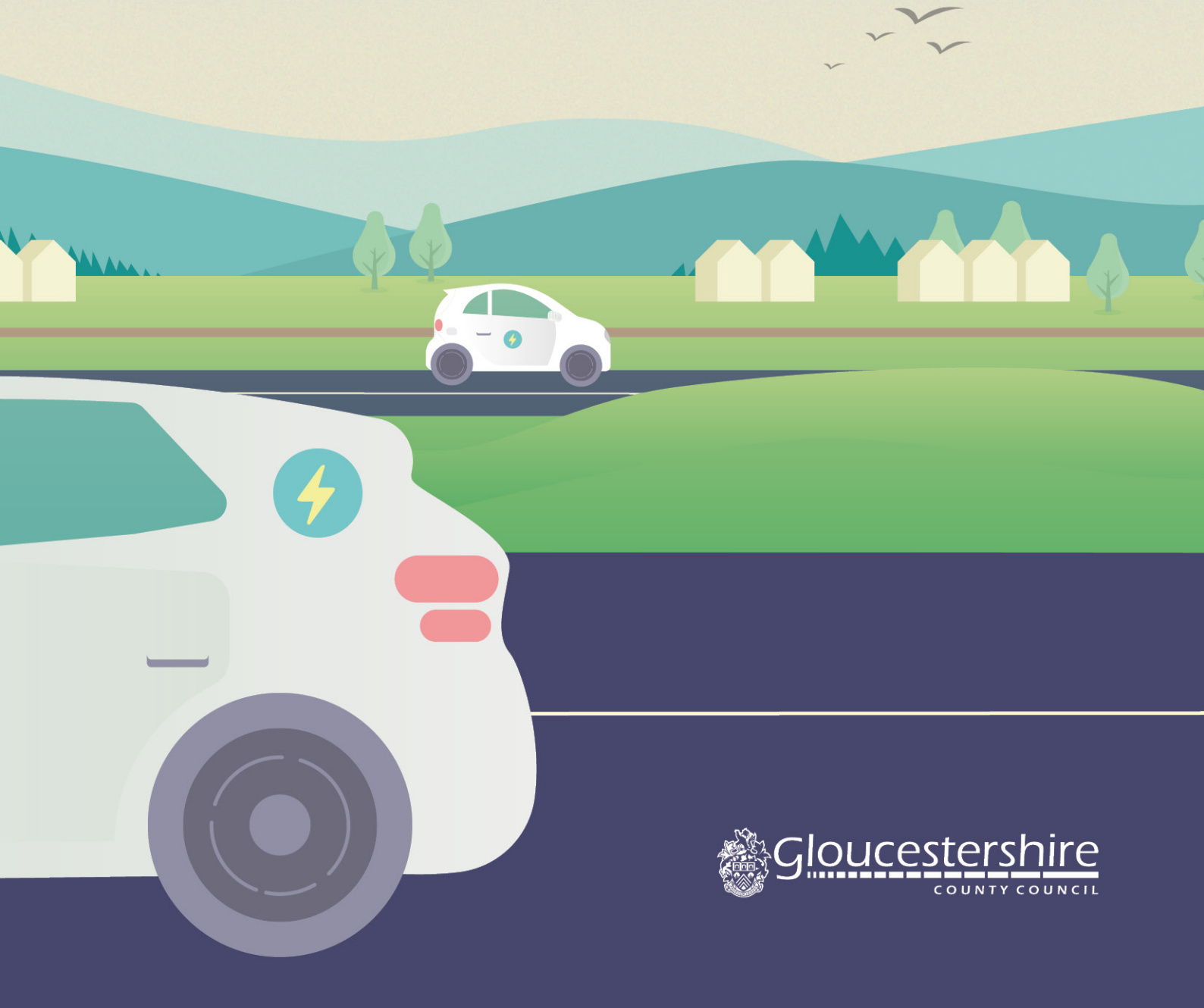
M5 Junction 10 Improvements Scheme

Technical Appraisal Report

Volume 1 - Report



Gloucestershire COUNTY COUNCIL

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Gloucestershire faces significant challenges to achieve its vision for economic growth. A Joint Core Strategy (JCS) – a partnership between Gloucester City Council, Cheltenham Borough Council and Tewkesbury Borough Council was formed to produce a co-ordinated strategic development plan to show how the region will develop during the period up to 2031. This includes a shared spatial vision targeting 35,175 new homes and 39,500 new jobs by 2031.

To unlock the housing and job opportunities, a highways network is needed that has the capacity to accommodate the increased traffic it will generate, within a sustainable transport context. A Business Case was submitted in March 2019 to the Housing Infrastructure Fund (HIF), wherein an investment case was made for the following infrastructure improvements, which together make up the M5 Junction 10 Improvement Scheme:

- An all-movements junction at M5 Junction 10;
- A new West Cheltenham Link Road from J10;
- Dualling of the A4019 to the East of the Link Road;
- A38/A4019 junction improvements at Coombe Hill; and
- Extension to Arle Court Park and Interchange.

Akins have been commissioned by Gloucestershire County Council to develop scheme proposals for following elements of the scheme which are related to the changes to the strategic road network.

- An all-movements junction at M5 Junction 10;
- A new West Cheltenham Link Road from J10;
- Dualling of the A4019 to the East of the Link Road

The A38/A4019 junction improvements at Coombe Hill; and extension to Arle Court Park and Interchange are geographically located away from the M5 Junction 10 improvements and are within Gloucestershire County Council's (GCC) road network. These elements of the scheme will not be appraised as part of this brief.

The M5 Junction 10 is located approximately 48 miles to the south of Birmingham and 40 miles to the north of Bristol.

Purpose of this Report

This Technical Appraisal Report (TAR) covers the technical aspects of the existing and future highway network and the sustainable and affordable alternative solutions for the above elements of the scheme which are related to the changes to the strategic road network.

The TAR brings together the traffic, economic, safety and environmental assessments, and is the basis for deciding which option(s) should be included in the Public Consultation. The purposes of the TAR are broadly to:

- Set out the physical, environmental, planning and traffic conditions of the area surrounding the junctions;
- Identify and evaluate sustainable options having regard to economic assessment and value for money, engineering, safety, effect on the economy, social and environmental factors;
- Describe the alternatives investigated and set out the reasons for rejection of any of those alternatives; and
- Recommend options for public consultation or recommend a single option consultation where there is the only one sustainable option, or one option is clearly the more sustainable than the others.

Scheme Objectives

Reflecting key elements of the Business Case objectives for this report, the following objectives are identified:

- Increase the capacity of the M5 Junction 10 to support future growth in housing, employment and the economy;
- Improve safety for all users of the junction to reduce accident numbers;
- Improve reliability of journey times through the junction;
- Deliver a high standard of highway design that is in keeping with the local environment;
- Minimise any adverse environmental impacts where feasible.

Current Issues at M5 Junction 10

The key identified issues at this location are summarised below:

- Junction 10 is of restricted design format and only provides slip roads from the north and to the north, with no southern access slip roads provided. This means that traffic from Cheltenham must access the southbound M5 via either Junctions 9 or 11. This has put increasing pressure on already congested local roads and particularly on Junction 11, which provides access to and from southern Cheltenham on the A40, also part of the Strategic Road Network;
- Junction 10 restricts emergency service operations on and off the M5 due to the junction not having any southern access slip roads;
- The junction lies within a Noise Important Area (NIA) and there are a number of residential receptors immediately adjacent to the junction;
- There are a number of residential properties and two businesses located in close proximity to Junction 10 and the M5. These properties may constrain and have an effect on a potential scheme;
- There are a number of environmental constraints in the vicinity of the junction including flood risk (Flood Zone 2 & 3), a scheduled monument south east of the junction, a small number of public rights of way, listed buildings in the wider surrounding area and a Green Belt designation (refer to Engineering Constraints Plan - GCCM5J10-ATK-HGN-XX_ML_Z-DR-LP-000001 to 000002); and
- The current Junction 10 layout would not be able to fully support the proposed level of housing, commercial and industrial development as outlined in the Joint Core Strategy.

Options Identified for Appraisal

A variety of studies, option identification and sifting exercises have previously been carried out related to the improvement of the M5 Junction 10. Amey Consulting developed three Concept Options which were included and assessed in the Homes England Business Case for funding in March 2019. These were:

- Concept Option 1 – Junction 10 moved north of its existing location
- Concept Option 2 – Upgrade to Existing Junction 10
- Concept Option 3 – Junction 10 moved south of its existing location

A workshop was held, attended by specialists in engineering, environmental and traffic modelling, to consider all previous options identified and to identify potential new options. The advantages and disadvantages of each option in relation to known constraints and were discussed and recorded. The options that were considered most likely to provide the benefits required and have the least impact on known constraints were identified. These were:

- Option 1A – As per Concept Option 1, but with J10 roundabout configuration amended to an elongated junction– New Junction North of Existing
- Option 2 – As per Concept Option 2 – Upgrade Existing Junction with Gyratory Roundabout
- Option 2A – As per Concept Option 2, but the junction moved slightly north to enable the retention of the existing bridge as the southern part of the gyratory carriageway.
- Option 3 – As per Concept Option 3 – New Junction South of Existing
- Option 4 – As per Concept Option 2, but with a dumbbell roundabout arrangement instead of a gyratory roundabout
- Option 5 –As per Concept Option 1, but with the junction located south of the existing junction

A sifting exercise was undertaken on the above six concept options. A qualitative assessment was carried out using a range of Economic/Engineering, Environmental and Social/Cultural criteria and the options were scored on a seven point scale. Options 3 and 4 were considered to have less benefits or greater impacts that relative to the other options and were therefore sifted out at this stage.

As part of this process, it became apparent that there was a further sub-option of Option 2, which was similar to Option 2A, but moved the junction slightly south, to enable the retention of the existing bridge as the northern part of the gyratory carriageway. This layout was called Option 2B. The options carried forward to the appraisal stage were therefore:

- Option 1A – New Junction North of Existing
- Option 2 – Upgrade Existing Junction with Gyratory Roundabout
- Option 2A - Upgrade Existing Junction with Gyratory Roundabout offset to the north
- Option 2B – Upgrade Existing Junction with Gyratory Roundabout offset to the south
- Option 5 - New Junction North of Existing (in alternative position to Option 1A)

All options will incorporate the addition of a new sections of dual carriageway linking the A4019 Tewkesbury Road and B4634 Old Gloucester Road. All options will also incorporate the upgrade of the A4019 Tewkesbury Road to a dual carriageway and all options propose to maintain the existing Walking, Cycling and Horse Riding provisions. A copy of the assessment table showing the relative scoring of each option is contained in Appendix C.

Traffic Analysis

From consideration of traffic patterns, volumes, differences in flows along the key links and the global network statistics, it can be interpreted that network performance doesn't differ significantly between scheme options. All the scheme options perform better than do-minimum and attracts more traffic from the south and Gloucester. Flows between J9 and J10 are similar with or without the scheme, which is expected as slips to J10 are available in do-minimum scenario as well.

Economic Assessment

The table below summaries the BCR and corresponding VfM category for each option. The stated VfM is based on definition set out within WebTAG guidance, comparison of Value for Money for M5 Junction 10 assessed options.

Comparison of BCR and VfM Assessments

Option	**BCR,** *with benefits from accident savings applied*	**VfM Category**
Option 1A	1.72	Medium
Option 2	2.28	High
Option 2A	2.52	High

Option 2B	2.36	High
Option 5	1.83	Medium

Environmental Assessment

The environemental assessments and Appraisal Summary Tables outlined in this report provides a qualitative summary of the potential environmental impacts of the Options. The appraisal and assessment covers impacts on human environment (noise, air quality and greenhouse gases), historic environment (archaeology and cultural heritage), biodiversity, landscape, soils and geology (land contamination, geology, geomorphology and agricultural land) and the water environment.

All five Options are likely to have a positive impact on people and communities, Options 2, 2A and 2B will be benefit from air quality, noise and vibration and while all options will have the potential for negative effects on road drainage and water environment, cultural heritage, landscape and biodiversity. The current environmental assessments are not definitive and will be subject to review as more detailed, quantitative assessments are undertaken in the future stages. This may change the potential effects, and their significance identified throughout this document.

Additional Assessments

Engineering impacts, safety, operational, technology and maintenance assessments were also appraised for each option in their respective chapters of this report.

Options to be taken forward

All options are considered to be compatible with the scheme objectives as set out within the in the brief provided by Gloucestershire County Council. The table below provides a summary of the cost estimate for each option. Cost estimates for the scheme will be subject to change in future stages, when more detailed assessments and design developments are undertaken.

Option	Total Scheme Cost (£)
Option 1A	305,578,943
Option 2	254,734,725
Option 2A	229,652,417
Option 2B	245,578,891
Option 5	294,077,040

It has been concluded that Option 1A and 5 should not be taken any further forward due to the complexities and affordability issues. It is recommended that Options 2, 2A and 2B are taken forward for further development, having all achieved a “High” VfM category. The economic analysis supporting this outcome will be continuously refined during subsequent development Stages to give Gloucestershire County Council (GCC) and stakeholders a continued confidence in the economic justification for the scheme. Although all options meet the scheme objectives fully, there is marginal difference in overall benefits or disadvantage of these recommended options when compared with each other. Due to marginal difference in benefits and disadvantages it is not possible to confirm a preferred solution at this stage. Therefore, it is proposed that Options 2, 2A and 2B are taken forward to the next stage for public consultation.

1 Introduction

1.1 Scheme Background

1.1.1 Gloucestershire faces significant challenges to achieve its vision for economic growth. A Joint Core Strategy (JCS) – a partnership between Gloucester City Council, Cheltenham Borough Council and Tewkesbury Borough Council was formed to produce a co-ordinated strategic development plan to show how the region will develop during the period up to 2031. This includes a shared spatial vision targeting 35,175 new homes and 39,500 new jobs by 2031. Major development of new housing (c.9,000 homes) and employment land (c.100ha) is proposed in strategic and safeguarded allocations in the West and North West of Cheltenham, much of which lies within Tewkesbury BC. This, in turn, is linked to wider economic investment, including a government supported and nationally significant Cyber Park 2 adjacent to GCHQ, predicted to generate c.7,000 jobs.

1.1.2 However, to unlock the housing and job opportunities, a highways network is needed that has the capacity to accommodate the increased traffic it will generate, within a sustainable transport context. A Business Case for was submitted in March 2019 to the Housing Infrastructure Fund (HIF), wherein an investment case was made for the following infrastructure improvements, which together make up the M5 Junction 10 Improvement Scheme:

- An all-movements junction at M5 Junction 10;
- A new West Cheltenham Link Road from J10;
- Dualling of the A4019 to the East of the Link Road;
- A38/A4019 junction improvements at Coombe Hill; and
- Extension to Arle Court Park and Interchange.

1.1.3 The M5 Junction 10 Scheme was also identified by Highways England in the Birmingham to Exeter Route Strategy (one of a number of Route Strategies produced to provide an analysis of the performance of the network), as a critical requirement to maintain the safe and efficient operation of the M5 corridor, whilst enabling the planned development and economic growth around Cheltenham, Gloucester and Tewkesbury.

1.1.4 Akins have been commissioned by Gloucestershire County Council to develop scheme proposals for the following elements of the scheme which are related to the changes to the strategic road network.

- An all-movements junction at M5 Junction 10;
- A new West Cheltenham Link Road from J10;
- Dualling of the A4019 to the East of the Link Road

1.1.5 The A38/A4019 junction improvements at Coombe Hill; and extension to Arle Court Park and Interchange are geographically located away from the M5 Junction 10 improvements and are within Gloucestershire County Council's (GCC) road network. These elements of the scheme will not be appraised as part of this brief.

1.2 Location of the scheme

1.2.1 M5 Junction 10 is located 48 miles to the south of Birmingham, 40 miles to the north of Bristol, five miles to the south of Tewkesbury, four miles to the north-west of Cheltenham, and eight miles to the north-east of Gloucester. It is the northernmost of four junctions serving the Gloucester and Cheltenham urban areas.

1.2.2 The junction is in a strategically important location for the region, particularly as northern and western Cheltenham are the sites of a number of large retail parks and employment areas, and the location of planned future housing and nationally significant business development.

1.2.3 The location of Junction 10 is shown in Figure 1-1 below:

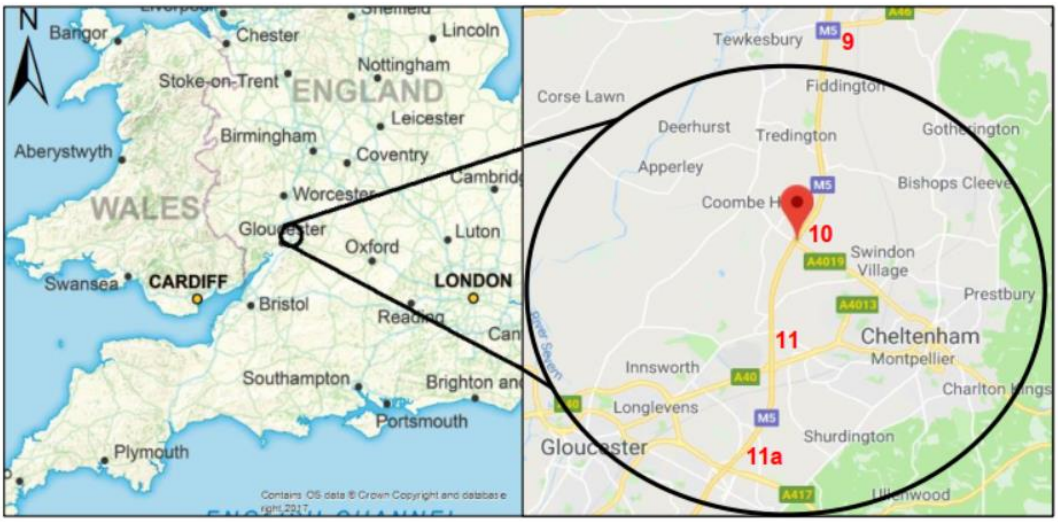


Figure 1-1 Location of the Scheme

1.2.4 The locations of the proposed infrastructure improvements that make up the M5 Junction 10 Improvements Scheme (and collectively make up the Scheme area) are illustrated in Figure 1-2 below, as well as the JCS strategic allocations in the adjacent area of the scheme and the two safeguarded sites located to the north-west and west of Cheltenham:

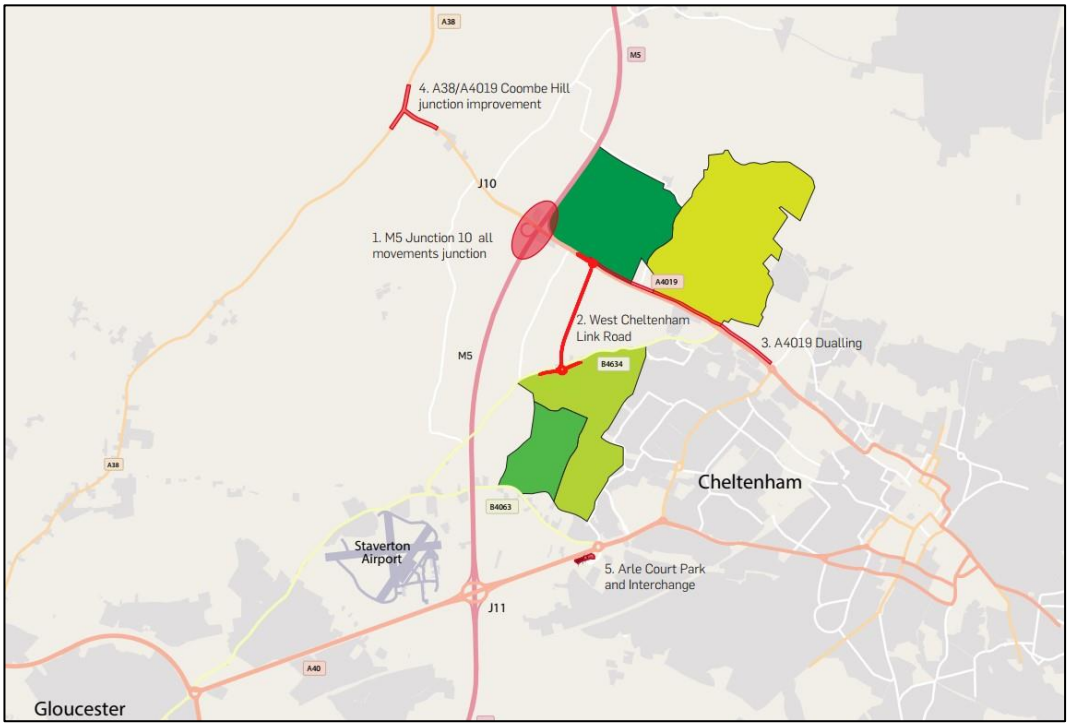


Figure 1-2 Location of Development Areas and Infrastructure Improvements

1.3 Purpose of this Report

1.3.1 This Technical Appraisal Report (TAR) is to report on the technical aspects of the existing or future highway problem and the sustainable and affordable alternative solutions for

- An all-movements junction at M5 Junction 10;
- A new West Cheltenham Link Road from J10;
- Dualling of the A4019 to the East of the Link Road

1.3.2 The TAR brings together the traffic, economic, safety and environmental assessments, and is the basis for deciding which option(s) should be included in the Public Consultation. The purposes of the TAR are broadly to:

- Set out the physical, environmental, planning and traffic conditions of the area surrounding the junctions;
- Validate the need for the scheme under the terms of reference set out in the Client Scheme Requirements;
- Identify and evaluate sustainable options having regard to economic assessment and value for money, engineering, safety, effect on the economy, social and environmental factors;
- Describe the alternatives investigated and set out the reasons for rejection of any of those alternatives; and
- Recommend options for public consultation or recommend a single option consultation where there is the only one sustainable option, or one option is clearly the more sustainable than the others.

1.3.3 Following public consultation, a Scheme Assessment Report will be produced that considers the comments and views expressed during the public consultation exercise and makes a recommendation, if any, for the Preferred Option. The Preferred Option will be the scheme that Gloucestershire County Council recommends should be taken forward to an application for statutory powers to construct.

2 Planning Brief

2.1 Introduction

2.1.1 The Planning Brief for the M5 Junction 10 improvement scheme is described in the brief provided by Gloucestershire County Council.

2.1.2 The Brief determines that the Consultants shall 'identify and evaluate all suitable alternatives in terms of engineering, traffic, safety, economics and environmental impact'.

