Thickthorn Interchange Improvements

Concept Scheme Options
Engineering Assessment

June 2013

Norfolk County Council

Mott MacDonald

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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
P1	May 2013	U Kangalli S Allen (Environment) H Husbands (Drainage) J Pattinson (Structures) J McKay (Lighting) N Lamprell (Signals)	A Howes	M Mandi-Ghomi	First Draft for Comment
P2	May 2013	U Kangalli	A Howes	M Mandi-Ghomi	Final Draft
P3	June 2013	U Kangalli	A Howes	M Mandi-Ghomi	Final

Contents

Executive Summary

Following the analysis of future traffic flows through the Norwich Area Transport Strategy (NATS) Model Thickthorn Interchange was identified as one of a number of major junctions that would see a significant increase in traffic demand. In its current form the junction would be unable to accommodate significant increase in traffic and therefore improvements would be required to cater for additional traffic arising from planned growth in the Norwich area as set out in the adopted Joint Core Strategy (JCS).

The purpose of this study is to assess engineering aspects for the potential options of an off-slip improvement and a bypass scheme, to cater for predicted growth at this intersection. It is proposed that a formal DMRB Stage 1 assessment is compiled during the next stage of development.

This report considers the Bypass Scheme (Option 13), and widening of the A47 westbound off-slip road (Option 17) as identified for progression in the previous study (Thickthorn Interchange Improvements Concept Scheme Options Traffic Assessment Report), including all additional alternatives that have arisen throughout the development of this stage.

The proposed bypass (previously option 13) consists of 4 options; Roundabout, Free flow, Dumb-bell, and Half Dumb-bell. Each has 1 to 4 alternatives, comprising 11 layouts in total. A summary table for all options and alternatives can be seen in section 3.2.

A short list of the 4 preferred options for the bypass, taken forward from the all options summary, containing further details of considerations, benefits and dis-benefits can be seen in the following tables. This table highlights the desire of the Highway Agency (HA) for the scheme to have minimal negative impact on their network, during both operation and construction. Utility diversions, effect on properties, Geotechnical considerations, and Environmental implications have all been considered for these 4 options, on which further details can be found in the main body of this report.

Thickthorn Intersection Improvements - Summary Table for preferred alternatives of each option: Roundabout Arrangement Alternative A Refer to Drawing Number: 100						
Alternative	**Variant**	**Estimated Cost[1] (±40%)**		**Option Specific considerations**	**Benefits**	**Dis-Benefits**
Roundabout Arrangement 'Alternative A'	A47 bridge	£27.2M	**Description of Scheme**			
			General Considerations	• Maximum Length:1000m • Bypass footprint 59,000m² • Dual carriageway from new 3 lane roundabout on A11 • connects with existing roundabout on Newmarket Road	• Use of existing Roundabout on Newmarket Road • Shortest length of all options • Lowest coast option • Total land take 43,000m²	• New roundabout on A11 • A11 roundabout too close to Thickthorn • Likely to require signalisation and extra stacking capacity between the two roundabouts • Traffic not free flowing • Creates additional delay to A11traffic which will affect economic benefits
			Engineering Assessment			
			Geotechnical Comments	• Cut slope stability through the glacial deposits will need to be assessed • Compressibility of the ground under the load of the proposed embankment will have to be determined during the site investigation • The over bridge will need to be founded on a competent stratum		
			Structures		• One Bridge required over A47 with a Span of 83m • Retaining walls might be used to reduce impact on houses	
			Utilities	• Possible diversions of underground electrical, Virgin Media cables and LP Gas main and other utilities. Costs to be determined	• Diversion of 400kV overhead electricity cables is not likely to be required	• Diversion of 132kV overhead electricity cables. Estimated cost is £3m • Diversion of 125mm PE LP gas main. Estimated cost is £60k
			Environmental Assessment			
			Environmental Comments	• Preferred Alternative	• Negligible effect on air quality on a regional scale • Least impact on archaeology	• Distance from Tumuli - 37m & 185m. • Remains of deserted Medieval Village likely to be encountered.
			Economic Assessment			
			Effect on properties	• 12 residential properties affected		• 12 residential properties affected
			HA Comments (informal)	• Roundabout arrangement is the Highway Agency's fourth preferred option • New Bypass to be designated as local road		
			Recommendation	Progress with feasibility		

1 Based on Q1 2013 prices. Estimates do not include land, diversion or property costs.

Thickthorn Intersection Improvements - Summary Table for preferred alternatives of each option: Free-Flow Arrangement Alternative B Refer to Drawing Number: 201						
Alternative	**Variant**	**Estimated Cost[2] (±40%)**		**Option Specific considerations**	**Benefits**	**Dis-Benefits**
Free flow Arrangement 'Alternative B'	A11 tunnel A47 bridge	£51M	**Description of Scheme**			
			General Considerations	• Maximum Length:1500m • Bypass footprint 72,000m² • Dual carriageway alignment with new diverge and merge tapers on A11 • Connects with existing roundabout on Newmarket Road	• Use of existing Roundabout on Newmarket Road • Free flow Alternative • No additional delay to A11 traffic	• It is possible that merge slip lanes could pass over the area identified as a refuse tip, careful assessment of the ground in the area will need to be undertaken • Second longest route • Total land take 61,000m²
			Engineering Assessment			
			Geotechnical Comments	• Cut slope stability through the glacial deposits will need to be assessed. It is possible that drainage of the cutting may be required. • Compressibility of the ground under the load of the proposed embankment will have to be determined. • Preferred Alternative		• The Tunnel under the existing A11 is likely to have to be excavated into the Alluvium • Glacial Deposits and Chalk, all of which could provide challenging and variable ground conditions • The groundwater level could be high due to the proximity of the watercourse, dewatering of the excavation will have to be ensured during the construction work
			Structures	• 1 Tunnel under A11, length 120m • 1 Bridge over A47 Span 115m		• Tunnel is costlier alternative • Two new structures are required
			Utilities	• Possible diversions of underground electrical, Virgin Media cables and LP Gas main and other utilities. Costs to be determined	• Diversion of 400kV overhead electricity cables is not likely to be required	• Diversion of 132kV overhead electricity cables. Estimated cost is £3m • Diversion of 125mm PE LP gas main. Estimated cost is £60k
			Environmental Assessment			
			Environmental Comments	• Preferred Alternative	• Negligible effect on air quality on a regional scale	• Affecting known archaeology remains • Affect scheduled monument • Remains of deserted Medieval Village likely to be encountered • Distance from Tumuli - 11m & 200m
			Economic Assessment			
			Effect on properties	• No residential properties affected	• No residential properties affected	
			HA Comments (informal)	• Free flow arrangement is the Highway Agency's first preferred option. • New Bypass to be designated as local road		
			Recommendation	Progress with feasibility		

2 Based on Q1 2013 prices. Estimates do not include land, diversion or property costs.

Thickthorn Intersection Improvements - Summary Table for preferred alternatives of each option: Dumbbell Arrangement Alternative C Refer to Drawing Number: 302						
Alternative	**Variant**	**Estimated Cost[3] (±40%)**		**Option Specific considerations**	**Benefits**	**Dis-Benefits**
Dumb-bell Arrangement 'Alternative C'	A11 bridge A47 bridge	£40M	**Description of Scheme**			
			General Considerations	• Maximum Length:1500m • Bypass footprint 82,500m² • Dual carriageway alignment with two new roundabout merge tapers on the A11	• Use of existing Roundabout on Newmarket Road • Dumb-bell arrangement reduces skew on A11 crossing thus reducing cost • Offers the opportunity to additionally remove the B1172 to A11 traffic from Thickthorn if a link back onto the B1172 is provided • No additional delay to A11 traffic	• Is less attractive as A11 Norwich bound traffic has to negotiate two extra roundabouts • A11 southbound on slip may conflict with tumulus • Traffic not free flows • Total land take 71,500m²
			Engineering Assessment			
			Geotechnical Comments	• Cut slope stability through the glacial deposits will need to be assessed • Compressibility of the ground under the load of the proposed embankment will have to be determined		• It is possible that merge slip lanes could pass over the area identified as a refuse tip, careful assessment of the ground in the area will need to be undertaken prior to construction • The two over bridges will need to be founded on a competent stratum which will be determined upon the ground investigation and upon knowledge of the proposed bridge structure
			Structures	• 1 Bridge over A11 span is 50m • 1 Bridge over A47 span is 70m	• Bridges are cheaper than tunnels	• Two new structures are required
			Utilities	• Possible diversions of underground electrical, Virgin Media cables and LP Gas main and other utilities. Costs to be determined	• Diversion of 400kV overhead electricity cables is not likely to be required	• Diversion of 132kV overhead electricity cables. Estimated cost is £3m • Diversion of 125mm PE LP gas main. Estimated cost is £60k
			Environmental Assessment			
			Environmental Comments	• May not be possible to proceed in heritage terms	• Negligible effect on air quality on a regional scale	• Affecting known archaeology remains. • Affect scheduled monument • Directly affects Bronze Age Burrows • Remains of deserted Medieval Village likely to be encountered
			Economic Assessment			
			Effect on properties	• 5 residential properties affected		• 5 residential properties affected
			HA Comments (informal)	• Dumbbell arrangement is the Highway Agency's third preferred option. • New Bypass to be designated as local road		
			Recommendation	Progress with feasibility		

3 Based on Q1 2013 prices. Estimates do not include land, diversion or property costs.

Thickthorn Intersection Improvements - Summary Table for preferred alternatives of each option: Dumbbell Arrangement Alternative E Refer to Drawing Number: 304						
Alternative	**Variant**	**Estimated Cost[4] (±40%)**		**Option Specific considerations**	**Benefits**	**Dis-Benefits**
Half Dumb-bell Arrangement 'Alternative A'	A11 bridge A47 bridge	£39.8M	**Description of Scheme**			
			General Considerations	• Maximum Length: 1650m • Bypass footprint 79,000m² • New roundabout to the west of A11 near Thickthorn Park and Ride • A11 Southbound merge is a direct connection to A11	• Use of existing roundabout on New Market Road • Half dumb-bell arrangement reduces skew on A11 crossing thus reducing cost • No additional delay to A11 traffic	• Traffic not free flowing • Is less attractive as A11 Norwich bound traffic has to negotiate an extra roundabout • A11 southbound slip road may encroach on Tumuli • Total land take 68,000m²
			Engineering Assessment			
			Geotechnical Comments	• Cut slope stability through the glacial deposits will need to be assessed • Compressibility of the ground under the load of the proposed embankment will have to be determined		• It is possible that merge slip lanes could pass over the area identified as a refuse tip, careful assessment of the ground in the area will need to be undertaken prior to construction • The two over bridges will need to be founded on a competent stratum which will be determined upon the ground investigation and upon knowledge of the proposed bridge structure.
			Structures	• 1 Bridge over A11 span is 50m • 1 Bridge over A47 span is 70m	• Bridges are cheaper than tunnels • Retaining walls might be used to reduce impact on houses	• Two new structures are required
			Utilities	• Possible diversions of underground electrical, Virgin Media cables and LP Gas main and other utilities. Costs to be determined	• Diversion of 400kV overhead electricity cables is not likely to be required	• Diversion of 132kV overhead electricity cables. Estimated cost is £3m • Diversion of 125mm PE LP gas main. Estimated cost is £60k
			Environmental Assessment			
			Environmental Comments	• May not be possible to proceed in heritage terms.	• Negligible effect on air quality on a regional scale	• Affecting known archaeology remains • Affect scheduled monument • Affects NW extent of Bronze Age Burrows • Remains of deserted Medieval Village likely to be encountered • Distance from Tumuli - 0m & 140m.
			Economic Assessment			
			Effect on properties	• 12 residential properties affected		• 12 residential properties affected
			HA Comments (informal)	• Dumbbell arrangement is the Agency's second preferred option. • New Bypass to be designated as local road		
			Recommendation	Progress with feasibility		

4 Based on Q1 2013 prices. Estimates do not include land, diversion or property costs.

1 Introduction

Following the analysis of future traffic flows through the Norwich Area Transport Strategy (NATS) Model Thickthorn Interchange was identified as one of a number of major junctions that would see a significant increase in traffic demand. In its current form the junction would be unable to accommodate significant increase in traffic and therefore improvements would be required to cater for additional traffic arising from planned growth in the Norwich area as set out in the adopted Joint Core Strategy (JCS).

The purpose of this study is to assess engineering aspects for the potential options of an off-slip improvement and a bypass scheme, to cater for predicted growth at this intersection. It is proposed that a formal DMRB Stage 1 assessment is compiled during the next stage of development.

1.1 Study Remit

Mott MacDonald as Norfolk County Council's Strategic Partner has been commissioned to carry out the assessment of alternative improvements identified from previous studies.

The principal objectives of the scheme are to enable the Thickthorn Junction to accommodate additional traffic arising from planned growth in the Norwich area, enhance bus priority at the interchange to meet the aspirations of local bus operators, also to promote sustainable transport.

There have been a number of previous studies and workshops considering different optioneering concepts but this document will focus on two practicable alternative improvement aspects; a new bypass and the widening of the A47 westbound off slip road.

1.2 Background

In November 2008 Mott MacDonald reported on an initial capacity assessment of three of the A47's Norwich Southern Bypass Junctions which included the A47/A11 Thickthorn Interchange. As part of this assessment three low cost options, and three major re-alignment options were proposed. Following a study workshop where the aforementioned options were discussed a seventh option was also developed.

In November 2010 AECOM were instructed by the Highways Agency to prepare some indicative options for the A47/A11 Thickthorn Interchange as potential small scale schemes. This study identified five different options which were traffic capacity assessed and were considered in different combinations with each other to create a number of implementation scenarios.

In May 2012 Mott MacDonald was commissioned to review all produced studies that have considered upgrades at the interchange and to appraise a short list of viable options with a view to arriving at a preferred option or options.

In October 2012, Mott MacDonald reported on their findings following Traffic Analysis of 25 options (See **Thickthorn Interchange Improvements Concept Scheme Options Traffic Assessment Report).** In discussion with Norfolk County Council, it was agreed to take forward two options reflecting the greatest traffic enhancement to the junction for further geometric analysis.

This report will consider Bypass Option (Option 13 in the above report) and widening on A47 westbound off-slip road (Option 17) which have been identified in the previous study, including any additional alternatives that arise as part of this study and through due consideration.

2 Existing Conditions

2.1 Engineering

Thickthorn Interchange is a 6 arm, signal controlled and grade separated roundabout at the intersection of A47 and A11. Both A11 and A47 are maintained by Highways Agency and have two lane dual carriageway sections in this part of the network (See Appendix A1).

On the A11, the number of lanes on the northbound direction, increases from 2 to 4 as it approaches the roundabout giveway line. A11 Southbound direction has two lanes at the roundabout exit and increases to three lanes with a taper to Cantley Lane.

The other four arms; A11 Newmarket Road on the east, Newmarket Road on the north east and B1172 Norwich Road on the northwest are maintained by Norfolk County Council. The nearby Thickthorn Park & Ride site is accessed via B1172 Norwich Road.

The circulatory island of Thickthorn Roundabout has an elliptic geometrical layout with a width of 100 m at its narrowest and 165 m at its widest point. The circulatory carriageway has a width varying between 12 to 15 m. The north part of the roundabout has four lanes, whilst there are only three lanes provided on the south part. Average elevation height for the roundabout is 28m and the average slope is 0.5%.

Carriageway slope of the A47 is around 1%, with elevation heights of 34.4 m on the bridge above the roundabout, dropping down to 29.9 m near the area where the proposed bypass cuts the A47.

Longitudinal slope of A11 is reducing from 2% in the first 150 m towards the south from the roundabout to 1% further south. Carriageway centreline elevation heights are around 28.8 m near the roundabout and reduce to 24.8 m near the Thickthorn Park & Ride, further reducing to 21.4 m at 500m south of the roundabout.

From the East in a clockwise direction, the roundabout's approach roads are:

- A11 Newmarket Road (East) flares to three lanes approximately 70 metres prior to the stop line, and there are four lanes at the stop line;
- The A47 (South) off-slip road joins the roundabout from the south-easterly direction. The slip road gradually flares to provide three lanes at the stop line. The nearside lane is marked with a left arrow, the middle lane with left and straight ahead arrows, whilst the outside lane is marked with a straight ahead arrow;
- The A11 (Southwest) approach widens from two lanes to four lanes approximately 130 metres from the stop line;
- The B1172 approach road is located to the northwest of the roundabout and is not signalised. The road connects the roundabout to the B1172 Norwich Road. Most of the length of the nearside lane is marked as bus lane. The bus lane stops approximately 27 metres prior to the roundabout.
- The A47 (North) off slip road is located to the northwest of the roundabout. The slip road widens to three lanes approximately 40 metres from the roundabout.

The old Newmarket Road is a track that runs parallel with the A11 Newmarket Road. The road serves as a private access to agricultural land and private properties along its north side. The approach road is not included in the existing traffic signal arrangement.

2.2 Traffic

Thickthorn Interchange in its current form is one of the junctions identified as being unable to cope with the traffic demand from the planned growth of developments in the surrounding areas. Please refer to **Thickthorn Interchange Improvements Concept Scheme Options Traffic Assessment Report** for further Traffic Information.

2.3 Environment

The environment surrounding the Thickthorn Interchange is a mosaic of land-uses and corresponding habitat types. Beyond the highway verges, which are dominated by either grassland, scrub or planted landscaping/screening vegetation, arable land is predominant. Although this has a degree of landscape value, it is of limited ecological value; the dividing hedgerows and tree-lines offer the only notable ecological assets in the farmland landscape, and as such are likely to be the focus of activity, commuting, foraging and shelter for species protected and otherwise.

An area of parkland exists to the west of the interchange, associated with Thickthorn Hall, although this has a heavy arable influence. A number of small woodland blocks and belts – broadleaved, coniferous and mixed – are located in the vicinity. Some are comparatively planted, as screening associated with the A11 and A47, whereas some are much older.

Ancient earthworks/tumuli are evident to the south of the A11. These are located within semi-natural and plantation woodland.

A small number of houses are located to the south of the junction. These have fairly large gardens, and so are of moderate ecological value at the local scale. The Park and Ride site, fuel station and hotel add a semi-urban aspect, to the immediate west of the junction.

2.4 Other Constraints

The land in the northeast and southeast quadrants is predominantly agricultural land, and the land in the southwest quadrant is mainly fields. The land in the northwest quadrant accommodates Thickthorn Park and Ride (P&R), Thickthorn Services; a Motel, an electricity substation and petrol filling station.

There are two overhead power cables parallel to A47. The cables on the east of A47 are 132 kV dual circuit line between the major substations at Norwich Main and Earlham and belong to UK Power Networks. The cables on the west of A47 are 400 kV dual circuit lines that belong to National Grid.

Also there are other BT, Water, Gas (Low Pressure) and electric cables crossing the A47 which may be affected by the proposed improvements.

3 Description of Options

As stated in Para 1.2 of this report, options being considered at this stage are;

- **Widening** on A47 (South) off-slip road
- **Bypass** road from A11 to Newmarket Road

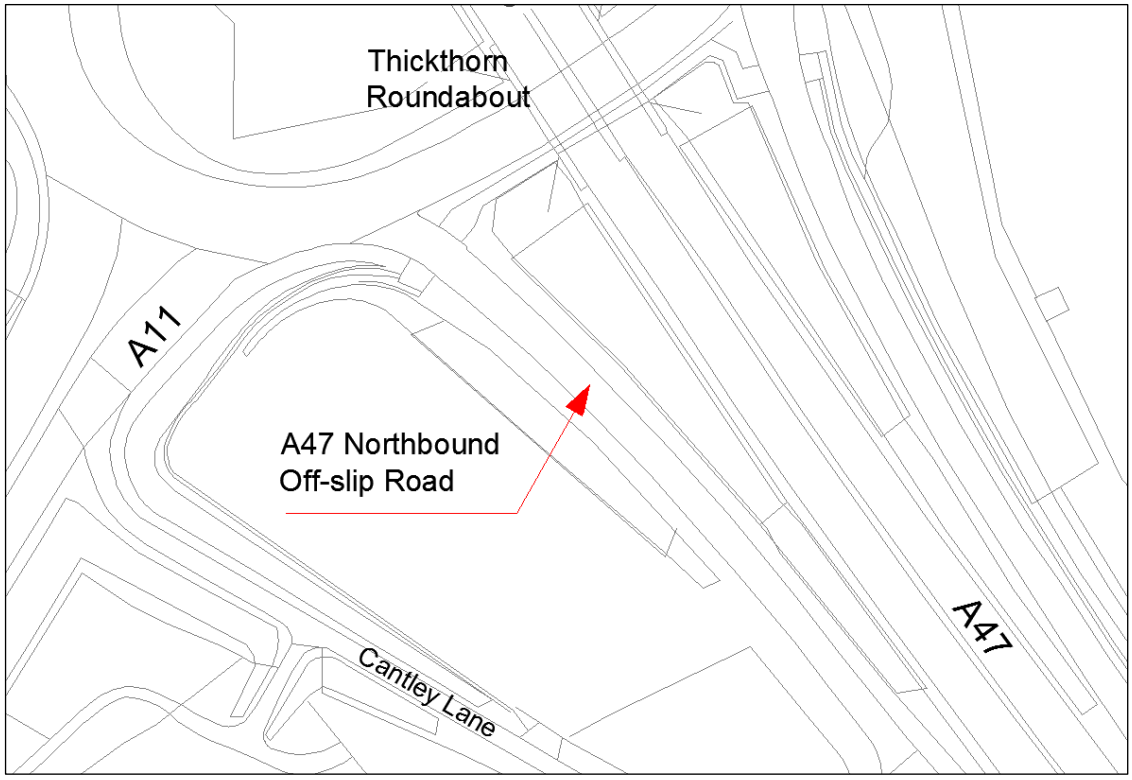
3.1 Widening on A47 (South) off-slip road

3.1.1 Description

The proposed widening provides an additional flared lane on the A47 (south) off-slip and also widening on the circulatory carriageway on the south-western quadrant of the interchange increasing the number of lanes from three to four.

This would increase the stop line saturation flows which could either improve the operational performance of the associated stop lines or alternatively; more green time could be given to more critical approaches. For the widening, two different options have been considered in terms of lane widths.

Layout of A47 Northbound Off-slip Road



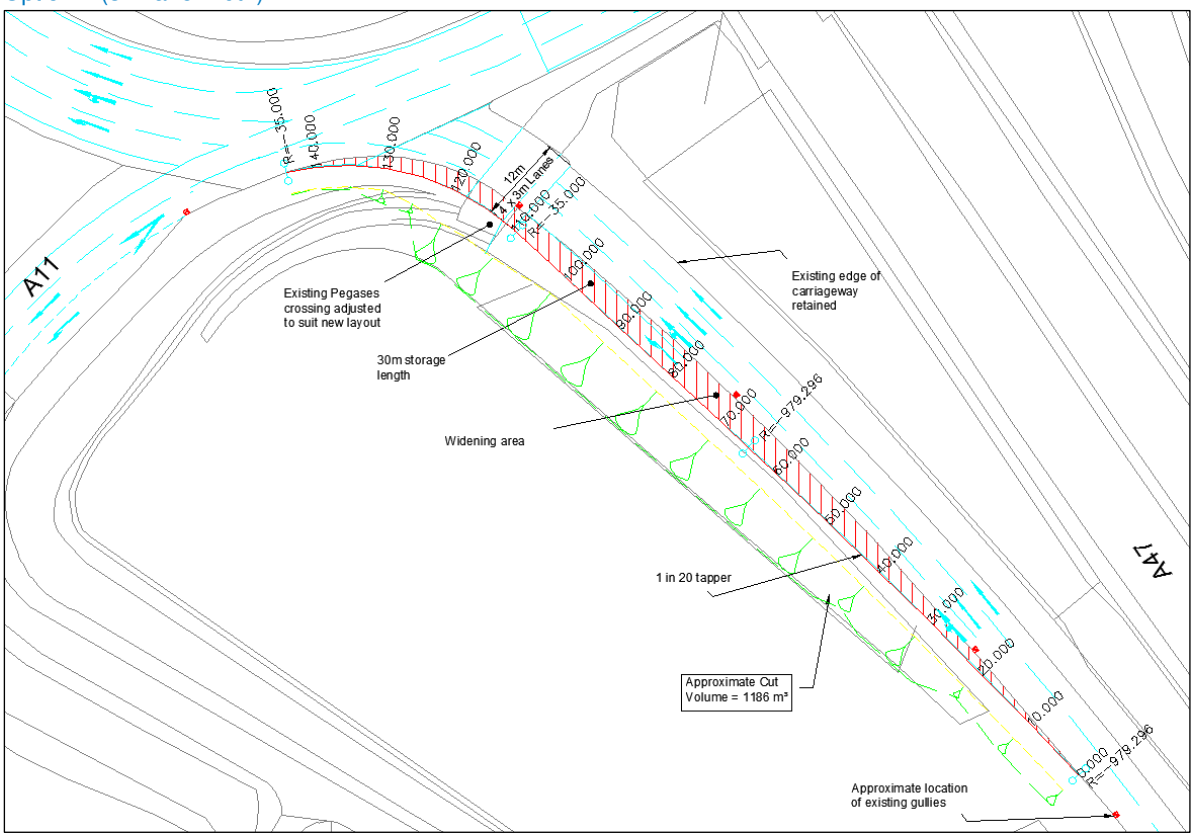
3.1.1.1 Option 1 (3m lane width)

In this option, the existing slip road width is increased from 9 metres to 12 metres providing four lanes with a width of 3m each.

Proposed widening requires steeper earthwork slopes on the offside than the existing slopes. At his stage a detailed ground investigation was not available so the slopes and cost calculations are shown indicative only. It is also assumed that the embankment will not be extended beyond the existing timber fence on top of the embankment.

