has been assumed for all cut material.	
DD06	NRDD	06/09/18	Cutting slopes have been based on research by TRRL (Perry, 1989) of highways slope failures.	• Steeper or slacker slope geometry may be possible based on local soil characteristics due to inherent variability.	

END

Appendix B - Risk Log

Ref.	Design Risk Item	Mitigation	Further work
RA1	Earthwork volume and footprint estimation – transitions in adjacent slope angles have not been modelled.	None.	Further detailed modelling would be required to apply transitions. At this stage is of diminishing returns.
RA2	Embankment and cutting heights / depths in general. Numerous embankments and cutting over 10m high / deep for (C(D)3 & C(D)3 Cambourne).	None. This reflects the topography and specified track gradient (generally 1:125)	Determination of cost/impact benefit between bridge vs large earthwork required.
RA3	Earthwork estimation - site strip.	Site strip based on a depth of 1.0m throughout new route lengths.	Site investigation required to aid accurate determination of strip depth.
RA4	Earthwork volume estimation - cut slope angles.	Volumes based on TRRL research for road earthworks. Specifically cutting and embankment failures in various types of superficial and solid geology.	Site investigation and slope stability analysis required to ascertain theoretical earthwork performance and any interventions required. i.e. treatment, pre-loading / draining.
RA5	Earthwork cut (site won) material re-use. 100% re-use assumed for general fill and site strip material. Compared to previous assumption that all cut material is disposed of and all fill material is imported.	None.	Site investigation required to ascertain insitu soil characteristics and suitability for re-use and identify any pre-treatment. Further investigation of earthworks arrangement/transportation i.e.cutting formation and consecutive embankment construction. Engage with a earthwork Principal Contractor as part of early engagement.

Appendix C - Mineral Extraction / Quarry Sites



MINERAL EXTRACTION MAP

NOT TO SCALE

Ref	Name	Owner	Location	Easting/Northing	Resource	Material use
BEDFORDSHIRE						
1	Willington Quarry	Hope Construction Materials	TL098 503	509800, 250300	Sand and gravel, Quaternary, River Terrace Deposits (River Great Ouse Gravel)	Graded sand and gravel concrete aggregate
2	Dairy Farm (Willington)	Hope Construction Materials	TL114 508	511400, 250800	Sand and gravel, Quaternary, River Terrace Deposits (River Great Ouse Gravel)	Graded sand and gravel concrete aggregate
3	Broom Quarry	LaFarge-Tarmac	TL172 434	517200, 241900	Sand and gravel, Quaternary, Glaciofluvial Deposits, Mid Pleistocene	Graded sand and gravel
4	Broom South Quarry	LaFarge-Tarmac	TL172 419	517200, 241900	Sand and gravel, Quaternary, Glaciofluvial Deposits, Mid Pleistocene	Graded sand and gravel
5	Kensworth Quarry	Cemex UK Cement	TL023 197	502300, 219700	Chalk, Cretaceous, White Chalk Subgroup (Middle Chalk)	Cement manufacture
6	Lower End Quarry (Totternhoe Lime Works)	H G Clarke & Son	SP980 222	498000, 222200	Chalk, Cretaceous, White Chalk Subgroup (Middle Chalk)	Building stone
CAMBRIDGESHIRE						
7	Whitenmoor, Marshalling Yard (Network Rail March Rail Depot)	Network Infrastructure Ltd	TL415 986	541500, 298600	Spent rail ballast	Recycled aggregates
8	Waterbeach Depot	Waterbeach Frimstone Ltd	TL489 689	548900, 268900	Construction and demolition waste	Recycled aggregates
9	Wisbech Depot	Wisbech Frimstone Ltd	TL455 079	545500, 207900	Construction and demolition waste	Recycled aggregates
10	Wicken Quarry (Dimmocks Cote)	Wicken francis Flower (Eastern)	TL543 723	554300, 272300	Limestone, Jurassic, Upware Limestone Member.	Crushed rock aggregate Asphalting and Agricultural lime
11	Block Fen Quarry	LaFarge-Tarmac	TL425 840	542500, 284000	Sand and gravel, Quaternary, River Terrace Deposits (Fen Edge Gravel)	Graded sand and gravel
12	Float Fish Farm Quarry	Mick George Ltd	TL224 946	522400, 294600	Sand and gravel, Quaternary, River Terrace Deposits	As dug aggregate
13	Kennett Hall (Kennett Hall Farm)	Mick George Ltd	TL691 690	569100, 269000	Sand and gravel, Quaternary, River Terrace Deposits	Graded sand and gravel
14	Lyon's Farm Reservoir	Mick George Ltd	TL452 893	545200, 289300	Sand and gravel, Quaternary, River Terrace Deposits	As dug aggregate
15	Mepal Quarry (Block Fen Quarry)	Aggregate Industries UK	TL431 837	543100, 283700	Sand and gravel, Quaternary, River Terrace Deposits (Fen Edge Gravel)	Graded sand and gravel
16	Mepal Quarry (Sutton Gault)	Sutton Gault Frimstone Ltd	TL406 816	540600, 281600	Sand and gravel, Quaternary, River Terrace Deposits	Graded sand and gravel
17	Must Farm and Kings Dyke Quarry (Whittlesey)	Hanson Building Products	TL231 970	523100, 297000	Sand and gravel, Quaternary, River Terrace Deposits	Graded sand and gravel
18	Needingworth Quarry	Hanson Aggregates	TL364 727	536400, 272700	Sand and gravel, Quaternary, River Terrace Deposits (River Ouse Gravel)	Graded sand and gravel
19	Sawston (Duxford, Dernford Farm)	Aggregate Industries UK	TL468 509	546800, 250900	Sand and gravel, Quaternary, River Terrace Deposits	Concrete aggregate

MINERAL EXTRACTION SITES

LEGEND/NOTES

1. REFER TO REPORT NR-IP-EN-IDG-TM145674-EWRCS-P2E-010 FOR FURTHER DETAILS.
2. MINERAL EXTRACTION SITES BASED ON BGS DIRECTORY OF MINES AND QUARRIES, CAMERON, 2014.
3. REPRODUCED FROM THE ORDNANCE SURVEY MAP WITH PERMISSION OF THE CONTROLLER OF HER MAJESTY'S STATIONARY OFFICE. © CROWN COPYRIGHT AND DATABASE RIGHTS 2018

KEY

- SAND & GRAVEL
- LIMESTONE
- CHALK
- RECYCLED AGGREGATES

Ordnance Survey

REV	DATE	DESCRIPTION OF REVISIONS	DRAWN	CHK'D	APPR'D

SAFETY HEALTH AND ENVIRONMENTAL INFORMATION

THE HAZARDS AND RISKS ASSOCIATED WITH THE WORKS SHOWN ON THIS DRAWING AND DESCRIBED IN THE SCHEDULE OF WORKS ARE CONSIDERED TO BE WITHIN THE REASONABLE, NORMAL AND ACCEPTABLE LIMITS FOR GENERAL BUILDING AND MAINTENANCE WORKS. PLEASE REFER TO DESIGNER RISK ASSESSMENT

DOCUMENT REF: N/A

STATUS: FOR INFORMATION | SUITABILITY CODE: N/A

CLIENT: NetworkRail

DESIGNER: DESIGN DELIVERY | NetworkRail

York I.C.C. Leeman Road, York, YO26 4ZD
Tel: 033 085 49683 Web: www.networkrail.co.uk

PROJECT :

EAST WEST RAIL
CENTRAL SECTION

DRAWING TITLE :

GEOTECHNICAL SENSITIVITY
MINERAL EXTRACTION MAP

DESIGNED	A. OLIVER	SIGNED	DATE 13-11-18
DRAWN	A. OLIVER	SIGNED	DATE 13-11-18
CHECKED	R. BELL	SIGNED	DATE 13-11-18
APPROVED	I. SAMWORTH	SIGNED	DATE 13-11-18

SCALE (@ A1 SHEET SIZE = 841 x 594): NOT TO SCALE | ELR: N/A | MILEAGE: N/A

DRAWING NUMBER: 145674-NRD-AL-EWR-DRG-C-CV-100020 | REVISION: P01

CAD TEMPLATE : NRDD-YORK-A1-v1.0.dwt

Appendix D – Route Earthwork Geometry

Route A(D)1

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
7.3	7.9	At Grade	Head deposits overlying Peterborough Member [Oxford Clay Formation]		N/A
7.9	11.8	Embankment	Peterborough Member – Mudstone [Oxford Clay Formation]. Stoke Goldington Member - Sand & Gravel and Head Deposits between A6 and A600		1v:2h
11.8	12.5	At Grade	Stoke Goldington Member - Sand And Gravel and Head Deposits between A6 and A600, overlying Peterborough Member – Mudstone [Oxford Clay Formation]		1v:2h
12.5	16.9	Embankment	Stoke Goldington Member - Sand And Gravel and Head Deposits, overlying Peterborough Member – Mudstone and Stewartby Member – Mudstone [Oxford Clay Formation]		1v:2h
16.9	18.3	Cutting (Sheerhatch Wood)	Oadby Member – Diamicton overlying Stewartby Member – Mudstone [Oxford Clay Formation]	16.7	1v:3.5h
18.3	19.6	Embankment	Stewartby Member – Mudstone [Oxford Clay Formation]. Predominantly no superficial deposits indicated to be present.		1v:2h
19.6	19.7	Cutting	Diamicton of the Oadby Member overlying Stewartby Member, Mudstone [Oxford Clay Formation]	1.2	1v:2.5h
19.7	22.7	Embankment	Intermittent Glaciofluvial Deposits – sand and gravel, or River Terrace Deposits – sand and gravel, overlying Stewartby Member, Mudstone [Oxford Clay Formation]		1v:2h

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
22.7	23.5	Structure	River Terrace Deposits – sand and gravel and Alluvium – silt, clay sand and gravel, overlying Stewartby Member, Mudstone [Oxford Clay Formation]		Viaduct structure proposed to cross alluvial floodplain.
23.5	26.1	Embankment	Alluvium – silt, clay sand and gravel overlying Sandstone of the Woburn Sands Formation		1v:2h
26.1	26.4	Cutting	Sandstone of the Woburn Sands Formation	2.8	1v:2h
26.4	28.2	Embankment	Alluvium (clay,silt sand and gravel at watercourse crossing and Oadby Member – Diamicton. Overlying predominantly. Sandstone of the Woburn Sands Formation		1v:2h
28.2	28.9	Cutting	Oadby Member – Diamicton overlying Mudstone of the Gault Formation	4.0	1v:5h
28.9	30.0	Embankment	Oadby Member – Diamicton overlying Mudstone of the Gault Formation		1v:2h
30.0	30.3	At Grade	Oadby Member – Diamicton overlying Mudstone of the Gault Formation		N/A
30.3	31.3	Embankment	Oadby Member – Diamicton overlying Mudstone of the Gault Formation. Alluvium local to the watercourse west of Eyeworth Road		1v:2h
31.3	32.2	Cutting	Oadby Member – Diamicton overlying Mudstone of the Gault Formation	6.2	1v:5h
32.3	34.5	Embankment	South and east of Tadlow Village no superficial deposits recorded. Bedrock, Mudstone of the Gault Formation. Alluvium local to the watercourse west of Eyeworth Road		1v:2h
34.5	36.5	At Grade	No superficial deposits recorded. Bedrock, Mudstone of the Gault Formation		N/A