2.2 Scheme Objectives

2.2.1 The overall scheme objectives contained in the Business Case submission were as follows:

Table 2-1 – M5 Junction 10 Improvement Scheme Objectives

Scheme Objectives			
To increase, accelerate and enhance housing supply in the JCS area		**To support economic growth within the JCS area and beyond**	**To provide an integrated scheme of transport infrastructure improvements that can facilitate housing and economic development**
Sub-Objectives			
1	Delivery of increased and accelerated housing, meeting or exceeding JCS targets up to 2031 and continuing an ambitious trajectory to meet the economic and social needs of Gloucester, Cheltenham and Tewkesbury	Support economic growth plans throughout Gloucestershire, including M5 Growth Zone, Growth Hub, GCHQ Cyber Park and GREEN	Ensure that the transport network provides adequate capacity and levels of service to meet the needs of current and future users
2	Delivery of a mix of housing (in terms of location, size, type, affordability and tenure) to meet the needs of the future population of Gloucester, Cheltenham and Tewkesbury and surrounding areas	Provide support to the economy of Gloucestershire and surrounding regions in terms of employment, workforce, connectivity and capacity (focus on retaining young people, attracting working age people and accommodating the growing older population)	Ensure that the transport network provides the required levels of safety, accessibility and integration to meet current and future needs
3	Enable land (including safeguarded land) to be made available for development, employment and job creation as well as housing use to create the step change needed in the demographic profile of Cheltenham		

2.2.2 There are three objectives/sub-objectives that are directly applicable to this Technical Appraisal Report and can be used in the assessment of different options for improving the M5 Junction. These are:

- Provide an integrated scheme of transport infrastructure improvements that can facilitate housing and economic development;
- Ensure that the transport network provides adequate capacity and levels of service to meet the needs of current and future users;
- Ensure that the transport network provides the required levels of safety, accessibility and integration to meet current and future needs;

2.2.3 Taking key elements of the Business Case objectives for this report, the following objectives are identified:

- Increase the capacity of the junction to support future growth in housing, employment and the economy;
- Improve safety for all users of the junction;
- Improve reliability of journey times through the junction;
- Deliver a high standard of highway design that is in keeping with the local environment;
- Minimise any adverse environmental impacts where feasible

3 Existing Conditions

3.1 Description of the Locality

3.1.1 M5 Junction 10 lies within the National Character Area (NCA) 106 Severn and Avon Vales as defined by Natural England 2012. The character is broadly defined as low lying agricultural vale landscape. It comprises of soft, gently undulating to flat landscape, but with intermittent locally elevated areas that project above the otherwise flatter landform. It has limited woodland cover with mature hedgerow trees.

3.1.2 The M5 transport corridor passes through the vale, aligned north south, beyond which is a network of local roads and lanes linking villages and hamlets. The most notable urban area is the city of Cheltenham located south-east of M5 Junction 10 and accessed via the A4019. Most of the area covered by the Scheme lies within land designated as Green Belt and consists mainly of agricultural and pastureland. The A4019 becomes gradually more urban as it approaches the edge of Cheltenham, and electricity pylons are noticeable towards the south east of Junction 10.

3.2 Existing Highway Network

3.2.1 M5 Junction 10 was originally opened in March 1971 as part of the section of motorway between Tewkesbury and south Gloucester (junctions 9-12).

3.2.2 The existing road layout are shown on Drawing Nos GCCM5J10-ATK-HGN-XX_ML_Z-DR-CH-000001 TO 00005 in Appendix A.

3.2.3 The M5 Junction 10 interchange provides links from the northbound M5 to the eastbound A4019. Traffic heading west from Cheltenham will cross over the M5 before bearing left onto a motorway slip road which turns through 270 degrees to join the northbound M5. Traffic heading south on the M5 can bear left onto a slip road which turns through 90 degrees to merge with the eastbound A4019. No other movements are possible at this junction. The two links provided are effectively free-flow.

3.2.4 The A4019 links Cheltenham with the A38 at Coombe Hill, crossing the M5 via a dual two-lane carriageway overbridge. The two-lane dual carriageway starts/finishes approximately 600-700m to either approach, the remaining A4019 is a single lane, single carriageway.

3.2.5 Stopped up sections of the A4019 during construction of the M5 have been retained, with the section to the east of the M5 forming Withybridge Gardens, a residential road of fourteen properties. The section to the east provides access to agricultural / industrial businesses.

3.2.6 The existing M5 Junction 10 layout consists of two slip roads and overbridge connecting the M5 motorway with the existing two lane A4019 dual carriageway.

3.2.7 The first slip road is the on-slip joining the M5 northbound carriageway. The on-slip comprises a 70m radii, two lane carriageway with an 30mph advisory speed limit.

3.2.8 The second slip road connects the M5 southbound carriage to the A4019 dual carriageway towards Cheltenham. The slip road comprises a 230m radii single lane carriageway. At the junction with the A4019 there is a 50mph speed limit.

3.2.9 The A4019 connects with the A38 at Coombe Hill, west of the M5. With a 50mph speed limit throughout, the A4019 starts as a single carriageway. Approximately 600m either side of the M5 overbridge the A4019 is a two-lane dual carriageway, before reverting into a single carriageway up to the signalised junction with the B4634. From this junction the A4019 continues as a two-lane dual carriageway up to the roundabout junction with Princess Elizabeth Way, Kingsditch Lane and Tewksbury Road. Along the length of the A4019 from Junction 10 to the signalised junction with the B4634 there are several crossings providing access to both the north and south.

3.2.10 A Pedestrian footway follows the northbound carriageway along much of the A4019. At the western end of the M5 overbridge the footway ends and becomes verge. It is evident from observations that the verge is used by pedestrians up to the junction of the M5 southern slip road, pedestrians then continuing along the footway towards Cheltenham.

3.2.11 There are many properties within close proximity of the A4019. The majority are located via side/access roads, however within the dual carriageway section at junction 10 there are two properties and a farm track which are accessed directly from the A4019 via the pedestrian footway.

3.2.12 To the south east of junction 10 is the turning for Withybridge Lane. Withybridge Lane is a 50mph single carriageway with property and field accesses located to both sides of carriageway throughout. To the north and within close proximity to its junction with the A4019 is the junction of Withybridge Gardens.

3.2.13 Withybridge Gardens runs parallel with the A4019 between Withybridge Lane and the M5. Fourteen residential properties are located to the south of Withybridge Gardens. There is a pedestrian footway in front of the houses with a pedestrian access ramp leading to the overbridge of the M5. To the north of the carriageway is a small retaining wall which supports the embankment for the A4019. On the opposite side of the A4019, there are two more residential properties located near the merging point of the M5 southbound to A4019 slip road.

3.2.14 To the north west of the junction are three residential properties and the Sheldon Nurseries business, and the Bank Farm buildings and yard are adjacent to the M5 northbound boundary approximately 0.9 km north of the existing A4019

3.3 Current Issues at M5 Junction 10

3.3.1 The key identified issues at this location are summarised below:

- Junction 10 is of restricted design format and only provides slip roads from the north and to the north, with no southern access slip roads provided. This means that traffic from Cheltenham must access the southbound M5 via either Junctions 9 or 11. This has put increasing pressure on already congested local roads and particularly on Junction 11, which provides access to and from southern Cheltenham on the A40.
- Junction 10 restricts emergency service operations on and off the M5 due to the junction not having any southern access slip roads;
- The junction lies within a Noise Important Area (NIA) and there are several residential receptors immediately adjacent to the junction;
- There are several residential properties and two businesses located in close proximity to Junction 10 and the M5. These properties may constrain and influence a potential scheme;
- There are a number of environmental constraints in the vicinity of the junction including flood risk (Flood Zone 2 & 3), a scheduled monument south east of the junction, a small number of public rights of way, listed buildings in the wider surrounding area and a Green Belt designation (refer to Engineering Constraints Plan - GCCM5J10-ATK-HGN-XX_ML_Z-DR-LP-000001 to 000002); and

- The current Junction 10 layout would not be able to fully support the proposed level of housing and industrial development as outlined in the JCS

3.4 Existing Structures

3.4.1 The locations of existing structures are shown on Drawings GCCM5J10-ATK-SGN-XX-DR-CB-000001 to 000004 contained in Appendix A. The main bridges, culverts and retaining walls within the vicinity of Junction 10 are described in the following sections. Information has been obtained from the Highways England Structures Management Information System (SMIS) and through consultation with Gloucestershire County Council (GCC). Where relevant the unique SMIS Structure Identification Key (Str. Key) has been provided in the title of each structure for ease of identification.

3.4.2 The Existing Structures Plan are shown on Drawing Nos GCCM5J10-ATK-SGN-XX-DR-CB-000001 to 000004 in Appendix A.

Green Farm Access Bridge (Str. Key: 1657)

3.4.3 Green Farm Access Bridge carries the Green Farm access track over the M5 motorway at marker post 75.9, north of the existing Junction 10 interchange. The bridge was constructed in 1970 and comprises a three-span continuous deck. The side spans are 16.76m long and the central span is 37.19m long, with a deck width of 5.18m wide.

3.4.4 The deck comprises a haunched voided post-tensioned concrete slab supported at each end by reinforced concrete skeleton abutments and elastomeric bearings. The intermediate pier supports are single tapered rectangular sections, which are integral with the deck at the top and include Freyssinet type hinges at the bottom. All supports are founded on 610mm diameter bored concrete piles.

3.4.5 The minimum headroom clearance is 5.09m, measured over the hard shoulder of the southbound carriageway as part of the 2018 Principal Inspection. A minimum headroom clearance of 5.63m was measured over the northbound hard shoulder during the Atkins project site walkover in June 2019.

Figure 3-1 South Elevation of Green Farm Access Bridge

3.4.6 The structure was assessed in 1994 in accordance with BD 21/93. The deck was found to have full capacity for Type HA loading and 45 units of HB loading. The pier supports were found to have insufficient shear capacity to resist horizontal collision loading in accordance with BD 48/93. High containment Concrete Step Barriers (CSB) were installed in 2012 to protect the piers from impact loading. At the time of the Atkins site walkover, the clear distance from the edge of the hard shoulder to the inside face of the northbound carriageway pier was measured as 1.7m.

3.4.7 The latest Principal Inspection Report (dated December 2018) found the structure to be in good condition. A Special Inspection completed in January 2011 included an endoscope survey of the post-tensioning cable ducting. Inspection of the east span found no evidence of grouting of the ducts, with some corrosion to the cable. The full extent of corrosion is unknown.

3.4.8 A Thaumasite Sulphate Attack (TSA) investigation was conducted on the structure in 2005 as part of a wider Area 2 initiative. Four core samples were extracted, two cores from the columns (below ground level) and two from the pile caps. Laboratory tests found that two cores had evidence of the development of TSA to a maximum depth of 9mm and 11mm respectively. Face logging of the geological strata around the excavation confirmed that firm grey slightly sandy slightly gravely clay was used as backfill to the piers. Testing of soil samples indicated that the Aggressive Chemical Environment for Concrete Classification was AC-2.

Hardwicke-Elmstone Hard Bridge (Str. Key: 1658)

3.4.9 Hardwicke-Elmstone Hard Bridge carries a non-classified road over the M5 motorway at marker post 76.7, north of the existing Junction 10 interchange. The bridge was constructed in 1970 and comprises a three-span continuous deck at a skew of 6.94 degrees. The side spans are 16.76m long and the central span is 37.19m long, with an overall deck width of 10.52m. A minimum headroom of 5.4m was measured over the southbound hard shoulder as part of the 2019 Principal Inspection.

3.4.10 The deck comprises a haunched voided post-tensioned concrete slab supported at each end by reinforced concrete skeleton abutments and elastomeric bearings. The intermediate pier supports are twin tapered rectangular sections, which are integral with the deck at the top and include Freyssinet type hinges at the bottom. All supports are founded on pad foundations. Services bays are located in the footways.

3.4.11 Based on current available information from relevant statutory undertakers, a Gigaclear telecoms service and a Severn Trent water main are shown to cross the structure within the north side service bay.

Figure 3-2 North Elevation of Hardwicke Elmstone Hard Bridge

3.4.12 The structure was assessed in 1993 in accordance with BD 21/84. The deck was found to have full capacity for Type HA loading and 30 units of HB loading. The pier supports were found to have insufficient shear capacity to resist horizontal collision loading in accordance with BD 37/88. High containment Concrete Step Barriers (CSB) were installed in 2012 to protect the piers from impact loading. The parapets were also assessed at the same time and found to be substandard. This is believed to still be the case based on available information.

3.4.13 The latest Principal Inspection Report (dated March 2019) found the structure to be in poor to fair condition. Large spalled areas of concrete were discovered on the soffit of the centre span, particularly over the southbound carriageway where reinforcement and void formers were also exposed.

3.4.14 A Thaumasite Sulphate Attack (TSA) investigation was conducted on the structure in 2006 as part of a wider Area 2 initiative. Four core samples were extracted, two cores from one of the columns (below ground level) and two from the pad foundation. Laboratory tests found that two cores had evidence of the development of TSA to a maximum depth of 9mm. Face logging of the geological strata around the excavation confirmed that firm grey slightly sandy slightly gravely clay was used as backfill to the piers. Testing of soil samples indicated that the Aggressive Chemical Environment for Concrete Classification was AC-3

Barn Farm Culvert (Str. Key: 34462)

3.4.15 Barn Farm Culvert is a twin precast concrete pipe culvert that carries Leigh Brook under the M5 motorway at marker post 77.6, north of the existing Junction 10 interchange. The culvert was constructed in 1995 and comprises two 1.25m diameter concrete pipes, with reinforced concrete head walls at the elevations. The total length of the pipes is recorded as 55m, skewed under the carriageway in a south east to north west direction.

3.4.16 The latest Principal Inspection was completed in December 2016 and found the structure to be in good condition throughout.

Figure 3-3 East Elevation of Barn Farm Culvert

Piffs Elm Interchange Bridge (Str. Key: 1659)

3.4.17 Piffs Elm Interchange Bridge carries the A4019 over the M5 at the existing Junction 10, at marker post 77.9. The bridge was constructed in 1970 and comprises a four-span continuous deck at a skew of 1.5 degrees. The span lengths from east to west are 11.0m, 21.6m, 26.2m and 14.9m. The deck is wider at the west abutment to accommodate the northbound slip road from the A4019 onto the M5, tapering down in width towards the east abutment. West and east overall deck widths are 28.6m and 25.6m respectively. A minimum headroom of 5.03m was measured over lane 3 of the east centre span as part of the 2018 Principal Inspection.

3.4.18 The deck comprises a post-tensioned voided concrete slab supported at each end by reinforced concrete skeleton abutments and elastomeric bearings. The intermediate pier supports each comprise five columns, which are integral with the deck at the top. Originally the abutments and piers were founded on pad foundations. However, in 2015 the pier footings were replaced with piled foundations placed between the existing spread footings as part of remedial measures to prevent the onset of Thaumasite Sulphate Attack (TSA) which had been identified through the results of an intrusive investigation conducted in 2006.

3.4.19 Based on current available information from relevant statutory undertakers, there is a BT telecommunication route located within the south footway service bay. No other services are known to be located within the bridge deck. However various services are shown to be located within the surrounding M5 carriageway area beneath the structure. This should be verified at the preliminary design stage following completion of more detailed utility surveys.

Figure 3-4 North Elevation of Piffs Elm Interchange Bridge

3.4.20 The main superstructure was assessed in 1994 to BD 21/93, the piers were assessed to BD 48/93 for HGV collision loading and the parapets in accordance with BD 52/93. The deck was found to have full capacity for Type HA loading and 45 units of Type HB loading. The columns were found to be inadequate for HGV collision loading. However, CSB protection was installed as part of the 2017 remedial works. The parapets were found to be non-compliant and were replaced with compliant units in 1997.

3.4.21 The latest Principal Inspection Report (dated February 2018) found the structure to be in fair to poor condition. Substantial horizontal cracking was observed at both abutments, more severe at the west abutment. Multiple concrete spalls were present throughout the deck soffit. For the most part these are a result of metal debris left during the original deck construction. Further areas of spalled concrete with exposed reinforcement were observed to the west end of both parapet edge beams. Both east and west asphaltic plug joints have failed, having cracked and debonded from the deck, allowing water seepage behind the abutments.

3.4.22 A further intrusive investigation in 2013, which was documented in a June 2017 Special Inspection (SI) Report, found TSA to the top of the foundations of the east abutment, to a depth of 25mm. No deterioration related to TSA was identified at the west abutment foundations. Although remedial measures were undertaken in 2017 to prevent further TSA to the bridge piers, no measures have been put in place to prevent TSA to the buried concrete surfaces of the abutment foundations.

Withybridge Gardens Retaining Wall

3.4.23 Withybridge Gardens Retaining Wall is located on the south east approach to Piffs Elm Interchange Bridge. The wall retains the raised section of the A4019 from the Withybridge Gardens residential cul-de-sac below. It is not identified as a separate structure on its own, and the only records are as part of the HE SMIS data for Piffs Elm Interchange Bridge, despite it being physically separate from the bridge. The retaining walls does not appear in GCC's structures database.

3.4.24 The wall runs for most of the length of Withybridge Gardens, a total length of approximately 224m (735ft), and it comprises three main sections. The section nearest to Piffs Elm Interchange Bridge is approximately 64.4m (211ft) in length and has an average retained height of 3.3m. The middle section is approximately 28m (92ft) in length and incorporates a pedestrian ramped footpath providing access to the A4019 above. The retained height of this section reduces to approximately 2.6m at the base of the ramp. The final section comprises a long, tapered wall extending east, approximately 131.7m (432ft) in length, reducing to a height of 1m at the east end.

3.4.25 All three sections of the wall comprise cantilever reinforced concrete panels with shear keys and dowel type joints between each panel.

Figure 3-5 View East along Withybridge Gardens Retaining Wall

3.4.26 There are no documented inspection records for this structure held by either HE or GCC. At the time of the Atkins project site walkover, the structure appeared to be in overall fair condition. However, a further detailed inspection would be needed at the preliminary design stage to confirm this brief observation.

Piffs Elm Service Culvert (Str. Key: 13574)

3.4.27 Piffs Elm Services Culvert was built in 1970 to carry service pipes under the M5 motorway. It is located at marker post 77.9, directly south of the existing Junction 10 interchange and Piffs Elm Interchange Bridge.

3.4.28 The culvert is a reinforced concrete box structure with an internal span of 3.06m and an approximate height of 2m. Its orientation is square to the motorway carriageways for a length of 86m before it turns to the north and extends a further 90m beneath the A4019. There are 14no. movement joints at approximately 12m intervals. Access into the culvert is gained via manholes at either end, with the east end located adjacent to the southbound carriageway and accessed via the end of Withybridge Gardens road. The fill depth is recorded as being 2m from the roof slab to the carriageway level.

3.4.29 The culvert contains one 300mm diameter medium pressure steel gas main, one 300mm diameter steel water main and one 225mm diameter steel water main. Further British Telecommunications services are shown to run in ducting cast into the deck slab of the culvert.

Figure 3-6 Typical View inside Piffs Elm Service Culvert

3.4.30 The structure was assessed in 1996 in accordance with BD 21/93 and BD 31/87. The structure was found to have full capacity to support Type HA loading and 45 units of HB loading.

3.4.31 The latest Principal Inspection Report (dated June 2013) found the structure to be in overall fair condition with minor concrete spalling and calcite staining. The culvert was found to be partially filled with water to a depth of between 1 and 1.5m. The source of the water was said to be unknown, however previous inspections suggested this could be an ingress of groundwater through the movement joints between the culvert sections.

Piffs Elm Culvert (Str. Key: 34468)

3.4.32 Piffs Elm Culvert was constructed in 1995 and passes under the M5 motorway at marker post 78.1, south of the existing Junction 10 interchange. It comprises a 1.3m diameter steel Armco type (i.e. corrugated steel buried pipe) structure with masonry bonded head walls at each elevation. The culvert is approximately 50m in length.

3.4.33 The inside of the culvert was last inspected in 2016 as part of a confined space Principal Inspection. It was found to be heavily vegetated at the elevations and silted to a depth of 100mm within the pipe. The detection of explosive gases prevented inspection of the western section. Evidence of full section loss and deformation to the crown of the culvert was observed near to the east elevation.

Figure 3-7 West Elevation of Piffs Elm Culvert

River Chelt Culvert (Str. Key: 1660)

3.4.34 River Chelt Culvert carries the M5 motorway over the River Chelt and a Public Right of Way (PROW) at marker post 78.8, south of the existing Junction 10 interchange. The culvert was constructed in 1970 and comprises a reinforced concrete box structure with square tapered reinforced concrete wing walls at the elevations. The PROW is accommodated by a cantilever walkway cast into the south abutment along its full length, with reinforced concrete staircases leading down to the structure at the elevations. The clear square span of the culvert is 6.1m, and the culvert has a skew angle of 14 degrees. The overall length of the culvert is 43m, with an internal height of 3.65m. The minimum fill depth above the roof slab is 0.5m.

3.4.35 The structure was assessed in 1995 in accordance with BD 21/93 and BD 31/87 and was found to have full capacity to support Type HA loading and 45 units of HB loading.

3.4.36 The latest Principal Inspection was completed in January 2019 and found the structure to be in good condition throughout. Inspection of the abutments found notable signs of periodic increased water levels within the culvert, extending to mid-height up the abutment walls. This suggests that during periods of high rainfall there is a significant flow of water through the culvert.

Figure 3-8 East Elevation of River Celt Culvert

Staverton Twin Culvert

3.4.37 Staverton Twin Culvert is a twin precast concrete pipe culvert that passes under the M5 motorway at marker post 79.0, south of the existing Junction 10 interchange. The culvert was constructed in 1995 and comprises two 1m diameter concrete pipes, with reinforced concrete head walls at the elevations. The total length of the pipes is recorded as 50m, with a slight skew under the carriageway in a south west to north east direction.

3.4.38 The latest Principal Inspection of the culvert was completed in December 2016. The culvert was found to be in a fair condition overall, with signs of minor joint separation between culvert pipe sections and cracking to the west head wall. Silt deposits of up to 200mm and debris build up were also observed.

Figure 3-9 East Elevation of Staverton Twin Culvert

Minor Retaining Walls

3.4.39 Within the wider project limits of the M5, there are a number of low-height retaining walls which retain the motorway verge embankments around motorway communication cabinets. These structures were constructed in 2001 and comprise free-standing blockwork retaining walls on mass concrete spread footings. Their retained heights range from 0.87m to 1.4m, with overall lengths ranging from 7.7m to 12.4m. A full list of these structures is provided below:

- Comcab R/W No.2 (Str. Key: 22294), at MP 75.4
- Comcab R/W No.3 (Str. Key: 22295), at MP 75.9
- *Unidentified R/W, at MP 76.4
- *Unidentified R/W, at MP 76.9
- Comcab R/W No.4 (Str. Key: 22296), at MP 78.3
- Comcab R/W No.5 (Str. Key: 22297), at MP 78.7
- Comcab R/W No.6 (Str. Key: 22298), at MP 79.2

*These retaining walls have been identified on site but do not have associated SMIS records. They appear to be a similar construction to the other Comcab retaining walls.