An existing Pegasus crossing is affected by the proposed works and needs to be widened accordingly.

Option 1 (3m lane width)



3.1.1.2 Option 2 (3.65 m lane width)

In this option, the existing slip road width is increased from 9 metres to 14.6 metres providing four lanes with a width of 3.65 metres each.

The earthworks for this option is again restricted with the existing timber fence on top of the embankment, so the proposed earthwork slopes are steeper compared to Option 1. The increased lane width will improve the capacity, however slope stabilisation is likely to be required and this needs to be investigated at a later stage.

An existing Pegasus crossing is affected by the proposed works and needs to be widened accordingly.

3.1.2 Preliminary Cost Estimates

Preliminary cost estimates for both options have been carried out based on 2013 Q1 prices. Due to limited information being available on the ground conditions, the estimates do not allow for slope stabilisation. The estimates exclude land purchases and service diversions.

3.1.2.1 Option 1

Preliminary cost estimate for Option 1 is **£138K (±40%)**.

3.1.2.2 Option 2

Preliminary cost estimate for Option 2 is **£180K (±40%)**.

3.2 Bypass Scheme

3.2.1 Description

4 different options to connect the A11 to the existing Round House Roundabout on Newmarket Road are analysed;

- **Roundabout Arrangement -** A new roundabout on A11, connected to Round House Roundabout
- **Free flow Arrangement -** New simple diverge/merge on A11 connected to Round House Roundabout
- **Dumbbell Arrangement -** New grade separated dumbbell on A11 connected to Round House Roundabout
- **Half Dumbbell Arrangement** - A new simple merge and half dumbbell diverge on A11 connected to Round House Roundabout

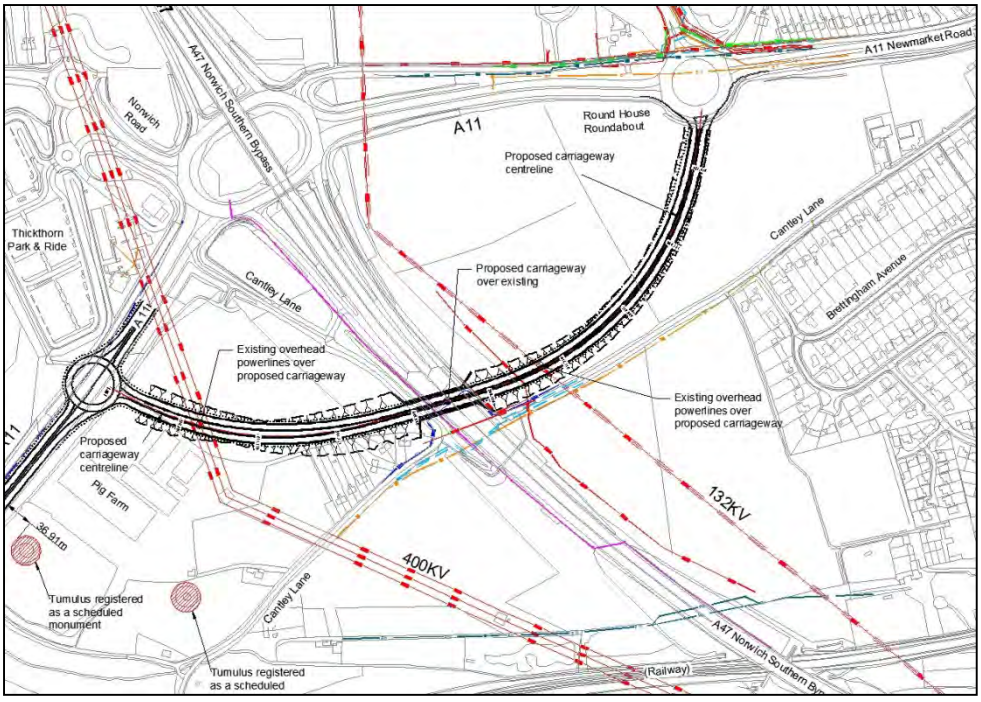
For the above 4 bypass options, 11 initial alternative layouts were produced where different structure types have been considered. For all these alternatives;

- Design is carried out to DMRB standards (with relaxations where necessary)
- Speed limit is 50 mph (85kph)
- Same route, that was adopted during the study done in 2012, is followed
- Road section is dual carriageway

3.2.2 Initial Alternatives

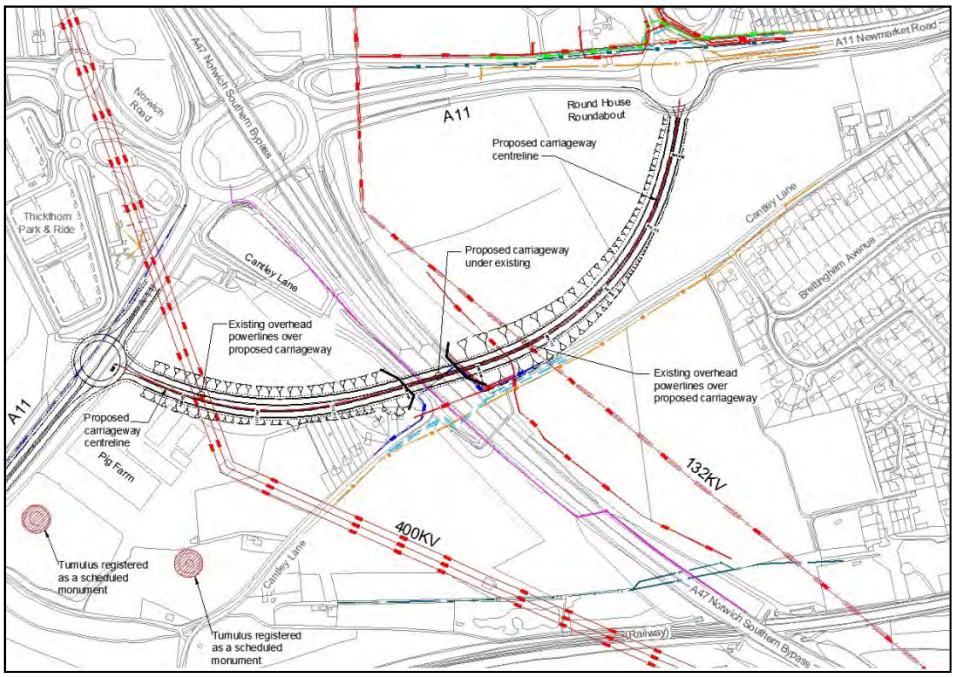
3.2.2.1 Roundabout Arrangement 'Alternative A'

Bypass connected to A11 with a new roundabout and A47 is crossed with an over bridge. This alternative is to be **considered further.**



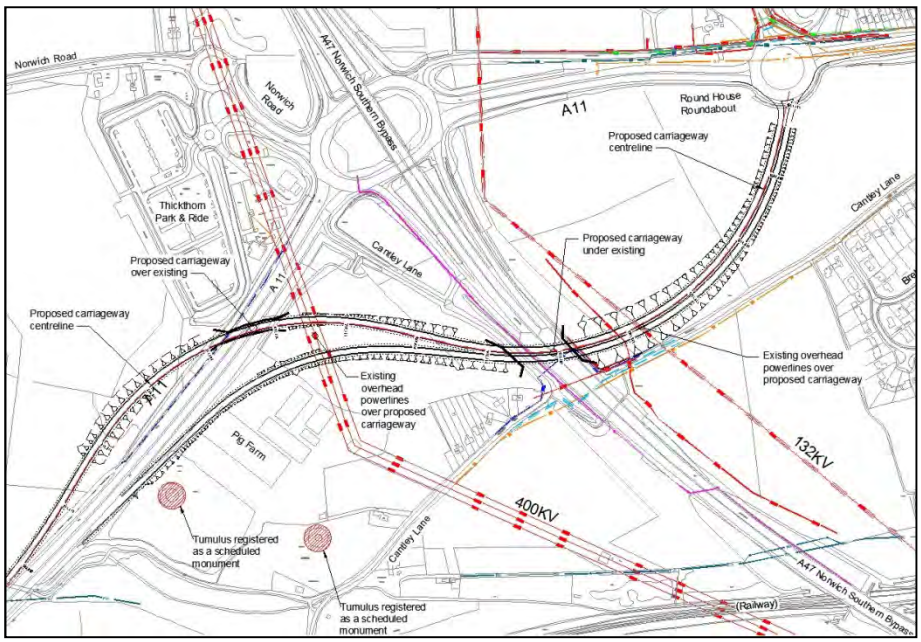
3.2.2.2 Roundabout Arrangement 'Alternative B'

Bypass connected to A11 with a new roundabout and A47 is crossed with an underground tunnel. This alternative **will not be considered further** as it is more expensive than Alternative A but operationally is no better.



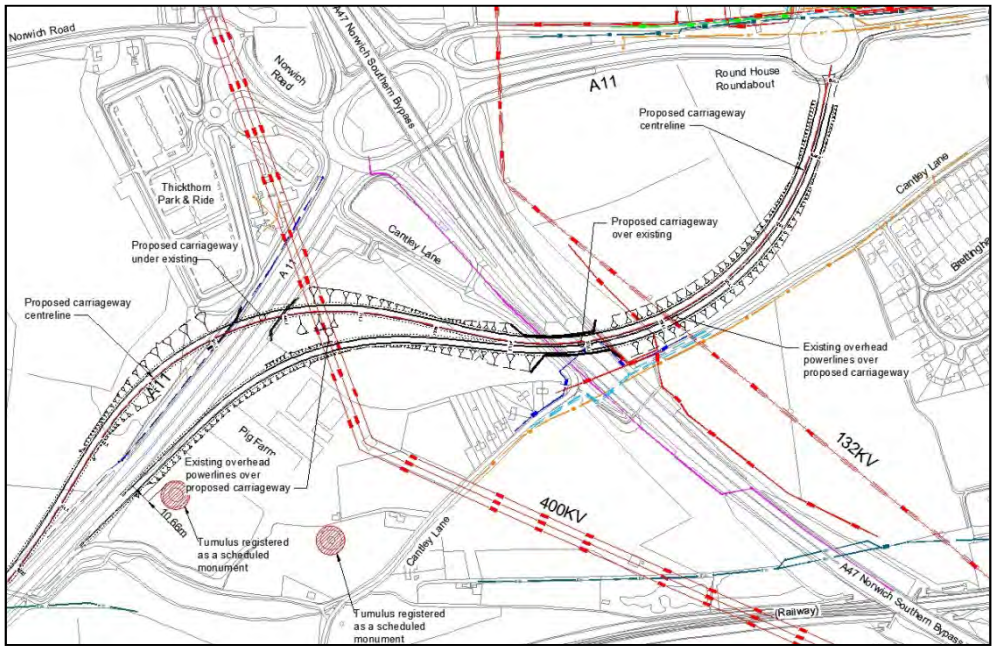
3.2.2.3 Free-Flow Arrangement 'Alternative A'

Northbound taper diverge from A11 crosses A11 with an overbridge and the bypass crosses A47 with an underground tunnel. This alternative **will not be considered further** due to estimated potential high costs.



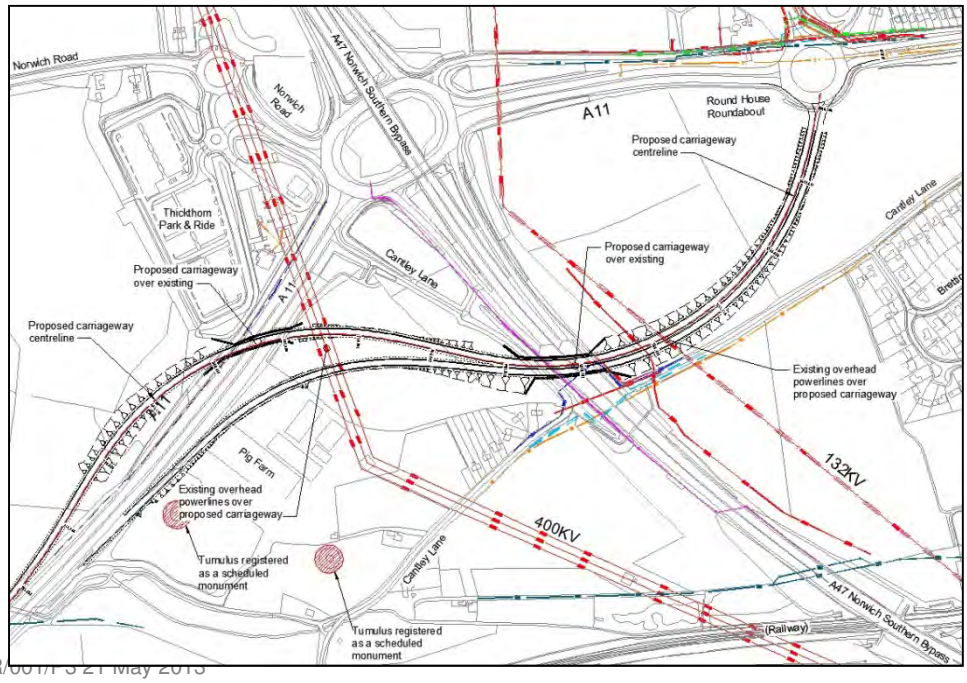
3.2.2.4 Free-Flow Arrangement 'Alternative B'

Northbound taper diverge from A11 crosses A11 with an underground tunnel and the bypass crosses A47 with an overbridge. This alternative is **to be considered further.**



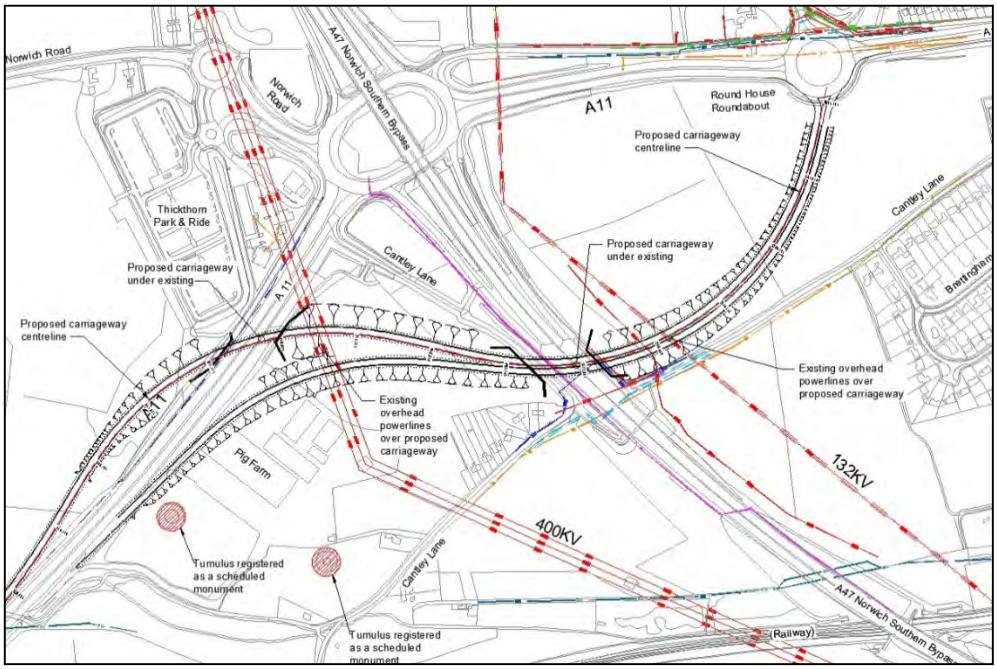
3.2.2.5 Free-Flow Arrangement 'Alternative C'

Northbound taper diverge from A11. Both A11 and A47 are crossed with overbridge. This alternative **will not be considered further** due to estimated potential high costs without additional operational benefits compared to Alternative B and the likely impact on the 400kV overhead electricity cables.



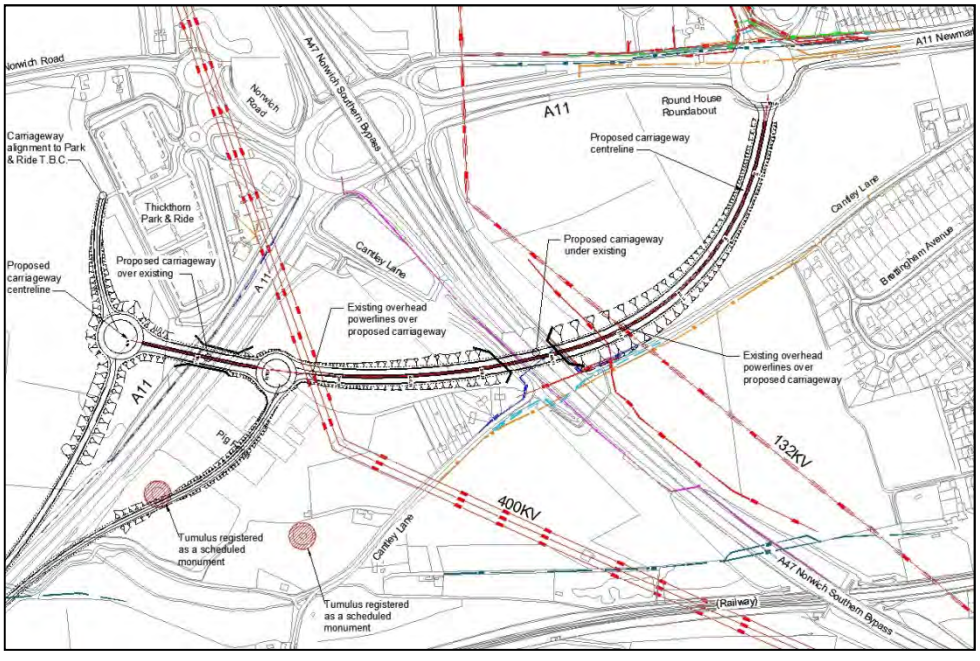
3.2.2.6 Free-Flow Arrangement 'Alternative D'

Northbound taper diverge from A11 crosses A11 with an underground tunnel and the bypass crosses A47 with an overbridge. This option **will not be considered further** as it is more expensive than Alternative B but operationally no better.



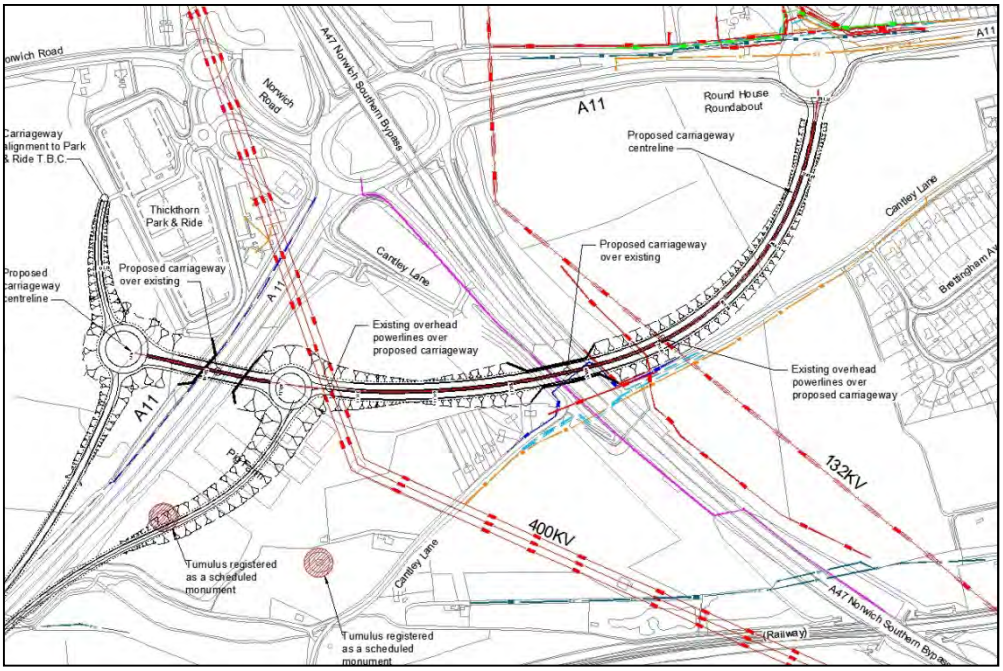
3.2.2.7 Dumbbell Arrangement 'Alternative A'

Dumbbell connection to A11 with a bridge over A11. The bypass crosses A47 with an underground tunnel. This alternative **will not be considered further** due to estimated potential high costs.



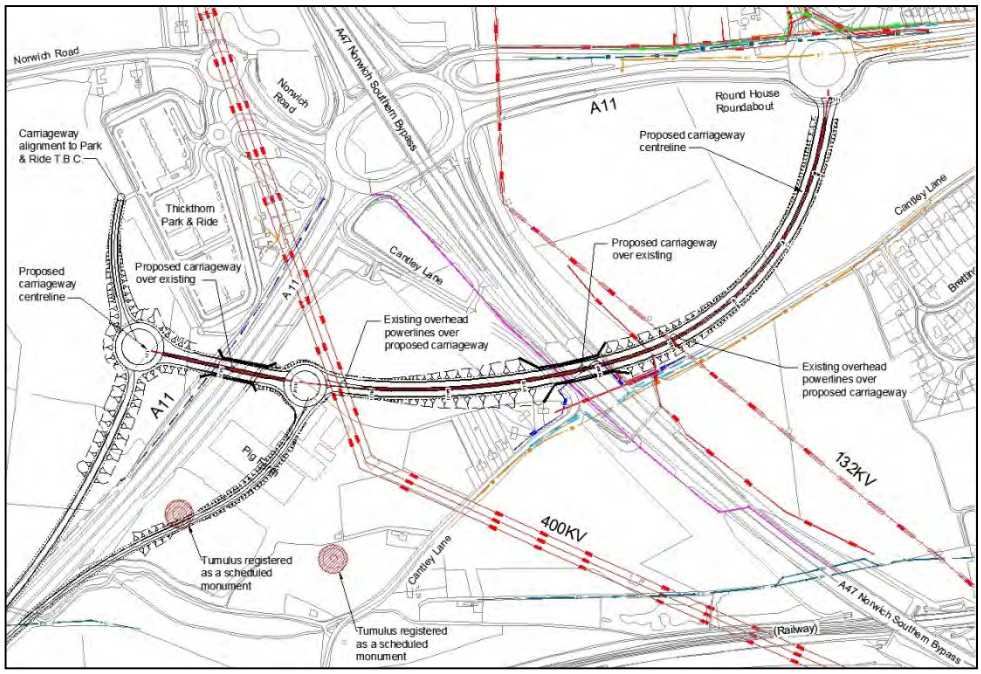
3.2.2.8 Dumbbell Arrangement 'Alternative B'

Dumbbell connection to A11 with an underground tunnel under A11. The bypass crosses A47 with an overbridge. This alternative is **not considered further** due to estimated potential high costs similar to Alternative A.



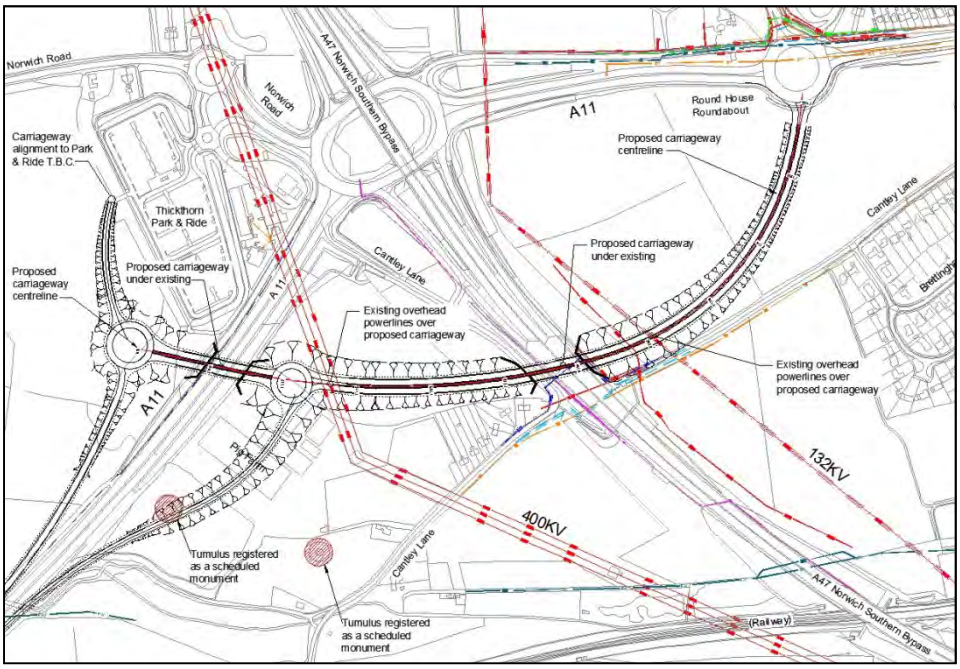
3.2.2.9 Dumbbell Arrangement 'Alternative C'

Dumbbell connection to A11 with a bridge over A11 and the bypass crosses A47 with an overbridge. This alternative **is to be considered further.**



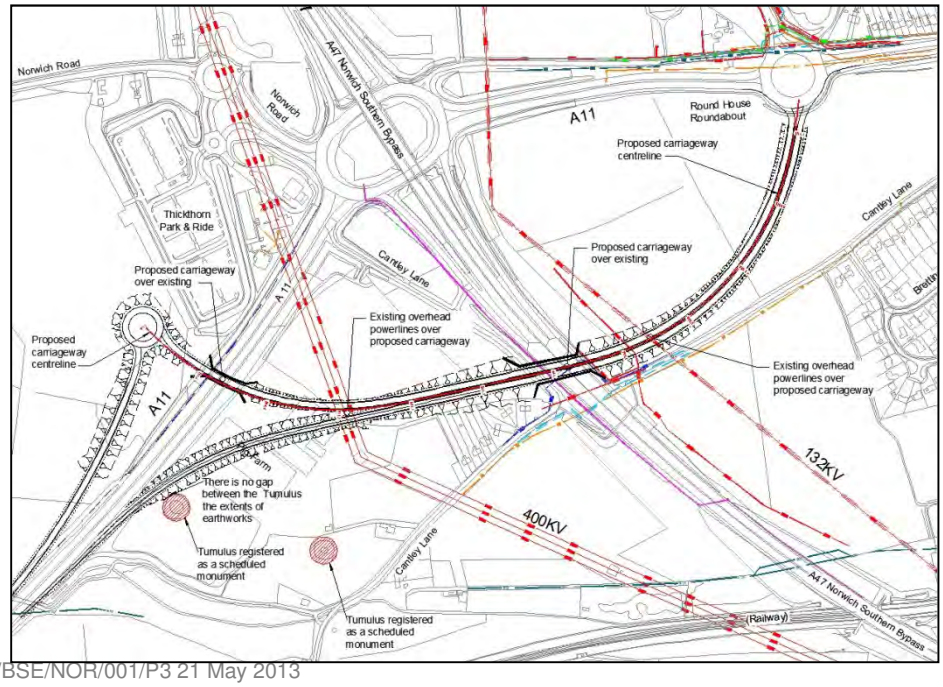
3.2.2.10 Dumbbell Arrangement 'Alternative D'

Dumbbell connection to A11 an underground tunnel under A11 and the bypass crosses A47 with an underground tunnel. This alternative **will not be considered further** as it is more expensive than Alternative C but operationally no better.



