# Regional Investment Programme

## A27 Arundel Bypass

## PCF Stage 1 – Technical Appraisal Report

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The Project Manager is responsible for production of this document, based on the contributions made by his/her team existing at each Stage.

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# A27 ARUNDEL BYPASS

## PCF STAGE 1

## TECHNICAL APPRAISAL REPORT

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The Road Investment Strategy (RIS) for the period 2015-2020, published in 2014 and known as 'RIS 1' comprises a long-term vision for England's motorways and trunk roads. It specifies those locations which are to be subject to technical study and considered for improvement through a programme of investment. The A27 in the vicinity of Arundel was identified by RIS[1] as an area for investment (referred to as 'A27 Arundel Bypass') and is the subject of this Technical Appraisal Report (TAR).

**The need for the scheme**

Based on the evidence review during earlier stages of scheme development, the following problems were identified:

Problem 1 – The A27 is a strategically important corridor on the south coast that caters for both local and strategic traffic movements, which has historically suffered from congestion and delay.

Problem 2 – There are existing capacity constraints at Arundel due to the single carriageway section, worsened by constrained capacity at the Ford Roundabout and Crossbush junctions.

Problem 3 – The current demand exceeds the theoretical capacity of a single carriageway road in Arundel.

Problem 4 – Future growth will result in the demand further exceeding capacity though Arundel, and this section of the A27 will act as a constraint to the planned growth in housing and employment along the corridor.

Problem 5 – The location of the A27 leads to severance through the town of Arundel.

Without appropriate intervention to alleviate congestion, the problems identified are expected to worsen with increased traffic levels. This would result in significant consequences for the efficiency of traffic flow, road safety, network resilience, and user satisfaction. As a consequence, the operation of the A27 would be constrained in its ability to perform its role in supporting local and regional development and economic growth.

Detailed scheme objectives have been defined to address the identified problems:

- Improve capacity of the A27 whilst supporting local planning authorities to manage the impact of planned growth.
- Reduce congestion, reduce travel time and improve journey time reliability along the A27.
- Improve the safety of travellers along the A27 and consequently the wider local road network.
- Improve accessibility for all users to local services and facilities.
- Deliver a scheme that minimises environmental impact and seeks to protect and enhance the quality of the surrounding environment through its high quality design.
- Respect the South Downs National Park and its special qualities in our decision-making.

[1] Road Investment Strategy

**Constraints**

A number of planning and other constraints have been identified and considered to inform which options are taken forward into Stage 2. These constraints include the South Downs National Park, ancient woodland and areas that are within floodplain.

**Option identification**

During Stage 1, a total of ten options were appraised in consultation with key stakeholders, including West Sussex County Council, Arun District Council and the South Downs National Park Authority. Of these, five options were ruled because they were not considered to provide the same scale of benefits as other options which were retained. The five options taken forward to Stage 2 are described in more detail as follows:

- **Option 0A:** Junction improvements only, and encompasses improvements to Crossbush junction, Causeway roundabout and Ford Road roundabout. This option would require widening of The River Arun bridge span near Ford Road roundabout to facilitate improvements to junction capacity.
- **Option 1**: Online dualling of the existing alignment from west of Arundel to Fitzalan Road, then the provision of an offline rural all-purpose dual carriageway to tie into Crossbush Junction.
- **Option 3**: An offline dual carriageway route bypassing the existing A27 alignment. The alignment extends from the existing A27 Arundel Road near Havenwood Park south east through ancient woodland at Tortington Common and requires four new under-bridges at Old Scotland Lane, Binsted Lane, Tortington Lane and Ford Road. It then turns east and requires two new over-bridges at the River Arun and Arun Valley Railway, and ties into the existing A27 to form a new grade separated interchange at Crossbush junction.
- **Option 5A**: An offline dual carriageway route tying in to the existing A27 dual carriageway west of Yapton Lane, passing south of Tortington Priory, joining the existing A27 dual carriageway to the east at Crossbush where a new grade separated junction would be provided. This option would pass through the South Downs National Park west of Binsted Lane and through ancient woodland at the western tie-in.
- **Option 5B**: An offline dual carriageway with a grade separated junction at Crossbush to connect with the existing A27 dual carriageway which would run west, south of Arundel town, and across the Arun floodplain between Tortington Priory and Tortington village. It would completely bypass the ancient woodland, passing between Binsted and Walberton, and would tie-in with the existing A27 dual carriageway north of the Hilton Hotel and Avisford Park Golf Course, west of the existing junction with Mill Lane/Tye Lane.

**Traffic appraisal summary**

The West Sussex County Model was updated following a comprehensive data collection programme and has been used to assess the five options recommended to be taken forward to Stage 2. The modelling results demonstrate that Option 5A would provide the best road network performance in terms of journey time and delay.

**Scheme cost and value for money**

Cost estimates for each of the options are set out below.

**Table 1-1: Scheme cost estimates**

| Option | Commercial range estimate* | | |
|---|---|---|---|
| | Minimum | Most Likely | Maximum |
| 0A | £27.92M | £39.22M | £73.91M |
| 1 | £96.09M | £134.47M | £250.17M |
| 3 | £207.54M | £260.00M | £853.18M |
| 5A | £199.76M | £249.34M | £772.48M |
| 5B | £259.65M | £330.33M | £889.62M |

**Cost estimates prepared in 2014 Q1 prices and then inflated to outturn costs*

The costs for the offline options assume the bypass would be constructed on an embankment across the floodplain, rather than a viaduct.

The 'most likely' costs are converted to 2010 prices and discounted to 2010 as part of an economic assessment, with the results summarised as a Benefit Cost Ratio (BCR) for each option. The least expensive option (0A) shows the highest BCR and the most expensive option (5B) shows the lowest BCR as shown in Table 1-2. All scheme options show a BCR of greater than 1.5, demonstrating the options would achieve at least a 'medium' level of value for money.

**Table 1-2: Benefit cost ratios**

| Benefit Cost Ratios | | | | | |
|---|---|---|---|---|---|
| Option | 0A | 1 | 3 | 5A | 5B |
| BCR | 4.41 | 3.60 | 2.01 | 2.60 | 1.64 |

**Value for Money rating - 1.50 – 1.99 = Medium, 2.00 – 3.99 = High, >4.00 = Very High*

**Summary of recommendation**

A total of ten options were considered during PCF Stage 1 comprising a range of online widening, new offline routes, and junction improvement schemes. Through a process of scheme appraisal and stakeholder engagement, five of these were prioritised for further consideration during PCF Stage 2.

# 2 INTRODUCTION

## 2.1 BACKGROUND

The Road Investment Strategy (RIS) for the period 2015-2020, published in 2014 and known as 'RIS 1' comprises a long term vision for England's motorways and trunk roads. It specifies those locations which are to be subject to technical study and considered for improvement through a programme of investment. The A27 in the vicinity of Arundel was identified by RIS[2] as an area for investment (referred to as 'A27 Arundel Bypass').

The development of the A27 Arundel Bypass is progressing through the Project Control Framework (PCF) which includes the production of a range of technical studies to consider the various challenges and opportunities to improving the route. The assessment described in this TAR is part of PCF[3] Stage 1; 'Option Identification'. During this stage:

- options are identified to be taken to public consultation
- options are initially assessed in terms of environmental impact, traffic forecasts and economic benefits
- option cost estimates are prepared

This TAR summarises the technical aspects of the existing transport, environment and other issues within the study area, and describes how a number of potential scheme options could resolve them. Following the Introduction, this report is set out with the following sections:

Section 3 describes the planning brief, which sets out the context of the scheme under consideration as well as the scheme objectives.

Section 4 comprises a description of the existing conditions including those relating to highways, traffic, safety, drainage and geological issues.

Sections 5 and 6 outline the existing environmental characteristics and designations including those in relation to noise, local air quality, biodiversity and heritage.

Section 7 describes the accessibility issues that are currently present along the route. Issues relating to severance and connectivity with the wider transport network are discussed.

Section 8 summarises the various land development policies that are relevant to the scheme. National, local and transport-specific policy documents are reviewed, and the expected development in terms of housing and employment land is tabled.

Section 9 presents details of the maintenance and repair strategy.

Section 10 discusses any other relevant factors.

[2] Road Investment Strategy
[3] Project Control Framework

Section 11 summarises the planning factors affecting the scheme. Such factors include land development, programming, and the statutory procedure for obtaining consent to implement the scheme.

Section 12 presents a description of the options considered, together with the reasons for their rejection at this stage. The section goes on to describe the options that have been given further consideration with reference to the various engineering and environmental factors that have been considered during the development of the options.

Sections 13 and 14 present the traffic and economic assessments for the options. These assessments are consistent with industry standard conventions for junction modelling and strategic / economic modelling.

Sections 15 to 18 describe how the proposed options would operate in the years following completion. Section 15 details the safety assessment in terms of impacts on road users and impacts during construction and operation. Section 16 describes how each of the options might be operated should they be taken forward to implementation. Section 17 assesses each of the options in terms of the opportunity to utilise technology. Section 18 describes the factors affecting maintenance activities following scheme implementation.

Section 19 details the results of an environmental assessment. It indicates the environmental effects associated with each option. The environmental assessment considers impacts during construction as well as operation.

The quantifiable impacts of all of the various assessments are summarised in the Appraisal Summary Table. This represents the key reference point when discussing the impact of the options in terms of their costs, benefits and overall performance. This table is included in section 20, alongside a summary of the engagement with key stakeholders.

Section 21 sets out a potential programme for the project, taking into account the various stage gates associated with the PCF[4].

Section 22 concludes the option identification process, and recommends which option(s) should be taken forward to non-statutory public consultation. This section, in summarising the whole TAR[5], provides substantiation for the options to be taken forward to Stage 2.

Section 23 provides the cost estimates of each of the options.

## 2.2 SCOPE OF ASSESSMENTS

The various analyses and assessments included within this report are proportionate to and in line with the requirements of the appraisal process at PCF Stage 1. A generally qualitative appraisal process has informed the sifting of the initial ten options down to five, resulting in a list of options that will be taken forward to Stage 2. Alongside and following the sifting process, more detailed assessment have been undertaken for the five prioritised options, including in relation to traffic, economics, highways and environmental impact.

[4] Project Control Framework
[5] Technical Appraisal Report

## 2.3 USE OF ACRONYMS AND FOOTNOTES

This report contains many technical terms. All abbreviations are expanded as footnotes on the same page where they appear. This is intended to improve the readability of the report, and removes the need for a reader to remember an acronym's definition with reference to a glossary table after its first use.

## 2.4 DRAWINGS

A set of drawings for the options are provided within Appendices A through to L, as listed below.

The options drawings series contain General Arrangements (GA), public utilities information, drainage proposals, and NMU[6] desire line proposals.

- Appendix A series of appendices show baseline information
- Appendix B series shows All options
- Appendix C series shows Option 0A drawings
- Appendix D series shows Option 1 drawings
- Appendix E series shows Option 3 drawings
- Appendix F series shows Option 5A drawings
- Appendix G series shows Option 5B drawings
- Appendix H shows typical structures

[6] Non-motorised users

# 3 PLANNING BRIEF

## 3.1 SCHEME CONTEXT

The A27 is a strategically important corridor on the south coast which is used by both longer distance strategic traffic and local traffic. The Arundel section is one of a number of bottlenecks which causes delay and variable journey times due to its single carriageway alignment and the number of adjoining junctions.

To address this, the Arundel Bypass was included in the DfT's[7] RIS[8]. Improvements to this section of the A27 would contribute to national transport objectives by:

- providing additional capacity
- enhancing journey time reliability
- supporting the development of housing and the creation of jobs

Following the announcement of the bypass in the RIS, the PCF[9] Stage 0 Report – Strategy, Shaping and Prioritisation was produced in September 2015. The report drew primarily on information provided as part of the A27 Corridor Feasibility Study. The Stage 0 report made the following recommendations:

*The solutions recommended for further consideration at Stage 1 PCF are for on-line dualling of the A27 and the consideration of an off-line section around Arundel station and the Station Hill section, and various off-line options, one of which corresponds to the previous preferred route. All options would improve conditions for non-motorised road users and would reduce traffic delays. The off-line options would provide additional significant benefits and will meet the aspirations of the Strategic Economic Plan of the Coast to Capital Local Enterprise Partnership. The environmental impacts of both on and off-line options will require extensive consultation and careful design to mitigate any concerns.*

A location plan for the A27 Arundel Bypass is provided at Appendix A-1.

## 3.2 SCHEME OBJECTIVES

The principal outcome of this study is to identify workable, achievable options which can alleviate congestion and provide journey time improvements to road users on the A27 around Arundel. However, all such options should meet both a set of high level objectives, as well as a series of detailed objectives. Both sets of objectives are described below.

### HIGH LEVEL OBJECTIVES

Following consultation with West Sussex County Council, Worthing and Adur Councils, Arun District Council and the South Downs National Park Authority, the following objectives were defined:

[7] Department for Transport
[8] Road Investment Strategy
[9] Project Control Framework

- improve capacity of the A27 whilst supporting local planning authorities to manage the impact of planned growth
- reduce congestion, reduce travel time and improve journey time reliability along the A27
- improve the safety of travellers along the A27 and consequently the wider local road network
- improve accessibility for all users to local services and facilities
- deliver a scheme that minimises environmental impact and seeks to protect and enhance the quality of the surrounding environment through its high quality design
- respect the South Downs National Park and its special qualities in our decision-making

## DETAILED OBJECTIVES

The high level objectives are then explained in more detail, as below.

Objective 1: To enhance the capacity, connectivity (including all modes of transport) and the resilience provided by the A27 route in order to contribute positively to strengthening the local and regional economic base, facilitating housing allocations within the Local Plans and promoting economic growth.

Objective 2: To improve the safety and personal security of travellers along the Arundel section of the A27 route of all road users including vulnerable road users.

Objective 3: To improve road safety and reduce dis-benefits to communities and vulnerable road users on the wider network caused by longer distance traffic avoiding congestion on the A27.

Objective 4: To reduce the community severance caused by the A27 through Arundel by improving links between:

- local communities, including for vulnerable road users
- local services and facilities, particularly for tourism
- access to railway stations and bus services
- access to the South Downs National Park, particularly for more sustainable modes of transport

Objective 5: To deliver a high standard of design for any A27 improvement that reflects the quality of the landscape and setting of Arundel, and minimises the adverse environmental impact of new construction, including habitat loss and takes into account the following objectives:

- plan for climate change
- work in harmony with the environment to conserve natural resources and encourage bio-diversity
- protect and enhance countryside and historic and archaeological environment
- reduces air and noise pollution

Objective 6: Recognising that any improvement would have a significant impact on the South Downs National Park (SDNP) and have regard to the purposes and special qualities of the National Park in designing and evaluating improvement options.

## 3.3 COMPLIANCE WITH OBJECTIVES

Sections 12 - 20 of this report describe and assess the various options that have been developed in order to meet the scheme objectives. This assessment is summarised in Section 20 with reference to a set of AST[10]'s.

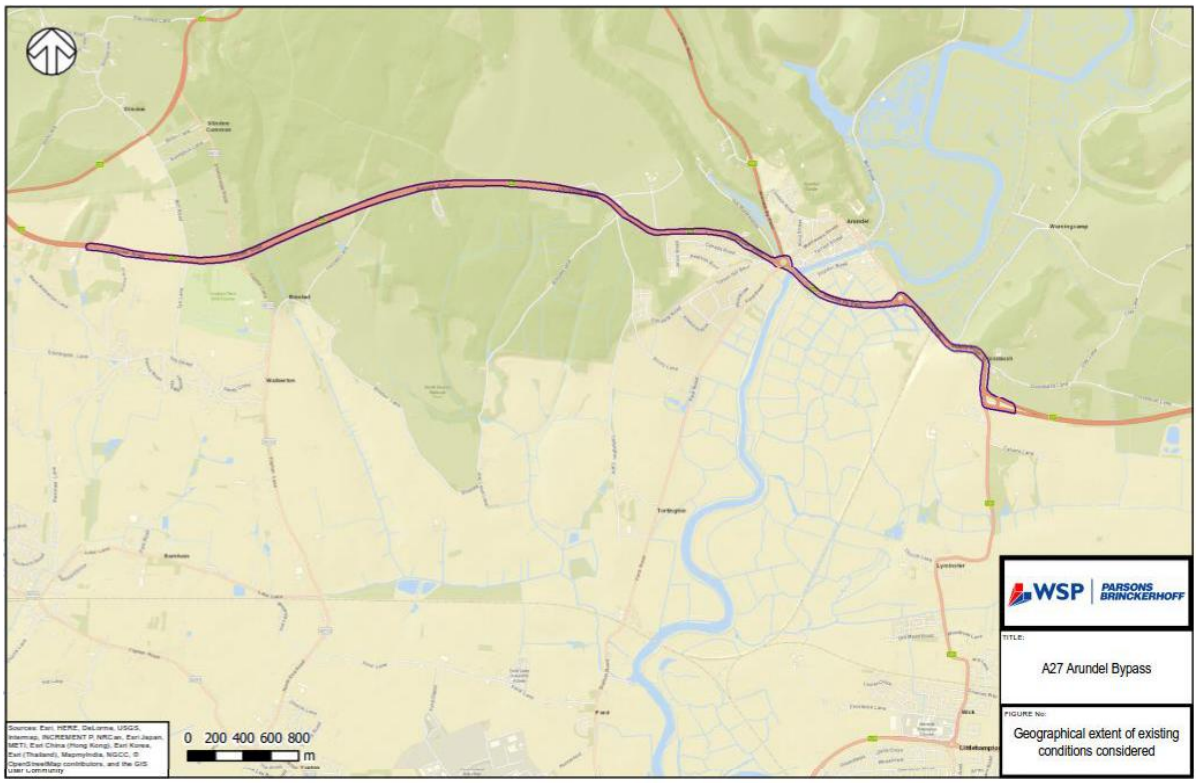
[10] Appraisal Summary Table

# 4 EXISTING CONDITIONS

## 4.1 OUTLINE

This section describes the existing conditions along the A27 corridor. The extent of the A27 Arundel Bypass scheme described by this section of the TAR is shown in Figure 3-1. The eastern limit is the approach to Crossbush junction, extending to the west of Arundel where the A27 Chichester Road dual carriageway is reduced to single carriageway standard (in the vicinity of the White Swan public house). Figure 4-1 shows the existing scheme section forming the extent of the study area.

**Figure 4-1: Geographical extent of existing A27 corridor**




## 4.2 DESCRIPTION OF THE LOCALITY

The A27 is the only east-west trunk road south of the M25. It links many of the various cities and towns along the south coast, including Portsmouth, Havant, Chichester, Arundel, Worthing and Lancing, Brighton and Hove, Lewes and Eastbourne. The A27 also provides access to Hayling Island, the Manhood Peninsula, Bognor Regis, Littlehampton and the ports of Portsmouth, Shoreham and Newhaven. It also provides businesses and residents in this corridor with access to the rest of the strategic road network (SRN).

The A27 around Arundel is located within the Arun District of West Sussex. Chichester is situated to the west, and Worthing to the east. The A27 corridor runs alongside and across the SDNP[11], and is also bounded by urban development and areas of ancient woodland along the route.

## 4.3 EXISTING HIGHWAY NETWORK

### GENERAL HIGHWAY ARRANGEMENT

The A27 around Arundel is a trunk road which is on an east / west orientation and consists of sections of single carriageway, dual carriageway, and a number of at-grade junctions. Uncontrolled at-grade roundabouts are provided at Ford Road and the Causeway in Arundel, whilst Crossbush Junction to the east of Arundel is partially signal-controlled. The 5-armed roundabout at Ford Road in particular experiences congestion which is severe at times.

The A27 connects with the A29 around 5.5km to the west of Arundel. It is formed of a two-lane dual carriageway between the A29 and a point approximately 1.3km west of Arundel, where it becomes a single carriageway with one lane in each direction. It connects with the A284, Maltravers Street and Ford Road to form a five-arm at-grade roundabout – referred to as Ford Road roundabout. Between this point and its connection with the A284 at Crossbush Junction – a non-standard signal controlled junction around 2km east of Arundel – the A27 is a single carriageway which crosses the River Arun, the Arun Valley railway line, and connects with The Causeway.

A plan of proposed housing developments and bus routes is provided at Appendix A-2, with a plan of public rights of way and bus stops shown at Appendix A-3.

## 4.4 PAVEMENT

This section summarises the findings from the Pavement Condition Report prepared by WSP | PB in 2015. It indicates the current construction and condition of the pavement along the A27 Arundel section. Section 16.5 of this TAR identifies the thickness of construction and the potential rehabilitation options for a range of design lives in light of the existing conditions.

### EXISTING CONSTRUCTION

The pavement construction of the existing A27 through Arundel is a mix of Flexible Composite; with either an average thickness of 260mm Pavement Quality Concrete (PQC) or 200mm Cementious Bound Material (CBM) base course; and Fully Flexible construction with either a 100mm Tar Bound Macadam (TBM) or 150mm Dense Bituminous Macadam (DBM) base course.

Typically the total pavement thickness is 325mm but can vary from 215mm to 595mm along the section in question.

The surface course is generally either a 40mm Thin Surface Course System (TSCS) or a 40-50mm Hot Rolled Asphalt (HRA) with some High Friction Surfacing (HFS) on the approaches to the roundabouts. Surfacing works have been undertaken in a piecemeal fashion in 1975, 1981, 1989, 1991-1998, 2001-2002, 2009, 2011-2013 and 2015.

Major structural works were undertaken to various sections of the A27 in 1975 and 1989 with the last major works taking place in 1995.

[11] South Downs National Park

TBM[12] has been identified in the HAPMS[13] sections 3800A27/210, 3800A27/226 and 3800A27/227 at a depth varying from 135mm to 325mm. Some areas are showing TBM present at a depth of 10mm below surface dressing, however it is believed that this is incorrectly logged on HAPMS on visual inspection of Google Streetview.

### EXISTING CONDITION

#### DEFLECTOGRAPH

Year 2010, 2013 and 2014 Deflectograph surveys were used for analysis to ensure sufficient coverage and residual life for the scheme. The last major maintenance was undertaken in 1995, so it is believed that the results analysed provide appropriate residual life figures.

#### SIDEWAY-FORCE COEFFICIENT ROUTINE INVESTIGATION MACHINE (SCRIM)

The SCRIM[14] survey used for pavement analysis was undertaken in September 2014 and is the current survey at the time of writing this report.

Significant areas of SCRIM failure are located in HAPMS sections 3800A27/210 (between the end of the dual carriageway and Ford Road roundabout) and 3800A27/220 (between Ford Road roundabout and Causeway roundabout)

#### TRAFFIC SPEED CONDITION SURVEYS (TRACS)

The TRACS[15] surveys used for pavement analysis were undertaken in June and September 2015 so are considered to be the current surveys.

### SUMMARY

The pavement construction is generally good and the Deflectograph testing suggests that the majority of the pavement under consideration has a good residual life. The surface condition, however, is considered to be generally quite poor with areas of low skid resistance, and TRACS defects covering large areas of the scheme.

## 4.5 TRAFFIC

Annual Average Daily Traffic (AADT) volumes on the single carriageway section through Arundel are close to or above the theoretical capacity of this section of the road, resulting in traffic congestion and journey time delays (see TA 46/97 Figure 2.1[16] ). The AADT volumes are presented in Table 4-1.

[12] Tar Bound Macadam
[13] Highways Agency Pavement Management System
[14] Sideway-force Coefficient Routine Investment Machine
[15] Traffic Speed Condition Surveys
[16] http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol5/section1/ta4697.pdf

**Table 4-1: AADT Values from WebTRIS for study area**

| LOCATION | 2016 AADT |
|---|---|
| A27 North of Crossbush Roundabout - Northbound | 14,676 |
| A27 North of Crossbush Roundabout - Southbound | 15,059 |
| A27 between A284 near Arundel (east) and A280 - Eastbound | 14,344 |
| A27 between A280 and A284 near Arundel (east) - Westbound | 13,869 |
| A27 between A284 near Arundel (west) and A29 near Bognor Regis (east) - Westbound | 13,338 |

Fuller details of existing traffic conditions are provided in the TDCR[17].

The peak hour traffic volumes are approaching or at the capacity of the single carriageway road. There are existing capacity constraints at Arundel due to the single carriageway section worsened by constrained capacity at the Ford Roundabout and Crossbush junctions.

The current traffic volumes exceed the theoretical capacity of a single carriageway road in Arundel[18] and future growth would result in the traffic volumes further exceeding capacity through Arundel. This section of the A27 would act as a constraint to the planned growth in housing and employment within the area.

The A27 results in severance through the town of Arundel, with limited provision of crossing points and high volumes of traffic.

## 4.6 ACCIDENTS AND JOURNEY TIME RELIABILITY

### INTERPRETATION OF COLLISION RECORDS

The collision data is provided at Appendix I.

A total of 68 collisions have been recorded over the five years between June 2010 and May 2015, which are mainly focussed at junctions throughout the route. The largest clusters are apparent at Ford Road roundabout and Crossbush Junction.

This following text provides an analysis of the recorded collisions on the A27 during the most recent five year period (01/06/2010 to 21/05/2015) in the vicinity of Arundel from Shellbridge Road / Yapton Lane in the west to the Crossbush Junction in the east. The extent of the collision data described in this section is represented by the boundary shown on Figure 4-1.

In total 68 accidents were recorded: two (2.9%) were classified as 'fatal', 12 (17.6%) were recorded as 'serious' and 54 (79.5%) were categorised as 'slight' in terms of severity.

### FATALITIES

Two fatal collisions occurred within the five year study period in the Arundel study area. One occurred on the A27 Station Road, 156m east of the junction for Warning Camp and one occurred on the A27 21m west of Binsted Lane.

The fatal collision on Station Road involved a car and a Heavy Goods Vehicle (HGV) greater than 7.5T in wet / damp conditions during daylight hours. The westbound vehicle lost control on a left

[17] Traffic Data Collection Report
[18] http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol5/section1/ta4697.pdf

hand bend and crossed into the eastbound lane into the path of an oncoming HGV[19]. This collision occurred within a cluster identified as having a high KSI[20] rate.

The fatal collision which occurred 21m west of Binsted Lane near the White Swan Hotel involved two cars in wet / damp conditions at night. The eastbound vehicle lost control on a right hand bend and crossed into the westbound lane and collided with an oncoming westbound car.

### NON-MOTORISED USERS

There were a total of six (8.8%) injury accidents recorded involving NMUs[21] in the Arundel search area, three of which were serious in nature. There were no fatal accidents involving NMUs on this section of the A27.

The three serious collisions all involved cyclists. One serious collision occurred, 281m west of the A284 Lyminster Road when a westbound cyclist was hit by the wing mirror of a vehicle. The second serious collision involving a cyclist occurred on the A27 Causeway 92m south of the A27 Arundel Bypass when a cyclist was knocked off by a HGV driver. The third serious collision occurred when a westbound cyclist on the A27 at the junction with Yapton Lane was hit by HGV turning right, heading south towards Yapton Lane.

There were collisions causing slight injury – two involving cyclists and one involving a pedestrian. The first involving a cyclist was caused by a vehicle passing too close. The other collision with a cyclist occurred when a vehicle failed to observe the cyclist waiting at the junction of Ford Road roundabout. A collision causing slight injury to a pedestrian occurred when a Light Goods Vehicle (LGV) passed too close a pedestrian.

Driver error is a key contributing factor in all of these collisions, including failing to judge other persons paths or speeds, careless / reckless driving and failing to look properly, according to West Sussex County Council (WSCC) Constabulary. 50% of the collisions occurred when a driver of a vehicle passed too close to a cyclist.

## 4.7 TOPOGRAPHY, LAND USE, PROPERTY AND INDUSTRY

The A27 corridor, between Portsmouth and Brighton is bounded by the SDNP[22], with its steep topography to the north and the Arun floodplain to the south of the A27, and various urban areas situated adjacent to the corridor. These elements and features, with the undulating topography and hidden valleys from earthworks and retaining structures at Binsted, create an intricate landscape composed of several locally distinctive character areas. The Causeway is largely surrounded by flat topography with intermittent views of agricultural land.

Arundel is the site of a number of industrial land uses based within 100 m of the northern study area boundary. These include substations, telecommunications, microelectronics, a vehicle repair, testing and servicing garage, a gunmaker, and a number of storage and distribution warehouses.

The local economy has strengths in advanced engineering, tourism and other sectors and has accommodated substantial population and household growth over the past decade, particularly in urban areas along the route and along the coast to the south.

[19] Heavy Goods Vehicle
[20] Killed and Seriously Injured
[21] Non-motorised Users
[22] South Downs National Park

## 4.8 CLIMATE

The closest weather station to the A27 Arundel Bypass is Bognor Regis Weather Station on the coast, approximately ten miles to the south west of Arundel. The data for the weather station was available from the Met Office[23] , and is presented in Table 4-2. The baseline climate data is shown as annual averages for the climate period 1981 – 2010.

**Table 4-2: Baseline climate data for Bognor Regis and Southern England**

| Weather station | Average mean daily maximum temperature | Average mean daily minimum temperature | Annual average number of days with an air frost | Annual average number of hours with sunshine | Average annual rainfall | Annual average number of rainy days (≥1mm): |
|---|---|---|---|---|---|---|
| Bognor Regis | 14.1ºC | 8.0ºC | 24 days | 1,921 hours | 725mm | 112 days |
| England South East & Central South | 14.3ºC | 6.3 ºC | 47 days | 1,628 hours | 788mm | 122 days |
| England South | 14ºC | 6.2ºC | 46 days | 1,554 hours | 794mm | 127 days |
| UK | 12ºC | 5ºC | 55 days | 1,373 hours | 1,154mm | 156 days |

Table 4-2 shows that the baseline climate for Bognor Regis is slightly warmer, and receives around 8% less rainfall than the regional average.

The average mean daily maximum temperature for Bognor Regis is around 2ºC higher, and the minimum temperature 3ºC higher than the national average. Rainfall in Bognor Regis is 37% lower in comparison to the UK annual average.

## 4.9 DRAINAGE

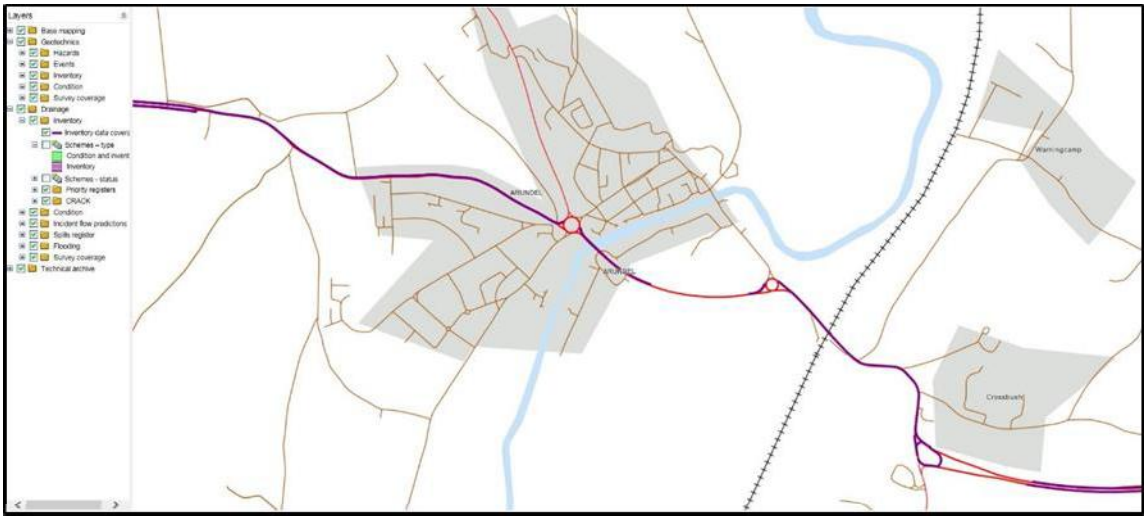
### EXISTING DRAINAGE ASSESSMENT

A desk study of asset records from HADDMS[24] was carried out, which established drainage conditions of the existing A27 Arundel Bypass. The findings are described below.

Figure 4-2 shows that extent of drainage asset within the highway boundary of the existing A27 in the vicinity of Arundel. The violet line denotes those areas with drainage assets and the red line represents those areas without.

[23] Bognor Regis climate, Meteorological Office, accessed 07/03/17 http://www.metoffice.gov.uk/public/weather/climate/gcp8bsvvw
[24] Highways Agency Drainage Data Management System

**Figure 4-2: Drainage extent of A27 Arundel Bypass (Source: HADDMS)**

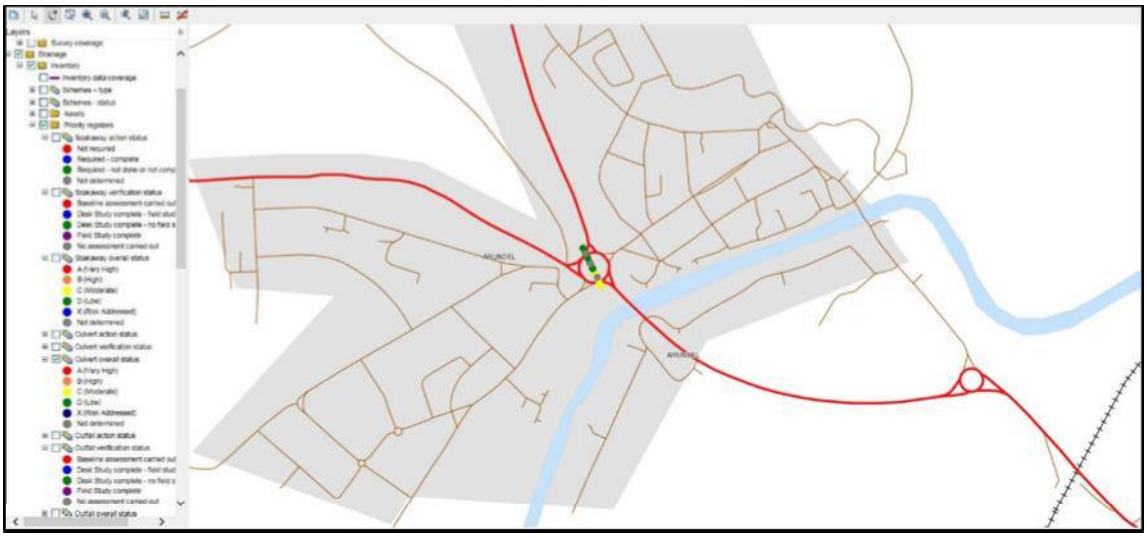


## CULVERT CONDITION

HADDMS identifies 13 culvert records at the roundabout near River Arun. However, these records seem to be for one single culvert which might have been recorded into varying short stretches.

Figure 4-3 illustrates the location of the single culvert, which crosses Ford Road Roundabout. The records state that this culvert has low to moderate risk of flooding. Flooding events are 'closed' in HADDMS once the issue has been mitigated.

**Figure 4-3: Culvert overall status (Source: HADDMS)**

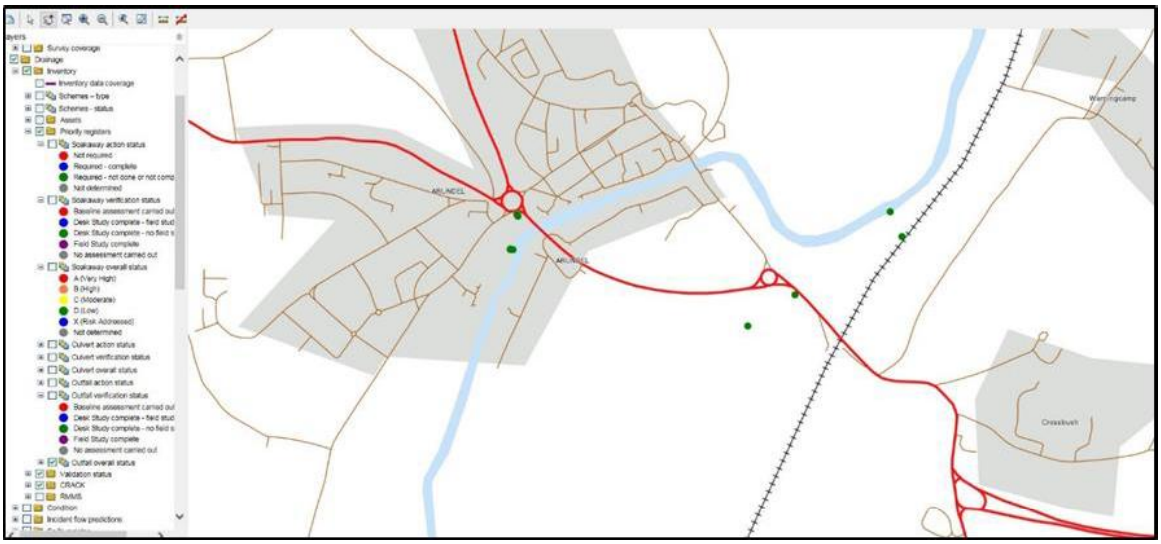


Due to overgrown vegetation around the roundabout it wasn't possible to asset the current condition of the culvert and therefore we assume the status shown in HADDMS as moderate and low is applicable until access and site investigation is available. For any proposed work at the roundabout, the culvert needs to be extended and a new headwall provided.

## OUTFALLS

HADDMS[25] identifies five outfalls which have low risk of flooding. Figure 4-4 shows the location of the various outfalls. The two dots identified to the north of the A27 and closest to the railway line, are considered to be outside of the highway boundary and scheme extents.

**Figure 4-4: Outfall locations (Source: HADDMS)**



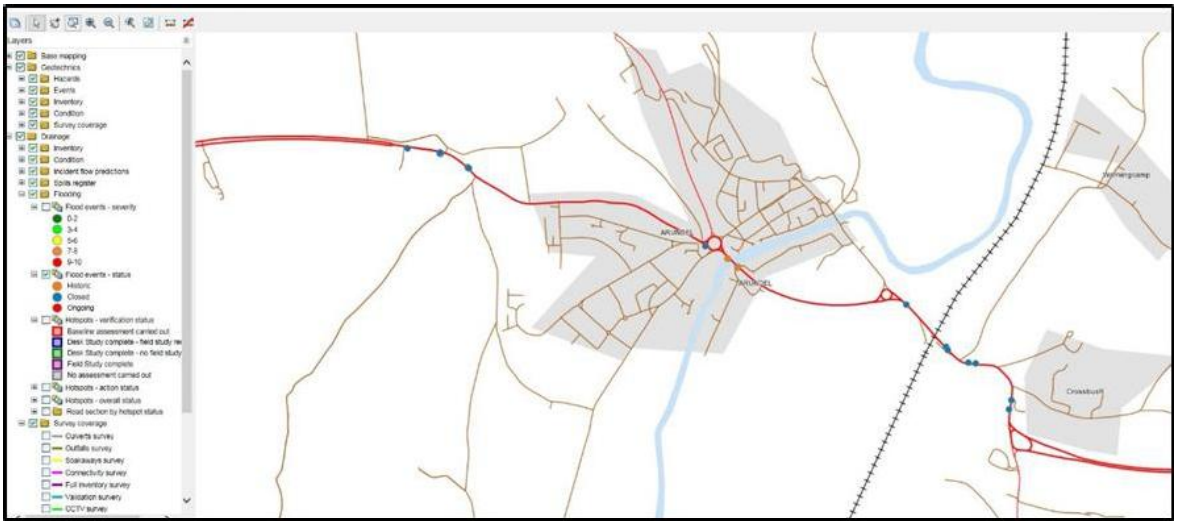
The drainage strategy for each option is provided in Appendix J.