Figure 3-10 Typical Arrangement of a Comcab Retaining Wall

3.4.40 As well as minor retaining walls, there are also a couple of minor structures within the project limits which support motorway communication systems. These structures are as follows:

CCTV Mast 00041 47774 NB (Str. Key: 26968)

3.4.41 This CCTV Mast is located at marker post 77.4, in the verge of the northbound carriageway. It was constructed in 2007 and comprises a steel square hollow section mast with a bolted base plate connection to a reinforced concrete pad foundation. The mast supports a traffic flow monitoring camera which can be winched up and down.

Figure 3-11 View of CCTV Mast 00041 Looking North

MS4 Cantilever Gantry 12 (Str. Key: 26925)

3.4.42 At the southern project limits of the M5 there is a Motorway Signal Mark 4 (MS4) cantilever gantry. The gantry is located within the verge of the southbound carriageway at approximate marker post 79.6. The structure was constructed in 2009. The cantilever gantry comprises a 508mm diameter steel circular hollow section mast, fixed via a steel plinth to a helical pile grillage with an embedment depth of between 6 and 8m.

Figure 3-12 View of MS4 Cantilever Gantry 12 Looking South

3.5 Existing Road Pavement

3.5.1 Information on the existing pavement construction and condition was extracted from the Highways Agency Pavement Management System (HAPMS) in August 2019.

3.5.2 Limited HAPMS data was only available for the following sections:

- M5 mainline (Northbound and Southbound)
- Northbound on slip
- Southbound off slip

3.5.3 Apart from the extents of the scheme defined in Section 4.4.2, information relating to the existing pavement was not available for the following sections:

- A new West Cheltenham Link Road from J10;
- Dualling of the A4019 to the East of the link road;
- A38/A4019 junction improvements at Coombe Hill; and
- Extension to Arle Court Park and Ride.

3.5.4 Since these sections are managed by Gloucestershire County Council (GCC) and not overseen by Highways England, they are not included in the HAPMS dataset. Therefore, for these sections, further investigation is required to determine the existing pavement condition and construction.

3.5.5 The HAPMS information on the existing pavement includes the following:

- As-built construction.
- Traffic Speed Condition Survey (TRACS) (Sept. 2018, April, May, June 2019)
- Sideways-force Coefficient Routine Investigation Machine (SCRIM) (May 2018).

- Traffic Speed Deflectometer (TSD) (Oct. 2018, Oct. 2019).

Existing Pavement Construction

3.5.6 The available pavement construction information in the HAPMS database was reviewed for each road section. The findings are summarized in Table 3-1 and discussed below.

Table 3-1 – HAPMS Construction Data Summary

Road Section	Direction	HAPMS Section	Lane	Coverage (%)	Fully Flexible Pavement Asphalt Thickness (mm)		
					Min	Max	Average
M5 Mainline	NB	1600M5/138	L1	100	380	520	425
			L2	100	495	495	495
			L3	100	460	470	464
			LH	100	460	460	460
	SB	1600M5/137	L1	71	573	585	576
			L2	71	580	580	580
			L3	71	532	582	557
			LH	71	462	462	462
M5 on slip	NB	1600M5/175	L1	100	300	505	385
			L2	100	300*	347	313
			LH	100	305	305	305
M5 off slip	SB	1600M5/174	L1	100	246	547	422
			LH	100	285	500	414
			RH	100	300	480	368

* Value has been assumed to match the minimum thickness of lane1 since the raw data appears mistakenly input for lane 2.

3.5.7 M5 mainline and slip roads construction is indicated as flexible pavement. For the M5 mainline northbound and southbound carriageway, the asphalt thickness ranges from 380 to 520mm and 462 to 585mm, respectively.

3.5.8 The northbound on slip section comprises 300 to 505mm of asphalt and the Southbound off slip section is made up of 246 to 547mm asphalt.

3.5.9 The typical surface course is 35 to 50mm of TSCS 14 (generic and with PMB) for the M5 mainline sections and 40 to 50mm of TSCS 10 for the slip roads sections.

3.5.10 Information on the subbase material type and thickness are not available in the HAPMS database.

3.5.11 Construction builds-up data was available for 71% of the Southbound M5 mainline section length within the scheme extents.

Existing Pavement Condition

3.5.12 The HAPMS TRACS data comprises surface condition i.e. rutting, texture depth and riding quality in terms of Enhanced Longitudinal Profile Variance (ELPV). SCRIM and TSD data were also examined, where available, to provide information on skid resistance and structural condition of the existing pavement.

The data coverage on the existing pavement condition are summarised in Table 3-2

Table 3-2 – Summary of HAPMS data coverage (%)

Road section	Direction	HAPMS section	Lane	Data coverage (%)		
				TRACS	SCRIM	TSD
M5 Mainline	NB	1600M5/138	L1	100	100	100
			L2	100	0	0
			L3	100	0	0
			LH	0	0	0
	SB	1600M5/137	L1	71	0	71
			L2	71	0	0
			L3	0	0	0
			LH	0	0	0
M5 on slip	NB	1600M5/175	L1	88	0	0
			L2	0	0	0
			LH	0	0	0
M5 off slip	SB	1600M5/174	L1	7	3	0
			LH	0	0	0
			RH	0	0	0

3.5.13 The available TRACS data, was evaluated based on the four condition categories in HD29/08 Table 2.1 for texture depth, rut depth and riding quality and in accordance with the threshold values in Annex 2A of HD29/08.

3.5.14 The TRACS rutting data revealed that there are no sections of rut category 3 or 4. The majority of M5 mainline and slip roads sections indicates category 1 (sound condition) with some locations (12% overall) of category 2 (low level of concern rutting). The data is presented in Figure 3-13.

Figure 3-13 TRACS Rutting Data Presentation

3.5.15 Figure 3-14 Two sections within the slip roads were found to be in category 3 or 4 (9% and 3% of slip length respectively) which are in moderate to severe deterioration category for the ELPV 3m and ELPV 10m. Sections defined of categories 3 and 4 are very localised, thus further investigation is recommended to confirm their riding quality condition.

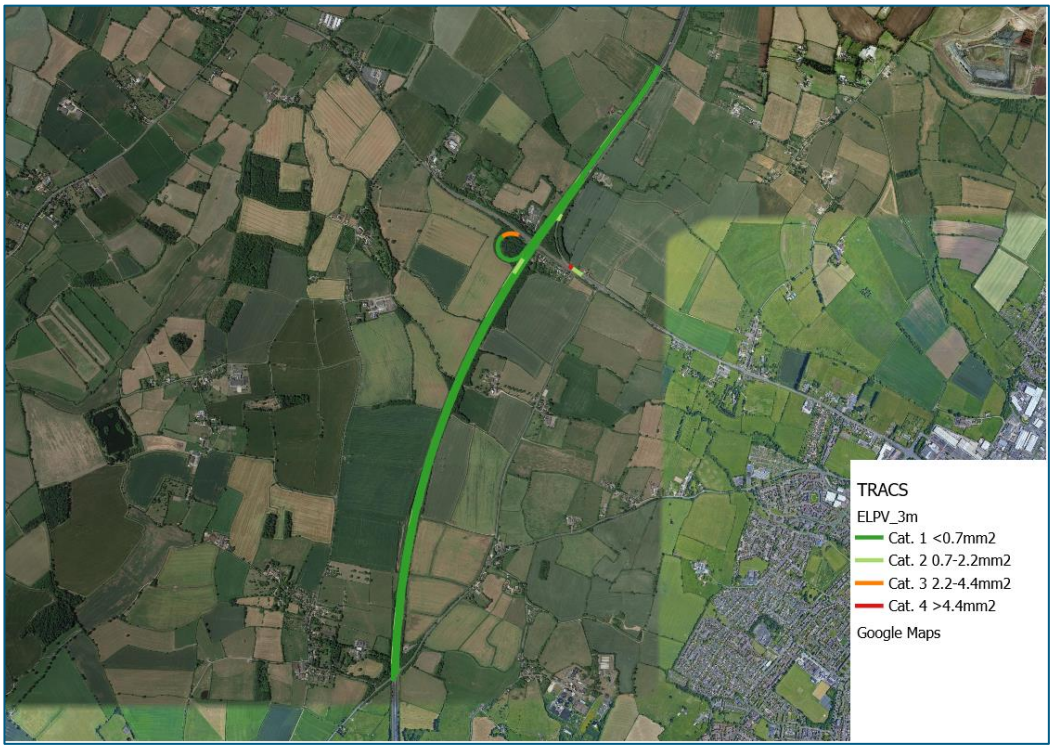


Figure 3-14 ELPV 3m Data Presentation

Figure 3-15 ELPV 10m Data Presentation

Figure 3-16 ELPV 30m Data Presentation

3.5.16 TRACS texture data showed sound condition with all of the M5 mainline sections in “category 1” with few sections of low level of concern “category 2”. The texture data for slip road sections indicated category 2 (see Figure 3-17)

Figure 3-17 ELPV 30m Data Presentation

3.5.17 Figure 3-18, SCRIM data revealed skid resistance with Corrected SCRIM Coefficient (CSC) above the required Investigatory Levels (IL). For slip roads, only one data point was identified on Southbound off slip section which does not satisfy the designated IL.

Figure 3-18 SCRIM Data Presentation

3.5.18 The TSD data was available for the mainline section of M5 lane 1. The analysis showed a number of M5 Northbound sections (65%) were in Category 3 and 4, especially for those sections approaching junction 10 as shown in Figure 3-19. This indicates moderate to severe deterioration; therefore, further detailed investigation is required to confirm the structural condition of the pavement for those sections. For the M5 Southbound sections, the TSD data showed category 1 and 2, which implies sound to some deterioration condition.

Figure 3-19 TSD Data Presentation

3.6 Existing Traffic Conditions

3.6.1 This section summarises the existing traffic conditions around junction 10 of the M5 using existing data sources and previously commissioned, collected and analysed data for the development of the 2013 Central Severn Vale (CSV) model along with readily available WebTRIS data which has been extracted for 2019.

3.6.2 In addition the Local Model Validation Report for the M5 J10 – J11 Paramics model has been reviewed and manual classified count data and queue length data pertaining to J10 is extracted and presented in this report.

3.6.3 The peak hours, that is the hours during which traffic volumes are greatest was determined during the development of the CSV model using existing traffic count data. Peak hours were found to be 08:00 – 09:00 in the morning and 17:00 – 18:00 in the evening peak. Inter-peak refers to the hours between 10:00-16:00 and flows presented in Table 3-3 to Table 3-5 are for an average of these hours.

3.6.4 Junction 10 is strategically located connecting M5 north-south mainline with A4019 east-west, thereby connecting Cheltenham to the motorway directly and providing alternate routes to Tewkesbury and Gloucester.

3.6.5 Table 3-3 below shows the peak hour average traffic flows on the M5 to the north of Junction 10. Data is presented for 2019 using neutral months (as defined by TAG) and also for the CSV base year of 2013. Data was available up to 30th of September 2019 at the time of the analysis.

Table 3-3 – M5 Mainline Traffic Counts – M5 J9 – J10 (veh)

Year	Data Source	Dir.	AM	IP	PM
2013	CSV LMVR	NB	3,239	2,824	4,103
		SB	4,038	2,600	3,502
2019	WebTRIS	NB	2,930	3,345	3,996
		SB	3,800	3,259	3,611
% Change		NB	-10%	18%	-3%
		SB	-6%	25%	3%

3.6.6 Count data for the M5 to the south of Junction 10 (between junction 10 and 11) has not been used during the development of the 2013 CSV model. However, it is readily available from the Highways England WebTRIS database and so has been extracted for this report and is shown in Table 3-4 below. Data presented is for an average weekday in a neutral month of 2019 and 2013 for comparison.

Table 3-4 – M5 Mainline Traffic Counts - M5 J10 – J11 (veh)

Year	Data Source	Dir.	AM	IP	PM
2013	WebTRIS	NB	2,843	2,854	3,472
		SB	3,330	2,522	3,162
2019	WebTRIS	NB	2,529	3,316	3,395
		SB	3,189	2,884	3,078
% Change		NB	-11%	16%	-2%
		SB	-4%	14%	-3%

3.6.7 Table 3-3 and Table 3-4 show the percentage change in peak hour flows between the current year and the CSV base year of 2013. It can be seen that the AM peak volumes have decreased by 10 - 11% northbound and 4-6% in the southbound direction. The PM peaks remain relatively consistent between years with changes not exceeding 3%. The inter-peak volumes follow a different trend, with volumes consistently increasing in both directions by between increases ranging between 14 and 25%

3.6.8 Of key consideration is whether the changes in traffic volumes between 2019 and 2013 are significant enough to render the CSV inappropriate for use in forecasting scheme impacts. In order to determine this, it is necessary to determine whether an increase or decrease in volume changes the volume to capacity ratio of the link such that the speeds and delays experienced by users is significantly different.

3.6.9 The Regional Traffic Model (RTM) provides guidance for typical capacities that should be used for modelling various road types. The default capacity for a three-lane motorway such as the M5 mainline between Junction 9 and 11 is given as 6,990 passenger car units (PCUs) per hour.

3.6.10 Based upon the traffic modelling guidance the volume to capacity ratio along the M5 mainline would be less than 50% along both sections, in both directions and in all three time periods. This is true both in 2019 and in 2013.

3.6.11 It is noted that the figures presented above are in vehicles, not passenger car units, however even so, the existing flows are sufficiently below the modelling guidance capacity such that it can be concluded that the M5 mainline in 2019 is operating within capacity.

3.6.12 No data is available for the number of HGVs that make up the total vehicles on the links, nor has any turning count data been used in the development of the CSV to enable an understanding of the movements around the junction.

3.6.13 Traffic flow ATC data for the A4109 for 2013 and 2019 is presented in Appendix A. This data demonstrates that the traffic pattern and volumes are not significantly different between the two years, further justifying the use of the 2013 base year CSV model.

3.6.14 Table 3-5 shows the peak hour average flows along the A4019 to the east and west of junction 10. Data presented is from the CSV model dataset and so is for 2013. As discussed above the traffic volumes have not changed significantly and so the figures presented below can be considered to be representative of the current traffic conditions.

Table 3-5 – A4019 West Count Sites - 2013 (veh)

Site	Dir.	AM	IP	PM
A4019 Tewkesbury Rd (East of J10)	WB (to J10)	739	696	1,127
	EB (from J10)	1,212	830	888
A4019 Tewkesbury Rd (West of J10)	WB (from J10)	323	257	639
	EB (to J10)	583	463	411

3.6.15 The eastern and western sections of the A4019 both have single lane approaches towards Withybridge, widening out to two lanes over the structure itself. As with the M5 mainline the RTM provides typical capacities for rural roads of this type in the range of 1,380 PCUs to 1,660 PCUs depending on carriage width and road condition.

3.6.16 Again, noting that the figures presented in Table 3-5 are in vehicles not PCUs, the peak hourly traffic volumes are generally well within capacity. The maximum volume in any time period is 1,212 vehicles which is approaching the point at which delays may be experienced, however it is unlikely that on an average day this volume causes significant congestion.

3.6.17 The eastern section experiences peak hour flows of 1,212 eastbound in the AM peak and 1,127 in the westbound direction in the PM peak with far lower flows in the opposing directions suggesting a tidal flow of commuter traffic accessing Cheltenham via the A4019 and Junction 10 and leaving via the same route in the evening peak.

3.6.18 Low flow volumes may also be a result of congestion, if traffic volumes on a link reach a critical threshold, average, vehicles speeds decrease resulting in a lower volume of traffic passing over a traffic count detector. Section 3.6.39 onwards of this report reviews the journey time data available around Junction 10, no evidence was found for low speeds through the scheme location.

3.6.19 Queue data was collected in November 2017 to inform J10-J11 Paramics model and is presented in Table 3-6 below. Note the queue data was collected in November 2017.

Table 3-6 - Maximum Observed Queue Length (vehs)

Site	AM	PM
A4019 (West of Tewkesbury Rd/Princess Elizabeth Way Roundabout)	123	114

A4019 (East of Tewkesbury Rd/Princess Elizabeth Way Roundabout)	135	99
M5 J10 Southbound Offslip	39	12

Source: M5 J10 – J11 Paramics Model Validation Report – 2018 (Jacobs)

3.6.20 The queue data in Table 3-6 above shows that in the AM peak queues form at J10 The data also shows queues further to the east of the offslip along the A4109 approach to the Tewkesbury Road/Princess Elizabeth Way Roundabout. This dataset indicates that, within the AM peak, the A4109 experiences significant congestion in the eastbound direction.

3.6.21 The queue data at the southbound offslip shows queue build-up in both AM and PM peaks though this is well within the stacking capacity of the slip road at present.

Collisions

3.6.22 The latest collision data for the five year period from 1 July 2014 to 30 June 2019 was obtained from Gloucestershire County Council for the area outlined in the map shown in Figure 3-20, specifically along the M5 and A4019. During this period 55 personal injury collisions (PICs) were recorded. Of the 55 collisions, 14 (25.5%) resulted in serious injury whilst the remaining 41 (74.5%) were slight injury collisions. No fatalities were recorded the five-year period.

3.6.23 The Collisions Data is shown on Drawing Nos GCCM5J10-ATK-HGN-XX_ML_Z-DR-CH-000031 to 000032 in Appendix A.

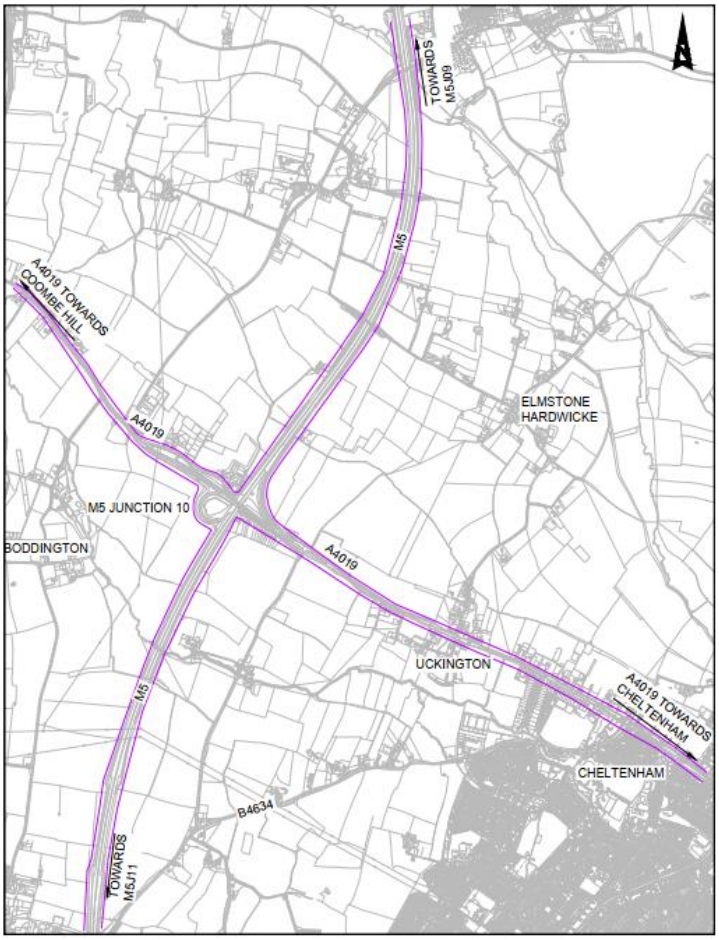


Figure 3-20 Collision Analysis Extents

3.6.24 The collision rate along the motorway and A road are shown in Table 3-7 and compared to expected rates along the SRN[1].

Table 3-7 – SRN Collision Rate[2]

	M5	Motorway	A4019	A Road
Length of road (miles)	3.4	1890	3.0	2587
Two-way daily traffic flow	83808	88227	22201	61806
No of collisions	21	4180	34	4663
Collision Rate (Col/HMVM)	4.04	6.87	27.61	13.90

3.6.25 The collision rate along the M5 within the study area is slightly lower than expected whilst the collision rate along the A4019 is higher than expected. The A4019 is subject to a 50mph speed limit for the majority of the route which falls within the study area. Particularly towards the eastern extents of the speed limit (beyond which the speed limit reduces to 40mph) there are residential properties with vehicle direct access onto the A4019 and uncontrolled junctions increasing the likelihood of conflicts occurring on the mainline.

3.6.26 Thirty-four collisions (61.8%) occurred along the A4019 and twenty-one collisions (38.1%) were recorded along the M5. Table 3-8 shows the percentage of KSIs along the M5 and A4019 compared to the average for these types of SRN routes3.

Table 3-8 – Comparison of KSIs on SRN

	M5	Motorway	A4019	A Road
KSI	28.6% (6)	10.5%	23.5% (8)	8%

Collision Overview

3.6.27 The percentage of KSIs along the M5 and the A4019 exceed that which would be expected along these types of route. However, the presence of the motorway junction and numerous other minor junctions along the A4019 could explain the higher than expected percentages of KSI collisions.

3.6.28 The highest hourly number of collisions on the M5 occurred between 17:00 and 18:00 whilst collision rates peaked along the A4019 between 08:00 and 09:00. These results indicate that collisions on the motorway are more likely to occur in the evening peak and collisions are most likely to occur on the A4019 in the morning peak when traffic flows are higher and routes are more congested.

3.6.29 The majority of the collisions recorded within the study area involved motorised vehicles. Five (9.1%) of all collisions involved powered two-wheelers, four collisions (7.3%) involved pedestrians and two collisions (3.6%) involved pedal cyclists. In total, less than 11% of the collisions involved vulnerable road users (pedestrians and cyclists). Unsurprisingly all of the collisions involving pedestrians and cyclists were on the A4019 and made up 18% of the total number of A4019 collisions.

3.6.30 Twenty-two (40.0%) collisions occurred at junctions (uncontrolled or signal controlled). Just one of these junction collisions was assigned to the M5 whilst the remaining twenty-one were assigned to the A4019. 72.7% of collisions which occurred at junctions took place at uncontrolled junction layouts whilst just 23.3% of junction collisions occurred at

[1] Although a comparison has been made with collision rates on SRN 'A' roads, the A4019 does not form part of the SRN and traffic flows are significantly lower than the comparator
[2] 'Reported Road Casualties on the Strategic Network 2017', Highways England
[3] 'Reported Road Casualties on the Strategic Network 2017', Highways England

signal-controlled layouts. These statistics show that in terms of collision numbers (not rate), there are more collisions at the uncontrolled junctions along the A4019, rather than at signal controlled junctions.