3.2.2.11 Half Dumbbell Arrangement 'Alternative A'

Northbound diverge on A11 connected to the bypass with a roundabout. Both A11 and A47 are crossed with overbridge. This option **will be considered further.**



Thickthorn Intersection Improvements - Summery Table for all options and alternatives							
Option / Alternative	**General Considerations**	**Structure**	**Length of Structure**	**Utilities**	**Estimated cost (±40%)**	**Comments**	**Recommendation**
Roundabout Arrangement / Alternative A	Maximum Length: 1000m Bypass footprint 59,000m²	A47 bridge	Bridge Span 70m	Relocate 132kV (estimated cost £3m)	£27.2M	A11 roundabout too close to Thickthorn. Likely to require signalisation and extra stacking capacity between the two roundabouts. Not as attractive as free flow options as A11 Norwich bound traffic has to negotiate a new roundabout on A11	Consider further as cheapest alternative of this option
Roundabout Arrangement / Alternative B	Maximum Length: 1000m Bypass footprint 65,500m²	A47 tunnel	Tunnel length 70m	Unaffected	£38M	A11 roundabout too close to Thickthorn. Likely to require signalisation and extra stacking capacity between the two roundabouts. Not as attractive as free flow options as A11 Norwich bound traffic has to negotiate a new roundabout on A11	Do not Consider further
Free flow Arrangement / Alternative A	Maximum Length: 1500m Bypass footprint 71,000m²	A11 bridge A47 tunnel	Bridge Span 70m, Tunnel length 80m	Relocate 132 kV (estimated cost £3m) and relocate 400kV	£63M	Free flowing traffic as A11 to A11 traffic bypasses Thickthorn and only has to negotiate Roundhouse Way roundabout	Do not Consider further
Free flow Arrangement / Alternative B	Maximum Length: 1500m Bypass footprint 72,000m²	A11 tunnel A47 bridge	Tunnel length 80m, Bridge Span 90m	Relocate 132kV (estimated cost £3m)	£51M	Free flowing traffic as A11 to A11 traffic bypasses Thickthorn and only has to negotiate Roundhouse Way roundabout	Consider further as cheapest alternative of this option
Free flow Arrangement / Alternative C	Maximum Length: 1500m Bypass footprint 66,000m²	A11 bridge A47 bridge	Bridge span 80m, Bridge span 90m	Relocate 132 kV (estimated cost £3m) and relocate 400kV	£83M	Free flowing traffic as A11 to A11 traffic bypasses Thickthorn and only has to negotiate Roundhouse Way roundabout	Do not Consider further
Free flow Arrangement / Alternative D	Maximum Length: 1500m Bypass footprint 89,500m²	A11 tunnel A47 tunnel	Tunnel length 80m, Tunnel length 90m	Unaffected	£73M	Free flowing traffic as A11 to A11 traffic bypasses Thickthorn and only has to negotiate Roundhouse Way roundabout	Do not Consider further
Dumb-bell Arrangement / Alternative A	Maximum Length: 1600m Bypass footprint 91,000m²	A11 bridge A47 tunnel	Bridge Span 50m, Tunnel length 80m	Unaffected	£48M	Dumb-bell arrangement reduces skew on A11 crossing thus reducing cost but is less attractive as A11 Norwich bound traffic has to negotiate two extra roundabouts. A11 southbound on slip may conflict with tumulus. Offers the opportunity to additionally remove the B1172 to A11 traffic from Thickthorn if a link back onto the B1172 is provided	Do not Consider further
Dumb-bell Arrangement / Alternative B	Maximum Length: 1600m Bypass footprint 100,000m²	A11 tunnel A47 bridge	Tunnel length 50m, Bridge span 70m	Relocate 132kV (estimated cost £3m)	£51M	Dumb-bell arrangement reduces skew on A11 crossing thus reducing cost but is less attractive as A11 Norwich bound traffic has to negotiate two extra roundabouts. A11 southbound on slip may conflict with tumulus. Offers the opportunity to additionally remove the B1172 to A11 traffic from Thickthorn if a link back onto the B1172 is provided	Do not Consider further
Dumbbell Arrangement / Alternative C	Maximum Length: 1500m Bypass footprint 82,500m²	A11 bridge A47 bridge	Bridge Span 50m, Bridge span 70m	Relocate 132kV (estimated cost £3m)	£40M	Dumb-bell arrangement reduces skew on A11 crossing thus reducing cost but is less attractive as A11 Norwich bound traffic has to negotiate two extra roundabouts. A11 southbound on slip may conflict with tumulus. Offers the opportunity to additionally remove the B1172 to A11 traffic from Thickthorn if a link back onto the B1172 is provided	Consider further as cheapest alternative of this option
Dumb-bell Arrangement / Alternative D	Maximum Length: 1600m Bypass footprint 107,000m²	A11 tunnel A47 tunnel	Tunnel length 50m Tunnel length 80m	Unaffected	£67M	Dumb-bell arrangement reduces skew on A11 crossing thus reducing cost but is less attractive as A11 Norwich bound traffic has to negotiate two extra roundabouts. A11 southbound on slip may conflict with tumulus. Offers the opportunity to additionally remove the B1172 to A11 traffic from Thickthorn if a link back onto the B1172 is provided	Do not Consider further
Half Dumb-bell Arrangement / Alternative A	Maximum Length: 1650m Bypass footprint 79,000m²	A11 bridge A47 bridge	Bridge span 70m, Bridge span 50m	Relocate 132kV (estimated cost £3m)	£39.8M	Half dumb-bell arrangement reduces skew on A11 crossing thus reducing cost but is less attractive as A11 Norwich bound traffic has to negotiate an extra roundabout	Consider further as cheapest alternative of this option

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3.2.3 Alternatives Further Studied

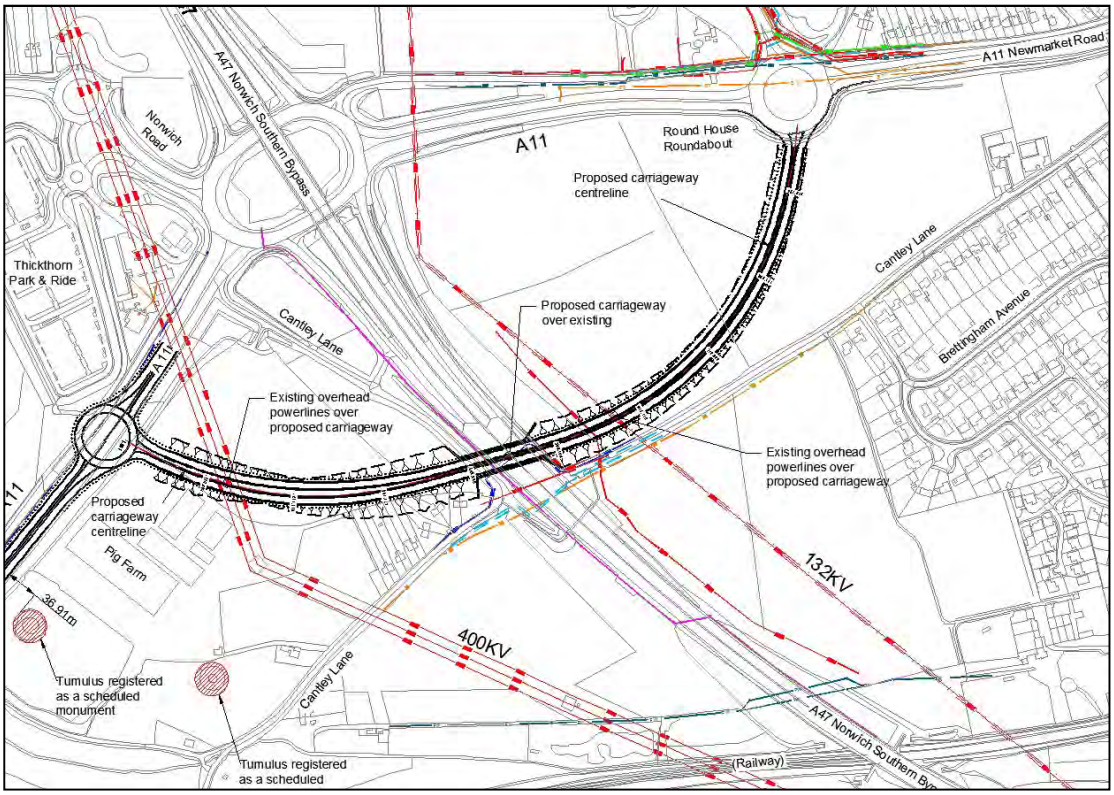
After consultation with NCC, 7 out of these 11 alternatives were not further considered because operationally, they offer no greater advantage to the other variants but are estimated to be more expensive. A contributing factor to the cost is the potential impact on the existing high voltage cables which might add significant diversion costs. The remaining alternatives are further considered.

- Roundabout Arrangement 'Alternative A'
- Free Flow Arrangement 'Alternative B'
- Dumbbell Arrangement ' Alternative C'
- Half Dumbbell Arrangement 'Alternative A'

3.2.3.1 Roundabout Arrangement 'Alternative A'

This alternative is a dual carriageway alignment starting from a new three circulatory lane roundabout on A11 near the southern edge of Thickthorn Park & Ride to the existing roundabout on Newmarket Road on the East (See Appendix A2). Bypass connects to A11 with a new roundabout and A47 is crossed with an over bridge.

Roundabout Arrangement 'Alternative A' Layout



Horizontal Geometry

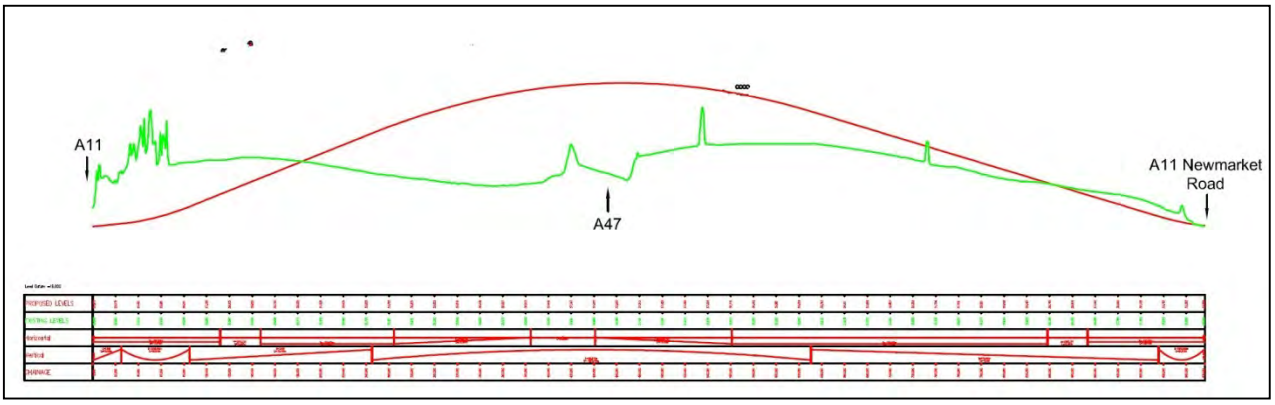
The alignment starts with a horizontal curve of 510m and a transition length of 112m, followed by a curve of radius 360m. It crosses A47 with a straight, making an angle of 29° with the centreline of A47. This is followed by a horizontal curve with a radius of 510m and 120m transition which ties into the existing roundabout on Newmarket Road with a curve of 360m.

A preliminary roundabout design has also been carried out with northern and southern arms of the new roundabout (on A11) are shown in the design, however this is based on the Ordnance Survey and the LIDAR survey. A full survey should be done for detailed design. The new bypass alignment is around 190m away from the registered tumuli near to Cantley Lane.

Vertical Geometry

The vertical alignment consists of a 4% gradient slope on the east, a 385 m vertical curve above A47, and a ramp with 3% slope down to the existing roundabout on Newmarket Road. At this stage, a detailed survey is not available and the details of the bridge are not certain yet, however the alignment provides approximately 5.5 m vertical clearance above A47, assuming a 1.5 m bridge structure depth. This needs to be confirmed at a later stage when a detailed survey is available.

Roundabout Arrangement 'Alternative A Long Section



Vertical geometry of this alignment will require diversion of existing 132kV overhead electricity cables on the east side of A47.

Following consultation with the National Grid it is established that for the 400kV overhead electricity cables on the west of A47, an 8.1 m vertical clearance is required. This alternative provides approximately 12 m clearance.

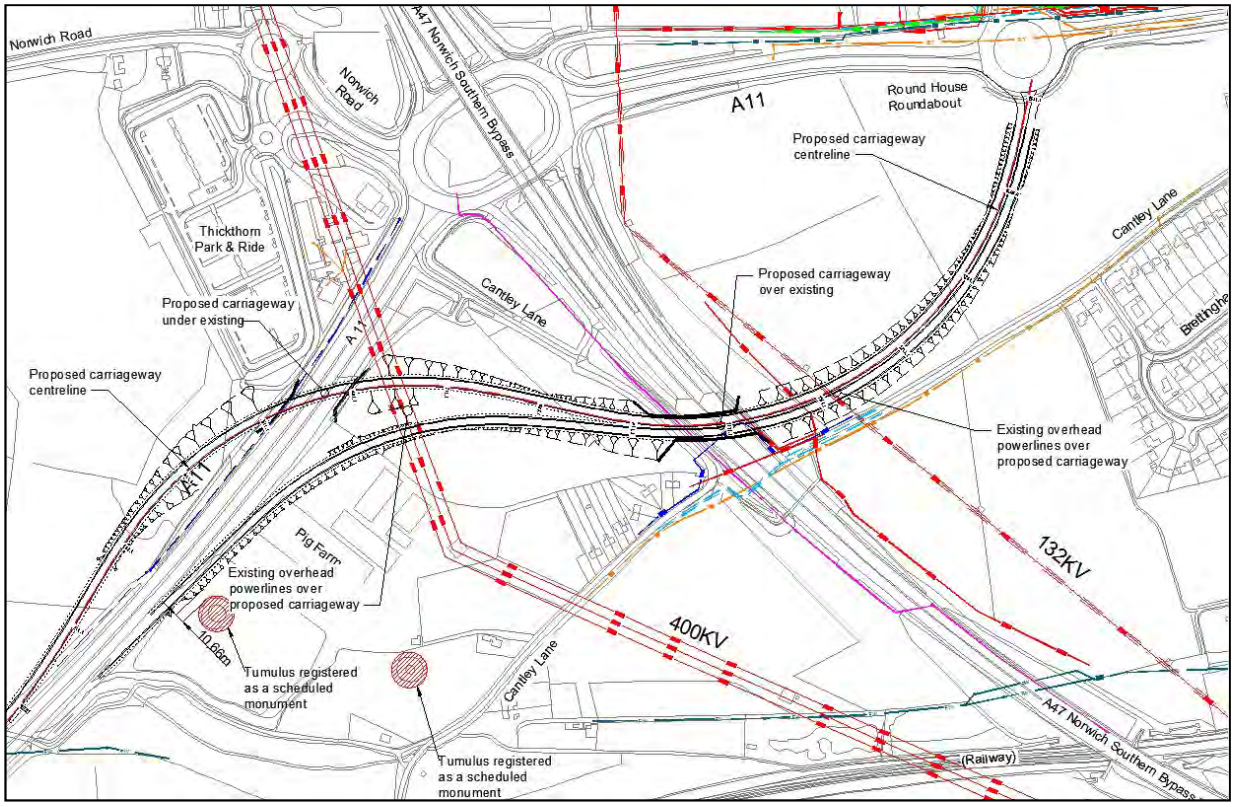
Traffic Signals and Crossings

- **Existing Thickthorn Roundabout**
  The existing traffic signal installation is controlled at each arm minus the Norwich Road northwest arm from Hethersett.
  There is an Equestrian "Pegasus" crossing across the westbound off-slip road of the A47 at the A11 and a cycle/pedestrian crossing across the eastbound off-slip road at the A11. These would have to be retained as there is no provision on the scheme for an over bridge, therefore traffic signal control would still be required on both the west and eastbound off-slip roads.
  The signallisation of the A11 north eastbound approach allows the Norwich Road (from Hethersett) to be uncontrolled so that vehicles and the bus lane can flow in the intergreen period between the circulatory and approach stages.
  Due to the relative close proximity of the existing roundabout to the new proposed roundabout careful consideration will be required on queue length and optimisation of the traffic signals.
- **Existing Rounds House Roundabout**
  The existing roundabout has a Toucan crossing across each carriageway just east of the Round House roundabout. This is currently underutilised, and consideration will need to be given to this when the full development adjoining north and south of Round House roundabout is in place with regards to the impact of the dual Toucan crossing.

3.2.3.2 Free-Flow Arrangement 'Alternative B'

This alternative is dual carriageway alignment starting with simple diverge and merge tapers on A11 (See Appendix A3). A11 is crossed with an underground tunnel and A47 with an overbridge.

Free Flow Arrangement 'Alternative B' Layout



Horizontal Geometry

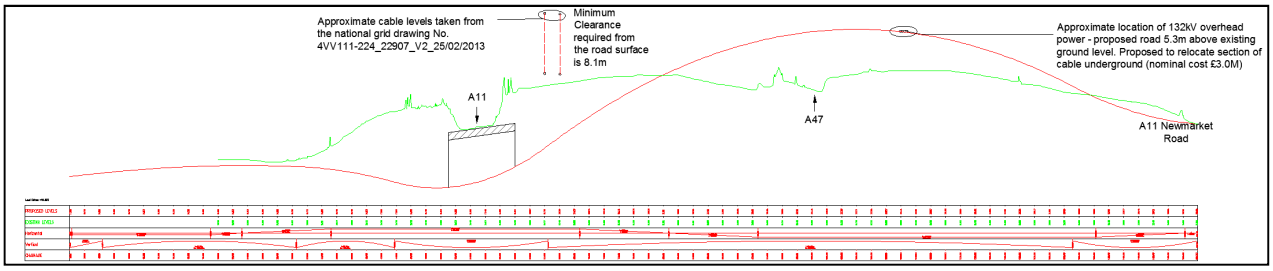
Northbound slip road alignment starts with a diverge taper on A11 approximately 800m to the south of Thickthorn Interchange. The slip road crosses A11 at an average angle of 40° and joins the Southbound merge slip road 400m after crossing A11.The southbound slip road alignment starts with a merge taper on A11 around 600m from the Thickthorn Interchange.

The dual carriageway section crosses A47 with an average angle of 53° and joins to the existing roundabout with a radius of 360m and transition length of 120m.

Vertical Geometry

The vertical alignment consists of a combination of ramps connected with vertical curves with a minimum vertical curve radius of 2000m. The maximum slope used in the preliminary design is 6%. Although considered as acceptable, this is above the maximum 4% recommended value in DMRB standards. However given the constraints of the area and the short distance between the proposed tunnel under A11 and the proposed bridge on A47, it was not possible to use shallower slopes.

Roundabout Arrangement 'Alternative A' Long Section



At this stage, a detailed survey is not available and the details of the bridge are not certain yet, however the alignment provides approximately 5.5m vertical clearance above A47, assuming a 1.5m bridge structure depth. Also for the tunnel option similar structure depth is assumed and 5.5m vertical clearance is provided. These need to be confirmed at a later stage when a detailed survey is available.

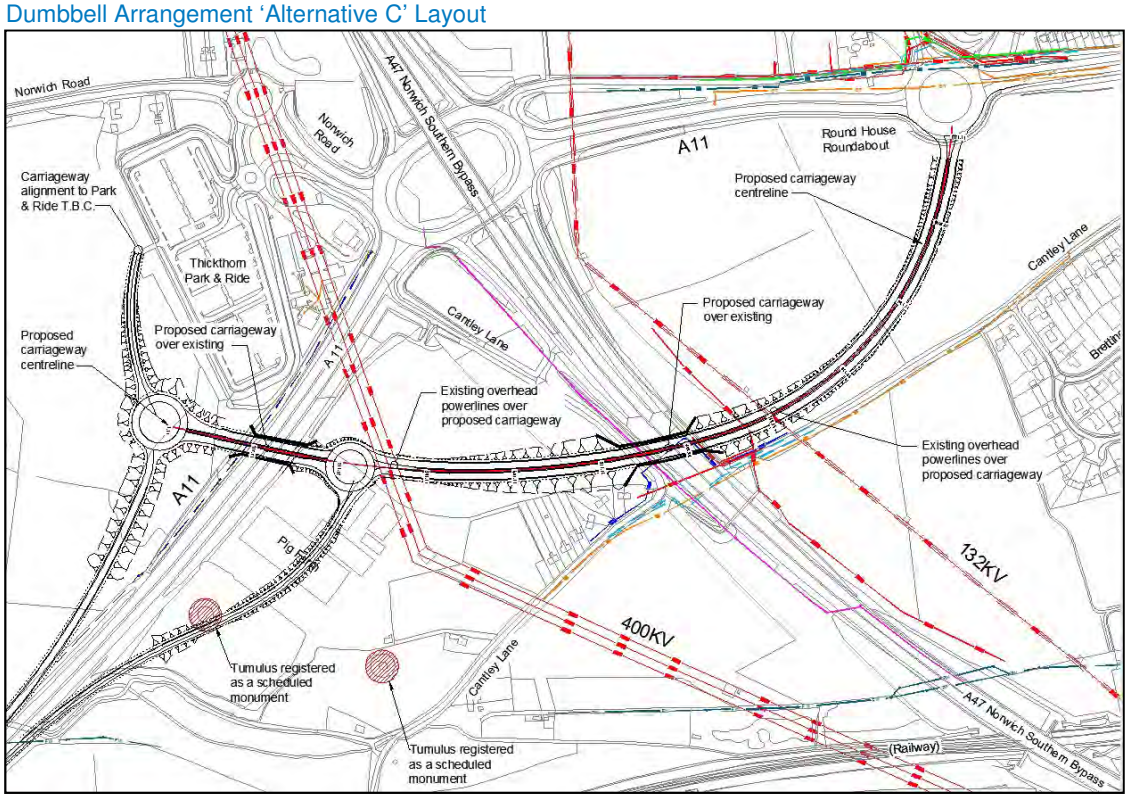
Traffic Signals and Crossings

- **Existing Thickthorn Roundabout**
  The existing traffic signal installation is controlled at each arm minus the Norwich Road northwest arm from Hethersett.
  There is an Equestrian "Pegasus" crossing across the westbound off slip road of the A47 at the A11 and a cycle/pedestrian crossing across the eastbound off slip road at the A11. These would have to be retained as there is no provision on the scheme for an over bridge, therefore traffic signal control would still be required on both the west and eastbound off-slip roads.
  The signalisation of the A11 north eastbound approach allows the Norwich Road (from Hethersett) to be uncontrolled so that vehicles and the bus lane can flow in the intergreen period between the circulatory and approach stages.
  Consideration could be given however to signalise the Norwich Road (Hethersett) approach so as to include a controlled bus lane on the roundabout (as outlined in the Traffic Assessment Report – Option 11)
- **Existing Round House Roundabout**
  The existing roundabout has a Toucan crossing across each carriageway just east of the Round House roundabout.
  This is currently underutilised and consideration will need to be given to when the full development adjoining north and south of Round House roundabout is in place as to the impact of the dual Toucan crossing.

3.2.3.3 Dumbbell Arrangement 'Alternative C'

This alternative is a dumbbell connection to A11 with bridges over A11 and A47 (See Appendix A4).

Dumbbell Arrangement 'Alternative C' Layout



Horizontal Geometry

The horizontal alignment consists of two new roundabouts on either side of A11 near the south edge of existing Thickthorn Park & Ride which form the typical 'dumbbell arrangement' used on trunk roads. The merge and diverge arms to/from A11 are connected with a simple tapers.

The roundabout on the west side of A11 is a three-arm roundabout and one of the arms is shown as redundant at this stage which can be utilized as a direct connection to the P&R or Norwich Road if necessary, or can be taken off completely.