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
36.5	37.1	Embankment	No superficial deposits recorded. Bedrock, Mudstone of the Gault Formation. Alluvium local to watercourse crossings		1v:2h
37.1	40.5	At Grade	No superficial deposits recorded. Bedrock, Mudstone of the Gault Formation. Alluvium local to watercourse crossings		N/A
40.5	40.7	Embankment	No superficial deposits recorded. Bedrock, Mudstone of the Gault Formation. Alluvium local to watercourse crossings		1v:2h
40.7	41.9	At Grade	No superficial deposits recorded. Bedrock, Mudstone of the Gault Formation. Alluvium local to watercourse crossings		N/A
41.9	42.1	Embankment	No superficial deposits recorded. Bedrock, Mudstone of the Gault Formation. Alluvium local to watercourse crossings		1v:2h
42.1	42.3	At Grade	No superficial deposits recorded. Bedrock, Chalk of the West Melbury Marly Chalk Formation Alluvium local to watercourse crossings		N/A
42.3	43.1	Embankment	Bedrock, Chalk of the West Melbury Marly Chalk Formation . Alluvium local to watercourse crossings		1v:2h
43.1	44.9	At Grade	River Terrace Deposits – sand and gravel to west of Barrington Road, overlying Chalk of the West Melbury Marly Chalk Formation		N/A
44.9	45.3	Embankment	River Terrace Deposits – sand and gravel to west of Barrington Road, overlying Chalk of the West Melbury Marly Chalk Formation . Alluvium local to watercourse crossings		1v:2h
45.3	46.7	At Grade	River Terrace Deposits – sand and gravel to west of Barrington Road, overlying Chalk of the West Melbury Marly Chalk Formation .		N/A

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
46.7	47.2	Embankment	River Terrace Deposits – sand and gravel to west of Barrington Road, overlying Chalk of the West Melbury Marly Chalk Formation		1v:2h
47.2	47.6	At Grade	River Terrace Deposits – sand and gravel to west of Barrington Road, overlying Chalk of the West Melbury Marly Chalk Formation		N/A
47.6	48.0	Cutting	Chalk of the West Melbury Marly Chalk Formation .or Chalk of the Totternhoe Stone Member	3.2	1v:2h

Route C(D)3

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
14.2	14.7	At Grade	Kellaways Sand Member – Interbedded Sandstone And Siltstone		N/A
14.7	15.6	Structure	Alluvium local to the River Great Ouse channel overlying Limestone / argillaceous rocks of the Great Oolite Group		N/A
15.6	16.3	Embankment	Stoke Goldington Member And Felmersham Member (undifferentiated) - Sand And Gravel, overlying Kellaways Formation - Sandstone, Siltstone And Mudstone, then Peterborough Member – Mudstone		1v:2h
16.3	18.0	Cutting	Oadby Member – Diamicton, overlying Peterborough Member - Mudstone.	16.0	1v:3.5h
18.0	18.8	Embankment	Oadby Member – Diamicton (where present) overlying Peterborough Member - Mudstone. Head deposits and Alluvium local to watercourse west of Cleat Hill		1v:2h
18.8	19.3	Cutting (Cleat Hill)	Oadby Member – Diamicton (where present) overlying Peterborough Member - Mudstone.	12.5	1v:3.5h
19.3	20.7	Embankment	Head deposits and Alluvium local to watercourse east of Cleat Hill, overlying Peterborough Member - Mudstone.		1v:2h
20.7	22.4	Cutting	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.	9.5	1v:3.5h
22.4	22.9	At Grade	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		N/A
22.9	23.1	Embankment	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:2h

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
23.1	24.0	Cutting	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.	1.5	1v: 1.75h
24.0	25.7	Embankment	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:2h
25.7	25.9	At Grade	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		N/A
25.9	27.0	Embankment	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:2h
27.0	27.3	At Grade	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		N/A
27.3	28.3	Embankment	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:2h
28.4	29.2	Structure	Oadby Member – Diamicton and River Terrace Deposits to western abutment. River Terrace Deposits - Sand and Gravel to eastern abutment. Alluvium present local to River Ivel channel. Underlying bedrock is Mudstone of the Peterborough Member.		N/A
29.1	35.2	Embankment	River Terrace Deposits - Sand and Gravel with no superficial deposits recorded from Ch.30.3km. Underlying bedrock is Mudstone of the Peterborough Member. From 35.km underlying bedrock changes to Mudstone of the West Walton Formation And Ampthill Clay Formation.		1v:2h

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
35.2	35.3	At Grade	Mudstone of the West Walton Formation And Ampthill Clay Formation. No superficial deposits recorded.		N/A
35.3	36.9	Embankment	Mudstone of the West Walton Formation And Ampthill Clay Formation. No superficial deposits recorded.		1v:2h
36.9	38.0	Cutting	From Ch.37.6km Oadby Member - Diamicton. Underlying bedrock is Sandstone of the Woburn Sands Formation then Mudstone of the Gault Formation from Ch.37.7km.	3.0	1v:1.75h
38.0	38.5	Embankment	Oadby Member – Diamicton, overlying Mudstone of the Gault Formation.		1v:2h
38.5	38.9	At Grade	Oadby Member – Diamicton, overlying Mudstone of the Gault Formation.		N/A
38.9	39.5	Cutting	Oadby Member – Diamicton, overlying Mudstone of the Gault Formation.	1.0	1v:1.75h
39.5	39.7	At Grade	Oadby Member – Diamicton, overlying Mudstone of the Gault Formation.		N/A
39.7	40.2	Cutting	Oadby Member – Diamicton, overlying Mudstone of the Gault Formation.	1.6	1v:1.75h
40.2	41.2	Embankment	Oadby Member – Diamicton, overlying Mudstone of the Gault Formation.		1v:2h
41.2	43.2	At Grade	Oadby Member – Diamicton, overlying Mudstone of the Gault Formation.		N/A

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
43.2	46.0	Embankment	Oadby Member – Diamicton, overlying the following bedrock formations: - - Ch. 43.2 to 43.5km: Mudstone of the Gault Formation - Ch.43.5km to 44.7km - Sandstone of the Woburn Sandstone Formation - Ch.44.7 to 45.6km: Mudstone of the Gault Formation - Ch.45.6 to 46.0km: Chalk of the West Melbury Marly Chalk Formation		1v:2h
46.0	46.5	At Grade	Oadby Member – Diamicton overlying Chalk of the West Melbury Marly Chalk Formation.		N/A
46.5	48.9	Cutting	Oadby Member – Diamicton overlying Chalk of the West Melbury Marly Chalk Formation.	7.5	1v: 3.5h
48.9	49.2	Embankment	Oadby Member – Diamicton overlying Chalk of the West Melbury Marly Chalk Formation.		1v:2h
49.2	49.5	Cutting	Oadby Member – Diamicton overlying Chalk of the West Melbury Marly Chalk Formation.	6.0	1v: 3.5h
49.5	51.3	Embankment	Bedrock of the West Melbury Marly Chalk Formation to Ch.50.2km. Mudstone of the Gualt Formation from Ch.50.2 to Ch.50.8km, then West Melbury Marly Chalk Formation to Ch.51.3km.		1v:2h
51.3	51.7	Cutting	Oadby Member – Diamicton overlying Chalk of the Totternhoe Stone Member and Zig Zag Chalk Formations .	10.5	1v: 3.5h
51.7	52.1	Embankment	Oadby Member – Diamicton overlying Chalk of the Totternhoe Stone Member and Zig Zag Chalk Formations.		1v:2h

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
52.1	54.1	Cutting	Oadby Member – Diamicton overlying Chalk of the Totternhoe Stone Member and Zig Zag Chalk Formations to Ch.53.7km. Then Chalk of the West Melbury Marly Chalk Formation to Ch.54.1km.	14.5	1v: 3.5h
54.1	57.6	Embankment	From Ch. 54.7km Alluvium along the River Cam channel course and River Terrace Deposits over the wider floodplain. Underlying bedrock is Mudstone of the Gault Formation from Ch.54.7 to Ch.56.6km, then Chalk of the West Melbury Marly Chalk Formation.		1v:2h
57.6	58.4	Structure	Alluvium along the River Cam channel course and River Terrace Deposits over the wider floodplain. Underlying bedrock is Chalk of the West Melbury Marly Chalk Formation.		N/A
58.4	59.1	Embankment	Alluvium along the River Cam channel course and River Terrace Deposits over the wider floodplain. Underlying bedrock is Chalk of the West Melbury Marly Chalk Formation.		1v:2h
58.7	59.1	Structure	Alluvium along the River Cam channel course and River Terrace Deposits over the wider floodplain. Underlying bedrock is Chalk of the West Melbury Marly Chalk Formation.		N/A
58.8	59.1	Embankment	Alluvium along the River Cam channel course and River Terrace Deposits over the wider floodplain. Underlying bedrock is Chalk of the West Melbury Marly Chalk Formation.		1v:2h
59.1	59.7	Cutting	Alluvium along the River Cam channel course and River Terrace Deposits over the wider floodplain. Underlying bedrock is Chalk of the West Melbury Marly Chalk Formation.	3.0	1v:2h

Route C(D)3 Cambourne

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
14.2	14.7	At Grade	Kellaways Sand Member – Interbedded Sandstone And Siltstone		1v:4h
14.7	15.5	Structure	Alluvium local to the River Great Ouse channel overlying Limestone / argillaceous rocks of the Great Oolite Group		N/A
15.5	16.3	Embankment	Stoke Goldington Member And Felmersham Member (undifferentiated) - Sand And Gravel, overlying Kellaways Formation - Sandstone, Siltstone And Mudstone, then Peterborough Member – Mudstone		1v:2h
16.3	18.0	Cutting	Oadby Member – Diamicton, overlying Peterborough Member - Mudstone.	16.0	1v: 3.5h
18.0	18.8	Embankment	Oadby Member – Diamicton (where present) overlying Peterborough Member - Mudstone. Head deposits and Alluvium local to watercourse west of Cleat Hill		1v:2h
18.8	19.3	Cutting (Cleat Hill)	Oadby Member – Diamicton (where present) overlying Peterborough Member - Mudstone.	12.5	1v: 3.5h
19.3	20.7	Embankment	Head deposits and Alluvium local to watercourse east of Cleat Hill, overlying Peterborough Member - Mudstone.		1v:2h
20.7	22.4	Cutting	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.	9.5	1v: 3.5h
22.4	22.9	At Grade	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:4h
22.9	23.1	Embankment	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:2h