## FLOODING EVENTS

The elevated carriageway is above the River Arun. HADDMS identifies two historic flooding events and 12 flooding events, which have been marked 'closed'. Figure 4-5 illustrates the location of the various flooding events that have been found to have occurred within the highway boundary of the A27 around Arundel. Orange dots represent historic flooding events, while the green dots signify flooding events which have been closed. Historic flooding events are those that have taken place in the more distant past and which have now been mitigated. Closed flood events took place in the more recent past and temporary or permanent measures have been undertaken to reduce the likelihood.

[25] Highways Agency Drainage Data Management System

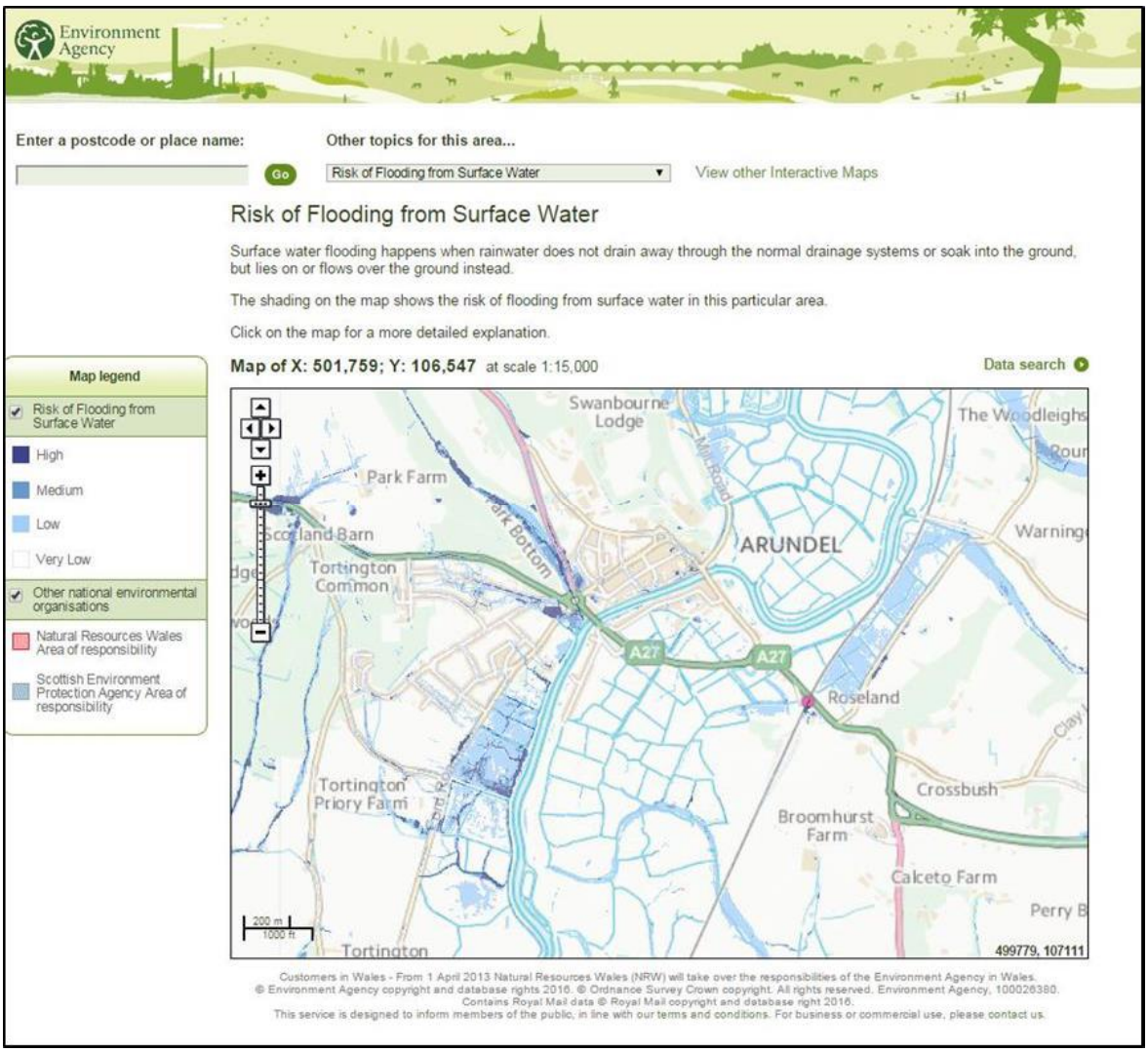
**Figure 4-5: Flood event type status (Source: HADDMS)**




Further study of the Environment Agency records, available via their website identified that the stretch of A27 Arundel bypass within the project area is not prone to flooding from surface water.

A review of the Environment Agency's Risk of Flooding from Surface Water map indicates that the A27 is not at significant risk of flooding from surface water sources. The risk of flooding can be seen in Figure 4-6.

**Figure 4-6: Arundel risk of flooding from surface water (Source: Environment Agency, UK)**

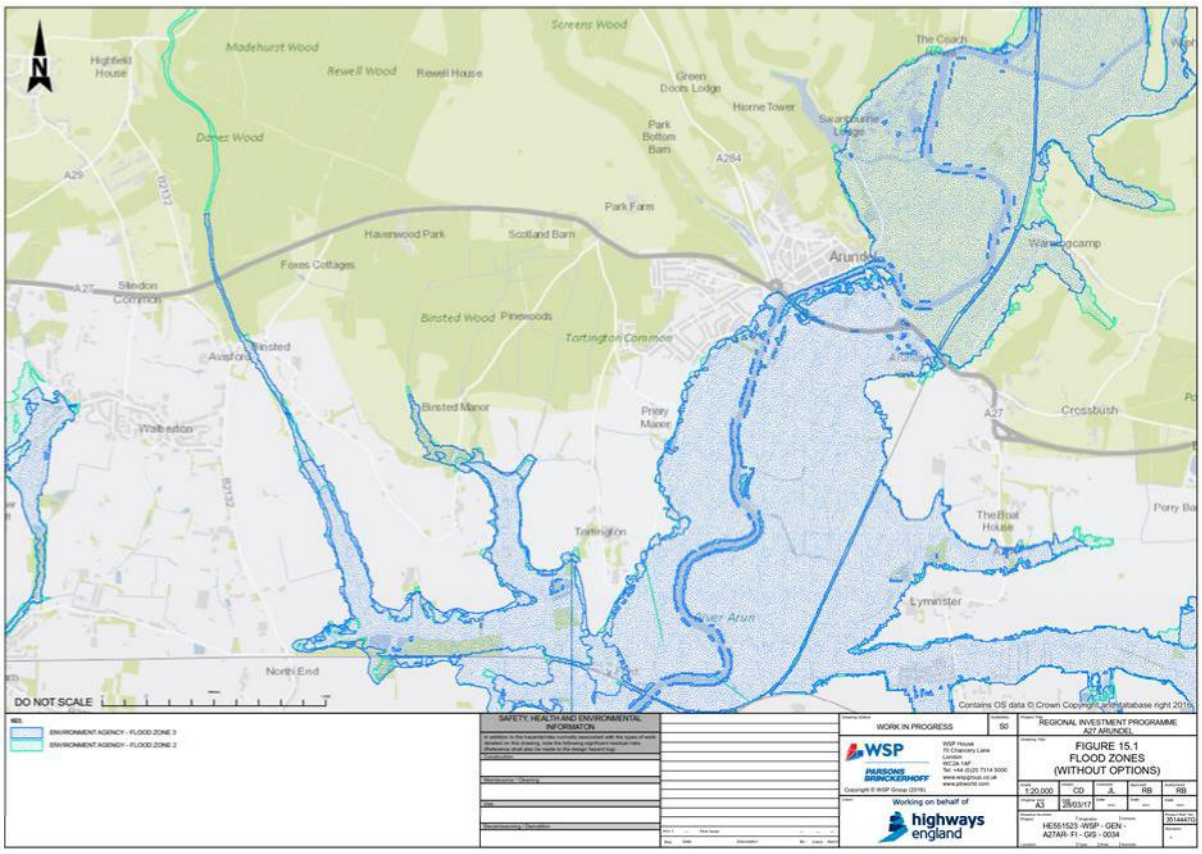



Flood defences are constructed along the banks of River Arun with the purpose of deterring the overflowing of the river along its bank. Figure 4-7 shows that without the flood defences, it is reasonable to expect that flooding would occur within the blue coloured area, as a worst case scenario.

HADDMS[26] identifies two outfalls on the banks of River Arun (as shown in Figure 4-4) – near Ford Road roundabout and south of the bridge location. The overall flooding status of these outfalls was marked 'low' and therefore it can be reasonably concluded that that these two outfalls are not prone to events of surface water flooding and river flooding.

[26] Highways Agency Drainage Data Management System

**Figure 4-7: Flood map for planning (rivers and sea) (Source: Environment Agency, UK)**




## FLOOD SEVERITY INDEX

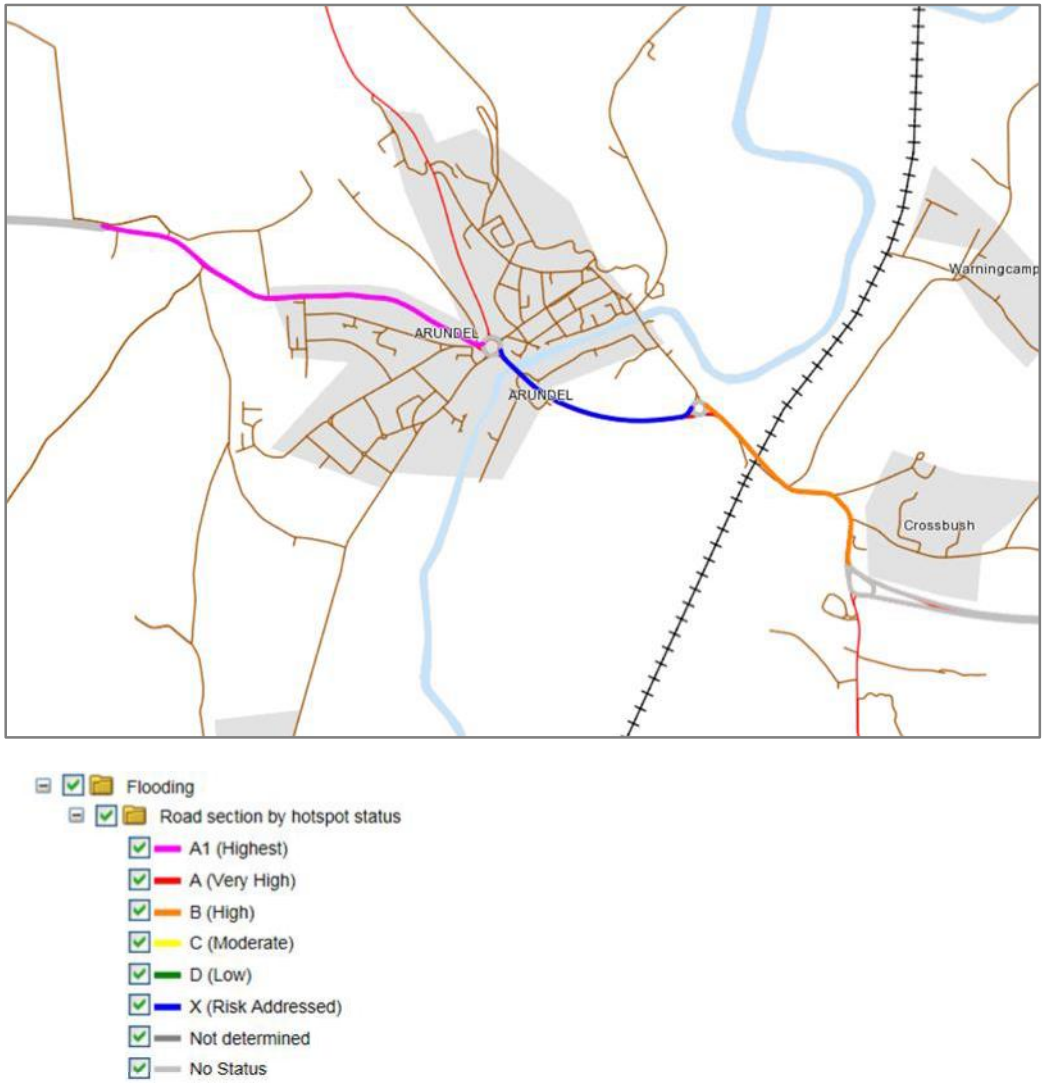
There are three areas with a classified flood severity index as seen in the Figure 4-8 below.

The pink section to the West of Arundel (Chichester Road) is classified as A1 (highest), there are eight recorded flood events with FSI scores ranging from 0.42 to 4.9.

The blue section (Arundel Bypass) is classified as X (risk addressed) illustrates that the flooding for the three recorded flood events the FSI scores are all 3.92, but there have been no recorded floods since 09/01/2008.

The amber section to the east of Arundel (The Causeway) illustrates seven flood events with FSI scores ranging between 3.92 and 1.12 and has a classification of B (high).

**Figure 4-8: Flood Severity Index**




## 4.10 GEOLOGY

Baseline information was gathered from the publicly available sources with no assurance is given as to their accuracy. As such, it should be noted that the desk based assessment is indicative only at this stage and is pending the findings of a future Preliminary Sources Study Report (PSSR) and subsequent geotechnical investigation.

The published geology for the area surrounding the site is shown on British Geological Survey 1:50,000 scale Sheet 317/332 for Chichester/Bognor and is summarised in Table 4-3.

The study area is be covered by a complex sequence of Quaternary age superficial deposits and Eocene and Cretaceous age bedrock geology comprising The London Clay Formation (Thames Group), The Lambeth Group and the White Chalk Sub-Group (formerly The Upper Chalk).

**Figure 4-9: Geology map for the scheme extents [Ref 3]**

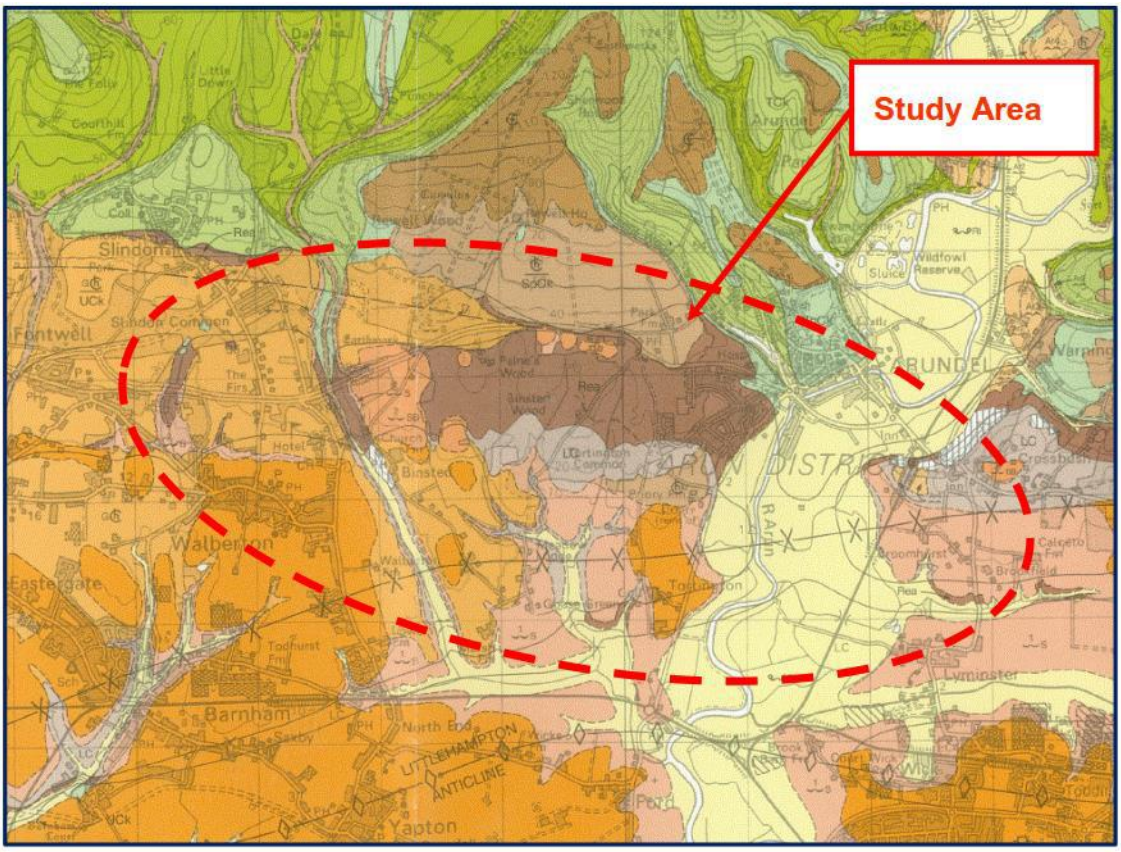


**Table 4-3: Summary of the published geology**

| Group | Strata | Series/Age | Thickness |
|---|---|---|---|
| - | Made Ground | Recent | Up to 5m |
| - | Head Deposits - Clay | Quaternary/ <1.8Mya | ~3m |
| - | Head Deposits – Gravel | | ~2m |
| - | Aeolian Deposits | | ~2m |
| - | Tidal River Deposits | | ~31m |
| - | Raised Beach Deposits | | |
| - | Raised Storm Beach Deposits | | |
| Unconformity (erosional hiatus) | | | |
| Thames | London Clay Formation | Eocene/ 55 – 49Mya | 80 – 115m |
| Disconformity (erosional/non-depositional hiatus) | | | |
| Lambeth | Reading Formation | Paleocene/ 56-55Mya | 30m |
| Unconformity (erosional hiatus) | | | |
| White Chalk Sub-Group | Portsdown Chalk | Upper Cretaceous/ 99-65Mya | 275m |
| | The Spetisbury Chalk Member | | |
| | Tarrant Chalk Member | | |
| | Newhaven Chalk Formation | | |
| | Seaford Chalk Formation | | |
| | Lewes Nodular Chalk Formation | | |

## MADE GROUND

Based on historical exploratory holes descriptions for the Embankment Fill and the possible Reworked Natural Strata, the Made Ground has been classified as either cohesive or granular. For the purposes of this assessment all areas defined as "possibly reworked Natural Strata" on the interpreted cross-sections have been taken as Made Ground. The Made Ground is confined to areas of existing highways earthwork within close proximity to the existing A27 carriageway. The Made Ground is described as a:

*"Soft to stiff orange/brown and grey sandy gravelly silty CLAY/clayey SILT with ash and chalk/white putty chalk fragments and gravel sized fragments of brick and flint".*

## SUPERFICIAL DEPOSITS

### HEAD DEPOSITS – CLAY

The Head Deposits (Clay) are typically composed of reddish brown to yellow brown, gravelly silty, sandy CLAY Borehole records suggest deposits are generally less than 3m thick but locally could be up to 5m thick.

### HEAD DEPOSITS – GRAVEL

A broad horizon of gravel covers the northern part of the coastal plain to the west of the River Arun. The deposits are predominantly made up of coarse angular flint gravels set into a stiff

matrix of sandy silty or chalky clay. The deposit varies in thickness across the region but is typically between 5m and 7m thick, however, locally this has been documented to increase to circa. 12m.

The published geology indicates the presence of isolated pockets of 'Head' deposits (colluvium) within the study area, typically found in the north west of the site at the foot of the South Downs to the north of the existing A27.

### AEOLIAN DEPOSITS

The aeolian deposits (loess) were laid down in coastal plain area and are predominantly wind-blown. In general these deposits (commonly known as 'brickearth') are less than 2m thick [Ref: **Error! Reference source not found.**].

### ALLUVIUM

These are a broad reaching, low lying piedmont alluvial horizon of course clayey gravels derived from one or more cold-climates [Ref: **Error! Reference source not found.**]. The deposit is typically composed of subrounded pebbles of chalk and flint that has been subjected to various degrees of decalcification and consequently little chalk exists at the surface.

### ARUN TERRACE DEPOSITS 1

These deposits a highly localised to the area of the railway cutting approaching the proposed Crossbush Junction and are made up of a sequence of clayey sands, sandy gravels and gravels. The deposit is of the order of 4m thick [Ref: **Error! Reference source not found.**].

### TIDAL RIVER DEPOSITS

Commonly (historically) referred to as Marine, Esturine & Raised Beach Deposits Alluvium, these are deposits that lie above the high water mark along the length of the River Arun. The deposits consist of soft brown and grey mottled laminated silty clays, silts, fine sands and some gravels. Historical borehole evidence suggests that up to 31m of soft alluvial sediments fill a buried valley in the vicinity of Arundel [Ref: **Error! Reference source not found.**].

### RAISED STORM BEACH DEPOSITS

The deposits are made up of near shore marine sands, gravels and fine sediments and form a low ridge of south of the current A27 alignment. They form localised deposits across the study area. Surface exposures are generally confined to river channels as the study area was subsequently overlain predominantly by head gravels.

## BEDROCK GEOLOGY

### LONDON CLAY FORMATION

The London Clay Formation within the study area is largely undivided of a very uniform blue-grey, pyritic, bioturbated silty and fine grained sandy clay with interbedded nodules of calcareous cementstone and flint pebbles [Ref: **Error! Reference source not found.**]. The London Clay Formation weathers typically to brown.

The London Clay Formation is present in the south and south east of the scheme, in the region of Option 5B and all routes tie in locations at Crossbush. The historical borehole data generally describes the units of the London Clay Formations is as follows:

- Stiff brown grey silty sandy CLAY (Weathered London Clay)

- Stiff to very stiff blue-grey silty sandy CLAY (Unweathered London Clay)

### LAMBETH GROUP

The Lambeth Group in the Arundel area is typically made up of units of the historical Reading Formation sub-group which are defined as a sequence of fine to coarse fluviatile deposits made up of brightly coloured sands and reddish brown, orange and grey mottled clays and silty clays [Ref: **Error! Reference source not found.**]. In the study area the Reading Formation is described as uniform in character with a thickness of up to 30m.

The Reading Formation unconformably overlies the White Chalk Group.

### THE WHITE CHALK SUB-GROUP (FORMERLY THE UPPER CHALK)

The White Chalk is a Sub-group of the Chalk Group and is generally characterised by layers of soft white Chalk interbedded with numerous seams of flint and marl. The Chalk sub-group is divided into seven formations and is approximately 275m thick [Ref: **Error! Reference source not found.**]. Below describes the three formations expected to be encountered in the study area:

- Culver Chalk Formation can be split into two Chalk members
    - The Tarrant Chalk - is a soft white Chalk with relatively widely spaced but large flint seams. The unit is of the order of 35m to 45m thick in the Sussex area, however this can be considerably reduced in area of syn-sedimentary river channel (e.g. The River Arun channel) [Ref: **Error! Reference source not found.**];
    - The Spetisbury Chalk - Firm white Chalk with regular large flint seams and is thought to be of the order of 35m thick in the Arundel area [Ref: **Error! Reference source not found.**];
- The Seaford Chalk - Firm white Chalk with conspicuous semi-continuous nodular and tabular flint seams; and
- The Lewes Chalk - Composed of hard to very hard nodular Chalks and hardgrounds with interbedded soft to medium hard Chalk (some grainy) and marls with some griotte Chalk. The softer Chalk becomes less abundant towards the bottom. Nodular Chalk is typically lumpy and iron-stained (usually marking sponges).

These sub-formations along with the Portsdown Chalk Formation are collectively formerly referred to as *"The Upper Chalk"*.

The Chalk in the region has been subjected to a number of periods of tectonic compression and deformation resulting in the formation of the northern limb of the Chichester syncline. The dip of the Chalk beds is predominantly in a southerly direction, but due to the scale of deformation in the area, localised anomalous dips could occur.

## GROUND CONDITIONS

Following analysis of historical ground investigation data, the indicative geological sequence across the scheme is shown in the Table 4-4. Further ground investigation will be undertaken in subsequent PCF Stages to confirm conditions along the preferred route.

**Table 4-4: Summary of geological sequence**

| FORMATION | PROBABLE CONSTITUENTS | DERIVED APPROXIMATE DEPTHS TO TOP OF STRATA (METRES BELOW GROUND LEVEL) |
|---|---|---|
| **Superficial Deposits** | | |
| Topsoil and Subsoil | - | GL |
| Made Ground | Clayey silt to sand and gravel with coarse gravel of flint and brick with occasional rootlets | GL – 0.3 |
| Alluvium | Soft silty CLAY with peat | 0.3 – 0.7 |
| Head Deposits (Locally encountered in the north of site) | Stiff sandy silty CLAY with much gravel. | GL – 1.3 |
| Raised Beach Deposits (Locally encountered in the south west of site) | Clay, silt, sand and gravel. | 1.8 |
| **Bedrock** | | |
| London Clay Formation (South and East of the site) | Stiff Brown grey (weathered), blue-grey (un-weathered) silty sandy CLAY | 0.4 – 11.8 |
| Lambeth Group (Site Wide) | Very stiff very silty CLAY occasional gravel size lithorelics of very weak claystone. | 0.4 – 11.5 |
| Upper Chalk[1] - Site Wide) | Grade IV[2]. (C574 correlation – $C_5$ Chalk)[3] | 6.5 – 19.6 |

**Notes:**

1. Historical data refers to the "Upper Chalk". This term has been superseded and the Upper Chalk has been divided into the White Chalk Sub-Group, of which a number of members are present on-site.
2. The Grade IV grading refers to the Mundford [Ref: 8] grading system for Chalk. This grading system was superseded by CIRIA C574, 2002 [Ref: 2]. An approximate correlation between the systems is presented in Table 3.6 of CIRIA C574.
3. Solution features are expected to exist within this stratum.

## SUBSIDENCE INSTABILITY OF THE NATURAL GROUND

Potential stability hazards at the site as described by both Groundsure Report, Arundel, 2016 [Ref 4] and HAGDMS are presented in Table 4-5. The risk range for specific hazards varies depending on the local geology.

**Table 4-5: Stability hazards**

| TYPE OF INSTABILITY | GROUNDSURE RISK RANGE | HAGDMS RISK RANGE |
|---|---|---|
| Collapsible Ground | Negligible – Low | Negligible – Low |
| Compressible Ground | Negligible – High[1] | Negligible - High[1]. |
| Ground Dissolution | Negligible – High[2] | Low - Very High[2] |
| Landslide | Negligible – High[3] | Low – High[3] |
| Running Sand | Negligible – Low | Negligible – Low |
| Shrinking or swelling clay | Negligible – High[4] | Low – High[4] |

**Notes:**

1. The compressible ground will primarily be attributable to the soft alluvial deposits across the flood plain. Both the Groundsure report and HAGDMS do not believe that the area of the River Arun Flood Plain to be stability hazard in terms of Collapsible Ground. The is not consistent with other research which suggests the risk is Very High due to documented evidence of up to 30m of soft alluvial deposits in this area.

2. The potential for ground dissolution features primarily exist to the far west of the study area and also just to the east of Crossbush associated with the Chalk.

3. To the east of the site between Crossbush and the Railway Station is an area of land exhibiting historical landslide instability due to solifluction within the London Clay which has undergone previous stabilisation by employment of a bored pile retaining wall.

4. The shrinking and swelling clays are primarily associated with the London Clay, however there is also a potential within the Reading Formation of the Lambeth Group. These two strata are likely to be encountered during construction in the area between Crossbush and Arundel railway station and the area from the flood plain section of the site heading west.

### HYDROGEOLOGY

AQUIFER CLASSIFICATION

Groundwater is governed by geology and can be split into superficial and bedrock geology. In terms of classification the Environment Agency classifies superficial and bedrock geologies as follows:

- Principal aquifer - These are layers of rock or superficial deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.
- Secondary (A) aquifer - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers; and
- Unproductive - These are rock layers or superficial deposits with low permeability that have negligible significance for water supply or river base flow.

### GROUNDWATER VULNERABILITY

The Environment Agency's interactive maps [Ref: **Error! Reference source not found.**] denotes the study area to have a range of groundwater vulnerability of low - high for both major and minor aquifers.

- The underlying Chalk is classified as a principal aquifer with a high vulnerability to leaching and contamination;
- The alluvial sands and gravels of the River Arun Flood Plain are classified and a minor or secondary (A) aquifer with a high vulnerability to leaching and the passage of contaminants
- The London Clay Formation and the Reading Formation of the Lambeth Group are both classified as minor or unproductive aquifers with a low vulnerability to leaching and contamination.

### HISTORICAL AND OPERATIONAL LANDFILL SITES

The Groundsure Report identifies 6No. historical landfill sites and 1No. operational landfill site within 200m of the existing A27 carriageway. Potential contamination from the historical landfill could only affect proposed route options that follow the existing A27 carriageway. However potential contamination from the operational landfill could affect all proposed works in the area of Crossbush gyratory.

### MAINTENANCE RECORDS

An interrogation of the HAGDMS did not identify any HD41/15 feature grade defects of existing earthworks to be affected by the proposed works, a number of remediated defects (Class 3) were

noted around the Crossbush Interchange. However a bored pile wall was installed to the north of the Crossbush interchange to arrest the migration of a solifluction lobe that was effecting the alignment of the existing carriageway.

**MINING AND QUARRYING**

There are 0No. recorded sites for any of the following mineral extraction activities within 1000m of the scheme boundaries:

- historical mining
- coal mining
- subterranean brine extraction
- subterranean gypsum extraction
- tin mining
- Johnson Poole & Bloomer

However, the Groundsure Report does identify 75No. sites of historical and current Chalk quarry extraction sites and clay pits of which 15 are within the study area.

**NATURAL CAVITIES**

There is one instance of natural cavities identified on site and one within 450m of the site as defined within the Groundsure Report [Ref 4]. The data is presented in Table 4-6.

**Table 4-6: Summary of natural cavities**

| Location | | Geology | Type | Onsite/ Buffer Zone |
|---|---|---|---|---|
| Easting | Northing | | | |
| 498300 | 107000 | Chalk Group, Lambeth Group | Sinkhole x1, Solution Pipe x1 | Onsite |
| 497900 | 107500 | Chalk Group | Solution Pipe x 3 | Buffer Zone (445m NW) |

## GEOLOGICAL SITES OF SPECIAL SCIENTIFIC INTEREST (SSSI);

There are no Sites of Special Scientific Interest (SSSI) SSSI within the scheme boundary, however, there are 5No. within 500m of the scheme boundary, none of which are of specific geological interest. The area is not regionally geologically important nor are there any sites of geomorphological interest.

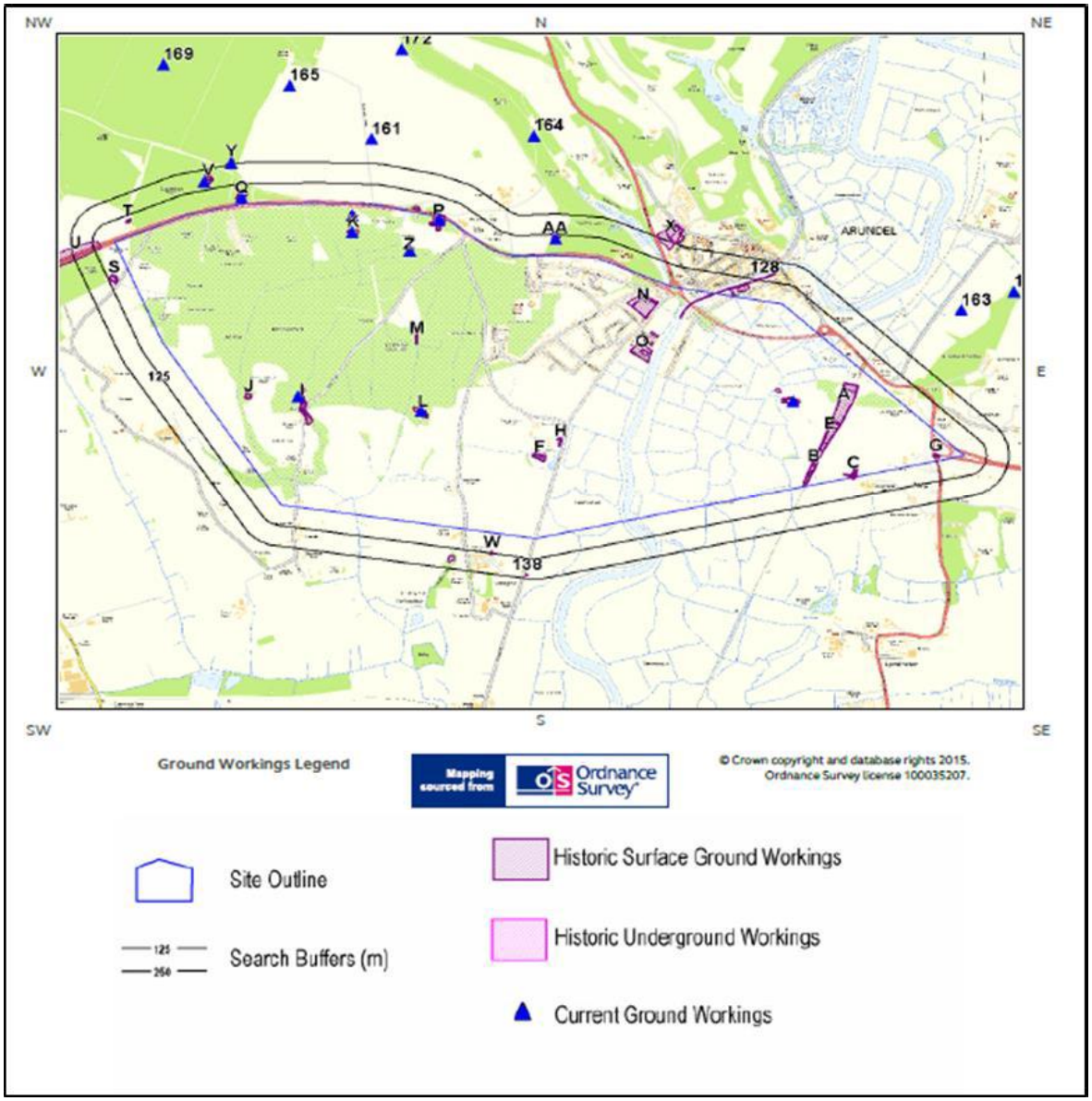
Highways Agency Geotechnical Data Management System (HAGDMS), http://www.hagdms.co.uk [Ref 1];
Lord, J.A, C.R.I Clayton, and R. N Mortimore. Engineering in Chalk. 1st ed. London: CIRIA C574, 2002. [Ref 2];
British Geological Survey web-hosted Onshore Geoindex (http://www.bgs.co.uk/geoindex/) [Ref 3];
Groundsure Report, Arundel, 2016. Ref GS-2047498 & GS-2047-499 [Ref 4];
British Geological Survey (BGS). 1996. Chichester and Bognor, England and Wales Sheet 317/332. Solid and Drift Geology, 1:50,000 (Keyworth, Nottingham: BGS). [Ref 5];
BGS, (1978), Hydrological map of the South Downs and adjacent parts of the Weald, 1:100,000 000 (Keyworth, Nottingham: BGS). [Ref 6]; and
British Geology Survey online 'Geology of Britain" Viewer. (http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer/). [Ref 7].

Ward, W.H., Burland, J.B and Gallois, R.W. (1968): Geotechnical assessment of a site at Mundford, Norfolk, for a large Proton Accelerator. Geotechnique, volume 18, pages 399-431 [Ref 8].

## 4.11 MINING

The Groundsure Report [Ref 4] identified 108 no. historical and current ground workings at the site and is presented in Figure 4-10.

**Figure 4-10: Ground workings map (Groundsure Report 2016 [Ref 4])**




Furthermore, The Groundsure Report [Ref 4] for the scheme also indicates there are 15 instances of non-coal mining related activity on site. The instances include:

- underground mining of the Chalk is known or considered likely to have occurred within or close to the area
- small scale mining of the Chalk may have occurred but restricted in extent

## 4.12 PUBLIC UTILITIES

All existing utilities companies and statutory authorities operating in the vicinity of the study area have been contacted under the New Roads and Street Works Act 1991. The authorities have been asked for details of any plant or apparatus that is located within the study area of the A27 Arundel Bypass scheme. The feedback from these authorities has been presented in a Statutory Undertakers Estimate Report. In summary, there is a significant amount of plant / apparatus located within the study area, which depending on the option that is taken forward, could be affected to either a significant or a very significant degree.

## 4.13 TECHNOLOGY

### INTELLIGENT TRANSPORT SYSTEMS (ITS) – TRAFFIC LOOPS, VARIABLE MESSAGING SIGNS (VMS), CLOSED CIRCUIT TELEVISIONS (CCTV) AND COMMUNICATIONS NETWORK

#### EXISTING ITS[27]

Currently there is very little ITS along the A27 around Arundel. There traffic signals within the area comprise a stand-alone junction and a crossing. The Crossbush junction has partial signal control. There is a PUFFIN[28] pedestrian crossing facility approximately 65m southeast of the roundabout on the A27 Causeway, to help provide safe access to the railway station. There are also Automatic Number Plate Recognition (ANPR) (thought to be 'TrafficMaster' for journey time monitoring) sites and several traffic flow count sites. The latter are available via WebTRIS online database: http://webtris.highwaysengland.co.uk/

As significant works are proposed along the full length of the A27 (relating to this project) it would be possible to install many features of the 'Expressway', as detailed below. The assumption is that Emergency Refuge Areas (ERA) would be provided along the full length of the scheme.

[27] Intelligent Transport System
[28] Pedestrian user friendly intelligent crossing

**Figure 4-11: Example of traffic conditions on the A27 (Source: Traffic England)**


## 4.14 MAINTENANCE ACCESS – LAY-BYS, ACCESS PATHS AND STEPS

Generally there is no provision for maintenance for any of the equipment, with the exception of the traffic signals at Crossbush Interchange, where dropped kerbs have been provided to allow vehicular access onto the island where the traffic signal controller is located. It is envisaged that to maintain the existing equipment, service vehicles are parked close to the units and the engineers walk along the footways to the units. Any proposals that are part of the A27 Arundel Bypass scheme would make the necessary provisions to accommodate adequate maintenance areas and accesses.

## 4.15 LIGHTING

### EXISTING LIGHTING COVERAGE

The existing at-grade Crossbush Junction is currently lit. The A27 the Causeway and A284 Lyminster Road approaches to the junction are fully lit. The A27 east of the junction is lit on its eastbound side from the circulatory carriageway for a distance of approximately 150m. On its westbound side it is lit from a distance around 170m east of the circulatory carriageway.