Collision Contributory Factors

3.6.31 Along the M5 the main contributory factors attributed include failure to look properly (405) (3 collisions) and impaired by alcohol (501) (3 collisions). These factors were assigned to 28.6% of the motorway collisions as 'factor 1'. Failure to look properly is ranked as the top contributory factor for motorway collisions[4]. 'Impaired by alcohol' does not feature in the top ten contributory factors for motorway collisions nationally[3], indicating that, unlike other motorways, there may be a specific issue with drink driving on the M5 although with fewer than one collision per year on average this may not be significant.

3.6.32 Table 3-9 illustrates the main contributory factors assigned as 'factor 1' to collisions along the A4019.

Table 3-9 – A4019 Common Contributory Factors

	Number of collisions on A4019	% of collisions
Failure to look properly (405)	12	35.3%
A Failure to judge other's path or speed (406)	5	14.7%
Poor turn or manoeuvre (403)	4	11.8%
Failed to look properly (pedestrian) (802)	4	11.8%
	25	73.5%

3.6.33 Almost three quarters of the collisions on the A4019 were assigned one of the four contributory factors listed in Table 3-9. The top three contributory factors along the A4019 feature in the top five contributory factors along A roads[5].

Collision Hotspots

3.6.34 Along the M5 on the approach to the A4019 off-slip, eight collisions have been recorded two of which resulted in serious injury. Collisions at this location account for 38.1% of all the motorway collisions in the study area. Four (50%) of these collisions were nose-to-tail shunts suggesting there may be queuing traffic along the motorway through the junction. Three (37.5%) of the collisions involved vehicles swerving, drifting or changing lanes into the path of another vehicle. It is possible that drivers could be making last minute lane switches to exit the motorway but this type of collision is also seen at locations where drivers are braking due to queuing ahead.

[4] Table 4-6 of Casualties on the Strategic Network, Highways England 2017
[5] Table 4-6 of Casualties on the Strategic Network, Highways England 2017

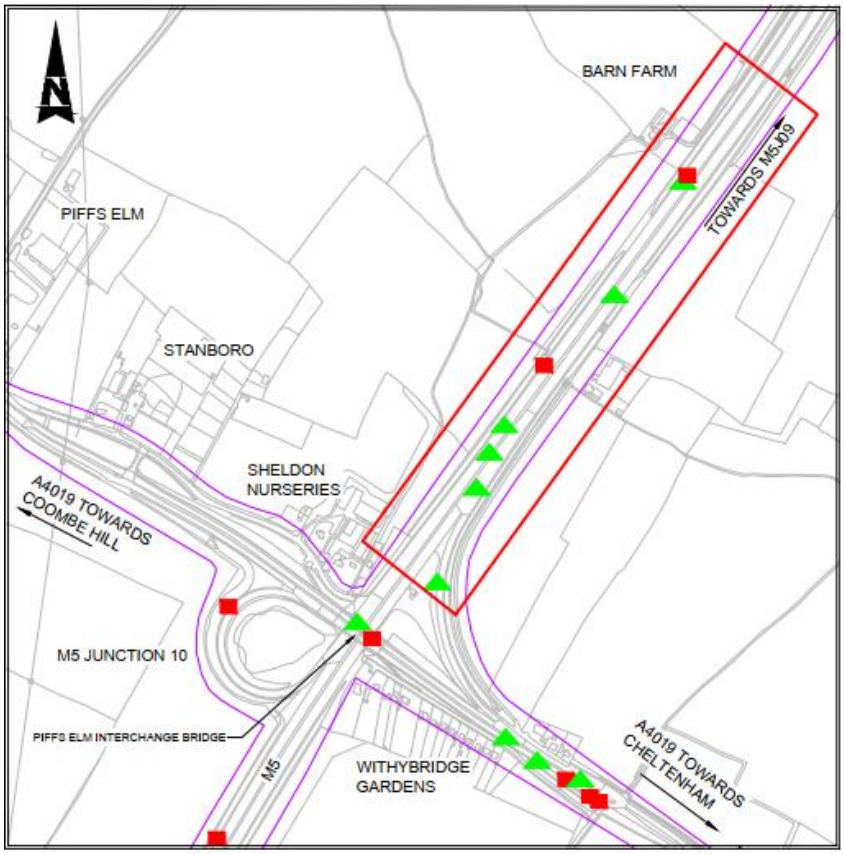


Figure 3-21 M5 Collision Hotspot

3.6.35 A second collision cluster site has been identified at the junction of the A4019 with an unnamed road at the Gloucester Old Spot public house. Eight collisions have been recorded at this location all of which resulted in slight injury. Three of the collisions occurred as a result of vehicles on the minor road failing to give-way to traffic on the A4019. Two collisions involved vehicles colliding with buses at the nearby bus stop and a further two collisions involved vehicles which were overtaking on the A4019. The eighth collision involved a vehicle which failed to stop for the police. The collision data indicates that improvements to this junction are required to reduce the risk of collisions occurring

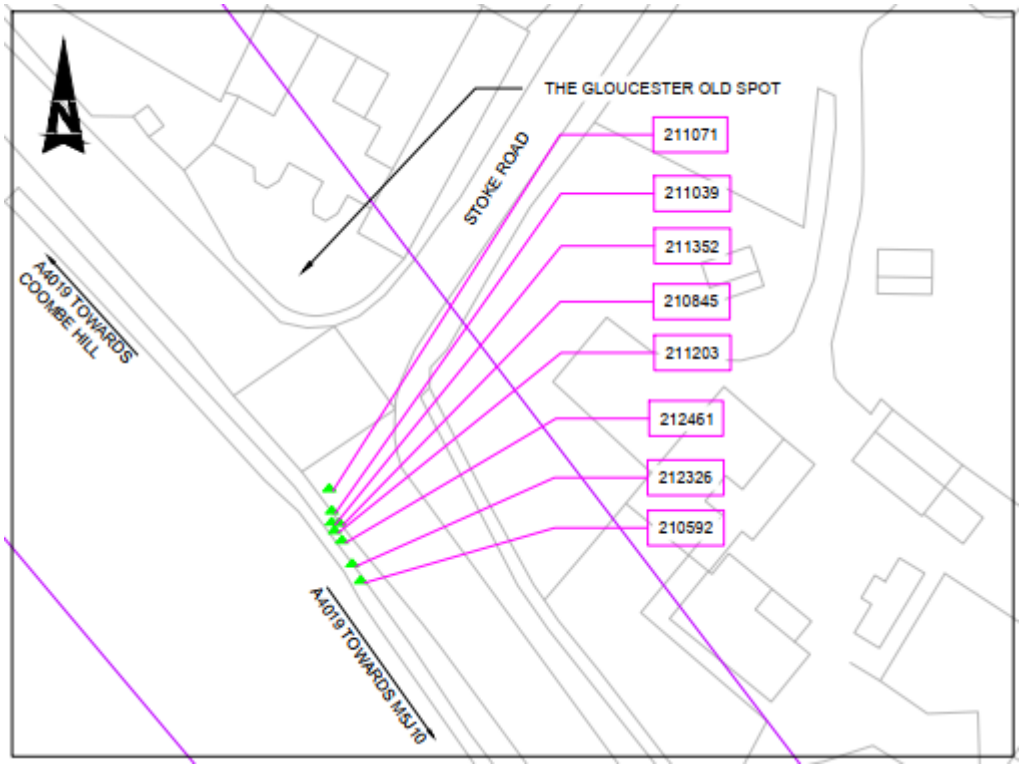


Figure 3-22 A4019 Un-named Road Collision Hotspot

3.6.36 A collision cluster site has also been identified at the junction of the A4019 with Withybridge Lane. The road layout between the M5 offslip and Withybridge Lane is somewhat complicated with three gaps in the central reserve in close proximity to one another to facilitate right turn movements at Withybridge Lane, a field access, access to properties along the north side of the A4019 and a travelers site at the M5 offslip. Access to the properties along the north side of the A4019 and to the travelers site for westbound traffic is gained via the gap in the central reserve and then continued along the kerbed hardstanding in front of the properties.

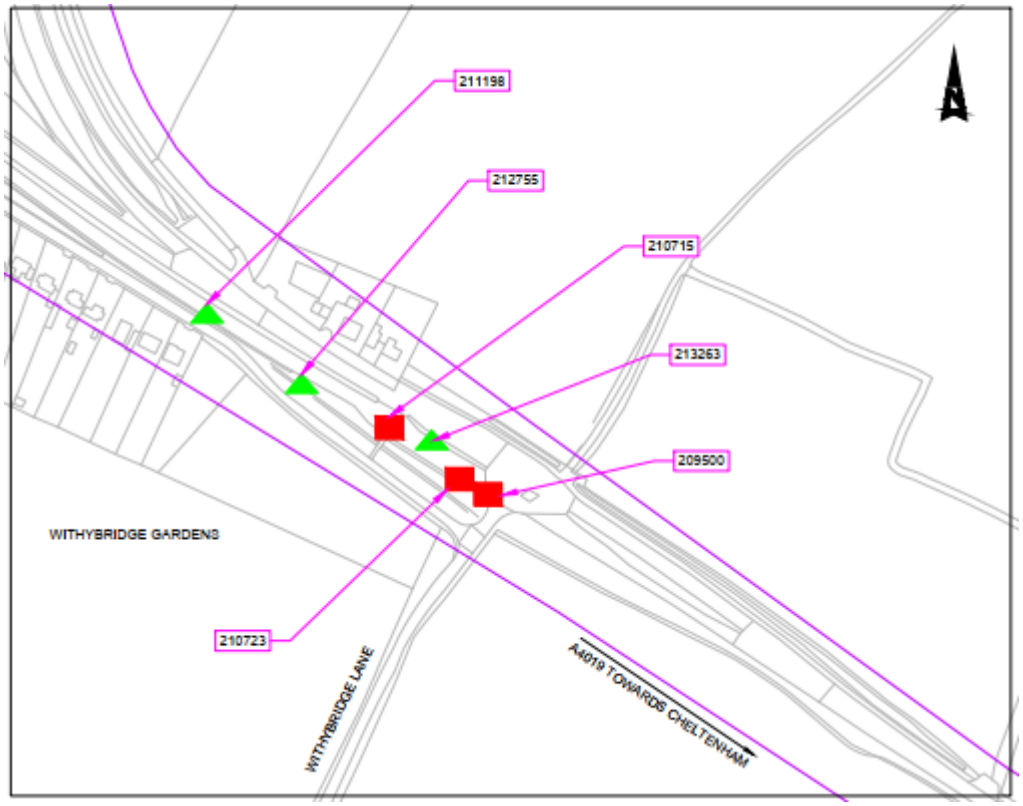


Figure 3-23 A4019 between M5 Off-slip and Withybridge Lane

3.6.37 Six collisions have been recorded at this location and of these 50% resulted in serious injury. Two of the collisions involved pedestrians (who were crossing the A4019) and one involved a cyclist (who collided with a vehicle exiting the M5 off-slip) possibly indicating a need for improved vulnerable road user facilities. A fourth collision involved a vehicle turning right out of Withybridge Lane into the path of a westbound vehicle. A fifth collision appears to have taken place at the M5 slip road entry onto A4019 and occurred when a vehicle entered the A4019 into the path of an eastbound vehicle with the impact of the collision sending the first vehicle into oncoming traffic across the central reserve. The sixth collision occurred when an eastbound vehicle on the A4019 moved over to the offside lane to prepare to turn right and was hit by another vehicle moving into the offside lane.

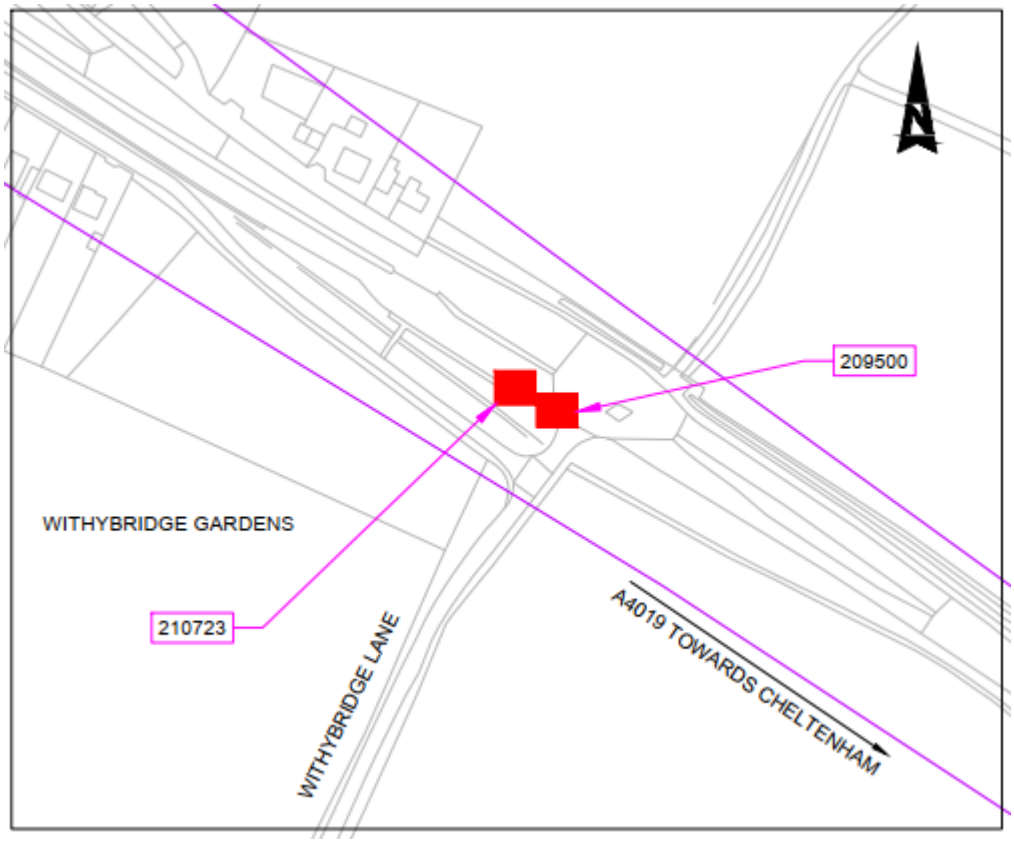


Figure 3-24 A4019/Withybridge Lane Collision Hotspot

3.6.38 41.2% of all collisions along the A4019 occur at the two hotspot locations identified above

Journey Time Reliability

3.6.39 Journey time data was collated and analysed for the 2013 CSV model development, however in order to understand journey time reliability it is necessary to calculate percentile journey times and assess how they vary from the median. To carry out these calculations journey time data was extracted from the Highways England Journey Time database between Junction 9 and 11 for 2019.

Highways England Journey Time Database

3.6.40 Highways England's journey time database (HE JTDB) was used to analyse how journey times vary along the M5 between Junctions 9 and 11, with sections Junction 9 – 10 and 10 -11 considered separately. Table 3-10 below shows the average and median journey times for each mainline section of the M5 between junctions 9 and 11. As with the traffic flows in Section 3.6, the data presented here pertains to a neutral month and for weekdays only.

3.6.41 The median is presented alongside the average as it is used as reference for the percentile data which demonstrates reliability and for comparison to the mean. Mean values higher than the median indicate a skewed distribution with greater incidences of journeys having times towards the higher end of the range.

Table 3-10 – Average and Median Journey Times

Section	Dir.	Average Journey Time (s)			Median Journey Time (s)		
		AM	IP	PM	AM	IP	PM
J9 – J10	NB	234	237	241	233	236	241

	SB	255	227	227	235	226	227
J10 – J11	NB	130	132	133	129	131	133
	SB	160	140	139	143	138	139

3.6.42 Presented below in Figure 3-25 to Figure 3-28 is the 5th, 25th, 75th and 95th percentile journey times for each section of the M5 for all three time periods.

3.6.43 The 25th and 75th percentile journey times provide the range of journey times that are typical for the 'core' 50% of journeys that take place along each section and provides an indication of the day-to-day variability in journey times experienced by users.

3.6.44 The 95th percentile journey time typically provides insight into the incident related variability. Note that the scales remain consistent between directions, but each section has a different scale to more clearly demonstrate the variability.