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
23.1	24.0	Cutting	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.	1.5	1v:1.75h
24.0	25.7	Embankment	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:2h
25.7	25.9	At Grade	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:4h
25.9	27.0	Embankment	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:2h
27.0	27.3	At Grade	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:4h
27.3	28.4	Embankment	Oadby Member – Diamicton overlying Peterborough Member - Mudstone.		1v:2h
28.4	29.2	Structure	Oadby Member – Diamicton and River Terrace Deposits to western abutment. River Terrace Deposits - Sand and Gravel to eastern abutment. Alluvium present local to River Ivel channel. Underlying bedrock is Mudstone of the Peterborough Member.		N/A
29.2	34.8	Embankment	River Terrace Deposits - Sand and Gravel then Diamicton (Till) of the Oadby Member with no superficial deposits recorded from Underlying bedrock is Mudstone of the Peterborough Member.		1v:2h
34.8	35.9	Cutting	Diamicton (Till) of the Oadby Member overlying Mudstone of the West Walton Formation And Ampthill Clay Formation.	10	1v: 3.5h

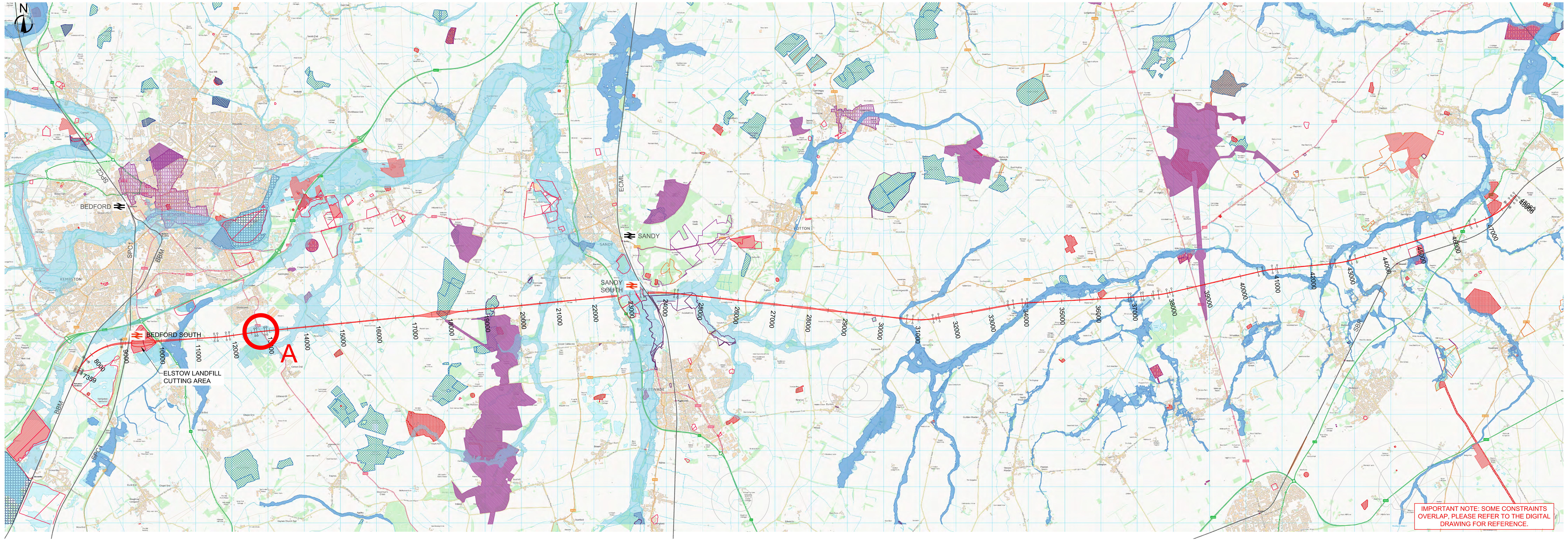
Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
35.9	36.1	Embankment	Mudstone of the West Walton Formation And Ampthill Clay Formation.		1v:2h
36.1	37.0	Cutting	Diamicton of the Oadby Member overlying Mudstone of the West Walton Formation And Ampthill Clay Formation.	3.5	1v:3h
37.0	42.0	Embankment	Diamicton of the Oadby Member from 37.0 to 37.3km (then no superficial deposits recorded), and Diamicton from 40.5 to 42km The following Bedford underlies: 37.0 – 37.5km - Mudstone of the West Walton Formation And Ampthill Clay Formation. 37.5km to 38.2km - Mudstone of the Peterborough Member 38.2 – 42.0km - Mudstone of the West Walton Formation And Ampthill Clay Formation.		1v:2h
42.0	42.5	At Grade	Diamicton of the Oadby Member overlying Mudstone of the West Walton Formation And Ampthill Clay Formation.		1v:4h
42.5	45.8	Embankment	Diamicton of the Oadby Member overlying Mudstone of the West Walton Formation And Ampthill Clay Formation.		1v:2h
45.8	46.8	Cutting	Diamicton of the Oadby Member overlying Mudstone of the West Walton Formation And Ampthill Clay Formation.	2.4	1v:1.75h
46.8	47.9	Embankment	Diamicton of the Oadby Member overlying Sandstone of the Woburn Sands Formation (Lower Greensand)		1v:2h
47.9	48.1	At grade	Diamicton of the Oadby Member overlying Sandstone of the Woburn Sands Formation (Lower Greensand)		1v:4h
48.1	48.5	Embankment	Diamicton of the Oadby Member overlying Sandstone of the Woburn Sands Formation (Lower Greensand)		1v:2h

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
48.5	49.0	Cutting	Diamicton of the Oadby Member overlying Mudstone of the Gault Formation	6.2	1v:3.5h
49.0	49.7	Embankment	Diamicton of the Oadby Member overlying Mudstone of the Gault Formation. Locally Alluvium and River Terrace Deposits along watercourses.	1.6	1v:2h
49.7	49.8	Cutting	Diamicton of the Oadby Member overlying Mudstone of the Gault Formation	1.5	1v:1.75h
49.8	50.7	Embankment	Diamicton of the Oadby Member overlying Mudstone of the Gault Formation. Locally Alluvium and River Terrace Deposits along watercourses.		1v:2h
50.7	50.8	At Grade	Diamicton of the Oadby Member overlying Mudstone of the Gault Formation		1v:4h
50.8	51.0	Embankment	Diamicton of the Oadby Member overlying Mudstone of the Gault Formation		1v:2h
51.0	51.2	Cutting	Diamicton of the Oadby Member to 51.1km overlying Mudstone of the Gault Formation. No superficial deposits recorded from 51.1km.	0.7	1v:3.5h
51.2	51.6	Embankment	No superficial deposits recorded. Bedrock is Mudstone of the Gault Formation.		1v:2h
51.6	51.8	Cutting	No superficial deposits recorded. Bedrock is Mudstone of the Gault Formation.	0.6	1v:3.5h
51.8	52.0	Embankment	No superficial deposits recorded. Bedrock is Mudstone of the Gault Formation.		1v:2h
52.0	52.3	Cutting	No superficial deposits recorded. Bedrock is Mudstone of the Gault Formation.	4.5	1v:4h

Chainage (km)		Earthwork Type (Reference)	Geology	Maximum Cutting Depth (m)	Slope Angle Ratio
From	To				
52.3	56.3	Embankment	Alluvium and River Terrace Deposits local to watercourse 52.0km to 52.8km. No superficial deposits recorded from 52.8 to 54km. Diamicton of the Oadby Member from 54 to 54.4km. Bedrock is Mudstone of the Gault Formation.		1v:2h
56.3	56.6	Cutting	No superficial deposits recorded. Bedrock is Mudstone of the Gault Formation.	1.6	1v:3.5h
56.6	62.7	Embankment	Superficial Deposits: - 56.6km - 58.0km: None recorded 58.0km - 59.2km: Alluvium and 59.2km - 61.0km: None recorded 61.0km – 62.7km: River Terrace Deposits. Bedrock is recorded to be Mudstone of the Gault Formation from 56.6km to 59.5km then Chalk of the West Melbury Marly Chalk Formation from 59.5km to 62.7km.		1v:2h
62.7	62.6	Cutting	River Terrace Deposits from 62.7km to 63.1km. No superficial deposits recorded from 62.1 to 62.6km. Bedrock is Chalk of the West Melbury Marly Chalk Formation.	3.2	1v:2.5h

Appendix E - Route General Arrangements

- A(D)1
- C(D)3
- C(D)3 - Cambourne



PLAN SHOWING HORIZONTAL OPTION A1

SCALE 1:50000

ROUTE LENGTH: 48.06 Km

ROUTE LENGTH FROM DIVERGENCE: 40.70 Km

ROUTE LENGTH FROM NODE A: 35.36 Km

CUT VOLUME: 1,204,109 Cu. m^3

FILL VOLUME: 1,483,738 Cu. m^3

NET VOLUME: CORRIDOR 279,629 Cu. m^3 DEFICIT

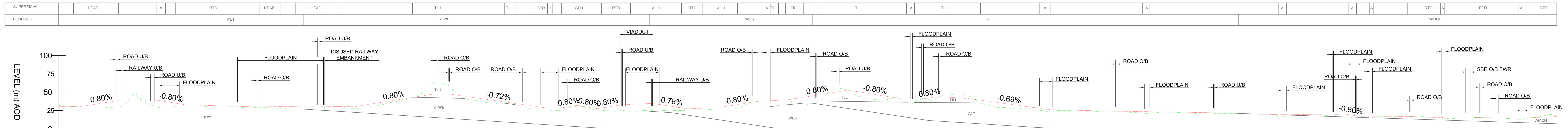
FOOTPRINT: 1,004,427 m^2

CUT VOLUME: 1,135,277 Cu. m^3

FILL VOLUME: 1,482,851 Cu. m^3

NET VOLUME: CORRIDOR 347,574 Cu. m^3 DEFICIT

FOOTPRINT: 991,984 m^2



Chainage	7358.754	8000.000	9000.000	10000.000	11000.000	12000.000	13000.000	14000.000	15000.000	16000.000	17000.000
Existing Levels	30.877	30.001	29.998	30.301	31.000	30.626	29.000	27.000	27.000	31.628	43.297
Proposed Levels	30.655	30.800	38.717	39.286	32.487	31.062	30.163	30.836	30.467	35.075	43.075

Chainage	18000.000	19000.000	20000.000	21000.000	22000.000	23000.000	24000.000	25000.000	26000.000	27000.000	28000.000
Existing Levels	57.275	35.659	29.942	26.000	25.999	23.992	25.484	26.242	32.244	31.000	37.650
Proposed Levels	47.267	40.079	32.892	28.674	27.580	33.539	30.739	28.304	34.679	39.108	46.240

Chainage	29000.000	30000.000	31000.000	32000.000	33000.000	34000.000	35000.000	36000.000	37000.000	38000.000
Existing Levels	47.103	42.244	39.675	46.477	29.076	25.000	24.000	24.000	21.535	21.893
Proposed Levels	51.159	43.159	42.070	41.522	34.961	28.042	25.316	24.077	23.401	22.586

Chainage	39000.000	40000.000	41000.000	42000.000	43000.000	44000.000	45000.000	46000.000	47000.000	[illegible]
Existing Levels	21.000	20.000	18.895	17.369	15.000	16.508	13.824	15.441	13.007	[illegible]
Proposed Levels	21.609	20.105	19.683	19.124	17.133	16.909	15.758	15.434	14.602	[illegible]