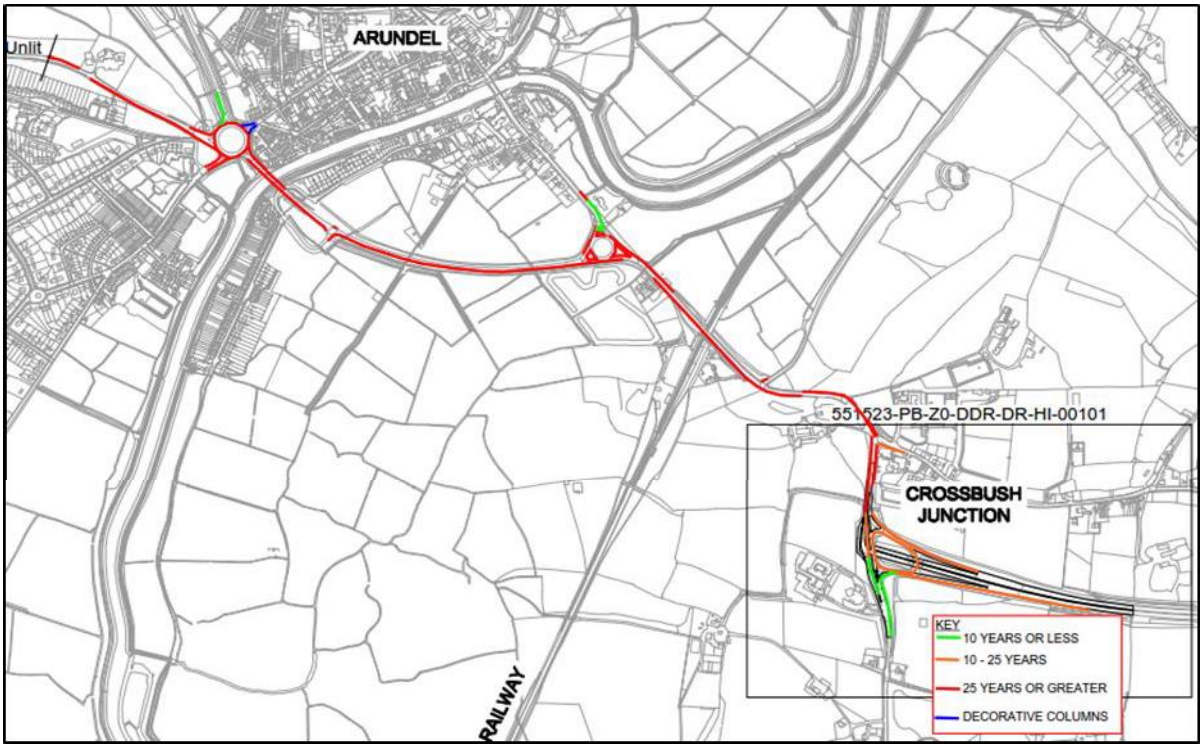
The A27 between Crossbush Junction and Causeway Junction is fully lit. Its junction with Crossbush Lane is lit although Crossbush Lane itself is unlit. The roundabout at The Causeway and the A27 Arundel Bypass is also fully lit with the northern spur of The Causeway lit to from the circulatory carriageway to a point around 75m north of the junction.

The A27 west of Causeway Roundabout is fully lit up to and including Ford Road roundabout. The Maltravers Street spur off this roundabout has decorative lighting columns and lanterns. The A27 Chichester Road west of the Ford Road Roundabout is lit from the roundabout circulatory to a point around 470m west of the circulatory carriageway. The A27 Chichester Road is unlit between this point and its connection with Copse Lane, where it is lit.

Copse Lane, Yapton Lane, Tye Lane, Binsted Lane, Tortington Lane and Ford Road, which are all within the vicinity of the A27 corridor, are also all unlit.

Figure 4-12 shows the lighting coverage on the A27 and adjoining local roads within the study area as well as the age profile of the lighting asset under consideration.

**Figure 4-12: Lighting coverage and age profile between Crossbush Junction and Arundel**




## AGE PROFILE

The age profile of the existing lighting infrastructure is mixed (Figure 4-12). The columns on A27 Lyminster Road at the northbound approach to Crossbush junction have been replaced and are less than ten years old. The lighting columns across the Crossbush junction itself and on the slips appear to be between 10-25 years old. The lighting columns on the A27 The Causeway - north of Crossbush Junction to the Causeway Roundabout are thought to be 25 years old or greater. The lighting columns on the northern arm of Causeway roundabout are ten years old or less.

The lighting columns on the A27 Arundel Bypass from The Causeway roundabout to Ford Road roundabout appear to be more than 25 years old and have been fitted with SON[29] lanterns. The lighting columns on the A27 Chichester Road from Ford Road roundabout to a point 470m west of Ford Road roundabout appear to be at least 25 years old.

[29] High Pressure Sodium

# 5 ENVIRONMENTAL STATUS

## 5.1 INTRODUCTION

This section describes environmental designations within the study area. This includes the status of South Downs National Park, air quality management areas, heritage assets, protected areas for conservation and flood and groundwater protection. An environmental constraints plan is provided in Appendix N. A detailed description and history of the options for the A27 Arundel Bypass scheme discussed in this section are provided in section 12.

## 5.2 DESIGNATIONS

The SDNP is the UK's newest national park. It was established in April 2010 and the planning authority for the national park came into effect, on 1st April 2011. All of the scheme options, with the exception of Option 5B, are at least partly within the SDNP. Option 5B is immediately adjacent to the SDNP boundary for approximately 200m at its eastern extent, and would be visible from within the SDNP.

There are no Air Quality Management Areas (AQMAs) within the district of Arun. There are two AQMAs located in adjoining districts, namely Storrington AQMA (Horsham District Council), located approximately 20km north east of the scheme options and the Worthing AQMA (Worthing Borough Council) located 8km east of the scheme options along the A27. These AQMAs were both declared for exceeding the UK's objective for annual mean nitrogen dioxide, due to high volumes of traffic on major roads and associated exhaust emissions.

The areas surrounding all route options include many historic environment assets, many of which are designated. The 1km study area around all of the scheme options includes five Scheduled Monuments (Goblestubbs Copse Earthworks, Ringwork 400m NNW of Batworthpark House, Madehurst Wood Earthworks, Tortington Augustinian Priory, Maison Dieu, Arundel Castle); five Grade I Listed Buildings (Church of St Nicholas, Roman Catholic Cathedral of St Philip Neri and piers surrounding churchyard , Fitzalan chapel, Arundel Castle, Parish of St Mary); seven Grade II* Listed Buildings; 198 Grade II Listed Buildings; one Registered Park and Gardens; two Conservation Areas; and five Archaeological Notification Areas. The scheme is located within a Historic Landscape as classified by the Sussex Historic Landscape Characterisation. Detailed assessment of the historic landscape is yet to be conducted.

Two statutory designated sites of international importance were identified within 10km of the Scheme Options. The Arun Valley Special Area of Conservation, Special Protection Area and Ramsar Convention on Wetlands of International Importance listed area, is approximately 6.8km to the north of the Scheme Options. Duncton to Bignor Escarpment Special Area of Conservation is located approximately 6km to the north of the Scheme Options. Details of these designations are identified within the Stage 1 ESR.

In addition to the Arun Valley and Duncton to Bignor Escarpment, there are three Special Areas of Conservation designated for bats were identified within 30km of all Scheme Options. These are: the Ebernoe Common Special Area of Conservation which is located approximately 19km to the north of the scheme options; The Mens Special Area of Conservation, which is located approximately 15.3km north of the scheme options; and Singleton and Cocking Tunnels Special Area of Conservation which is located approximately 14km to the north-west of the Scheme Options.

The Arundel Park Site of Special Scientific Interest, is within 2km of all Scheme Options; the nearest being Option 1 which is approximately 0.5km north. The Fairmile Bottom Site of Special

Scientific Interest is within 2km of Options 3, 4, 5 and 5A; the nearest being Option 4 approximately 1.5km north.

Scheme Options 2, 3, 4 and 5 are situated within the Binsted Wood Complex Local Wildlife Site. Options 0A and 1 are situated along the northern boundary of Binsted Wood Complex Local Wildlife Sites. All Scheme Options except Options 0A, 0BA and 5A are situated along the southern boundary of Rewell Wood Complex Local Wildlife Sites. Parts of both areas of woodland are also designated as Ancient Woodland. There are also a number of Veteran Trees within the study area.

The South Downs Way Ahead Nature Improvement Area is approximately 4.0km north and 4.0km east of the route options. Nature Improvement Areas are a landscape scale approach to nature conservation introduced by the Government as part of the Natural Environment White Paper.

The scheme area is also within the Ebernoe Focus Area, which is part of Natural England's Woods and Parks Landscape Scale Project for Sussex and Kent. The objective of this area is to secure a robust and resilient network of this habitat through the landscape.

There is a narrow strip of land north of Tortington, known as Broad Green Waste, which is registered as Common Land under the Countryside and Rights of Way Act 2000. Options 3 and 4 cross this piece of land. No other community land is found within the study area.

The River Arun runs through the study area and is designated a Main River by the Environment Agency. Flood Zones 2 and 3 (medium and high probability of river and tidal flooding) are located south of Arundel town.

The Environment Agency's Flood Map for Planning identifies flood defences located adjacent to the east and west banks of the River Arun within the scheme area, although the standard of protection provided by these defences is currently unknown.

The Environment Agency's Flood Map for Planning also indicates fluvial and/or tidal flood risk associated with the main rivers that convey flow from the west and south of Binsted Wood to the River Arun. Options 4, 5, 5A and 5B pass through these areas of risk and therefore flooding is a key consideration. Land within this area is predominantly agricultural, although OS mapping indicates that individual residences are located in close proximity to the mapped extents.

Groundwater Source Protection Zones are located near the study area. However, these are not expected to be impacted by the scheme.

# 6 ENVIRONMENT

## 6.1 NOISE

The NIAs are predominantly located along the existing A27 corridor and are concentrated within Arundel town.

**Table 6-1: Noise Important Areas**

| NIA | Design Option |
|---|---|
| 12488 | 0A, 0B, 0BA and 1 |
| 5487 | 0A, 0B, 0BA and 1 |
| 5488 | 0A, 0B, 0BA and 1 |
| 12489 | 0A, 0B, 0BA and 1 |
| 5486 | 0A, 0B, 0BA and 1 |
| 5484 | 0B and 0BA |
| 5485 | 0A, 0B, 0BA and 1 |
| 6157 | 0B and 0BA |
| 6158 | 0B |
| 5490 | 0B and 5B |
| 5491 | 0B |
| 12485 | 0B |

A preliminary noise survey was undertaken on 19th January 2016 to establish the current noise climate within close proximity to road links potentially affected by the scheme. The survey methodology followed the shortened measurement procedure described in Calculation of Road Traffic Noise (CRTN) over three consecutive hours on a typical weekday. Noise descriptors LA10, LA90, LAeq, LAmin, LAmax were recorded (Table 6-2).

**Table 6-2: Noise survey results**

| Measurement Location | Indicative Address | Distance from the Carriageway (m) | $L_{A10, 3H}$ dB | $L_{A10, 18H}$ dB | $L_{AEQ, 3H}$ dB | $L_{A90, 3H}$ dB |
|---|---|---|---|---|---|---|
| ML1 | Ford Road, Arundel BN18 | 1.5 | 74 | 73 | 70 | 43 |
| ML2 | Chichester Road (A27), Arundel BN18 0UX | 8 | 75 | 74 | 73 | 43 |
| ML3 | Arundel Bypass (A27), Arundel BN18 9JU | 10 | 67 | 66 | 65 | 59 |
| ML4 | London Road (A284), Arundel BN18 9JL | 10 | 73 | 72 | 68 | 48 |

Observations on site concluded that the existing noise climate is dominated by road traffic. The results in Table 6-2 above demonstrate that the existing noise is generally above LA10, 18h 68 dB (the threshold which could determine that residents are entitled to sound insulation) at locations within close proximity to the road network. Some residential properties are within close proximity to the main roads, such as the first row of dwellings at Ford Road, as represented by ML1, and properties lying within the NIAs along the A27, as represented by ML2 and ML3.

## 6.2 LOCAL AIR QUALITY

AQMA information is detailed in section 5.1. Air quality within Arun District Council is monitored by a network of non-automatic (NO2 diffusion tubes) managed by the local authority. There are no automatic monitoring stations within the Council's boundaries. The air quality in the district is generally good, with annual mean NO2 concentrations in 2014 ranging from 12-25µg/m3, well below the UK/EU objective of 40µg/m3.

No exceedances of any air quality objective have been measured or predicted in Arun District. Eight of Arun District Council's monitoring sites lie within the study area and a summary of measurements taken at these sites is provided in Table 6-3.

**Table 6-3: Summary of Air Quality Management Undertaken by Arun District Council**

| SITE ID | EASTING (M) | NORTHING (M) | ANNUAL MEAN NO2 CONCENTRATION ( µG/M3 ) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Arundel High Street | 501825 | 107165 | 20 | 23 | 18 | 17 | 18 | 14 |
| A27 The Causeway | 502337 | 106555 | 40 | 38 | 33 | 29 | 33 | 25 |
| A27 The Causeway Hotel Façade | 502337 | 106555 | - | - | 19 | 19 | 18 | 15 |
| King Street | 501478 | 107052 | 19 | 17 | 16 | 16 | 16 | 12 |
| A27 Chichester Road | 501320 | 106901 | - | - | - | - | 26 | 23 |
| Priory Road | 500886 | 106491 | 12 | 18 | 13 | 11 | - | - |
| A27 The Causeway 2 | 502337 | 106555 | 38 | 40 | 35 | 34 | - | - |
| Ford Road | 500301 | 104374 | | | | | 19 | 16 |

The highest monitored values within the scheme study area were recorded at a roadside location on the section of A27 known as The Causeway. The roadside value in 2014 was 25µg/m3 as an annual mean, well below the UK/EU objective of 40µg/m3. There is a general trend of decreasing concentrations at this and all other monitored locations in the study area and no anticipated risk of future exceedances of any objective.

## 6.3 GREENHOUSE GASES

Greenhouse gases are atmosphere gases that absorb and emit radiation within the thermal infrared range; this process is the fundamental cause of the greenhouse effect. For the purposes of the assessment of the potential impact of the scheme on climate change, the gas of interest is carbon dioxide.

Consideration will be given at a later stage to possible approaches to reducing adverse effects due to greenhouse gases.

## 6.4 LANDSCAPE AND TOWNSCAPE

The current alignment of the A27 bypasses the historic centre of Arundel. However, development to the west of Arundel has resulted in the A27 currently aligned between the eastern (historic centre) and western regions of the town. This section of the A27 lies at the boundary between the South Downs and the coastal plain, at the foot of the chalk dip slope where the River Arun cuts through the Downs. The road skirts the southern edge of the SDNP on the eastern side of the town and lies within the SDNP boundary to the west of the town.

The town of Arundel lies in a steep vale of the South Downs in West Sussex where it is overlooked by two famous landmarks; the substantial medieval Arundel Castle and Arundel Cathedral. Arundel Castle is situated on a prominent chalk bluff above the valley floor within the historic part of the town on the south facing slopes running down to the river and into the margins of the floodplain. The town is a major bridging point over the meandering River Arun which runs

through the eastern side of the town. Generally, the older part of the town lies to the north and is separated by the A27 from newer development to the south west of the historic town centre.

To the north of the A27 the River Arun has wide meanders across the flat valley floor, with the South Downs rising steeply to the east and west. There is a complex network of drains within the valley floor that are the boundaries to small scale fields under pasture. South of the A27, the Arun valley floor widens and crosses the coastal plain towards Littlehampton and the sea. The valley floor has little enclosure from vegetation where its sides rise towards the coastal plain. There are long views along the valley floor with intervisibility between Littlehampton and Arundel to the east.

High sensitivity visual receptors within 1km of the scheme include:

- residential properties at Fitzalan Road, Ford Road, Priory Lane and Dalloway Road on the southern edge of Arundel
- residential properties at Tortington
- Broomhurst Farm due south of Arundel
- residential properties at Binsted south west of Arundel
- residential properties at Lyminster between Arundel and Littlehampton

High sensitivity recreational receptors include: people visiting Arundel Castle and pleasure grounds; the historic town; and the bridge over the River Arun. There are also sensitive views from PRoW that are in close proximity to the scheme site. These include Monarch's Way and the public footpath on the western bank of the River Arun. Receptors also include people travelling to or past Arundel via the railway network, in particular the view across the floodplain from the train carriage.

The SDNP Authority report, SDNP: View Characterisation and Analysis Study (November 2015) mapped and analysed views to, from and within the SDNP in order to guide future planning and development management decisions by SDNP Authority and its partner authorities. The following viewpoints in the study have been considered:

- Arundel Castle from High Street, near SDNPA Viewpoint 50 (Grid ref. 501841, 107365). The castle is noted as a particularly distinctive landmark standing at a commanding position at the southern end of the Arun Valley (See View 3 at the end of the report)
- Arundel River, Monarch's Way - Viewpoint 19, which lies close to the A27 / The Causeway roundabout on the south eastern edge of the town. It is a SDNPA photographic monitoring point selected for its view of Arundel Castle, and its relationship with the Downs, valley and settlement of Arundel. The A27 and roundabout are prominent in the view (Grid ref. 502333, 106730) (See View 4 at the end of the report)
- Hiorne Tower, Arundel Park - landmark feature

## 6.5 HERITAGE AND HISTORIC RESOURCES

Details of designated heritage assets are provided in section 5.2. There is a potential for inter-visibility, historical and functional relationship between assets in the vicinity of the A27 Arundel section, and therefore careful design of any new structures and landscaping design is required.

## 6.6 ARCHAEOLOGY

There is the potential for below-ground heritage assets associated with all historical periods within all the scheme study areas. The available evidence suggests that there has been occupation / activity for all archaeological and historical periods within the vicinity of the A27 Arundel section and there is potential for currently unknown buried archaeological remains to be present.

## 6.7 BIODIVERSITY

### DESIGNATED SITES

Details of the designated nature conservation sites are provided in section 5.2.

A number of protected and notable species records were identified within the study area. Additionally, habitats within the study area have been identified which have the potential to support various unrecorded protected and notable species. The species records and habitats within the study area indicate that the following species may be present:

- Great crested newt
- Bats
- Badger
- Dormouse
- Otter
- Water vole
- White clawed crayfish
- Reptiles

### HABITATS PRESENT

The Extended Phase 1 Habitat Survey identified 11 habitat types within the survey area:

- Semi-natural broadleaved woodland
- Semi-natural broadleaved woodland (ancient woodland inventory)
- Coniferous plantation woodland
- Scattered trees
- Dense / continuous scrub / scattered scrub
- Poor semi-improved grassland
- Semi-improved neutral grassland
- Arable
- Intact species-poor hedge, defunct species-poor hedge and species-poor hedge and trees
- Running / standing water
- Buildings and hard-standing

## 6.8 WATER ENVIRONMENT

### SURFACE WATER FEATURES

The River Arun is designated as a Main River and is therefore under the jurisdiction of the Environment Agency (EA). The quality of the River Arun in the area of the A27 Arundel section has been assessed against objectives of the Water Framework Directive (WFD) and the results show that its current ecological quality is assessed to be poor.

The EA has developed a Lower Tidal River Arun strategy which outlines recommendations for managing flood risk in the Arun Valley, from Pallingham Weir to Littlehampton and Ford for the next 100 years. The Strategy was approved in 2014. The report is available at:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/307894/Lower_Tidal_River_Arun_final_strategy_report.pdf

The land drains are primarily designated as ordinary watercourses and are therefore under the jurisdiction of WSCC as Lead Local Flood Authority (LLFA). However, the key carrier drains that convey flow from the west and south of Binsted Wood to the River Arun are designated as Main Rivers and are therefore under the jurisdiction of the EA. These features have not been assessed against the WFD.

### FLOOD RISK

The potential flood risk is described in section 4.9 of this report.

### GROUNDWATER

Ground water features are identified in section 4.10. Groundwater quality is monitored against objectives of the WFD within the Principal Aquifer to the north of the existing A27 alignment. The results indicate that the current quantitative and chemical quality are assessed to be poor.

## 6.9 PHYSICAL FITNESS

The state of health of all residents in Arun, the South East and England as recorded within the 2011 census[30] is shown in Table 6-4. Arun has a lower number of people listed as in very good health, than both the South East and England.

**Table 6-4: Health of people in Arun, the South East and England in 2011**

| | Arun | South East | England |
|---|---|---|---|
| Very Good Health | 62,774 (42%) | 4,232,707 (49%) | 25,005,712 (47.2%) |
| Good Health | 54,975 (36.8%) | 2,989,920 (34.6%) | 18,141,457 (34.2%) |
| Fair Health | 23,299 (15.6%) | 1,037,592 (12%) | 6,054,092 (13.1%) |
| Bad Health | 6,608 (4.4%) | 291,456 (3.4%) | 2,250,446 (4.2%) |
| Very Bad Health | 1,862 (1.2%) | 83,075 (1%) | 660,749 (1.2%) |

Table 6-5 outlines the numbers of people within Arun, the South East and England who consider their day-today activities to be limited by their health[31].

**Table 6-5: Day to day Activity Limited by Health in Arun, the South East and England in 2011**

| | Arun | South East | England |
|---|---|---|---|
| Day-to-Day Activities Limited a Lot | 13,984 (9.4%) | 593,643 (6.9%) | 4,405,394 (8.3%) |
| Day-to-Day Activities Limited a Little | 17,505 (11.7%) | 762,561 (8.8%) | 4,947,192 (9.3%) |
| Day-to-Day Activities Not Limited | 118,029 (78.9%) | 7,278,546 (84.3%) | 43,659,870 (82.4%) |

[30] Office for National Statistics (2011)
[31] Office for National Statistics (2011)

## 6.10 JOURNEY AMBIENCE

The views from the A27 for motorised travellers on the surrounding road network provide a positive experience. From west to east of the existing A27, views from the road are as follows:

- Travelling towards Arundel from the west, on Chichester Road, the road is level with the surrounding land. There are intermittent views on both sides of agricultural land, screened in part by roadside vegetation;
- West of Yapton Lane, vegetation becomes denser, providing no view beyond the immediate border;
- Travelling towards Arundel, and after passing the cricket ground intermittent views of fields are visible on the north side of the road;
- Bordering the road on the approach to Ford Road roundabout from the west, vegetation restricts views beyond;
- Travelling along the Arundel Bypass between Ford Road Roundabout and the Causeway, the views of surrounding agricultural land are intermittent;
- West of the Crossbush roundabout, the Causeway is largely surrounded by flat topography with intermittent views of agricultural land with some screening provided by vegetation and existing buildings. Looking west towards Arun, the views of Arundel are long distance, and provide travellers with a positive experience.

# 7 ACCESSIBILITY

## 7.1 SEVERANCE

The A27 causes severance of Arundel, and the interaction of traffic, junctions, pedestrian crossing activity and cycling gives rise to safety concerns. Severance disproportionately impacts vulnerable groups, including those without a car, the elderly, those with disabilities, and people with pushchairs. Children are also vulnerable to severance as they may cross in unsafe places or find it difficult to gauge the speed of oncoming traffic.

Improvements of the A27 aim to prevent congestion, decrease severance, and facilitate further economic growth for the town.

Existing conditions and the general impact of the options considered on non-motorised users (NMU's) are discussed in the NMU Context Report.

# 8 INTEGRATION

## 8.1 INTRODUCTION

8.1.1 This section describes the existing transport interchange issues and the national and local planning land use policies with which the A27 Arundel Bypass Scheme must align. The policy constraints for the scheme must be balanced against the need for the scheme.

8.1.2 Local and national planning policy establish the need for new transportation infrastructure, in particular where this is delivered sustainably and is consistent with policy. The A27 corridor serves an important function as a strategic route on the south coast which is used by both long distance strategic traffic and local traffic alike. The nearby local authorities have plans for development of communities in the vicinity of the scheme. Congestion on the A27 is a constraint to the future development of these communities, and the improvements to the A27 are important to supporting the sustainable development of local development plans. This section demonstrates how the scheme must integrate with and support both national and local planning and land use policies, as described below.

8.1.3 National planning land use policy will be a primary consideration for the Secretary of State when considering Development Consent of those scheme options which are considered Nationally Significant Infrastructure Projects (NSIPs). The A27 is located in an area which is sensitive environmentally, and includes designations which are protected by national planning and land use policy. The potential conflicts with policies which protect these land use designations are also described below.

## 8.2 NATIONAL PLANNING AND LAND USE POLICY

8.2.1 The **National Planning Policy Framework (2012)** emphasises the importance of rebalancing the transport system in favour of sustainable transport modes, whilst encouraging local authorities to plan proactively for the transport infrastructure necessary to support the growth of major generators of travel demand. Such infrastructure should be made available in the right places and at the right time to support economic growth and innovation. However, the Framework does not contain specific policies for nationally significant infrastructure projects, which should instead be considered in light of the Planning Act 2008, and National Networks National Policy Statement (2014).

8.2.2 The **National Policy Statement for National Networks (NNNPS) (2014)** sets out the Government's vision and strategic objective for national networks, including the Strategic Road Network (SRN). It provides planning guidance for promoters of Nationally Significant Infrastructure Projects (NSIPs) on the road network, ensuring that the road schemes delivered under the policy are well designed, and comprise sustainable development; appropriately balancing economic, social and environmental impacts.

8.2.3 The NNNPS is the main basis on which the Secretary of State makes decisions on whether specific schemes should be consented. In determining the application for a Development Consent Order, the Secretary of State considers whether the scheme is acceptable in terms of the NNNPS, and taking a view on whether the balance between scheme impacts and benefits. The options have therefore been tested for compliance against the policies within the NNNPS, this is summarised in Section 8.6 below.

## 8.3 LOCAL LAND USE POLICY AND DEVELOPMENT PLANS

8.3.1 The A27 Arundel Bypass scheme would support the growth of communities along the network including the neighbouring districts of Adur, Arun, Chichester and Worthing. Planning policy which guides development in these districts consists of a the following development plans:

- Proposed Submission Adur District Local Plan (2016)
- Emerging Arun Local Plan (2014)
- Worthing Core Strategy (2011)

### PROPOSED SUBMISSION ADUR LOCAL PLAN 2016

8.3.2 The proposed submission Adur Local Plan 2014 was published in 2014 and it was anticipated that the Local Plan would then be submitted to the Secretary of State in 2015. However, some proposed changes relating to a strategic allocation were raised through the representation process, and so the plan is still under consideration. The **Proposed Submission Adur District Local Plan (2016)**, which is expected to be adopted in its current form, provides the strategy for development in Adur up to 2031. The plan will facilitate the regeneration of Adur and provide a balance in meeting development needs such as housing, employment retail and community facilities. The Plan seeks to deliver a package of measures over the plan period in order to:

- work towards meeting the objectively assessed development needs of Adur as far as possible, taking into account environmental assets and constraints and the capacity of infrastructure (which will also entail working with other local authorities in the sub-region, and possibly further afield)
- facilitate the regeneration of Adur

### EMERGING ARUN LOCAL PLAN 2014

8.3.3 The Emerging Arun Local Plan 2014 sets out the strategic vision, objectives, policies, and proposals which affect the whole district or parts of it, to 2031. The strategic objectives described in the Plan include:

- To strengthen Arun's economic base and provide local job opportunities by increasing, diversifying and improving the quality of employment within the district through the provision of appropriate employment sites, better infrastructure including road access, quality affordable accommodation and the development of business support and partnerships
- To plan and deliver a range of housing mix and types in locations with good access to employment, services and facilities to meet the District's housing requirements and the needs of Arun's residents and communities both urban and rural, ensuring that issues of affordability and the provision of appropriate levels of affordable housing are addressed while supporting the creation of integrated communities
- To protect and enhance Arun's outstanding landscape, countryside, coastline, historic, built and archaeological environment thereby reinforcing local character and identity

8.3.4 Option 3, the previously announced Preferred Route, is safeguarded in the Arun Local Plan under policies LAN DM2 and T SP3.

### WORTHING CORE STRATEGY 2011

8.3.5 The Worthing Core Strategy was adopted in 2011 and, as part of the local development framework, helps to guide development in the Borough up to 2026. The Core Strategy sets out the overall vision and strategy for place-making in the borough and provides the context for all development considerations in the coming years. The key objectives of the strategy include delivering a sustainable economy, protecting the natural environment, and meeting Worthing's housing needs. The housing strategy will meet the housing delivery targets placed on the Borough and in so doing will seek to meet the needs of all sectors of the community.

### QUANTITATIVE SUMMARY OF HOUSING POLICIES

8.3.6 Each of the three development plans considered above sets out an estimate of the amount of dwellings that will be constructed over the period that the plans relate to. Table 8-1 below shows these figures.

**Table 8-1: Housing Policies in Adur, Arun and Worthing authorities**

| AUTHORITY | SOURCE | NUMBER OF DWELLINGS |
|---|---|---|
| Adur | Proposed Submission Adur Local Plan 2016 | 3,600 over plan period |
| Arun | Arun Local Plan 2014 | 8,026 over the plan period |
| Worthing | Worthing Core Strategy (2011) | 4000 between 2006 and 2026. |

### QUANTITATIVE SUMMARY OF POLICIES RELATING TO EMPLOYMENT

8.3.7 It is expected that the number of people employed within the three authorities will increase over each of their Plan periods. Table 8-2 below details the estimated increase in employment land in each of the three authorities. It does so with reference to a variety of documents.

**Table 8-2: Estimated employment increase over plan periods**

| AUTHORITY | NEW EMPLOYMENT LAND | SOURCE | NUMBER OF JOBS | SOURCE |
|---|---|---|---|---|
| Adur | 41,000sqm | Proposed Submission Adur Local Plan 2016 | 3,000 over 20 years | Adur Employment Land Review – Update Report (December 2014) |
| Arun | 813,500sqm | Arun Local Plan 2014 | 9,900 over 20 years | Arun Local Plan Validation Study: Economy & Enterprise (October 2014) |
| Worthing | 94,761sqm | Worthing Core Strategy (2011) | 5,679 over 20 years | Final Report Economic Research - Employment Land (October 2009) |

## 8.4 TRANSPORT INTERCHANGE

8.4.1 Arundel Station is a transport interchange. It has a large car park and a half hourly bus service between Arundel Town and Littlehampton stops on the A27 close to the station entrance. Trains stopping at Arundel during weekdays connect between Arun Valley stations between Bognor Regis and Horsham. Passengers are also able to travel beyond Horsham to London Victoria via Three Bridges and Gatwick Airport without changing trains.

## 8.5 INTEGRATION WITH LOCAL TRANSPORT POLICIES

8.5.1 The West Sussex Local Transport Plan (2011) states that improvements to the A27 trunk road, and specifically the bottleneck at Arundel, is one of the West Sussex Highways Authority's highest priorities. The Plan seeks to deliver increase of capacity, as well as improved reliability and safety will increase the competitiveness of local businesses and help to attract investment. The Authority's stated approach to the Strategic Road Network is to tackle issues on the A27 by liaising with Highways England.

8.5.2 The A27 Arundel Bypass scheme seeks to resolve the existing congestion issues and increase journey time reliability across the area and West Sussex Highways Authority has been consulted at various stages through the project's life.

8.5.3 The **Worthing Infrastructure Delivery Plan (2010)** notes that there are long standing plans to resolve the congestion problems of the A27 corridor from Worthing through to Chichester. It records both the institutional and the engineering challenges associated with resolving the congestion issues on the A27 and states that Adur and Worthing councils aim to cooperate with West Sussex Highway Authority and Highways England to promote improvements to the A27 as this will support its aspirations towards economic growth.

8.5.4 The **Adur District Local Plan (1996)** seeks to promote improvement to traffic flow and safety provided such interventions are consistent with improvements to the general environment of the district. The Plan highlights an aspiration to reduce community severance in Lancing and Sompting caused by traffic on the A27 through the construction of a close downland bypass for Lancing and Sompting.

8.5.5 The emerging **Adur District Local Plan (2016)**, which is expected to be adopted in its current form, does not retain a specific aspiration to construct a bypass of Lancing and Sompting. Rather, the document records the objectives of the West Sussex Local Transport Plan (2011) as they relate to the A27 and also its goal of reducing road congestion. It further states that the Plan's larger allocated sites (at New Monks Farm, West Sompting, and Shoreham Airport) would each have an impact on the A27 either in its form or operation. Adur District will continue to cooperate with West Sussex Highways Authority and Highways England in supporting measures that will improve the A27 so as to enable the development of land in the district.

8.5.6 The **Worthing Core Strategy (2011)** states that car dependency in the Borough is high and that levels of traffic and congestion on the A27 are a key concern for local people. Furthermore such conditions hinder economic growth and have a negative impact on air quality. It goes on to describe how the difficulties in implementing road building schemes in the borough have exacerbated the problem of severe road congestion on the A27. The key aim of the Core Strategy is to reduce the need to travel, while the challenge in relation to the A27 is to develop effective partnership between Highways England, West Sussex County Council, and Worthing and Adur Councils.

8.5.7 The **Emerging Arun Local Plan (2014)** refers to key transport issues identified by the West Sussex Transport Plan 2011-2026. Of specific interest is the road congestion on the A27 during peak hours which causes disruption and air pollution around Arundel. The Plan states that improving such transport issues within Arun could help to encourage economic activity and sustainable development. Policy LAN DM2 specifies that the A27 Arundel Bypass must be constructed to a high design standard that reflects the quality of the landscape and the setting of Arundel.

## 8.6 POTENTIAL PLANNING AND LAND USE POLICY CONFLICTS

8.6.1 The A27 Arundel Bypass is located in an area which is sensitive environmentally, and includes designations which are protected by national planning and land use policy. West of Arundel, the existing A27 is within the South Downs National Park and also adjoins areas of ancient woodland. In addition, Arundel and its surrounding area contains heritage assets which are nationally significant, including Tortington Priory and Arundel Castle (designated as Scheduled Monuments). A bypass and new crossing of the River Arun and its floodplain would potentially affect landscape around Arundel, and would be visible from the South Downs National Park, which is protected by the National Planning Policy Framework as having the highest status of protection in relation to landscape and scenic beauty.

8.6.2 The five Scheme Options which are being taken forward (see Section 12) are described below, including those planning and land use policy constraints where the scheme options may be non-compliant:

- Option 0A – junction improvements only at Crossbush Causeway and Ford Road. As this option consists of online junction improvements, it is not classified as an NSIP, and therefore compliance with the NNNPS is not applicable to this option.
- Option 1 – online dualling with junction improvements up to Ford Road, passes through areas of Ancient Woodland west of Arundel, and partly within the SDNP;
- Option 3 – Offline route south of Arundel, crossing ancient woodland to the west of Arundel, and partly within the SDNP;
- Option 5A –Offline route south of Arundel, crossing ancient woodland north of Binsted and partly within the SDNP;
- Option 5B – southernmost and longest offline route largely avoiding SDNP and completely avoiding ancient woodland.

8.6.3 This summary provided below is based on a detailed review of NNNPS policies as set out in the NNNPS Accordance Table[32]. This summary focuses on policies which feature strict requirements regarding the environmental performance of national networks infrastructure, where there is potential for non-compliance, or the options perform differently against these strict policy requirements.

### BIODIVERSITY INCLUDING ANCIENT WOODLAND AND VETERAN TREES

8.6.4 Policy 5.32 strongly discourages development within ancient woodland or loss of aged or veteran trees. The policy indicates that *the Secretary of State should not grant development consent for any development that would result in the loss or deterioration of irreplaceable habitats including ancient woodland and the loss of aged or veteran trees found outside ancient woodland, unless the national need for and benefits of the development, in that location, clearly outweigh the loss.*

8.6.5 This policy means that a strong justification is required to take ancient woodland, especially if there are better options. The options are listed in the approximate order from lowest to greatest potential impact, based on a preliminary calculation of the areas affected.

- Option 5B would not result loss of Ancient Woodland, however the option is in close proximity to two veteran trees

[32] HE551523_WSP-PB_A27A_P322_DCO_PS_NPS_A

- Option 1 would result in the loss of approximately five hectares of Ancient Woodland along the northern edge of Binsted Wood and southern edge of Rewell Wood
- Option 5A would result in the loss of approximately six hectares of Ancient Woodland towards the north-west corner of Binsted Wood Complex. The option is also in close proximity to ten veteran or notable trees
- Option 3 would result in the loss of approximately 24 hectares of Ancient Woodland at Binsted Wood. The option is also in close proximity to one veteran tree

### NATIONAL PARK

8.6.6 Policies 5.150, 5.151, 515.4 and 5.555 provide guidance for development of infrastructure in or near to National Parks. Policy 5.150 indicates that *the Secretary of State should refuse development consent in these areas except in exceptional circumstances and where it can be demonstrated that it is in the public interest*. 5.154 – 5.154 also indicates that infrastructure development should avoid compromising the *special purposes* of National Parks. The special purposes of national parks are:

1. to conserve and enhance the natural beauty, wildlife and cultural heritage of the park
2. to promote opportunities for the understanding and enjoyment of the special qualities of the park by the public.

8.6.7 The options are listed in the approximate order from lowest to greatest potential impact:

- Option 5B is largely outside the boundary of the SDNP, but development south of Arundel would be highly visible from the Park and could potentially compromise the special purposes of the designation;
- Option 1 is located partly within the SDNP, however much of the development within the boundary of the Park would be along the alignment of the existing A27. Offline sections which are outside of the boundary would be visible from the Park and therefore have the potential to compromise the special purposes of the designation;
- Options 3 and 5A are located partly within the SDNP. Sections of Options 3 and 5A which are within the Park boundary are also within areas of Ancient Woodland which contributes to the special purposes of the Park. In addition, development of offline sections south of Arundel would be visible from the Park and therefore have the potential to compromise the special purposes of the designation.

### NATIONALLY SIGNIFICANT HERITAGE ASSETS

8.6.8 Scheduled monuments (formerly called Scheduled Ancient Monuments) and listed buildings are designated at the national level for their heritage significance. Development on or near to them has the potential to harm their significance. Where this harm is substantial, NNNPS Policy 5.133 states that *the Secretary of State should refuse consent unless it can be demonstrated that the substantial harm or loss of significance is necessary in order to deliver substantial public benefits that outweigh that loss or harm*. This means that there would need to be a strong justification provided where harm caused to the significance of these heritage assets, especially if there are better options. The options are listed in the approximate order from lowest to greatest potential impact on heritage assets, however at this stage the level of harm to individual assets has not been substantiated:

- Option 1 has the potential to harm the significance of three listed buildings and Arundel Castle Scheduled Monument;
- Option 3 has the potential to harm the significance of eight listed buildings, Tortington Priory Scheduled Monument and Arundel Castle Scheduled Monument;

- Option 5A has the potential to harm the significance of 19 listed buildings, Tortington Priory Scheduled Monument, and Arundel Castle Scheduled Monument; and
- Option 5B may result in substantial loss or harm to the significance of 52 listed buildings, Tortington Priory Scheduled Monument, and Arundel Castle Scheduled Monument.

### MINERALS CONSULTATION AREAS

8.6.9 The NNNPS protects Minerals Safeguarding Areas which have potential value for extraction of minerals resources. All options are partly located within these areas, and therefore may be non-compliant with Policy 5.169, which states that '*Applicants should safeguard any mineral resources on the proposed site as far as possible.*' The policy is not as strictly worded as others, and at this time it is uncertain whether measures can be undertaken to avoid/minimise/mitigate (routeing, prior extraction). There is insufficient certainty around the likelihood of compliance for all options.

### OTHER NNNPS POLICIES

8.6.10 The NNNPS sets out in some detail how to assess and mitigate (where possible) environmental effects. It should be noted that in addition to the above policies, other policy constraints may also be relevant and are considered in the NNNPS Accordance Table[33]. All relevant policy protections will be taken into account during design development.

[33] HE551523_WSP-PB_A27A_P322_DCO_PS_NPS_A

# 9 MAINTENANCE AND REPAIR STRATEGY STATEMENT

## 9.1 INTRODUCTION

The Maintenance and Repair Strategy Statement (MRSS) is a PCF[34] Stage 2 product that outlines key strategic design assumptions and decisions taken during the design and construction of the scheme. These relate to how the maintenance of assets within the scheme limits can be carried out efficiently during its lifetime, and how risks to road workers are kept as low as reasonably practicable. It should detail the likely impact on network availability, identify any specific resource requirements and highlight any safety issues for road users and operatives.

The aim is to provide a high level strategic document demonstrating that a design for maintenance approach has been taken during the design and construction of roads, roadside assets, and associated technology. This is to enable maintenance to be carried out safely and cost effectively whilst ensuring that any future maintenance interventions which expose road workers to risk are minimised.

The MRSS[35] is not intended to provide a detailed statement describing how the maintenance is to be undertaken. It is the responsibility of the maintenance service provider to identify and implement appropriate methods of work for the required maintenance activities.