The roundabout on the east side of the roundabout is again a three arm normal roundabout with one of the arms connected to the other roundabout with a bridge over A11.

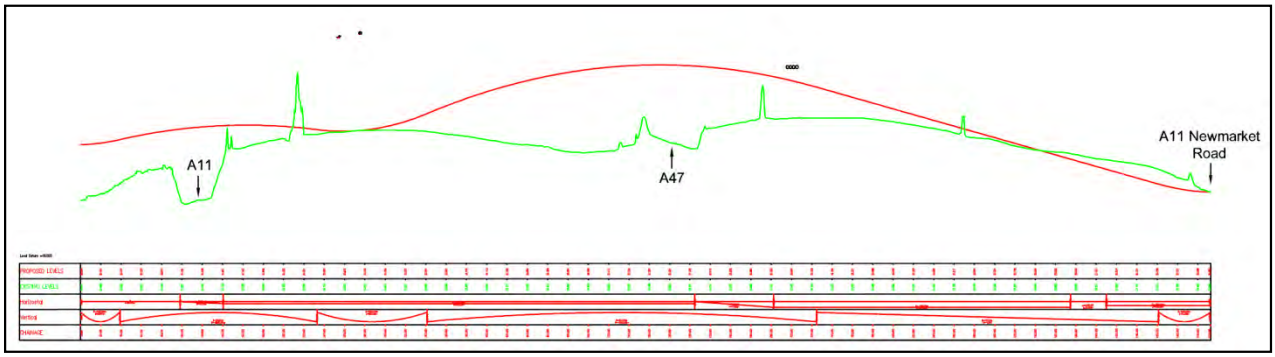
The dual carriageway section crosses A47 with an average angle of 59° and a horizontal curve over 360m with a transition length of 75m. It joins the existing roundabout on Newmarket Road with a radius of 510m and transition length of 35m.

Vertical Geometry

The vertical alignment consists of a combination of ramps connected with vertical curves with a minimum curve radius of 2000m. The maximum slope used in the preliminary design is 3% and this is below the maximum recommended value in DMRB.

At this stage, a detailed survey is not available and the details of the bridge are not certain yet, however the alignment provides approximately 5.5m vertical clearance above A47, assuming a 1.5m bridge structure depth. Also for the over A47, similar structure depth is assumed and 5.5m vertical clearance is provided. These need to be confirmed at a later stage when a detailed survey is available.

Dumbbell Arrangement 'Alternative C' Long Section



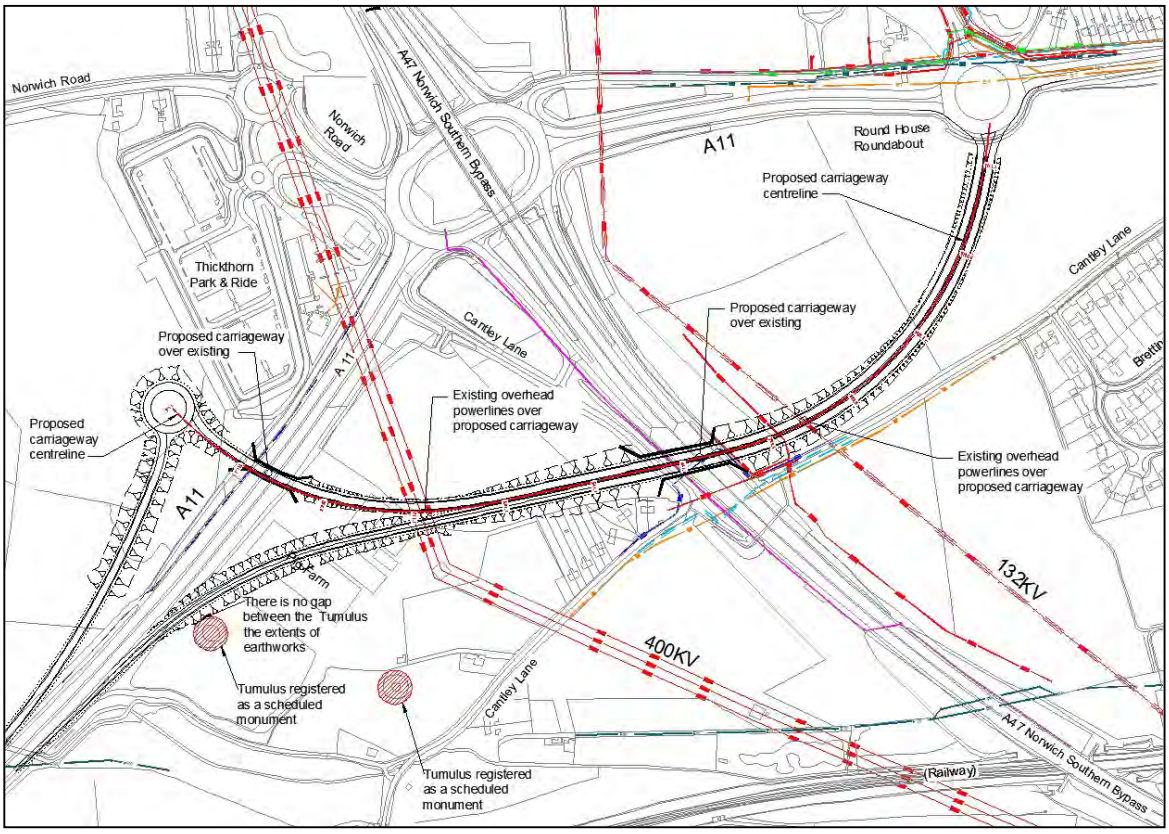
Traffic Signals and Crossings

- **Existing Thickthorn Roundabout**
  The existing traffic signal installation is controlled at each arm minus the Norwich Road northwest arm from Hethersett.
  There is an Equestrian "Pegasus" crossing across the westbound off-slip road of the A47 at the A11 and a cycle/pedestrian crossing across the eastbound off-slip road at the A11. These would have to be retained as there is no provision on the scheme for an over bridge, therefore traffic signal control would still be required on both the west and eastbound off-slip roads.
  The signalisation of the A11 north eastbound approach allows the Norwich Road (from Hethersett) to be uncontrolled so that vehicles and the bus lane can flow in the intergreen period between the circulatory and approach stages.
  Consideration could be given however to signalise the Norwich Road (Hethersett) approach so as to include a controlled bus lane on the roundabout (as outlined in the Traffic Assessment Report – Option 11)
- **Existing Round House Roundabout**
  The existing roundabout has a Toucan crossing across each carriageway just east of the Round House roundabout.
  This is currently underutilised and consideration will need to be given to when the full development adjoining north and south of Round House roundabout is in place as to the impact of the dual Toucan crossing.

3.2.3.4 Half Dumbbell Arrangement 'Alternative A'

Northbound diverge on A11 connected to the bypass with a roundabout (See Appendix A5). Both A11 and A47 are crossed with overbridge.

Half Dumbbell Arrangement 'Alternative A' Layout



Horizontal Geometry

The horizontal alignment consists of a new roundabout on the west side of A11 near the southern edge of existing Thickthorn Park & Ride for A11 northbound diverge. A11 southbound merge arm is a direct connection to A11. Both merge and diverge arms join A11 with simple tapers.

The roundabout on the west side of A11 is a two-arm roundabout however a new arm can be added to the layout and can be utilized as a direct connection to the P&R or Norwich Road if found necessary.

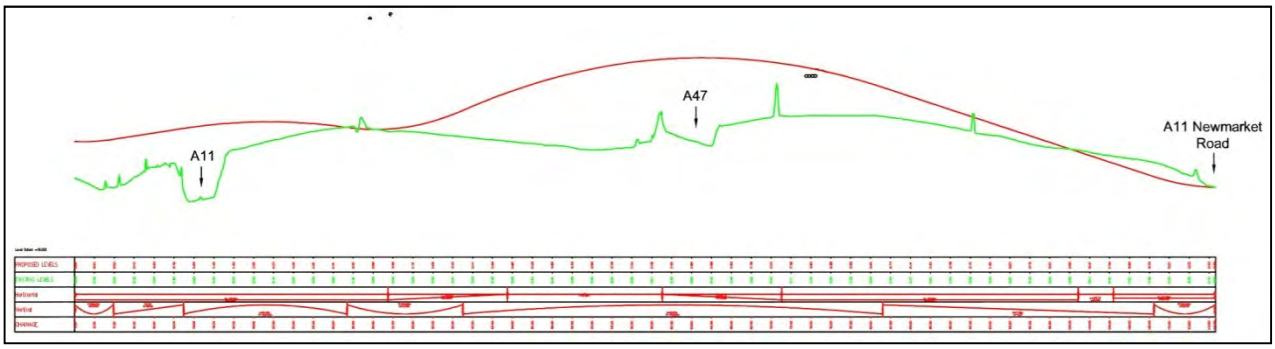
The dual carriageway section crosses A47 with an average angle of 57° and a horizontal curve over 360m with a transition length of 75m. It joins the existing roundabout on Newmarket Road with a radius of 510m and transition length of 35m.

Vertical Geometry

The vertical alignment consists of a combination of ramps connected with vertical curves with a minimum curve radius of 2000 m. The maximum slope used in the preliminary design is 4.25%. Although considered as acceptable this is above the 4% maximum recommended value in DMRB.

At this stage, a detailed survey is not available and the details of the bridge are not certain yet, however the alignment provides approximately 5.5 m vertical clearance above A47, assuming a 1.5 m bridge structure depth. Also for the over A47, similar structure depth is assumed and 5.5 m vertical clearance is provided. These need to be confirmed at later stage when a detailed survey is available.

Half Dumbbell Arrangement 'Alternative A' Long Section



Traffic Signals and Crossings

- **Existing Thickthorn Roundabout**
  There is an Equestrian "Pegasus" crossing across the westbound off slip road of the A47 at the A11. The crossing is underutilised, originally installed as the Keswick stables have a field on the land west of the crossing.
  The crossing if retained there would require re-configuring of the signal timings, as well as the general traffic signal poles/heads/push button units re-assessed.
  The option shows just the widening of the westbound off slip road and widening of the circulatory lanes as outlined in the Traffic Assessment Report – Option 17

3.2.4 Preliminary Cost Estimates

A cost estimate study based on 2013 Q1 prices is carried out for the four bypass alternatives. These estimates do not include planning and approval charges, land purchases and utility diversions except the diversion of 132kV overhead electric cables, for which £3m is allowed as an initial estimate.

3.2.4.1 Roundabout Arrangement 'Alternative A'

Preliminary cost estimate for the roundabout arrangement 'Alternative A' is **£27.2 m** with ±40%.

3.2.4.2 Free-Flow Arrangement 'Alternative B'

Preliminary cost estimate for Free-Flow Arrangement 'Alternative B' is **£51 m** with ± 40%.

3.2.4.3 Free-Flow Arrangement 'Alternative C'

Preliminary cost estimate for Free-Flow Arrangement 'Alternative C' is **£40 m** with ±40%.

3.2.4.4 Half Dumbbell Arrangement 'Alternative A'

Preliminary cost for Half Dumbbell Arrangement 'Alternative A' is **£39.8 m** with ±40%.

4 Engineering Assessment

4.1 Condition of Existing Road Pavements and Highway Structures

The focus of this study was looking at the feasibility of possible alignment and structure options that will be required to achieve scheme objectives. At this stage a detailed analysis of existing road pavements has not been carried out. In the next stages of the scheme a detailed design of proposed pavements needs to be carried out following the ground investigations and existing pavement condition survey.

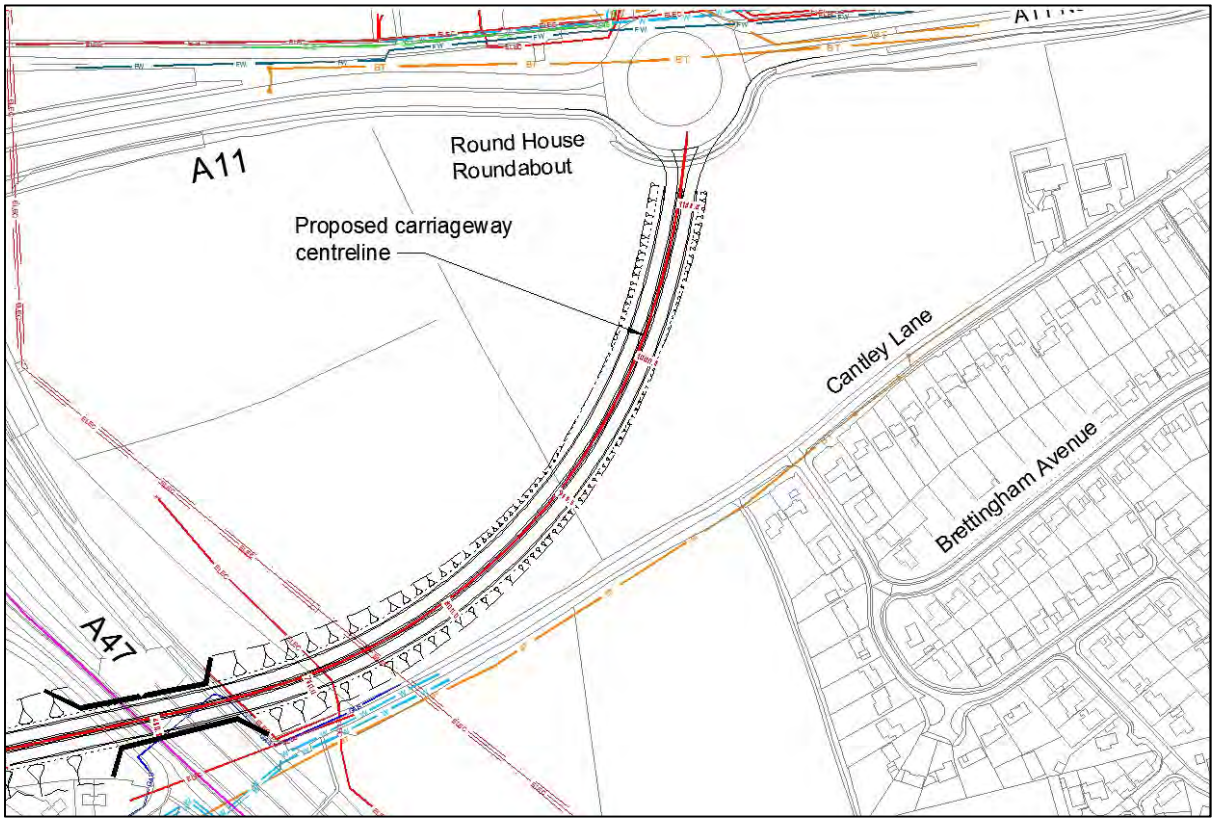
It is anticipated that the proposed bypass options and the new structures will not affect the existing structures at Thickthorn Roundabout. This bridge is on Highways Agency network and currently maintained by the Agency.

4.2 Topography and Land Use

During this study it is assumed that all sections of the road which are elevated or below the existing ground, would be supported by embankments with a slope of 1 in 2.5. The layouts prepared at this stage show the earthworks based on this assumption and need to be verified after carrying out the ground investigation and considering other constraints such as land use, feasibility and cost.

The footprints of the proposed bypass alternatives on the east of A47, for both tunnel and overbridge variants, are similar.

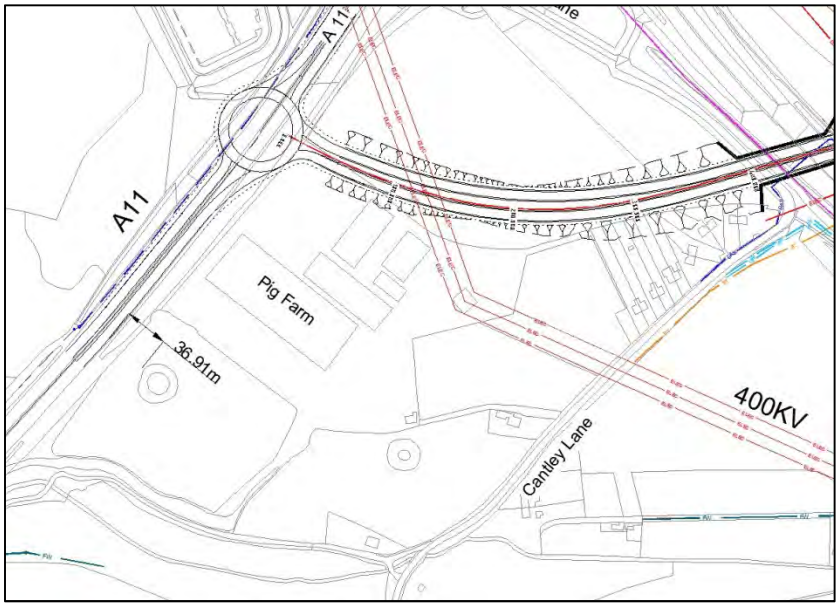
Layout showing approximate land use on the east of A47



4.2.1 Roundabout Arrangement 'Alternative A'

The footprint of this alternative is around 59,000m² however approximately 16,000m² of this overlaps with existing highways and total landtake is estimated to be in the region of 43,000m². The earthworks design based on above assumption extends beyond the fences of the houses on Cantley Lane on the west of A47. This alternative requires minimum land take from the Park & Ride and services area.

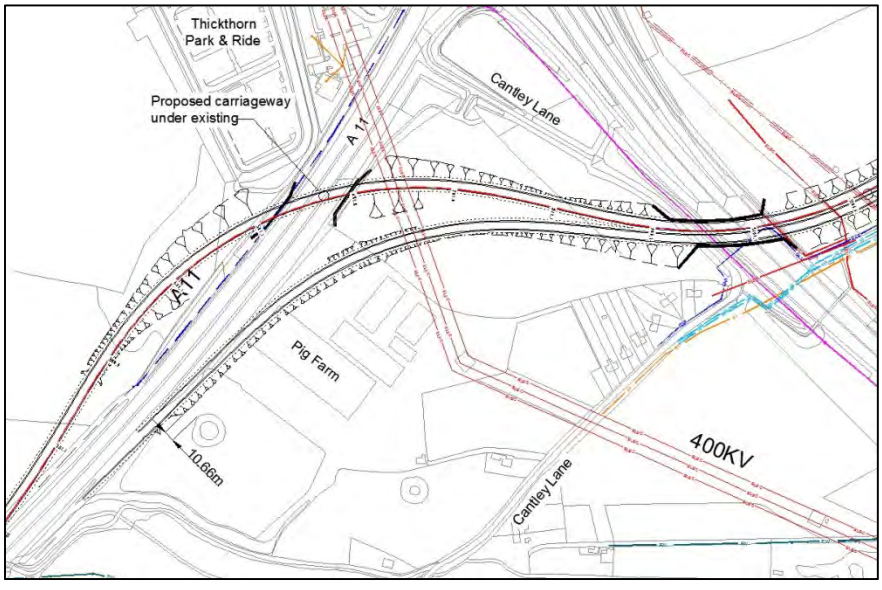
Roundabout Arrangement 'Alternative A' potential land use



4.2.2 Free Flow Arrangement 'Alternative B'

The footprint of this alternative is around 72,000m² however approximately 11,000m² of this overlaps with existing highways and total landtake is estimated to be in the region of 61,000m². Proposed earthworks are not likely to affect the houses on Cantley Lane directly, but will have visual impact. This option would require around 14,000 m² land on the Park & Ride side and also would have an impact on the pig farm.

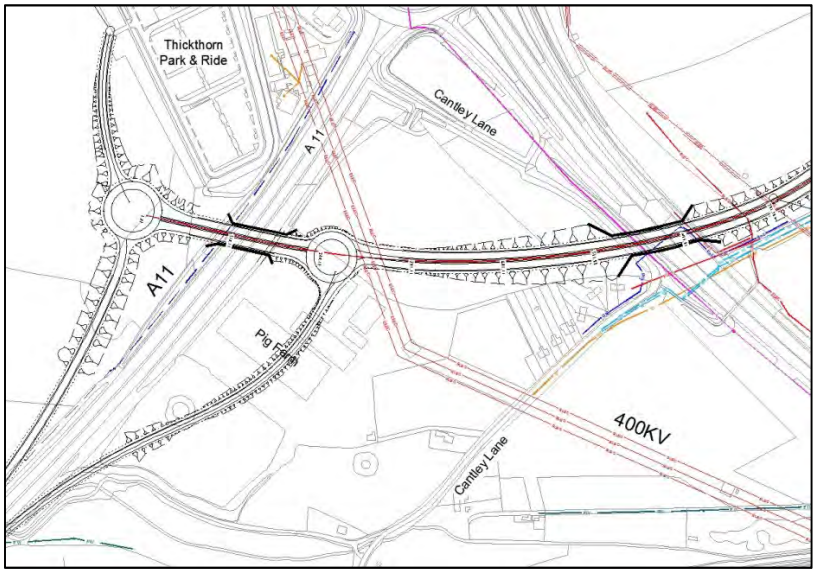
Free Flow Arrangement 'Alternative B' potential land use



4.2.3 Free Flow Arrangement 'Alternative C'

The footprint of this alternative is around 82,500m² however approximately 11,000m² of this overlaps with existing highways and total landtake is estimated to be in the region of 71,500m². The extent of indicative earthworks is very close to the fences of the houses on Cantley Lane. This option would have significant impact on the pig farm and also would require approximately 24,000 m² land on the Park & Ride side.

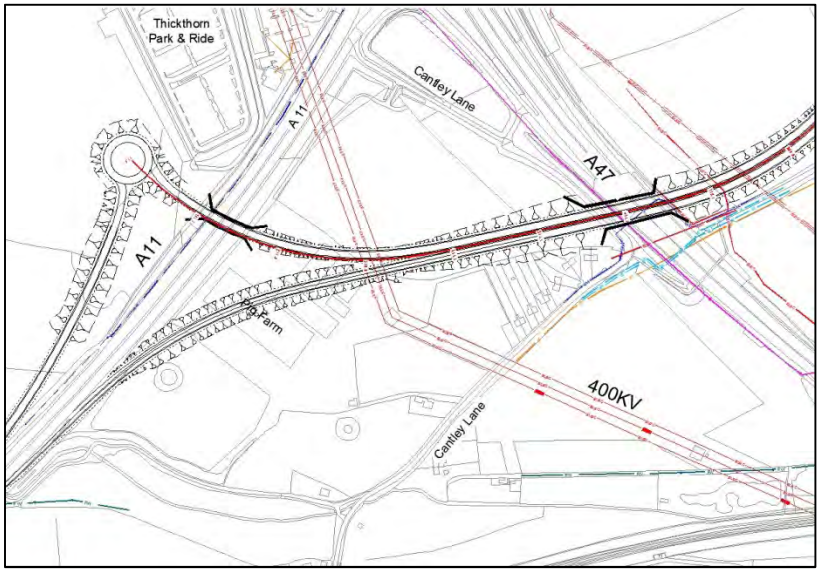
Free Flow Arrangement 'Alternative C' potential land use



4.2.4 Half Dumbbell Arrangement 'Alternative A'

The footprint of this alternative is around 79,000m² however approximately 11,000m² of this overlaps with existing highways and total landtake is estimated to be in the region of 68,000m². The extent of indicative earthworks crosses the fences of the houses on Cantley Lane and similar to previous alternative; it would have significant impact on the pig farm and would require around 22,000 m² land on Park & Ride side.

Half Dumbbell Arrangement 'Alternative A' potential land use



4.3 Proposed Highway Structures

The four proposed options have requirements for significant connections with the A47 and the A11. The proposed variants are;

- Roundabout Arrangement 'Alternative A' – Roundabout at A11 and bridge over A47
- Free Flow Arrangement 'Alternative B' – Tunnel under A11 and bridge over A47
- Dumbbell Arrangement 'Alternative C' – Bridge over A11 and bridge over A47
- Half Dumb Bell Arrangement 'Alternative A' – Bridge over A11 and bridge over A47

At this stage it is not possible to make detailed comment regarding the forms of structure required, due to the lack of detailed Geotechnical Information and Topographical Survey information; however it is possible to make initial general assumptions.

Currently only bridges are being considered as the means for crossing the A47, the narrow width of the central reservation would appear to exclude the use of a central pier, therefore it would be envisaged that single span structures would need to be considered.

The approximate range of spans for a bridge over the A47 is between 70m and 90m; this is beyond the limits of pre-stressed concrete bridge beams and would tend towards the use of a steel and concrete composite bridge deck.

The design of the abutments for any bridge over the A47 would likely involve piling, though the exact requirements cannot be confirmed at this stage due to a lack of geotechnical information and the fact that the form of structure has yet to be settled upon. Adjacent to the proposed structure there are numerous buried services, including gas and water mains, these would be subject to additional surcharge loading and therefore would need to either be diverted or protected by means of a structural solution in order to ensure that they remain readily accessible whilst not being subject to surcharge loading.

At the A11, bridges spanning over the carriageway would again require to be single span, though the length is shorter than at the A47, approximately 50m.

For tunnel type structures beneath the A11, two variants come to mind, the use of "cut and cover", or box jacking. Cut and cover would require to be constructed in stages in order to enable traffic flow to be maintained, whereby piled walls would be constructed, and either the roof would be constructed and the box excavated beneath down to slab level, or instead there would be an excavation to the base slab level, this would be constructed and then the roof.

Box jacking would see a concrete box section that will form the tunnel being constructed adjacent to the carriageway, this would then be slid beneath the carriageway of the A11, with excavation taking place as it is inched forward, the benefit being that it is possible to maintain carriageway operation with minimal traffic management. These solutions would need extensive ground investigation to be undertaken to enable their practicality and viability to be assessed.

4.4 Geology and Geomorphology

Geology and geomorphology is discussed in detail in **Preliminary Sources Study Report** in appendix B.