VERTICAL PROFILE OPTION A1

HORIZONTAL SCALE1:50000
VERTICAL SCALE 1:2500

SCALE 1:50,000

LEGEND/NOTES

1. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE.
2. DO NOT SCALE FROM THIS DRAWING.
3. CHAINAGE USED IS CALCULATED USING 0m AT LIDLINGTON STATION.
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EXTENTS OF PROPOSED CORRIDOR
EXISTING GROUND
PROPOSED HORIZONTAL CENTERLINE AND VERTICAL ALIGNMENT
EXISTING RAILWAY

DRAWING NEEDS TO BE PRINTED IN COLOUR

REV	DATE	DESCRIPTION OF REVISIONS	DRAWN	CHK'D	APPR'D
P01	99/99/99	Type Here	ANO	ANO	ANO

SAFETY HEALTH AND ENVIRONMENTAL INFORMATION

THE HAZARDS AND RISKS ASSOCIATED WITH THE WORKS SHOWN ON THIS DRAWING AND DESCRIBED IN THE SCHEDULE OF WORKS ARE CONSIDERED TO BE WITHIN THE REASONABLE, NORMAL AND ACCEPTABLE LIMITS FOR GENERAL BUILDING AND MAINTENANCE WORKS. PLEASE REFER TO DESIGNER RISK ASSESSMENT

DOCUMENT REF: N/A

STATUS: FOR INFORMATION
SUITABILITY CODE: N/A

CLIENT: NetworkRail

DESIGNER: DESIGN DELIVERY | NetworkRail

PROJECT: EAST WEST RAIL CENTRAL SECTION

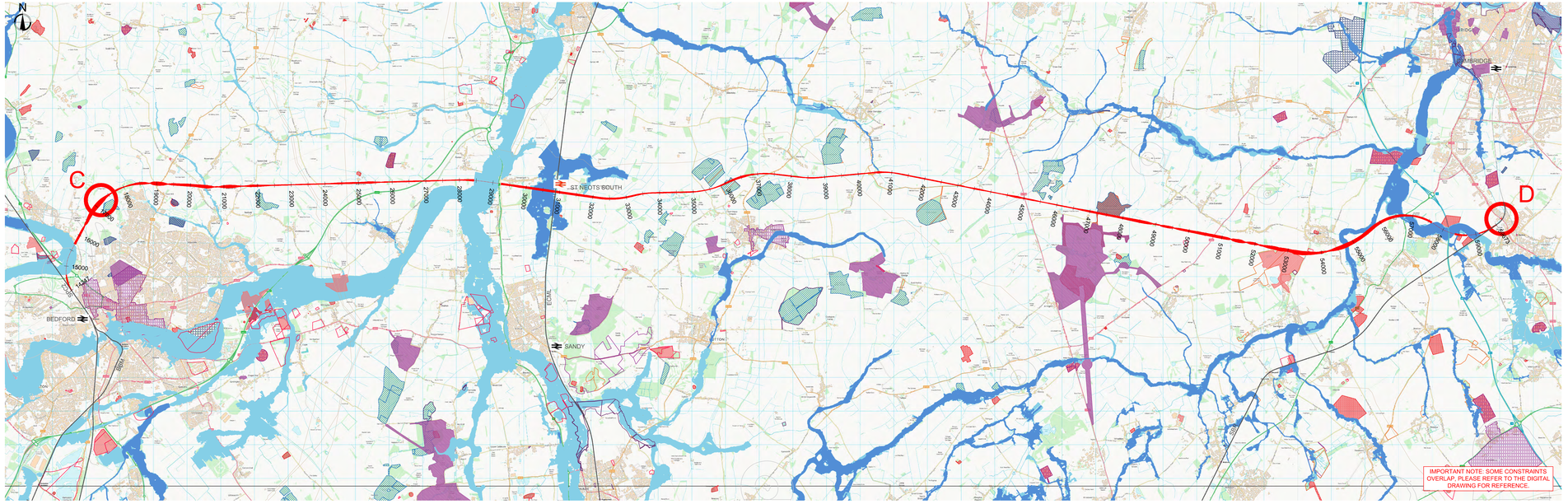
DRAWING TITLE: GEOTECHNICAL SENSITIVITY OPTION AD1

DESIGNED	A. OLIVER	SIGNED		DATE	13-11-18
DRAWN	A. OLIVER	SIGNED		DATE	13-11-18
CHECKED	R. BELL	SIGNED		DATE	13-11-18
APPROVED	I. SAMWORTH	SIGNED		DATE	13-11-18

SCALE (@ A1+2 SHEET SIZE = 1261 x 594): 1:50000
ELR: N/A
MILEAGE: N/A

DRAWING NUMBER: 145674-NRD-[illegible]R-AD1-DRG-C-CV-200400
REVISION: P01

CAD TEMPLATE : NRDD-B&C-YORK-A1-v1.0.dwt



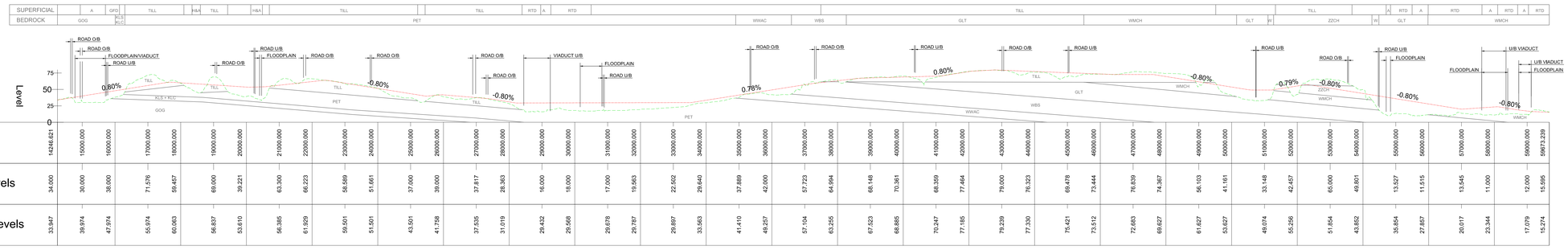
PLAN SHOWING HORIZONTAL OPTION C3

SCALE 1:50000

ROUTE DETAILS	
ROUTE LENGTH:	59.7 Km
ROUTE LENGTH FROM DIVERGENCE:	45.4 Km
ROUTE LENGTH FROM NODE C:	42.4 Km

CUTTING BALANCED	
CUT VOLUME:	3,718,475 Cu. m^3
FILL VOLUME:	6,603,551 Cu. m^3
NET VOLUME: CORRIDOR	2,885,076 Cu. m^3 DEFICIT
FOOTPRINT:	1,908,366 m^2

TUNNEL BALANCED	
CUT VOLUME:	3,351,859 Cu. m^3
FILL VOLUME:	6,603,553 Cu. m^3
NET VOLUME: CORRIDOR	3,251,694 Cu. m^3 DEFICIT
FOOTPRINT:	1,807,340 m^2



Chainage	14246.621	15000.000	16000.000	17000.000	18000.000	19000.000	20000.000	21000.000	22000.000	23000.000	24000.000	25000.000	26000.000	27000.000	28000.000	29000.000	30000.000	31000.000	32000.000	33000.000	34000.000	35000.000	36000.000	37000.000	38000.000	39000.000	40000.000	41000.000	42000.000	43000.000	44000.000	45000.000	46000.000	47000.000	48000.000	49000.000	50000.000	51000.000	52000.000	53000.000	54000.000	55000.000	56000.000	57000.000	58000.000	59000.000	59873.239
Existing Levels	34.000	30.000	38.000	71.376	59.457	69.000	39.221	63.300	66.223	58.589	51.661	37.000	39.000	37.817	28.363	16.000	18.000	17.000	19.563	22.502	29.640	37.889	42.000	57.723	64.994	68.148	70.361	68.359	77.464	79.000	76.323	69.478	73.444	76.839	74.367	56.103	41.161	33.148	42.457	65.000	49.801	13.527	11.515	13.545	11.000	12.000	15.595
Proposed Levels	33.947	39.974	47.974	55.974	60.063	56.837	53.610	56.385	61.929	59.501	51.501	43.501	41.768	37.535	31.019	29.432	29.568	29.678	29.787	29.897	33.563	41.410	49.257	57.104	63.255	67.523	68.885	70.247	77.185	79.239	77.330	75.421	73.512	72.693	69.627	61.627	53.627	49.074	55.256	51.854	43.852	35.854	27.857	20.017	23.344	17.079	15.274

VERTICAL PROFILE OPTION C3

HORIZONTAL SCALE1:50000
VERTICAL SCALE 1:2500

0 1 2 3 4 5km
SCALE 1:50,000

LEGEND

ENVIRONMENTAL CONSTRAINTS

- RAMSAR
- SPECIAL AREAS OF CONSERVATION SAC
- SPECIAL PROTECTION AREAS SPA
- SITES OF SPECIAL SCIENTIFIC INTEREST SSSI
- ANCIENT WOODLAND
- AREAS OF OUTSTANDING NATURAL BEAUTY AONB
- NATIONAL NATURE RESERVES
- LOCAL NATURE RESERVES
- RSPB RESERVES

HISTORIC ENVIRONMENT

- SCHEDULED MONUMENTS SAM
- REGISTERED PARKS AND GARDENS
- HERITAGE ASSETS

WATER

- FLOOD ZONE 2
- FLOOD ZONE 3
- SURFACE WATER FLOODING

RECREATIONAL ACCESS

- CROW ACCESS LAND
- CROW ACCESS LAND DEDICATED AND ACCESS LAND
- CROW ACCESS LAND
- COMMONS REGISTERED

UTILITIES

- OVERHEAD ELECTRICITY PYLONS
- ELECTRICITY CABLES
- SEWAGE ASSETS
- GAS LINES
- GAS SITES

SURFACE ASSETS

- ELECTRIFIED RAILWAYS
- UNELECTRIFIED RAILWAYS

GEOLOGICAL

- HEADHEAD DEPOSITS
- ALLUVIUM DEPOSITS
- RIVER TERRACE DEPOSITS
- ERB MEMBER
- GACIA
- GLACIOFLUVIAL DEPOSITS
- BSC BRASSINGTON FORMATION
- MCHC MELTON FORMATION
- RMA
- SCARBOROUGH FORMATION
- GACIA
- ACE ESTUARINE DEPOSITS
- CHALK GROUP

LEGEND/NOTES

1. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE.
2. DO NOT SCALE FROM THIS DRAWING.
3. CHAINAGE USED IS CALCULATED USING 0m AT LIDLINGTON STATION.
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LINE

- EXTENTS OF PROPOSED CORRIDOR
- EXISTING GROUND
- PROPOSED HORIZONTAL CENTERLINE AND VERTICAL ALIGNMENT
- EXISTING RAILWAY