Findings included within this report will feed into the MRSS.

[34] Product Control Framework
[35] Maintenance and Repair Strategy Statement

# 10 OTHER RELEVANT FACTORS

None

# 11 PLANNING FACTORS

This section comprises a number of planning factors in terms of local, strategic and national plans within the following contexts:

- Housing and employment
- Transport and connectivity
- Transport technology
- Programming
- Environmental
- Statutory process
- Interface with third parties

## 11.1 HOUSING AND EMPLOYMENT

As described elsewhere in this TAR, it is expected that there will be significant growth in housing and employment levels in the three authorities which are considered to be in immediate vicinity of the study area. The traffic models used for assessing the A27 Arundel Bypass Scheme take into account all relevant committed developments and land allocations that are expected to affect travel within the study area. The Local Model Validation Report and the traffic analysis section of this TAR (Section 13) detail the assumptions that have been made with regards to housing and employment.

## 11.2 TRANSPORT AND CONNECTIVITY

In conjunction with the A27 Arundel Bypass Scheme, consideration is being given to potential improvements to the A27 through Worthing and Lancing. This project is at PCF[36] Stage 1 and as such the option selection process for this scheme has not yet been completed.

WSCC[37], in its role as Highways Authority for the local highway network in the vicinity of the A27, is currently progressing three significant highways schemes. These are detailed in Table 11-1.

**Table 11-1: West Sussex County Council Highway Schemes**

| SCHEME | OPENING YEAR | STATUS |
|---|---|---|
| Lyminster Bypass | Open to traffic Summer 2018 | Planning application to be submitted and determined. |
| A259 dualling and junction improvements at Littlehampton and Roundstone Bypass | Phase 1 - 2017-2019<br><br>Phase 2 & 3 – To Be Confirmed (TBC) | Phases 2 and 3 of the scheme are dependent on strategic development for funding and timescale, which are in turn dependent on Local Plan examination and adoption processes for Arun and Worthing Councils. |
| Bognor Regis Relief Road | Phase 1 - Dec '14<br>Phase 2 - Mar '16 | |

[36] Project Control Framework
[37] West Sussex County Council

The strategic traffic model used for assessing the A27 Arundel Bypass Scheme (and described in section 13) takes into account the highway improvement schemes detailed above in their forecast year scenarios.

## 11.3 TRANSPORT TECHNOLOGY

Enhancement of transport technology is not the principal driver of the A27 Arundel Bypass scheme. However, consideration has been given to providing a greater level of technology along the route through the introduction of ITS[38]. Section 16.2.1 describes this exercise in detail.

## 11.4 PROGRAMMING

The programme is constrained by the requirement for a construction start date of spring 2020 and the need for the scheme to be taken through the Development Consent Order (DCO) process. The DCO process takes 18 months from submission up to the end of the challenge period, and this timescale cannot be shortened. Another six months must be allowed for the Inspector to write up the report of the hearing.

The programme for the PCF stages is provided in Appendix K, with key dates shown in Table 11-2.

**Table 11-2: PCF programme with estimated start / finish dates**

| PCF Stage | Start | Finish |
|---|---|---|
| PCF Stage 1 : Options Identification | Nov-16 | Apr-17 |
| PCF Stage 2 : Options Selection | Apr-17 | Feb-18 |
| PCF Stage 3 : Preliminary Design | Feb-18 | Oct-18 |
| PCF Stage 4: Statutory Procedures and Powers | Oct-18 | Mar-20 |
| PCF Stage 5: Construction Preparation | Mar-20 | Sep-20 |
| PCF Stage 6: Construction, Commissioning and Handover | Sep-20 | Aug-22 |
| PCF Stage 7: Closeout | Aug-22 | Aug-23 |

The top five risks are detailed in Table 11-3 below.

[38] Intelligent Transport Systems

**Table 11-3: Top five risks**

| RISK | DESCRIPTION | IMPACT | ACTION / MITIGATION |
|---|---|---|---|
| 1 | If Start of Works slipped, we would miss an earth moving season which would cause the plan to slip by 1 year. A wet summer can also impact on ability to move earth. | Start of works delayed beyond RIS 1 period. | Buildability review SGAR 3<br>Early Contract engagement Weekly calls to TPG to ensure TPG and project team are fully informed |
| 2 | Increase in Policing of protesters required for offline options | Estimated cost of policing is £20million<br>Cost of securing the site (unknown cost at current) | HE communications team to ensure liaison and discussions |
| 3 | During the land acquisition process could appear objections by the landowners | Delaying programme and increasing costs | Consider minimising land acquisition while selecting options. Smooth out the process by public consultation at all stage of the project.<br>Early engagement with stakeholders. |
| 4 | No suitable route options identified avoiding all ancient woodland | Absence of an option avoiding all ancient woodland or absence of robust justification for taking ancient woodland may result in the rejection of the scheme at DCO | Agree the most suitable option which minimises impact on ancient woodland. |
| 5 | No suitable option which is compliant with Policy Planning Statement and National Accordance Statement. | Potential rejection of Preferred Option at DCO | Ensure at least one suitable option is compliant with Policy Planning Statement and National Accordance Statement. |

## 11.5 ENVIRONMENTAL STATUS

The environmental status of the A27 through Arundel (and its vicinity) is discussed in section 5 of this TAR[39].

## 11.6 STATUTORY PROCESS

The paragraphs below set out the various statutory routes that could be followed in fulfilment of the scheme.

### NATIONALLY SIGNIFICANT INFRASTRUCTURE PROJECT (NSIP)

It is considered that an application to the Planning Inspectorate will be made in order to designate the A27 Arundel Bypass scheme as a NSIP[40]. Each of the options for improvements (which are described in Section 11) considered within the scheme would require this designation. The statutory process applying to the scheme is therefore the procedure defined by The Planning Act 2008 and the Localism Act 2011.

[39] Technical Appraisal Report
[40] Nationally Significant Infrastructure Project

The application for NSIP[41] status will be examined by the Planning Inspectorate, which would make a recommendation to the Secretary of State for Transport, once all relevant representations and consultation activities have been concluded.

A successful recommendation to the Secretary of State could lead to granting of a DCO, which combines a grant of planning permission with a range of other separate consents (such as environmental licenses).

Following the issuing of planning consent it will be the responsibility of the local planning authority (Arun) to enforce the conditions associated within the DCO.

### STANDARD PLANNING PROCESS

Should the preferred option for improvement not require designation as an NSIP, then the statutory process which will guide the implementation of the scheme would be the standard planning process, in accordance with the Highways Act 1980. However for the Arundel scheme, it is assumed that a DCO will be necessary.

For any route not being determined as an NSIP and not within the Highways Act Powers of Highways England to process, a planning application would be submitted to the relevant local planning authority (Arun). The authority is then likely to publicise the proposal and enact a formal consultation period. A determination will then be made with reference to the local development plans. Section 8.3 of this TAR[42] discussed the local development and transport plans that will be referred to by the local planning authorities.

Any widening contiguous with the existing highway and not being determined as an NSIP would be able to be progressed in accordance with the Highways Acts. Within this process any unresolved objections with landowners or with statutory bodies such as local authorities, the police and emergency services would be subject to a public local inquiry.

## 11.7 INTERFACE WITH THIRD PARTIES

A key planning factor will be to ensure that the design and the subsequent construction work will be planned such that disruption to and diversion of services will be minimised as far as possible. This will contribute to reducing overall construction costs, and reducing disruptions to all road users. However it is recognised that there will be considerable interaction with services and those authorities responsible for those services. Detailed consideration will be given to liaising with all such third parties.

Schedule1 of S.I. 2264 Infrastructure Planning (http://www.legislation.gov.uk/uksi/2009/2264/pdfs/uksi_20092264_en.pdf) specifies the stakeholders who must be consulted at the DCO stage.

[41] Nationally Significant Infrastructure Project
[42] Technical Appraisal Report

# 12 DESCRIPTION OF ROUTE OPTIONS

## 12.1 INTRODUCTION

This section summarises the history of the A27 Arundel scheme and sets out the route options that were identified and taken forward for appraisal during Stage 1. The process and rationale for further developing and sifting the options is described, along with the results of this process. This section presents the short list of options that are recommended to be taken forward for further consideration during the next stage.

## 12.2 PREVIOUS STUDIES, CONSULTATIONS AND OPTIONS

There are long standing objectives relating to the A27 in Arundel to reduce congestion, improve safety, and improve environmental conditions within the town centre by removing through traffic. Improvements to the A27 have been under consideration since the 1980's through technical studies, public consultations and preferred route announcements. To date, scheme proposals have not been taken forward to later stages of scheme development due to reasons which include scheme cost, environmental impact and value for money. The key events and milestones that have guided the historical development of the scheme are summarised below in Figure 12-1.

**Figure 12-1: Historic scheme development - key milestones**

| Date | Studies, events and decisions |
|---|---|
| 1985 | Scheme Assessment Report outlines route options |
| 1987 | Public Consultation |
| 1989 | Secretary of State decision on preferred 'Orange' bypass route following production of an updated Scheme Assessment Report |
| 1991 | Public consultation on Orange route amendments to identify means to reduce environmental impact |
| 1992 | Addendum to Scheme Assessment Report |
| 1993 | DfT issued updated preferred and safeguarded 'Pink-Blue' route |
| 1996 | Inclusion of Scheme in DfT Main Roads programme |
| 1997 | Scheme removed from programme following change in Government, pending further review |
| 2002 | South Coast Multi-Modal Study prepared for Government Office for the South East which recommends new bypass be constructed around Arundel |
| 2003 | Secretary of State cancelled previously preferred 'Pink-Blue' route and advised that alternative solutions should be identified |
| 2013 | A Route Strategy and Action Plan for the A27 (WSCC) is published |
| 2013 | Commencement of A27 Corridor Feasibility Study |
| 2014 | DfT announces inclusion of A27 Arundel scheme in Road Investment Strategy Period 1 |
| 2015 | Final A27 Corridor Feasibility Study published |

The preferred 'Pink-Blue' route comprised approximately 5.4km of offline dual two lane all purpose carriageway which would link the extent of the existing dual carriageway to the west of

Arundel with Crossbush roundabout to the east. The route is protected from development in accordance with the provision of Article 15 of the Town and Country Planning General Development Order 1988 (SI 1988 No.1813)" The route is also safeguarded in the Arun Local Plan ."

Following the publication of the SoCoMMS report, the Secretary of State for Transport announced in 2003 that the Pink-Blue route would not be taken forward citing reasons of environmental impact, but recommending that alternative solutions are identified in line with the need to support planned economic growth.

The A27 Corridor Feasibility Study was developed between 2013 and 2015 and set out a review of the case for improvements on the A27 between Havant and Pevensey, including a wide range of previously considered and new options. These options considered in the study include online and offline highway options, including tunnelling, and non-highway options relating to public transport, walking and cycling.

A long list of scheme options was subject to an initial sift and then further assessed using the Early Assessment and Sifting Tool (EAST) . This tool supports decision making within the DfT by providing a summary of evidence on options in a clear and consistent format whilst ensuring that a robust audit trail for the option sifting process is maintained. The process allows an initial sift to reject options that clearly:

- fail to meet the key intervention-specific objectives
- do not fit with existing local, regional and national programmes and strategies, and do not fit with wider government priorities
- are unlikely to pass key viability and acceptability criteria (or represent significant risk) in that they are unlikely to be:
  - deliverable in a particular economic, environmental, geographical or social context e.g. options which would result in severe adverse environmental impacts which cannot be mitigated against or where the cost of doing so is too high
  - technically sound
  - financially affordable
  - acceptable to stakeholders and the public

The study confirmed that an improvement to the A27 at Arundel would provide significant congestion relief and economic benefit and should be re-examined.

On the basis of the evidence available, the study concluded that there is an investment case for a dual carriageway bypass at Arundel to the south of the existing A27 which could provide value for money. The Department for Transport accepted this conclusion and in November 2014 the Government's RIS included the A27 Arundel Bypass as a scheme for delivery during the first RIS periods, subject to further consultation with the local planning authorities, West Sussex County Council, Statutory Bodies, Coast to Capital Local Economic Partnership and the public. The final A27 Corridor Feasibility Study was published in February 2015, alongside the RIS and accompanying investment plan.

## 12.3 STRATEGY, SHAPING AND PRIORITISATION (STAGE 0)

The A27 Corridor Feasibility Study provided a key input to the strategy, shaping and prioritisation stage. The options that were considered as part of that study were reviewed, resulting in some modifications to the scope of some of the options before these were taken forward for further consideration.

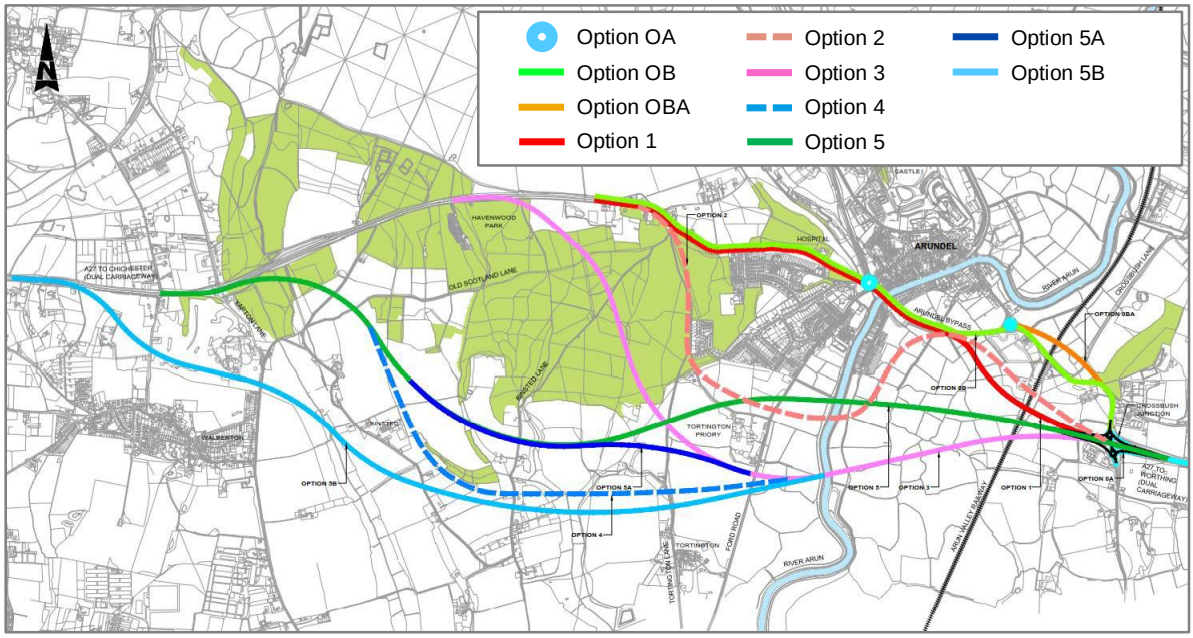
The Stage 0 study process included a programme of stakeholder meetings to inform scheme strategy and prioritisation. This process commenced with a stakeholder meeting in March 2015 which was attended by Highways England, Arun District Council, Adur & Worthing Councils, South Downs National Park Authority, Atkins and WSP. The purpose of this meeting was to discuss and review the key options identified from the A27 Corridor Feasibility Study.
In April 2015, a meeting took place with West Sussex County Council, during which the further consideration of potential online widening options was discussed.

The outputs from these workshops informed the Stage 0 technical studies that took place during 2015. These studies focused upon:

- the identification of new or refined options, including those that have the potential to reduce the environmental impact of the scheme
- the design specification for the scheme, including standards and speed limits for online options
- the junction strategy for the scheme, including the scope of new proposed junctions, and treatment of connections with Ford Road

During the process a total of ten options were considered. These options comprise fully offline solutions including options similar to the previous preferred routes. In addition, options which include partial on-line widening and modest packages of junction improvements were considered. The ten options are illustrated in Figure 12-2 and described further below. Drawings of each option are presented in Appendix B.

**Figure 12-2: Scheme options considered during Stage 1**



**Option 0A –** Junction improvements only **–** encompassing improvements to Crossbush Junction, Causeway roundabout and Ford Road roundabout.

**Option 0B –** Consists of a narrowed urban D2UAP[43] corridor along the existing A27 alignment, in addition to the improvements at Crossbush Junction, Causeway roundabout and Ford Road roundabout.

**Option 0BA –** A narrowed urban D2UAP corridor along the existing A27 alignment, in addition to the improvements at Crossbush Junction, Causeway roundabout and Ford Road roundabout. Supplemented by a short offline section past Arundel Railway Station. The current road section past the railway station would become a local off-slip/ on slip from the short new offline dual carriageway section.

**Option 1** - D2UAP widening on current existing alignment, then offline D2AP[44] to tie into Crossbush Junction to incorporate an online then offline improvement, running west to east.

**Option 2 –** D2AP offline bypass with the route situated lower in the valley. This alignment is approximately 4.4km in length and commences from a proposed new interchange adjacent to The White Horse Public House, to the west of Arundel, on the existing A27 Chichester Road. The alignment then turns toward the south to run adjacent to Tortington Lane and then south-eastward. The alignment continues in a south east direction to cross the River Arun, and then turns northwards to run adjacent to the existing A27. This alignment then continues on to cross over the Arun Valley Railway and ties into the existing A27 to form a new grade separated interchange at Crossbush Junction. Option 2 would incorporate the standard D2AP corridor along its entire length.

**Option 3** - An offline D2AP route bypassing the existing A27 alignment. This alignment continues in a south east direction through ancient woodland at Tortington Common to create four new under-bridges at Old Scotland Lane, Binsted Lane, Tortington Lane and Ford Road. The alignment then turns eastwards to create two new over-bridges at the River Arun and Arun Valley Railway. The alignment then ties into the existing A27 to form a new grade separated interchange at Crossbush Junction.

**Option 4** - An offline D2AP route. This option commences further west than Options 2 and 3. The alignment continues in a south east direction adjacent to the border of the South Downs National Park with four new under-bridges at Binsted Lane (north), Old Scotland Lane, Binsted Lane (south) and Ford Road. The alignment then continues east, similar to Option 3, and would include two new over-bridges at the River Arun and Arun Valley Railway. The alignment then ties into the existing A27 to form a new grade separated interchange at Crossbush Junction.

**Option 5 –** An offline D2AP route. Option 5 runs north of Tortington Priory, thereby allowing for the shortest distance possible over the floodplain, then intersects the ancient woodland and SDNP. The alignment then continues east, similar to Option 3 above, and will create two new over-bridges at the River Arun and Arun Valley Railway. The proposed alignment then ties into the existing A27 to form a new grade separated interchange at Crossbush Junction.

**Option 5A –** An Offline D2AP route. A hybrid of Option 3 and Option 5 alignments, avoiding passing south of the Guest Houses on Priory Lane along Ford Road, joining with the existing A27 dual carriageway at Crossbush and a new grade separated junction near Yapton Lane.

**Option 5B –** An offline D2AP route starting at Crossbush Junction to form a new grade separated interchange with the existing A27 dual carriageway, running west, south of Arundel town, across the Arun floodplain between Tortington Priory and Tortington village. It bypasses the ancient

[45] HE5515234_WSP-PB_A27AWL_P013_TFR_v1.3.1, March 2017
[45] HE5515234_WSP-PB_A27AWL_P013_TFR_v1.3.1, March 2017

woodland areas completely running between Binsted and Walberton, to join the existing A27 dual carriageway north of the Hilton Hotel and Avisford Park Golf Course, west of the existing junction with Mill Road/Tye Lane.

## 12.4 OPTION IDENTIFICATION (STAGE 1)

The purpose of stage 1 is to develop the evidence and options that were prioritised during Stage 0. During this stage further appraisal is undertaken, alongside further engagement with key stakeholders. This process informs decisions about which scheme should be progressed into Stage 2 and considered for inclusion in public consultation.

During this stage a further programme of engagement was undertaken, including meetings with Historic England in November 2015 and a Focus Group meeting in October 2016. The environmental and engineering impacts of the options was considered, and the results are presented in Appendix M and O respectively. Table 12-1 presents a summary of the appraisal during Stage 1 and includes a recommendation for which options should be progressed.

**Table 12-1: Summary of stage 1 scheme appraisal**

| SCHEME OPTIONS | | KEY BENEFITS AND ISSUES | | TAKE FORWARD TO STAGE 2 | |
|---|---|---|---|---|---|
| REF | DESCRIPTION | BENEFITS | ISSUES | | |
| **OA** | Improvements to Crossbush, Causeway, and Ford Road junctions | • No impact on SDNP and ancient woodland<br>• Strong value for money case | • Poor strategic case<br>• Limited support to economic growth<br>• Residual traffic performance issues | Y | • Low cost option retained for consideration |
| **OB** | Online dualling with junction improvements | • Minimal impact on SDNP and ancient woodland<br>• Strong value for money case | • Impact on properties adjacent to A27 and on heritage sites.<br>• Impact on bridge over railway | N | • Engineering and property issues. Discarded in favour of other part-online options |
| **OBA** | Online dualling as option OB with new bridge across the railway | • Route avoids weak bridge over railway<br>• Minimal impact on SDNP and ancient woodland<br>• Strong value for money case | • Deliverability issues for new railway bridge associated with a veteran tree | N | • Engineering and property issues. Discarded in favour of other part-online options |
| **1** | Online dualling with offline section from east of River Arun to Crossbush roundabout | • Strong value for money case<br>• Link east of Arundel avoids property impacts | • Involves substantial earth-works (cutting)<br>• Floodplain issues | Y | • Optimal part-online scheme which would deliver RIS objectives. Retained for consideration. |
| **2** | Offline link aligned to the north of Tortington Priory | • Makes use of the existing A27 dual carriageway | • Close to existing urban area resulting in noise and vibration issues<br>• Landscape and visual impact | N | • Engineering issues in relation to alignment. Does not mitigate landscape impacts. Discarded in favour of other offline |

| SCHEME OPTIONS | | KEY BENEFITS AND ISSUES | | TAKE FORWARD TO STAGE 2 | |
|---|---|---|---|---|---|
| REF | DESCRIPTION | BENEFITS | ISSUES | | |
| | | | • Sub-standard alignment due to sharp bends | | options |
| **3** | Offline link to the south of Tortington Priory.<br><br>*Similar to 'Pink Blue' route.* | • Makes full use of existing dual carriageway<br>• Strong value for money case | • Floodplain issues<br>• Landscape and visual impact<br>• Impacts on SDNP and ancient woodland | Y | • Selected as the Preferred Route previously, this route is supported by many key stakeholders |
| **4** | Offline link to the south of Tortington Priory, a variation of Option 3 | • It reduces impact on ancient woodland in comparison to other offline options<br>• Strong value for money case | • Bypasses existing dual carriageway section west of Arundel.<br>• Floodplain issues<br>• Route passes close to Binsted<br>• The section outside the National Park is still within the area of influence of SDNP<br>• Impacts on ancient woodland at western end | N | • Does not provide further scope for mitigation of SDNP and ancient woodland impacts and is discarded in favour of other offline options as it provides no additional benefit |
| **5** | Offline route to the north of Tortington Priory | • Minimises impact on ancient woodland and SDNP in comparison to other offline options<br>• Limits floodplain issues<br>• Strong value for money case | • Close to existing urban area<br>• Bypasses existing dual carriageway sections<br>• Engineering issues associated with topography and a requirement for a higher crossing of River Arun | N | • Inferior to other offline options due to engineering issues and greater visual and heritage impacts |
| **5A** | Offline route to the south of Tortington Priory. Hybrid of other options.<br><br>*Similar to 'Orange' Route* | • Reduced negative visual impact on Tortington Priory<br>• Minimises impact on ancient woodland and SDNP in comparison to other offline options<br>• Strong value for money case | • Bypasses existing dual carriageway section west of Arundel | Y | • Reduced visual and heritage impacts and limited ancient woodland impact compared with other offline options. |

| SCHEME OPTIONS | | KEY BENEFITS AND ISSUES | | TAKE FORWARD TO STAGE 2 | |
|---|---|---|---|---|---|
| REF | DESCRIPTION | BENEFITS | ISSUES | | |
| **5B** | Offline route to the south of Tortington Priory connecting with the existing A27 west of Yapton Lane | • No impact on ancient woodland<br>• Limited impact on SDNP<br>• Reduced negative visual impact on Tortington Priory | • Higher cost option<br>• Modest value for money case<br>• Runs close to Binsted | **Y** | • No impact on ancient woodland and limited impact on SDNP. Reduced visual impacts in comparison to other offline options |

Five options are recommended for further consideration during Stage 2. A detailed set of drawings for the five prioritised options are presented in Appendices C to G. These drawings include General Arrangements (GA), public utilities information, drainage proposals, and NMU desire lines. Appendix H presents typical structures associated with these options.

# 13 TRAFFIC ANALYSIS

## 13.1 INTRODUCTION

The section of the TAR summarises the traffic modelling and forecasting undertaken, as detailed in full within the Traffic Forecasting Report[45].

A Base Year model was developed using traffic data collected in 2015, and the West Sussex County Model network as agreed with West Sussex County Council. The same model was used to appraise the A27 Worthing-Lancing Improvements scheme.

[45] HE5515234_WSP-PB_A27AWL_P013_TFR_v1.3.1, March 2017

The model was validated to WebTAG validation criteria and acceptability guidelines[46]. A Local Model Validation Report[47] was produced. This report demonstrates that the base model is robust and suitable for traffic forecasting.

## 13.2 TRAFFIC DATA

### TRAFFIC SURVEYS

In order to create, calibrate and validate the traffic model to appraise the A27 Arundel Bypass scheme, a programme of data collection was carried out in the summer and autumn of 2015.

The following traffic and operational data have been collected:

- Roadside Interviews (RSIs) (to enable new matrices to be produced);
- Manual Classified Counts (MCCs) and Junction Turning Counts (JTCs) at or near all RSI sites (to provide volumetric data to expand interview origin-destination data proportions to the volumes of traffic on the day of the interview);
- Automatic Traffic Counts (ATCs) at or near the RSI sites (to adjust the MCC data to an average weekday);
- TrafficMaster data and MCO journey time surveys (for journey time validation);
- Collision data (for economic appraisal of accident savings); and
- WebTRIS data for the A27 in the Arundel area to provide independent data to validate flows in the base year model to be used to appraise the A27 Arundel and Worthing-Lancing schemes.

Full details of the surveys are provided within the Traffic Data Collection Report[48], which provides full details of the traffic data collected.

### MODEL YEARS AND FORECAST DEVELOPMENT

The aforementioned traffic surveys were used to create a validated base model, and then two forecast years were produced, as summarised below.

- 2015 Base Year
- 2023 Opening Year
- 2041 Horizon Year

The horizon year is the last year used for traffic forecasting. The year 2041 is the recommended horizon year in the Draft Technical Advice Note on Traffic Forecasting for Major Schemes.

The following model periods were assessed.

- AM Peak average hour: 07:00 – 10:00
- IP Average hour: 10:00 – 16:00

[46] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427124/webtag-tag-unit-m3-1-highway-assignment-modelling.pdf
[47] HE5515234_WSP-PB_A27AWL_P014_LMVR_v1.4.1, February 2017
[48] HE551523,4_WSP-PB_A27AWL_P012_TDCR_v1.4.1, September 2016

→ PM Peak average hour: 16:00 – 19:00

Local authorities provided information for potential residential and employment development sites. This information was analysed and the development sites were entered into an Uncertainty Log. The Uncertainty Log outlines the developments which were explicitly modelled and the evidence behind this inclusion. Table 13-1 presents the planned growth in housing and jobs provided by Arun District Council used in the model demand forecasts.

**Table 13-1: Overview of Committed Development**

| Housing (dwellings) | Total Jobs |
|---|---|
| 14,642 | 219 |

To date only a core scenario has been tested, it is proposed that low and high growth scenarios are tested in the future. Trip generation totals for site-specific developments were calculated using the TRICS[49] database and added to the forecast trip matrices, as appropriate and controlled to the National Trip End Model (NTEM)[50] V6.2. It is noted that NTEM 6.2 has now been superseded, future forecasting will use an updated version of NTEM. Growth factors were derived from NTEM V6.2 datasets accessed via the TEMPRO[51] V6.2 program for Car User Classes while the National Transport Model (NTM) was used for light goods vehicle (LGV) and heavy goods vehicle (HGV) growth.

Table 13-2 shows the percentage growth in matrix totals for the Core scenario as compared to the 2015 Base scenario. This represents growth in traffic within the modelled area.

**Table 13-2: Growth in Matrix Totals over base year of 2015**

| Period | 2023 | 2041 |
|---|---|---|
| AM | 10.5% | 30.0% |
| IP | 11.8% | 36.4% |
| PM | 10.3% | 30.1% |

Committed network improvements were then assessed and modelled.

Table 13-3 presents the network statistics for the Arundel options. The results show that all five options have similar impact on the network.

**Table 13-3: Arundel Network Statistics**

| | AM | IP | PM | AM | IP | PM | AM | IP | PM | AM | IP | PM | AM | IP | PM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2023 Opt 0a | | | 2023 Opt 1 | | | 2023 Opt 3 | | | 2023 Opt 5a | | | 2023 Opt 5b | | |
| Total Travel Time (PCU/hrs) | 7,198 | 6,076 | 8,165 | 7,068 | 5,962 | 7,904 | 7,047 | 5,964 | 7,861 | 6,926 | 5,884 | 7,817 | 6,950 | 5,921 | 7,879 |

[49] Trip Rate Information Computer System
[50] National Trip End Model
[51] Trip End Model Presentation Program

| | AM | IP | PM | AM | IP | PM | AM | IP | PM | AM | IP | PM | AM | IP | PM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Delay (PCU/hrs) | 590 | 465 | 648 | 571 | 446 | 619 | 540 | 425 | 594 | 518 | 416 | 585 | 526 | 416 | 593 |
| Total Travel Distance (PCU/km) | 366,073 | 328,798 | 391,667 | 367,727 | 327,909 | 398,807 | 372,083 | 331,843 | 405,838 | 372,643 | 331,260 | 404,729 | 370,047 | 328,686 | 403,248 |
| Average Speed (km/hr) | 51 | 54 | 48 | 52 | 55 | 51 | 53 | 56 | 52 | 54 | 56 | 52 | 53 | 56 | 51 |
| Total Trips (PCU) | 30,674 | 26,935 | 33,644 | 30,674 | 26,935 | 33,644 | 30,674 | 26,935 | 33,644 | 30,674 | 26,935 | 33,644 | 30,674 | 26,935 | 33,644 |
| | 2041 Opt 0a | | | 2041 Opt 1 | | | 2041 Opt 3 | | | 2041 Opt 5a | | | 2041 Opt 5b | | |
| Total Travel Time (PCU/hrs) | 8,997 | 7,900 | 10,318 | 8,972 | 7,766 | 9,970 | 8,901 | 7,702 | 10,014 | 8,766 | 7,607 | 9,863 | 8,781 | 7,625 | 10,376 |
| Total Delay (PCU/hrs) | 759 | 638 | 825 | 742 | 612 | 816 | 703 | 577 | 780 | 684 | 564 | 772 | 678 | 560 | 773 |
| Total Travel Distance (PCU/km) | 425,563 | 389,279 | 440,427 | 428,005 | 387,924 | 458,668 | 433,093 | 394,836 | 464,348 | 429,939 | 391,378 | 463,444 | 427,831 | 390,444 | 432,939 |
| Average Speed (km/hr) | 47 | 49 | 43 | 48 | 50 | 46 | 49 | 51 | 46 | 49 | 52 | 47 | 49 | 51 | 42 |
| Total Trips (PCU) | 36,138 | 32,839 | 39,685 | 36,138 | 32,839 | 39,685 | 36,138 | 32,839 | 39,685 | 36,138 | 32,839 | 39,685 | 36,138 | 32,839 | 39,685 |

Table 13-4 to Table 13-9 below presents the traffic volumes for key sections of road network in the AM peak, Inter peak and PM peak for the 2023 and 2041 scenarios. The traffic volumes in these tables are colour coded, representing the higher traffic flow with a darker colour to aid comparison of traffic flow by option.

The tables show that Option 0A attracts more road users to the existing key junctions than the DM model in all scenarios. Option 1 attracts the largest amount of users to a potential bypass than the other options and also increases flow over both junctions, but decreases it significantly going into Arundel.

Option 3, Option 5A and Option 5B attract a significant amount of traffic away from Ford Road roundabout to the potential bypass, but increases traffic using Crossbush roundabout.

**Table 13-4: Traffic volume in the 2023 AM peak for the options**

| 2023 AM PEAK | FLOWS | | | | | | |
|---|---|---|---|---|---|---|---|
| | Base (2016 only) | Core (DM) | Option 0A | Option 1 | Option 3 | Option 5A | Option 5B |
| New bypass - eastbound | N/A | N/A | N/A | 1811 | 1267 | 1446 | 1508 |
| New bypass - westbound | N/A | N/A | N/A | 1600 | 1197 | 1374 | 1480 |
| East of new bypass connecting junction - eastbound | N/A | N/A | N/A | 1 | 28 | 32 | 30 |
| East of new bypass connecting junction - westbound | N/A | N/A | N/A | 0 | 52 | 111 | 116 |
| West of new bypass connecting junction - eastbound | N/A | N/A | N/A | 1812 | 1295 | 1465 | 1490 |
| West of new bypass connecting junction - westbound | N/A | N/A | N/A | 1544 | 1249 | 1462 | 1549 |
| East of Crossbush Roundabout – A27 eastbound | 1263 | 1473 | 1812 | 1961 | 1868 | 2020 | 2080 |
| East of Crossbush Roundabout – A27 westbound | 1115 | 1520 | 1582 | 1716 | 1609 | 1733 | 1861 |
| North of Crossbush Roundabout – A27 northbound | 1284 | 1331 | 1404 | 52 | 282 | 282 | 287 |
| North of Crossbush Roundabout – A27 southbound | 1500 | 1500 | 1707 | 145 | 603 | 594 | 593 |
| East of Ford Roundabout – A27 eastbound | 1301 | 1224 | 1661 | 1812 | 531 | 522 | 521 |
| East of Ford Roundabout – A27 westbound | 1267 | 1310 | 1315 | 1544 | 245 | 244 | 249 |
| West of Ford Roundabout – A27 eastbound | 1152 | 1170 | 1273 | 1320 | 28 | 67 | 58 |
| West of Ford Roundabout – A27 westbound | 1116 | 1196 | 1152 | 1196 | 52 | 93 | 97 |

**Table 13-5: Traffic volume in the 2041 AM peak for the options**

| 2041 AM PEAK | Flows | | | | | | |
|---|---|---|---|---|---|---|---|
| | Base (2016 only) | Core (DM) | Option 0A | Option 1 | Option 3 | Option 5A | Option 5B |
| New bypass - eastbound | N/A | N/A | N/A | 2,141 | 1,434 | 1,561 | 1,664 |
| New bypass - westbound | N/A | N/A | N/A | 1,950 | 1,443 | 1,655 | 1,682 |
| East of new bypass connecting junction - eastbound | N/A | N/A | N/A | 1 | 23 | 26 | 45 |
| East of new bypass connecting junction - westbound | N/A | N/A | N/A | 0 | 105 | 168 | 290 |
| West of new bypass connecting junction - eastbound | N/A | N/A | N/A | 2,142 | 1,475 | 1531 | 1492 |
| West of new bypass connecting junction - westbound | N/A | N/A | N/A | 1,885 | 1,548 | 1,752 | 1,756 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| East of Crossbush Roundabout – A27 eastbound | 1,263 | 1,500 | 2,041 | 2,360 | 2,274 | 2,367 | 2,370 |
| East of Crossbush Roundabout – A27 westbound | 1,115 | 1,666 | 1,826 | 2,013 | 1,900 | 2,076 | 2,135 |
| North of Crossbush Roundabout – A27 northbound | 1,284 | 1,458 | 1,700 | 62 | 402 | 402 | 424 |
| North of Crossbush Roundabout – A27 southbound | 1,500 | 1,550 | 1,943 | 167 | 795 | 772 | 698 |
| East of Ford Roundabout – A27 eastbound | 1,301 | 1,247 | 1,905 | 2,142 | 710 | 687 | 614 |
| East of Ford Roundabout – A27 westbound | 1,267 | 1,204 | 1,619 | 1,885 | 353 | 353 | 375 |
| West of Ford Roundabout – A27 eastbound | 1,152 | 1,118 | 1,392 | 1,450 | 23 | 77 | 41 |
| West of Ford Roundabout – A27 westbound | 1,116 | 1,294 | 1,341 | 1,441 | 105 | 111 | 111 |

**Table 13-6: Traffic volume in the 2023 Interpeak for the options**

| 2023 Inter Peak | Flows | | | | | | |
|---|---|---|---|---|---|---|---|
| | Base (2016 only) | Core (DM) | Option 0A | Option 1 | Option 3 | Option 5A | Option 5B |
| New bypass - eastbound | N/A | N/A | N/A | 1,512 | 1,192 | 1,381 | 1,496 |
| New bypass - westbound | N/A | N/A | N/A | 1,380 | 999 | 1,178 | 1,187 |
| East of new bypass connecting junction - eastbound | N/A | N/A | N/A | 5 | 57 | 100 | 8 |
| East of new bypass connecting junction - westbound | N/A | N/A | N/A | 0 | 66 | 139 | 145 |
| West of new bypass connecting junction - eastbound | N/A | N/A | N/A | 1,517 | 1,248 | 1,471 | 1,483 |
| West of new bypass connecting junction - westbound | N/A | N/A | N/A | 1,337 | 1,065 | 1,287 | 1,311 |
| East of Crossbush Roundabout – A27 eastbound | 1,160 | 1,419 | 1,552 | 1,670 | 1,621 | 1,790 | 1,893 |
| East of Crossbush Roundabout – A27 westbound | 1,040 | 1,581 | 1,634 | 1,722 | 1,655 | 1,781 | 1,827 |
| North of Crossbush Roundabout – A27 northbound | 1,107 | 1,273 | 1,329 | 139 | 404 | 401 | 410 |
| North of Crossbush Roundabout – A27 southbound | 1,416 | 1,500 | 1,551 | 231 | 510 | 506 | 504 |
| East of Ford Roundabout – A27 eastbound | 1,264 | 1,335 | 1,402 | 1,517 | 328 | 326 | 324 |
| East of Ford Roundabout – A27 westbound | 1,003 | 1,155 | 1,164 | 1,337 | 262 | 262 | 267 |
| West of Ford Roundabout – A27 eastbound | 1,064 | 1,139 | 1,178 | 1,247 | 57 | 109 | 57 |
| West of Ford Roundabout – A27 westbound | 861 | 1,022 | 949 | 994 | 66 | 130 | 135 |

**Table 13-7: Traffic volume in the 2023 Interpeak for the options**

| 2041 Inter Peak | Flows | | | | | | |
|---|---|---|---|---|---|---|---|
| | Base (2016 only) | Core (DM) | Option 0A | Option 1 | Option 3 | Option 5A | Option 5B |
| New bypass - eastbound | N/A | N/A | N/A | 1,892 | 1,379 | 1,661 | 1,565 |
| New bypass - westbound | N/A | N/A | N/A | 1,678 | 1,258 | 1,308 | 1,634 |
| East of new bypass connecting junction - eastbound | N/A | N/A | N/A | 6 | 60 | 47 | 33 |
| East of new bypass connecting junction - westbound | N/A | N/A | N/A | 0 | 80 | 170 | 349 |
| West of new bypass connecting junction - eastbound | N/A | N/A | N/A | 1,897 | 1,439 | 1,696 | 1,500 |
| West of new bypass connecting junction - westbound | N/A | N/A | N/A | 1,626 | 1,338 | 1423 | 1,884 |
| East of Crossbush Roundabout – A27 eastbound | 1,160 | 1,478 | 1,914 | 2,047 | 1,990 | 2,243 | 2,196 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| East of Crossbush Roundabout – A27 westbound | 1,040 | 1,852 | 1,934 | 2,078 | 1,982 | 1,998 | 2,353 |
| North of Crossbush Roundabout – A27 northbound | 1,107 | 1,468 | 1,669 | 175 | 472 | 468 | 485 |
| North of Crossbush Roundabout – A27 southbound | 1,416 | 1,500 | 1,889 | 280 | 702 | 686 | 690 |
| East of Ford Roundabout – A27 eastbound | 1,264 | 1,318 | 1,745 | 1,897 | 476 | 462 | 467 |
| East of Ford Roundabout – A27 westbound | 1,003 | 1,235 | 1,509 | 1,626 | 294 | 294 | 311 |
| West of Ford Roundabout – A27 eastbound | 1,064 | 1,226 | 1,377 | 1,432 | 60 | 89 | 65 |
| West of Ford Roundabout – A27 westbound | 861 | 1,190 | 1,155 | 1,212 | 80 | 158 | 161 |

**Table 13-8: Traffic volume in the 2023 PM peak for the options**

| 2023 PM Peak | Flows | | | | | | |
|---|---|---|---|---|---|---|---|
| | Base (2016 only) | Core (DM) | Option 0A | Option 1 | Option 3 | Option 5A | Option 5B |
| New bypass - eastbound | N/A | N/A | N/A | 1,759 | 1,257 | 1,374 | 1,498 |
| New bypass - westbound | N/A | N/A | N/A | 1,981 | 1,511 | 1,621 | 1,501 |
| East of new bypass connecting junction - eastbound | N/A | N/A | N/A | 15 | 61 | 95 | 18 |
| East of new bypass connecting junction - westbound | N/A | N/A | N/A | 0 | 79 | 128 | 141 |
| West of new bypass connecting junction - eastbound | N/A | N/A | N/A | 1,774 | 1,318 | 1,453 | 1,475 |
| West of new bypass connecting junction - westbound | N/A | N/A | N/A | 1,948 | 1,590 | 1,669 | 1,601 |
| East of Crossbush Roundabout – A27 eastbound | 1,227 | 1,390 | 1,519 | 1,669 | 1,624 | 1,694 | 1,793 |
| East of Crossbush Roundabout – A27 westbound | 1,476 | 1,681 | 1,761 | 1,929 | 1,867 | 1,869 | 1,872 |
| North of Crossbush Roundabout – A27 northbound | 1,437 | 1,500 | 1,773 | 40 | 398 | 350 | 408 |
| North of Crossbush Roundabout – A27 southbound | 1,500 | 1,500 | 1,834 | 395 | 819 | 802 | 795 |
| East of Ford Roundabout – A27 eastbound | 1,263 | 1,245 | 1,530 | 1,774 | 485 | 468 | 470 |
| East of Ford Roundabout – A27 westbound | 1,311 | 1,055 | 1,790 | 1,948 | 375 | 327 | 381 |
| West of Ford Roundabout – A27 eastbound | 1,006 | 1,025 | 1,173 | 1,242 | 61 | 95 | 53 |
| West of Ford Roundabout – A27 westbound | 1,281 | 1,327 | 1,428 | 1,475 | 79 | 111 | 120 |

**Table 13-9: Traffic volume in the 2041 PM peak for the options**

| 2041 PM Peak | Flows | | | | | | |
|---|---|---|---|---|---|---|---|
| | Base (2016 only) | Core (DM) | Option 0A | Option 1 | Option 3 | Option 5A | Option 5B |
| New bypass - eastbound | N/A | N/A | N/A | 2,113 | 1,405 | 1,607 | 1,697 |
| New bypass - westbound | N/A | N/A | N/A | 1,402 | 1,747 | 2,007 | 1,951 |
| East of new bypass connecting junction - eastbound | N/A | N/A | N/A | 17 | 70 | 72 | 62 |
| East of new bypass connecting junction - westbound | N/A | N/A | N/A | 0 | 114 | 290 | 368 |
| West of new bypass connecting junction - eastbound | N/A | N/A | N/A | 2,130 | 1,475 | 1,533 | 1,500 |
| West of new bypass connecting junction - westbound | N/A | N/A | N/A | 2,365 | 1,861 | 2,062 | 2,060 |
| East of Crossbush Roundabout – A27 eastbound | 1,227 | 1,244 | 1,564 | 1,994 | 1,881 | 2,027 | 2,090 |
| East of Crossbush Roundabout – A27 westbound | 1,476 | 1,768 | 1,869 | 2,249 | 2,142 | 2,278 | 2,326 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| North of Crossbush Roundabout – A27 northbound | 1,437 | 1,500 | 1,940 | 43 | 506 | 413 | 517 |
| North of Crossbush Roundabout – A27 southbound | 1,500 | 1,500 | 1,945 | 473 | 999 | 984 | 983 |
| East of Ford Roundabout – A27 eastbound | 1,263 | 1,178 | 1,658 | 2,130 | 627 | 621 | 612 |
| East of Ford Roundabout – A27 westbound | 1,311 | 928 | 1,904 | 2,365 | 503 | 419 | 514 |
| West of Ford Roundabout – A27 eastbound | 1,006 | 1,062 | 1,197 | 1,378 | 70 | 87 | 76 |
| West of Ford Roundabout – A27 westbound | 1,281 | 1,319 | 1,533 | 1,601 | 114 | 145 | 144 |

## 13.3 CONCLUSIONS

The model has been developed to a level of detail which is appropriate for Stage 1 options appraisal. It has been validated to WebTAG acceptability criteria and guidelines, using origin-destination traffic data collected in 2015. The model is therefore sufficiently up to date and is a robust tool to assist in decision-making.