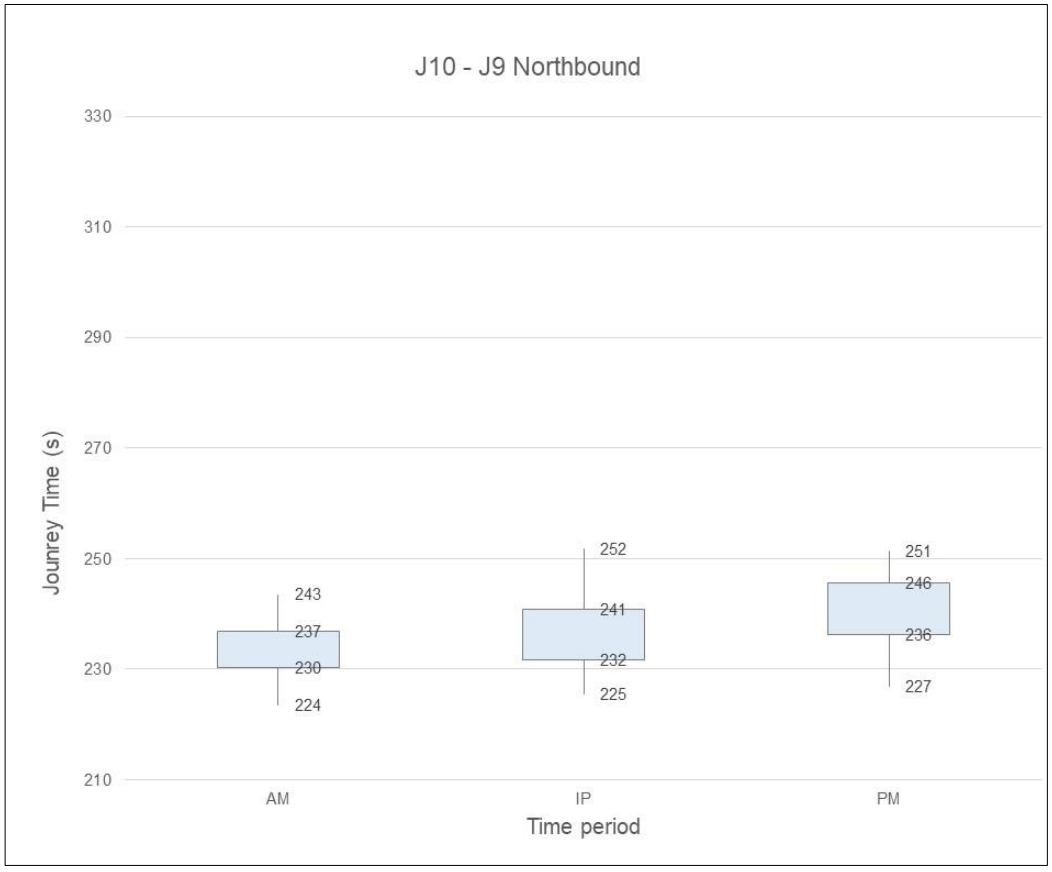


Figure 3-25 Journey Time Percentiles - J10 - J9 Northbound

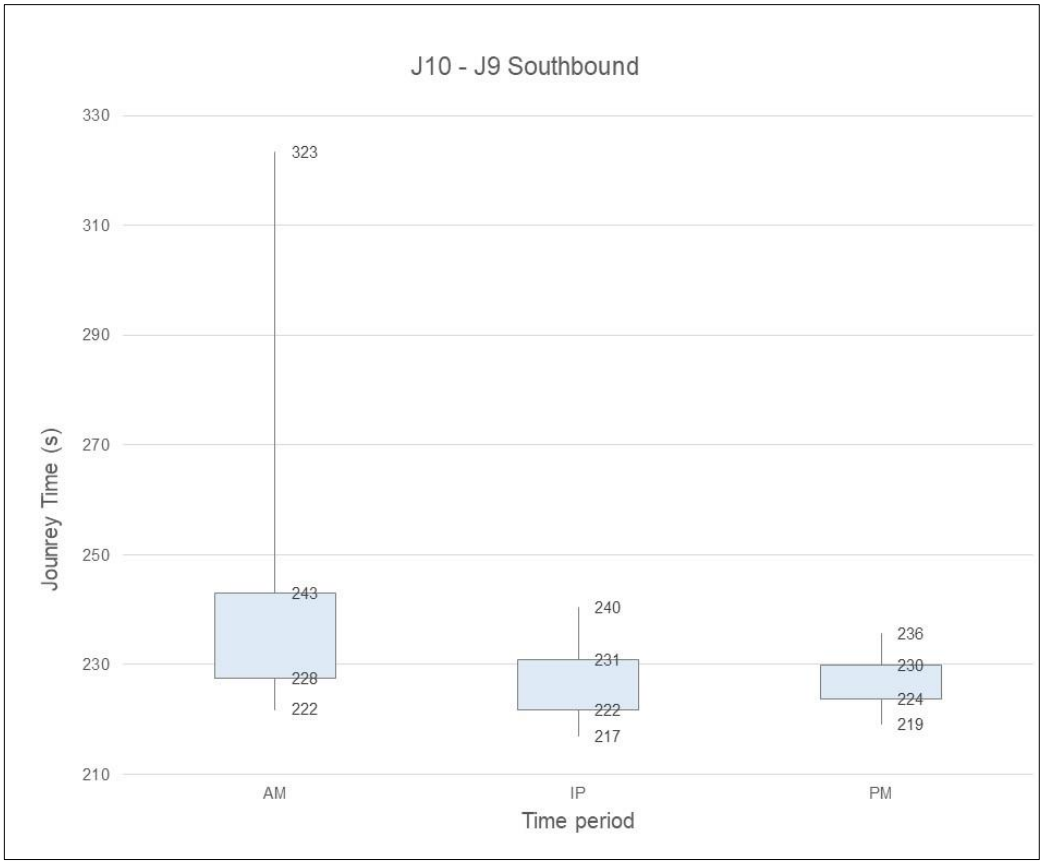


Figure 3-26 Journey Time Percentiles - J10 - J9 Southbound

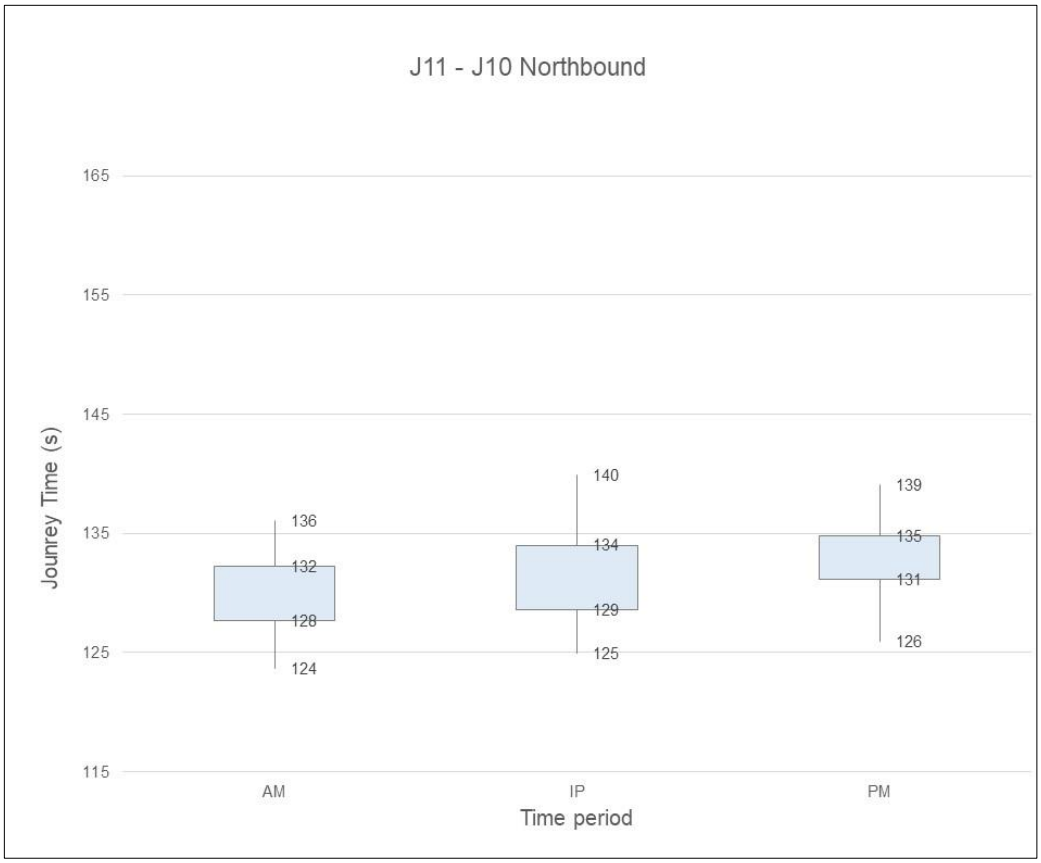


Figure 3-27 Journey Time Percentiles - J11 - J10 Northbound

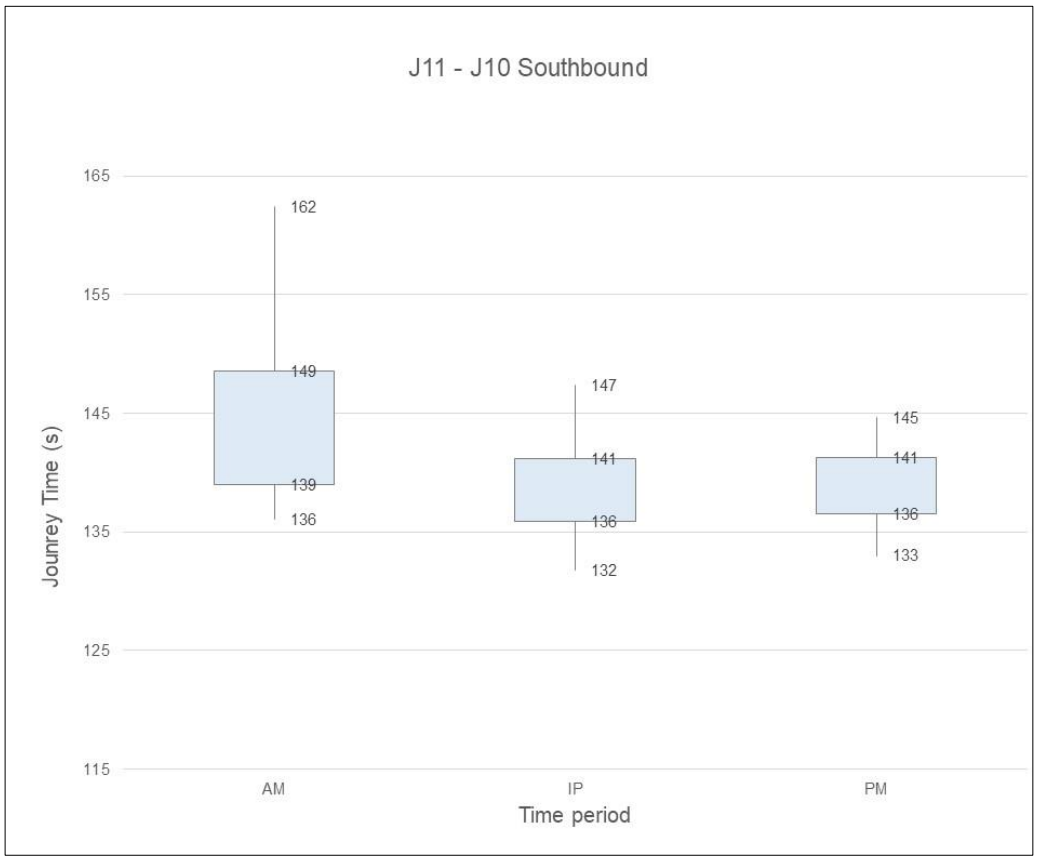


Figure 3-28 Journey Time Percentiles - J11 - J10 Southbound

3.6.45 Junction 9 – 10 southbound in the AM peak shows a significantly larger 95th percentile journey time than the 75th and median indicating that this section experiences significant delays and is less resilient than the others.

3.6.46 In order to determine whether the high 95th percentile is truly representative of the network conditions the analysis was repeated with 2015, 2016 and 2019 data for investigation. In both 2015 and 2019 an exceptionally high 95th percentile journey time was observed (80s and 98s higher than the 75th percentile respectively), though in 2016 the 95th percentile journey time was only 14s higher than the 75th showing a much smaller range of variance.

3.6.47 Closer inspection of the 2015 and 2019 dataset showed that the exceptionally high 95th percentile journey times were due to one specific day where it is likely an incident occurred. No data is available regarding the type of incident which resulted in the high 95th percentile travel times in 2015 and 2019 and so it is not possible to conclude whether this section of the M5 has a problem with incident related reliability. Minor incidents may only result in small increases in journey times whereas the significant delays seen in 2015 and 2019 dataset are likely to result from a significant incident.

3.6.48 Given the absence of high 95th percentile journey times in 2016 and in the non-incident days, it is unlikely that the M5 mainline southbound J9 – J10 is significantly impacted by regular incidents such that the section would be considered unreliable by frequent users.

3.6.49 Overall, it can be seen that the day to day reliability along the M5 mainline is good as the time difference between the 25th and 75th percentile journey times for the J9 – J10 and J10 – J11 sections does not exceed 7%. This indicates that the journey times along these sections are predictable for road users.

Central Severn Vale Journey Time Data

3.6.50 Several journey times routes have been used to validate the CSV model. Data for fourteen routes has been collated an analysed, these routes are shown in Figure 3-29 below.

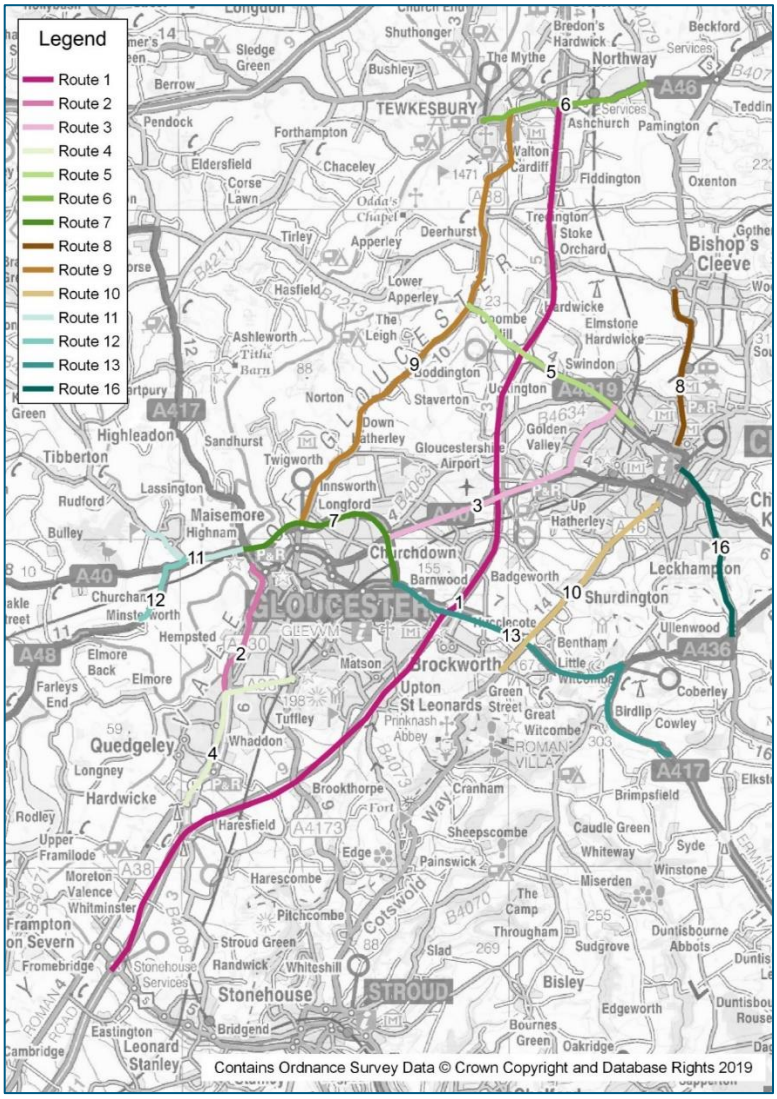


Figure 3-29 CSV Model Journey Time Routes

3.6.51 It can be seen from Figure 3-29 that of the fourteen routes, three are in close proximity to Junction 10. Routes 1 and 5 traverse the scheme location itself and route 9 runs parallel to the M5 providing an alternate north-south route.

3.6.52 Table 3-11 below shows the average observed journey times in seconds as well as the average journey speed in kph for each of these three key routes.

Table 3-11 – Key Journey Time Routes

Route		Dir.	Length (km)	Average Journey Times (s)			Average Journey Speed (kph)		
				AM	IP	PM	AM	IP	PM
1	**M5 Junction 13 to 9**	NB	31.98	1,103	1,057	1,097	104	109	105
		SB	31.98	1,076	1,019	1,091	107	113	106
5	**A38 Coombe Hill to A4019 Tewkesbury Rd, Cheltenham**	EB	6.23	661	522	616	34	43	36
		WB	6.23	480	477	510	47	47	44
9	**A38 Longford Roundabout to A438 Tewkesbury**	NB	15.25	774	731	836	71	75	66
		SB	15.25	929	726	837	59	76	66

3.6.53 Table 3-11 above shows that, as would be expected speeds are generally higher in the Inter-peak time period than the AM and PM peaks due to lower traffic volumes. It can also be seen that the M5 mainline average speed in all three time periods is not far beneath the 70 mph (approximately 113kph) speed limit indicating that traffic is close to free flowing.

3.6.54 Overall, the network around M5J10 and on A4019 is operating to acceptable level in 2013 with respect to variability in journey times. Based on HE JTDB and CSV model journey times data, it can be concluded that the data doesn't provide evidence that any of the three main routes faces day to day journey time reliability issues in 2013. Though it was observed that southbound slips between J9-J10 experienced some incidents which led to increased 95th percentile accidents in 2015, but it was not the case in 2016. It should be noted that this is 2013 condition and is subject to change for future years with increased traffic and enhanced junction 10.

3.7 Topography, Land Use, Property and Industry

3.7.1 The local topography is that of low-lying open farmland consisting of agricultural and pasture land, there are small patches of scattered copses and vegetation along watercourses.

3.7.2 The M5 is a key feature of the area, although this major transport corridor is generally well screened by vegetation and overbridges also tend to be well concealed by perimeter vegetation.

3.7.3 The River Chelt runs east-west across floodplain farmland south of the A4019 and high voltage pylons march in pairs across the southern section of this floodplain.

3.7.4 The area contains several Public Rights of Way (PRoW), footpaths and bridleways, including the Long-Distance Footpath of Cheltenham Circular. The PRoWs are generally within fields, along hedged boundaries or streams but also cross open fields.

3.7.5 There are quite distinct clusters of properties dotted within the study area, usually forming parts of the local villages and settlements or focussed on farm properties. Many of the residential properties are also surrounded by outbuildings and garden, boundary and roadside vegetation.

3.7.6 The majority of the A4019 from the M5 J10 to the village of Uckington is generally bordered by low field hedges with a few residential properties and public houses. East of Uckington, the A4019 becomes more enclosed by residential and community properties, and associated perimeter vegetation, becoming urban in character with retail and business parks appearing on the approach to the junction with the B4634.

3.8 Climate

3.8.1 The climate in the project area is generally typical of the United Kingdom with warm sunny summers and mild winters. Snowfall is infrequent, but winter days can be frosty and clear. High pressure systems can occasionally cause very hot summer temperatures or very cold winter temperatures.

3.9 Flood Risk

3.9.1 The Flood Map for Planning has been prepared by the Environment Agency. This identifies areas potentially at risk of flooding from fluvial or tidal sources. An extract from the mapping is shown in Figure 3-30 EA Map; Risk of Flooding from Rivers and Sea & Figure 3-31. Note that areas not in Flood Zone 2 or 3 are by default Flood Zone 1. These zones are defined in the NPPF as follows:

- Flood Zone 1 (Low Probability) comprises land assessed as land having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%).
- Flood Zone 2 (Medium Probability) comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.
- Flood Zone 3 (High Probability) comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

3.9.2 The 1 km study area is mainly located within Flood Zone 1. However, significant areas of land just south of the A4019, which runs east and west of the M5 J10, are classified as Flood Zone 2 and 3. These floodplain areas are predominantly associated with the River Chelt (classified as a Main River).

3.9.3 The land extending south west of the M5 J10, including parts of Knightsbridge, Coombe Hill and Boddington, is predominantly classified as Flood Zone 2. There are also areas of Flood Zone 3 south west of the M5 J10, alongside the River Chelt.

3.9.4 The land extending south east of the M5 J10 and also south of Withbridge Gardens, is predominantly classified as Flood Zone 3. Fluvial flows extend considerably further southwards from the M5 J10 and continue past the east and west borders of the study area, alongside the River Chelt.

3.9.5 Approximately 2.5 km north east of the M5 J10, near Stoke Orchard, there are areas classified as Flood Zone 3. These fluvial flows extend across the length of the study area, beyond the east and west borders. These areas of Flood Zone 3 are associated with the River Swilgate (classified as Main River) and Dean Brook (classified as Ordinary Watercourse, tributary of River Swilgate).

3.9.6 There is also a small section of land classified as Flood Zone 2, just north of the southern border of the study area, alongside the Hatherley Brook (Ordinary Watercourse).

3.9.7 The Environment Agency mapping indicates that limited sections of the M5 are overtopped near both the north and south boundaries of the study area. Fluvial risk is identified as the primary flood risk within the study area.

3.9.8 Flood risk in this area has been identified as a major consideration by the Environment Agency. For this reason, the floodplain importance is considered to be very high.

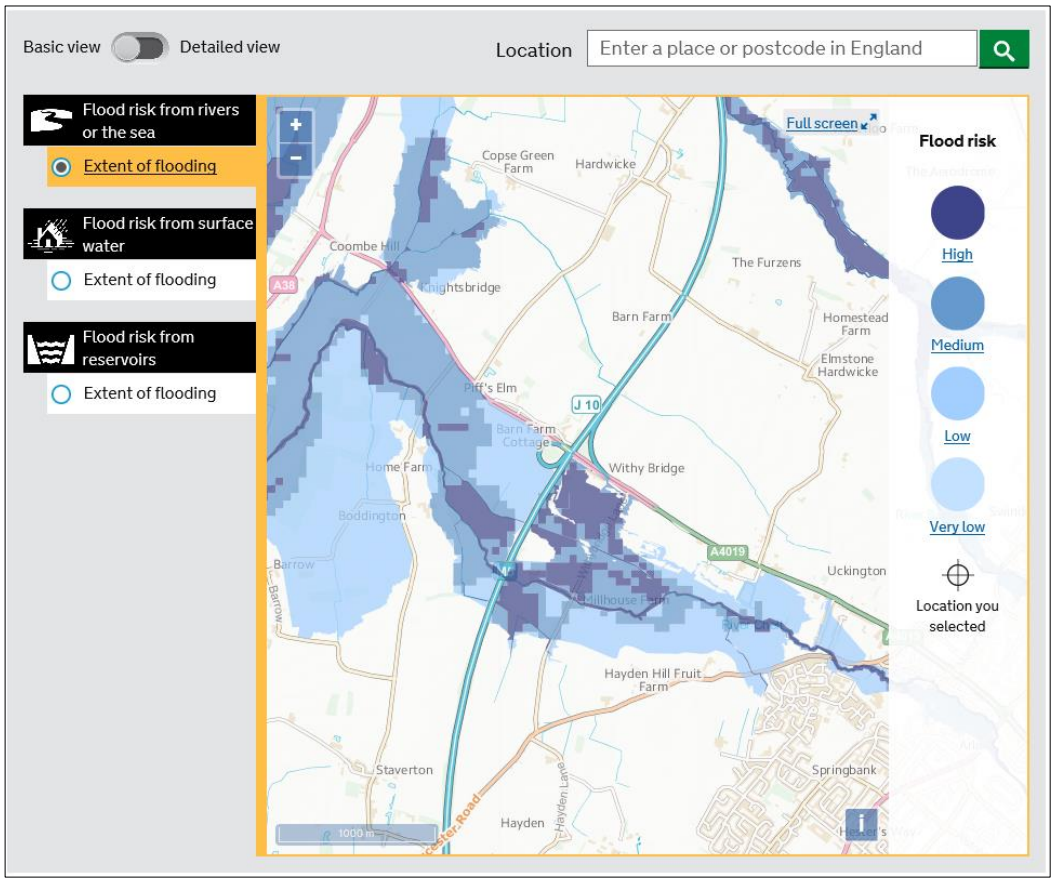


Figure 3-30 EA Map; Risk of Flooding from Rivers and Sea

3.9.9 The surface water flooding map (Risk of Flooding from Surface Water – RofSW) prepared by the Environment Agency (and included as Figure 3-31) shows that there is a risk of surface water flooding in the areas immediately east of Junction 10. The risk level varies from low to high, i.e. 0.1% to 3.33% Annual Exceedance Probability (AEP) respectively.

3.9.10 The 'high' risk of flooding extends north and south along the east side of the M5. Surface water appears to pond along the north east border of the M5 J10 southbound off slip road. This is shown to affect several residential properties; however, no overtopping of the motorway is shown in this area.

3.9.11 The only indication of surface water flows overtopping the M5 is in the northern extent of the study area, approximately 2.7km north of M5 J10 and just west of Stoke Orchard, where an unnamed road and the M5 intersect.

3.9.12 Instances of surface water flooding in the study area are likely to be primarily associated with the watercourses here, i.e. (from north to south) the Dean Brook, the River Swilgate, the Leigh Brook, the River Chelt, the unnamed tributary of the River Chelt and the Hatherley Brook. Flood risk for certain watercourses is also represented by the Flood Zone maps.

3.9.13 As the potential surface water flooding affects residential properties, with the potential to affect an increased number, the importance of surface water flood risk is classed as high.

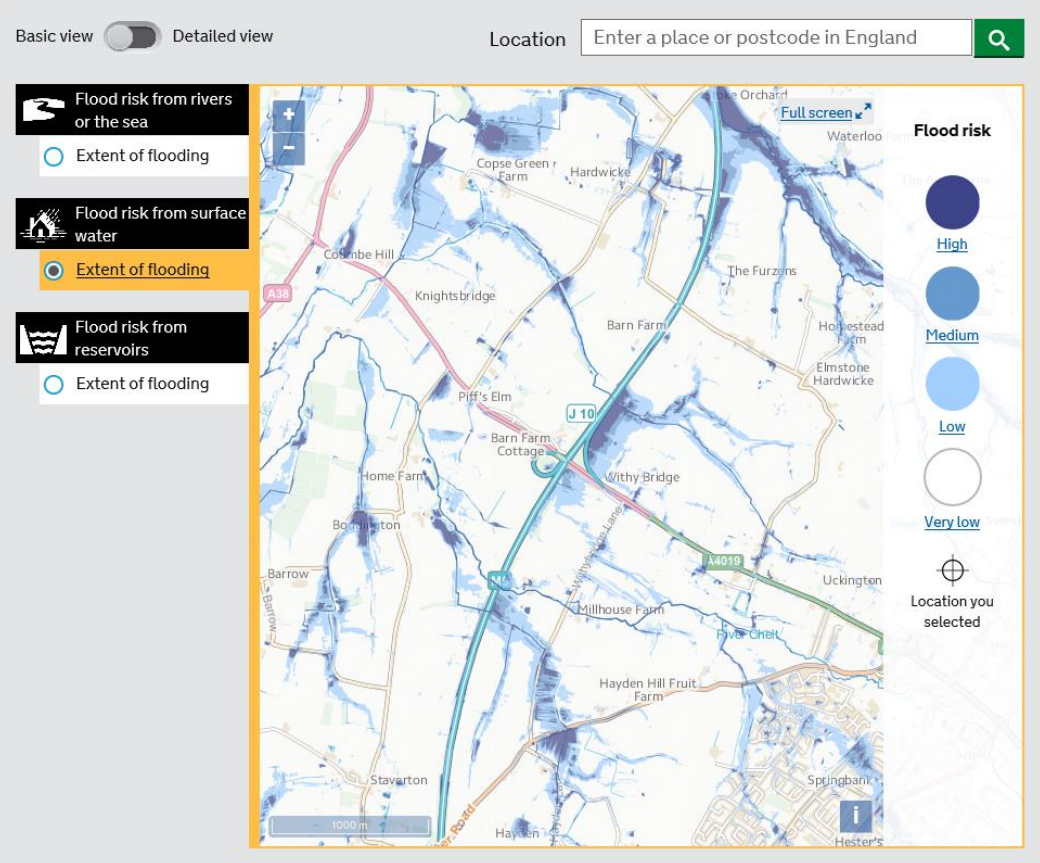


Figure 3-31 EA Map; Risk of Flooding from Surface Water

Historical Highways England Flood Events

3.9.14 HE DDMS (Highways England Drainage Data Management System) has records of eight flood events occurring on the motorway and trunk roads in the area of the M5 J10 since 2011. These flood events typically occur in autumn/winter (August to November), and vary in severity from 0 to 7 (where 10 is the maximum flood severity). The flood events are shown in Figure 4.10.5. The A4019 within the study area has been classified with a 'very low' flood hotspot status. The status of flood events is shown in Figure 3-32 and Figure 3-33.