DRAWING NEEDS TO BE PRINTED IN COLOUR

REV	DATE	DESCRIPTION OF REVISIONS	DRAWN	CHKD	APPRD
P01	31/08/18	FOR INFORMATION	AO	RB	ANO

SAFETY HEALTH AND ENVIRONMENTAL INFORMATION

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DOCUMENT REF: N/A

STATUS	SUITABILITY CODE
FOR INFORMATION	N/A

CLIENT: Network Rail

DESIGNER: DESIGN DELIVERY | Network Rail

York I.C.C. Leeman Road. York, YO26 4ZD
Tel: 033 085 49683 Web: www.networkrail.co.uk

PROJECT:

EAST WEST RAIL
CENTRAL SECTION

DRAWING TITLE:

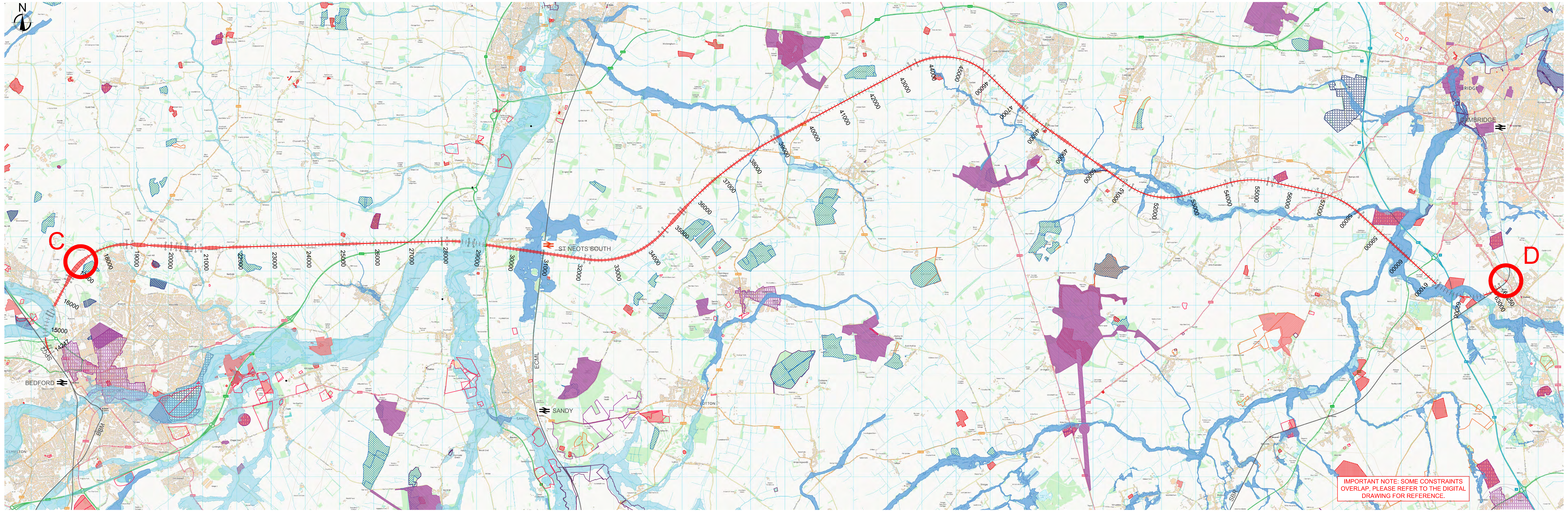
GEOTECHNICAL SENSITIVITY OPTION C3

DESIGNED	A. OLIVER	SIGNED	DATE 13-11-18
DRAWN	A. OLIVER	SIGNED	DATE 13-11-18
CHECKED	R. BELL	SIGNED	DATE 13-11-18
APPROVED	I. SAMWORTH	SIGNED	DATE 13-11-18

SCALE @ A1 (1:1 SHEET SIZE = 420 x 594)	ELR	MILEAGE
1:50000	N/A	N/A

DRAWING NUMBER	REVISION
145674-NRD-J R-CD1 -DRG-C-CV-200401	P01

CAD TEMPLATE : NRDD-B&C-YORK-A1-v1.0.dwt



R□□□E□□E□DE□AI□S	
ROUTE LENGTH:	63.3 Km
ROUTE LENGTH FROM DIVERGENCE:	49.1 Km
ROUTE LENGTH FROM NODE C:	46.1 Km

□□□□BA□A□CED□□R□□I□E	
CUT VOLUME:	2,324,293 Cu. m^3
FILL VOLUME:	4,859,990 Cu. m^3
NET VOLUME: CORRIDOR	2,535,697 Cu. m^3 DEFICIT
FOOTPRINT:	1,679,955 m^2

□□□□BA□A□CED□□R□□I□E□□I□H□□ARIAB□E C□□□I□G□S□□□ES	
CUT VOLUME:	2,092,793 Cu. m^3
FILL VOLUME:	4,859,986 Cu. m^3
NET VOLUME: CORRIDOR	2,767,193 Cu. m^3 DEFICIT
FOOTPRINT:	1,611,152 m^2

PLAN SHOWING HORIZONTAL OPTION CAMBOURNE

SCALE 1:50000

GE□□□GICA□□□E□

HEAD□□HEAD DE□□SI□S SI□□□C□A□□SA□D□□GRA□E□
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G□G□GREA□□□□□I□E GR□□□

SUPERFICIAL	A	GFD	TILL	H&A	TILL	H&A	TILL	H	TILL	RTD	A	RTD	TILL	TILL	H	TILL	H	RTD & TILL	A	TILL	RTD	RTD	A	RTD	TILL	RTD & A	RTD & A	RTD & A	RTD	A	RTD
BEDROCK	GOG	KLS + KLC	PET	WWAC	PET	WWAC	WBS	GLT	WMCH																						

Chainage	Existing Levels	Proposed Levels
14246.621	34.000	33.947
14500.000	36.633	35.974
15000.000	30.000	39.974
15500.000	30.000	43.974
16000.000	38.000	47.974
16500.000	58.885	51.974
17000.000	71.576	55.974
17500.000	63.201	59.975
18000.000	59.457	60.063
18500.000	45.668	58.450
19000.000	69.000	56.837
19500.000	44.652	55.223
20000.000	39.221	53.610
20500.000	35.284	53.950
21000.000	63.300	56.385
21500.000	59.258	59.157
22000.000	66.223	61.929
22500.000	63.436	63.499
23000.000	58.589	59.501
23500.000	57.004	55.501
24000.000	51.661	51.501
24500.000	39.513	47.501
25000.000	37.000	43.501
25500.000	33.777	39.967
26000.000	39.000	41.724
26500.000	35.550	39.649
27000.000	37.817	37.540
27500.000	33.748	35.032
28000.000	28.363	31.032
28500.000	16.000	29.360
29000.000	16.000	29.432
29500.000	21.278	29.504
30000.000	18.000	29.575
30500.000	17.000	29.647
31000.000	17.000	29.718
31500.000	18.000	29.790
32000.000	19.563	29.861
32500.000	20.646	29.933
33000.000	22.510	32.690
33500.000	25.736	36.696
34000.000	30.812	40.702
34500.000	36.569	44.708
35000.000	57.166	48.714
35500.000	60.000	52.720
36000.000	53.039	54.467
36500.000	52.925	50.467
37000.000	47.330	46.467
37500.000	36.000	42.467
38000.000	31.044	38.467
38500.000	29.099	35.072
39000.000	29.000	38.631
39500.000	32.000	42.631
40000.000	36.681	46.631
40500.000	47.155	50.631
41000.000	53.505	54.631
41500.000	57.591	58.631
42000.000	62.415	62.631
42500.000	65.978	65.942
43000.000	63.960	65.221
43500.000	60.000	64.499
44000.000	55.363	63.777
44500.000	54.049	63.055
45000.000	61.713	62.334
45500.000	56.109	61.612
46000.000	63.009	60.890
46500.000	61.949	60.168
47000.000	53.176	59.447
47500.000	56.772	58.725
48000.000	58.000	58.002
48500.000	55.101	54.176
49000.000	53.047	50.176
49500.000	37.231	46.176
50000.000	32.386	42.176
50500.000	31.000	38.176
51000.000	33.969	34.176
51500.000	28.991	30.176
52000.000	27.140	27.685
52500.000	23.517	27.183
53000.000	22.000	27.141
53500.000	25.298	31.141
54000.000	32.000	34.357
54500.000	30.126	31.681
55000.000	28.644	29.005
55500.000	24.891	26.330
56000.000	21.307	23.654
56500.000	22.000	20.978
57000.000	18.000	19.033
57500.000	15.000	18.758
58000.000	11.670	18.483
58500.000	12.733	18.208
59000.000	13.839	17.933
59500.000	9.000	17.658
60000.000	9.000	17.383
60500.000	14.909	17.108
61000.000	13.076	16.833
61500.000	11.459	16.558
62000.000	12.479	16.283
62500.000	12.000	16.008
[illegible]	[illegible]	[illegible]

VERTICAL PROFILE OPTION CAMBOURNE

HORIZONTAL SCALE1:50000
VERTICAL SCALE 1:2500

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- S□ECIA□□R□□EC□I□□AREAS□S□A□
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- SI□ES□□□S□ECIA□SCIE□□I□IC I□□ERES□□SSSI□
- A□CIE□□□□□D□A□D□□CA□I□□
- □A□I□□A□□A□□RE RESER□ES□□□R□
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LEGEND/NOTES
1. ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE.
2. DO NOT SCALE FROM THIS DRAWING.
3. CHAINAGE USED IS CALCULATED USING 0m AT LIDLINTILLON STATION.
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□E□
- EXTENTS OF PROPOSED CORRIDOR
- EXISTING GROUND
- PROPOSED HORIZONTAL CENTERLINE AND VERTICAL ALIGNMENT
- EXISTING RAILWAY

DRAWING NEEDS TO BE PRINTED IN COLOUR

REV	DATE	DESCRIPTION OF REVISIONS	DRAWN	CHK'D	APPR'D
P01	31/08/18	FOR INFORMATION	AO	RB	ANO

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DOCUMENT REF: N/A

STATUS: FOR INFORMATION
SUITABILITY CODE: N/A

CLIENT: NetworkRail

DESIGN DELIVERY | NetworkRail

PROJECT: EAST WEST RAIL CENTRAL SECTION

DRAWING TITLE: GEOTECHNICAL SENSITIVITY OPTION CAMBOURNE

DESIGNED	A. OLIVER	SIGNED	[signature]	DATE	13-11-18
DRAWN	A. OLIVER	SIGNED	[signature]	DATE	13-11-18
CHECKED	R. BELL	SIGNED	[signature]	DATE	13-11-18
APPROVED	I. SAMWORTH	SIGNED	[signature]	DATE	13-11-18

SCALE (@ A1+2 SHEET SIZE = 1261 x 594): 1:50000
ELR: N/A
MILEAGE: N/A

DRAWING NUMBER: 145674-NRD-□ R-CAM-DRG-C-CV-200402
REVISION: P01

CAD TEMPLATE : NRDD-B&C-YORK-A1-v1.0.dwt

Appendix F - Buildings and Civils Supporting Design Information

- Part 1 - ‘Major’ Engineering Elements
- Part 2 - Building Impact
- Part 3 - Designated Environmental and Heritage Sites
- Part 4 - Bridge and Viaduct Infrastructure Requirements

Appendix F: Part 1 - Route Options 'Major' Engineering Elements

Includes embankments >10m in height, cuttings >10m in depth and viaduct/multi-span bridge construction.