The modelling results demonstrate that, in terms of overall network summary statistics, Option 5A and Option 5B have the best performing road network. Nevertheless, all options are shown by the model to accrue significant journey time savings which demonstrate that there is the basis for an economic case for the scheme.

# 14 ECONOMIC ASSESSMENT

## 14.1 INTRODUCTION

This section summarises the economic appraisal of the A27 Arundel Bypass options as described in the Economic Assessment Report[52].

## 14.2 APPLICATION OF ASSESSMENT SOFTWARE

The economic assessment is being undertaken using TUBA version 1.9.8 to assess journey time benefits. Accident benefits are appraised using COBALT version 2016.2. All option testing was undertaken using the 2023 and 2041 central growth scenarios.

## 14.3 INDIVIDUAL IMPACTS

Table 14-1 presents a summary of the results from TUBA for each option, providing the Analysis of Monetised Costs and Benefits (AMCB) for each scheme option for the fixed assignment. Table 14-2 shows the AMCB with the accident benefits included.

**Table 14-1: Analysis of Monetised Costs and Benefits, Fixed Assignments (TUBA only)**

| Type | Option 0A (£000s) | Option 1 (£000s) | Option 3 (£000s) | Option 5A (£000s) | Option 5B (£000s) |
|---|---|---|---|---|---|
| Greenhouse Gases | 0 | 0 | 0 | 0 | 0 |
| Economic Efficiency: Consumer Users (Commuting) | 40,676 | 95,704 | 90,739 | 117,253 | 96,154 |
| Economic Efficiency: Consumer Users (Other) | 22,356 | 57,682 | 50,539 | 65,641 | 52,957 |
| Economic Efficiency: Business Users and Providers | 52,629 | 129,889 | 131,869 | 167,873 | 142,217 |
| Wider Public Finances (Indirect Taxation Revenues) | -3,047 | -8,129 | -863 | -5,317 | -4,417 |
| Present Value of Benefits (PVB) | 112,614 | 275,146 | 272,284 | 345,450 | 286,911 |
| Broad Transport Budget | 25,573 | 87,190 | 166,997 | 162,005 | 213,756 |
| Present Value of Costs (PVC) | 25,573 | 87,190 | 166,997 | 162,005 | 213,756 |
| Overall Impacts | | | | | |
| Net Present Value (NPV) | 87,041 | 187,956 | 105,287 | 183,445 | 73,155 |
| Benefit to Cost Ratio (BCR) | 4.40 | 3.16 | 1.63 | 2.13 | 1.34 |

**Table 14-2: Analysis of Monetised Costs and Benefits, Fixed Assignment (with Accident Impacts)**

| Type | Option 0A (£000s) | Option 1 (£000s) | Option 3 (£000s) | Option 5A (£000s) | Option 5B (£000s) |
|---|---|---|---|---|---|
| Present Value of Benefits (PVB) (TUBA) | 112,614 | 275,146 | 272,284 | 345,450 | 286,911 |
| Accident Impacts (COBALT) | 53 | 38,504 | 63,715 | 76,412 | 63,833 |
| Sub Total Value of Benefits (sum of above two rows) | 112,667 | 313,650 | 335,999 | 421,862 | 350,744 |
| Present Value of Costs (PVC) | 25,573 | 87,190 | 166,997 | 162,005 | 213,756 |
| Overall Impacts | | | | | |
| Net Present Value (NPV) | 87,094 | 226,460 | 169,002 | 259,857 | 136,988 |
| Benefit to Cost Ratio (BCR) | 4.41 | 3.60 | 2.01 | 2.60 | 1.64 |

[52] HE551523,4_WSP-PB_A27AWL_P009_EAR_1.4.1, April 2017

The Transport Economic Efficiency, Public Accounts and Analysis of Monetised Cost and Benefit tables are presented in Appendix L-2. They show the breakdown of the options costs and benefits, discounted to 2010 at 2010 prices.

## 14.4 DISCUSSION OF OVERALL RESULTS

The economic benefits presented in this section principally comprise journey time savings, vehicle operating cost savings and benefits due to reductions in accidents over a 60 year appraisal period. All of the options show a high Benefit Cost Ratio (BCR) value of 2.0 or more, except for Option 5B, which shows a medium BCR of 1.64. Option 0A and Option 1 are shown to produce the highest BCR values of 4.41 and 3.60 respectively. Option 0A is deemed to show a high benefit due to the relatively lower cost of the scheme. Of the bypass scheme options, Option 1 shows the highest economic benefit relative to the cost of the scheme.

Whilst the online Option 0A shows the highest BCR of all options, it also shows the lowest benefits. The economic are estimated at £112.7m, compared with £336.0m for the offline bypass Option 3 and £421.9m for the offline bypass Option 5A. Option 0A also provides substantially lower benefit than the partially online and partially offline Option 1, which shows savings of £313.6m. The level of benefit associated with accidents is greater for the offline options.

Whilst Option 0A shows good value for money in terms of BCR, it would not deliver substantial decongestion benefits as it would remain as single carriageway standard. The demand forecasts suggest that traffic at the opening year would be at the point of congestion with no potential to accommodate further growth without further congestion. The dual carriageway options are able to provide substantial traffic and economic benefits which are not achievable if the section remains at single carriageway standard.

# 15 SAFETY ASSESSMENT

## 15.1 IMPACT ON ROAD USER – STRATEGIC SAFETY ACTION PLAN

### ROUTE OPTIONS CONSIDERED

A safety assessment has been undertaken for the route options as follows:

- Option 0A – improvements to Ford Road roundabout, Causeway roundabout and Crossbush Junction only;
- Option 1 – dualling of the existing A27 west up to Ford Road roundabout and offline new dual carriageway up to Crossbush Junction;
- Option 3 - Offline route south of Arundel, crossing SDNP ancient woodland to the west and joining with existing A27 dual carriageway at Crossbush and a new grade separated junction west of Arundel near Havenwood caravan park;
- Option 5A – new offline dual carriageway between Crossbush Junction and Yapton Lane; and
- Option 5B – new offline dual carriageway (completely avoiding the ancient woodland areas) between Crossbush Junction and Tye Lane.

An NMU[53] context report and objectives have been produced and the comments are referenced in context with the scheme drawings provided for this review only.

The NMU context report states that with each off-line option, certain PROW routes and farm tracks were to be closed where they met the option alignments, and at the time of the report it was not certain whether these routes would be diverted. However, where PROW routes and tracks are to be continued and physically cross the option alignments, this is to be achieved by the construction either of underpasses or footbridges under/over the alignment, to separate NMUs from traffic, with some local diversions to the routes and tracks. This is intended to maximise safety for NMUs. Any proposed at-grade NMU crossing points will be designed to provide the highest possible standards of safety and visibility, whilst existing at-grade NMU crossing points which are to be retained, will be reviewed and improved as required, as part of scheme proposals.

### OPTION 0A

### FORD ROAD ROUNDABOUT

Ford Road roundabout is a five arm roundabout with short flares on the approach to the junction. The existing pedestrians facilities include a footway around the external circumference of the roundabout with informal crossing points to the central island on A284 Arundel by-pass, A27 (northwest bound approach) and Ford Road roundabout arms. There are central islands on all other approach roads with verge but no dropped kerbs or footway facilities provided.

There are 13 collisions recorded at this junction, with a cluster of six multi-vehicle shunts on the northwest bound approach to the roundabout on A27 Arundel By-pass over the River Arun. There were three collisions in the circulatory carriageway and the remaining were shunts on different approach arms.

[53] Non-Motorised User

The proposals include the signalisation of Ford Road roundabout, increasing the internal capacity of the roundabout from two to three lanes, increasing the flare length of the approach lanes on most arms of the roundabout and the introduction of pedestrian controlled facilities on certain arms of the junction.

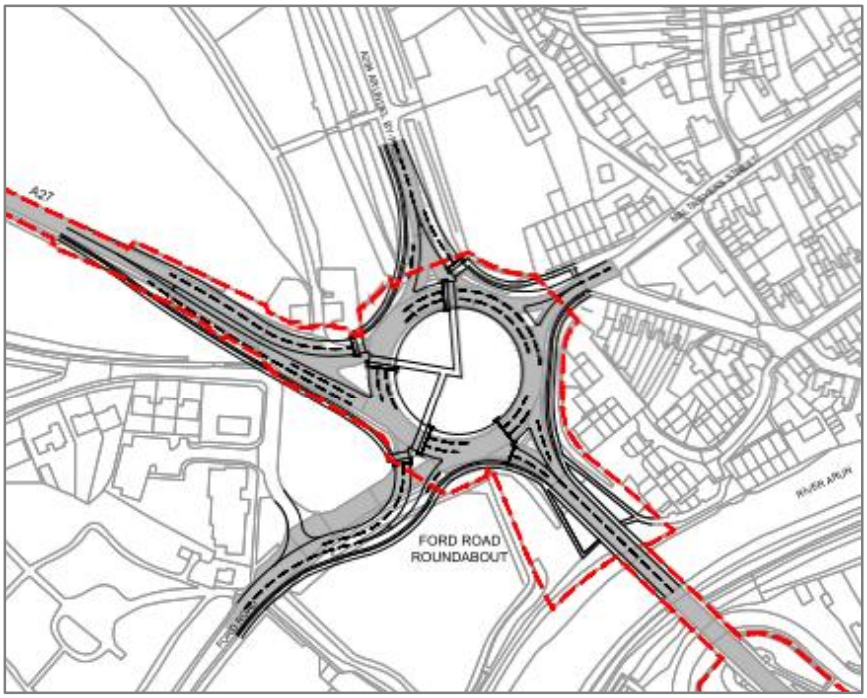
Traffic signals at a roundabout may improve internal capacity and balance high traffic flows. The introduction of signals will also assist in controlling entry speeds into and within the circulatory carriageway which may assist reducing collisions within the circulatory carriageway.

The A27 northwest bound exit arm from the roundabout has a short length of three lanes before merging down to two lanes in a section which currently has a bus stop lay-by. There may be conflict from vehicles merging from two directions.

The A27 northwest bound entry arm to the roundabout has a short two lane flare to the roundabout. Six of the collisions at this junction occurred at this location. The introduction of traffic signals may increase the number of collisions that occur at this junction as it may increase queue lengths.

In the proposed Figure 15-1 there are controlled pedestrian facilities across half the carriageway of the A27 southwest bound approach to the central island, half the carriageway of Ford Road and half the carriageway of Arundel by-pass. There are crossings to the centre of the roundabout from these three central islands.

**Figure 15-1: Proposed layout of Ford Road roundabout, Option 0A**




Pedestrians may find themselves on the central islands or middle of the roundabout and attempt to cross the carriageway using the shortest route at uncontrolled locations to avoid the longer, convoluted route across the roundabout.

There are existing bus stop facilities on the A27 southeast bound approach that create a desire to cross the A27 for pedestrians. The proposed pedestrian facilities require a pedestrian to cross four pedestrian crossings to the centre of the roundabout to cross between the roundabouts and it is unlikely pedestrians will use this route. Pedestrians may attempt to cross at unsuitable locations

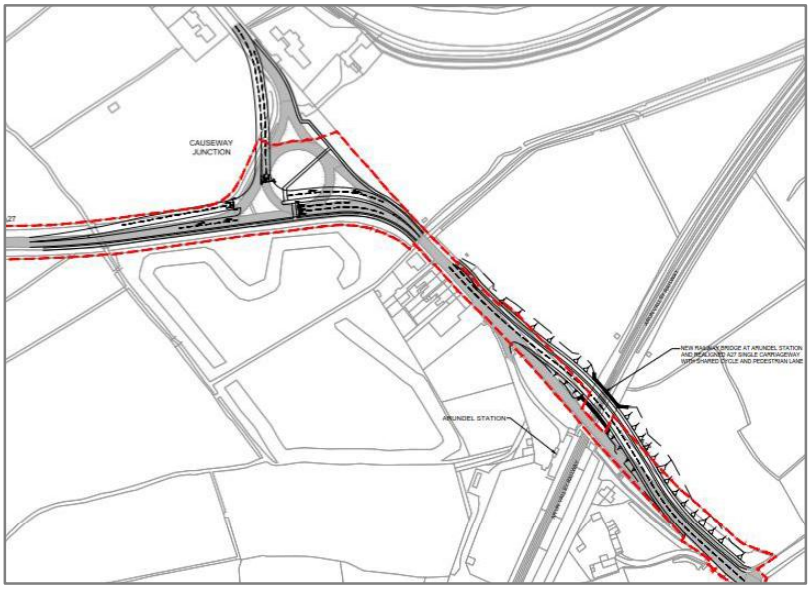
across the increased width of the carriageway and two lanes and increased vehicles speeds. Ensure that all desire lines for pedestrians have been catered for.

## CAUSEWAY ROUNDABOUT

The existing road alignment of The Causeway roundabout with Arundel Bypass is a roundabout which has three wide single lane approach roads and a wide circulatory carriageway with no carriageway markings. There were two collisions at this junction, a shunt and a side swipe on the circulatory carriageway. The northbound and eastbound approach roads each contained multi vehicle shunts that could be attributed to queuing on the approach to the roundabout.

The proposals include realigning the junction and the introduction of traffic signals and a new bridge over the railway line, as seen in Figure 15-2.

**Figure 15-2: Proposed layout for Causeway roundabout, Option 0A**




If the flows on a roundabout are unbalanced, traffic signals may help to give more opportunities to those roads with less flow. Forward visibility to the signal heads for northwest bound drivers is restricted due to the vertical alignment of the carriageway. The possibility of shunts may increase at this location due to restricted visibility and queuing traffic.

The eastbound approach on the A27 Arundel by-pass is a fairly straight road which encourages higher vehicle speeds. Shunts and overshoots may occur if visibility and awareness of the traffic signals head is not considered carefully.

There is an existing PRoW[54] which is accessed from The Causeway where the new alignment is proposed to re-join the existing carriageway. Pedestrians crossing to / from the PRoW will have their visibility to vehicles approaching from the south reduced due to the horizontal alignment, in particular if they are crossing in a northeast bound direction.

[54] Public Right of Way

The southbound exit carriageway merges from two lanes to one lane where the horizontal alignment changes and side swipe collisions could occur. Ensure that vehicles are merged before the bend.

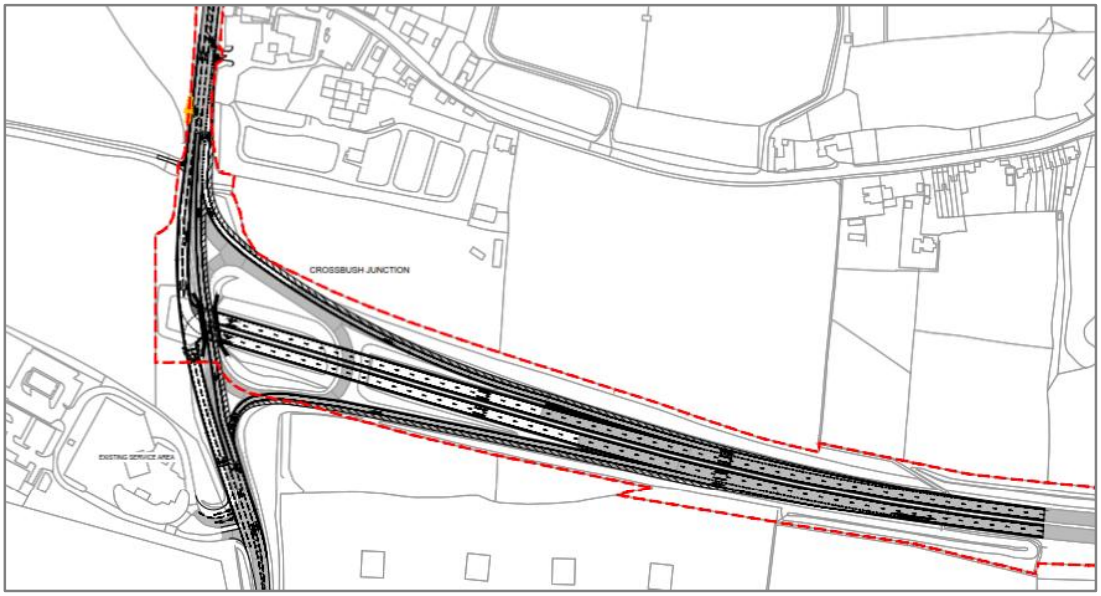
The change in the horizontal alignment of The Causeway on the south side and the horizontal and vertical alignment as a result of the introduction of the new road bridge may result in reduced sightlines to the existing controlled pedestrian crossing. An increase in shunts or overshoots may occur which may increase pedestrian collisions.

## CROSSBUSH JUNCTION

The existing carriageway alignment for Crossbush Junction is a signal controlled roundabout with three approach arms and one off-slip exit onto the A27 eastbound. The A27 eastbound entry is not signal controlled and the internal circulatory carriageway gives way to vehicles entering from the A27.

The proposed alignment (Figure 15-3) is partly grade separated and the A27 continues at ground level under the junction as a dual carriageway two lane road to a signal junction. Vehicles travelling south to north do so via a new bridge over the signal junction.

**Figure 15-3: Proposed layout for Crossbush Junction, Option 0A**




The A27 westbound has seven collisions on the approach to the Causeway roundabout, three of these are shunts. The introduction, of traffic signals and a new section of carriageway at ground level may increase vehicle speeds, which may result in shunts at the traffic signals beneath the bridge.

There is a short weaving length for vehicles travelling from east to west into the services. Vehicles travelling north to south are unopposed due to grade separation and drivers exiting from the westbound A27 heading south may not have sufficient gap-seeking opportunities. It is also an awkward angle for drivers to see over their shoulders to their right.

There are fewer opportunities to gap seek to turn right into the services as vehicles have to cross two lanes of traffic. The right turn pocket may not have sufficient capacity to contain turning vehicles and shunts may occur. Vehicles turning right out of the services may find their path blocked by vehicles queuing to turn right into the services.

The merge length on the northbound arm may not be sufficient for vehicles and side swipes may occur.

There is an existing farm access on the western side of the northbound arm. Slower moving farm vehicles may be forced to use extended lengths of the carriageway as the proposed alignment may stop them from taking the shortest route. Shunts and inappropriate overtaking collisions may result.

## OPTION 1

### ONLINE LINK ROAD IMPROVEMENTS FROM WEST OF BINSTED LANE TO FORD ROAD ROUNDABOUT.

The proposals to increase the existing road layout from single carriageway to dual carriageway with two lanes in each direction will increase the capacity of the road network, reducing congestion and queuing. The existing section of westbound A27 carriageway has a number of shunt collisions recorded, suggesting queuing at this location.

A number of turns in this section will be removed and junctions will be left in and left out only. Whilst the physical prevention of right turns will remove any associated collisions problems, it may migrate collisions to further along the network where turns are permissible or u-turns can be performed. The sightlines for properties and side roads that exit onto the A27 will need to be checked at the next design stage to ensure adequate visibility is maintained. In particular, the exit from the Arundel hospital sightlines will need to be checked in proximity to the proposed retaining wall.

Continuity for pedestrians will also need to be considered, in particular at locations where the footway ends and pedestrians cross the carriageway using existing refuges. The introduction of a two lane dual carriageway may increase the risks for pedestrians crossing the road.

### FORD ROAD ROUNDABOUT

The Ford Road roundabout proposals are as per Option 0a and all comments remain relevant in this proposal.

### NEW LINK ROAD FROM FORD ROAD ROUNDABOUT TO CROSSBUSH JUNCTION

The proposal to construct a new standard dual carriageway with two lanes in each direction link road from Fitzalan Road to Crossbush Junction will increase the network capacity.

However a single lane approach is still retained for the northwest bound approach over the River Arun. This requires the two lane approach to the signalised roundabout to merge into one lane which may result in shunts and side swipe collisions.

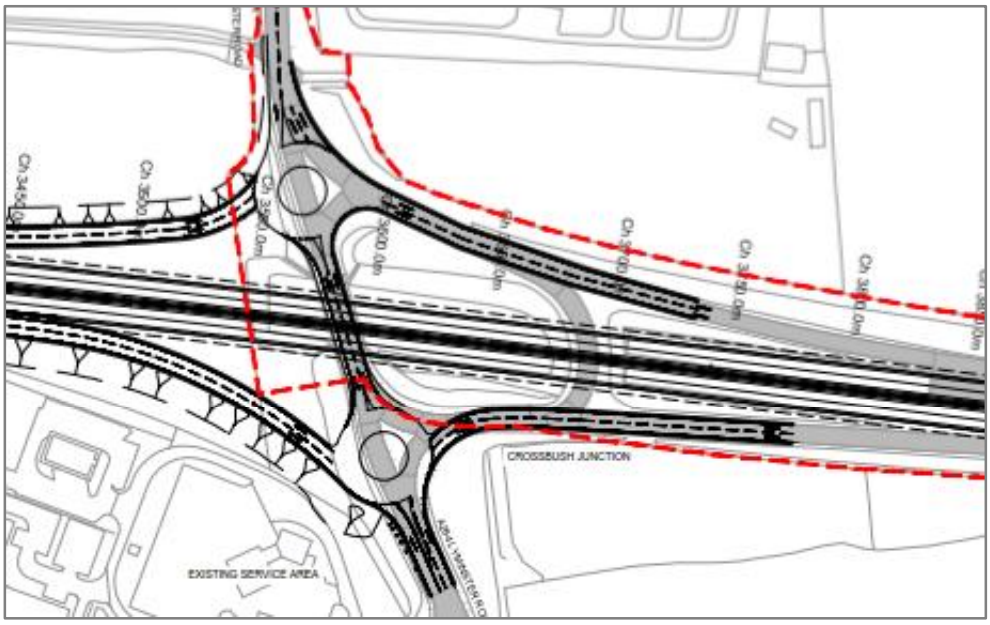
The horizontal and vertical alignment should be considered to ensure that speeds of vehicles are appropriate for joining in with the existing network.

### CROSSBUSH JUNCTION

The existing carriageway alignment for Crossbush Junction is a signal controlled roundabout with three approach arms and one off-slip exit onto the A27 eastbound. The A27 eastbound is not signal controlled and the internal circulatory carriageway gives way to oncoming traffic.

The proposed alignment (Figure 15-4) is a grade separated dumb bell roundabout and the A27 continues at ground level under the junction as a dual carriageway two lane road. Vehicles travelling south to north do so via a new bridge.

**Figure 15-4: Proposed layout for Crossbush Junction, Option 1**




The A27 westbound has seven collisions on the approach to the Causeway roundabout, three of these are shunts. With the introduction of a new westbound route, vehicles only need to use the slip roads to continue their north / south journey, resulting in fewer vehicles using this and reduced queue lengths.

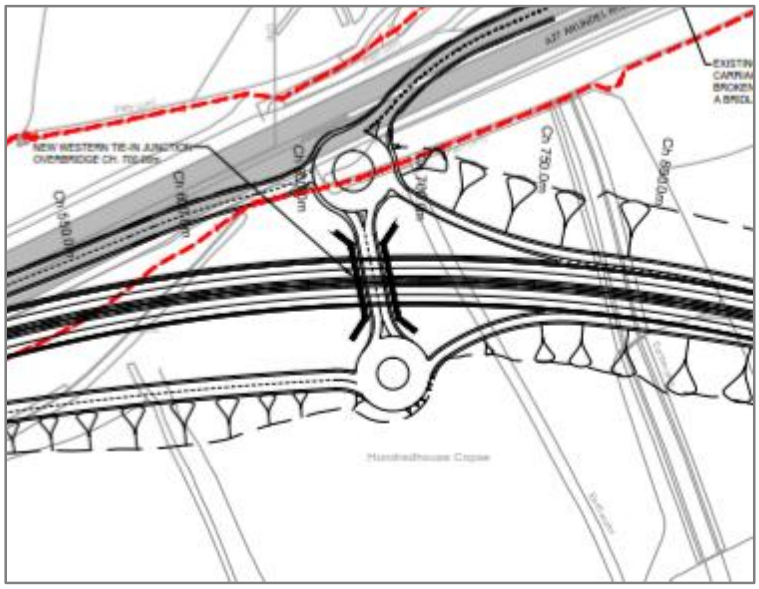
Pedestrians travelling north / south will be required to cross either the exit or entry slip to / from the A27. Both the entry and exit slips are two lanes and vehicles are likely to be approaching these at sufficient speed to make gap seeking for pedestrians to cross these arms difficult.

## OPTION 3 AND 5A

### NEW DUMB BELL ROUNDABOUT JUNCTION WITH A27 (NR YAPTON LANE)

Option 3 and 5A proposes a new offline carriageway between the A27 (east of Yapton Lane) to Crossbush Junction (Figure 15-5). The two new junctions where the offline carriageway re-joins with the existing A27 dual carriageway are both grade-separated with dumb bell roundabouts.

**Figure 15-5: Proposed layout for New Dumb Bell Roundabout, Option 5A**



Pedestrians travelling north / south will be required to cross either the exit or entry slip to / from the A27. Both the entry and exit slips are two lanes and vehicles are likely to be approaching these at sufficient speed to make gap seeking for pedestrians to cross these arms difficult.

The new link section between these two junctions crosses numerous Rights of Way and farm roads and alternatives are only proposed for some of these locations. Pedestrians and slow moving farm vehicles may find themselves on longer diversion routes and may try to take inappropriate short cuts. Slow moving farm vehicles may cause shunts or inappropriate overtaking manoeuvres.

### CROSSBUSH JUNCTION

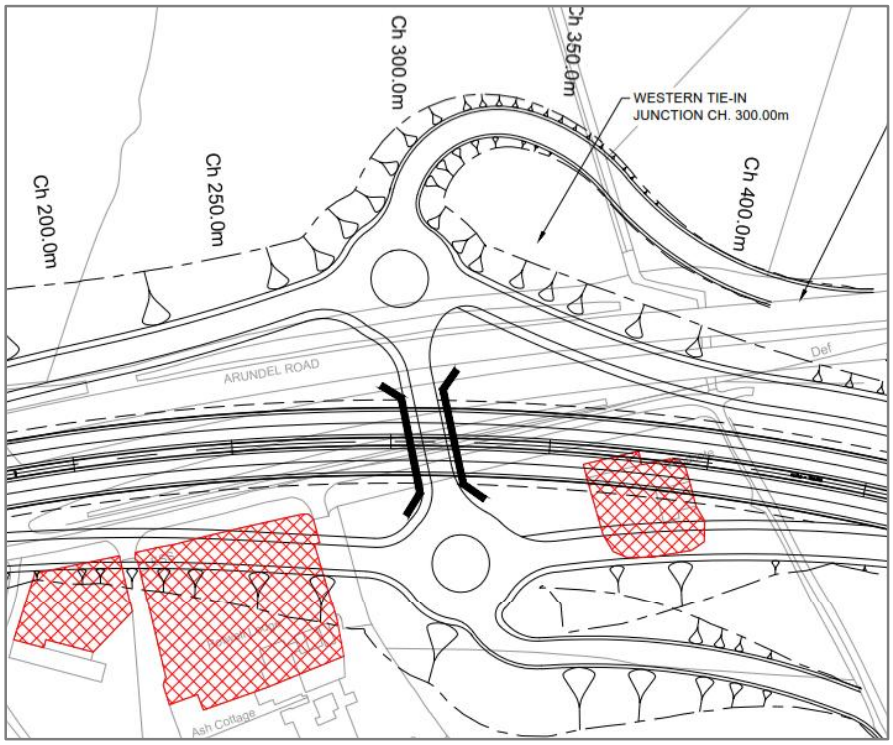
The Crossbush Junction proposals are as per Option 1 and all comments remain relevant in this proposal.

## OPTION 5B

### NEW GRADE-SEPARATED JUNCTION WITH A27 (NR TYE LANE)

Option 5B proposes a new offline carriageway between the A27 (west of Tye Lane) to Crossbush Junction (Figure 15-6). The two new junctions where the offline carriageway re-joins with the existing A27 dual carriageway are both grade-separated with dumb bell roundabouts.

**Figure 15-6: Proposed layout, Option 5B**




Pedestrians travelling north / south will be required to cross either the exit or entry slip to / from the A27. Both the entry and exit slips are two lanes and vehicles are likely to be approaching these at sufficient speed to make gap seeking for pedestrians to cross these arms difficult.

The new link section between these two junctions crosses numerous Rights of Way and farm roads and alternatives are only proposed for some of these locations. Pedestrians and slow moving farm vehicles may find themselves on longer diversion routes and may try to take inappropriate short cuts. Slow moving farm vehicles may cause shunts or inappropriate overtaking manoeuvres.

## CROSSBUSH JUNCTION

The Crossbush Junction proposals are as per Option 1, 3 and 5A and all comments remain relevant in this proposal.

## DEPARTURES AND RELAXATIONS

A number of departures and relaxations have been identified along the route in Options 1 and Option 5A/5B which involve the mainline vertical and horizontal geometry. No relaxations or departures have been associated with Stopping Sight Distances. It would be preferable to design these to standard and avoid the need for relaxations and departures, however it is understood that this may be necessary in some instances to provide environmental and / or cost benefits.

However, a combination in close proximity to each other may increase the safety concerns. The A27 is an east / west route and drivers vision may be affected by either the sun rise or sun setting, if this is in a combination with a series of alignment changes this may increase safety concerns.

Where relaxations have been justified by following the existing highway alignment, there may be increased risks due to increased speeds of vehicles. For instance, where the proposed design increases the carriageway to two lanes in each direction this may ease congestion and increase vehicle speeds, which may result in increased risks at existing substandard alignment changes on the network which may need to be mitigated.

There are also a number of relaxations on the approach to junctions which should be avoided if possible.

There are no departures identified for Option 0A, two departures identified in Option 1 and one departure identified for Option 5A. Option 5B is still to undergo a review for departures.

Option 1 first departure contains two elements which occur at the same location and involve substandard vertical curve and super-elevation on the approach to a junction which is understood to be tie into the existing highway network at a junction. This should be avoided if possible.

The second departure for Option 1 is a vertical gradient of 8.2% occurring instantaneous over a distance of 4m which is of no increased concern as it follows the existing road profile. It is unknown what the gradient is on the approaches to this 4m section and over what distance it covers, which may add to the impact of this departure.

Option 5A departure involves substandard vertical and horizontal curvatures where the proposals at the western extent of the scheme tie the existing highway network into the new dumb bell roundabout. This should be avoided if possible.

## 15.2 IMPACT DURING CONSTRUCTION AND OPERATION

### GENERAL

Assessment of safety related issues which may arise during construction and subsequent maintenance of the respective options has been carried out based on proposals shown on the options:

- Option 0A – Appendix C
- Option 1 – Appendix D
- Option 3 – Appendix E
- Option 5A - Appendix F
- Option 5B – Appendix G

The issues raised are from a high level review and include what are considered to be significant construction activities with risks to safety and exclude items which a competent contractor would be expected to deal with as part of day to day site management and his general health and safety related duties.

The results of the review are shown in tabular form below.