4.5 Hydrology and Drainage

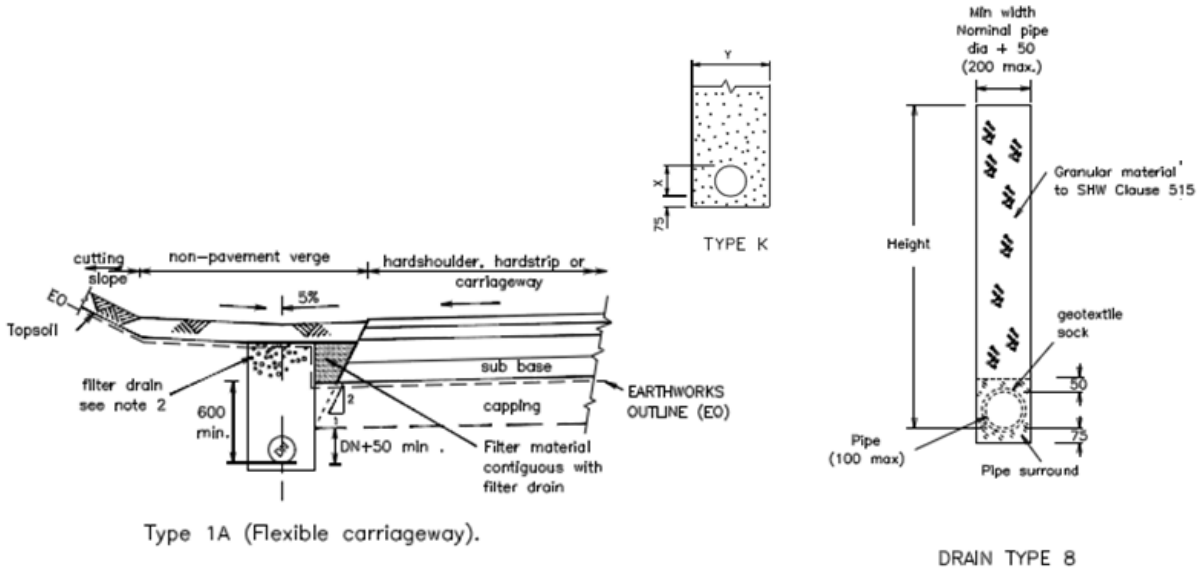
4.5.1 Existing Site Drainage

The existing drainage regime at the site has been ascertained from the Atkins Geotechnical Report dated August 2005, and the Highways Agency Geotechnical Data Management System (HAGDMS).

The existing drainage network is made up of filter drains, kerb drains and triangular concrete open channel drains with collector gullies which feed into carrier drains prior to outfall. The existing drainage information available mainly focuses on the A47 to the south of the existing interchange. Study of the HAGMS maps shows that a number of soakaways are present, although the Atkins drawings do not show these.

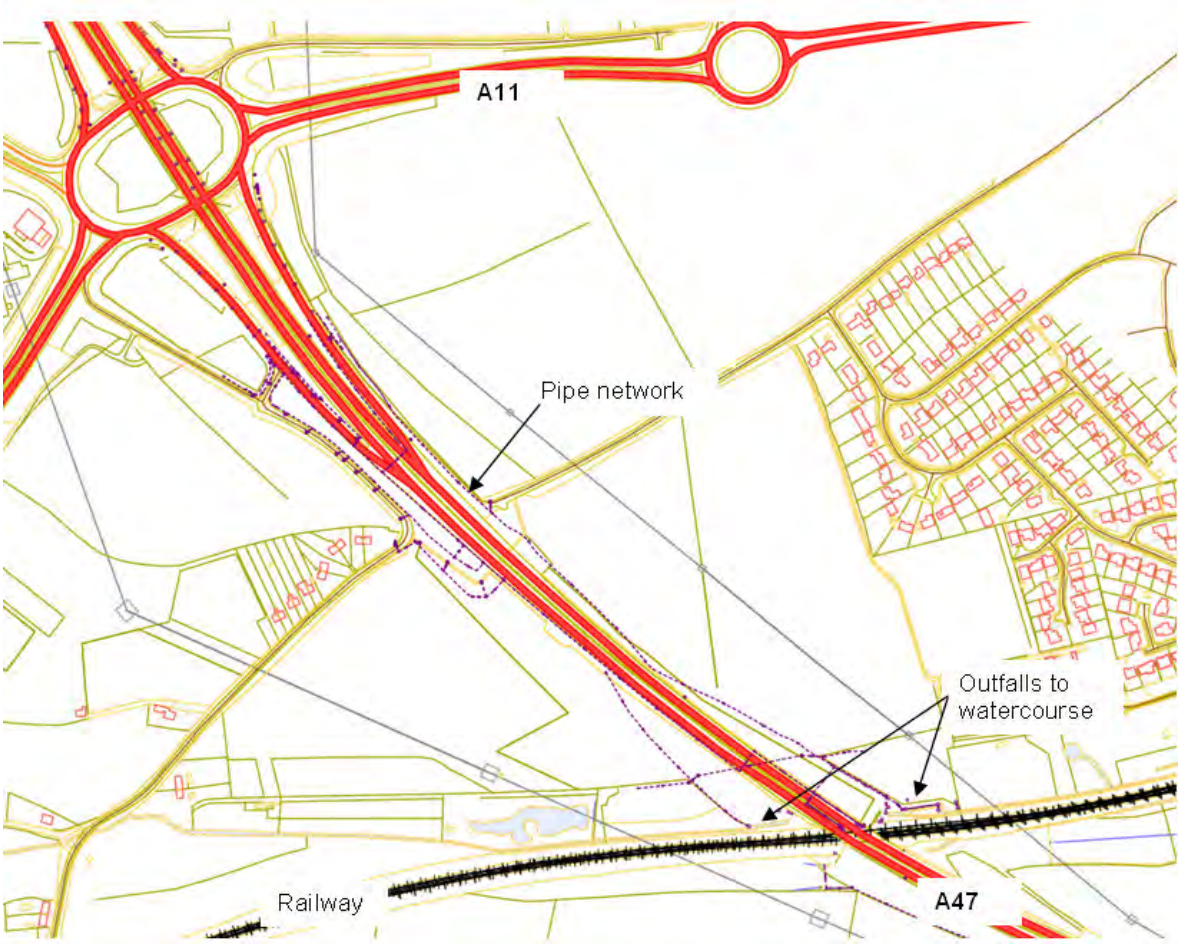
Figure 4.1 below shows the filter drain types specified during the interchange upgrade by Atkins; these are present in the verges adjacent to the carriageway especially at the base of earth embankments to prevent runoff from these affecting the carriageway. The filter drains intercept surface water prior to the carriageway; the surface water percolates through the gravel and to the perforated pipe, which joins the network of carrier drains.

Figure 4.1: Drain types specified by Atkins for A11/A47 Interchange upgrade



Source: Manual of Contract Documents for Highways Works, Volume 3 Highway Construction Details

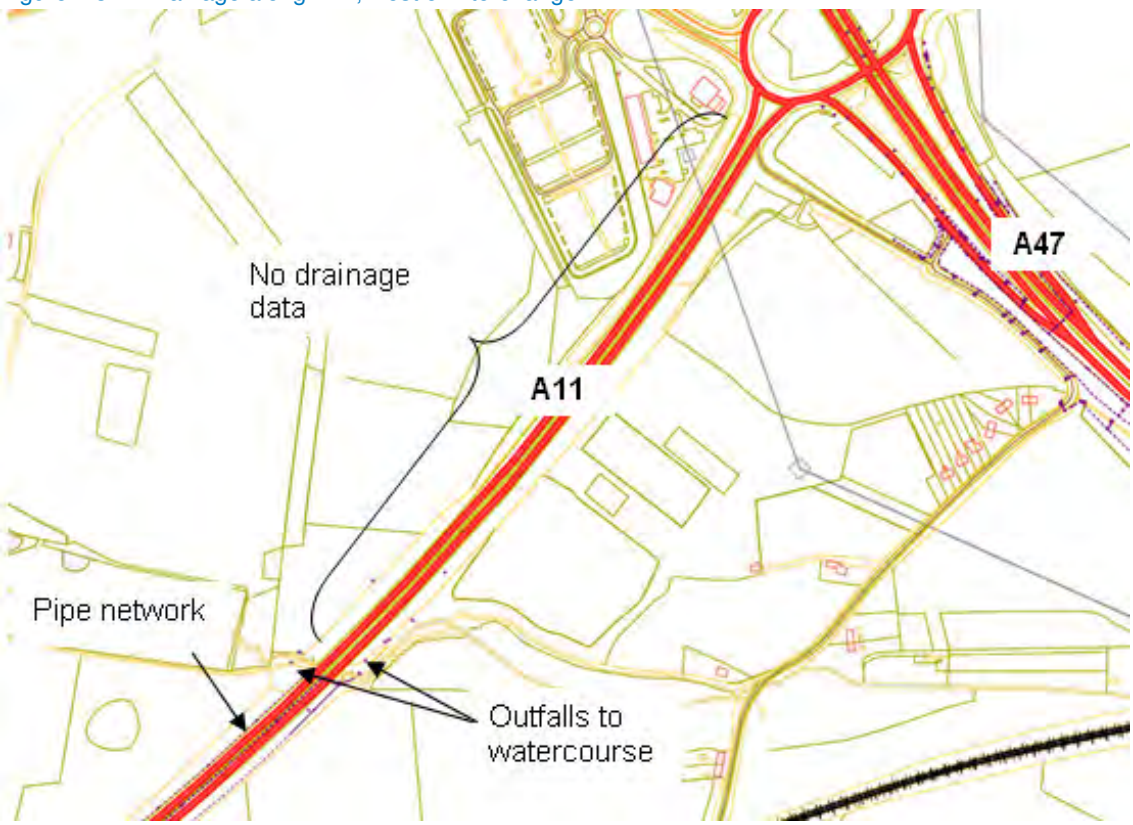
Figure 4.2: Drainage along A47, south of interchange



Source: HAGDMS map data, March 2013

The carrier drains (pipe network) along the A47, south of the interchange, discharge through an outfall to a stream to the north of the railway line as shown in Figure 4.2, this stream is a tributary to the River Tas, which then flows downstream to the River Yare approximately 1.5km east of the site. The map extract shown in Figure 4.2 displays only the pipe network of carrier drains; filter drains and surface water channels are omitted for clarity.

Figure 4.3: Drainage along A11, west of interchange



Source: HAGDMS map data

There is not any drainage data for the A11 immediately west of the interchange, as shown in Figure 4.3. Further south along the A11 there are some carrier drains shown, which outfall to the stream and some land ditches. Filter drains and gullies are present along the carriageway, although the below ground drainage network is not known. The map extract shown in Figure 4.3 displays only the pipe network of carrier drains; filter drains and surface water channels are omitted for clarity.

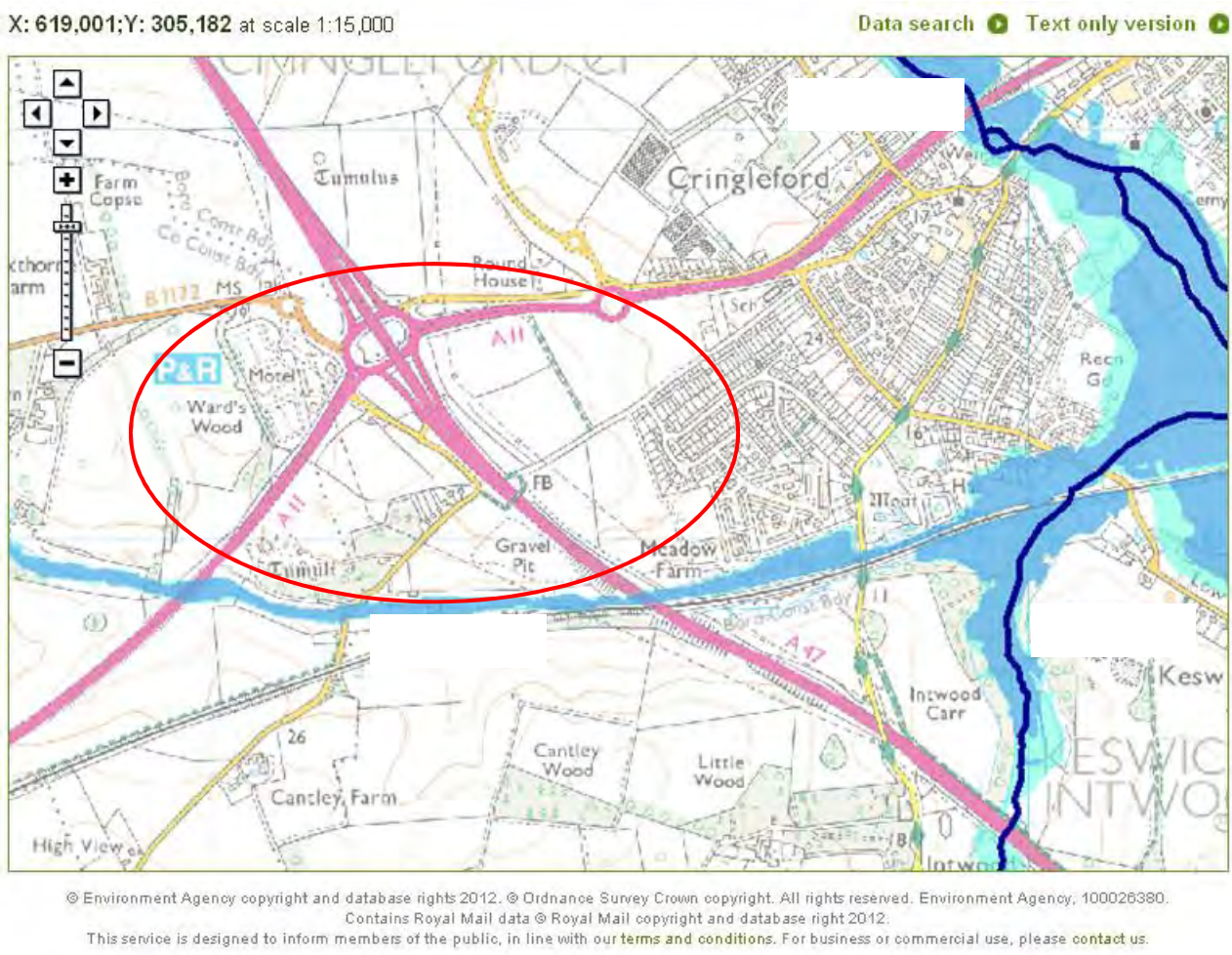
The filter drain and open concrete channel drain types are utilised along the main carriageways, both in the verges and central reservations. The existing interchanges and roundabout are drained via gullies and underground pipes. Embankments are drained using filter drains where necessary.

4.5.2 Flood Risk

The Environment Agency (EA) flood maps show a narrow band of Flood Zone 2 (1 in 100 year event) to the south of the site, showing flooding to the stream. There are two main rivers within the vicinity of the site, the Tas and the Yare, though the flood extents from these rivers do not appear to affect the site for the modelled flood events.

Analysis of the Norfolk County Council Level 1 Strategic Flood Risk Assessment (SFRA) and the South Norfolk Council Level 2 SFRA do not indicate any other sources of flooding (for example groundwater of sewer flooding) that would affect the site. This would need to be confirmed at a detailed design stage through correspondence with the EA.

Figure 4.4: Flood Zone Map



Source: Environment Agency website, accessed 12/03/13

4.5.3 Hydrology

The increase in impermeable area associated with the proposed scheme will affect the hydrological cycle of the area. Larger volumes of rainfall runoff will need to be considered, with increased flow rates due to an increased volume of water entering the surface water drainage network at similar times in the rainfall event.

The requirements for the drainage of the proposed scheme will depend on the proposed impermeable area of the carriageway, which varies for each option. It is therefore preferable to keep the increase in impermeable area to a minimum to reduce the extent of drainage infrastructure required.

4.5.4 Drainage Strategy

The drainage strategy for the proposed scheme must take into account the need to quickly drain surface water from the carriageway, to provide adequate drainage to the foundation layers and any embankments, and to control any pollutants that may enter the highway drainage system.

The drainage strategy for the proposed interchange improvements should follow the design of the existing drainage network as this has been shown to work in general highway drainage situations, but also specifically for this site. The drainage strategy should take into account any updated legislation and the requirement to consider Sustainable Urban Drainage systems (SUDs). The existing drainage regime will need to be investigated in more detail at detailed design stage, including the capacity of the existing pipe network to take an increase in surface water runoff and the connections to the soakaways shown on the HAGDMS plans.

It is unlikely that the existing drainage system has spare capacity as it would have been designed specifically for the existing impermeable area, therefore the proposed system will require a new network of carrier drains to outfall at the watercourse. If the increase in impermeable area is shown to result in unacceptable flow rates at the existing outfalls then specific attenuation storage such as a balancing pond may need to be considered.

The filter drains adjacent to the carriageway are assumed to provide some level of pollutant control for the existing drainage network, and the open concrete surface water channels are believed to be routed through catch pits prior to connection with the carrier drain. Filter drains have good removal performance for sediments and associated pollutants. Catch pits have a sediment filter, which will also trap pollutants bound to the sediment. The main pollutants associated with major roads are sediments, hydrocarbons, and metals. The removal of these will need to be considered for the proposed system. The existing pollutant control system of filter drains and catch pits may provide adequate control for removal of pollutants but the proposed system could look to provide betterment through use of SUDs techniques.

4.5.5 Ground conditions

The site area is within a ‘Major Aquifer Intermediate’ groundwater vulnerability zone, which reflects the vulnerability of the groundwater to pollution at a preliminary design stage. The underlying bedrock is classed as a Principal Aquifer, and the superficial deposits are classified as Secondary A Aquifers/ Unproductive Strata. Immediately north of the interchange is an Outer Zone (Zone 2) Groundwater Source Protection Zone (SPZ).

The Highways document, HD 45/09 Road Drainage and the Water Environment recommends that sites within Zone 2 do not discharge surface water via soakaways.

As described in the Preliminary Sources Study Report**,** the superficial deposits in the site area are mainly glacial soils - clays and sands - underlain by Norwich Crag. The Factual Geotechnical Report produced on behalf of Atkins in September 2004 reports on 25 boreholes in the immediate vicinity of the existing interchange. The ground make up is largely similar, with predominantly firm clays with a few layers of dense sand; the Norwich Crag is typically encountered from 7 - 9m below ground level.

Clay soils typically act as aquicludes, due to the low permeability nature of the soil structure. The ground make up, and the presence of groundwater vulnerability zones make the use of infiltration drainage unlikely. It is therefore assumed that the surface water runoff due to the increase in impermeable area will need to drain to a watercourse.

The above discussion leads towards a potential drainage system solution comprising filter drains, channels and a carrier pipe network to surface water outfalls. The considerations to be made at preliminary design stage include the feasibility of discharge to the nearest watercourse, and any limiting factors. At a detailed design stage, the exact requirements will need to be ascertained, and the drainage regime considered in

relation to general performance, pollutant removal, sustainability, cost, and maintenance. Any drainage solution will need to be included in discussions/ agreements relating to safety.

4.5.6 Existing Topography and Land Drainage

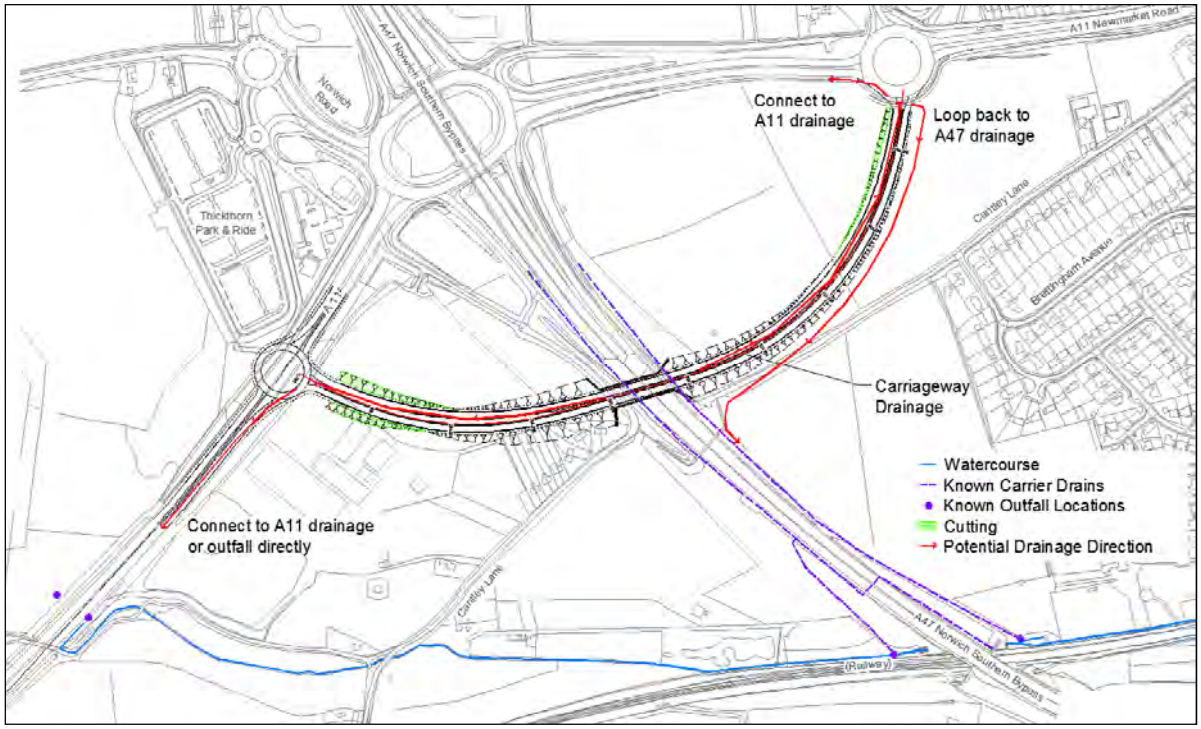
The existing ground surface generally slopes towards stream to the south of the site. The land to the south east of the existing interchanges falls to the south east, away from the A47. The current land usage in the area is predominantly arable, with some areas of woodland.

4.5.7 Roundabout Arrangement 'Alternative A'

The road layout proposed for Roundabout Alternative A would increase the impermeable area by approximately 21,500m². The proposed bridge over the A47 means the road slopes down towards the A11 on both sides. The drainage could connect directly to the drainage for the A11 (although the existing drainage is not known in detail) or the carriageway surface water drains could connect to existing/ new carrier pipes to take the water back towards the A47 to outfall at the stream.

If possible, the route of the existing carrier drains (A11 or A47) could be followed, however the route of these and exact outfall locations would need to be investigated at a later stage. The drainage systems adjacent to the carriageway would likely be a combination of filter drains and channel drains. Filter drains will be needed where the proposed road is in a cutting, to prevent runoff from the embankment entering the carriageway. The drainage for the rest of the system is likely to be concrete surface water channels, as the road is elevated above the existing and the bridge creates a steeper road gradient making the runoff water conveyance more favourable. At the roundabout, kerb drains are likely to be most suitable if the longitudinal and cross falls are flat, otherwise gullies and underground pipes could be selected. Where the embankments slope away from the road, drainage at the toe of these may only need to be considered if stability may be an issue. Drainage Strategy will be undertaken during detailed design stage.

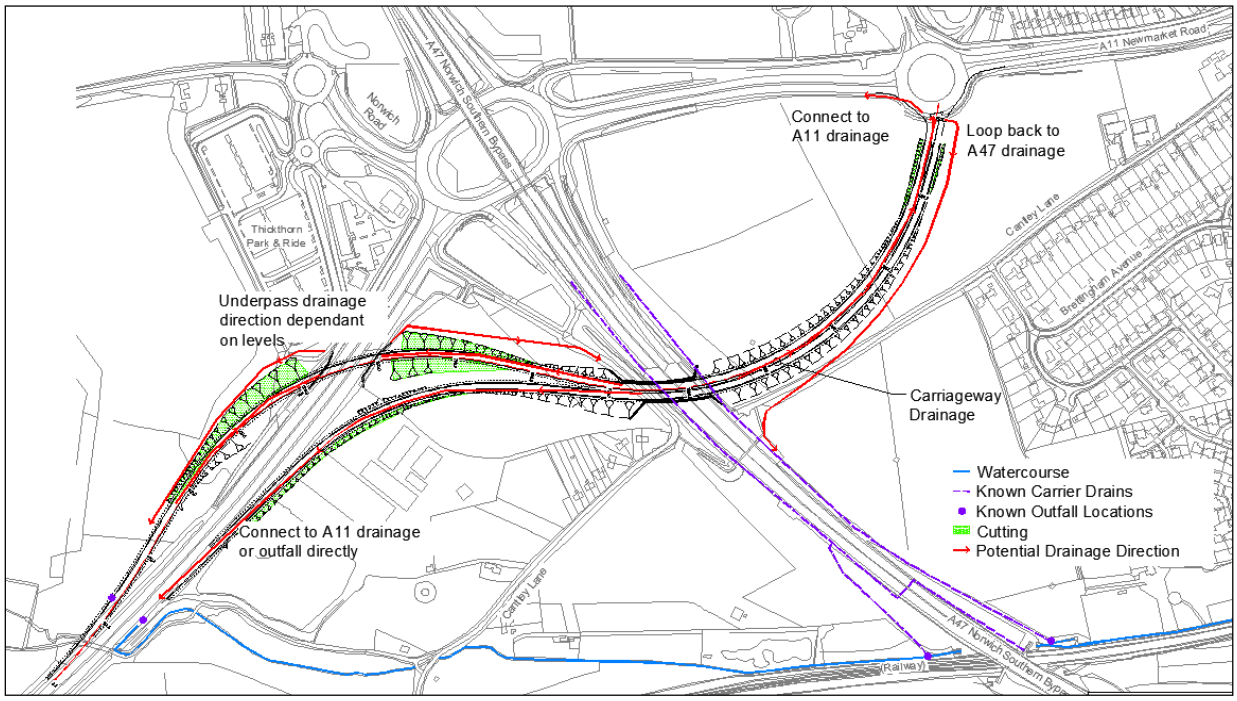
Figure 4.5: Roundabout Arrangement 'Alternative A'



4.5.8 Free-Flow Arrangement 'Alternative B'

The road layout proposed for Free Flow Alternative B would increase the impermeable area by approximately 26,500m². The drainage of the carriageway east of the A47 would be similar to Roundabout Alternative A, the proposed drainage network could either connect to the existing A11 drainage, or a carrier pipe could be run back to the A47 drainage to outfall at the stream.