Route	Chainage (km)		Description	Viaduct Length (m)
	From	To		
A(D)1	9.1	9.9	Elstow Landfill Heap partial removal - 919,908m³	
	16.9	18.3	17.5m deep cutting partially through Sheerhatch Wood 17.6km	
	22.6	23.5	A1 dual carriageway, River Ivel, Flood Zone and ECML	860
	27.4	28.2	Embankment up to 10.8m high	
			Totals	**860**

C(D)3	14.7	15.6	River Great Ouse and Flood Zone	800
	14.8		A6 River Great Ouse and EWR Overbridge	332
	15.6	16.3	Embankment rising into Clapham hillside up to 15.3m high	
	16.3	17.5	Cutting up to Point C through Clapham hillside up to 16.0m deep	
	18.0	18.8	Embankment crossing valley to Cleat Hill up to 13.4m deep	
	18.8	19.3	Cutting through Cleat Hill up to 12.5m deep	
	19.3	20.7	Embankment crossing valley east of Cleat Hill up to 20.6m high	
	24.0	25.6	Embankment up to 11.1m high	
	28.3	29.1	Flood Zone, River Great Ouse, dual carriageway A1 and Unknown single carriageway road (immediately east and parallel with A1)	800
	29.2	35.2	Embankment up to 11.8m high	
	35.2	36.9	Embankment up to 11.2m high	
	40.3	41.0	Embankment up to 10.8m high locally	
	44.3	45.5	Embankment up to 10.2m high locally	
	49.5	51.3	Embankment up to 16.4m high	
	51.3	51.7	Cutting up to 10.3m deep locally	
	51.7	52.1	Embankment up to 14.9m high	
	52.1	54.0	Cutting through north-east corner of Barrington Chalk Pit up to 14.2m deep	
	54.0	57.6	Embankment up to 15.4m high	
	57.6	58.4	River Cam and Flood Zones 2 & 3	700
	58.8	59.1	River Cam and Flood Zones 2 & 3	300
			Totals	**2932**

C(D)3 Cambourne	14.7	15.6	River Great Ouse and Flood Zone	800
	14.8		A6 River Great Ouse and EWR Overbridge	332
	15.6	16.3	Embankment rising into Clapham hillside up to 15.3m high	
	16.3	17.5	Cutting up to Point C through Clapham hillside up to 16.0m deep	
	18.0	18.8	Embankment crossing valley to Cleat Hill up to 13.4m deep	
	18.8	19.3	Cutting through Cleat Hill up to 12.5m deep	
	19.3	20.7	Embankment crossing valley east of Cleat Hill up to 20.6m high	
	24.0	25.6	Embankment up to 11.1m high	
	28.3	29.1	Flood Zone, River Great Ouse, dual carriageway A1 and Unknown single carriageway road (immediately east and parallel with A1)	800
	29.2	34.8	Embankment up to 12.7m high	
	37.0	40.9	Embankment up to 10.8m high	
	42.8	44.8	Embankment up to 11.6m high locally	
	46.8	47.4	Embankment up to 14.2m high locally	
	48.2	48.5	Embankment up to 11.2m high locally	
	49.0	49.7	Embankment up to 10.7m high locally	
	49.8	50.7	Embankment up to 12.3m high locally	
	61.3	62.0	River Cam and Flood Zones 2 & 3	700
	62.3	62.6	River Cam and Flood Zones 2 & 3	300
			Totals	**2932**

Elstow Landfill Earthwork Volume Assessment

Alignments A(D)1 and E3 would pass through the Elstow Landfill Site. An assessment of the landfill site was undertaken to determine a representative earthwork volume. From Light Detection and Ranging Digital Terrain Model information, a cutting with shallow 1 in 8 slopes was modelled through the landfill heap area and an embankment then formed within the cutting at 1 in 2 slopes, as depicted in Figure 4.1 . A simple base level for a new cutting was applied using levels east and west of the heap and therefore no account has been made for any pit that may be underlying and infilled.

Volume of landfill to be removed is calculated to be 919,908m³. In comparison, full removal of the above ground landfill is estimated to be around 1,300,000m³. New embankment construction through the landfill site is calculated to be 157,242m³.

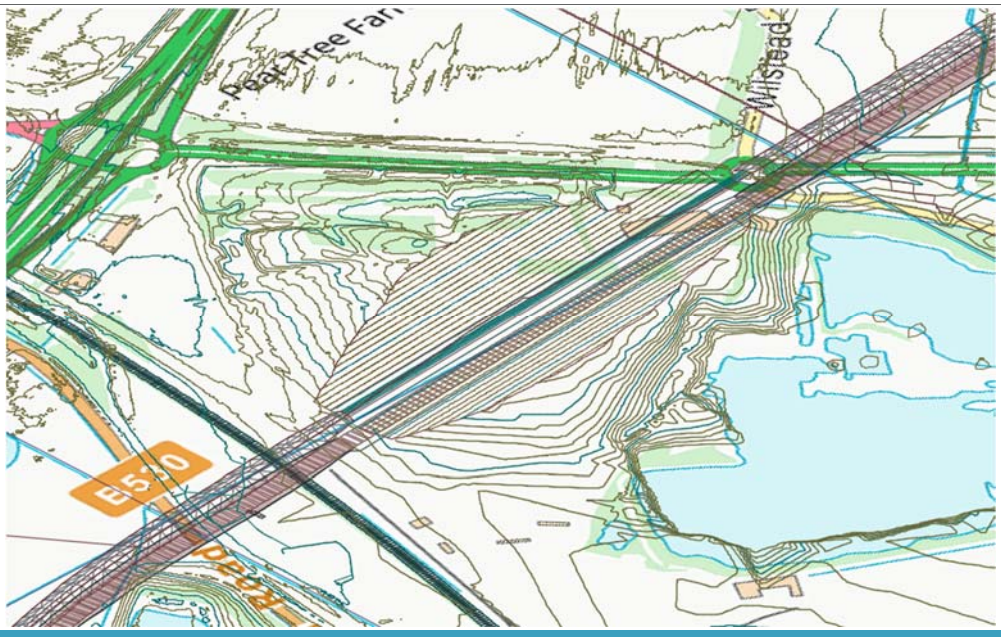

Figure 4.1 Elstow Landfill Volume Assessment (AutoCAD Civils 3D model)

Appendix F: Part 2 - Breakdown of identified buildings, which would require modification / mitigation, removal (purchase/relocation) for route development

Route	Chainage (km)	Building Reference/Description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Number of		
A(D)1	9.7	Elstow Waste Transfer Building would require relocating	2	2	2
	11.2	Medbury Cottages (2nr) would require relocating	2	2	2
	11.2	The business at end of Medbury Lane would require removal/relocating	1	1	1
	13.1	Buildings associated with Cardington Studios/Airships (NOT Grade II Listed Hangars) would require removal/relocating	1	1	1
	15.1	Route would partially cross an impounded reservoir	1	1	1
	15.9	Wood End Farm	1	1	1
	17.6	Covered reservoir adjacent to Northill Road	1	1	1
	19.9	Two residential buildings on western side of Thorncote Road	2	2	2
	21.0	Savin Wholesalers Ltd building adjoining Vinegar Hill Road	1	1	1
	21.0	Fishery business (unknown whether related to (above) wholesalers business) adjoining Vinegar Hill Road	1	1	1
	30.6	Wrestlingworth sewage Treatment Works	1	1	1
	35.9	The Wendy House day Nursery / Manor Farm Business Park	1	1	1
	45.9	College Farm / Caravan and Camping Site adjoining Barrington Road	1	1	1
	46.0	Three residential properties adjoining Barrington Road	3	3	3
	46.2	Bleak House - house and farm buildings adjoining Cambridge Road	1	1	1
		Totals	**20**	**20**	**20**

Route	Chainage (km)	Building Reference/Description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Number of		
C(D)3	14.1	Route infringes of sports field associated with Alexander Sports Centre	1	0	0
	14.3	Electricity Distribution Site – minor compound impingement only (Phase 2e routes)	1	1	1
	20.1	Struttle End Farm north of Renhold	1	1	1
	21.7	Residential property adjoining Wilden Road	1	1	1
	29.4	Kier Ltd building, access and land. Reassessed access and land in Phase 2e	1	0	0
	36.8	One or two small buildings of unknown type adjoining Goat Lane. Encroachment into part of Waresley Park Stud Estate.	1	1	1
	37.1	Residential property, or building associated with Waresley Park Stud, adjoining Gamlingay Road – The Gate House	1	1	1
	53.4	Unknown building type adjoining Chapel Hill Road, south of Haslingfield Village	1	1	1
	56.4	Football pitch and other outdoor sports areas	1	0	0
	56.5	Effluent disposal site impingement – New Mill House	0	1	1
	56.5	Hauxton Meadows housing development site adjoining the A10, thought to be under development at time of writing	1	0	0
	57.0	Westfield Cottages	0	3	3
	57.2	Residential property / Farm buildings	0	1	1
	57.5	Residential property north of Hauxton	1	0	0
		Totals	**10**	**11**	**11**

Route	Chainage (km)	Building Reference/Description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Number of		
C(D)3 Cambourne	14.1	Route infringes of sports field associated with Alexander Sports Centre	Route developed for Phase 2e	-	-
	14.3	Electricity Distribution Site – minor compound impingement only (Phase 2e routes)		1	1
	20.1	Struttle End Farm north of Renhold		1	1
	21.7	Residential property adjoining Wilden Road		1	1
	29.4	Kier Ltd building, access and land. Reassessed access and land in Phase 2e		-	-
	36.8	One or two small buildings of unknown type adjoining Goat Lane. Encroachment into part of Waresley Park Stud Estate.		-	-
	37.1	Residential property, or building associated with Waresley Park Stud, adjoining Gamlingay Road – The Gate House		-	-
	47.6	Bourn Lodge		1	1
	48.1	Alms Hill Road		1	1
	48.3	Grade II listed building		1	1
	53.4	Unknown building type adjoining Chapel Hill Road, south of Haslingfield Village		-	-
	54.5	Grade I listed building – St Mary's Church		1	1
	56.4	Football pitch and other outdoor sports areas		-	-
	56.5	Effluent disposal site impingement – New Mill House		-	-
	56.5	Route would pass through the Hauxton Meadows housing development site adjoining the A10, thought to be under development at time of writing		-	-
	57.0	Westfield Cottages		-	-
	57.1	Properties adjoining Wimpole Road (including two Grade II listed buildings)		9	9
	57.2	Residential property		-	-
	57.5	Farm building or business		1	1
	57.5	Residential property north of Hauxton		-	-
	59.0	Cantelupe Farm		1	1
		Totals		**18**	**18**

Appendix F: Part 3 - Listing of designated Environmental and Heritage sites directly impacted by route corridors