## OPTION 0A

| OPTION 0A – ALL SITES - GENERIC ISSUES | | |
|---|---|---|
| Drawing Numbers – HE551523–WSP–HGN–A27AR–DR–D-0101 to 0103 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Works in general | | Position of site access/egress will require careful consideration as numerous drains and ditches exist and there are residential properties. Major impact on surrounding roads and Arundel Town Centre through congestion, delays and increased air pollution.<br>Intensive Traffic management measures required with potential road /partial carriageway closures. Focus on worker safety especially with night working. |
| Works in general | Working on Roads with High Traffic Volumes | Intensive Traffic management measures required with potential road /partial carriageway closures. Focus on worker safety especially with night working. |
| Statutory Undertakers' Services | | Underground Services present along and across the existing alignment.<br>Risk of services not being to expected line and level which will involve unforeseen costs for diversions. |
| Construction noise and vibration | | Measures to reduce noise and vibration to safe levels as far as possible is needed to reduce nuisance to adjacent properties - to be taken at all times. |

| SITE – A27/FORD ROAD/CHICHESTER ROAD ROUNDABOUT – SPECIFIC ISSUES | | |
|---|---|---|
| Drawing Number – HE551523–WSP–HGN–A27AR–DR–D-0101 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Widening of roundabout circulatory area and junction approaches | | Access to central roundabout for construction plant and materials through heavy traffic flows will need specific planning. Safety could be increased by stockpiling as much plant and materials on island and working from island itself.<br>Certain established trees on the roundabout will likely be affected and need felling. Special H &S measures to be taken to ensure controlled felling operations. |
| Maintaining access to properties | | Safe access/egress arrangements required for Chalk Springs Trout Farm, Fly Fishery and bungalows. |

| SITE – ROUNDABOUT OF A27/THE CAUSEWAY AND NEW BRIDGE OVER RAILWAY AT ARUNDEL STATION – SPECIFIC ISSUES | | |
|---|---|---|
| Drawing Number – HE551523–WSP–HGN–A27AR–DR–D-0102 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| New pedestrian footway at south east end of bridge scheme, by access to Station Road | | Safety of any pedestrians using the existing verge will need to be safeguarded whilst new footway is constructed. Safe crossing points to be established further down from the site. |
| Maintaining access to properties | | Safe access/egress arrangements required for Chalk Springs Trout Farm, Fly Fishery and bungalows. |
| New Bridge deck | | If existing bridge is to be used for craning the new bridge deck in position, its safe load carrying capacity and condition must be determined in advance. |
| New and Existing Bridge Decks | Inspection and Maintenance of Bridge Structure including Soffit | Special rail based Health & Safety training and clearances required for construction staff.<br>Special training required for use of Mobile Elevated Working Platforms for below carriageway level structural inspections and maintenance activities. |

| SITE – JUNCTION OF A27/A284 LYMINSTER ROAD/THE CAUSEWAY (CROSSBUSH JUNCTION) | | |
|---|---|---|
| Drawing Number – HE551523–WSP–HGN–A27AR–DR–D-0103 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Support of existing road and bridge | | Adequate embankment and bridge support measures need to be applied to ensure no subsidence occurs to existing road and bridge whilst new on/off ramps to A27 dual carriageway are constructed. This also needs to be considered as part of the permanent works solution. |
| Headroom under existing bridge | | Special awareness of the presence of the bridge in relation to construction activities required. |
| Existing bridge over new ramps to A27 | Inspection and Maintenance of Bridge Structure including Soffit | Special Health & Safety training and clearances required for construction staff.<br>Special training required for use of mobile elevated workers platforms for below carriageway level structural inspections and maintenance activities. |
| Services Area south of junction | | Special consideration required to maintain safety and access for users of the services area. |

## OPTION 1

| OPTION 1 – ALL SITES - GENERIC ISSUES | | |
|---|---|---|
| Drawing Numbers – HE551523–WSP–VUT–A27AR–DR-Z-0501 to 0505 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Works in general | | Position of site access/egress will require careful consideration as numerous drains and ditches exist and there are residential properties. Major impact on surrounding roads and Arundel Town Centre through congestion, delays and increased air pollution. |
| Works in general | Working on Roads with High Traffic Volumes | Intensive Traffic management measures required with potential road /partial carriageway closures. Focus on worker safety especially with night working. |
| Statutory Undertakers' Services | | Underground and Overhead Services present along and across the existing alignment.<br>Risk of services not being to expected line and level which will involve unforeseen costs for diversions. |

| SITE – A27 OPTION 1 ARUNDEL BYPASS ONLINE ROUTE LINK CHAINAGE 0M TO 900M | | |
|---|---|---|
| Drawing Number – HE551523–WSP–VUT–A27AR–DR–Z-0501-0502 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Maintaining access to properties | | Measures to provide safe access/egress to all properties fronting the new alignment required at all times |
| Sightlines | Safe maintenance of sightlines | Attention to be paid to worker safety whilst working on left hand bend and potentially unsighted from vehicles travelling west. |

| SITE – A27 OPTION 1 ARUNDEL BYPASS ONLINE ROUTE LINK CHAINAGE 900M TO 1650M | | |
|---|---|---|
| Drawing Number – HE551523–WSP–VUT–A27AR–DR–Z-0502-0503 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Maintaining access to properties | | Measures to provide safe access/egress to all properties fronting the new alignment required at all times especially for Arundel District Hospital. |
| Construction noise and vibration | | Measures to reduce noise and vibration as far as possible to adjacent properties to be taken at all times. |

| SITE – A27/FORD ROAD/CHICHESTER ROAD ROUNDABOUT – SPECIFIC ISSUES | | |
|---|---|---|
| Drawing Number – HE551523–WSP–HGN–A27AR–DR–D-0101 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Widening of roundabout circulatory area and junction approaches | | Access to central roundabout for construction plant and materials through heavy traffic flows will need specific planning. Safety could be increased by stockpiling as much plant and materials on island and working from island itself.<br>Certain established trees on the roundabout will likely be affected and need felling. Special H &S measures to be taken to ensure controlled felling operations. |
| Maintaining access to properties | | Safe access/egress arrangements required for Chalk Springs Trout Farm, Fly Fishery and bungalows. |

| SITE – A27 OPTION 1 ARUNDEL BYPASS OFF LINE ROUTE LINK CHAINAGE 1846.7M TO 2550M | | |
|---|---|---|
| Drawing Number – HE551523–WSP–VUT–A27AR–DR–Z-0503-0504 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Widening of existing road bridge over River Arun | | Special attention to Health and Safety required in relation to working across the river including additional training for construction staff where deemed required. |
| Widening of existing road bridge over River Arun | Inspection and Maintenance of Bridge Structure including Soffit | Special Health and Safety training and clearances required for construction staff.<br>Special training required for use of mobile elevated workers platforms for below carriageway level structural inspections and maintenance activities. |
| Contaminated Land | | Investigation required to determine whether contaminated land is present along the alignment. |
| Construction over low lying land/greenfield sites | | Special attention to be given to load bearing capacity of subgrade prior to tracking by plant and personnel |
| Sightlines | | No adequate safety sightlines shown for the junction with Fitzalan Road. These need to be provided. |

| SITE – A27 OPTION 1 ARUNDEL BYPASS OFF LINE ROUTE LINK CHAINAGE 2550M TO 3450M | | |
|---|---|---|
| Drawing Number – HE551523–WSP–VUT–A27AR–DR–Z-0504-0505 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| New Road bridge over railway | | Special rail based Health & Safety training and clearances required for construction staff. |
| New Road bridge over railway | Inspection and Maintenance of Bridge Structure including Soffit | Special rail based Health & Safety training and clearances required for construction staff.<br>Special training required for use of mobile elevated workers platforms for below carriageway level structural inspections and maintenance activities. |
| Construction over low lying land/greenfield sites | | Special attention to be given to load bearing capacity of subgrade prior to tracking by plant and personnel |
| Contaminated Land | | Investigation required to determine whether contaminated land is present along the alignment. |

| SITE – JUNCTION OF A27/A284 LYMINSTER ROAD/THE CAUSEWAY (CROSSBUSH JUNCTION) | | |
|---|---|---|
| Drawing Number – HE551523–WSP–HGN–A27AR–DR–D-0103 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Support of existing road and bridge | | Adequate embankment and bridge support measures need to be applied to ensure no subsidence occurs to existing road and bridge whilst new on/off ramps to A27 dual carriageway are constructed. This also needs to be considered as part of the permanent works solution. |
| Headroom under existing bridge | | Special awareness of the presence of the bridge in relation to construction activities required. |
| Existing bridge over new ramps to A27 | Inspection and Maintenance of Bridge Structure including Soffit | Special Health & Safety training and clearances required for construction staff.<br>Special training required for use of mobile elevated workers platforms for below carriageway level structural inspections and maintenance activities. |
| Services Area south of junction | | Special consideration required to maintain safety and access for users of the services area. |

| SITE – JUNCTION OF A27/A284 LYMINSTER ROAD/THE CAUSEWAY (CROSSBUSH JUNCTION) CHAINAGE 3450M TO 3896.6M | | |
|---|---|---|
| Drawing Number – HE551523–WSP–VUT–A27AR–DR–Z-0505 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Headroom under services and existing bridge | | Special awareness of overhead services and the bridge in relation to construction activities required. |
| New section of dual carriageway passing through east side of existing junction | | This will require new on/off ramps to the A27 eastbound to be constructed prior to removal of the east side circulatory carriageway and excavation down to the lower through carriageway level. |
| Contaminated Land | | Investigation required to determine whether contaminated land is present along the alignment. |

## OPTION 3 / 5A / 5B

| OPTION 3/5A/5B – ALL SITES - GENERIC ISSUES | | |
|---|---|---|
| Drawing Numbers – HE551523–WSP–VUT–A27AR–DR-Z-0601 to 0604<br>HE551523-WSP-HGN-A27AR-DR-D-0701 to HE551523-WSP-HGN-A27AR-DR-D-0704 | | |
| Construction Safety Issue | Maintenance Safety Issue | Comments |
| Works in general | | Position of site access/egress will require careful consideration as numerous drains ditches and tracks exist.<br>Sites at each end of the scheme are likely to have major impact on surrounding roads and Arundel Town Centre through congestion, delays and increased air pollution |
| Works in general | Working on Roads with High Traffic Volumes | Intensive Traffic management measures required with potential road /partial carriageway closures. Focus on worker safety especially with night working. |
| Statutory Undertakers' Services | | Underground and Overhead Services present along and across the existing alignment.<br>Risk of services not being to expected line and level which will involve unforeseen costs for diversions. |
| Contaminated Land | | Investigation required to determine whether contaminated land is present along the alignment. |
| Construction over low lying land/greenfield sites | | Special attention to be given to load bearing capacity of subgrade prior to tracking by plant and personnel |
| Working amongst ditches and ponds | | Risk of waterborne diseases. Health and Safety awareness needs to be emphasised. |
| Headroom under overhead services | | Special awareness of overhead services in relation to construction activities required. |
| Public Right of Way (PROW) closed | | Potential local opposition to closure and diversionary route may affect safety at works site. |

The safety assessment will continue to be developed as the scheme progresses into later stages of development.

# 16 OPERATIONAL ASSESSMENT

## 16.1 INTRODUCTION

The existing A27 around Arundel suffers from traffic congestion due to a number of reasons, ranging from physical bottle necks due to the road alignment / junctions to congestion due to increased traffic levels during the summer 'tourist' periods or when there are events e.g. Goodwood Festival of Speed etc. The operation of the proposed options which include dualling would be significantly better than the existing, mainly because of the dualling of the carriageway but also due to the technology that can be incorporated into the scheme. Items such as VMS / CCTV / incident detection / weather stations etc. all help improve the operation of the proposed road, but these measures also help the carriageway recover quicker following any incident (CCTV allowing the RCC to view the incident and set the VMS to advise drivers of the situation and the best course of action to take, and also by viewing the incident, the correct / appropriate emergency / repair services can be notified and sent to the scene).

## 16.2 ROAD CHARACTERISTICS AND OPTION DESIGN IMPLICATIONS

### SCHEME OPERATING REGIME

The RCC can monitor traffic flows and conditions via the CCTV, traffic count sites and the LCCD (Low Cost Incident Detection- which will detect when vehicle speeds reduce or stop). With this information the RCC can use the VMS to influence driver behaviour and help manage any situation and speed up recovery of the network. The weather stations will provide notice of adverse conditions such as fog, high winds or freezing conditions, again allowing the RCC to set the VMS to inform drivers.

### DRIVER COMPLIANCE

Generally the schemes propose dualling of the carriageways, with some options also including grade separation. It is unlikely VMSL will be included in any of the proposals so there is little for drivers to comply with apart from the normal speed limits / general road rules. VMS should help with compliance for specific circumstances, eg lane closures due to road works or maintenance etc, and if spot speed cameras are provided, these will help restrain speeds to the speed limit, especially around the locations of the cameras.

## 16.3 LIGHTING

This subsection of the TAR[55] describes each of the route options in terms of what street lighting solutions could be employed. Each of the following route options has been assigned three lighting options; (i) Do Minimal, (ii) Do Something; and (iii) Do All. A recommendation is then made for each of the route options.

- Option 0A
- Option 1
- Option 3

[55] Technical Appraisal Report

- Option 5A
- Option 5B

It is noteworthy that The International Dark-Sky Association (IDA) named the South Downs National Park as the world's newest International Dark Sky Reserve in May 2016. The implications of this when designing lighting levels for the A27 Arundel Bypass options are clearly an important consideration.

All lighting would be to DMRB standards.

## ROUTE OPTIONS 0A AND 1

### OPTIONS

1- Relocate the existing street lighting equipment to accommodate the new junction alignment and complement with additional lighting columns as required to maintain the existing lighting standard.

2 - Design new street lighting scheme for new junction layout to TD34/07, BS5489-1:2013 and Institution of Lighting Professionals (ILP) PLG02 and Institution of Lighting Professionals Technical Report 12 (ILPTR12) - Lighting of pedestrian crossings.

### RECOMMENDATIONS

There is a potential issue with relocating the existing lighting equipment. Accurate photometric data will be required to produce calculations based on existing lanterns and optic settings.

### RECOMMENDED FUTURE ACTIONS

- Liaise with maintaining agent to determine lighting policy and equipment standards;
- Liaise with maintaining agent to determine accurate existing lighting equipment inventory details;
- Project Appraisal Report TA49/07 (lighting justification) if applicable;
- Passively safe risk assessment; and
- Review of environmental assessment report to establish presence of wildlife potentially affected by the introduction of street lighting or if SSSI[56].

## ROUTE OPTION 3

### OPTIONS

1 - Relocate the existing street lighting equipment to accommodate the new junction and carriageway alignments and complement with additional lighting columns as required to maintain the existing lighting standard. Design lighting at new junction and roundabouts at 'tie in'.

2 - Design new street lighting scheme for new junction layout to TD34/07, BS5489-1:2013 and ILP[57] PLG02.

[56] Site of Special Scientific Interest
[57] Institution of Lighting Professionals

It may be possible to provide no lighting between junctions. The offline section after the Crossbush Junction crosses open fields, unlit roads and/or unmade tracks and passes through a section of woodland. There is a potential for conflict with wildlife, particularly if there are bat roosts, maternity roosts or foraging routes in the vicinity as certain species can be adversely affected by the introduction of street lighting.

### RECOMMENDATIONS

Option 3 would entail undertaking a complete redesign in line with the new junction layout and in accordance with current lighting standards and guidance offers the opportunity to change the light source to LED[58] which would reduce energy costs, $CO_2$[59] emissions and future maintenance.

Due to the rural nature of the proposed offline route it would be classified as an E2 Environmental Zone (Low district brightness) for the purposes of street lighting. The general presumption is that street lighting should not be provided in Zone E2 areas unless the maintaining authority deems it in the best interest of the local community from either a road safety or a personal security point of view. The decision to provide lighting or not will be dependent on maintaining agents lighting policy,TA47/07 (lighting justification) and any relevant environmental impact report.

### RECOMMENDED FUTURE ACTIONS

- Liaise with maintaining agent to determine lighting policy and equipment standards;
- Liaise with maintaining agent to determine accurate existing lighting equipment inventory details;
- Project Appraisal Report TA49/07 (lighting justification) if applicable;
- Passively safe risk assessment;
- Review of environmental assessment report to establish presence of wildlife potentially affected by the introduction of street lighting or if SSSI[60]; and
- Consideration to be given as to the requirements for lighting pedestrian and/or vehicular underpasses. (BS5489-1:2013 7.4.7 Table 4).

## ROUTE OPTIONS 5A AND 5B

### OPTIONS

1 - Relocate the existing street lighting equipment to accommodate the new junction and carriageway alignments and complement with additional lighting columns as required to maintain the existing lighting standard. Design lighting at new junction and roundabouts at 'tie in'.

2 - Design new street lighting scheme for new junction layout to TD34/07, BS5489-1:2013 and ILP[61] PLG02.

It may be possible to provide no lighting between junctions. The offline section after the Crossbush Junction crosses open fields, unlit roads and/or unmade tracks and passes near to areas of woodland. There is a potential for conflict with wildlife, particularly if there are bat roosts, maternity roosts or foraging routes in the vicinity as certain species can be adversely affected by the introduction of street lighting.

[58] Light Emitting Diode
[59] Carbon Dioxide
[60] Site of Special Scientific Interest
[61] Institution of Lighting Professionals

### RECOMMENDED FUTURE ACTIONS

- Liaise with maintaining agent to determine lighting policy and equipment standards;
- Liaise with maintaining agent to determine accurate existing lighting equipment inventory details;
- Project Appraisal Report TA49/07 (lighting justification) if applicable;
- Passively safe risk assessment;
- Review of environmental assessment report to establish presence of wildlife potentially affected by the introduction of street lighting or if SSSI[62]; and
- Consideration to be given as to the requirements for lighting pedestrian and/or vehicular underpasses. (BS5489-1:2013 7.4.7 Table 4).

## 16.4 DRAINAGE ASSESSMENT

The purpose of this Section is to present findings of drainage asset condition study of section of the A27 Arundel bypass improvement and formulate drainage strategy for different options under consideration at PCF[63] stage 1.

The following works have been carried out to prepare this report:

- Desk study of existing drainage assets such as gullies, manholes, gravity flow pipe, channels, culverts, soakaways and outfall;
- Desk study of surface water, outfall and river flooding;
- Assess the impact on existing drainage system; and
- Formulate drainage strategies for different options under consideration.

### EXISTING GEOLOGY AND GEOTECHNICAL ASSESSMENT

Desk assessments of existing geology are exclusively based on geological survey maps and borehole scans provide by British Geological Survey website. The findings of the desk study are described below:

- The extent of area within option 0B is covered by London clay formation (clay, silt and sand), Lambeth group (clay, silt and sand) and chalk formation;
- The extent of area within option 0b alternative & option 1 is covered by London clay, Lambeth group & chalk formation; and
- The extent of area within option 3, option 5, option 5A and option 5B is covered by London clay formation & Lambeth group.

### GENERAL DRAINAGE STRATEGY FOR ONLINE OPTIONS

The proposed general drainage strategy for A27 Arundel Bypass section is:

- Positive drainage such as kerb and gully units and channels, which are the first point of drainage discharge, shall be relocated to edge of widened pavement. These assets need to

[62] Site of Special Scientific Interest
[63] Project Control Framework

be reconnected to the underground network which requires additional excavation till underground network;

- The peak discharge cannot be increased without the consent of LLFA[64] or EA[65]. Attenuation and flow control at outfall points to be proposed to maintain pre-development condition within project site; and
- Wherever possible, the drainage assets shall be retained to an extent. Underground pipes for CAT[66] 3, CAT 4 and CAT 5 defects shall be either replaced or repaired.

### OPTION 0A (ONLINE OPTION)

A desk assessment of existing and proposed road profile of widened carriageway has been carried out. A total of seven no. outfalls could be logically deduced along the stretch of road for existing and proposed carriageway. Further site investigation shall be required to verify the existing drainage assets identified through the desk study. The existing impermeable area for the existing A27 Arundel Bypass within project site is 7.4 ha. approximately. The proposed widening of A27 Arundel Bypass stretch shall increase impermeable paved area to 8.3 ha. approximately.

The existing catchment summary is tabulated below in Table 16-1.

**Table 16-1: Existing catchment summary for Option 0A**

| Catchment Extent | Hardened Paved Area (in ha.) | Verge Area (in ha.) (50% impermeable) | Total Impervious area (in ha.) |
|---|---|---|---|
| Catchment 1 | 0.8 | 0.0 | 0.8 |
| Catchment 2 (Ford Road Roundabout Area) | 1.5 | 0.2 | 1.7 |
| Catchment 3 | 0.1 | 0.0 | 0.1 |
| Catchment 4 (Causeway Roundabout Area) | 1.3 | 0.1 | 1.4 |
| Catchment 5 | 0.2 | 0.0 | 0.2 |
| Catchment 6 | 0.3 | 0.0 | 0.3 |
| Catchment 7 (Crossbush Junction Area) | 2.5 | 0.4 | 2.9 |
| **Total** | 6.7 | 0.7 | 7.4 |

The proposed catchment summary is tabulated below in Table 16-2:

**Table 16-2: Proposed catchment summary for Option 0A**

| Catchment Extent | Hardened Paved Area (in ha.) | Verge Area (in ha.) (50% impermeable) | Total Impervious area (in ha.) |
|---|---|---|---|
| Catchment 1 | 0.8 | 0.0 | 0.8 |
| Catchment 2 (Ford Road Roundabout Area) | 1.7 | 0.1 | 1.8 |
| Catchment 3 | 0.1 | 0.0 | 0.1 |
| Catchment 4 (Causeway Roundabout Area) | 1.5 | 0.1 | 1.6 |
| Catchment 5 | 0.2 | 0.1 | 0.3 |

[64] Lead Local Flood Authority
[65] Environment Agency
[66] Category

| Catchment Extent | Hardened Paved Area (in ha.) | Verge Area (in ha.) (50% impermeable) | Total Impervious area (in ha.) |
|---|---|---|---|
| Catchment 6 | 0.3 | 0.0 | 0.3 |
| Catchment 7 (Crossbush Junction Area) | 2.9 | 0.5 | 3.4 |
| **Total** | 7.5 | 0.8 | 8.3 |

Though proposed road profile closely matches with existing road profiles, there are significant changes at junctions and kerb edges along the corridor stretch.

The proposed drainage strategy for option 0A is summarised in Table 16-3:

**Table 16-3: Outfall impact assessment for Option 0A**

| Catchment Extent | Existing Impermeable Area (in ha.) | Proposed Impermeable Area (in ha.) | Additional Area which requires Attenuation (in ha.) | Remarks |
|---|---|---|---|---|
| Catchment 1 | 0.8 | 0.8 | 0.0 | As identified from HADDMS[67] data, seven existing gullies need to be relocated to the proposed kerb edge. Further site investigation would be required to ascertain the number of existing gully. Flow & Volume attenuation are not required as there is no change in additional paved area. |
| Catchment 2 (Ford Road roundabout Area) | 1.7 | 1.8 | 0.1 | As identified from HADDMS data, 53 existing gullies need to be relocated to the proposed kerb edge. Further site investigation would be required to ascertain the number of existing gully. Due to widening of junction, additional gullies will be required at junction kerb edge to maintain the flow width. Flow rate from additional paved area shall be attenuated to pre-development flow rate of 230 l/sec at single discharge point (Assuming peak rainfall intensity as 50mm/hr). Oversize pipes with flow control structures shall be proposed at outfall location to attenuate flow and volume. Further site investigation and basic engineering design data shall be required to ascertain the oversized attenuation pipe in place of existing pipes. |
| Catchment 3 | 0.1 | 0.1 | 0.0 | Existing drainage asset information not available on HADDMS. Google Street View Maps indicate presence of gullies as first point of discharge. Further site investigation shall be required. Existing gullies shall be relocated to proposed kerb edge. |

[67] Highways Agency Drainage Data Management System

| Catchment Extent | Existing Impermeable Area (in ha.) | Proposed Impermeable Area (in ha.) | Additional Area which requires Attenuation (in ha.) | Remarks |
|---|---|---|---|---|
| | | | |  |
| Catchment 4 (Causeway roundabout Area) | 1.4 | 1.6 | N/A | Existing drainage asset information not available on HADDMS. Google Street View Maps indicate presence of gullies as first point of discharge especially at junction. Further site investigation shall be required. Existing gullies, if any, shall be relocated to proposed kerb edge. Additional gullies might be required at junction due to proposed improvement. Flow rate from additional paved area shall be attenuated to pre-development flow rate of 190 l/sec at single discharge point (Assuming peak rainfall intensity as 50mm/hr). Oversize pipes with flow control structures shall be proposed at outfall location to attenuate flow and volume. Further site investigation and basic engineering design data shall be required to ascertain the oversized attenuation pipe in place of existing pipes.  |
| Catchment 5 | 0.2 | 0.3 | N/A | There is a deviation in proposed alignment corridor from existing alignment corridor. Drainage network has been proposed for proposed corridor. Further site investigation shall be required to assess the proposed outfall condition and structure. |
| Catchment 6 | 0.3 | 0.3 | 0.0 | |
| Catchment 7 | 2.9 | 3.4 | N/A | Junction is proposed to be modified significantly. Existing network details are insufficient. A number of gullies shall be required along this junction to maintain the flow width. A drainage network has been proposed for improvised |

| Catchment Extent | Existing Impermeable Area (in ha.) | Proposed Impermeable Area (in ha.) | Additional Area which requires Attenuation (in ha.) | Remarks |
|---|---|---|---|---|
| | | | | junction and shall discharge to existing pipe network at pre-development flow rate condition of 400 l/sec at single discharge point (Assuming peak rainfall intensity as 50mm/hr). Oversize pipes with flow control structures shall be proposed at outfall location to attenuate flow and volume. |

## GENERAL DRAINAGE STRATEGY FOR OFFLINE OPTIONS

The proposed drainage strategy for offline options is based on the following:

- Longitudinal and Vertical profile of the proposed road;
- Existing ground level;
- Cross section of the road;
- Existing and proposed structures;
- Approximate location of natural streams/ponds as per Google Maps; and
- Ordinary watercourses and ditches to be culverted.

### OPTION 1 (OFFLINE OPTION)

The alignment for Option 1 stretches from chainage 1846.7 to chainage 3896.6.

3 outfalls have been identified along the stretch of the road

The summary of individual catchment characteristic is tabulated below in Table 16-4:

**Table 16-4: Catchment characteristic summary for Option 1**

| Catchment extent (From Chainage-To Chainage) | 1846.7-1900 | 1900-3050 | 3050-3896.6 |
|---|---|---|---|
| Outfall location at chainage | Discharge to natural stream | 2050 | 3200 |
| Total contributing area | | 5.31 ha. | 3.39 ha. |
| Effective impervious area | | 4.07 ha. | 2.82 ha. |
| Peak rural outfall discharge rate (Based on 5 l/s/ha) | | 26.6 l/s ~ | 16.9 l/s ~ |
| Approximate storage required | | 2500 $m^3$ ~ | 1800 $m^3$ ~ |
| Existing ground level at proposed attenuation pond location | | 4.200 m ~ | 14.740 m ~ |
| Design road level at outfall chainage | | 3.095 m | 14.556 m |
| Sag level along the catchment extent | | 3.095 m | 13.798 m |
| Approximate pipe dia. at outfall location | | 750 mm | 600 mm |
| Proposed Invert Level | | 1.200 m ~ | 11.740 m ~ |
| Proposed attenuation pond depth | | 3.0 m ~ | 3.0 m ~ |

### OPTION 3 (OFFLINE OPTION)

The alignment for Option 3 stretches from chainage 0000 to chainage 5153.

3 outfalls have been identified along the stretch of the road.

The summary of individual catchment characteristic is tabulated below in Table 16-5:

**Table 16-5: Catchment characteristic summary for Option 3**

| CATCHMENT EXTENT (FROM CHAINAGE-TO-CHAINAGE) | 0000-1400 | 1400-2700 | 2700-3100 | 3100-4300 | 4300-5153 |
|---|---|---|---|---|---|
| Outfall location at chainage | 1400 | 2450 | 3100 | 3350 | 4500 |
| Total contributing area | 8.58 ha. | 6.62 ha. | 2.56 ha. | 5.90 ha. | 3.34 ha. |
| Effective impervious area | 6.12 ha. | 5.01 ha. | 1.78 ha. | 4.52 ha. | 2.79 ha. |
| Peak rural outfall discharge rate (based on 5 l/s/ha) | 42.9 l/s~ | 33.1 l/s~ | 12.8 l/s~ | 29.5 l/s~ | 16.7 l/s~ |
| Approximate storage required | 3700 $m^3$ | 3100 $m^3$ | 1100 $m^3$ | 2800 $m^3$ | 1800 $m^3$ |
| Existing ground level at proposed attenuation pond location | 20.330 m~ | 9.460 m~ | 1.600 m~ | 0.980 m~ | 13.625 m~ |
| Design road level at outfall chainage | 22.232 m | 8.908 m | 7.626 m | 4.083 m | 14.269 m |
| Sag level along the catchment extent | 22.232 m | 6.311 m | 7.626 m | 3.662 | 12.714 m |
| Approximate pipe dia. at outfall location | 900 mm | 600 mm | 375 mm | 900 mm | 525 mm |
| Proposed Invert Level | 17.330 m~ | 4.460 m~ | -0.400 m~ | -1.520 m~ | 10.625 m~ |
| Proposed attenuation pond depth | 3.0 m~ | 5.0 m~ | 2.0 m~ | 2.5 m~ | 3.0 m~ |

## OPTION 5A (OFFLINE OPTION)

The alignment for Option 5A stretches from chainage 0000 to chainage 6458.

8 outfalls have been identified along the stretch of the road.

The summary of individual catchment characteristic is tabulated below in Table 16-6:

**Table 16-6: Catchment characteristic summary for Option 5A**

| CATCHMENT EXTENT (FROM CHAINAGE-TO-CHAINAGE) | 0000 - 0400 | 0400 - 1750 | 1750 - 2500 | 2500 - 3000 | 3000 - 4000 | 4000 - 4400 | 4400 - 5600 | 5600 - 6458 | 5600 - 6944 |
|---|---|---|---|---|---|---|---|---|---|
| Outfall location at chainage | 0400 | 1750 | 2400 | 3000 | 3400 | 4350 | 4650 | 5800 | 5750 |
| Total contributing area | 1.10 ha. | 7.21 ha. | 4.98 ha. | 1.82 ha. | Proposed pumping station | 2.56 ha. | 5.90 ha. | 3.34 ha. | 3.34 ha. |
| Effective impervious area | 1.10 ha. | 5.37 ha. | 3.50 ha. | 1.82 ha. | | 1.78 ha. | 4.52 ha. | 2.79 ha. | 2.82 ha. |
| Peak rural outfall discharge rate (based on 5 l/s/ha) | 5.7 l/s~ | 32.1 l/s~ | 18.6 l/s~ | 6.2 l/s~ | | 12.8 l/s~ | 29.5 l/s~ | 16.7 l/s~ | 16.7 l/s~ |
| Approximate storage required | Pipe Storage | 3500 $m^3$ | 2500 $m^3$ | 1300 $m^3$ | | 1100 $m^3$ | 2800 $m^3$ | 1800 $m^3$ | 1800 $m^3$ |
| Existing ground level at proposed attenuation pond location | 22.150 m~ | 20.260 m~ | 11.680 m~ | 8.700 m~ | | 1.600 m~ | 0.980 m~ | 13.625 m~ | 13.840 m~ |
| Design road level at outfall chainage | 22.226 m | 23.052 m | 18.407 m | 9.663 m | | 7.626 m | 4.083 m | 14.269 m | 14.327 m |
| Sag level along the | 22.226 | 23.052 | 17.146 | 9.663 | | 7.626 | 3.662 | 12.714 | 13.786 |

| CATCHMENT EXTENT (FROM CHAINAGE-TO-CHAINAGE) | 0000 - 0400 | 0400 - 1750 | 1750 - 2500 | 2500 - 3000 | 3000 - 4000 | 4000 - 4400 | 4400 - 5600 | 5600 - 6458 | 5600 - 6944 |
|---|---|---|---|---|---|---|---|---|---|
| catchment extent | m | m | m | m | | m | m | m | m |
| Approximate pipe dia. at outfall location | 900 mm | 900 mm | 900 mm | 525 mm | | 375 mm | 900 mm | 525 mm | 525 mm |
| Proposed Invert Level | | 17.760 m~ | 9.746 m~ | 6.700 m~ | | -0.400 m~ | -1.520 m~ | 10.625 m~ | 11.340 m~ |
| Proposed attenuation pond depth | | 2.5 m~ | 3.5 m~ | 2.0 m~ | | 2.0 m~ | 2.5 m~ | 3.0 m~ | 2.5 m~ |

### OPTION 5B ALTERNATIVE (OFFLINE OPTION)

The alignment for Option 5B stretches from chainage 0000 to chainage 7352.

Where there are existing ordinary watercourses, the proposal is to culvert them under the road alignment, and divert where possible to reduce the number of culverts where practicable.

8 outfalls have been identified along the stretch of the road.

The summary of individual catchment characteristic is tabulated below Table 16-7:

**Table 16-7: Catchment characteristic summary for Option 5B**

| CATCHMENT EXTENT (FROM CHAINAGE-TO-CHAINAGE) | 0000 - 0600 | 0600 – 1300 | 1300 – 2200 | 2200 – 4400 | 4400 – 4850 | 4850 – 5300 | 5300 – 6500 | 6500 - 7352 |
|---|---|---|---|---|---|---|---|---|
| Outfall location at chainage | 0100 | 1300 | 2050 | 3600 | 4800 | 5250 | 5550 | 6700 |
| Total contributing area | 5.24 ha. | 2.23 ha. | 4.81 ha. | 12.33 ha. | 2.46 ha. | 2.16 ha. | 5.74 ha. | 4.12 ha. |
| Effective impervious area | 4.27 ha. | 2.03 ha. | 3.59 ha. | 9.03 ha. | 1.80 ha. | 1.67 ha. | 4.44 ha. | 3.14 ha. |
| Peak rural outfall discharge rate (based on 5 l/s/ha) | 26.3 l/s~ | 11.2 l/s~ | 24.1 l/s~ | 61.6 l/s~ | 12.3 l/s~ | 10.8 l/s~ | 28.7 l/s~ | 20.6 l/s~ |
| Approximate storage required | 4700 $m^3$ | 2900 $m^3$ | 4100 $m^3$ | 9900 $m^3$ | 1500 $m^3$ | 1500 $m^3$ | 3500 $m^3$ | 4700 $m^3$ |
| Existing ground level at proposed attenuation pond location | 24.435 m~ | 20.570 m~ | 13.000 m~ | 6.200 m~ | 4.470 m~ | 1.665 m~ | 1.550 m~ | 13.630 m~ |
| Design road level at outfall chainage | 24.436 m | 19.440 m | 10.356 m | 4.770 m | 10.428 m | 4.340 m | 3.126 m | 14.273 m |
| Sag level along the catchment extent | 24.314 m | 19.440 m | 9.481 m | 3.123 m | 9.373 m | 3.985 m | 3.126 m | 12.720 m |
| Approximate pipe dia. at outfall location | 450 mm | 600 mm | 600 mm | 900 mm | 450 mm | 375 mm | 900 mm | 600 mm |
| Proposed Invert Level | 21.685 m~ | 17.570 m~ | 8.500 m~ | 1.700 m~ | 2.470 m~ | -0.335 m~ | -0.450 m~ | 11.130 m~ |
| Proposed attenuation pond depth | 2.5 m~ | 3.0 m~ | 4.5 m~ | 4.5 m~ | 2.0 m~ | 2.0 m~ | 2.0 m~ | 2.5 m~ |

## 16.5 PAVEMENT DESIGN PARAMETERS

### INTRODUCTION

The existing condition of the pavement through the study area has been assessed in terms of material construction, SCRIM[68] surveys, deflectograph surveys and TRACS analysis. The results of this assessment are discussed in paragraph 4.4.

The various route options described at Section 12.2 have been designed in response to the findings of the existing conditions. In particular, consideration has been given to the optimal method of rehabilitating the existing pavement for the on-line options.

The paragraphs that follow detail the parameters that have been applied in the design of the options set out in Section 12.

### TRAFFIC CALCULATION

To ascertain the thickness of pavement construction required a set of traffic calculations to HD24/06 were undertaken. The results are given below.

As no requirement has been given for a design life for the final construction designs have been developed for 10, 20 and 40 years.

AADF[69] figures used have been gained from Department for Transport data available at http://www.dft.gov.uk/traffic-counts/. These values have been adjusted using growth figures from HD24/06 to a realistic year of opening figure for the purposes of the calculation.

### PAVEMENT REHABILITATION – ONLINE OPTIONS

Construction options have been developed using HD26/06 to provide the total thickness of new material required to achieve the design life based on the traffic value identified in the previous section of this report. The materials and thicknesses have been selected using BS 594987-2015.

For areas where the Deflectograph survey (discussed in Section 4.4) suggests a residual life of ≤10 years it is recommended that for an online option, the existing carriageway is removed to its full bound depth and replaced with the construction as detailed in Table 16-8. The existing foundation should be assessed and if necessary re-compacted to ensure sound construction of the bound pavement layers.

Where identified by the existing information and confirmed by in-situ investigation it may be possible to retain some of the existing pavement structure. It is recommended that a minimum thickness of 100mm inlay; comprising of 40mm surface course and 60mm binder course is applied to areas identified as suitable for inlay; dependent on layer configuration and material suitability.

### PAVEMENT REHABILITATION - OFF-LINE OPTIONS

The proposed off-line options detailed in Section 12.2 should be constructed with reference to values found in Table 16-8, depending on the design life requirement of the scheme.

[68] Sideways Force Coefficient Routine Investigation Machine
[69] Annual Average Daily Traffic Flow

## PAVEMENT REHABILITATION – TIE INS

Where the proposed new construction ties in to the existing carriageway the current construction must be confirmed by on site investigation and the new material stepped in by a minimum of 300mm per pavement layer. The thickness of material can be adjusted to match the existing layer thicknesses within the guidelines outlined in BS 594987-2015ity and current condition.

**Table 16-8: Adjusted AADF figures for traffic calculations**

| Design Life (Years) | Surface Course | Binder Course | Base Course 1 | Base Course 2 | Total Thickness |
|---|---|---|---|---|---|
| 10 | 40 mm TSCS[70] 10 | 60 mm AC[71] 20 dense or HDM[72] bin | 90 mm AC 32 dense or HDM base | 90 mm AC 32 dense or HDM base | 280 mm |
| | | 50 mm AC 20 dense or HDM bin | 50 mm AC 20 dense or HDM bin | 170 mm CBGM[73] B C8/10 | 310 mm |
| | 40 mm HRA[74]+ PCC[75] | 60 mm AC 20 dense or HDM bin | 90 mm AC 32 dense or HDM base | 90 mm AC 32 dense or HDM base | 280 mm |
| | | 50 mm AC 20 dense or HDM bin | 50 mm AC 20 dense or HDM bin | 170 mm CBGM B C8/10 | 310 mm |
| 20 | 40 mm TSCS 10 | 60 mm AC 20 dense or HDM bin | 100 mm AC 32 dense or HDM base | 100 mm AC 32 dense or HDM base | 300 mm |
| | | 50 mm AC 20 dense or HDM bin | 70 mm AC 32 dense or HDM base | 180 mm CBGM B C8/10 | 340 mm |
| | 40 mm HRA+ PCC | 60 mm AC 20 dense or HDM bin | 100 mm AC 32 dense or HDM base | 100 mm AC 32 dense or HDM base | 300 mm |
| | | 50 mm AC 20 dense or HDM bin | 70 mm AC 32 dense or HDM base | 180 mm CBGM B C8/10 | 340 mm |
| 40 | 40 mm TSCS 10 | 60 mm AC 20 dense or HDM bin | 120 mm AC 32 dense or HDM base | 120 mm AC 32 dense or HDM base | 340 mm |
| | | | 80 mm AC 32 dense or HDM base | 210 mm CBGM B C8/10 | 390 mm |
| | 40 mm HRA+ PCC | 60 mm AC 20 dense or HDM bin | 120 mm AC 32 dense or HDM base | 120 mm AC 32 dense or HDM base | 340 mm |
| | | | 80 mm AC 32 dense or HDM base | 210 mm CBGM B C8/10 | 390 mm |

## FOUNDATION THICKNESS – ALL OPTIONS

The following foundation thicknesses have been developed using IAN 73/06.

In this instance, as there has been no information provided regarding the condition of the subgrade, particularly the CBR[76] a set of designs based on the common bands of CBR values has been provided below in Table 16-9.

For the purposes of this scheme an unbound class 2 foundation has been used for the design.

[70] Thin surface course system
[71] Asphalt Concrete
[72] Highway Development Management
[73] Cement Bound Granular Mixture
[74] Hot Rolled Asphalt
[75] Portland Cement Concrete
[76] California Bearing Ratio

**Table 16-9: CBR design based on common bands**

| Sub-Base Only Design | | | Sub-Base + Capping Design | | |
|---|---|---|---|---|---|
| CBR Band | Sub-Base Thickness | Total Thicknes | Sub-Base Thickness | Capping Thickness | Total Thickness |
| ≤2.5% | 450 mm | 450 mm | 350 mm | 250 mm | 600 mm |
| >2.5% - ≤5% | 450 mm | 450 mm | 350 mm | 250 mm | 600 mm |
| >5% - ≤10% | 325 mm | 325 mm | 240 mm | 210 mm | 450 mm |
| >10% - ≤15% | 250 mm | 250 mm | 180 mm | 170 mm | 350 mm |
| >15% | 200 mm | 200 mm | 150 mm | 150 mm | 300 mm |

# 17 TECHNOLOGY ASSESSMENT

## 17.1 INTRODUCTION

This section of the TAR assesses each of the options in terms of the opportunity to utilise technology. It does so in terms of ITS systems, and also in terms of the RCC and associated systems.

## 17.2 OPTION DESIGN IMPLICATIONS FOR THE UTILISATION OF TECHNOLOGY:

### ITS SYSTEMS - TRAFFIC LOOPS, VMS, CCTV ETC

### OPTION 0A: EXISTING JUNCTION IMPROVEMENTS ONLY AND SHORT SECTION OF REALIGNED A27 NEAR ARUNDEL STATION

This option is limited to junction improvements at the existing three main junctions:

- Ford Road roundabout;
- Causeway roundabout; and
- Crossbush Junction.

Due to the proposals being focused at the junctions, there is very little scope to add ITS[77] measures to the remainder of the route which is primarily urban in nature.