Figure 4.6 Free-Flow Arrangement 'Alternative B'



West of the A47, the carriageway splits with each side connecting to the appropriate A11 carriageway. The northbound carriageway joins via an underpass to the A11. The drainage at the underpass would need to be considered as a separate system with the levels of the road drainage at the underpass and possible outfall levels investigated. The drainage to either side may also be able to connect to the existing A11 and A47 drainage (subject to full assessment). The southbound carriageway slopes down towards the A11, and joins the A11 not far from an existing outfall.

The drainage systems adjacent to the carriageway would likely be a combination of filter drains and open concrete channel drains as above, with kerb drains and gullies at the underpass. At the toe of the embankments taking the carriageway down to the underpass, filter drains would be required to prevent flow of surface water onto the carriageway from the embankment.

Drainage Strategy will be undertaken during detailed design stage.

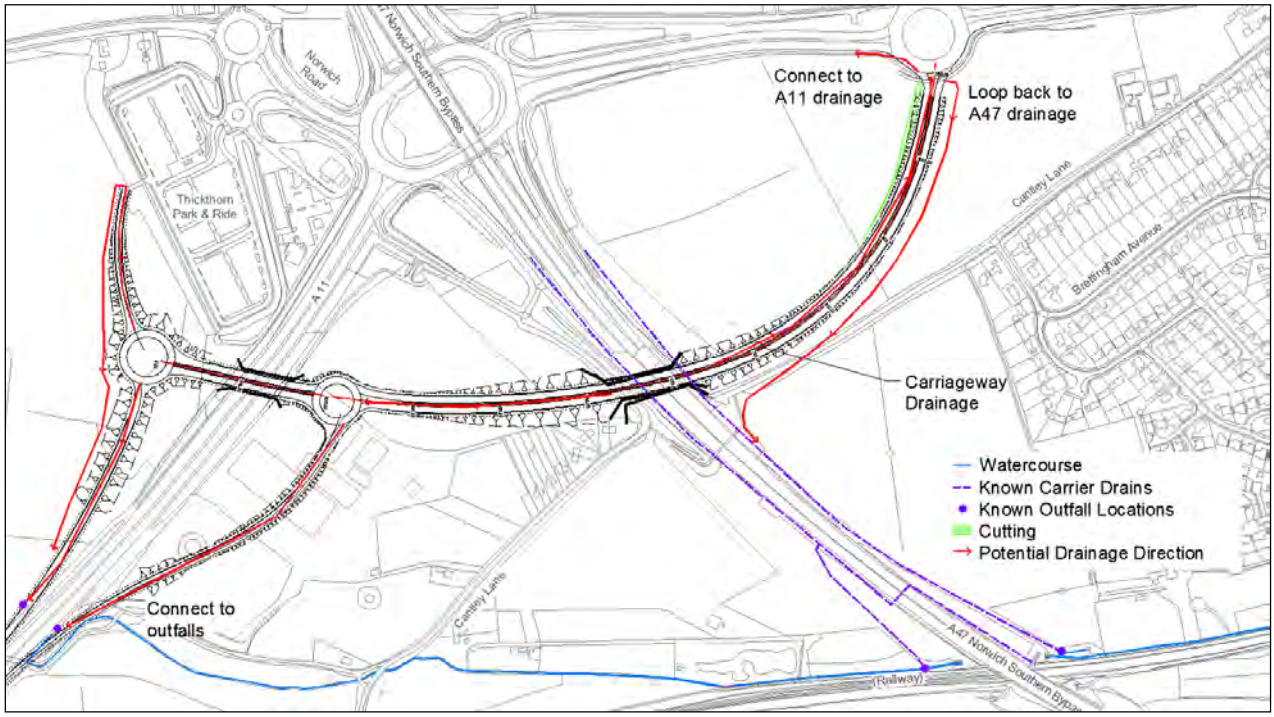
4.5.9 Dumbbell Arrangement 'Alternative C'

The road layout proposed for Dumbbell Option C would increase the impermeable area by approximately 33,500m². The drainage layout for the section of road east of the A47 would be as described above.

The proposed road layout to the west of the A47 comprises two roundabouts and a bridge over the A11. The majority of the drainage for this section could connect to the existing A11 drainage as the levels and slope of the ground in this area would be most suited to this, however as before the capacity of this system would need to be better understood otherwise an upgrade/ modifications may be required.

Most of the drainage will be surface water channel drains, due to the gradient of the roads dictated by the proposed bridges. The gradient of the carriageway will be steep longitudinally, so open concrete drainage channels will drain effectively with the need for only minimal collector gullies. Drainage Strategy will be undertaken during detailed design stage.

Figure 4.7: Dumbbell Arrangement 'Alternative C'

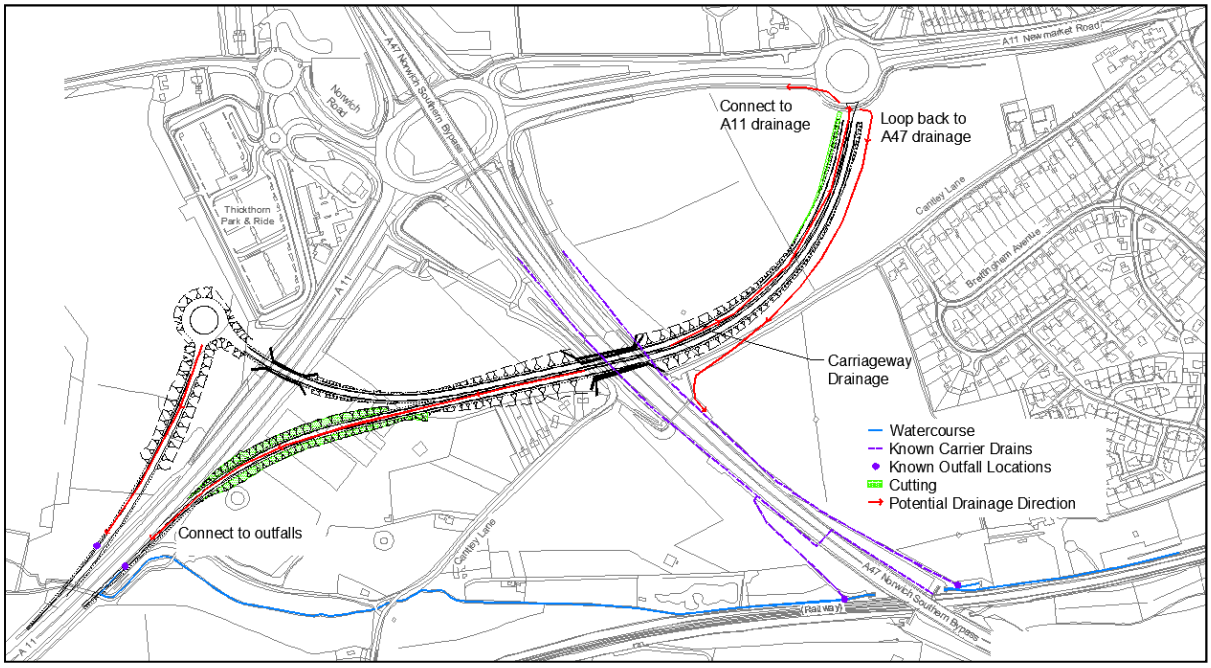


4.5.10 Half Dumbbell Arrangement 'Alternative A'

The road layout proposed for Half Dumbbell Alternative E would increase the impermeable area by approximately 30,000m². The drainage layout would be very similar to Dumbbell Alternative C. The main difference between these options is the southbound carriageway joining the A11 via a roundabout in Dumbbell Alternative C. The proposed southbound carriageway for this alternative needs to be cut into the existing ground prior to re-joining the carriageway; this section would most likely require the use of filter drains.

The drainage systems adjacent to the carriageway would likely be a combination of filter drains and open concrete channel drains. Drainage Strategy will be undertaken during detailed design stage.

Figure 4.8: Half Dumbbell Arrangement 'Alternative A'



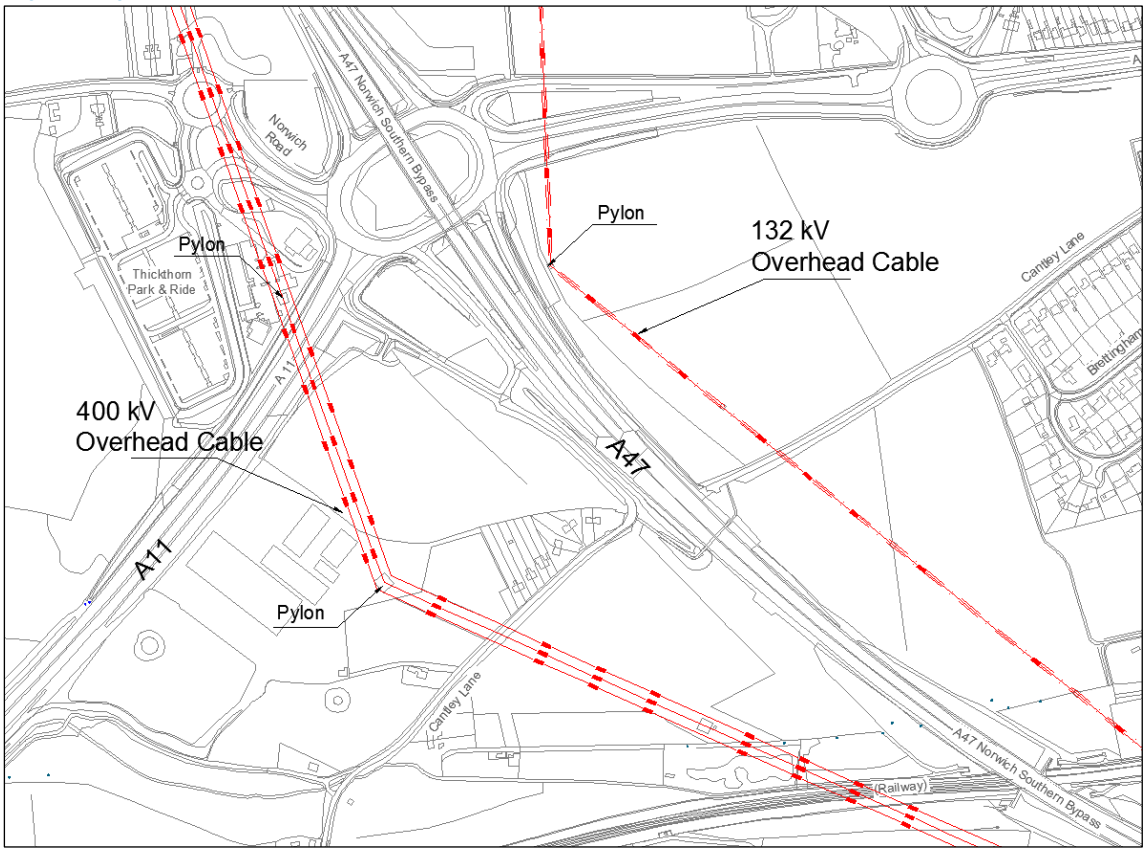
4.6 Public Utilities

The main utilities likely to be affected from the proposed bypass are the two high voltage overhead cables present in the area.

One of these cables is National Grid(NG) 400kV dual circuit line and after initial consultation with NG, it is agreed that diversion or undergrounding of these cables is very unlikely unless it is presented as a business case with significant national importance. However, the minimum vertical clearance between the overhead cables and any carriageway underneath them is given as 8.1 metres. This requirement is achieved in most of the bypass alternatives. The variants that cannot provide this clearance are discounted.

The other cable is UK Power Networks dual circuit 132kV line between the major substations at Norwich Main and Earlham. Although it was not possible to get an official cost estimate for the diversion or undergrounding of these cables at this stage, consultation with UKPN showed that these cables can be modified for the purposes of this scheme and an informal cost estimate of £3m is given. This needs to be confirmed at a later stage. Alternatives with a bridge over A47 require diversion of this cable.

High Voltage Electric Cables



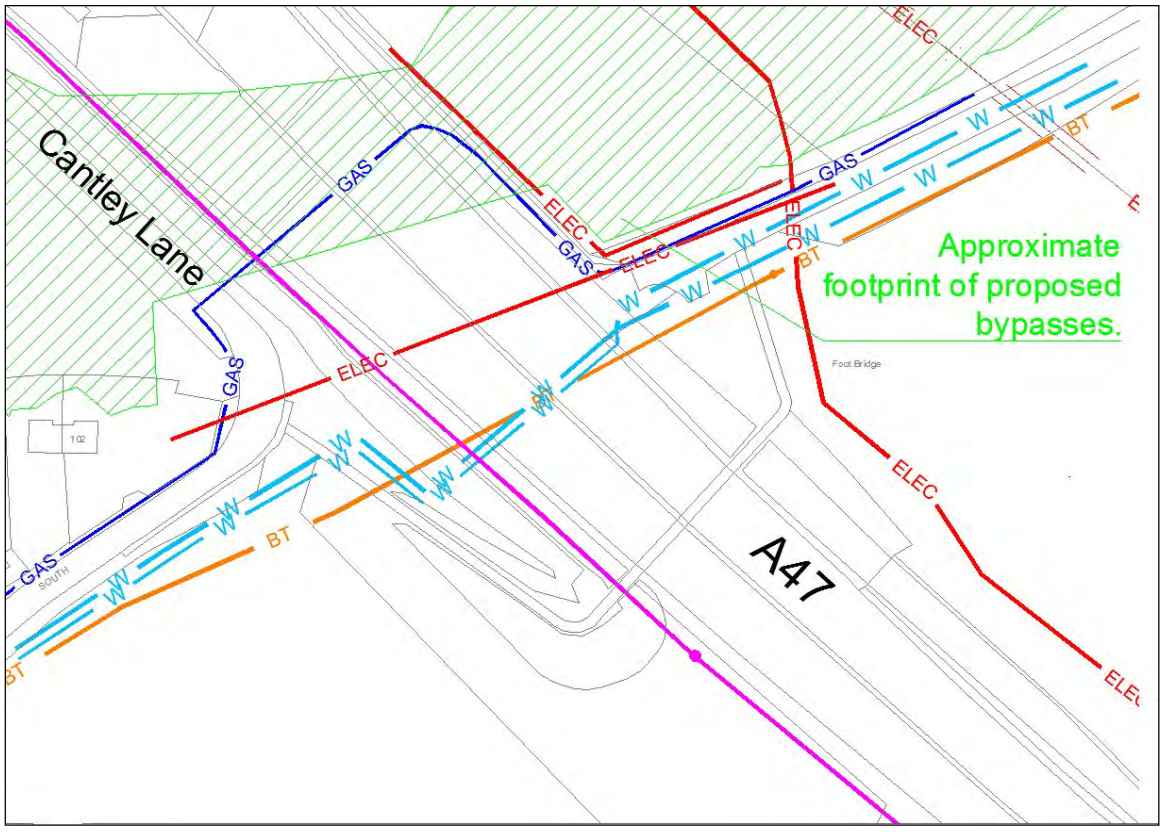
Source: Crown Copyright and database rights 2013 Ordnance Survey 1000019340

Majority of the proposed alternative alignments do not affect the existing utilities except the section where the proposed bypass crosses A47. In this area it is anticipated that;

- 125mm Low Pressure Gas Mains
- 95 Ew and two other electric cables
- Virgin Media underground cable (Shown in magenta)
- BT underground cable
- 125mm MDPE/PE80 and 8in PVCu water pipes

are likely to be affected by the proposed bridge works in this section. At this stage of the scheme development detailed impact of the proposals could not be gathered.

Approximate footprint of the crossing over A47 and the utilities



4.7 Street Lighting

4.7.1 Roundabout Arrangement 'Alternative A'

This option includes for a new link road between the existing roundabout on the eastern section of A11 and a proposed roundabout intersecting with the western section of the A11.

- The existing A11 eastern section roundabout is currently provided with lighting and thus will need to be assessed taking into account the proposed additional leg. This assessment will need to consider potential column moves caused by this addition.

- The conflict area lighting on this existing roundabout will need to be extended 53 metres based on a 50mph speed limit for this proposed leg.
- Due to the proximity of the existing lighting for the lead in on the A11 to the Thickthorn roundabout, the proposed roundabout on the A11 western section will require lighting. This lighting will need to extend:
  - 96 metres (based on 70mph speed limit) on the southern London bound leg of the roundabout.
  - 53 metres (based on 50mph speed limit) on the proposed road linking the existing A11 eastern section roundabout.
  - Up to the existing lighting installation on the lead in to the Thickthorn Roundabout.
- The remaining section of the proposed link road will not require lighting as the distance between the two lit sections at either end (one being the existing A11 eastern roundabout and the other being the proposed A11 western section roundabout) is approximately 853 metres. The minimum distance between lit areas for a road with a speed limit of 50mph is 640 metres.

Potential issues with lighting these areas are:

- The overhead electricity transmission lines crossing the A11 (London bound leg of the Thickthorn Roundabout). The exact position and height from the carriageway of these lines will need to be established to assess the implication.
- The location and capacity of Low Voltage electricity supplies in the area and the associated connection costs.

4.7.2 Free-Flow Arrangement 'Alternative B'

This option includes for a new link road between the existing roundabout on the eastern section of A11 and two proposed slip roads (Norwich bound and London bound) onto the A11. The link road will spilt into the two separate slip roads after the link road has bridged over the A47. The Norwich bound slip road has a tunnel which crosses under the A11.

- The existing A11 eastern section roundabout is currently provided with lighting and thus will need to be assessed taking into account the proposed additional leg. This assessment will need to consider potential column moves caused by this addition.
- The conflict area lighting on this existing roundabout will need to be extended 53 metres based on a 50mph speed limit for this proposed leg.
- The tunnel on the Norwich bound slip road will require day and night lighting and the lighting will need to extend a distance of 2 x the stopping distance in either direction of the tunnel. Based on a 50mph speed limit this will equate to 106 metres in either direction.
- The remaining sections of the proposed link and slip roads will not require lighting as:
  - The existing section where the slip roads join the A11 is not currently lit.
  - The distance between the two lit sections at either end (one being the existing A11 eastern roundabout and the other being the tunnel section) is approximately 740 metres. The minimum distance between lit areas for a road with a speed limit of 50mph is 640 metres.

Potential issues with lighting these areas are:

- The overhead electricity transmission lines which will cross the carriageway in the proximity to the exit of the tunnel. The exact position and height from the carriageway of these lines will need to be established to assess the implication.
- The location and capacity of Low Voltage electricity supplies in the area and the associated connection costs.

4.7.3 Free-Flow Arrangement 'Alternative C'

This option includes for a new link road between the existing roundabout on the eastern section of A11 and two proposed roundabouts. The first of these proposed roundabouts will join the link road to a slip lane for the A11 Norwich bound traffic and the Park and Ride site and the secondary roundabout will join the link road to a slip lane for the A11 London bound traffic. The two roundabouts will be linked via a bridge over the A11.

- The existing A11 eastern section roundabout is currently provided with lighting and thus will need to be assessed taking into account the proposed additional leg. This assessment will need to consider potential column moves caused by this addition.
- The conflict area lighting on this existing roundabout will need to be extended 53 metres based on a 50mph speed limit for this proposed leg.
- Due to the conflict associated with roundabouts and the levels of usage, lighting should be provided for the two roundabouts and associated link between the two. This lighting will need to extend:
  - 96 metres (based on 70mph speed limit) on the two slip roads onto the A11.
  - 53 metres (based on 50mph speed limit) from the secondary roundabout on the proposed road linking the existing A11 eastern section roundabout.
  - 53 metres (based on 50mph speed limit) from the first roundabout on the proposed road linking the Park and Ride site.
- The remaining section of the proposed link road will not require lighting as the distance between the two lit sections at either end (one being the existing A11 eastern roundabout and the other being the proposed secondary roundabout) is approximately 762 metres. The minimum distance between lit areas for a road with a speed limit of 50mph is 640 metres.

Potential issues with lighting these areas are:

- The overhead electricity transmission lines crossing the proposed lead in to the secondary roundabout. From an aspect of providing lighting the location of these lines at the entrance to the roundabout will be extremely problematic. The exact position and height from the carriageway of these lines will need to be established to assess the implication.
- The location and capacity of Low Voltage electricity supplies in the area and the associated connection costs.

4.7.4 Half Dumbbell Arrangement 'Alternative A'

This option includes for a new link road between the existing roundabout on the eastern section of A11 and two proposed slip roads (Norwich bound and London bound) onto the A11. The link road will spilt into the two separate slip roads after the link road has bridged over the A47. The Norwich bound slip road utilises a roundabout to alter the direction of traffic prior to crossing a bridge over the A11.

- The existing A11 eastern section roundabout is currently provided with lighting and thus will need to be assessed taking into account the proposed additional leg. This assessment will need to consider potential column moves caused by this addition.
- The conflict area lighting on this existing roundabout will need to be extended 53 metres based on a 50mph speed limit for this proposed leg.
- The roundabout on the Norwich bound slip road will require lighting. This lighting will need to extend:
  - 96 metres (based on 70mph speed limit) on the Norwich bound slip road on the A11.
  - 53 metres (based on 50mph speed limit) on the section of road prior to the bridge crossing the A11.
- The remaining sections of the proposed link and slip roads will not require lighting as:
  - The existing section where the slip roads join the A11 is not currently lit.

- The distance between the two lit sections at either end (one being the existing A11 eastern roundabout and the other being the roundabout section) is approximately 990 metres. The minimum distance between lit areas for a road with a speed limit of 50mph is 640 metres.

Potential issues with lighting these areas are:

- The location and capacity of Low Voltage electricity supplies in the area and the associated connection costs.

5 Environmental Assessment

5.1 The Scope of this Chapter

This chapter is intended as an initial appraisal of the likely environmental constraints for the proposed Alternatives. Each of the four Alternatives being considered at this stage are very similar; the start and end points for the proposed scheme are a short distance apart and the existing physical constraints at the Thickthorn junction itself mean that the Alternatives being considered at this stage are, more appropriately assessed as variations of one design.

To this end the majority of the sections below, each relating to a specific environmental discipline or set of constraints, are based on a single study area within which the four alternatives would be located, with small-scale differences identified where the alignments differ locally.

This chapter provides initial (pre-Scoping) high level input, following the requirements laid down in DMRB where possible and appropriate, to identify any issues or factors that would need to be considered as the optioneering process and subsequent design process is undertaken.

5.2 Air Quality

5.2.1 Introduction

In considering the likely impacts on air quality of a road scheme, DMRB states that:

"Road transport sources account for a large proportion of the emissions of several air pollutants, although most of the pollutants emitted by road vehicles are also produced by a wide range of industrial, commercial and domestic processes. The vehicle-derived pollutants of concern, and the environmental effects to which they contribute, are summarised in Annex A. The pollutants of most concern near roads are nitrogen dioxide (NO2) and particles (PM10) in relation to human health and oxides of nitrogen (NOx) in relation to vegetation and ecosystems."

And that:

"Clean air is an essential ingredient for a good quality of life. The Government is committed to meeting health based air quality criteria for human health and for the protection of vegetation and ecosystems."

Air quality is directly, inextricably linked to traffic volumes and patterns. Even at the Scoping stage, the earliest stage of scheme assessment, it is usually necessary to use traffic model data to be able to assess the air quality scenarios for Do Something and Do Nothing, at base year, opening year and a future year, usually taken as the worst year (in air quality terms) in the first fifteen years after opening. No traffic data is available at this pre-Scoping stage of input, and so qualitative input is given here instead.

The four options being considered;
- Roundabout Arrangement Alternative A (**Roundabout-A**),
- Free Flow Arrangement Alternative B (**Free Flow-A**),
- Dumbbell Arrangement Alternative C (**Dumbbell-C**) and
- Half Dumbbell Arrangement Alternative A (**Half Dumbbell-A**)

These four options are all very similar in terms of layout, there is only very localised variation. This means that in terms of initial, high level input into the air quality impacts, there is no real benefit in differentiating between them.

5.2.2 Changes to Local Air Quality

When considering local air quality, all those properties within 200 metres of any affected roads should be considered. Affected road are those that meet any of the following criteria:

- road alignment will change by 5 m or more; or
- daily traffic flows will change by 1,000 AADT or more; or
- Heavy Duty Vehicle (HDV) flows will change by 200 AADT or more; or
- daily average speed will change by 10km/h or more; or
- peak hour speed will change by 20km/h or more.

This is likely to include the proposed Alternatives and some or all of the arms of the interchange.

The study area is therefore likely to include the twelve residential properties located on Cantley Lane South. Roundabout-A, Dumbbell-C and Half Dumbbell-A would be located immediately adjacent to the property boundaries; Alternative B is slightly further away.

Many residential properties at Roundhouse Park and Cantley Lane/Brettingham Avenue in Cringleford would also be likely to fall within the study area. The Alternatives all use the same alignment in this area though, so there should be no discernible difference in changes to air quality in these locations between the Alternatives. Cringleford Primary School and Surgery are both located within this area.