Route	Chainage (km)	Site Name and Designation	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
A(D)1	17.7 – 18.0	Sheerhatch Wood – Ancient Woodland	x	x	x
	19.0 – 19.3	College Wood – Ancient Woodland (and Common land)	x	x	x
	38.8 – 39.0	Wimpole Estate Boulevard/Avenue – Registered Parks and Gardens	x	x	x
C(D)3	35.9 – 36.2	Sand Wood – Ancient Woodland, SSSI	x	x	x
	47.2 – 47.9	Eversden Wood – Ancient Woodland, SAC	x	x	x
	52.4 – 53.2	Barrington Chalk Pit - SSSI	x	x	x
	53.1 – 58.3	Scheduled Monument	x	x	x
	58.2 – 58.3	Scheduled Monument	x	x	x
	58.5 – 58.6	Scheduled Monument	x	x	x
	56.7	Grade II listed building – Milestone Hauxton Mill Bridge	-	x	x
C(D)3 Cambourne	35.9 – 36.2	Sand Wood – Ancient Woodland, SSSI	Route developed for Phase 2e	-	-
	47.2 – 47.9	Eversden Wood – Ancient Woodland, SAC		-	-
	48.3	Grade II listed building		x	x
	50.3	Local Nature Reserve		x	x
	52.4 – 53.2	Barrington Chalk Pit - SSSI		-	-
	54.6	Grade I listed building – St Mary's Church		x	x
	57.1	Two Grade II listed buildings		x	x
	58.1 – 58.3	Scheduled Monument		-	-
	58.5 / 62.1	Scheduled Monument		x	x
	58.5 – 58.6	Scheduled Monument		-	-

Appendix F: Part 4 - Route Bridge and Viaduct Infrastructure Requirements

Table Road Crossing Type Acronyms/Abbreviations

FZ = Flood Zone / Floodplain

U/B = Underbridge

O/B = Overbridge

SL = Single Lane Road

SC = Single Carriageway Road

DC = Dual Carriageway Road

TC = Triple Lane Carriageway Road

T = Track

ATC = Additional (vehicular) Track Crossing

FP = Footpath

WC = Local Watercourse Crossing

Route A(D)1

No change due to line speed sensitivity.

Chainage (km)	Crossing type	Name/description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Bridge Type Required		
8.9	SC	B530 Ampthill Road	U/B	U/B	U/B
9.1	Railway	SPC1	U/B	U/B	U/B
9.8	DC	A6	U/B	U/B	U/B
11.1	FP	John Bunyan Trail walking route	O/B	O/B	O/B
11.3	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
12.7	SC	A600	O/B	O/B	O/B
13.8	FP	Footpath	U/B	U/B	U/B
13.6	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	U/B	U/B	U/B
14.4	SC	Southill Road	U/B	U/B	U/B
15.2	T	Access to impounded reservoir	O/B	O/B	O/B
15.5	T	Park Lane Track	U/B	U/B	U/B
15.7	FP	Footpath (following path diverted)	U/B	U/B	U/B
16.5	FP	Footpath	U/B	U/B	U/B
17.0	FP	Footpath	O/B	O/B	O/B
16.6	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	U/B	U/B	U/B
17.6	SC	Northill Road	O/B	O/B	O/B
17.7	T	Access Track to Moxhill Farm	O/B	O/B	O/B
17.9	SC	Unknown (Bedford Road)	U/B	U/B	O/B
19.1	T/FP	Track/path into College Wood	U/B	U/B	U/B
19.5	FP	Footpath	O/B	O/B	O/B
19.9	SC	Thorncote road	O/B	O/B	U/B
21.1	SC	Vinegar Hill Road	O/B	O/B	U/B

Chainage (km)	Crossing type	Name/description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Bridge Type Required		
21.7	T	Farm track crossing	O/B	O/B	O/B
22.0	T/FP	Farm track and footpath	O/B	O/B	O/B
22.6 – 23.8	Multiple	A1 dual carriageway, River Ivel, Flood Zone and ECML	**U/B Viaduct**	**U/B Viaduct**	**U/B Viaduct**
24.3	FP	Footpath	U/B	U/B	U/B
24.2	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route alignment	U/B	U/B	U/B
24.3	WC	Watercourse	-	U/B	U/B
24.9	WC	Watercourse	-	U/B	U/B
25.7	T	Farm track from Portobello Farm to fields	U/B	U/B	U/B
26.2	SC	Biggleswade Road	O/B	O/B	O/B
26.5	T	Track – The Belt	U/B	U/B	U/B
26.7	WC	Watercourse	-	U/B	U/B
26.7	FP	Footpath	U/B	U/B	U/B
26.9	T	Farm track	U/B	U/B	U/B
27.1	T/FP	Farm track and footpath	U/B	U/B	U/B
27.4	T	Farm track	U/B	U/B	O/B
27.9	SC	Sutton Road	U/B	U/B	U/B
28.5	SL	High Street	O/B	O/B	U/B
28.9	T/FP	Farm track and footpath	O/B	O/B	O/B
30.0	FP	Footpath	O/B	O/B	O/B
30.5	FP	Footpath	U/B	U/B	U/B
29.9	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	U/B	U/B	U/B
30.8	SC	Eyeworth Road	O/B	O/B	O/B
31.3	SC	(Wrestlingworth) High Street	1U/B	1O/B	O/B
32.0	FP	Footpath	O/B	O/B	O/B
33.3	FP	Footpath (three nearby footpaths consolidated)	O/B	O/B	U/B
32.4	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	U/B	U/B	U/B
33.4	T	Access track from Tadlow Bridge Farm to road network	U/B	U/B	U/B
34.1	WC	River Cam	-	U/B	U/B
34.5	FP	Footpath	O/B	O/B	O/B
35.9	FP	Footpath (previous footpath consolidated)	O/B	O/B	O/B
34.7	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
36.0	SC	Flecks Lane	O/B	O/B	O/B
37.4	T/FP	Farm track and footpath	O/B	O/B	O/B

Chainage (km)	Crossing type	Name/description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Bridge Type Required		
38.7	SC	A1198 Ermine Way (Roman Road)	U/B	U/B	U/B
38.9	FP	Footpath within boundary of Wimpole Estate Avenue	O/B	O/B	O/B
39.4	FP	Harcamlow Way	O/B	O/B	O/B
40.7	WC	River Cam	-	U/B	U/B
41.4	FP	Footpath	O/B	O/B	O/B
39.7	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
40.7	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	U/B	U/B	U/B
41.6	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
42.5	WC	River Cam	-	U/B	U/B
42.6	SC	Malton Road	O/B	O/B	O/B
42.8	T	Farm track access (following track diverted	O/B	O/B	O/B
43.6	T	Brook Farm track access to fields	O/B	O/B	O/B
44.1	SC	Barrington Road	O/B	O/B	O/B
44.7	FP	Footpath	O/B	O/B	O/B
45.5	T	Access track to business	O/B	O/B	O/B
45.8	Railway	SBR 2800 (three tracks)	O/B	-	-
46.0	SC	Barrington Road	O/B	O/B	O/B
46.4	SC	A10	O/B	O/B	O/B
47.2	WC	Hoffer brook	-	U/B	U/B
47.5	T	Access track	O/B	O/B	O/B

Route C(D)3

Chainage (km)	Crossing type	Name/description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Bridge type required		
14.6	SC	The Great Ouse Way (under construction/partially constructed)	O/B	O/B	O/B
14.7 - 15.6	FZ	River Great Ouse and Flood Zone	**U/B Viaduct**	**U/B Viaduct**	**U/B Viaduct**
114.8	**DC (EWR lines + FZ)**	**A6 Paula Radcliffe Way bridge reconstruction**	**O/B Viaduct**	**O/B Viaduct**	**O/B Viaduct**
15.7	SC	Clapham Road	U/B	U/B	U/B
16.4	FP	Footpath	O/B	O/B	O/B
16.5	T/FP	Carriage Drive / John Bunyan Train	O/B	O/B	O/B
17.8	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
19.0	SC	Bedford Road (previous road diverted)	O/B	O/B	O/B
19.7	FP	Footpath	U/B	U/B	-
20.0	FP	Footpath	U/B	U/B	U/B
20.1	SC	Ravensden Road	U/B	U/B	U/B
20.3	FP	Footpath crossing – following footpath would be consolidated	U/B	U/B	U/B
20.7	FP	Footpath	U/B	U/B	U/B
21.4	FP	Footpath	U/B	U/B	U/B
21.6	SC	Wilden Road	O/B	O/B	O/B
22.0	T/FP	Track and footpath	O/B	O/B	O/B
22.2	T/FP	Track and footpath	O/B	O/B	O/B
22.9	FP	Footpath	O/B	O/B	O/B
23.7	SC	Barford Road	O/B	O/B	O/B
23.9	T	Track from Northfield Farm	O/B	O/B	O/B
24.6	FP	Footpath	U/B	U/B	U/B
24.8	T	Track to Little Birchfield Farm	U/B	U/B	U/B
25.2	FP	Footpath	U/B	U/B	U/B
25.7	FP	Footpath	O/B	O/B	O/B
25.8	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
26.8	DC	A421 (additional single lane refuge to southern bound carriageway)	O/B	O/B	O/B
27.2	SC	Roxton Road/Bedford Road (marginally wider due to chevron lane divider)	O/B	O/B	O/B
28.0	T/FP	Roxton to Ouse Valley Way	U/B	U/B	O/B
28.3 - 29.1	Multiple	Flood Zone, River Great Ouse, dual carriageway A1 and Unknown single carriageway road (immediately east and	**U/B Viaduct**	**U/B Viaduct**	**U/B Viaduct**

Chainage (km)	Crossing type	Name/description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Bridge type required		
		parallel with A1)			
29.3	T	Access road to Kier Ltd buildings	U/B	U/B	U/B
30.7	Railway	ECML	U/B	U/B	U/B
30.9	FP	Footpath	U/B	U/B	U/B
30.2	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	U/B	U/B	U/B
31.1	T	Track from Woodbury Farm (further track would be consolidated)	U/B	U/B	U/B
32.3	FP/T	Route of old Roman Road	U/B	U/B	U/B
33.8	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	U/B	U/B	U/B
35.2	SC	Tetworth Hill Road	U/B	U/B	O/B
36.2	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route alignment	U/B	U/B	U/B
37.2	SC	Gamlingay Road	O/B	O/B	O/B
39.2	FP	Footpath south of Waresley Wood (following paths would be consolidated)	O/B	O/B	O/B
38.7	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route alignment	O/B	O/B	O/B
40.2	SC	B1046 Main Road	U/B	U/B	O/B
41.5	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route alignment	U/B	U/B	U/B
42.8	SC	B1046 High Street	O/B	O/B	O/B
43.9	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
44.9	SC	A1198 Ermine Way	U/B	U/B	U/B
45.8	FP	Footpath	O/B	O/B	O/B
46.8	FP	Harcamlow Way Walking route	U/B	U/B	O/B
47.0	FP	Footpath to Eversden Wood (following footpath would be consolidated/removed)	U/B	U/B	O/B
45.8	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
46.6	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
47.5	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	O/B
48.3	T/FP	Wimpole Road (track) and footpath	O/B	O/B	O/B
49.6	FP	Footpath (following footpath would be consolidated)	U/B	U/B	U/B
49.5	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	O/B	O/B	U/B
50.6	SC	A603 (Roman Road)	U/B	U/B	U/B