### FORD ROAD ROUNDABOUT

A signal controlled roundabout is proposed for the interchange; see Figure 17-1 below:

[77] Intelligent Transport Systems

**Figure 17-1: Proposed Ford Road roundabout Traffic Signal controlled roundabout. Minor arm (N/E) not signalled.**

OPTIONS

### 0A (i) Do minimal

SIGNAL CONTROL - To operate safely the roundabout must operate under traffic signal control (VA[78] or FT[79]) to accommodate traffic and pedestrians / cyclists. This is considered the minimum ITS at this location, and it would be intended that traffic signals would utilise either local MOVA[80] control or centralised SCOOT[81] control on their network, in preference to VA or FT.

### 0A (ii) Do something

SIGNAL CONTROL, LINKED MOVA - The roundabout must operate under traffic signals, which should be controlled via 'linked MOVA'. MOVA is a high level traffic signal control strategy, which is much more efficient than 'vehicle actuation' (VA), and is a standard requirement on trunk roads (where another form of control hasn't been specifically requested). The detection for the junction will need to be via inductive loops cut into the carriageway. Pedestrian and cyclist facilities should be incorporated for the desire lines. This is true for all the traffic signal junctions along the route / options, so this will not be repeated for the other junctions.

### 0A (iii) Do all

CCTV - should be provided at several locations around the junction to allow monitoring of the traffic and operation of the traffic signals. As the signals will be MOVA controlled, it will not be possible to adjust the timings remotely, however their operation can be observed and the MOVA strategy amended accordingly (on site) if required. Ideally full coverage of the main approaches

[78] Vehicle Actuated
[79] Fixed Time
[80] Microprocessor Optimised Vehicle Actuation
[81] Split Cycletime Offset Optimisation Technique

will be provided and this can usually be achieved by mounting PTZ[82] cameras on columns within the central roundabout island. A detailed survey will be required to finalise the positioning. Ideally CCTV[83] communications will be via Fibre-Optic or ADSL[84] fixed line (if available at this location), but 3G mobile phone communications are possible with recent CCTV[85] compression / codecs, however the quality is not ideal and the recurring costs of mobile data service can be expensive.

VMS[86] should be installed on the main A27 and minor roundabout approaches to allow information to be provided to all drivers. If the A27 is problematic, drivers can be made aware upstream and may be encouraged to use an alternative route, helping the A27 recover quicker. Full colour matrix VMS like the Motorway MS4 sign are now available at smaller sizes (e.g. MS4R) and dot pitches suitable for lower speed and urban applications, whilst retaining much of the text and pictogram signage capability of the full size MS4 sign. Smaller full colour matrix urban VMS may be suited to locations where the speed limit is lower than Motorway speed. We believe these would comply with the VMS requirement for Expressways.

RECOMMENDATIONS

→ 0A (iii) – This option is recommended.

Option 0A (iii) CCTV and VMS would allow the RCC[87] to have full knowledge of the conditions / operation of the junction and to be able to change parameters as required to help improve the any situation as quickly and efficiently as possible. The junction would also comply with the minimum requirement for MOVA[88] control.

### CAUSEWAY ROUNDABOUT

The proposal here is to replace the roundabout with a traffic signal controlled, at grade 'T' junction, with pedestrian / cyclist facilities, see Figure 17-2 below:

[82] Pan Tilt Zoom
[83] Close Circuit Television
[84] Asymmetrical Digital Subscriber Line
[85] Closed Circuit Television
[86] Variable Message Signs
[87] Regional Control Centre
[88] Microprocessor Optimised Vehicle Actuation

**Figure 17-2: Proposed Causeway roundabout Traffic Signal controlled 'T' junction**

## OPTIONS

### 0A (i) Do minimal

To operate safely the 'T' junction must operate under traffic signal control. This is considered the minimum ITS at this location, but HE guidance states that traffic signals should utilise either MOVA[89] or SCOOT[90] control on their network.

Ideally the existing PUFFIN[91] should be removed as the proposal is to have pedestrian and cyclist facilities at the junction, and it is not advisable to have a controlled crossing close to a controlled junction. However, this would increase the distance pedestrians have to walk to the station, so it may be an unpopular move. Although not ideal, the crossing could be retained and physically linked to the traffic signals at the junction, to help ensure safe and efficient operation.

### 0A (ii) Do something

The 'T' junction must operate under traffic signals, which should be controlled via 'MOVA'. As mentioned for the Ford Road roundabout, MOVA is a high level traffic signal control strategy, which is much more efficient than VA[92], Pedestrian and cyclist facilities should be incorporated into the junction as required for the desire lines, but if necessary, the existing PUFFIN can be physically linked to the junction traffic signals.

### 0A (iii) Do all - In addition to the 'Do something' above,

CCTV should be provided at several locations around the junction to allow monitoring of the traffic and operation of the traffic signals. As the signals will be MOVA controlled, it will not be possible to adjust the timings remotely, however their operation can be observed and the MOVA strategy amended accordingly (on site) if required. Ideally full coverage of the main approaches will be

[89] Microprocessor Optimised Vehicle Actuation
[90] Split Cycletime Offset Optimisation Technique
[91] Pedestrian User Friendly Intelligent Crossing
[92] Vehicle Actuation

provided and this can usually be achieved by mounting PTZ[93] cameras on columns within the central roundabout island. A detailed survey will be required to finalise the positioning. Ideally CCTV[94] communications will be via Fibre-Optic or ADSL[95] fixed line (if available at this location), but 3G mobile phone communications are possible with recent CCTV compression / codecs, however the quality is not ideal and the recurring costs of mobile data service can be expensive.

VMS (Variable Message Signs) should be installed on the main and minor A27 approaches to allow information to be provided to all drivers. If the A27 is problematic, drivers can be made aware upstream and may be encouraged to use an alternative route, helping the A27 recover quicker. Full colour matrix VMS[96] like the Motorway MS4 sign are now available at smaller sizes (e.g. MS4R) and dot pitches suitable for lower speed and urban applications, whilst retaining much of the text and pictogram signage capability of the full size MS4 sign. Smaller full colour matrix urban VMS may be suited to locations where the speed limit is lower than Motorway speed. We believe these would comply with the VMS requirement for Expressways.

### RECOMMENDATIONS

→ 0A (iii) - This option is recommended.

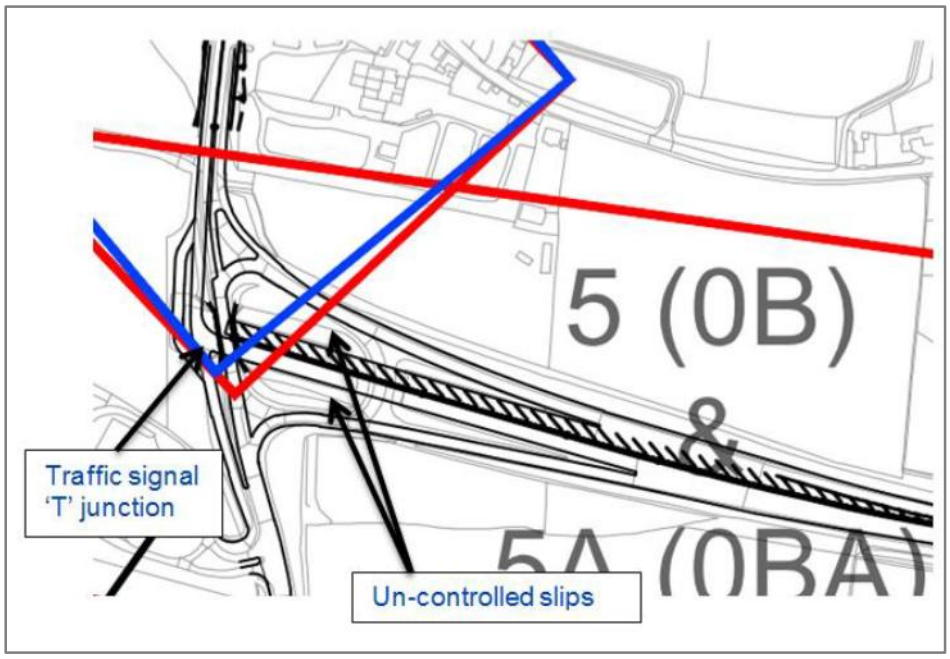
Option 0A (iii) CCTV and VMS would allow the RCC[97] to have full knowledge of the conditions / operation of the junction and to be able to change parameters as required to help improve the any situation as quickly and efficiently as possible. The junction would also comply with the minimum requirement for MOVA[98] control.

## CROSSBUSH JUNCTION

The proposal here is to replace the roundabout / gyratory, with a traffic signal controlled, at grade 'T' junction (restricted movements), with uncontrolled east bound access and south bound egress from the A27 east of the junction. See Figure 17-3 below.

[93] Pan Tilt Zoom
[94] Closed Circuit Television
[95] Asymmetric Digital Subscriber Line
[96] Variable Message Signs
[97] Regional Control Centre
[98] Microprocessor Optimised Vehicle Actuation

**Figure 17-3: Proposed Crossbush Junction (Traffic Signal controlled 'T' junction and uncontrolled slips)**




## OPTIONS

### 0A (i) Do minimal

To operate safely the 'T' junction must operate under traffic signal control. This is considered the minimum ITS[99] at this location.

### 0A (ii) Do something

The 'T' junction must operate under traffic signals, which should be controlled via 'MOVA'. As mentioned for the Ford Road roundabout, MOVA[100] is a high level traffic signal control strategy, which is much more efficient than 'vehicle actuation' (VA), Pedestrian and cyclist facilities could be incorporated into the junction if required for any desire lines, however they would still have to cross the un-controlled slip roads without signals.

### 0A (iii) Do all – In addition to the 'Do something' above,

CCTV should be provided at several locations around the junction to allow monitoring of the traffic and operation of the traffic signals. As the signals will be MOVA controlled, it will not be possible to adjust the timings remotely, however their operation can be observed and the MOVA strategy amended accordingly (on site) if required. Ideally full coverage of the main approaches will be provided and this can usually be achieved by mounting PTZ[101] cameras on columns within the central roundabout island. A detailed survey will be required to finalise the positioning. Ideally CCTV[102] communications will be via Fibre-Optic or ADSL[103] fixed line (if available at this

[99] Intelligent Transport System
[100] Microprocessor Optimised Vehicle Actuation
[101] Pan Tilt Zoom
[102] Closed Circuit Television

location), but 3G mobile phone communications are possible with recent CCTV compression / codecs, however the quality is not ideal and the recurring costs of mobile data service can be expensive.

VMS[104] should be installed on the main and minor A27 approaches to allow information to be provided to all drivers. If the A27 is problematic, drivers can be made aware upstream and may be encouraged to use an alternative route, helping the A27 recover quicker. Full colour matrix VMS like the Motorway MS4 sign are now available at smaller sizes (e.g. MS4R) and dot pitches suitable for lower speed and urban applications, whilst retaining much of the text and pictogram signage capability of the full size MS4 sign. Smaller full colour matrix urban VMS may be suited to locations where the speed limit is lower than Motorway speed. We believe these would comply with the VMS requirement for Expressways.

Reactive 'pedestrians ahead' signs - these could be provided to help make drivers on the uncontrolled slips aware that pedestrians are at the un-controlled crossing points ahead. These use standard pedestrian detectors to identify if pedestrians are present and then set signs to alert drivers.

### RECOMMENDATIONS

→ 0A (iii) - This option is recommended

Option 0A (iii) CCTV[105] and VMS would allow the RCC[106] to have full knowledge of the conditions / operation of the junction and to be able to change parameters as required to help improve the any situation as quickly and efficiently as possible. The junction would also comply with the minimum requirement for MOVA[107] control. The reactive signs would help pedestrian safety at the un-controlled slip roads.

### RECOMMENDED FUTURE ACTIONS

→ Incorporate all the measures detailed in Option 0A (iii) within the design.

→ Consult with the RCC and Local Authority on the proposals and clarify who will have control. This will influence the network design / architecture.

→ Ensure all equipment complies with the visibility and Passively Safe regulations / guidance etc.

## MAINLINE ROUTE CONSIDERATIONS

### OPTIONS

With this option the proposed works are only at the main junctions along the A27, so very little can be done along the rest of the route. The distance between the junctions is too large to allow for average speed camera enforcement (with the cameras located at the junctions only), however spot speed enforcement remains a possibility, especially at specific incident black-spots.

Due to the nature of this route and lack of kerbside space, provision of CCTV or VMS at set intervals along the unaltered route would seem in-appropriate.

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[103] Asymmetrical Digital Subscriber Line
[104] Variable Message Signs
[105] Closed Circuit Television
[106] Regional Control Centre
[107] Microprocessor Optimised Vehicle Actuation

### 0A (i) Do minimal

Limit the works to the junctions already discussed within this section, so nothing along the general route away from the junctions.

### 0A (ii) Do something

VMS[108] – As mentioned above, these should be provided for each of the junctions. They should be provided upstream of the main junction decision points and if possible at other strategic locations along the route. Well positioned VMS can provide significant benefits to the travelling public. Communications to the VMS can be either Fibre –Optic or ADSL[109] fixed line (if that facility is available at the locations) or by 3G mobile phone communications. VMS, unlike CCTV[110] is not bandwidth hungry or so much affected by data stream latency, so 3G communications with extra security is a viable control and monitoring method.

Spot speed enforcement placed at specific incident black-spots along the route.

### 0A (iii) Do all – In addition to 0A above,

Journey time monitoring could be provided, although only the three main junctions are to be modified, journey time information can be gathered at these junctions and possibly at a couple of points further along the A27 (either end) to help provide 'real time' information to drivers and also to the RCC[111] for monitoring / performance stats. Journey time information can be obtained by either ANPR[112] (expensive) or Bluetooth units (much more cost effective) and displayed on the VMS when no other higher priority information needs to be displayed. The Journey Time information can be transmitted back to the RCC via 3G mobile phone communications as there isn't a NRTS[113] communications link to this area. ANPR based journey time monitoring is more accurate and gathers information on many more vehicles and therefore provides better results, however it is much more expensive to install and run. Bluetooth journey time monitoring is now widely used as it generally gathers sufficient information to provide reliable journey time information, but without the high initial and on-going costs.

Meteorological outstations - As the route runs parallel and close to the coast, fog can be a problem. Meteorological equipment can detect this (and other factors, high winds for example) and prompt RCC staff to consider setting VMS to warn of the conditions. They are also useful when deciding if there is a requirement to use salt along a route due to freezing conditions. As there will be a need for communications and power at the journey time monitoring sites, these would also be ideal locations for co-locating Meteorological outstations.

RECOMMENDATIONS

- → 0A (i) - Works at the junctions are an integral part of the scheme.
- → 0A (ii) - The provision of CCTV and VMS is strongly recommended as these will help provide valuable benefits for the travelling public.
- → 0A (iii) - This is the preferred option, adding meteorological outstations and journey time gathering equipment will complement the measures in 0A (ii) – CCTV and VMS.

[108] Variable Messaging Signs
[109] Asymmetrical Digital Subscriber Line
[110] Closed Circuit Television
[111] Regional Control Centre
[112] Automated Number Plate Recognition
[113] National Roads Telecommunication Service

→ Recommended future action incorporate all the measures suggested in Option 0A (iii) into the scheme.

OPTIONS

### Option 1– part on / part off-line dualling

This option will provide a new grade separated junction at Crossbush, and D2AP[114] (Dual 2-lane All Purpose) from the Crossbush Junction to the existing dual carriageway to the west of Arundel Cricket Club. There is a single at grade roundabout at Ford Road, Arundel, where the existing five arm roundabout is located. As works are proposed along the full route, it will be possible to incorporate many 'Expressway' compliant measures.

### FORD ROAD ROUNDABOUT

A signal controlled roundabout is proposed for the interchange, see Figure 17-4 below.

**Figure 17-4: Proposed Ford Road roundabout (Traffic Signal controlled roundabout. Minor arm in the north east not signalled)**

OPTIONS

### 1 (i) Do minimal

SIGNAL CONTROL - To operate safely the roundabout must operate under traffic signal control (VA[115] or FT[116]) This is considered the minimum ITS at this location.

[114] Dual Carriageway Two Lame Rural All Purpose
[115] Vehicle Actuated
[116] Fixed Time

### 1 (ii) Do something

SIGNAL CONTROL, LINKED MOVA[117] - The roundabout must operate under traffic signals, which should be controlled via 'linked MOVA'.

### 1 (iii) Do all

CCTV[118] - should be provided at several locations around the junction to allow monitoring of the traffic and operation of the traffic signals. Full coverage can usually be achieved by mounting PTZ[119]cameras on columns within the central roundabout island. Ideally CCTV communications will be via Fibre-Optic or ADSL[120] fixed line (if available at this location), but 3G mobile phone communications are possible.

VMS[121] should be installed on the main A27 and minor roundabout approaches to allow information to be provided to all drivers

RECOMMENDATIONS

→ 1 (iii) – This option is recommended.

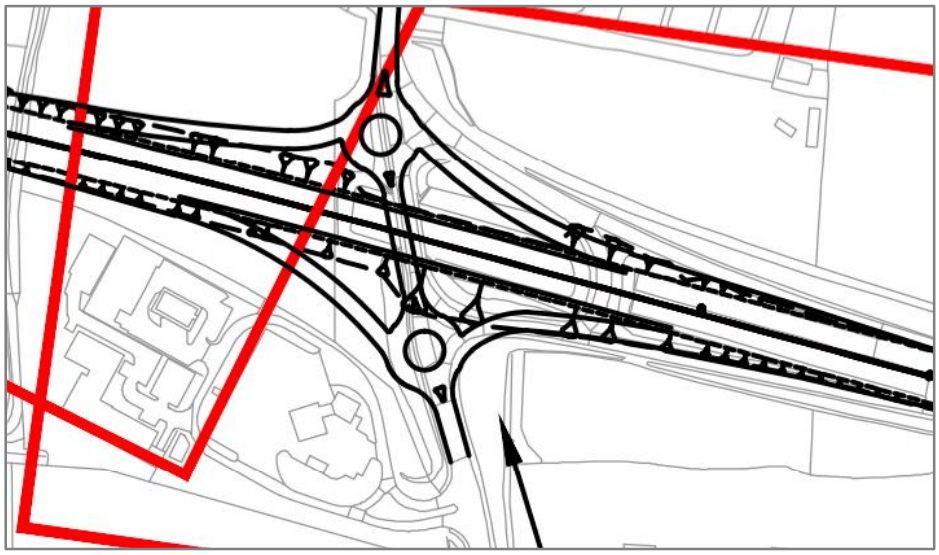
Option 1 (iii) CCTV and VMS would allow the RCC[122] to have full knowledge of the conditions / operation of the junction and to be able to change parameters as required to help improve the any situation as quickly and efficiently as possible. The junction would also comply with the minimum requirement for MOVA control.

### CROSSBUSH JUNCTION

A grade separated 'dumb bell' junction is proposed to replace the partially signalised gyratory. This will allow A27 traffic much better progression through the interchange. See Figure 17-5 below.

[117] Microprocessor Optimised Vehicle Actuation
[118]Closed Circuit Television
[119] Pan Tilt Zoom
[120] Asymmetric Digital Subscriber Line
[121] Variable Message Signs
[122] Regional Control Centre

**Figure 17-5: Proposed Dumbbell roundabout, Crossbush Junction**



OPTIONS

### 1 (i) Do minimal

The interchange could operate without any ITS[123].

### 1 (ii) Do something

Provide VMS[124] upstream on the A284 and old A27 approaches to provide drivers with information about the conditions on the A27. At this time it is likely information will only be available for the A27 to the west. If the A27 is problematic, drivers can be made aware upstream and may be encouraged to use an alternative route, helping the A27 recover quicker. Full colour matrix VMS like the Motorway MS4 sign are now available at smaller sizes (e.g. MS4R) and dot pitches suitable for lower speed and urban applications, whilst retaining much of the text and pictogram signage capability of the full size MS4 sign. Smaller full colour matrix urban VMS may be suited to locations where the speed limit is lower than Motorway speed. We believe these would comply with the VMS requirement for Expressways.

### 1 (iii) Do all

In addition to the 'Do something' above, CCTV[125] should be provided at the junction to allow monitoring of the traffic. Ideally full coverage of the main approaches will be provided and this can usually be achieved by mounting PTZ[126] cameras on columns within the central roundabout island. A detailed survey will be required to finalise the positioning. Ideally CCTV communications will be via Fibre-Optic or ADSL[127] fixed line (if available at this location), but 3G mobile phone communications are possible with recent CCTV compression / codecs, however the quality is not ideal and the recurring costs of mobile data service can be expensive.

[123] Intelligent Transport Systems
[124] Variable Message Signs
[125] Closed Circuit Television
[126] Pan Tilt Zoom
[127] Asymmetrical Digital Subscriber Line

RECOMMENDATIONS

→ 1 (ii) – This option should be considered.

→ 1 (iii) – This option is recommended.

Option 1 (iii) this would satisfy HE[128] Expressway guidance for both VMS[129] and CCTV[130] coverage of the carriageway.

RECOMMENDED FUTURE ACTIONS

→ Incorporate all the measures detailed in Option 1 (iii) within the design.

→ Ensure all equipment complies with the visibility and Passively Safe regulations / guidance etc.

**MAINLINE ROUTE CONSIDERATIONS**

As significant works are proposed along the full length of the A27 (relating to this project) it will be possible to install many features of the 'Expressway', as detailed below. However the assumption is that ERA[131] will not be provided on the existing section of dual carriageway, they will only be provided on the new sections of D2AP[132].

OPTIONS

**1 (i) Do minimal**

No additional ITS[133] is provided along the route apart from at the signal controlled roundabout discussed above.

**1 (ii) Do something**

Comprehensive CCTV coverage should be provided along the route. If ERA's are spaced at 2.5km intervals it is likely that cameras placed at the ERA's would have adequate range to provide full coverage, subject to survey. If ERA's are not provided for the existing dual carriageway section then dedicated CCTV will be required along with suitable communications.

Provide VMS along the route and at strategic upstream locations on the approaches to the A27 to provide drivers with information about the conditions on the A27. At this time it is likely information will only be available for the A27 to the west. If the A27 is problematic, drivers can be made aware upstream and may be encouraged to use an alternative route, helping the A27 recover quicker. Full colour matrix VMS like the Motorway MS4 sign are now available at smaller sizes (e.g. MS4R) and dot pitches suitable for lower speed and urban applications, whilst retaining much of the text and pictogram signage capability of the full size MS4 sign. Smaller full colour matrix urban VMS may be suited to locations where the speed limit is lower than Motorway speed. We believe these would comply with the VMS requirement for Expressways.

[128] Highways England
[129] Variable Message Signs
[130] Closed Circuit Television
[131] Emergency Refuge Area
[132] Dual Carriageway Two Lane Rural All Purpose
[133] Intelligent Transport Systems

### 1 (iii) Do all – in addition to the measures in 1(ii) above,

Consider providing VMSL[134], this usually requires gantries and regular signing / cameras along the route which have a negative visual impact. Average speed enforcement cameras are much less intrusive, however they don't allow for varying the speed limit and don't provide any congestion management or stopped vehicle warning (both of which are required on Expressways). For compliance with 'Expressways', consideration should be given to including VMSL[135] in preference to average speed enforcement. Currently this requires overhead gantries for the cameras and signing, but there are trials underway that utilise verge mounted cameras (covering all lanes) and signing.

It is understood ERA[136]'s will be provided along at least the new part of the route, the Expressway guidance is for these to be areas where the ITS equipment is located if possible, as the ERA provides a safe place for maintenance vehicles and as the ERA's will require power and communications, they are ideal for any equipment which also requires power and communications.

Journey time and meteorological monitoring equipment should be placed strategically along the route to ensure adequate coverage, again, if ERA's are to be provided then this equipment can be co-located close to them as advised in the Expressway guidance.

Provision of Above Ground Detection system – we have assumed this is referring to a system that will feed into MIDAS[137] and provide information on vehicles speeds / flows / queue detection etc. Currently there are no systems approved however the 'Wavetronics' digital radar system is undergoing trials and expected to be the only system recommended. It is expected this will require radar units to be placed approximately every 500m and power and communications will be required at these locations.

LCCD[138] - There is an alternative solution (to the Wavetronics – MIDAS mentioned above) however it only provides congestion detection and is expected to feed into CHARM[139] rather than MIDAS. LCCD uses a solar powered radar detector mounted on a short pole (possibly a marker post for example) to scan the nearside lane for slow moving vehicles, which signal the on-set of congestion. As they use wireless communications there is no need for any ducting etc, making them very cost effective. It is expected they will need to be positioned every 1km, with one each side of the carriageway. LCCD would be ideal for the existing section of dual carriageway where little work is expected to take place.

RECOMMENDATIONS

→ 1 (ii) – This option should be considered.

→ 1 (iii) – This option is recommended.

Option 1 (i) would not comply with HE Expressway guidance.

**Option 1 (ii) this would satisfy the HE Expressway guidance relating to VMS's only.**

[134] Variable Mandatory Speed Limit
[135] Variable Mandatory Speed Limit
[136] Emergency Refuge Area
[137] Motorway Incident Detection and Automatic Signalling
[138] Low Cost Congestion Detection
[139] Common Highways Agency Rijkswaterstaat Model

**Option 1 (iii) this would satisfy HE Expressway guidance for both VMS and CCTV[140] coverage of the carriageway.**

RECOMMENDED FUTURE ACTIONS

- → Incorporate all the measures detailed in Option 1 (iii) within the design.
- → Ensure all equipment complies with the visibility and Passively Safe regulations / guidance etc.

### Option 3, 5A and 5B – off-line dualling

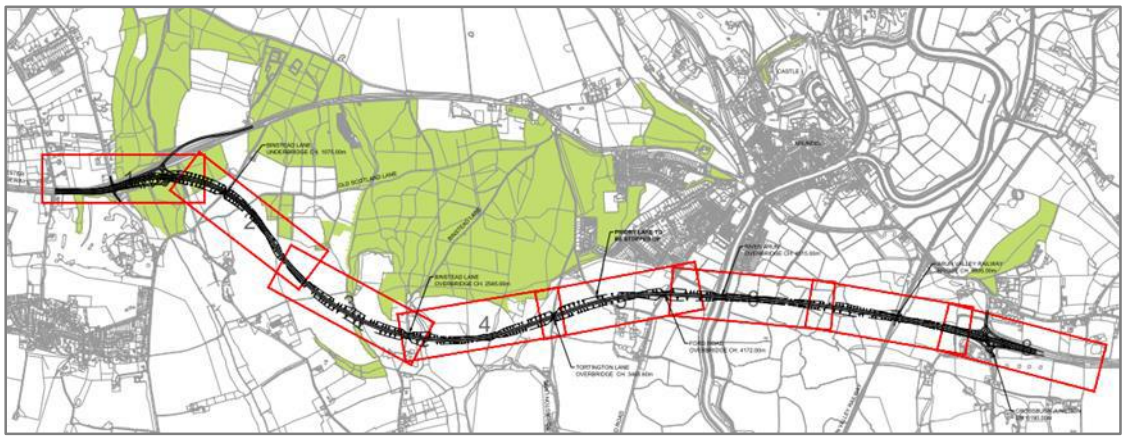
These options will provide a new 'dumb-bell' grade separated junction at Crossbush, and D2AP[141] from the Crossbush Junction to the existing dual carriageway close to Binsted. Access / egress to the old A27 will be accommodated by another 'dumb-bell' grade separated junction. The junctions at either end are the same, but the alignment of 5A and 5B are different.

Options 3 and 5 are similar as they start with the same 'dumb-bell' grade separated junction at Crossbush. Option 5 terminates at the same Binsted location with the 'dumb-bell' grade separated junction but shares the start of the route with Option 3. Option 3 is shorter, terminating closer to Arundel at the Havenwood Park area.

As works are proposed along the full route, it will be possible to incorporate many 'Expressway' compliant measures.

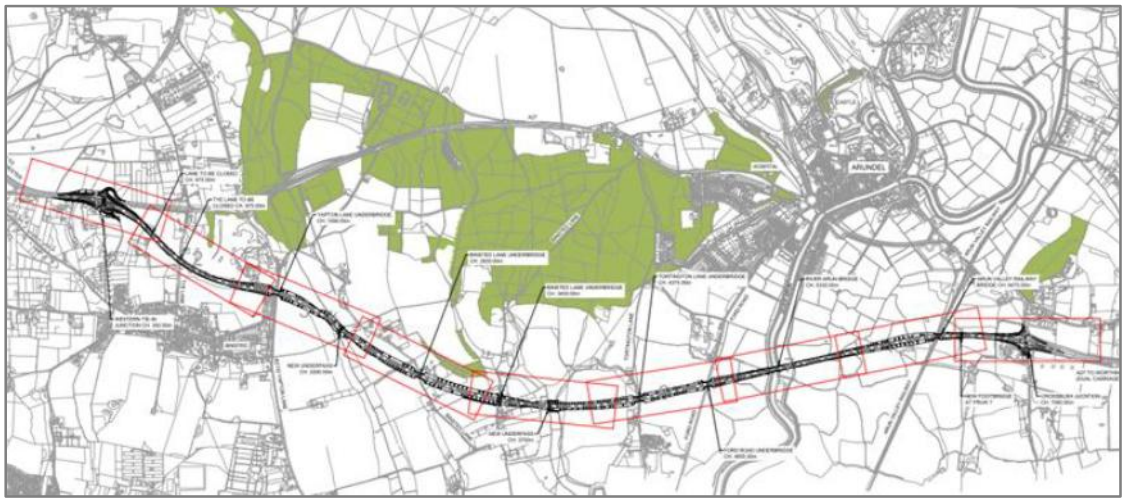
Option 5A and 5B shown respectively in Figure 17-6 and Figure 17-7 start and finish at the same locations but 5B is slightly further south, 5A shown above, 5B below.

**Figure 17-6: Option 5A route**



[140] Closed Circuit Television
[141] Dual Carriageway Two Lane Rural All Purpose

**Figure 17-7: Option 5B route**



OPTIONS

### 5A/5B (i) Do minimal

No ITS[142] is provided along the route.

### 5A/5B (ii) Do something

Comprehensive CCTV[143] coverage should be provided along the whole route. If ERA's[144] are spaced at 2.5km intervals it is likely that cameras placed at the ERA's would have adequate range to provide full coverage, subject to survey.

Provide VMS[145] along the route and at strategic upstream locations on the approaches to the A27 to provide drivers with information about the conditions on the A27.

### 5A/5B (iii) Do all – in addition to the measures in 5A/5B (ii) above,

Consider providing VMSL[146], this usually requires gantries and regular signing / cameras along the route which have a negative visual impact. Average speed enforcement cameras are much less intrusive, however they don't allow for varying the speed limit and don't provide any congestion management or stopped vehicle warning (both of which are required on Expressways). For compliance with 'Expressways', consideration should be given to including VMSL in preference to average speed enforcement. Currently this requires overhead gantries for the cameras and signing, but there are trials underway that utilise verge mounted cameras (covering all lanes) and signing.

It is understood ERA's will be provided along the route, the Expressway guidance is for these to be areas where the ITS[147] equipment is located if possible, as the ERA provides a safe place for

[142] Intelligent Transport Systems
[143] Closed Circuit Television
[144] Emergency Refuge Area
[145] Variable Message Signs
[146] Variable Mandatory Speed Limit
[147] Intelligent Transport Systems

maintenance vehicles. As the ERA's will require power and communications, they are ideal for any equipment which also requires power and communications.

Journey time and meteorological monitoring equipment should be placed strategically along the route to ensure adequate coverage. Again, they should be located around the ERA's as advised in the Expressway guidance.

Provision of Above Ground Detection system – we have assumed this is referring to a system that will feed into MIDAS[148] and provide information on vehicles speeds / flows / queue detection etc. Currently there are no systems approved however the 'Wavetronics' digital radar system is undergoing trials and expected to be the only system recommended. It is expected this will require radar units to be placed approximately every 500m and power and communications will be required at these locations.

LCCD[149] - There is an alternative solution (to the Wavetronics – MIDAS mentioned above) however it only provides congestion detection and is expected to feed into CHARM[150] rather than MIDAS. LCCD uses a solar powered radar detector mounted on a short pole (possibly a marker post for example) to scan the nearside lane for slow moving vehicles, which signal the on-set of congestion. As they use wireless communications there is no need for any ducting etc, making them very cost effective. It is expected they will need to be positioned every 1km, with one each side of the carriageway. LCCD would be ideal for the existing section of dual carriageway where little work is expected to take place.

### RECOMMENDATIONS

- → 5A/5B (ii) – This option should be considered.
- → 5A/5B (iii) – This option is recommended.

Option 5A/5B (i) would not comply with HE[151] Expressway guidance.

**Option 5A/5B (ii) this would satisfy the HE Expressway guidance relating to VMS's[152] only.**

**Option 5A/5B (iii) this would satisfy HE Expressway guidance for both VMS and CCTV[153] coverage of the carriageway**.

### RECOMMENDED FUTURE ACTIONS

- → Incorporate all the measures detailed in Option 5A/5B (iii) within the design.
- → Ensure all equipment complies with the visibility and Passively Safe regulations / guidance etc.

[148] Motorway Incident Detection and Automatic Signalling
[149] Low Cost Congestion Detection
[150] Common Highways Agency Rijkswaterstaat Model
[151] Highways England
[152] Variable Messaging Signs
[153] Closed Circuit Television

## 17.3 RCC SYSTEMS AND SUB SYSTEMS & COMMUNICATIONS NETWORK

### OPTION 0A: EXISTING JUNCTION IMPROVEMENTS ONLY

#### FORD ROAD ROUNDABOUT

##### 0A (II) DO SOMETHING

MOVA[154] controlled junctions do not require frequent communication to a central control system as would be the case for SCOOT[155]. If available, a PSTN[156] line can be used or alternatively a 3G mobile phone connection can be used for remote traffic signal controller interrogation. The traffic signal controller should be connected to a RMS[157] or FMS[158] for remote interrogation and automatic fault reporting, this could be in the RCC[159] or local authority depending on who will be responsible for the maintenance / operation of the traffic signals.

#### CAUSEWAY ROUNDABOUT

##### 0A (II) DO SOMETHING

As for the Ford Road roundabout, MOVA controlled junctions do not require frequent communication to a central control system so a PSTN line or 3G mobile phone connection can be used for remote traffic signal controller interrogation and fault monitoring purposes on the RMS / FMS.

#### CROSSBUSH JUNCTION

##### 0A (II) DO SOMETHING

As for the Ford Road roundabout, MOVA controlled junctions do not require frequent communication to a central control system so a PSTN line or 3G mobile phone connection can be used for remote traffic signal controller interrogation and fault monitoring purposes on the RMS / FMS.

### OPTION 1– PART ON / PART OFF-LINE DUALLING

#### FORD ROAD ROUNDABOUT

##### 1 (II) DO SOMETHING

A PSTN line or 3G mobile phone connection can be used. The traffic signal controller should be connected to a RMS or FMS.

[154] Microprocessor Optimised Vehicle Actuation
[155] Split Cycletime Offset Optimisation Technique
[156] Public Switched Telephone Network
[157] Remote Monitoring System
[158] Fault Management System
[159] Regional Control Centre

### GENERAL ROUTE

#### 1 (II) DO SOMETHING

COMMUNICATIONS – (new dual section) a Fibre-Optic cable network can be installed along the new D2AP part of the scheme as the Expressway standard backbone communications infrastructure. All the ITS related equipment would be attached to this fibre backbone (CCTV / VMS / traffic signals / journey time monitoring / pollution + weather monitors etc). However, this fibre-optic network segment would be in isolation from the main HE (NRTS) national network. As there aren't any other NRTS communications links to the RCC locally, a dedicated backhaul link will need to be provided, this could probably be a BT service (or similar) as they will already have infrastructure in the area. BT can provide secure, private lines, however they can be expensive. The A27 fibre-optic network segment and linking this to the main network will necessarily need involve NRTS[160] in its planning, procurement and commissioning, and 'Code of Connection' issues must be complied with.

It is assumed a fibre network will not be provided along the existing dual A27 section so communications for the ITS equipment will need careful consideration. NRTS will need to be involved with this aspect.

## OPTION 5A AND 5B – OFF-LINE DUALLING

### GENERAL ROUTE

#### 5A/5B (II) DO SOMETHING

A Fibre-Optic cable network can be installed along the new D2AP[161] as the Expressway standard backbone communications infrastructure. All the ITS related equipment would be attached to this fibre backbone (CCTV[162] / VMS[163] / traffic signals / journey time monitoring / pollution + weather monitors etc). However, this fibre-optic network segment would be in isolation from the main HE[164] (NRTS) national network. As there aren't any other NRTS communications links to the RCC[165] locally, a dedicated backhaul link will need to be provided, this could probably be a BT service (or similar) as they will already have infrastructure in the area. BT can provide secure, private lines, however they can be expensive. The A27 fibre-optic network segment and linking this to the main network will necessarily need involve NRTS in its planning, procurement and commissioning, and 'Code of Connection' issues must be complied with. Communications along the existing dual A27 section will need careful consideration and be dependent on each item of ITS[166] equipment.

[160] National Roads Telecommunication System
[161] Dual Carriageway Two Lane Rural All Purpose
[162] Closed Circuit Television
[163] Variable Message Signs
[164] Highways England
[165] Regional Control Centre
[166] Intelligent Transport System

# 18 MAINTENANCE ASSESSMENT

## 18.1 OPTION DESIGN MAINTENANCE IMPLICATIONS

An initial overview of the maintenance and repair strategy has been set out in Section 8 of this TAR[167], providing a description of the existing maintenance access points and physical provisions throughout the study area. The main PCF[168] product relating to maintenance, the Maintenance and Repair Strategy Statement, will be produced in Stage 2 where requirements will be considered in more detail.

All of the options under consideration (and set out in Section 11.2 of this TAR) will result in a change to the maintenance regime applied to the A27 through Worthing and Lancing. The detailed impact on maintenance regimes will be set out in the Maintenance and Repair Strategy. However, the factors that will affect maintenance activities following scheme implementation are detailed in the paragraphs that follow.

## 18.2 MAINTENANCE AND REPAIR STRATEGY

### 18.2.1 CIVILS INFRASTRUCTURE

#### HIGHWAYS FOOTPRINT

Each of the options would result in a degree of additional highway footprint. This will have an impact on the volume of maintenance activities relating to the following:

- Drainage;
- Pavement inspection / maintenance;
- Vehicle restraint systems;
- Signing and lining; and
- Vegetation / verges.

The additional volume of maintenance activities varies greatly depending on which option is taken forward.

For example, an increase in the surface area of a junction would result in a slight increase in surface friction inspection and pavement resurfacing. Similarly an increase in carriageway widths on links could result in increased frequency in gully cleaning activities.

However, those options which incorporate an offline solution will necessarily result in much more significant increases in all maintenance activities for the new link and its junctions with the existing road network. The present maintenance regime would have to continue on the existing A27 on a similar level to that currently undertaken.

[167] Technical Appraisal Report
[168] Project Control Framework

Similarly, while options which only affect junction arrangements will have an impact on signing and lining maintenance activities, those options which incorporate offline solutions will have a much greater impact in this regard.

### STRUCTURES

All but one of the Options (Option 0A) will incorporate new structures which will result in increased volume of maintenance activities relating to routine structures inspections. The structures included within the offline options include rail bridges, river bridges, over passes and underpasses as well as footbridges.

### STANDARDS OF MAINTENANCE

Regardless of the Option that is taken forward, and the factors that that Option comprises in terms of maintenance requirements, it is expected that the A27 around Arundel will be maintained in accordance with best practice. Specifically, the A27 will continue to be subject to maintenance regimes informed by Highways England's Network Management Manual and Routine and Winter Service Code.