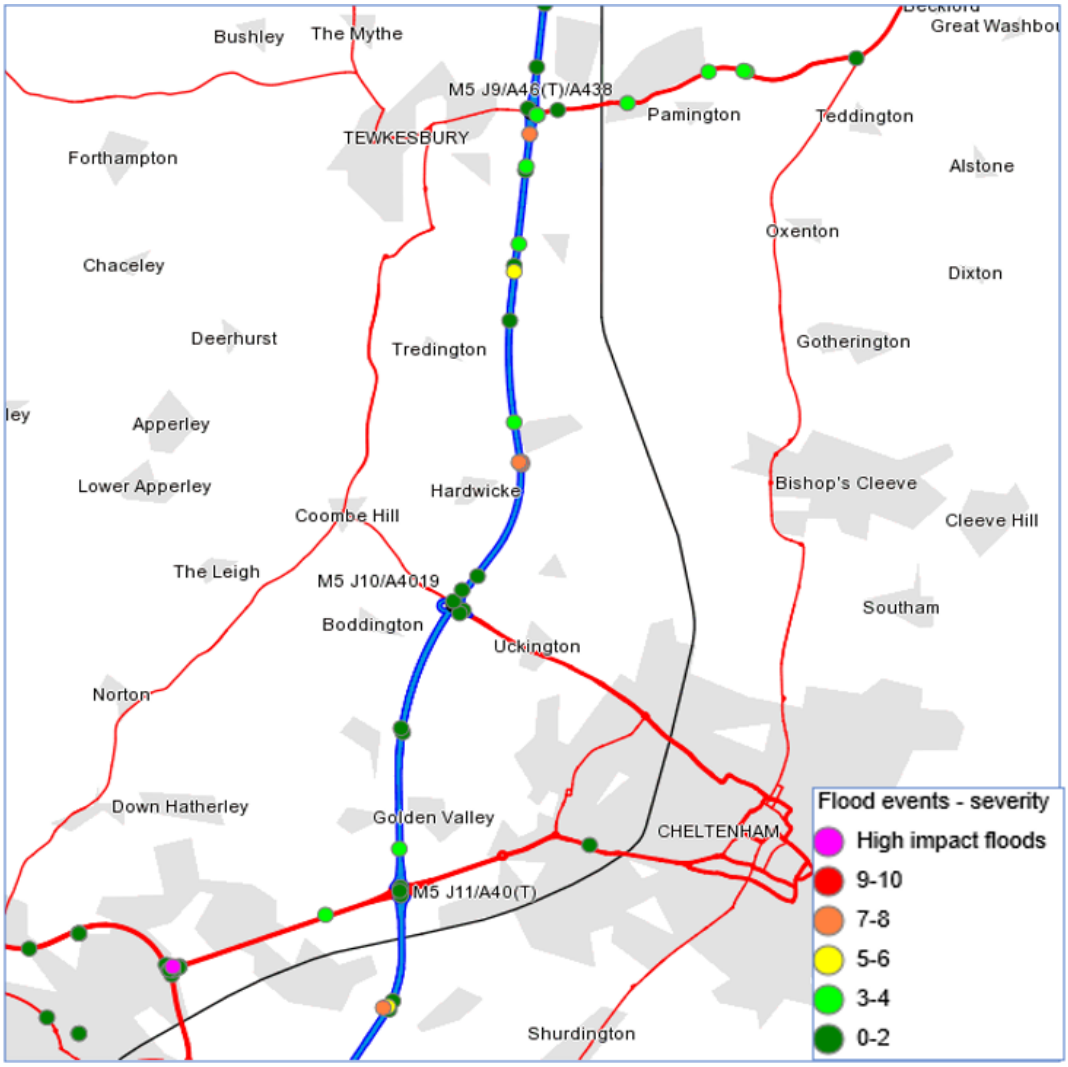


Figure 3-32 HE DDMS Flood Events Severity

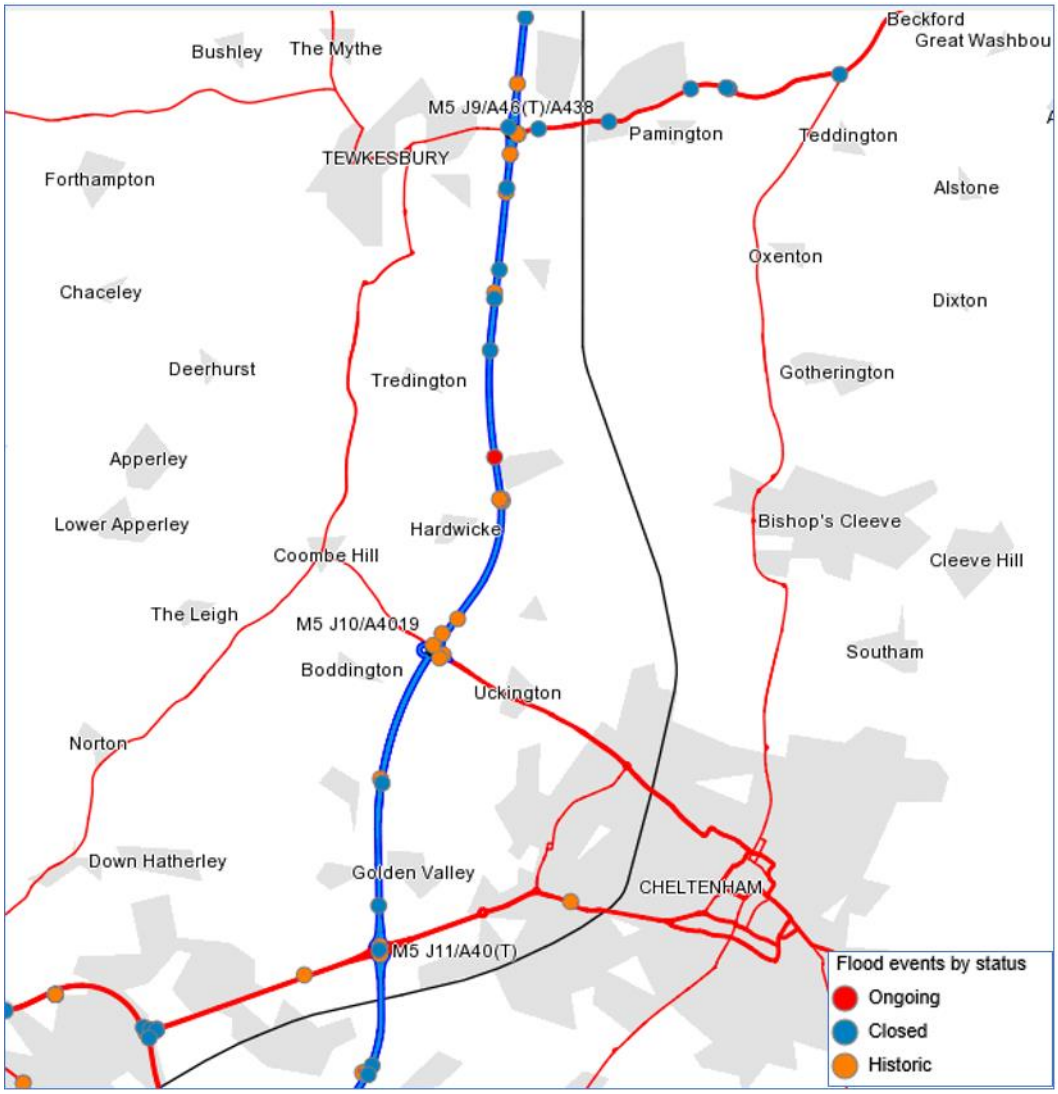


Figure 3-33 HE DDMS Flood Events by Status

3.10 Existing Road Drainage

3.10.1 The assessment of the existing drainage has been undertaken based primarily on information available from Google Street View, Highways England Drainage Data Management System (HE DDMS) data, the Gloucestershire County Council (GCC) GIS and by applying engineering judgement. The available as-builts do not contain any drainage information.

Mainline M5

3.10.2 Existing collection systems for the M5 mainline are mainly a gully and kerb arrangement, various types of kerb inlet and filter drains (with gullies) in central reservations. Some smaller sections of slot drains are also present at the super elevated section to the north of the junction. The conveyance systems are generally in the form of carrier drains or ditch systems, which typically receive connections from individual gullies.

Northbound On-slip

3.10.3 The collection system at the north bound on slip road is a mix of gully and kerb or kerb inlets. It is unclear from HE DDMS what the existing conveyance system arrangement is, with phantom nodes indicating missing information.

Southbound Off-slip

3.10.4 The collection system at the south bound off-slip is a mix of gully and kerb, kerb inlets, and slot drains. HE DDMS does not contain any information regarding conveyance systems. Existing outfalls are identified on the HE DDMS website, which can be seen in the extract of outfall locations shown in Figure 4.10.7. Outfalls details are given in Table 3-12 below

Table 3-12 – Existing Outfalls Identified

Existing Outfall No	Easting	Northing	Location	Description	Downstream watercourse
OF-1	390467	225668	North-west of Junction (A46_M5)		Unknown
OF-2A	390747	226041	Near NB CW, South of River crossing		Leigh Brook
OF-2B	390749	226045	Near NB CW, North of River crossing		Leigh Brook
OF-2C	390779	225992	Near SB CW, South of River crossing		Leigh Brook
OF-2D	390782	225997	Near SB CW, North of River crossing		Leigh Brook
OF-3A	389991	224842	Near NB CW, north of River crossing		River Chelt
OF-3B	389986	224836	Near NB CW, South of River crossing		River Chelt
OF-3C	390042	224801	Near SB CW, North of River crossing		River Chelt
OF-3D	390038	224796	Near SB CW, South of River crossing		River Chelt
OF-4A	389925	224648	Near NB CW, South of River crossing		Tributary of River Chelt
OF-4B	389927	224652	Near NB CW, North of River crossing		Tributary of River Chelt
OF-4C	389981	224634	Near SB CW, South of River crossing		Tributary of River Chelt
OF-4D	389982	224637	Near SB CW, North of River crossing		Tributary of River Chelt
OF-5A	391366	228113	Near NB CW, North of River crossing		River Swilgate
OF-5B	391365	228098	Near NB CW, South of River crossing		River Swilgate
OF-6a	391331	228370	Near NB CW, North of River crossing		Dean Brook

OF-6b	391333	228362	Near NB CW, South of River crossing		Dean Brook
OF-6c	391380	228388	Near SB CW, North of River crossing		Dean Brook
OF-6d	391381	228384	Near SB CW, South of River crossing		Dean Brook
OF-7a	389617	222685	Near NB CW, North of River crossing		Hatherley Brook
OF-7b	389617	222678	Near NB CW, South of River crossing		Hatherley Brook
OF-7c	389694	222673	Near SB CW, North of River crossing		Hatherley Brook
OF-7d	389696	222663	Near SB CW, South of River crossing		Hatherley Brook
OF-8a	389634	222176	Near NB CW, North of River crossing		Hatherley Brook
OF-8b	389698	222120	Near SB CW, South of River crossing		Hatherley Brook
OF-8c	389702	222123	Near SB CW, North of River crossing		Hatherley Brook

A4019

3.10.5 The collection system at A4019 consists of a mix of gully and kerb arrangements and kerb inlets. Carriageway widening along the A4019 road will affect the existing drainage. Existing drainage collection system data can be obtained from the Gloucestershire County Council GIS (https://gis.gloucestershire.gov.uk/LocalViewPub). No information regarding conveyance systems or outfalls is currently available.

B4634/Old Gloucester Road

3.10.6 The collection system serving the B4634/Old Gloucester Road is predominantly grips cut into the verge, with gullies and kerb inlets at junctions with Hayden Lane, Withy bridge Lane and a few short sections of kerb. Existing drainage collection system data can be obtained from the Gloucestershire County Council GIS (https://gis.gloucestershire.gov.uk/LocalViewPub). No information regarding conveyance systems or outfalls is currently available.

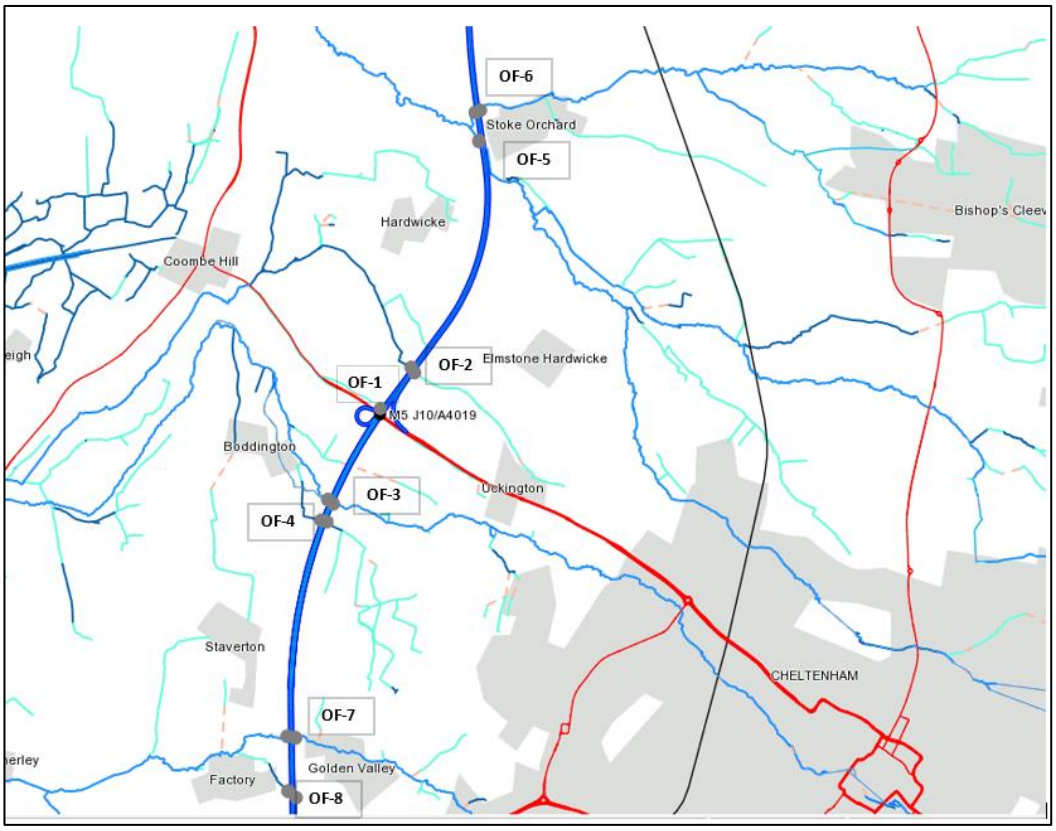


Figure 3-34 Existing Outfall Locations from HE DDMS Website

3.11 Geology

3.11.1 The following sources of information have been used to write this section of the report:

- British Geological Survey Map Sheet 216 (Tewkesbury), 1:50,000 scale, 1988
- Geology of the country around Tewkesbury: Memoir for BGS Map Sheet 216 (England and Wales), HMSO London, 1989
- British Geological Survey GeoIndex (online) - https://www.bgs.ac.uk/geoindex
- British Geological Survey Lexicon of Named Rock Units (online) - https://www.bgs.ac.uk/lexicon
- MAGIC website, Environment Agency/Natural England (online) - https://magic.defra.gov.uk
- Engineering Geology of British Rocks and Soils – Lias Group. British Geological Survey, 2012
- M5 J10 Preliminary Sources Study Report (PSSR), Amey Consulting, Jan. 2019

Made Ground

3.11.2 One large area of 'artificially modified ground' has been identified from the BGS GeoIndex within the scheme extents. This corresponds to the historic Colman's Farm Landfill which is located at the northern extent of the scheme to the west of the M5. The materials are likely been placed in an uncontrolled manner and are variable in strength. This has the potential to cause differential settlement and any future ground investigation will need to characterise the underlying material for design. Other made ground can be expected along the route alignments where they intersect existing roads, associated earthworks and areas of previous industry.

Superficial Geology

3.11.3 The BGS GeoIndex confirms that superficial deposits are present throughout the majority of the scheme area and comprise both Alluvium and Cheltenham Sand and Gravels.

3.11.4 The Superficial Geology are shown on Drawing Nos GCCM5J10-ATK-EGT-XX_ML_Z-DR-CH-000001 in Appendix A.

3.11.5 The Alluvium deposits are predominantly associated with the River Chelt and Leigh Brook which trend east-west across the site. The deposits are soft to firm, normally consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. In the vicinity of the river network, Alluvium approximately 1-2m thick can be expected with the potential for settlement and consolidation.

3.11.6 The Cheltenham Sands and Gravels are widespread along the route of the A4019 to the east of the M5 and in isolated pockets to the north of the scheme. The deposits are generally described as fine to medium grained sand with seams of poorly sorted gravel and vary between 6-15m thick.

Bedrock Geology

3.11.7 The bedrock geology of the area consists of lithologies belonging to the Lias Group. The scheme area is predominantly underlain by the Charmouth Mudstone Formation whilst the Rugby Limestone Member may be encountered within the western extents of the scheme area. It should be noted that the Charmouth Mudstone Formation is associated with sulphate derived from pyrite bearing strata i.e. Thaumasite Sulphate Attack (TSA) and any buried concrete will need to be designed accordingly.

3.11.8 The Bedrock Geology are shown on Drawing Nos GCCM5J10-ATK-EGT-XX_ML_Z-DR-CH-000002 in Appendix A.

3.11.9 There is no record of major structural features within the scheme area, but minor faulting and fractures can be expected within the bedrock geology.

Hydrogeology

3.11.10 Data available on the MAGIC website confirms that the Alluvium, Cheltenham Sands and Gravels and Rugby Limestone Member are ‘Secondary A’ Aquifers whilst the Charmouth Mudstone Formation is ‘Unproductive’ due to its low permeability.

3.11.11 In addition, the superficial deposits have the potential for groundwater flooding both at the surface and subsurface.

Hydrology

3.11.12 Any potential routes could cross both the River Chelt and Leigh Brook. Surface water flooding is particularly associated with the River Chelt.

Existing Historic Borehole Records

3.11.13 There are many existing historic borehole records present within the study area. However, the majority of these are concentrated along the alignment of the M5 or in close proximity to Cheltenham. As a result, there is a lack of existing ground information for the proposed routes and a thorough route-specific ground investigation with groundwater monitoring is considered essential as the scheme progresses.

3.12 Geohazards

3.12.1 A detailed project-wide Geotechnical Risk Register will be included in the PSSR for this scheme. Initial key identified risks include:

- Presence of compressible ground (Alluvium/Peat/Existing Landfill/River Chelt Floodplain) resulting in settlement/differential settlement;
- Shrink-swell potential of the Charmouth Mudstone causing change in volume and subsequent ground movement;
- Aggressive ground chemistry of the Charmouth Mudstone causing Thaumasite Sulphate Attack (TSA) on buried concrete;
- Contamination associated with the Colman's Farm landfill site;
- Surface and groundwater flooding; and
- A lack of route specific ground/groundwater information.

3.13 Groundwater

3.13.1 Groundwater data is limited in the scheme area and there is no evidence of consistent groundwater monitoring. Surface and groundwater issues relating to groundwater level and flooding is considered a high geotechnical risk for the scheme. As stated in Section 3.11.13 above, due to the lack of existing ground information for the proposed routes, a thorough route-specific ground investigation with monitoring of the groundwater regime is considered essential.

3.14 Contaminated Land

3.14.1 The study area considered in the assessment of potential sources of contaminated land are considered in areas to the north of Junction 10 and in areas at or surrounding the existing M5 Junction 10. Potential contamination sources associated with the study area's historic and current usage are presented below

Potential Sources of Contamination in areas north of M5 Junction 10

3.14.2 Based on a review of the available data potential sources of contamination in the area are given in Table 3-13 below.

Table 3-13 – Potential Sources of Contamination north of M5 Junction 10

Potential source of contamination	Contaminants of concern	Location
Made Ground associated with the construction of existing carriageways and activities associated with their operation.	A range of inorganic and organic contaminants within Made Ground including asbestos. Fuels and oils attributed to spills from vehicles on the roads included within the site boundary, plus exhaust particulates.	On-site
Agricultural land within site boundary with the potential for unmapped farmers tips.	Contamination risk from herbicides, pesticides, silage, effluent, and fuel oils. Risk of inorganic and organic contamination including metals and hydrocarbons, polychlorinated biphenyls (PCBs), asbestos, etc.	
Historical landfill at Colman's Farm.	Range of inorganic and organic contaminants including metals, hydrocarbons, PAHs, PCBs, asbestos and ground gases.	

Potential source of contamination	Contaminants of concern	Location
Violet Villa historical landfill located adjacent to the eastern extent of the site.	Range of inorganic and organic contaminants including metals, hydrocarbons, PAHs, PCBs, asbestos and ground gases.	Off-site
Historical sewage works 300 m west of the site.	Potential contamination may comprise metals, inorganic contaminants, fuels and oils, PCBs, treatment chemicals, and a potential for hazard gas generation from sludges (as well as sanitary waste).	
Engineering works 480 m east of the site.	Range of inorganic and organic contaminants including metals, petroleum, petrol additives, diesel, oils and lubricants.	
Agricultural land including nurseries and allotments. **Potential for unmapped farmers tips.**	Contamination risk from herbicides, pesticides, silage, effluent, and fuel oils. Risk of inorganic and organic contamination including metals and hydrocarbons, polychlorinated biphenyls (PCBs), asbestos, etc.	
Made Ground / fill material associated with infilled land located within 500m of the site.	Fill Material is unknown but potential contaminants may include metals, inorganic and organic contaminants, fuels, oils, asbestos and a potential for vapour and, or ground gas generation.	
Waste management facility 380 m north of the site and Waste transfer site 430 m south of the site.	Range of inorganic and organic contaminants including metals, hydrocarbons, PAHs, PCBs, asbestos.	
Car breakers and scrap metal merchants within 500 m of the site.	Range of inorganic and organic contaminants including metals, hydrocarbons, PAHs, PCBs, asbestos.	

3.14.3 The Envirocheck report (Landmark Information Group, 2019) indicates that the site does not lie within a radon affected area, as less than 1% of homes are above the action level. No radon protective measures are therefore considered necessary.