Chainage (km)	Crossing type	Name/description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Bridge type required		
50.9	T/FP	Whole Way (track) Byway (open to all traffic)	U/B	U/B	U/B
52.2	FP	Footpath (following footpath would be consolidated/removed)	U/B	U/B	O/B
52.2	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	U/B	U/B	O/B
53.4	SC	Chapel Hill Road	O/B	O/B	O/B
54.3	SC	Haslingfield Road	U/B	U/B	U/B
54.8	WC	River Cam	-	U/B	U/B
54.9	T/FP	Extension of Burton end (road)	U/B	U/B	U/B
55.1	FP	Footpath crossing	-	U/B	U/B
55.8	T/FP	Track and footpath	U/B	U/B	U/B
56.6	WC	River Granta	-	U/B	U/B
56.7	DC	A10	U/B	U/B	U/B
56.8	FP	Path following River Cam	U/B	U/B	U/B
56.6 – 57.9	FZ	River Cam and Flood Zone 3, M11 dual carriageway	**U/B Viaduct**	**U/B Viaduct**	**U/B Viaduct**
58.4 – 58.8	Multiple	River Cam and Flood Zone 3	**U/B Viaduct**	**U/B Viaduct**	**U/B Viaduct**
57.9	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route	U/B	U/B	U/B
59.1	T	Track from Rectory Farm with existing crossing over the SBR	U/B	U/B	O/B

Route C(D)3 – Cambourne

Chainage (km)	Crossing type	Name/description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Bridge type required		
14.6	SC	The Great Ouse Way (under construction/partially constructed)	Route developed for Phase 2e	O/B	O/B
14.7 - 15.6	FZ	River Great Ouse and Flood Zone		**U/B Viaduct**	**U/B Viaduct**
15.0	DC (EWR lines + FZ)	A6 Paula Radcliffe Way bridge reconstruction		**O/B Viaduct**	**O/B Viaduct**
15.8	SC	Clapham Road		U/B	U/B
16.4	FP	Footpath		O/B	O/B
16.6	T/FP	Carriage Drive / John Bunyan Train		O/B	O/B
17.8	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		O/B	O/B
18.6	SC	Bedford Road		O/B	U/B
19.0	FP	Footpath		U/B	O/B
20.0	FP	Footpath		U/B	U/B
20.3	SC	Ravensden Road		U/B	U/B
20.5	FP	Footpath crossing – following footpath would be consolidated		U/B	U/B
20.7	FP	Footpath		U/B	U/B
20.9	FP	Footpath		U/B	O/B
21.7	SC	Wilden Road		O/B	O/B
22.0	T/FP	Track and footpath		O/B	O/B
22.3	T/FP	Track and footpath		O/B	O/B
23.1	FP	Footpath		O/B	O/B
23.8	SC	Barford Road		O/B	U/B
23.9	T	Track from Northfield Farm		O/B	O/B
24.6	FP	Footpath		U/B	U/B
24.9	T	Track to Little Birchfield Farm		U/B	U/B
25.3	FP	Footpath		U/B	U/B
25.9	FP	Footpath		O/B	O/B
25.9	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		O/B	O/B
26.9	DC	A421 (additional single lane refuge to southern bound carriageway)		O/B	O/B
27.4	SC	Roxton Road/Bedford Road (marginally wider due to chevron lane divider)		O/B	O/B
28.0	T/FP	Roxton to Ouse Valley Way		U/B	U/B
28.4 - 29.2	Multiple	Flood Zone, River Great Ouse, dual carriageway A1 and Unknown single carriageway road (immediately east and		**U/B Viaduct**	**U/B Viaduct**

Chainage (km)	Crossing type	Name/description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Bridge type required		
		parallel with A1)			
29.5	T	Access road to Kier Ltd buildings		U/B	U/B
30.9	Railway	ECML		U/B	U/B
30.9	FP	Footpath		U/B	U/B
30.4	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		U/B	U/B
31.2	T	Track from Woodbury Farm (further track would be consolidated)		U/B	U/B
32.4	T/FP	Route of old Roman Road		U/B	U/B
33.8	T	Track / Bridleway		U/B	U/B
34.1	T	Farm Track Access		U/B	U/B
35.6	SL	Tetworth Hill Road		O/B	O/B
36.9	SL	Drewels Lane		O/B	O/B
37.3	FP	Footpath		O/B	U/B
38.2	SC	B1046 Gransden Road		U/B	U/B
39.0	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		U/B	U/B
39.9	SC	B1040 Potton Road		U/B	U/B
40.3	T	Farm Track		O/B	U/B
41.4	SC	Eltisley Road		O/B	O/B
41.9	T	Track / Bridleway		O/B	O/B
43.3	FP	Track – Caxton Drift		O/B	U/B
44.9	SC	Ermine Street		O/B	O/B
45.2	FP	Footpath		O/B	U/B
45.6	T	Track / Bridleway		U/B	U/B
45.7	SC	A1198 Caxton Bypass		O/B	O/B
46.1	T/FP	Track and Footpath		O/B	O/B
47.1	FP	FP		U/B	U/B
47.1	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		U/B	U/B
48.1	SC	Alms Hill Road		O/B	O/B
48.3	T	Track / Byway		O/B	U/B
48.8	T	Track / Byway		U/B	O/B
49.0	T	Track / Byway		U/B	O/B
49.2	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		U/B	U/B
49.7	FP	Footpath		O/B	O/B
50.3	SC	B1046 Toft Road		U/B	U/B
50.1	WC	Watercourse - Bourne Brook		U/B	U/B
50.7	SC	Church Lane		O/B	U/B

Chainage (km)	Crossing type	Name/description	Phase 2d 125mph	Phase 2e 125mph	Phase 2e Geotech
			Bridge type required		
51.6	FP	Footpath		U/B	O/B
51.9	T	Almshord Lane – Track / Bridleway		U/B	O/B
52.3	FP	Footpath		U/B	O/B
52.7	WC	Watercourse - Bourne Brook		U/B	U/B
53.2	T	Track (from B1046)		U/B	U/B
53.5	FP	Footpath		O/B	U/B
54.4	SC	Royston Lane		O/B	U/B
54.6	FP	Footpath (The Causeway)		O/B	O/B
55.0	T	Track / Byway		O/B	O/B
56.1	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		O/B	U/B
57.1	FP	Footpath		O/B	O/B
57.1	SC	A603 Wimpole Road		O/B	O/B
57.5	T	Track – Access/Byway		U/B	U/B
58.1	WC	Bourne Brook		U/B	U/B
58.6	T	Track / Bridleway and Footpath		U/B	U/B
59.3	WC	River Cam		U/B	U/B
59.6	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		U/B	U/B
59.9	WC	River Granta		U/B	U/B
60.6	SC	A10 Road		O/B	O/B
61.3 – 62.0	Multiple	River Cam + Flood Zone & M11		**U/B Viaduct**	**U/B Viaduct**
61.6	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		U/B	U/B
62.5	ATC	Additional vehicular track crossing to meet minimum of 1 per 1600m of route		U/B	U/B
62.3 – 62.6	Multiple	River Cam + Flood Zone		**U/B Viaduct**	**U/B Viaduct**

Appendix F: Part 5 - Route Bridge and Viaduct Infrastructure Requirements

Crossing Type	Description
Footbridge Overbridge Design	Maximum Circular Hollow Section or trestles heights for footbridges will dictate whether footbridges or Subways (box culverts) are recommended where pedestrian crossings are required over proposed embankments. NR/CIV/SD/412 specifies a maximum CHS height of 8.2m for main supports whiles NR/CIV/SD/410 specifies a maximum height of 7.7m if trestles are preferred. At this stage it has been assumed that CHS supports will be used. Assuming a 6.2m clearance from top of rail to underside of footbridge is required; footbridge can be utilised with a maximum embankment height of 2.0m.
Subway Underbridge Clearance and Construction Depth Design Values	Subway footpath crossings have been specified where it is not feasible to use the Network Rail Standard Design (NR/CIV/SD/412) for a 'CHS' column type overbridge. This does not take into account potential issues relating to poor ground conditions, ground water level at each proposed bridge location. Underbridges have been typically specified where embankment height is greater than 2.0m.
Vehicular Track Crossings (i.e. farm track) - Overbridges	Overbridges are based on vehicular track crossing design (single carriageway road width for volumes) due to railway clearance requirements. Clearance has been simplified at this stage of design to 5.7m with 2.0m of bridge structure thickness.
Vehicular Track Crossings - Underbridges	Underbridges have been based on track crossings (single carriageway road) width at this stage of design. Clearance has been simplified at this stage of design to 5.7m with 2.0m of bridge structure thickness. Underbridges have been typically specified where embankment height is greater than 2.0m.
Bridleway - Overbridges	There in multiple instances of bridleways coinciding with a track crossing being indicated there has been based on a track crossing, as above.
Bridleway - Underbridges	As per 'Track Crossings' above.

<u>Design Assumptions and Key Risks</u>

- CHS footbridge construction type assumed throughout to achieve a higher maximum crossing height, as opposed to lower trestles.
- A 6.2m clearance has been applied for OLE equipment passive provision for footbridge design, as per standard detail design.
- A 5.7m clearance for all other clearance requirements with 2.0m structure depth assumed for all non-pedestrian overbridges.
- The presence of adverse ground conditions and groundwater level at specific sites have not been reviewed in the specifying of underbridges.
- No earthwork (cut or fill) has been calculated for pedestrian or bridleway crossings.

- Earthwork volumes for underbridges are not based on measured embankment heights, instead the maximum 2.0m embankment height has been applied throughout, and similarly for overbridges.
- Track cut and fill volumes have been allocated based on 'at grade' crossings using volumes for a single lane carriageway.
- There is further scope for increasing bridge provision accuracy in the following design stages due to the simplifications applied in terms of at grade crossing volumes. The table below provides an indication of the savings in underbridge geometry that could be used: -

Local underbridge Crossing General Dimensions

Crossing Type	Subway length (m)	Vertical Clearance (mm)	[1]Construction Depth from Track (mm)	Total Width (mm)
Subway				
Pedestrians only	<23	2300	4043	5000
Pedestrians only	23 or greater	2600	4343	5000
Cycles	<23	2400	4143	6000
Cycles	23 or greater	2700	4443	6000
Equestrians (with mount / dismount point)	-	2700	4443	6000
Underbridge				
Track (i.e. farm track)	-	[2]4500	5500	

Notes

1. See table below for typical subway construction thicknesses
2. 4.5m based on DMRB Standards for Highways – BD 60/04 The Design of Highway Bridges for Vehicle Collision Loads.

[1]Typical Structure and Formation Depths

Layer / Element	Depth (mm)
Track construction depth (Rail + sleeper + pads)	368
Ballast Depth	300
Top RC Slab Depth	500
Bottom RC Slab depth	500
Blinding Concrete	75
Walls - total width	1000