## 18.2.2 ROAD SIDE TECHNOLOGY

An overview of the existing technology provision is presented in Section 3.13. Section 16 sets out the ITS[169] provision associated with each of the options. This section describes the implication of the options on the maintenance and repair of the proposed road side technology.

The maintenance regime for the scheme shall generally refer to the following:

- Network Management Manual;
- Routine and Winter Service Code; and
- Technology Management and Maintenance Manual.

There will be option-specific modifications to the ITS and traffic signals. Details of these modifications and the technology that may be adopted are covered in the A27 Arundel ITS report, specific details will be determined in subsequent PCF[170] Stages. The final maintenance and repair strategy is therefore unknown, but will need to cover the following items as a minimum.

### OPTION 0A – EXISTING JUNCTION IMPROVEMENTS ONLY

- The roundabouts will become traffic signal controlled, so they will need to be included within a traffic signal maintenance contract which details SLAs[171], routine maintenance and standards etc. The signals will be automatically monitored for faults and the RCC[172] will get notification of any issues. LED[173] signal heads will be used which require no routine maintenance, and the new specification ELV[174] controllers are more reliable than the previous versions. A maintenance bay should be provided near the traffic signal controller.

[169] Intelligent Transport Systems
[170] Project Control Framework
[171] Service Level Agreements
[172] Regional Control Centre
[173] Light Emitting Diode
[174] Extra Low Voltage

- It is proposed that other ITS equipment is co-located with the traffic signals, to ease maintenance. ITS such as CCTV[175], VMS[176], journey time monitors and Meteorological outstations are suggested. The majority of these are now very reliable and need little or no routine maintenance, but will still need to be included within a maintenance contract.

## OPTION 0B – ON-LINE DUALLING, WITH JUNCTION IMPROVEMENTS

With this option ERA's[177] are assumed to be included and traffic signals added to the at grade junctions.

- The roundabouts will become traffic signal controlled, so they will need to be included within a traffic signal maintenance contract which details SLA's, routine maintenance and standards etc. The signals will be automatically monitored for faults and the RCC[178] will get notification of any issues. LED[179] signal heads will be used which require no routine maintenance, and the new specification ELV[180] controllers are more reliable than the previous versions. A maintenance bay should be provided near the traffic signal controller.
- ERA's will be provided along the route, it is proposed ITS equipment is co-located at the ERA's to ease maintenance. ITS[181] such as CCTV [182], VMS[183], speed enforcement cameras, above ground detection, journey time monitors and Meteorological outstations are suggested. The majority of these are now very reliable and need little or no routine maintenance, but will still need to be included within a maintenance contract. The ERA's can be used to safely park maintenance vehicles.

## OPTION 1 & 0BA – PART ON-LINE AND PART OFF-LINE

With this option ERA's are assumed to be included along both sections and traffic signals added to the at grade junctions, Crossbush becomes grade separated (dumb-bell roundabouts).

- The roundabouts will become traffic signal controlled, so they will need to be included within a traffic signal maintenance contract which details SLAs[184], routine maintenance and standards etc. The signals will be automatically monitored for faults and the RCC will get notification of any issues. LED signal heads will be used which require no routine maintenance, and the new specification ELV controllers are more reliable than the previous versions. A maintenance bay should be provided near the traffic signal controller.
- ERA's will be provided along the route, it is proposed ITS equipment is co-located at the ERA's to ease maintenance. ITS such as CCTV, VMS, speed enforcement cameras, above ground detection, journey time monitors and Meteorological outstations are suggested. The majority of these are now very reliable and need little or no routine maintenance, but will still need to be included within a maintenance contract. The ERA's can be used to safely park maintenance vehicles.

[175] Closed Circuit Television
[176] Variable Message Signs
[177] Emergency Refuge Area
[178] Regional Control Centre
[179] Light Emitting Diode
[180] Extra Low Voltage
[181] Intelligent Transport Systems
[182] Closed Circuit Television
[183] Variable Message Signs
[184] Service Level Agreement

## OPTION 3, 5, 5A AND 5B – OFF-LINE DUALLING, GRADE SEPARATED JUNCTIONS

With this option ERA's are assumed to be included and all junctions become grade separated.

- ERA's will be provided along the route, it is proposed ITS equipment is co-located at the ERA's to ease maintenance. ITS such as CCTV, VMS, speed enforcement cameras, above ground detection, journey time monitors and Meteorological outstations are suggested. The majority of these are now very reliable and need little or no routine maintenance, but will still need to be included within a maintenance contract. The ERAs[185] can be used to safely park maintenance vehicles.

[185] Emergency Refuge Area

# 19 ENVIRONMENTAL ASSESSMENT

An Environmental Study Report (ESR) has been produced to support the consideration of options during PCF Stage 1. The ESR assesses the potential for environmental effects associated with each option. The ESR will be updated, and will support further consideration of the scheme options as they develop in PCF Stages 2. During PCF Stage 3 it will be updated to support an Environmental Impact Assessment. The following sections summarise the conclusions presented in the ESR.

## 19.1 AIR QUALITY

During the construction phase, dust soiling (nuisance) and human health impacts as a result of increased PM10, are unlikely to be significant. The sensitivity of the construction area is assessed as being high due to the density of residential properties along the A27 within Arundel. Although the sensitivity of parts of the construction study area is high, the existing concentrations of PM10 are low (<20 µg/m3). Therefore, the risk to human health through increased exposure to PM10 is low. The magnitude of dust emissions is also considered to be low. No ecological receptors have been identified that are specifically sensitive to dust deposition at this stage.

Traffic impacts as a result of the construction phase are likely to be greater for options with online elements (Options 0A and 1), where congestion will increase due to traffic management, than for offline options. For online options, some diversion of traffic may be expected along alternative routes to avoid the delays due to potential congestion along the A27. It is possible that traffic will divert along the A283 to the north through Storrington, as well as congestion effects along the A27 to the east affecting the Worthing and Lancing AQMA. Offline options minimise the risk of increased congestion apart from the entry and exit points to the existing road network.

Table 19-1 summarises the local operational air quality impacts for each scheme option.

**Table 19-1: Air quality impacts**

| OPTION | IMPACTS |
|---|---|
| **Option 0A** | Operationally, congestion is likely to be reduced as a result of the junction improvements, improving air quality in the short-term. However, the existing single carriageway will have less capacity than demand at peak periods over the medium to long-term. Traffic growth in future years is likely to negate, if not worsen, any air quality benefits from junction improvements. |
| **Option 1** | Operationally, improvements in air quality at the roadside are expected between Crossbush and Causeway junctions through diversion of the traffic from the current alignment onto the scheme. However, at the Ford Road junction the increase in flows risks negating any improvements from reduced congestion. Overall, traffic growth in future years is likely to reduce any benefits from reduced congestion. |
| **Option 3** | During operation, the off-line alignment will remove the traffic congestion around Crossbush junction and along the existing A27, resulting in significant improvements in air quality. Further re-routing of local traffic may also benefit existing roadside properties. These options are likely to result in substantial benefits to communities living along the existing A27. |
| **Options 5A and 5B** | During operation, the off-line alignments will remove the traffic congestion around Crossbush junction and along the existing A27, resulting in significant improvements in air quality. Further re-routing of local traffic may also benefit existing roadside properties. Residential properties on Yapton Lane, to the north of Walberton are likely to experience a worsening in air quality due to the scheme. Overall there is expected to be scheme-wide improvements in air quality, although there may be some localised worsening. |

During Operation all options are predicted to lead to an increase in vehicle flows along the A27 which may counteract any air quality improvements as a result of reduced congestion. Within the Storrington AQMA there may be an improvement in air quality due to shifting of traffic south along the A27.

With PCM modelled roadside concentrations well within the EU limit values, there is a low risk of any of the scheme options adversely affecting compliance with the EU Air Quality Directive.

With respects to ecological receptors, Option 3 is most likely to have a negative impact on the Ancient Woodlands to the west of Arundel. This is due to the introduction of roadside NOx emissions at locations that were previously not near a road.

Further detailed assessment of air quality impacts will be undertaken at PCF Stages 2 and 3, once detailed scheme designs and traffic modelling data become available.

## 19.2 CULTURAL HERITAGE

There is the potential for currently unknown buried archaeological remains to be present within the footprint of all options, and therefore also the potential for loss or disturbance of these remains.

Ground disturbance activities will include the widening of existing roads, the excavation of new roads and the excavation of associated services. Topsoil stripping for compounds, landscaping features and drainage ponds will also cause an impact. The removal of areas of Ancient Woodland (Options 1, 3 and 5A) will almost certainly disturb archaeological features relating to occupational activity and historic stock management from the Prehistoric Period onwards.

Archaeological investigative fieldwork could improve the understanding of the archaeological remains. Where ground disturbance is required, where viable this will afford the opportunity to investigate the significance of the known and unknown archaeological receptors.

All scheme options may have negative impacts on the setting of scheduled monuments, historic landscapes, conservation areas and built heritage assets. Currently there is a potential for inter-visibility, historical and functional relationships between assets in the vicinity of the scheme options. Therefore, careful design of any new structures and landscaping is required. Potential adverse impacts upon the setting of designated assets are likely to include: harm to the relationship between the asset and its setting so that the relationship is no longer appreciable; the interpretability of the significance of the asset could be significantly reduced; or a loss or reduction of rural tranquillity where noise and air pollutants are likely to increase. The potential for impacts on nationally important (most sensitive) assets are described below.

Option 3, 5A and 5B are located within 50m of Tortington Augustinian Priory Scheduled Monument and have the potential to harm the relationship between the asset and its setting.

Options 3, 5A and 5B all involve new crossings of the Arun Valley, which will be prominent in the historic landscape and therefore have the potential to harm the relationship between Arundel Castle Scheduled Monument and its setting.

Options 0A is located within 500m of Arundel Castle Scheduled Monument. However, as this is an online improvement, this option is likely to result in a smaller magnitude of effects on the setting of the Castle.

No heritage assets of national importance, which merit preservation in-situ, are considered to be at risk of physical direct impacts from the scheme options.

The potential for significant effects on cultural heritage assets are considered to be broadly comparable between the offline options. Options 5A and 5B are located further south of Arundel than Options 1 and 3, and would therefore have a reduced adverse effect on the setting of Arundel Castle. Options 5A and 5B have increased potential for adverse effects on Tortington Augustinian Priory, and also the potential for impacts on below ground assets would be increased.

The impacts on heritage assets are considered likely to be most adverse for the offline options (Options 3, 5A and 5B).

Impact mitigation measures would be implemented to reduce the scale and intensity of these potential, indirect impacts. Specifically, there may be opportunities to improve the setting of designated heritage assets through improved public realm, landscaping, and reduced traffic congestion. Where possible, affected heritage assets or their settings could be enhanced by returning these to their historic state (as consistent with historically valuable assets which still exist), facilitating views to related heritage assets, or by encouraging better understanding of the historic environment through signage.

## 19.3 LANDSCAPE AND VISUAL

Table 19-2 summarises the landscape and visual impacts of the scheme options. Further assessment of landscape and visual impacts will be undertaken at PCF Stages 2 and 3, once detailed scheme designs become available. Where impacts are common to a number of options these have been combined.

**Table 19-2: Landscape and visual impacts**

| OPTION | IMPACT |
|---|---|
| Primarily Online Options 0A and 1 | Landscape and visual impacts associated with the increase in built form including the road widening, new road, earthworks, lighting, signage and traffic.<br>Landscape impacts associated with loss of mature trees, shrub and hedgerow cover within the existing highway boundary.<br>Adverse impact on views of the scheme from Monarch's Way National Trail. |
| Option 1 | Loss of agricultural land including field boundaries and patterns.<br>Views of the scheme from Arundel Castle grounds (SDNPA Viewpoint 50 and SDNPA 360 degree Viewshed) would be substantially screened by the castle walls allowing only brief glimpses of the new offline section.<br>Potential impacts on landscape character and landscape resources would be reduced by undertaking most of the improvements within the existing highway corridor, which lies outside the SDNP boundary. |
| All Offline Options (Options 3, 5A, 5B) | Loss of landscape features and elements which are in the path of the two-lane dual carriageway.<br>Loss of mature trees, shrub and hedgerow cover within the existing highway boundary.<br>Loss of agricultural land including field boundaries and patterns.<br>Landscape impacts of new mitigation screen planting.<br>Loss of tranquillity of SDNP and River Arun footpath.<br>Introduction of a new large scale, prominent and uncharacteristic feature in the Arun Valley landscape, including from the SDNP, Arundel Conservation Area, and from properties that currently have long distance views to the south.<br>Visual impact on views from Arundel Castle grounds.<br>Visual impact of scheme and associated traffic from residential properties, Arundel Conservation Area, SDNP, River Arun footpath. |
| Option 3 | The route would bisect Binsted Wood resulting in the irreplaceable loss of up to 24ha of mature woodland (ancient semi-natural woodland) and significant disturbance to woodland paths, rides and PRoWs.<br>At the western end of the scheme there would be direct effects on landscape elements and features within the SDNP. Loss of tranquillity in this area, which could not be mitigated, would adversely affect one of the SDNP's special qualities - its tranquil and unspoilt places.<br>Views of the scheme would be available from dwellings at Arundel, Torton Hill, Tortington Lane and Crossbush where it would become a noticeable feature of the view. |
| Options 5A and 5B | The western sections of these options are close to, but mainly outside, the boundary of the SDNP. They are located within a complex small-scale landscape comprising small fields under pasture, large-scale arable fields, hamlets, farmsteads and glasshouses. Mitigation planting would be appropriate in this context. The impact on landscape resources in this area would be greater than for the comparable offline options (2 and 3) due to the length of the route. |
| Option 5A | Commences further west than Option 3 in order to affect a smaller area of the SDNP. Would require the loss of up to 6ha ancient semi-natural woodland at Binsted Wood. East of Binsted Lane 5A is located on the same alignment as Option 3, and follows the same route to Crossbush Junction. It would have the same landscape and visual impacts at Option 3 in this area. |
| Option 5B | The longest offline route extending further west and south to avoid the SDNP as far as possible and ancient semi-natural woodland. The eastern section of the route would follow the same alignment as Option 3 between the River Arun and Crossbush Junction where it would have the same adverse landscape and visual impacts.<br>Mature woodland on the northern edge of Potwell Copse would be removed from the footprint of the route and there would be direct impacts on two detached residential properties that lie within the Copse. Continuing eastwards the route bisects large-scale flat arable fields at Hooe Farm to cross Tye Lane on an overbridge to the north of Walberton. Although mitigation (woodland screen planting) would be appropriate in this location, the overbridge and traffic could not be screened. |

| OPTION | IMPACT |
|---|---|
| | Between Tye Lane and Binsted the proposed route would lie within Avisford Golf Course, an attractive mature parkland landscape, before crossing the steep hidden wooded valley at Binsted. The road, earthworks, retaining structures and overbridge necessary to cross this small-scale undulating landscape would introduce uncharacteristic large-scale features that would cause widespread damage to its distinctive character and elements. There would be a noticeable deterioration in views from nearby PRoWs, residential properties at Walberton, and Binsted and Avisford Golf Course. People at Avisford Golf Course would experience loss of visual amenity and general enjoyment of the rural landscape which could not be mitigated.<br>The route would head southeast between Binsted Church and Tortington crossing through small fields, paddocks and horticultural nurseries lying close to residential properties. The pattern would be lost and it is unlikely the severed land would be viable for agricultural or horticultural use. Adverse visual impacts would arise in relation to several rural residential properties, including Tortington Manor where the road and traffic would be prominent in the foreground of the view of Arundel and the SDNP. Tranquillity would be lost, which despite the close proximity of the existing A27, is high in the rural landscape over most of the route. |

Of the offline options, the potential for significant effects on landscape and visual assets are considered to reduce for options which are located further from more sensitive landscape and visual assets including the South Downs National Park, and views from Arundel. It would not be possible or appropriate to screen the options to limit impacts on sensitive views across the Arun Valley, including from within Arundel and from the South Downs National Park.

Options 5A and 5B are located further south from Arundel, and any bridge or embankment across the Arun Valley will appear more visually distant. As a consequence, Options 5A and 5B are expected to perform better than options closer to Arundel, such as Option 3.

Relative to the offline options, the online options (Options 0A and 1) are likely to have less significant effects on the landscape and sensitive views. These options are located online or close to the existing A27 alignment and therefore have a lower potential to change the landscape, and also a greater potential for mitigation of adverse effects. However, these options are still likely to result in significant adverse effects without mitigation.

## 19.4 GREENHOUSE GASES

To fully assess the impact of the scheme on greenhouses gases, detailed traffic modelling information is required as it is dependent on the combination of changes to flow, vehicle speeds and impact on surrounding road links. The effect on GHG emissions was scoped out of the ESR, as a detailed traffic model was not available. Quantitative modelling will be undertaken in future PCF Stages, once the data is available, to determine if the works would have a net beneficial or detrimental effect on GHG emissions.

When the flow of traffic is changed in terms of speed and or volume, it can alter GHG emissions. Increased speed and stop/start traffic would have an adverse effect on emissions due to vehicles operating at lower fuel efficiency. Conversely, a reduction in queuing vehicles would have an overall beneficial impact on GHG emissions as vehicles are operating at higher levels of efficiency.

The proposal to relieve congestion and thus queuing along the A27 is aimed at improving traffic flow during busy periods. Reduced queuing would have an overall beneficial impact on GHG emissions.

The greenhouse gas impacts of all options will be determined using a detailed transport model at PCF Stage 2. The results of the assessment of greenhouse gases will be incorporated into the PCF Stage 2 Environmental Assessment Report (EAR)

## 19.5 NATURE CONSERVATION

A preliminary Assessment of Implications on European Sites (AIES) has been completed for the Scheme Options following DMRB guidance. It concluded that significant effects as a result of the Scheme Options were unlikely on the statutory designated sites, as well as three further European sites within 30km which have been designated for bats: Ebernoe Common SAC; The Mens SAC; and Singleton and Cocking Tunnel SAC. However, at this early stage, it is not possible to definitively conclude that there will be no 'likely significant effects' on the ecological integrity of European Sites.

The Scheme Options are not situated within or immediately adjacent to any SSSIs or NNRs. The nearest such site is Arundel Park SSSI, which is approximately 500m north of Option 1, and approximately 1 to 2km north of Options 0A, 3, 5A and 5B. On the basis of proximity, direct and indirect impacts and effects are not anticipated on any national statutory designated site.

All options, apart from Option 0A and 5B, will result in the loss of ancient woodland including within Binsted Wood Complex LWS and Rewell Wood Complex LWS. The relative impact on ancient woodland is a key differentiating factor between the Scheme Options. The maximum loss of ancient woodland for each option is described below:

- Option 1 – 5ha
- Option 3 – 24ha
- Option 5A – 6ha

The NPPF states that "*planning permission should be refused for development resulting in the loss or deterioration of irreplaceable habitats, including Ancient Woodland and the loss of aged or veteran trees found outside Ancient Woodland, unless the need for, and benefits of, the development in that location clearly outweigh the loss*[186]". This is echoed in the National Policy Statement for National Networks and Natural England's Standing Advice for Ancient Woodland and Veteran Trees. The loss of ancient woodland is likely to adversely affect the integrity of the affected LWSs, and is likely to have significant adverse impacts at a national level.

It is widely recognised that, due to its age and complexity, ancient woodland is irreplaceable and therefore its loss cannot be compensated for as the nature conservation value of ancient woodland cannot be recreated in anything less than hundreds of years. However, where loss of ancient woodland is unavoidable it may be possible to partially compensate for the loss of ancient woodland through a combination of techniques including soil and vegetation translocation, new woodland planting and enhancement and restoration of existing woodland areas. These measures can be used to create new woodland or enhance existing woodland for its nature conservation value. As ancient woodland is irreplaceable, these techniques should be used only as a last resort. Compensation for loss of ancient woodland would be necessary and is likely to involve translocation of soils, litter material and where practical, trees and shrubs to an alternative site. Consultation and agreements still need to be made with Natural England. Compensation for loss of ancient woodland will require consultation with key stakeholders and landowners.

[186] Department for Communities and Local Government (2012) National Planning Policy Framework pg 28 [online] Accessed 22/12/2016

All options will result in the permanent loss of various habitats, including: woodland and scrub; hedgerow; grassland; watercourses; and water bodies. Online options (0A and 1) will have the least impact, whist the offline options (3, 5A and 5B) will have the greatest impact on habitats as a consequence of increased landtake. At this stage it is assumed that habitats affected by the Scheme Options are of ecological interest; therefore loss associated with any option may compromise the conservation status of these. Further surveys at PCF Stages 2 and 3 are required to identify the levels of habitat loss and impact on the conservation status of these and connective habitat types.

Veteran trees are also located within the Study Area, both isolated and associated with the woodland parcels in the area. Veteran trees are important for their ecological, visual and cultural heritage significance, and are awarded similar levels of protection as Ancient Woodland.

Habitats, including Habitats of Principal Importance (HPIs), have been identified within the study area which have the potential to support various protected and notable species, including: great crested newt; dormice; bats; otter; water vole; badger; reptiles; terrestrial and aquatic invertebrates. In the absence of detailed protected and notable species survey data, it is not possible to accurately determine the impacts resulting from each of the Scheme Options. Further survey and assessment will be undertaken at PCF stages 2 and 3 in order to accurately determine the impacts and magnitude of impacts for protected and notable species.

## 19.6 GEOLOGY AND SOILS

The offline options (Options 3, 5A and 5B) would require agricultural land take. The extent of land take is yet to be quantified. The affected agricultural land is primarily of Agricultural Land Classification (ALC) Grades 3 to 4 and is therefore likely to comprise Best and Most Versatile (BMV) agricultural land (Grades 1, 2 and 3a). It is conservatively assumed within the assessment that the loss of BMV may exceed 50ha, resulting in the offline options having a negative impact on soils. The online options (Options 0A and 1) involve smaller areas of land take, therefore impacts on soil are expected to be of lower significance.

The Scheme Options will have a neutral effect on geology and geomorphology. Although the scheme will require minor changes to existing ground levels during construction, resulting in some geological and geomorphological change, there are no geological SSSI or RIGS within the study area.

There is a potential for the construction process to create new migratory pathways for contaminative substances which could impact on ground and surface water features. A Preliminary Risk Assessment indicates that the study area is unlikely to contain significant sources of contaminative substances. The creation of migratory pathways is therefore unlikely to lead to viable contaminate linkage and no change is expected. The effect of all Scheme Options on ground and surface waters is expected to be neutral in both the construction and operational phases.

The preferred option should use appropriate construction materials that would be resistant to any aggressive chemicals that may be within the ground and which have the potential to attack concrete. Although tests have not been undertaken to characterise these determinants in the soil and groundwater within the scheme extent, it is assumed that this information will be available during subsequent PCF Stages.

The scheme is unlikely to result in adverse human health effects, as construction workers will be required to adhere to best practice, avoiding risks arising from possible oral, inhalation, or dermal exposure to substances in shallow soils. As contamination is also considered to be unlikely, there is limited potential for adverse effects on construction workers and end users.

## 19.7 WATER ENVIRONMENT

The Scheme Options have the potential to impact the water environment during construction. These impacts include: increased pollution risks from mobilised suspended solids, spillage of fuels or other harmful substances; impacts to the hydromorphological and ecological quality of watercourses; and increased flood risks associated with temporary works within areas identified to be at risk of fluvial and/or tidal flooding. However, these impacts are unlikely to occur as long as adequate mitigation measures are introduced through the implementation of a CEMP and best practice guidelines.

Once operational, the potential impacts to surface and ground water features include the potential for polluted road surface runoff (containing silts and hydrocarbons) from the scheme entering surface or groundwater. In addition, the scheme has the potential to increase flood risk in the scheme area due to the increased rates and volumes of surface runoff resulting from new areas of hard standing.

The primarily online options (0A and 1) largely follow the alignment of the existing A27. Therefore, the risk to the quality of the water environment is likely to be comparatively minimal during construction and operation. This assumes that appropriate pollution control measures, as outlined within a CEMP, are implemented during construction and a robust surface water drainage system is installed during operation. These options may also offer an opportunity for betterment during the operational phase if the existing drainage systems are upgraded. The greatest risks to water quality during construction will be associated with works within the channel of the River Arun if improvements to the existing bridge are required. At this stage, the magnitude of the potential risk to the quality of the water environment is considered likely to be negligible to minor adverse. The construction of Option 1 will require landtake from undeveloped land within the Arun Valley floodplain and the crossing of a number of land drains. The greatest risks are likely to be associated with loss of fluvial floodplain storage and impacts to fluvial flood flow conveyance, which may adversely impact adjacent property and infrastructure. The capacity of drains should be maintained, with further assessment of the fluvial and tidal relationship undertaken to assess appropriate mitigation for floodplain loss.

The offline options (3, 5A and 5B) cross the channel of the River Arun floodplain and its associated floodplain. The options may also impact on several smaller tributaries of the River Arun. It is likely that risks to the quality of the water environment can be largely mitigated during construction through the implementation of a CEMP and during operation through the implementation of a robust surface water drainage system. However, the options will require a new bridge across the River Arun and risks to water quality will be difficult to mitigate entirely.

The greatest flood risks during construction and operation will be associated with temporary and permanent works within the floodplain and the channel of the River Arun. Any reduction in the fluvial capacity of the watercourse or floodplain (or impacts to existing flood defences) could increase flood risk to urban areas of Arundel and to Priory Farm to the south of the existing A27 alignment. By maintaining the capacity of the fluvial watercourse by providing a clear span structure, and by maintaining the capacity of the fluvial floodplain by allowing flood flow conveyance and providing compensatory storage, the impacts could be reduced. The magnitude of the impact will be heavily dependent on the fluvial and tidal characteristics of flooding in this area and will need to be informed via detailed hydraulic analysis.

Consultation with the EA has also suggested that tidal flood defence benefits could be provided through the design of the scheme and associated embankments. These benefits could be realised in conjunction in development of the offline options (Options 3, 5A and 5B), which would require a combination of embankments and a bridge across the Arun Valley. Several other watercourses may be impacted by the longer offline options (Options 5A and 5B). However, it is anticipated that the carrying capacity of these will be maintained through the use of appropriate culverts and bridges.

The landscape and visual amenity aspects of the flood plain are discussed in Section 19.3.

## 19.8 NOISE AND VIBRATION

During the construction phase, residential properties within close proximity of the proposed options could experience significant noise impacts arising from the construction activities. The predominantly online Options (0A and 1) with improvements to the existing A27 alignment are likely to result in significant noise impacts due to the proximity of sensitive receptors. This includes potentially negatively impacting Noise Important Areas (NIA). Construction noise can be minimised by applying Best Practical Means (BPM) control measures which will be outlined in a CEMP, mitigating construction noise effects and reducing significance.

During operation, the predominantly online options are likely to negatively impact sensitive receptors along the existing A27 corridor, including those within NIAs, due to an increase in traffic flows.

The predominantly offline options are expected to reduce noise levels experienced by receptors in central Arundel and along the existing A27 route, although Option 3 may impact residential properties in the southern extent of the town. Overall the offline options are expected to affect less NIAs than the online options, due to these being concentrated within Arundel and along the A27 alignment. Options 5A and 5B are in close proximity to a number of properties in rural locations, including Binsted and Tortington, which will experience increases in noise levels. Additionally, Option 5B is likely to affect noise sensitive receptors in the village of Walberton. Potential mitigation measures for adverse impacts are yet to be determined and will be investigated once noise modelling is completed.

## 19.9 PEOPLE AND COMMUNITIES

### EFFECTS ON ALL TRAVELLERS

The predominantly online options (0A and 1) may temporarily increase driver stress as a result of construction works and associated traffic issues. However, once operational, it is anticipated that driver stress will decrease as a consequence of local improvements in traffic flow and reduced congestion. The scheme are expected to provide a long term benefit to Motorised Travellers (MTs), meeting expected increases in demand up to 2041. The improvements are predominantly along the existing A27 alignment and therefore views from the road are unlikely to be affected. Non-motorised user (NMU) amenity may be temporarily affected by diversions to Public Rights of Way (PRoW). This is not anticipated to increase journey time.

The predominantly offline options (3, 5A and 5B) may temporarily increase driver stress as a result of construction works and associated traffic issues. This is likely to be localised to areas where the proposed options intersect with the existing A27. In the long-term the offline options are expected to reduce driver stress due to local improvements in traffic flow and reduced congestion. The options are expected to provide a long term benefit to MTs, meeting expected increases in demand up to 2041. The options will run predominantly through agricultural land with extents of woodland. Where the options traverse agricultural land, the views are likely to be more open, resulting in a beneficial impact to users. All PRoWs crossed by the offline options will see a localised permanent reduction in amenity due to visual intrusion and increased noise levels. There is the potential for NMU journey time to increase if diversions are put in place. A number of diversions to the existing right of way will also be required although these will not add significantly to journey time

## EFFECTS ON COMMUNITIES

The predominantly online options (0A and 1) will not cause further severance to existing communities, provided that existing PRoWs are accommodated within the design and access remains in the same locations. Journey lengths for NMUs may be altered if the number of crossings or access points are changed, providing more or less opportunities to cross the road. Tourism and recreational facilities will be unaffected. The options do not require the demolition of existing housing, nor will they adversely affect future housing development. Option 1 will result in the loss of a small amount of agricultural land. Approximately eight to nine fields will be bisected, which may impact on their viability.

The predominantly offline options (3, 5A and 5B) have the potential for community severance, in particular affecting NMUs. Although it is likely that journeys between communities will be made by road, several PRoWs affected by the options provide direct links between communities. Access for MTs between communities is unlikely to be affected providing existing roads remain as a means of access to Arundel. Private assets, including a camping ground (Options 3 to 5B) and a golf course (Option 5B), will potentially become unviable businesses. Option 5B is also likely to result in the demolition of several existing residential properties. However, none of the offline options are expected to impact on future housing developments.

All offline options will result in the loss of agricultural land which is likely to be more than 20ha. The majority of these fields will be bisected, which may impact the future economic viability of the land for farming.

## EFFECTS ON PEOPLE

All options are likely to result in beneficial effects on journeys on the Strategic Road Network by reducing congestion and journey time. Reductions in congestion would improve air quality in these areas. However, areas which are in close proximity to the offline routes, including Tortington, Binsted and Walberton, may see a decrease in air quality. These areas are also likely to be negatively impacted by increases in noise. The offline routes will have a permanent adverse impact on a camping ground, with Option 5B running through the footprint of a golf course. The commercial viability of these businesses is likely to be compromised. Option 5B will also impact on the residents of several properties which will be demolished. It is not expected that any of the options will directly impact on the areas of strategic growth and employment land allocations within Arun.

# 20 ASSESSMENT SUMMARY

## 20.1 SUMMARY

A total of ten options were considered during PCF Stage 1 comprising a range of online widening, new offline routes, and junction improvement schemes. Through a process of scheme appraisal and stakeholder engagement, five of these were prioritised for further consideration during PCF Stage 2.

## 20.2 APPRAISAL SUMMARY TABLES (AST)

The Appraisal Summary Tables (ASTs) for the options being taken forward are provided at Appendix M of this report.

## 20.3 SUMMARY OF CONSULTATION WITH PUBLIC BODIES

The WSP project team have consulted with a number of different public bodies during PCF Stage 1 of the A27 Arundel Bypass Improvements study. The primary means of communicating the progress and findings of the Study to consultees has been through workshops and meetings. The following meetings / workshops were undertaken during PCF Stage 1:

- May 2016 – Arundel Stakeholder Meeting
- 21st July 2016 – Key Stakeholder Liaison Group Meeting (1)
- 17th October 2016 – KSLG 2
- 1st February 2017 – KSLG 3 / Focus Group Meeting
- 22nd February 2017 – Focus Group Meeting

The Stakeholder Meeting comprised a presentation and discussion of the scheme in general terms. The scheme objectives were presented and the process through which the study is to be undertaken was discussed. A wide variety of diverse external bodies were invited to the meeting.

The Key Stakeholder Liaison Group meetings were an opportunity for the Project Team to talk to statutory consultees (including emergency services) about the proposals. Separate matters (tech modelling) discussed after KSLGs.

The purpose of the Focus Group Meeting was to liaise with Local Authorities and the South Downs National Park about the Public Consultation which is due to be undertaken as part of PCF Stage 2.

Below is a list of the various public bodies that have been consulted and / or contacted by the study team:

- Action in Rural Sussex
- Adur & Worthing Councils
- Angmering Park Estate
- Arun Business Partnership
- Arun District Council
- Arundel Bypass Neighbourhood Committee

- Arundel Bypass Support Group
- Arundel Chamber of Commerce
- Arundel Town Council
- Arundel SCATE (South Coast Alliance for Transport and Environment)
- BBMM (Balfour Beatty Mott Macdonald)
- Bognor Regis Regeneration Board
- British Horse Society
- Campaign for Better Transport
- C.J Lock and Partners (Blakehurst Farm)
- Coast to Capital LEP
- Coastal West Sussex Partnership
- Comfort Keepers
- Compass Travel
- Campaign to Protect Rural England – Sussex
- Cycle Touring Club
- Environment Agency
- Ford Parish Council
- Forestry Commission
- Freight Transport Association
- GTR / Southern Railway
- Historic England
- Horsham District Council
- Lyminster and Crossbush Parish Council
- Mid Arun Valley Environmental Survey
- MP for Arundel and South Downs
- MP for Bognor Regis and Littlehampton
- National Trust Slindon Estate
- Natural England
- Norfolk Estates
- Pallant of Arundel
- Park Farm – Farm and Livery Yard
- Ramblers Association
- South Coast Alliance for Transport and Environment
- South Downs National Park Authority
- South Downs Society
- South East Coast Ambulance Service
- Surrey and Sussex Association of Local Councils

- Stagecoach
- Sussex Partnership NHS Foundation Trust
- Sussex Police
- Sussex Enterprise
- Sussex Wildlife Trust
- SUSTRANS
- Walberton Parish Council
- West Sussex County Council
- West Sussex Fire and Rescue
- Wildfowl and Wetland Trust Centre

# 21 PROGRAMME

The programme is provided at Appendix K.

# 22 CONCLUSION AND RECOMMENDATIONS

This report describes the technical assessment of the A27 Arundel Bypass options and considers in detail the various technical issues associated with the proposals. The scheme is being progressed in accordance with the PCF. Specifically, the assessment is at PCF Stage 1; 'Option Identification'. This is the stage where:

- options are identified to be taken to public consultation
- options are assessed in terms of environmental impact, traffic forecasts and economic benefits
- cost estimates are carried out

This TAR summarises the technical aspects of the existing highways, transportation, environmental and other issues within the study area, and describes how a suitable scheme could resolve them. It has been prepared with reference to the Guidance on Technical Appraisal Reports document, and its format and chapters follow such guidance.

During the appraisal process at Stage 1, ten options were investigated. In the course of the appraisal and option identification, five of these options or sub-options were discarded. The main reasons for discarding certain options were because the perceived benefits of the option were not as significant and may not outweigh the impacts, relative to other options.

The rationale behind taking some options forward and discarding others is described herein.

From the original ten options, the following options were identified as suitable for being taken forward into Stage 2:

- Option 0A
- Option 1
- Option 3
- Option 5A
- Option 5B

Option 0A is a purely online option. Option 1 is partly online and partly offline, whilst Options 3, 5A and 5B are offline bypass routes.

The Appraisal Summary Tables represent the key reference point when discussing the impact of the competing options in terms of their costs, benefits and overall performance. All of the options were shown to offer value for money, with options 0A, 1, 3 and 5A showing a high Benefit Cost Ratio (BCR) and Option 5B showing a medium BCR.

Decisions on taking forward options are not decided purely on cost benefit grounds. Environmental considerations are an important part of the appraisal. There may also be other costs and benefits which cannot be quantified. The economic and environmental benefits of the option are reported in the Appraisal Summary Table (AST).

## 22.1 OPTION(S) FOR PUBLIC CONSULTATION

The process of considering which of the five options should be presented at public consultation will be considered at the start of Stage 2.

## 22.2 PREFERRED SOLUTION

An announcement of the preferred option will be made following the public consultation, when comments from all consultees have been considered and assessed.

# 23 DETAILED COST ESTIMATE

The Highways England commercial estimates are provided at Appendix L-1, and are summarised below. The cost estimates are prepared in 2014 Q1 prices and then inflated to outturn costs using projected construction related inflation.

**Table 23-1: Option Cost Estimates**

| | Range estimate | | |
|---|---|---|---|
| Option | Minimum | Most likely | Maximum |
| Option 0A | £27.92m | £39.22m | £73.91m |
| Option 1 | £96.09m | £134.47m | £250.17m |
| Option 3 | £207.54m | £260.00m | £853.18m |
| Option 5A | £199.76m | £249.34m | £772.48m |
| Option 5B | £259.65m | £330.33m | £889.62m |

# Appendix A

**DRAWINGS OF EXISTING CONDITIONS**

# APPENDIX A-1

## LOCATION PLAN

# APPENDIX A-2

## TRANSPORT CONSIDERATIONS

# APPENDIX A-3

## PUBLIC RIGHTS OF WAY AND BUS STOPS

# APPENDIX A-4

## TREE CONSTRAINTS

# Appendix B

**DRAWINGS OF ALL OPTIONS**

# APPENDIX B-1

## DRAWINGS OF ALL OPTIONS

# Appendix C

**DRAWING OF OPTION 0A**

# APPENDIX C-1

## OPTION 0A – GA PLANS

# APPENDIX C-2

## OPTION 0A - STATS

# APPENDIX C-3

## OPTION 0A - DRAINAGE

# APPENDIX C-4

## OPTION 0A – NMU PROPOSALS

# Appendix D

**DRAWINGS OF OPTION 1**

# APPENDIX D-1

## OPTION 1 – GA PLANS

# APPENDIX D-2

## OPTION 1 - STATS

# APPENDIX D-3

## OPTION 1 - DRAINAGE

# APPENDIX D-4

## OPTION 1 – NMU PROPOSALS

# Appendix E

**DRAWINGS OF OPTION 3**

# APPENDIX E-1

## OPTION 3 – GA PLANS

# APPENDIX E-2

## OPTION 3 – STATS

# APPENDIX E-3

## OPTION 3 – DRAINAGE

# APPENDIX E-4

## OPTION 3 - NMU PROPOSALS

# Appendix F

**DRAWINGS OF OPTION 5A**

# APPENDIX F-1

## OPTION 5A – GA PLANS

# APPENDIX F-2

## OPTION 5A – STATS

# APPENDIX F-3

## OPTION 5A – DRAINAGE

# APPENDIX F-4

## OPTION 5A – NMU PROPOSALS

# Appendix G

**DRAWINGS OF OPTION 5B**

# APPENDIX G-1

## OPTION 5B – GA PLANS

# Appendix H

**DRAWINGS OF TYPICAL STRUCTURES**

# APPENDIX H-1

## TYPICAL STRUCTURES

# Appendix I

**COLLISION DATA**

# APPENDIX I-1

## COLLISION DATA

# Appendix J

**DRAINAGE STRATEGY**

# Appendix K

**PROGRAMME**

# APPENDIX K-1

## PROGRAMME

# Appendix L

**COST ESTIMATE AND ECONOMIC ASSESSMENT**

# APPENDIX L-1

## COST ESTIMATE

# APPENDIX L-2

## ECONOMIC ASSESSMENT TABLES

highways
england

# Appendix M

**APPRAISAL SUMMARY TABLE**

# APPENDIX M-1

## APPRAISAL SUMMARY TABLE

# Appendix N

**ENVIRONMENTAL CONSTRAINTS PLAN**

# APPENDIX N-1

## ENVIRONMENTAL CONSTRAINTS PLAN

# Appendix O

**ENGINEERING ASSESSMENT TABLE**