A plan showing potential impacted properties, Figure A, can be found in Appendix C1.

It should be noted that air quality can improve as well as deteriorate. The overarching aim of the scheme is to decrease congestion at the Thickthorn interchange, with associated lessening of queuing volumes of traffic and decreased queuing times, so the air quality modelling and assessment that is likely to be required as the scheme progresses could demonstrate this.

No Designated Sites are located close enough to be affected by potential changes in air quality associated with this scheme.

The whole of central Norwich is an Air Quality Management Area. This is sufficient distance from the scheme that none of the Alternatives are likely to have any effect on this designation, either adversely or positively.

5.2.3 Impacts at a Wider Scale

Air Quality at a regional level should also be assessed, although in this case it is likely that, at a regional level, effects on air quality would be negligible; this prediction would need to be borne out by modelling and further input from air quality specialists when appropriate. The aim of the scheme is to reduce congestion and free up capacity at the Thickthorn junction, with the direct effect of reducing adverse impact on air quality in this area. The on-going rise in traffic levels may negate and even override this potential benefit at a regional level. There is not likely to be any difference in the changes in air quality at a regional level between the four Alternatives.

5.3 Cultural Heritage

5.3.1 Introduction

For ease of use, the following assessment is based on each of the four design applications (known as Alternative Roundabout-A, Free Flow-A, Dumbbell-C and Half Dumbbell-A respectively, where Roundabout-A is the least intrusive, and Half Dumbbell-A the most) and assesses the impact of the heritage asset against each design.

A simple breakdown of each heritage asset affected by the scheme, and possible mitigation is given within Table 5.1 at the end of this appraisal. A plan showing the locations of the described features in relation to the proposed development, Figure B, can in found in Appendix C2.

5.3.2 Heritage Assets affected

5.3.2.1 Built Heritage

A total of two Listed structures were located within close proximity to the scheme;

- One Grade II Listed Building, The Round House, Listed Building Number 226901 (NHER 11613). An early Nineteenth Century Octagonal house, which has original pan tiles and lead tracery.
- One Grade II Listed structure. A milestone, Listed Building Number 226922, (NHER 43210 and 56346). Constructed for the Norwich and Thetford Turnpike Trust. Constructed of limestone, wedge shaped, and approximately 60cm high with a rounded cap, tapering from 14 to 31 cm. The face has a recessed full width panel inscribed with NORWICH 4 MILES and THETFORD 25 MILES.

It is thought that neither Listing is likely to be affected by any of the scheme proposals; Listed Building Consent is therefore not required due to this. It is unlikely the works will affect the setting of either Listing due to the original setting being within a Highway environment.

5.3.2.2 Buried Archaeology

A search of the Norfolk Historic Environment Record (NHER) returned a total of twenty five entries, demonstrating archaeological activity within the area from the Mesolithic period to the Modern period (see Table 1 below for further information).

This study has only considered the archaeology in the immediately vicinity of the four options, and whilst this allows a good understanding of what archaeological features may be present within the immediate landscape, further research would be recommended prior to the works being undertaken. All alternatives are affecting known archaeological remains, with Roundabout-A causing the least impact, and Free Flow-A, Dumbbell-C and Half Dumbbell-A equally adversely affecting known archaeological deposits. The most significant archaeological remains are prehistoric earthworks, which would require archaeological mitigation prior to construction.

5.3.2.3 Scheduled Monuments

There is one Scheduled Monument, which is likely to be affected by the proposed route of alternatives Free Flow-A, Dumbbell-C and Half Dumbbell-A:

- Two Bronze Age Round Barrows (NHER 9463 and 9464) NGR TG 183 049, Scheduled Monument number 1003977.

Whilst the proposals for Alternative Roundabout-A and Free Flow-A do not impact directly upon these monuments, Alternative Dumbbell-C would directly impact on the monument, with Alternative Half Dumbbell-A affecting the north-western extent of Scheduled Monument NHER 9463.

In accordance with the Ancient Monuments and Archaeological Areas Act 1979, any works which are likely to directly impact upon the Scheduled Monument will require Scheduled Monument Consent, which, if appropriate would be granted by the Secretary of State following consultation with English Heritage's Inspector for the East of England. It is considered that consent would not be granted if there were viable alternatives. If this is the only viable option, consideration must be given in the design of the scheme to incorporate or preserve the monument within the scheme.

5.3.2.4 Parks and Gardens

No designated Parks and Gardens are due to be affected by the scheme. However, all the proposed alternatives will have an immediate impact upon the nineteenth century park of Thickthorn Hall (NHER 33732, centred on NGR 175 052, and to the west of the development). This landscaped park includes a medieval moat which was redesigned as part of the landscaping in the nineteenth century, and now represents an ornamental lake, grounds for lodges and concrete greenhouses which date from the 1930's. Although not listed, this Park has the potential to contain post medieval archaeological remains.

5.3.2.5 Deserted Medieval Villages

The deserted medieval village of Cantley (NHER 9469) is mentioned in the Domesday Book, when it was held by the King. Cantley was also a large and valuable holding and is listed with four hundred sheep. The village was located close to the route of the A11, and the name is preserved as Cantley Farm, Cantley Wood and Cantley Lane. Remains of Medieval date are therefore likely to be encountered within the proposed development area.

5.3.2.6 Conservation Areas

Cringleford and Eaton Conservation Areas are located to the east of the proposed Alternatives. Their location, where the stream of traffic using the proposed scheme has rejoined the existing A11 traffic, means that there should be negligible additional effects on the Conservation Areas.

5.3.3 Conclusions

The proposed developments (Alternatives Dumbbell-C and Half Dumbbell-A) have the potential to impact primarily upon two Bronze Age barrows, which are both Scheduled Monuments. In archaeological terms, these alternatives should be discarded – it is considered unlikely that Scheduled Monument Consent would be granted for these works if other scheme options are viable. This alternative would also impact upon buried archaeology of possible Mesolithic through to Post Medieval date.

Alternatives Roundabout-A and Free Flow-A do not impact the Scheduled Monument, although there is potential for archaeological deposits to be present and is likely that these proposals will require further archaeological investigation prior to works being undertaken at the site. It is likely that prehistoric activity will be encountered within the area, and this is likely to relate to the enclosures observed as cropmarks to the north and west of the development. Furthermore, there are significant medieval remains located to the south of the main line of sight from the A11 to the A47 bridging area, and all alternative design proposals are likely to impact upon archaeology within these areas.

To summarise – most of the options have archaeological issues, Alternatives Half Dumbbell-A and in particular Dumbbell-C may not be possible in heritage terms. Alternatives Roundabout-A and Free Flow-A would be the preferred options in heritage terms.

Next steps would be to carry out a more detailed desk-top survey and walkover of the preferred option(s) – this will inform a targeted survey schedule which could include:

- Aerial Photographic and LIDAR analysis;
- Fieldwalking;
- Geophysical survey; and/or
- Trial Trenching

The surveys will inform a mitigation strategy. The most cost-efficient mitigation will be to make alterations to the route to avoid significant archaeology. If the archaeology cannot be avoided it will need to excavated in advance of development, and following current legislative policy.

Table 5.1: Heritage Assets affected by proposed routes

Heritage Asset	Details and location of Heritage Asset	Potential Impacts on Heritage Asset	Affected by Alternative RB-A, FF-B, DB-C or HDB-A?[5]	Mitigation required?	Recommended action?	Overall Potential Impacts
Built Heritage						
A **Grade II Listed Building**; The Round House, Listed Building Number 226901.	Located at grid reference TG 188 056, approximately 120m to the west of the A11 Newmarket Road roundabout. Octagonal structure, early Nineteenth century construct.	Affecting setting of Listed structure may result in delisting of structure or lower classification.	RB-A, FF-B, DB-C and HDB-A	No	The effect of the construction will not be direct upon the Listed Structure. The setting of the Listed structure is currently within a highway setting.	None
A **Grade II Listed structure**; A late Eighteenth century Milestone, (Listed Building Number 226922).	Located at TG 180 055, and approximately 240m to the north of the proposed routes.	Loss of setting	N/A	No	None	None
Buried Archaeology (Norfolk Historic Environment Record Number NMER)						
NHER 54474 WWII Anderson type shelters	NGR TG 194 090. Located 184m to the northeast of proposed roundabout	N/A	N/A	N/A	N/A	None

5 RB: Roundabout Arrangement, FF: Free Flow Arrangement, DB: Dumbbell Arrangement, HDB: Half Dumbbell Arrangement

Heritage Asset	Details and location of Heritage Asset	Potential Impacts on Heritage Asset	Affected by Alternative RB-A, FF-B, DB-C or HDB-A?[5]	Mitigation required?	Recommended action?	Overall Potential Impacts
	location off A47					
NHER 40136 Possible pit and multi-period finds	NGR TG189 057. Located 90m to the north of proposed roundabout off A11	Possible that features could continue to the south of roundabout	N/A	No	N/A	None known
NHER 40130 Possible field boundaries and multi-period finds	NGR TG188 058. Located 170m to northwest of proposed roundabout off A11	Possible that features could continue to south	N/A	N/A	N/A	None known
NHER 40940 Excavation by NAU 2004 found evidence of Neolithic and Bronze Age occupation	NGR TG191 054. Located 154m to the southeast of proposed development	Possible continuation of features to west, within development	RB-A, FF-B, DB-C and HDB-A	Yes	Scheme of archaeological monitoring prior to and during proposal works	Negligible
NHER 9366 Find spot of Roman Coins	NGR TG190 053. Located 180m to southeast of A11 roundabout	None	N/A	N/A	N/A	None known
NHER 36138 Cropmarks of undated period	NGR TG190 050.Located 425m to south of A11 roundabout	Lies to south of proposals; possible that archaeology could encroach on southern area of development.	N/A	N/A	N/A	None known.
NHER 22828 Neolithic artefacts found during A11 construction	NGR TG183 053. Located within 100m on western branch of A11. Found during original development of A11 highway.	None	N/A	N/A	N/A	None known
NHER 9464 Bronze Age Round Barrow (**Scheduled**	NGR TG183 049.Located approximately 500m to the southwest of	**Damage to Scheduled Monument**	Directly affected by DB-C. Indirectly affected by	**Scheduled Monument Consent required prior to**	Avoid routes which affect this monument (Alternative DB-	**Significant.**

Heritage Asset	Details and location of Heritage Asset	Potential Impacts on Heritage Asset	Affected by Alternative RB-A, FF-B, DB-C or HDB-A?[5]	Mitigation required?	Recommended action?	Overall Potential Impacts
Monument number 1003977)	A47/A11 roundabout.		FF-B and HDB-A due to affects to secondary **Scheduled Monument** below	**works affecting monument**	C)	
NMER 16685 Site of Limekilns and Tramway	NGR TG182 049.Located approximately 500m to the south of main A11/A47 roundabout.	Works lie on outskirts of proposals.	DB-C	N/A	Possible archaeological monitoring of area prior to works.	Negligible
NMER 54403 Copmarks showing possible prehistoric activity	NGR TG179 051. Located approximately 400m from main A11/A47 roundabout.	Damage to possible prehistoric remains	FF-B, DB-C and HDB-A	Yes	Scheme of archaeological monitoring prior to and during proposal works	Negligible
NHER 33732 Thickthorn Park	NGR TG175 052. Located 400m to west of A11/A47 roundabout, and within western extent of proposals.	Damage to possible post medieval remains	FF-B, DB-C and HDB-A	Yes	Scheme of archaeological monitoring prior to and during proposal works	Negligible
NHER 22812 Neolithic Flint Find spot	NGR TG180 050. Located 260m to southwest of A11/A47 roundabout	Potential prehistoric remains may exist within development area	N/A	N/A	Scheme of archaeological monitoring prior to and during proposal works	Negligible
NHER 11820 Remains of possible med/ post medieval building platform	NGR TG179 054. Located to west of Thickthorn Park and Ride	Loss of platform, potential damage to unknown archaeological features	DB-C	Yes	Scheme of archaeological monitoring prior to and during proposal works	Negligible
NHER 22813 Find spot of Neolithic artefacts	NGR TG179 048. Located approximately 500m to south west of A11/ A47 roundabout	Possible unknown archaeological remains may extend into proposal areas	FF-B, DB-C, HDB-A	Yes	Scheme of archaeological monitoring prior to and during proposal works	Negligible
NHER 18186 Cropmarks at	NGR TG176 047. Located	Damage to undefined	FF-B, DB-C, HDB-A	Yes	Scheme of archaeological	Negligible

Heritage Asset	Details and location of Heritage Asset	Potential Impacts on Heritage Asset	Affected by Alternative RB-A, FF-B, DB-C or HDB-A?[5]	Mitigation required?	Recommended action?	Overall Potential Impacts
Hethersett Racecourse.	within 500m to southwest of A11/A47 roundabout	archaeological remains			monitoring prior to and during proposal works	
NHER 22758 Multiperiod finds from Cantley stream culvert	NGR TG179 048. Located within 500m southwest of A11/ A47 roundabout	Possible that settlement remains may extend into development areas	RB-A, FF-B, DB-C and HDB-A	Yes	Scheme of archaeological monitoring prior to and during proposal works	Negligible
NHER 22814 Meolithic find spots found during original A11 construction phase	NGR TG178 048. Located within 500m to the southwest of A11/ A47 roundabout	Possible that unknown archaeological remains may exisit within this area	RB-A, FF-B, DB-C and HDB-A	Yes	Scheme of archaeological monitoring prior to and during proposal works	Negligible

5.4 Ecology and Nature Conservation

5.4.1 Introduction

DMRB defines ecology as “the scientific study of living organisms, and their relationship both with each other and their environment (e.g. soils, climate, and topography).” It also states that nature conservation is “concerned with maintaining a viable population of the country's characteristic fauna and flora and the communities they comprise.

Conservation of wildlife species and their habitats is important both for human inspiration, enjoyment and general well-being and to sustain the value of the natural environment for future generations as an asset for recreation, education and direct economic benefit including genetic resources.

At an early stage of assessment such as this, it is felt appropriate to map all Designated Sites in the area and identify any that may be directly or indirectly affected, and to identify all the predominant habitat types, highlighting all the potential constraints/areas of ecological importance, and where further surveys are likely to be required. This is in line with the recommendations/requirements in DMRB for the Scoping stage of assessment.

The impacts of a road scheme on ecological assets can be many and varied, over a wide area or locally, short term, long term or permanent. In the case of this scheme, a significant road network is already in place, with additions proposed, so the focus of this section is directed towards impacts additional to those already in existence.

DMRB acknowledges that ecological impacts can occur through:

- direct habitat loss;
- severance of wildlife corridors;

- mortality of creatures using regular commuting routes;
- disruption to local hydrology, with impacts on habitats;
- pollution of watercourses through run-off from the proposed road;
- new structures causing problems for birds (bird strike etc.);
- road lighting disrupting the habits of fauna locally;
- air pollutants affecting species and habitats;
- salt-laden spray form the carriageway affecting adjacent habitats; and
- disturbance during construction

5.4.2 Designated Sites

There are no Statutory Designated Sites within 2km of the study area, and no Designated Sites within 1km of the study area. Four County Wildlife Sites, valuable at a regional/locale level, are located within 1km of the site however; these are:

- Meadow Farm Meadow CWS (Ref. 199) 450m to southeast;
- Intwood Carr CWS (Ref. 200) 1.1km to east;
- Bluebell Marsh CWS (Ref. 1445) 960m to northeast;
- Softley Drive Meadow CWS (Ref. 2217) 950m to northeast;

A plan showing Designated Sites in relation of the Proposed Development, Figure C, can be found in Appendix C3.

5.4.3 Habitats

To the east of the A47, and the south of the A11, the area is primarily arable. A mixture of species rich and species poor hedgerows is situated along the field boundaries, many of which contain trees. Colney Lane is lined with mature trees on both sides.

The verges of the A47 are poor semi-improved neutral grassland, likely to have been seeded artificially after construction a decade or so ago, with colonisation by additional species in the intervening years. The grassland here is predicted to be of low ecological value. Areas of shrubs are also present along the road corridors, planted primarily as screening features. The species richness is generally high, although the structure of the planting, with little or no ground flora, and no mature trees, means that the ecological value is limited. No direct access was available due to safety reasons.

West of the A47 the landscape is a mosaic of habitat types. There are several arable fields with hedgerows, as above. Many of the hedgerows are defunct, although still species-rich. Small blocks of woodland are located here, both semi-natural broadleaved and coniferous plantation, the former of moderate ecological value, and the latter low value.

Close to the Thickthorn junction, between the A47 and the Cantley Lane spur, is an area of scrub habitat. Some areas are sparse, over poor semi-improved grassland, and some more dense. The area is subject to fly tipping, and aerial photos show that this area has been used by travellers.

An area of shrubby vegetation is located close to the A11, possibly associated with an old landfill site that has been capped and landscaped. It is of moderate species diversity, and of moderate ecological value.

A pig farm unit is located adjacent to the A11. The land here is generally bare, having been rooted up by the pigs. This area would benefit from being considered in terms of contamination/point-source pollution etc.

North of the A11 is more screening woodland, slowly growing towards semi-maturity, another block of mature broadleaved woodland and extensive areas of arable land.

A Habitat Map, Figure D, can be found in Appendix C4.

5.4.4 Potential for Protected Species

Mature trees have the potential for providing roost sites for bats, so these, whether directly and indirectly affected, would need surveys to ascertain population levels. . Hedgerows and tree-lines are likely to be used as commuting and foraging routes, so surveys to investigate the degree of usage, and hence the magnitude of impact would also be required. A combination of activity and emergence/re-entry surveys is recommended to identify the on-going level of activity in the area, and usage of individual features respectively. It is recognised that, although a generally rural area, the potential bat populations may be limited locally due to the high levels of on-going disturbance, noise, and light pollution at night.

It is likely that reptiles of various species could be found locally. Reptile surveys are recommended where suitable habitats exist. Field margins, grassland and scrub, woodland edges etc all have the potential to provide shelter for snake and lizard species, so this should also be investigated. Populations are not anticipated to be particularly large due to the disturbance and severance associated with the existing highway network.

Breeding birds are likely to use all habitats throughout the study area. As with the above sets of species, bird populations are likely to be directly affected by the existing highways network, however specific surveys will provide definitive information on breeding territories and general population size/distribution, and hence allow impacts to be assessed.

An investigation to determine if there are badger setts located in the area should be carried out at the appropriate time, to identify whether badgers would be affected by the proposed scheme.

5.4.5 Conclusions

The impacts associated with the four Alternatives are likely to be similar, as described previously in this chapter. The most valuable habitats, and the areas most likely to contain protected and valuable species are the areas of broadleaved woodland, and species rich hedgerows, so those Alternatives that minimise impacts on these habitats are preferable in this respect.

This means that Alternative Roundabout-A has the least adverse impacts, whereas Alternatives Dumbbell-C and Half Dumbbell-A have the highest adverse impacts.

5.5 Landscape Effects

5.5.1 Baseline Information

5.5.1.1 General

The purpose of this feasibility report is to:

- Provide landscape guidance on the strengths, constraints and opportunities of alternative bypasses
- Identify the landscape and visual impacts arising from the scheme and
- Provide general mitigation measures to reduce the potential significant effects.

5.5.1.2 Existing Landscape Character

The site is located on the western edge of the village of Cringleford, Norfolk. The A11 and A47 are key infrastructure routes which dissect the surrounding landscape, as shown in Photo 5.1. The landscape consists largely of agricultural fields with boundary vegetation comprising trees and shrubs, with occasional blocks of woodland to the west of the A47.

Photo 5.1: Photo showing the A47 bypass and surrounding fields and vegetation

Source: Source: Mott MacDonald 05.03.2013

The surrounding fields are largely bordered by hedgerows and scattered trees which are generally irregular, as shown in Photo 5.2. The large roundabout connecting the A11 with the A47 is planted with well established, mature native tree and shrub plantations. Cantley Wood, located on grid reference (618791, 304382) and Wards Wood, located on grid reference (618118, 305165) are within close proximity of the sketch options. These woodlands contain mature, well established, native species deciduous tree and shrub plantations.

Photo 5.2: Photo Showing irregular field boundary vegetation

Source: Source: Mott MacDonald 05.03.2013

North east of Cantley Wood is a small row of post-war, semi-detached two storey houses, which have back gardens and windows that face in the direction of the proposed development. South of the A11, Newmarket Road and east of the A47 is a larger residential area of post-war, mixed housing types and densities, which forms the western fringe of Cringleford. North of the A11 Newmarket Road and east of the A47 is Round House Park, a modern housing development, which is still being constructed. There is a Public Right of Way which runs along the boundary of existing arable fields, from an existing farm track, terminating at the A11. The farm track runs from Cantley Lane to a footbridge over the A47, providing a link to Cantley Lane South.

The landform gently undulates in a north west direction towards the A47 and A11 Thickthorn roundabout. The landform together with the existing vegetation largely screens the Thickthorn roundabout.

5.5.1.3 Statutory and Non-Statutory Designations

Within the study area there the following statutory and non-statutory landscape related designations:
- Two Scheduled Monuments within Cantley Wood; and
- Two Public Rights of Way; footpath and footbridge.

5.5.1.4 Key Visual Receptors

There are three key significant visual receptors of the proposed development as listed and as shown in the photos below;
- Public Right of Way footpath;
- Residential properties located along Cantley Lane South; and
- Residential properties located adjacent to the south of Cantley Lane.

Figure 5.3: VP1 - View looking east along Cantley Lane South

Source: Mott MacDonald 05.03.2013

Figure 5.4: VP2 - View looking north west from residential properties along Cantley Lane South onto proposed development site.

Source: Mott MacDonald 05.03.2013

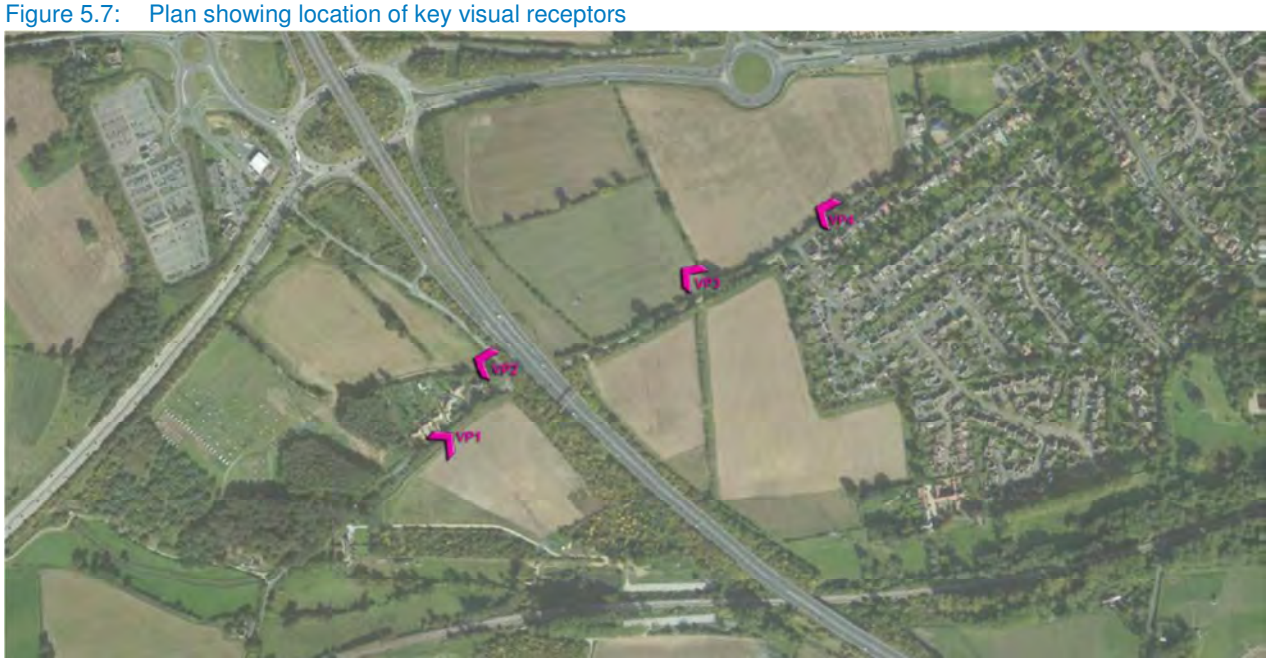
Figure 5.5: VP3 - View from Public Right of Way footpath looking onto the development site

Source: Mott MacDonald 05.03.2013

Figure 5.6: VP4 - View from Cantley Lane looking west onto the proposed development site

Source: Mott MacDonald 05.03.2013

Figure 5.7: Plan showing location of key visual receptors



Source: Mott MacDonald 08.03.2013

5.5.2 Design Feasibility

5.5.2.1 Roundabout Arrangement 'Alternative A'

Strengths

- The roundabout is placed within the western route of the A11 road and will, therefore, have minimal interference with Ward's Wood; and
- The proposed carriageway slightly curves away from the pasture land, south west of Thickthorn roundabout.

Constraints

- The proposed carriageway curves within close proximity of the rear gardens of the properties along Cantley Lane South. The properties would potentially have significant views during the construction and operation of the road;
- Properties facing on to Cantley Lane will have direct, albeit filtered views of the proposals during construction and Years 1 to 15 of operation;
- It is likely that the pasture land, south west of Thickthorn roundabout will be disturbed throughout the construction and operation of the proposed carriageway; and
- The eastern part of the proposed carriageway dissects a Public Right of Way.