Potential Sources of Contamination in areas at and surrounding the existing M5 Junction 10

3.14.4 Table 3-14 shows Potential Sources of Contamination at or surrounding the existing M5 Junction 10

Table 3-14 – Potential Sources of Contamination at or surrounding the existing M5 Junction 10

Potential source of contamination	Contaminants of concern	Location
Made Ground associated with the construction of existing carriageways and activities associated with their operation.	A range of inorganic and organic contaminants within Made Ground including asbestos. Fuels and oils attributed to spills from vehicles on the roads included within the site boundary, plus exhaust particulates.	On-site
Agricultural land within site boundary with the potential for unmapped farmers tips.	Contamination risk from herbicides, pesticides, silage, effluent, and fuel oils. Risk of inorganic and organic contamination including metals and	

	hydrocarbons, polychlorinated biphenyls (PCBs), asbestos, etc.	
Three historical landfills within 500 m of the site.	Range of inorganic and organic contaminants including metals, hydrocarbons, PAHs, PCBs, asbestos and ground gases.	Off-site
Historical sewage 300 m west of the site.	Potential contamination may comprise metals, inorganic contaminants, fuels and oils, PCBs, treatment chemicals, and a potential for hazard gas generation from sludges (as well as sanitary waste).	
Agricultural land including nurseries and allotments. **Potential for unmapped farmers tips.**	Contamination risk from herbicides, pesticides, silage, effluent, and fuel oils. Risk of inorganic and organic contamination including metals and hydrocarbons, polychlorinated biphenyls (PCBs), asbestos, etc.	
Made Ground / fill material associated with infilled land located within 500m of the site.	Fill Material is unknown but potential contaminants may include metals, inorganic and organic contaminants, fuels, oils, asbestos and a potential for vapour and, or ground gas generation.	
Waste management facility 380 m north of the site.	Range of inorganic and organic contaminants including metals, hydrocarbons, PAHs, PCBs, asbestos.	
Car breakers and scrap metal merchants within 500 m of the site.	Range of inorganic and organic contaminants including metals, hydrocarbons, PAHs, PCBs, asbestos.	

3.14.5 The Envirocheck report (Landmark Information Group, 2019) indicates that the site does not lie within a radon affected area, as less than 1% of homes are above the action level. No radon protective measures are therefore considered necessary.

3.15 Agricultural Soils

Agricultural Land Use

3.15.1 A historical review of agricultural land use shows that the study area is under arable crops, principally winter cereals, in rotation with grass and fodder crops. Grass predominates in some years and arable in others.

Soils

3.15.2 The soils of the Cheltenham Sand and Gravel are the Badsey association of well drained, calcareous loamy soils over limestone gravel. The alluvium of the River Chelt is the Fladbury association of clayey soils with a high-water table.

3.15.3 The soils of the Charmouth Mudstone Formation are the Evesham association of permeable clay soils. However, in the vicinity of the Cheltenham Sand and Gravel deposit the topsoils are lighter, improving their structure and drainage

3.15.4 A field west of the existing M5 north of the existing Junction 10 is an historical landfill site (Coleman's Farm landfill) that has been restored to grassland.

Agricultural Land Classification (ALC):

3.15.5 The land in the study area is mainly Grade 3 land (good to moderate quality), except on the Cheltenham Sand and Gravel on either side of the A4019 where the ALC is Grade 1 and 2 (excellent and very good quality).

3.15.6 There is no detailed ALC survey of the study area itself. However, there is a detailed survey of the MAGIC website (DEFRA, 2019) of the land directly to the west of the M5. This shows best and most versatile (BMV) land in Grade 3a (good quality) in the vicinity of Junction 10, presumably due to the influence of the Cheltenham Sand and Gravel deposit on lightening the topsoil. Elsewhere, on the Alluvium of the river Chelt and the Charmouth Mudstone the ALC is Grade 3b (moderate quality, non BMV). It is possible to extrapolate this information to the area east of the M5 within the study area. The Cheltenham Sand and Gravel Deposit and land in its vicinity is likely to be of BMV quality (Grades 2 and 3a), while the remainder is of non-BMV quality (grade 3b).

3.15.7 The restored landfill at Colemans Farm is unlikely to be better than Grade 4 (poor quality).

3.15.8 BMV land extends for around 500 m north and south of the A4019.

3.16 Public Utilities

C2 Preliminary Enquiries

3.16.1 In order to fully understand the extent to which Statutory Undertakers' apparatus is present in the study area, preliminary (C2) enquiries were sent out to all Statutory Undertakers in the region in accordance with the New Roads and Streetworks Act 1991 (NRSWA 1991). This preliminary enquiry process requests the Statutory Undertaker's to provide any information they have available that may impact on the scheme. Appendix A.

3.16.2 Table 3-15 identifies the Statutory Undertakers that were consulted during the C2 Preliminary Enquiry stage.

3.16.3 Drawings identifying the locations of existing utilities are included in Appendix A.

Table 3-15 – List of Statutory Undertakers Consultees

Statutory Undertaker	Date Received	Apparatus Present	Potential to be affected by an Improvement Scheme
Openreach - BT	15/08/19	Yes	Yes
Severn Trent Water (STW) - Foul	12/08/19	Yes	Yes
Severn Trent Water (STW) – Water	12/08/19	Yes	Yes
Virgin	06/08/19	Yes	Yes
Wales and West Utilities	06/08/19	Yes	Yes
Western Power Distribution	06/08/19	Yes	Yes
SSE – (Telecom, Gas, Electric, Water, Sewage, Steam)	15/08/19	Yes	Yes
Vodafone	06/08/19	Yes	No
Zayo Group UK Ltd C/O JSM Group Ltd	06/08/19	Yes	Yes
GTC (Telecom, Gas, Electric, Water)	05/08/19	Yes	Yes

Instalcom – (Centurylink, Global Crossing, Fibrenet and Fibrespan)	09/08/19	Yes	No
Gigaclear Plc	06/08/19	Yes	Yes
Environment Agency	08/08/19	Yes	Yes
C.A Telecom UK (Colt Technology Services)	13/08/19	Yes	No
LinesearchbeforeUdig	06/08/19	Yes	Yes
Energetics	06/08/19	No	No
euNetworks	05/08/19	No	No
Gloucestershire County Council	09/08/19	No	No
Network Rail	05/08/19	No	No
Sky Telecommunications	05/08/19	No	No
Utility Assets	15/08/19	No	No
Verizon	05/08/19	No	No

3.17 Operational Maintenance Regime

3.17.1 M5 junction 10 falls within the northern operational area of Gloucestershire County Council Highways (GCC). The M5 and the junction slip roads fall under the responsibility of Highways England Area SW.

3.17.2 Ringway, the Maintenance Service Provider (MSP) for GCC, is responsible for:

- Pothole repairs
- Winter gritting and snow clearing
- Gully cleaning
- Verge and grass cutting
- Surface dressing

3.17.3 GCC have an adverse weather plan in place. Following severe flooding in recent years, Surface Water Management Plans have been created for areas of Gloucestershire. M5 junction 10 falls outside the north Gloucester Surface Water Management area.

3.17.4 In terms of winter maintenance, Highways England Area SW are responsible for gritting the M5 north and south of junction 10. GCC are responsible for gritting the A4019 and Withybridge Lane which are considered to be primary gritting routes.

3.17.5 Consultation with MSPs will be arranged in greater depth once more detail of the preferred option becomes available.

3.17.6 Technology maintenance in the area is by Highways England's Regional Technology Maintenance Contractor and the National Road Telecommunications Service provider.

3.18 Existing Road Lighting

M5 Junction 10

3.18.1 The only lighting in the vicinity is a single lighting column with a twin-arm bracket and high-pressure sodium luminaires, which is located on the A4019 at the nosing of the westbound off-slip to the M5 (north).

A4019

3.18.2 There are two sections of existing lighting within the extents of the A4019 dualling. There is a short section of LED luminaires between the Cheltenham West Community Fire Station and Homecroft Drive, and a longer lit section, again with LED luminaires, from approximately 200 m west of Hayden Road to the roundabout with Princess Elizabeth Way.

B4634

3.18.3 There is currently no existing lighting located on the B4634.

3.19 Existing Technology Provision

General

3.19.1 The study area has limited existing Intelligent Transport Systems (ITS) technology. Current deployment consists of Emergency Response Telephones (ERTs), Closed Circuit Television (CCTV), central reserve signals and associated cables and interface cabinets. A Variable Message Sign (VMS) is installed on the southbound M5 at the south of the study area, this is a MS4 (Motorway Signal Mk4).

3.19.2 Within M5 Junction 10 is a transmission station (TS) related to NRTS (National Roadside Telecommunications Service). This contains transmission and other equipment to enable communication services along the motorway network.

3.19.3 No ITS equipment is installed on the junction's slip roads or the connecting (off-motorway) road network.

3.19.4 Technology in the area surrounding M5 Junction 10 is monitored and operated by Highways England's South West Regional Control Centre (SWRCC) located near Avonmouth.

3.19.5 The information referred to within this section is obtained from NRTS Record drawings (Date: January 2015), supplemented by Google Earth images. No surveys have been undertaken.

Uckington Transmission Station

3.19.6 Within the land bounded by the M5 and the Junction 10 Southbound off-slip is located Uckington minor Transmission Station. This houses equipment critical to the operation of the NRTS network which delivers communications to facilitate the monitoring and operation of roadside technology operated by Highways England.

3.19.7 The NRTS service provider (currently Telent) requires 24-hour access to the TS so that they can undertake maintenance activities and respond to network faults. The TS has an adjacent safe parking area accessed from the M5 southbound to facilitate this access.

3.19.8 Figure 3-35 shows a transmission diagram of the TS and features the two NRTS network links that lie within the proposed scheme extents, 088 (North of Junction 10) and 087 (South of Junction 10).

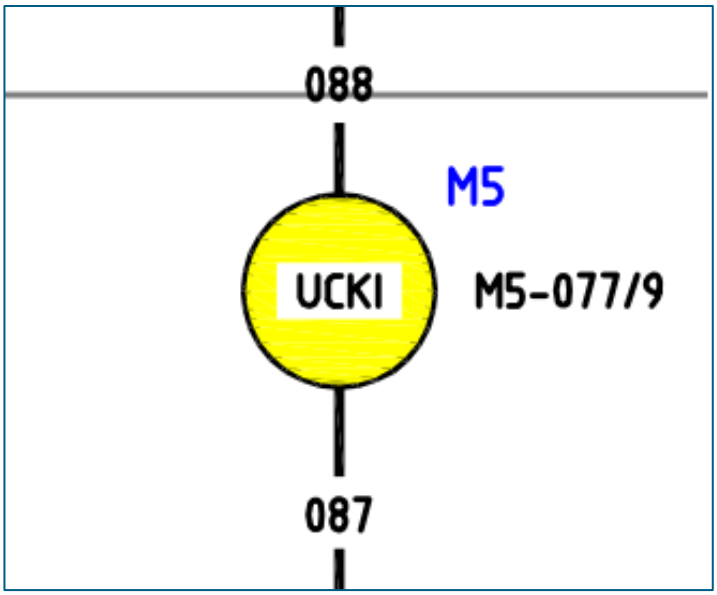


Figure 3-35 NRTS Transmission Diagram for M5 Junction 10 Area

Cabling and Duct Infrastructure

3.19.9 The cabling infrastructure in the area of M5 Junction 10 consists of:

- Longitudinal 40-pair copper cable and optical fibre (OF) installed along the M5 A (southbound) carriageway;
- Local cabling (copper and fibre) between ITS equipment and communications/power interface cabinets.

3.19.10 The cable infrastructure is installed within ducts. Cross carriageway and through structure ducting have been installed where applicable.

3.19.11 Buried chambers are utilised to provide for cable installation and duct connection.

ITS Equipment

3.19.12 ITS Equipment installed in the area around Junction 10 comprises:

- Emergency Roadside Telephones (ERT's): pairs at MP79/2A & B, MP78/2A & B, MP774A & B, MP75/9A & B;
- Post-mounted, central reserve MS1 (Motorway Signal Mk1): MP79/2B (single sided), MP77/4A & B (double sided);
- Cantilever mounted MS4 (Motorway Signal Mk4): MP79/6A;
- CCTV Cameras: MP79/6A (mounted on MS4), MP77/4B;
- Associated cabinets: various locations housing signal and telephone transponders, power connections, protection and isolation devices, fibre optic and copper cable jointing equipment.

3.19.13 Cabinets are generally installed in groups on hard-standings within the motorway boundary along with associated features such as steps, handrails, and pathways facilitate safe maintenance access.

3.19.14 Electrical interface (EI) cabinets providing connection to the local power distribution network are generally installed within the motorway boundary fence.

3.19.15 Motorway Incident Detection and Alert System (MIDAS) equipment is not installed through the proposed scheme area although there is a loop site adjacent to the above referenced MS4 at the limit of a sequence of detection sites to the south of the proposed scheme.

Traffic Signals

3.19.16 There are no traffic signals currently in use at Junction 10, and no existing infrastructure related to traffic signals.

3.20 Existing Earthworks

A review of the condition of existing earthworks at the existing M5 J10 interchange has been undertaken using HAGDMS, please refer to Figure 3-36.

3.20.1 Table 3-16 shows that three earthworks are designated a 'High' or 'Very High' Slope Hazard Rating. A more detailed review of earthwork condition will be included in the Preliminary Sources Study Report (PSSR) to be prepared for the scheme.

Figure 3-36 Existing Earthworks at M5 J10

Table 3-16 – Summary of Earthworks at M5 J10

Earthwork Ref	Earthwork Type	C/W Direction	Observations					Slope Hazard Rating
			1A	1D	2	3	Other	
2_M5_29067	At Grade	S/B					1	N/A
2_M5_29081	At Grade	S/B		1			5	N/A
2_M5_29089	At Grade	S/B					2	N/A
2_M5_29098	At Grade	S/B					1	N/A
2_M5_29099	Cutting	S/B			1		3	Very Low
2_M5_29176	At Grade	N/B					3	N/A
2_M5_29178	At Grade	N/B		1	1		4	N/A
2_M5_59662	At Grade	S/B					3	N/A
2_M5_63888	At Grade	N/B					1	N/A
2_M5_63889	Embankment	N/B					0	High
2_M5_63890	Embankment	N/B					0	High
2_M5_63891	Embankment	N/B			1		0	Very High
2_M5_29191	At Grade	N/B		1			2	N/A
2_M5_29071	At Grade	S/B					4	N/A
2_M5_29190	At Grade	N/B					1	N/A

4 Environmental Status

4.1.1 More detailed environmental baseline information is presented within the Preliminary Environmental Assessment of Options Report (PEAOR). A summary of the key designations within the study area is presented below with environmental topic baseline information provided in section 5.

4.1.2 The Environmental Constraints illustrate the key constraints of the area which are shown on Drawing Nos GCCM5J10-ATK-EGN-XX_GS-GI-000001 in Appendix A.

4.2 Designations

4.2.1 The majority of the scheme lies within land designated as Green Belt.

4.2.2 The Cotswolds AONB is a nationally designated area of importance. Although over 4.5km and 6km from the extents of the A4019 and Junction 10 respectively, views from the AONB and its setting should be considered due to its status.

4.2.3 Combe Hill Canal SSSI is over 2km to the east of the existing M5J10.

4.2.4 There are several Listed Buildings and one Scheduled Monument within the Scheme area, these are highlighted in more details in section 5.6 Heritage and Historic Resources.

4.2.5 There are seven Noise Important Areas within the immediate vicinity of the Scheme, which are located along the M5 and A4019.

4.2.6 Cheltenham Air Quality Management Area (AQMA) sits just beyond the A4019 work extents at the B4634 junction. The boundary of the AQMA follows the alignment of the A4019 approximately 350m south from the Scheme footprint heading west towards Uckington before sweeping south where it would be approximately 650m away from Scheme footprint.

5 Existing Environmental Conditions

5.1.1 The text below is a brief summary of the existing environmental conditions relevant to each topic. A fuller description can be obtained in the PEAOR.

5.2 Noise

5.2.1 No baseline noise monitoring has been undertaken as part of this assessment. Therefore, baseline noise conditions have been determined from the modelled Do Minimum Opening year noise levels. This approach is considered appropriate due to road traffic noise being the predominant source within the study areas. All other noise sources have been excluded from the assessment.

5.2.2 Most receptors within the study area have baseline noise levels in the range 40-45dB $L_{A10,18h}$. Receptors which are close to the motorway have baseline noise levels up to 75dB $L_{A10,18h}$.

5.2.3 There are 2 Noise important Areas near the scheme. The first is NIA 3951 (Highways England) which covers the existing junction and contains approximately 22 receptors. The second is NIA 3952 (Highways England) which is on the M5 approximately 800m north of the existing junction and contains 1 receptor.

5.2.4 Other NIAs within the study area are listed below:

- 3948 (Gloucestershire) – A4019
- 3950 (Gloucestershire) – A4019
- 3893 (Gloucestershire) – A4019
- 3894 (Gloucestershire) – Princess Elizabeth Way
- 3946 (Gloucestershire) – Princess Elizabeth Way

5.3 Local Air Quality

5.3.1 The local air quality study area is defined as the area within 200 m of the affected road network (ARN). For the purposes of identifying the existing conditions (2017 base year) a combined study area has been derived. The combined ARN includes sections of the following key roads: A40, A4019, A4013, B4063, B4633, B4634, M5

5.3.2 The Scheme study area for air quality is situated within the administrative boundary of Cheltenham Borough Council (CBC) and Tewkesbury Borough Council (TBC) and includes the borough wide AQMA administered by CBC, declared in 2011 for exceedances of the national NO2 annual mean AQS objective. Baseline air quality conditions have been evaluated by use of monitoring data provided by CBC and TBC as part of their Local Air Quality Management obligations.

5.3.3 Continuous (automatic) monitoring is undertaken at one location within the CBC AQMA, at the intersection of St George's Street and A4019. The monitored values show that NO2 concentrations as an annual mean approach but do not exceed the AQS objective of 40 µg/m3. There were no reported exceedances of the short-term hourly objective of 200 µg/m3 between 2014 and 2018. Annual mean NO2 concentrations are also measured by both CBC and TBC using passive diffusion tubes. There are several diffusion tubes located in the proximity of The Scheme. The diffusion tube results show that NO2 concentrations at roadside locations approach and sometimes exceed the annual mean AQS objective of 40 µg/m3. The data shows a general improvement in conditions over time, with a reduction in the number of locations exceeding the 40 µg/m3 annual mean objective between 2014 (six out of 18) and 2018 (one out of 30). It is notable that the

locations with NO2 concentrations exceeding the 40 µg/m3 annual mean NO2 objective in 2017 and 2018 (Site ID 4, 5 and 6) were along the northern access routes to northern areas of Cheltenham Spa centre, A4019 and St Margaret's Street. These areas, which have relevant areas of public exposure at roadside locations, are likely to be the most sensitive to air quality impacts of the Scheme.

5.3.4 There are no statutory designated ecological sites within the air quality study area.

5.3.5 The air quality study area includes a road identified by DEFRA as exceeding the EU Limit Value for annual mean NO2 concentrations. The latest update of the PCM modelling indicates that the EU Limit Value was exceeded at roadside locations in 2017 on part of the A40, running from the B4063 at Arle Court Roundabout to the A4013 at Princess Elizabeth Way Roundabout on the western side of Cheltenham. The PCM model estimates that the EU Limit Value will, however, be achieved by 2019. An EU compliance assessment may be required to determine the impact the Scheme will have on achieving the EU Limit Value.

5.4 Greenhouse Gases

5.4.1 Global greenhouse gas emissions from all sources amount to approximately 50 billion tonnes of carbon dioxide equivalent (CO_2e). The UK is the world's eighth largest emitter of CO_2e, with the total UK emissions for 2017 (the last reported year) being 460 million tonnes of CO_2e. The transport sector was the largest emitting sector of UK greenhouse gas emissions in 2017, emitting 27% of all emissions. The existing infrastructure currently generates emissions from the following sources:

- Road users' vehicles
- Maintenance and refurbishment of the infrastructure
- Operational energy use, e.g. from lighting and technology

5.4.2 Through the Climate Change Act (as amended), the government is committed to reducing UK emissions by at least 100% of 1990 levels by 2050. Additionally, Gloucestershire County Council announced a Climate Emergency in May 2019 to further highlight concerns in the county of ongoing climate change and in December 2019 issued Gloucestershire's Climate Change Strategy. The vision for this strategy is by 2030 to have reduced carbon emissions in the county by 80% (on 2005 levels) and to be carbon neutral by 2050. To help meet the emissions reduction target, the government has set carbon budgets, which currently run to 2032. These limit the amount of greenhouse gas the UK can legally emit in a five-year period. The carbon budgets are shown in Table 5-1.

Table 5-1 – UK Carbon Reduction Targets

Carbon Budget	Carbon Budget Level
3rd carbon budget (2018 to 2022)	2,544 $MtCO_2e$
4th carbon budget (2023 to 2027)	1,950 $MtCO_2e$
5th carbon budget (2028 to 2032)	1,725 $MtCO_2e$

5.4.3 The construction of the Scheme will occur during the third carbon budget period (2018 to 2022), which has a budget of 2,544 $MtCO_2e$. With a likely Opening Year of 2024, operation of the scheme will fall in the fourth budget period and beyond. The budget for the fourth budgetary period is 1,950 Mt CO_2e. In June 2019, a target of net zero carbon emissions by 2050 was enshrined in UK law.

5.5 Landscape

5.5.1 As noted above, the study area lies within the National Character Area (NCA) 106 Severn and Avon Vales, which is broadly defined as low lying agricultural vale landscape.

5.5.2 The County Landscape Type of Settled Unwooded Vale and Local Landscape Character Area Vale of Gloucester have been defined by the Gloucester Landscape Character Assessment (LDA Design 2006) which notes the key characteristics, typical also of the Scheme area, to be:

- To the east, the Vale is defined by the rising landform of the Cotswolds escarpment and Oxenton Hill. To the west of the Vale lies the Floodplain Farmland landscape character type.
- The intermittent small ridges, hillocks and undulations that rise above the general level of the Vale are important local features.
- Woodland is not a characteristic feature of the Vale of Gloucester and is generally limited to few small copses.
- The M5 forms a spine through the heart of the vale and although often screened by the adjacent cuttings, and vegetation, there are frequent filtered views towards the motorway from the surrounding vale landscape and the noise generated by motorway traffic is readily audible.
- There is a widespread network of pylons and transmission lines.
- Large watercourses including Hyde Brook, River Swilgate, River Chelt and Hatherley Brook, run generally east-west across this landscape before heading south to join the River Severn.

5.5.3 Visual receptors within the study area include Public Rights of Way (PRoW) and properties (residential, business, and community receptors).

5.5.4 The PRoW are generally within fields, along hedged boundaries or streams but also cross open fields. Short range views tend to be limited to by intervening hedge boundaries, buildings and the flat topography. Longer ranging, more distant, but indistinct views are possible of the raised land beyond the study area.

5.5.5 Views towards the Scheme area from these raised land forms, such as the open access land and PRoWs within the Cotswold AONB, are possible but over very long distances.