Opportunities

- Suggest the western section of the proposed carriageway is moved further north east to minimise the interference with the neighbouring pasture land;
- Propose moving the western section of the proposed carriageway further north to reduce the impact upon views from the residential properties along Cantley Lane S during the construction and operational phases;
- Re-direct the Public Right of Way;

- Mitigation planting adjacent to the proposed carriageway to reduce the visual impact of proposals; and
- Strengthening the hedgerow along Cantley Lane to reduce the visual impact of proposal upon receptors.

5.5.2.2 Free-Flow Arrangement 'Alternative B'

Strengths

- The proposed carriageway is located further north of the properties along Cantley Lane South, which would reduce visual impacts upon these receptors during the construction and operational phases;

Constraints

- North west of the A11 the proposed carriageway dissects Wards Wood and would likely require the removal of a number of well established, mature woodland vegetation and the loss of Wards Wood;
- The proposed carriageway cuts through a small proportion of the area of pasture land;
- The proposed carriageway cuts through a small part of the north western corner of Cantley Wood and is located within close proximity to a Scheduled Monument;
- Properties facing on to Cantley Lane will have direct, albeit filtered views of the proposals during construction and Years 1 to 15 of operation; and
- The eastern part of the proposed carriageway dissects a Public Right of Way.

Opportunities

- Providing the roundabout solution on the western section of the proposed scheme in Plan A, whilst maintaining the distance from the properties on Cantley Lane South shown in this proposal would provide the most appropriate solution in landscape terms;
- Re-direct the Public Right of Way;
- Mitigation planting adjacent to the proposed carriageway to reduce the visual impact of proposals; and
- Strengthening the hedgerow along Cantley Lane to reduce the visual impact of proposal upon receptors.

5.5.2.3 Dumbbell Arrangement 'Alternative C'

Constraints

- North west of the A11 the proposed carriageway dissects Wards Wood and would likely require the removal of a number of well established, mature woodland vegetation and the loss of Wards Wood;
- South east of the A11 the proposed carriageway dissects Cantley Wood and the Scheduled Monument;
- South east of the A11 the proposed carriageway cuts straight through the pasture land;
- Would require significantly more landtake;
- The proposed carriageway will reduce the size of the rear gardens of properties along Cantley Lane South;
- The proposed carriageway curves within close proximity of the rear gardens of the properties along Cantley Lane South. The properties would have significant views during the construction and operation of the road;
- Properties facing on to Cantley Lane will have direct, albeit filtered views of the proposals during construction and Years 1 to 15 of operation; and
- The eastern part of the proposed carriageway dissects through a Public Right of Way.

Opportunities

- Mitigation planting adjacent to the proposed carriageway to reduce the visual impact of proposals;
- Strengthening the hedgerow along Cantley Lane to reduce the visual impact of proposal upon receptors;
- To produce a design that does not dissect Ward's Wood and Cantley Wood;
- Avoid running the road through the pasture land;
- Curve the road further north away from the residential properties along Cantley Lane South;
- Avoid running the road through or close to the Scheduled Monument; and
- Re-direct the Public Right of Way.

5.5.2.4 Half Dumbbell Arrangement 'Alternative A'

Constraints

- North west of the A11 the proposed carriageway dissects Wards Wood and would likely require the removal of a number of well established, mature woodland vegetation and the loss of Wards Wood;
- South east of the A11 the proposed carriageway dissects Cantley Wood and the Scheduled Monument;
- South east of the A11 the proposed carriageway cuts straight through the pasture land;
- Would require significantly more landtake;
- The proposed carriageway earthworks will reduce the size of rear gardens of the residential properties located along Cantley Lane South;
- The proposed carriageway curves within close proximity of the rear gardens of the properties along Cantley Lane South. The properties will have significant views during the construction and operation of the road;
- Properties facing on to Cantley Lane will have direct, albeit filtered views of the proposals during construction and Years 1 to 15 of operation; and
- The eastern part of the proposed carriageway dissects a Public Right of Way.

Opportunities

Same as Dumbbell Arrangement – Alternative C

5.5.3 Mitigation

- The proposed carriageway earthwork embankments should be planted with native species tree and shrub plantations to reduce the impact upon visual receptors;
- Enhance the woodland planting within Ward's Wood and Cantley Wood, where possible;
- Enhance the existing hedgerow along Cantley Lane with native species tree and shrub planting to reduce the impact of the proposals upon visual receptors along Cantley Lane;
- Plant any awkward spaces with screening planting; and
- Divert the Public Right of Way.

5.5.4 Conclusions

Overall, it is considered that Alternatives Free Flow-B, Dumbbell-C and Half Dumbbell-A are the least acceptable in landscape terms, due to the impacts upon the local landscape character and visual receptors. The sketch design which has the least constraints on the local landscape character and visual

amenity is Roundabout-A. However, this option shows the carriageway earthworks, west of the A47, cutting through the back gardens of the residential properties located along Cantley Lane South. Subsequently these residential properties would have significant views of the proposed carriageway during the construction and operational phases of the development. It is recommended that the proposed carriageway is located further north, as shown in Free Flow-B, of the residential properties located along Cantley Lane South, to reduce the visual impact upon these receptors.

Finally, Alternative Roundabout-A shows the proposed carriageway earthworks to be within too close the proximity of the pasture land, south west of Thickthorn roundabout. It is therefore recommended that the final design is located further away from these fields.

5.6 Land Use

5.6.1 Introduction

This section will consider the effects of the proposed scheme on a number of aspects, including:

- Demolition of private property;
- Loss of community land;
- Effects on development land; and
- Effects on agricultural land and Environmentally Sensitive Areas;

In this section it is not necessary to differentiate between the four Alternatives, and they would all have similar, if not the same, effects.

5.6.2 Demolition of Private Properties

No direct impacts on private buildings are anticipated, so no demolition would be required. It is likely that some of the temporary structures associated with the pig units, in common with the whole pig farm area, would be directly affected by the scheme.

5.6.3 Loss of Community Land

No community land would be affected by the proposed scheme.

5.6.4 Effects on Development Land

The area comes within the South Norfolk Council administrative area. Their currently adopted plans are in the Local Development Framework (LDF), which was previously known as the Local Plan.

The LDF is due to be superseded by a new document, on which South Norfolk Council are currently consulting. This will also be called the Local Plan.

All of the Alternatives lie within three parishes, Hethersett, Ketteringham and Cringleford. The original (currently adopted) Local Plan/LDF does not include for any development land within or close to the study area. The areas affected by the scheme are all designated as Strategic Gaps, tying up with Environmental Policy. The land to the east of the A47 is also designated as Southern Bypass Landscape Protection Zone.

The upcoming Local Plan, which has yet to be adopted, also does not include for any development land with the parishes of Hethersett and Ketteringham that would be affected by the proposed Alternatives. The Local Plan does not appear to include any plans for Cringleford; instead a Cringleford Neighbourhood Development Plan is being prepared.

The consultation draft includes areas of housing in the area immediately to the south of the Roundhouse roundabout on the A11, which would be directly affected by the scheme. The proposed scheme would affect and alter access arrangements to the housing area. A 250 metre landscaped buffer zone between existing/allocated housing and the A47 would also be severed by the proposed scheme.

The proposed scheme would therefore have a direct, impact on the Cringleford Neighbourhood Development Plan consultation draft, but it is hoped that the final plan can reflect accommodating the proposed improvement scheme.

5.6.5 Effects on Agricultural Land

Agricultural soil survey records are available for the land affected by the scheme, to the east of the A47. Land here is Grade 3B, moderate quality agricultural land, defined as:

Land capable of producing moderate yields of a narrow range of crops, principally cereals and grass or lower yields of a wider range of crops or high yields of grass which can be grazed or harvested over most of the year.

No data is available for the remainder of the agricultural land in the study area, however baseline data in the wider landscape demonstrates that there is also likely to be land of Grade 3A, good quality agricultural land, and Grade 2, very good quality agricultural land. These classifications are defined as:

Grade 3A, good quality agricultural land is capable of consistently producing moderate to high yields of a narrow range of arable crops, especially cereals, or moderate yields of a wide range of crops including cereals, grass, oilseed rape, potatoes, sugar beet and the less demanding horticultural crops.

And

Grade 2, very good quality agricultural land, with minor limitations which affect crop yield , cultivations or harvesting. A wide range of agricultural and horticultural crops can usually be grown but on some land in the grade there may be reduced flexibility due to difficulties with the production of the more demanding crops such as winter harvested vegetables and arable root crops. The level of yield is generally high but may be lower or more variable than Grade 1.

Impacts on this agricultural land would appear to be unavoidable as the range of options for linking the two parts of the A11 are limited.

No Environmentally Sensitive Areas would be affected by the proposed scheme.

5.7 Noise and Vibration

5.7.1 Introduction

When considering noise and vibration, DMRB states that:

Traffic noise is a general term used to define the noise from traffic using the road network.

A road project has the potential to cause both increases and decreases in traffic noise on an existing road by altering the traffic composition. In the case of a new road, for example a bypass, a completely new noise source can be created.

As with air quality assessment described in a previous section, noise and vibration are directly linked to traffic volumes and characteristics. No traffic model is available, so no detailed input can be given in terms of noise impacts.

5.7.2 Potential Effects

The nature of the study area, in terms of the noise climate, is one of background noise from the A47 and the A11, both of which are dual carriageways carrying significant volumes of traffic. At this early stage, in advance of analysis of the traffic model, on-site noise monitoring etc. it is not possible to predict impacts. However, as with the air quality chapter, there is likely to be little difference in the effects between the four Alternatives due to their inherent commonality.

The twelve properties on Cantley Lane South are the most likely to be affected, due to the proximity of the proposed Alternatives and the potential change in noise levels, a detailed assessment of the impacts here will be required.

As with the Air Quality section above, there may be effects on the neighbourhoods at Roundhouse Park and Cantley Lane/Brettingham Avenue in Cringleford, so further assessment is likely to be required, once traffic details are available.

5.8 Pedestrians, Cyclists, Equestrians and Community Effects

This section considers the impacts of the proposals on the above groups, as well as those making local journeys by car. In both cases, it considers severance, and the changes on journey routes and times. It identifies changes in amenity, where severance is caused, and where existing severance may be removed.

It is not necessary to consider the separate Alternatives in this section, as impacts and effects are likely to be the same in all cases.

The study area is sufficiently small, and the proposed Alternatives so localised as to affect very few people and their journeys. Further, the nature of the study area, being centred on a major highway interchange, means that it holds little value or interest for non-motorised users. The effects are limited to the severance of Cringleford Footpath No.1, to the southwest of the Roundhouse Park roundabout, and localised implications for Cringleford Bridleway 5 and Footpath 5a, both of which tie up and cross the A47 where the Alternatives also cross.

There are also equestrian facilities at the existing Thickthorn Interchange, although there are no specific bridleways here. The additional carriageways that the proposed Alternatives create may sever these routes to the extent where equestrian use becomes unviable. It may therefore be necessary to consider providing alternative equestrian routes.

Each of the Alternatives would include provision for bridging Cantley Lane South, within the same structure as that crossing the A47. This means that any severance issues for the residents of the twelve properties would be during the construction phase only. The alternative route could be quite lengthy, and is likely to involve travelling via East Carleton to the B1113 to commute to and from Norwich. Once complete, the existing road network and access regime would be reinstated.

It is unlikely that the proposed Alternatives would have any specific impact on access to facilities used by the community – post offices, schools, doctors' surgeries etc.

A map showing many of the above constraints, Figure E, can be found in Appendix C5.

5.9 Vehicle Travellers

Assessment of the impacts on vehicle travellers is made in terms of both the view from the road, driver stress. As with the above section, it is not necessary to consider the effects and impacts of all the Alternatives individually.

The view from the proposed scheme would, as a function of its required height, be positive, as wider views would be afforded. Conversely, the view from the road of user of the A47 and other, nearby minor roads, would be adversely affected, as the size of the bridge structure, earthworks, approach ramps etc would be considerable.

On the assumption that the proposed scheme achieved its aims and freed up congestion for at least some movements at the Thickthorn interchange, then the impact on driver stress should generally be positive. Aside from the construction period, when congestion would likely get worse temporarily, the smoother running traffic should result in higher average speeds and quicker journeys through the junction, reducing the stress that comes with congestion, low speeds, driver uncertainty etc.

5.10 Road Drainage and the Water Environment

This section considers four specific aspects of the water environment, and how the proposed Alternatives may affect it. At this stage it is not necessary to differentiate between the four Alternatives. It assesses:

- Effects of Routine Runoff on Surface Waters;
- Effects of Routine Runoff on Groundwater;
- Pollution Impacts from Spillages; and
- Flood Impacts

The impacts of pollution are a significant factor for consideration. DMRB acknowledges that

"Pollution from road drainage can arise from a variety of sources including: collisions, general vehicle and road degradation, incomplete fuel combustion, leaks of oil, fuel or other pollutants, fires and atmospheric deposition."
It describes four types of pollution event, namely:

- Diffuse pollution, whereby ongoing low levels of contaminants/pollutants occur over a large area, or from a number of point sources. Road runoff is generally considered as diffuse pollution.
- Acute pollution, associated with specific events such as traffic accidents where fuel enters the water system, or spikes in salt loading, for example during periods of very cold weather; and
- Chronic pollution, which is the result of ongoing low levels of pollutants resulting in non-lethal pollution. Effects are likely to include reduced feeding rates and fecundity of organisms in affected water.
- Routine runoff, is the normal runoff from roads that may include the contaminants washed off the surface in a rainfall event and can result in either acute or chronic impacts. It excludes the effect of spillages and major leaks which usually result in acute impacts.

All of the above types of pollution have the potential to adversely affect both surface water and ground water.

The south-western end of the study area directly impacts on a small area of Flood Zones 2 and 3. Those Alternatives that include slip roads here will need to consider this directly, although even those that do not directly affect them will also need to consider the implications of its location. A map showing Flood Zones 2 and 3, Figure F, can be found in Appendix C6.

Best practice in terms of road drainage design, coupled with the many and numerous pieces of legislation relating to water quality and quantity (for example the Water Framework Directive, and the upcoming establishment of the SuDS Approvals Board), mean that the majority of the impacts associated with the above issues will be considered as the detailed design progresses.

Unlike the existing drainage regime at the existing interchange, the new road is likely to be required to drain to infiltration/attenuation lagoons, where flood events can be contained and dissipated, water quality issues addressed, and acute pollution events accounted for. No additional surface water that would contribute to flood risk would be permitted, and the quality of existing surface and ground water must not be adversely affected; instead, schemes should seek to improve the water quality wherever possible.

The above requirements means that the footprint for the scheme is likely to need to include for such lagoons, or other features as deemed appropriate, the impacts of which will also need assessing.

Consultation with the Environment Agency will be required as the scheme progresses, and input from water quality and drainage specialists sought early on in the design and assessment process.

5.11 Geology and Soils

The implications of the proposed Alternatives on geology and soils have been assessed in Preliminary Sources Study Report.

5.12 On-going Recommendations and Requirements

5.12.1 Screening for EIA

To move beyond high level environmental input it will be necessary to identify whether the scheme requires Environmental Impact Assessment. The scheme may fall within Schedule Two of the Town and Country Planning (Environmental Impact Assessment) Regulations 2011 a Screening Opinion should be sought from the Local Planning Authority as the scheme moves to the next stage of feasibility/design. The

LPA will consult with the statutory environmental bodies such as Natural England, English Heritage and the Environment Agency, for their considered opinions, and a decision made.

5.12.2 Record of Determination and Notice of Determination

Both the A11 and A47 are trunk roads, administered by the Highways Agency. This means that, alongside the above Screening process, the Highways Agency will need to carry out its own, internal process to determine whether EIA would be required. The process effectively mirrors the above, only the HA consult directly with the Secretary of State as opposed to the LPA.

Both or either of the above processes could determine that EIA is required. At this point a full Scoping Report to DMRB guidelines could be produced. Alternatively, as the scheme extents are fairly confined and optioneering will have already taken place, it may be that it is deemed more appropriate to instead move directly to a Simple Environmental Impact Assessment. This report would need to closely follow the DMRB guidelines and requirements, at the same time incorporating and expanding on the contents of this report.

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Thickthorn Intersection Improvements – Environmental Impacts Table for preferred alternatives				
Discipline	**Roundabout Arrangement 'Alternative A'**	**Free Flow Arrangement 'Alternative B'**	**Dumbbell Arrangement 'Alternative C'**	**Half Dumbbell Arrangement 'Alternative A'**
Air Quality	Impacts at a local scale are possible, as the route runs close to several properties on Cantley Lane South, as well as the fringes of Cringleford. Traffic model data would be required to quantify impacts.	Impacts at a local scale are possible, as the route runs close to several properties on Cantley Lane South (although this option is fractionally further away than the other three), as well as the fringes of Cringleford. Traffic model data would be required to quantify impacts.	Impacts at a local scale are possible, as the route runs close to several properties on Cantley Lane South, as well as the fringes of Cringleford. Traffic model data would be required to quantify impacts.	Impacts at a local scale are possible, as the route runs close to several properties on Cantley Lane South, as well as the fringes of Cringleford. Traffic model data would be required to quantify impacts.
Cultural Heritage	The least intrusive alternative. The scheduled monuments are avoided, and the fewest known archaeological records impacted. No listed buildings would be directly affected, although the settings of two may be impacted, along with the setting of one historic park associated with Thickthorn Hall, and the deserted medieval village of Cantley.	Would indirectly impact on one Scheduled Monument, and several known archaeological records would be directly impacted. No listed buildings would be directly affected, although the settings of two may be impacted, along with the setting of one historic park associated with Thickthorn Hall, and the deserted medieval village of Cantley.	Would directly impact on one Scheduled Monument, and several known archaeological records would be directly impacted. No listed buildings would be directly affected, although the settings of two may be impacted, along with the setting of one historic park associated with Thickthorn Hall, and the deserted medieval village of Cantley.	The most intrusive alternative. Would directly impact on one Scheduled Monument, and several known archaeological records would be directly impacted. No listed buildings would be directly affected, although the settings of two may be impacted, along with the setting of one historic park associated with Thickthorn Hall, and the deserted medieval village of Cantley.
Ecology and Nature Conservation	No Designated Sites are directly impacted by this alternative. Four County Wildlife Sites are located within 1km of the scheme, although direct impacts are unlikely. A small-scale mosaic of arable, woodland (both semi-natural and plantation), scrub, grassland and hedgerow habitats would be directly and indirectly affected, some of which have the potential to offer shelter for protected species. As the Alternative with the smallest footprint, this has the least direct adverse impacts.	No Designated Sites are directly impacted by this alternative. Four County Wildlife Sites are located within 1km of the scheme, although direct impacts are unlikely. A small-scale mosaic of arable, woodland (both semi-natural and plantation), scrub, grassland and hedgerow habitats would be directly and indirectly affected, some of which have the potential to offer shelter for protected species.	No Designated Sites are directly impacted by this alternative. Four County Wildlife Sites are located within 1km of the scheme, although direct impacts are unlikely. A small-scale mosaic of arable, woodland (both semi-natural and plantation), scrub, grassland and hedgerow habitats would be directly and indirectly affected, some of which have the potential to offer shelter for protected species. As the Alternative with the largest footprint, this jointly has the most numerous direct adverse impacts.	No Designated Sites are directly impacted by this alternative. Four County Wildlife Sites are located within 1km of the scheme, although direct impacts are unlikely. A small-scale mosaic of arable, woodland (both semi-natural and plantation), scrub, grassland and hedgerow habitats would be directly and indirectly affected, some of which have the potential to offer shelter for protected species. As the Alternative with the largest footprint, this jointly has the most numerous direct adverse impacts.
Landscape	Avoids impacts on Wards Wood, although impacts on the properties on Cantley Lane South, from where the residents would have a direct view during construction and operation. Loss of pasture land is also likely.	Slightly greater distance from the Cantley Land properties than the other Alternatives, so a slightly lesser impact on the landscape. Disects Wards Wood and Cantley Wood, and cuts through pasture land. Jointly the least acceptable in landscape terms.	Jointly the least acceptable in landscape terms. Disects Wards Wood and Cantley Wood, as well as the setting of the Scheduled Monument. Requires land take from gardens of properties on Cantley Lane South, and will hence have sizeable adverse impacts on the immediate landscape.	Jointly the least acceptable in landscape terms, and requires the largest degree of landtake. Disects Wards Wood and Cantley Wood, as well as the setting of the Scheduled Monument. Requires land take from gardens of properties on Cantley Lane South, and will hence have sizeable adverse impacts on the immediate landscape.
Land Use	No requirement for demolition of private residential property, or on Community Land. Bisects land designated for development in the Cringleford Neighbourhood Plan. Requires the loss of Grade 2 or 3 Agricultural Land (to be confirmed by survey when appropriate.	As Roundabout Arrangement 'Alternative A'.	As Roundabout Arrangement 'Alternative A'.	As Roundabout Arrangement 'Alternative A'.

Discipline	Roundabout Arrangement 'Alternative A'	Free Flow Arrangement 'Alternative B'	Dumbbell Arrangement 'Alternative C'	Half Dumbbell Arrangement 'Alternative A'
Noise and Vibration	As with air quality, impacts at a local scale are possible, as the route runs close to several properties on Cantley Lane South, as well as the fringes of Cringleford. Traffic model data would be required to quantify impacts.	As with air quality, impacts at a local scale are possible, as the route runs close to several properties on Cantley Lane South, as well as the fringes of Cringleford. Traffic model data would be required to quantify impacts.	As with air quality, impacts at a local scale are possible, as the route runs close to several properties on Cantley Lane South, as well as the fringes of Cringleford. Traffic model data would be required to quantify impacts.	As with air quality, impacts at a local scale are possible, as the route runs close to several properties on Cantley Lane South, as well as the fringes of Cringleford. Traffic model data would be required to quantify impacts.
Pedestrians, Cyclists, Equestrians and Community Effects	Severs one public footpath, and would require the localised diversion of one footpath and one bridleway. Equestrian facilities at Thickthorn Interchange likely to require some consideration as the design progresses. Temporary, construction-phase severance likely to be felt be the residents on Cantley Lane South.	As Roundabout Arrangement 'Alternative A'.	As Roundabout Arrangement 'Alternative A'.	As Roundabout Arrangement 'Alternative A'.
Vehicle Travellers	The view from the proposed road would generally be improved, mostly as a virtue of it's elevation. Driver stress should be decreased as congestion issues become alleviated.	As Alternative A, although part is to be in tunnel beneath the existing A11, which would lessen the beneficial effects on the view from the road.	As Roundabout Arrangement 'Alternative A'.	As Roundabout Arrangement 'Alternative A'.
Road Drainage and the Water Environment	Potential to have direct and indirect impacts on Flood Zones 2 and 3. Flood risk, sustainable drainage, pollution control and contamination risk will need consideration as design progresses.	As Roundabout Arrangement 'Alternative A'.	As Roundabout Arrangement 'Alternative A'.	As Roundabout Arrangement 'Alternative A'.
Geology and Soils	The geology of the site comprises a complex sequence of interbedded Glacial Sand and Gravels and Glacial Tills over Upper Chalk, with a thin ribbon of Alluvium cutting the site from northwest to southeast. The main potential sources of contamination on site are: • an historic landfill situated in the west of the area; • A fuel station to the immediate north; • Farming Activities across site; • Pollution incidents to controlled water; • Major road network cross cutting the site; and , • Generation of ground gases. The risk from ground contamination is currently considered low to moderate and the risk from ground gases low. An intrusive investigation is required to verify these initial conclusions (See PSSR for further details). No SSSI's relating to geology or geological features of regional interest are thought to exist within the site.	As Roundabout Arrangement 'Alternative A'.	As Roundabout Arrangement 'Alternative A'.	As Roundabout Arrangement 'Alternative A'.

6 Traffic and Economic Assessment

For details of the Traffic Assessment please see **Thickthorn Interchange Improvements Concept Scheme Options Traffic Assessment Report**. An economic assessment of the scheme will be carried out in the next stage of the scheme.

7 Stakeholders and Affected Parties

7.1 Highways Agency

Consultation during April 2013 with HA officers was met with approval in principle of all 4 tabled layouts. The options with least negative impact on trunk road users, both in operation and during construction, were the preferred variants i.e. free flow.

It was stated that the bypass and its slip roads would be expected to remain as local roads, but maintenance of bridges over and tunnels under the existing trunk roads would generally be the responsibility of the HA, however the desire to move away from this was suggested as a possibility for this project.

HA confirmed that closures of their network would only be possible overnight, and that lane closures would require like-for-like diversions with 2 lanes in each direction remaining open at all times.

7.2 House Owners

There are 12 private semi-detached houses located to the south east, along Cantley Lane. Some options considered have alignments that come close to or require construction affecting the back gardens of these properties.

7.3 Pig Farmer

There is a Pig farm located to the south west, adjacent to the A11. Some options considered have alignments that come close to or require the removal of livestock and large sheds. This Pig farm is considered replaceable and relatively easy to relocate.

8 Conclusion and Recommendations

8.1 Bypass

It is recommended that the preferred alternative for each of the 4 options is progressed further to the next stage.

Current thinking, backed by HA opinion, is that 'Free Flow Alternative B' is recommended as the preferred option for the bypass at this stage.

8.2 Off-slip widening

It is recommended that this work is progressed to the next stage for development of the most cost effective lane width solution.

Appendices

Appendix A. Location Plan and Scheme Drawings

A.1 Site Location Plan

A.2 Roundabout Arrangement 'Alternative A'
MMD-306537-WA-SK-0100B

A.3 Free Flow Arrangement 'Alternative B'
MMD-306537-WA-SK-0201B

A.4 Dumbbell Arrangement 'Alternative C'
MMD-306537-WA-SK-0302B

A.5 Half Dumbbell Arrangement 'Alternative A'
MMD-306537-WA-SK-0304B

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Appendix B. Preliminary Sources Study Report

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Appendix C. Environmental Assessment Drawings