5.5.6 There are quite distinct clusters of properties dotted within the study area usually forming parts of the local villages and settlements. Many residential properties are also surrounded by outbuildings. Garden, boundary and roadside vegetation often aid screening.

5.5.7 Views vary; sometimes enclosed by property vegetation, sometimes open across quite a rural landscape, occasionally punctuated with detrimental views of pylons or road infrastructure and, particularly toward the eastern end of the A4019, over a more urbanised landscape.

5.6 Heritage and Historic Resources

5.6.1 The Scheme area includes a total of 31 designated heritage assets. One Scheduled Monument, Moat House moated site (1016835), is located on the A4019 at Moat Lane in Uckington. This medieval moated site is also home to four Grade II listed buildings, which post-date the Scheduled Monument: Moat House (1091874); Bridge and attached pair of lodges Moat House (1154528); Moat Cottage (1303797); and Barn c. 30m north-west of the Moat House (1340069). With the exception of the bridge and lodges (1154528), which date from the 19th century, the remaining listed buildings at the moated site date from the 17th and 18th centuries, and likely overlay earlier, medieval remains.

5.6.2 A single Grade I listed building, the Chapel of St James the Great (1091878), is located within the study area, c. 390m east of the northern edge of the study area, in Stoke Orchard.

5.6.3 The remaining 25 designated heritage assets are made up of Grade II listed buildings that are widely dispersed through the study area. They include farms, stables, barns, and cottages dating from the 16th to 19th centuries and represent the built heritage of the early post-medieval period and reflect the agricultural landscape of the time.

5.6.4 In addition to the nationally-designated heritage assets mentioned above, a single locally-designated building, a half-timbered building that was originally part of a wing to a former mill building (now demolished) on Newland View, Cheltenham (GHER 43890).

5.6.5 A total of 65 non-designated heritage assets have been identified within the study area. There is the potential for as-yet unknown archaeological remains to be present within the study areas.

5.7 Biodiversity

5.7.1 The study areas for ecological features were determined by the potential Zone of Influence (ZoI) of the Scheme[6]:

- 30 km for European Sites where bats are a qualifying feature;
- 2 km for other statutory designated sites (extended where there is a direct hydrological connection) and records of bats;
- 1 km for non-statutory designated sites, priority habitats, ancient woodland and records of protected and notable species;
- 500 m for waterbodies that could support great crested newt;
- 250 m for terrestrial habitat assessment and records of ancient and veteran trees;
- 150 m for aquatic habitat assessment (extended to 2 km for aquatic species records where watercourses are present within 150 m); and
- 100 m for building and tree bat roost assessments.

5.7.2 Desk study and field survey have been undertaken to identify ecological features within the above study areas. Field survey has comprised terrestrial and aquatic habitat walkover surveys, bat roost survey and great crested newt survey. Further field surveys are under way, but at the time of writing (October 2019) the results are not yet available for consideration in this report.

5.7.3 Three statutory designated sites are present within the study areas:

- Wye Valley and Forest of Dean Bat Sites Special Area of Conservation (SAC) – approx. 21 km west of Scheme;
- Coombe Hill Site of Special Scientific Interest (SSSI) – approx. 1.9 km north west of Option 2B (not within study area for other options); and
- Severn Estuary SAC/Special Protection Area (SPA)/Ramsar/SSSI – hydrological connection to Scheme (approx. 40 km downstream).

[6] These distances are measured from the edge of the proposed Scheme footprint for each option. However, the study areas were defined before inclusion of the attenuation ponds, which extend the Scheme option footprints by at least 100 m in places. Due to timing, the study areas were not extended. However, the ponds have been included in the assessment, as they are all located within the exiting study areas.

5.7.4 There are no records of non-statutory sites, ancient woodlands or ancient/veteran trees within the study areas. Records of priority habitats within 1 km comprise deciduous woodland, traditional orchard, lowland meadows and pastures, and coastal and floodplain grazing marsh.

5.7.5 Terrestrial habitats within 250 m of the Scheme are dominated by large arable fields, improved grasslands and poor semi improved grasslands, most of which are bordered by species-poor hedgerows. Notable exceptions include pockets of broadleaved and mixed plantation woodland, traditional orchard, semi-improved neutral grassland, and one field of unimproved neutral grassland. The walkover survey also identified veteran trees within some of the hedgerows. One particularly notable combination of habitats has been identified as a distinct feature and named 'Colman's Farm Habitat Network' (CFHN).

5.7.6 A number of aquatic habitat features have been identified within the 150 m study area. These comprise the River Chelt (and two of its tributaries), Leigh Brook (and one of its tributaries), the River Swilgate and three field drains. A total of 30 ponds have also been identified within 500 m of the Scheme.

5.7.7 Suitable habitats have been identified for protected and notable species. These are summarised in Table 5-2, along with details of any survey evidence and/or previous records of protected and notable species.

Table 5-2 – Protected and Notable Species confirmed or Potentially present within Study Area.

Species/Group	Suitable Habitats within Study Area	Survey Evidence	Previous Records
Bats	Yes – 87 buildings and 406 trees with bat roost potential recorded to date, plus a range of suitable commuting and foraging habitats	Yes – 21 confirmed building roosts to date, including brown long-eared bat, common pipistrelle, soprano pipistrelle, lesser horseshoe and at least one Myotis species. Also, one confirmed tree roost to date (barbastelle).	Yes - records of five species: brown long-eared bat, common pipistrelle, Daubenton's bat, lesser horseshoe and soprano pipistrelle
Dormouse	Yes – woodland, hedgerows and scrub	No	Yes - one record
Badger	Yes – range of habitats	Yes – badger sightings and multiple setts	Yes – five records
Otter	Yes – range of terrestrial and riparian habitats	Yes – spraints and footprints along River Chelt	Yes – three records
Water Vole	Yes – riparian habitats and ponds	No	No
Other Notable Mammals	Yes – range of habitats	Yes – brown hare and polecat sightings	Yes – multiple records of hedgehog
Breeding & Wintering Birds	Yes – range of habitats	Yes – numerous observations of notable species, including barn owl	Yes – records of 31 notable species
Reptiles	Yes – combinations of rough grassland and scrub / woodland edge	Yes – one observation of grass snake	Yes – records of common lizard and slow worm

Amphibians	Yes – ponds, rough grassland, hedgerows, scrub and woodland	Yes – great crested newt eDNA confirmed in 7 ponds to date	Yes – records of great crested new and common toad
Terrestrial Invertebrates	Yes – particularly traditional orchards and other deadwood habitats	No	No

5.8 Water Environment

5.8.1 The study area for the water environment has been broadly defined as 1km from the footprint of the potential M5 J10 Scheme. Flood risk baseline has been discussed at section 3.9 so will not be repeated here.

5.8.2 There are five surface water reported WFD reaches and three Main Rivers (not designated under the WFD) within the study area. The nearest watercourse to the M5 J10 is the Leigh Brook (Ordinary Watercourse), approximately 0.5 km north west, which is a tributary of the River Chelt. The River Chelt joins the River Severn approximately 5.7 km north west of the M5 J10. Both the Leigh Brook and the River Chelt flow east to west and cross the M5 within the study area. The Leigh Brook crosses the M5 approximately 0.5 km north east of J10, and the River Chelt crosses the M5 approximately 0.9 km south of J10.

5.8.3 There are two surface water abstractions and 32 surface water discharges in the study area.

5.8.4 The study area is underlain by bedrock geology consisting of Rugby Limestone Member (Mudstone and Limestone, Interbedded) and Charmouth Mudstone Formation (Mudstone). The Rugby Limestone Member (Mudstone and Limestone, Interbedded) lithology is designated as a Secondary A type aquifer. The Charmouth Mudstone Formation (Mudstone) is designated as a Secondary (Undifferentiated) type aquifer.

5.8.5 There are two designated WFD groundwater bodies within the study area: Severn Valley – secondary combined; and Warwickshire Avon – secondary mudrocks.

5.8.6 There are no Source Protection Zones or Groundwater abstractions in the study area. There are two Groundwater discharges.

5.9 People and Communities

5.9.1 Due to the isolated nature of M5 Junction 10, there are few key settlements of note located in and around the study area, with the exception of Cheltenham, which is located approx. 2km south-east of the Scheme. There are, however, a number of small settlements with a limited number of private dwellings within the study area, as well as a small number of private dwellings in proximity to M5 Junction 10.

5.9.2 There are a limited number of community assets in proximity to the Scheme due to the rural nature of the location. Those community assets identified within 500m of the Scheme include a horse-riding school, a village hall and a place of worship.

5.9.3 There are several businesses located within the study area, particularly in proximity to:

- Staverton;
- Golden Valley / Hayden;
- M5 Junction 10; and
- Hardwicke.

5.9.4 There are four unimplemented or partially implemented planning permissions which have been granted in the vicinity of the Scheme. Furthermore, there are several allocated sites in the Joint Core Strategy and saved local plans located in the vicinity of the Scheme.

5.9.5 Although there is very little public green space in the study area, the majority of the study area lies within Green Belt land.

6 Accessibility

6.1 Option Values

6.1.1 There are currently five scheduled bus services which travel along the A4019 and cross the M5 at Withy Bridge. These services connect Cheltenham and Tewkesbury via several different routes. The routes and frequencies are as follows:

Table 6-1 – Existing Bus Services

Service Number	Destinations	Frequency
41	Cheltenham - Kingsditch - Tewkesbury - Northway	Monday to Friday – Every 20 minutes Saturday – Every 30 minutes Sunday – Hourly
42	Cheltenham - Walton Cardiff - Wheatpieces - Tewkesbury	Monday to Friday – Every 30 minutes during peak hours. Hourly off-peak Saturday and Sunday – Hourly
43	Cheltenham - Walton Cardiff - Wheatpieces – Tewkesbury - Prior's Park	Monday to Friday – 4 services per day Saturday – 5 services Sunday – No service
43A	Cheltenham - Walton Cardiff - Wheatpieces – Tewkesbury	Monday to Saturday – 5 services per day Sunday – No service
650	Cheltenham to Bamfurling/Tredington	Monday to Friday – 1 service per day

6.1.2 Along the A4019 and within the study area, the above bus services serve four eastbound and four westbound bus stops. These are described in the table below.

Table 6-2 – Existing Bus Stops

Name	Location	Services
The Plant Centre (East)	The Plant Centre, Uckington, A4019	41, 42, 43, 43A
The Plant Centre (West)	The Plant Centre, Uckington, A4019	41, 42, 43, 43A
Moat Lane (East)	Moat Lane, Uckington, A4019	41, 42, 43, 43A
Moat Lane (West)	Moat Lane, Uckington, A4019	41, 42, 43, 43A
Cooks Lane (East)	Cools Lane, Uckington A4019	41, 42, 43, 43A
Cooks Lane (West)	Cools Lane, Uckington A4019	41, 42, 43, 43A
Withy Bridge Gardens (East)	Withy Bridge Gardens, Withy Bridge, A4019	41, 42, 43, 43A, 650
Withy Bridge Gardens (West)	Withy Bridge Gardens, Withy Bridge, A4019	41, 42, 43, 43A, 650

6.1.3 In addition, a further two bus stops are located just outside the study area on the A4019 by Gallagher Shopping Centre.

6.2 Existing footpaths and public rights of way

6.2.1 The surrounding area is predominantly rural agricultural land and existing highways infrastructure. The few pedestrian links available in the area comprise roadside footpaths and public rights of way (PRoW) through agricultural land.

6.2.2 Public rights of way in proximity of Junction 10 include Bridleway AUC1, which crosses agricultural land east of the M5 between Elmstone Hardwick and the A4019 at Withybridge Lane. Public Footpath AUC8 joins the A4019 east of Uckington.

6.2.3 West of the M5, at the north end of the study area, Public Footpaths AEH20 and AEH23 connect with a small network of PRoW at Hardwick. Public Footpath ABO14 links Boddington and the A4019 westbound carriageway to the immediate west of Junction 10.

6.2.4 Public Footpath ABO16 passes beneath the M5 to the south of Junction 10, ABO16 follows the River Chelt to Withybridge Lane and connects with Public Footpath ABO24, which continues eastwards to Bridleway ABO25. To the north of the River Chelt, Public Footpath AUC11 runs north-eastwards from Withybridge Lane towards the A4019.

6.2.5 Public Footpath ABO26 links the B4634 with Hayden Farm.

6.2.6 An undesignated footpath is present along the eastbound section of the A4019 to the east of the Junction 10 slip road. There is a missing section of footpath immediately west of the slip road, which extends towards the bridge; at this location desire lines in the highway verge are observable. The footpath recommences on the bridge and continues to Stanboro Lane and onwards towards Coombe Hill.

6.3 Transport Interchange

6.3.1 Cheltenham Bus Stations is located in Cheltenham town centre, approximately 2 km from the study area of the Scheme. The bus station serves as a hub for local and regional routes.

6.3.2 Cheltenham Spa Railway Station lies to the west of the bus station, approximately 1.75 km south of the study area and an approximate ten minute journey time via private vehicle. Cheltenham Spa Railway Station serves Great Western trains, as well as Crosscountry and Transport for Wales Services.

7 Maintenance and Repair Statement

7.1 Introduction

7.1.1 The Maintenance and Repair Strategy (MRSS) outlines key strategic design assumptions and decisions taken during design and construction of the scheme. These relate to how the maintenance of assets (new and existing) can be carried out efficiently during its lifetime, and how risks to road workers are kept as low as reasonably practicable. It details the likely impact on network availability, identifies any specific resource requirements and highlights any safety issues for road users and operatives.

7.1.2 The Highways England & GCC Maintenance Area are shown on Drawing Nos GCCM5J10-ATK-HGN-XX_ML_Z-DR-CH-000021in Appendix A.

7.1.3 The aim is to provide a high-level strategic document that demonstrates that maintenance requirements have been considered and steps taken to ensure that works to maintain assets can be carried out safely and cost effectively minimising exposure and risk to road workers. Consideration should be given to the ease of maintenance and access requirements of assets introduced to the scheme as well as to the construction and design of the roadway.

7.1.4 The MRSS is not intended to provide a detailed account of maintenance methods. It is the responsibility of the Maintenance Service Provider (MSP) to identify and implement appropriate methods of work for the required maintenance activities.

7.2 Maintenance requirements

7.2.1 Maintenance requirements need to be considered at the earliest opportunity in the design process to ensure that any necessary provision can be built into the scheme. Consideration should be given to the following:

- Grouping assets closely together so that they can be accessed from a single location to avoid extended periods of operatives walking to multiple sites with heavy equipment;
- Providing assets in the verge rather than in the central reserve to provide a larger and safer working space for operatives
- Providing adequate clearances between working areas and adjacent running lanes to protect assets and operatives from errant vehicles
- Avoiding working at height by providing wind-down assets which can be accessed from ground level
- Providing hardstanding in laybys to reduce the risks of operatives slipping during wet weather
- Where possible providing off-network access to assets with footways to allow operatives to walk to assets protected from passing traffic
- Minimising maintenance requirements of bridges by providing integrated structures with no bearings
- Avoiding the planting of any high-level vegetation which could affect visibility and avoid planting species which require a high level of maintenance
- Locating gullies and drainage provision where it can be easily accessed without the need for operatives to disembark from maintenance vehicles
- Providing lighting which can be controlled remotely and low maintenance LED lanterns

- Installing rigid concrete barriers rather than steel barriers in the central reserve
- Erecting self-cleaning sign faces to reduce cleaning requirements
- Installing fixed access gantries to avoid lane closures and avoid operatives working at height from elevated platforms
- Protecting accesses to assets which could be abused by the general public and subject to fly tipping
- Winter maintenance where additional road space will be provided increasing salt demand and demand for additional gritters.
- Providing access to earthworks for periodic inspections

7.2.2 Specific maintenance requirements for potential solutions will be realised at a later stage however it is preferable that the option with the lowest maintenance demand is progressed. Close liaison with the MSP at an early stage is essential to gain assurance that the proposals are workable and expose their operatives to minimal risk during maintenance periods.

8 Planning Factors

8.1 Introduction

8.1.1 Relevant local and national plans variously set out the development policies, targets and priorities for the area; establishing the planning context for the Scheme. This chapter cites the most pertinent planning and transport context for the following development types in relation to the Scheme:

- Housing
- Employment
- Transport and connectivity

8.1.2 The chapter identifies environmental designations contained in planning documents that are relevant to the Scheme; makes reference to programming of development, as set out in the relevant local and national plans; and concludes with a brief consideration of the likely need for land purchase to deliver the Scheme.

8.1.3 The planning constraint layout are shown on Drawing Nos GCCM5J10-ATK-HGN-XX_ML_Z-DR-LP-000006 in Appendix A.

8.2 Housing

8.2.1 The JCS was adopted in December 2017 by the three authorities that authored it in partnership – GCC, TBC and CBC. All planning applications should confirm with the policies contained within the JCS as well as any other saved policies of earlier adopted planning policy documents that together form the relevant Development Plan for each of the authorities, unless material considerations demonstrate otherwise. The JCS identifies the need for 35,175 new homes by 2031 (c. 1759 per year).

8.2.2 Of this total, 4,285 dwellings are to be delivered at the North West Cheltenham strategic allocation and 1,100 at the West Cheltenham strategic allocation. Additionally, several sites located to the north west and west of Cheltenham have been removed from the Green Belt and are safeguarded for future housing development. These sites have capacity to deliver approximately 3,500 new dwellings.

8.2.3 An Issues and Options Consultation on the JCS Review for the period 2021 to 2041 was concluded in January 2019. The consultation document stated the expectation that the minimum requirement of new homes to be delivered in the JCS area each year will increase to around 1,780.

8.2.4 The Consultation document states that the JCS Review will incorporate the planning of the safeguarded sites to deliver the longer-term development needs for Cheltenham. In addition, the Consultation document refers to the opportunities for further allocations, which would build on the significant highway improvements planned in the area. This underlines the JCS intention that significant planned growth should be delivered within the vicinity of the Scheme in the coming years, including while the JCS Review is underway.

8.3 Employment Areas

8.3.1 The JCS identifies the need for a minimum of 192 hectares of B-class employment land to support approximately 39,500 new jobs by 2031 (c.1975 per year).

8.3.2 The strategic allocations and safeguarded land to the north west and west of Cheltenham also include significant employment development including the 45-hectare West Cheltenham Cyber Park.

8.3.3 The extension of the plan period to 2041 through the JCS Review will mean new land to support economic growth is required. The Issues and Options Consultation, which concluded in January 2019, included a 'call for sites', inviting developers to promote undeveloped land for future employment development. While the location of this additional employment land is not currently known, the Consultation document identifies opportunities for additional employment allocations to the west of Cheltenham in proximity to the existing allocations and planned highway improvement projects.

8.4 Transport and Connectivity

8.4.1 The Gloucestershire Local Transport Plan (LTP) 2015-2031 includes the Central Severn Vale Connecting Places Strategy. The Strategy details the significant growth forecasts for the area near Junction 10 of the M5 and refers to several specific solutions along the M5 corridor. These solutions include the upgrading of Junction 10.

8.4.2 The LTP sets out a comprehensive list of short-term and long-term transport infrastructure priorities for the County. Improvements to J10 of the M5 and to the A4019 corridor are prominent on the list of highways improvements; while the expansion of Arle Court Park and Ride is a key priority for bus improvements.

8.4.3 The JCS Strategic Allocation Policy A4 North West Cheltenham includes reference to the provision of primary vehicle access from A4019. Strategic Allocation A7 West Cheltenham includes reference to the need for links to the M5 J10.

8.5 Environmental

8.5.1 The A4019 forms part of the boundary of the Gloucester Green Belt. The elements of the Scheme that are situated to the south of the A4019 are within the Green Belt.

8.5.2 The Moat House Moated Site Scheduled Monument is situated within 100m of the A4019 at Uckington. There are numerous listed buildings within the area. The Grade II listed Butler's Court Farmhouse, Cottages by Drive to Butler's Court and Withybridge Mill and Adjoining Barn are located at Withy Bridge within 400m of the Scheme. The grade II listed Uckington Farmhouse and Stableblock and Open Fronted Cart Store are located within 100m of the A4019 at Uckington Farm. To the south of the A4019 at Uckington is the Grade II listed Moat Cottage. These heritage designations and the potential impacts and resultant effects on their settings will be a key consideration for the Scheme.

8.5.3 The River Chelt is the only designated main river within the Scheme boundary. There are extensive areas of Flood Zone 2 and 3 on both banks of the river. The Scheme will cross the flood plain and the river.

8.5.4 Public Footpaths AUC11 and ABO24 cross the Scheme as they run parallel to the River Chelt, north and south of the river, respectively. Bridleway AUC1 and Public Footpath AUC8 join the A4019 from the north.

8.6 Programming

8.6.1 There is potential for the construction phase of the Scheme to run concurrently with the numerous strategic land allocations and highways capital investment priorities that are planned to be delivered in the area to the west of Cheltenham. The project programme should give consideration to the potential cumulative effects during the construction phase, including any additional disruption to traffic.

8.6.2 The implemented Scheme will directly unlock the development of more than 7,250 houses, which represents 80% of the homes to be delivered at the North West and West Cheltenham strategic allocations and half of the homes required in the JCS area to the end of the plan period of 2031. Therefore, the timely implementation of this Scheme would

be early in the JCS plan period, as cited in relation to allocations A4 and A7, to enable the delivery of the housing requirement and the fulfilment of the JCS housing objectives. The Scheme will also unlock safeguarded sites that are earmarked for further development through the JCS Review.

8.6.3 In addition to directly unlocking development sites and enabling further growth, the Scheme will increase the capacity of the highways network in the region, which is needed to mitigate the traffic impacts of the growth planned in the adopted JCS as a whole.

8.7 Statutory Process

8.7.1 Each potential solution may require land acquisition and so, a statutory process may be required to obtain the powers to compulsorily acquire land.

8.7.2 In addition, an application for full planning permission through the Town and Country Planning Act 1990 will be required, subject to confirmation that the Scheme falls below the thresholds and is not identified as a Nationally Significant Infrastructure Project as set out in the Planning Act 2008.

8.7.3 While it is not yet confirmed, it is expected that the project will be EIA development under Schedule 2 of the EIA Regulations applicable to planning applications. Should significant environmental effects be considered likely, an environmental impact assessment would be required.

9 Options Identified for Appraisal

9.1 Scheme History

9.1.1 A variety of studies, option identification and sifting exercises have previously been carried out related to the improvement of the M5 Junction 10 as described in the following paragraphs.

9.2 Previous M5 Junction 10 Studies

9.2.1 Previous study work was undertaken by Highways England in July 2012 and February 2018.

9.2.2 JMP Consultants Ltd produced a report in July 2012 titled “M5 Junction 10 – Feasibility Study of conversion to an all movements junction”. This considered four options for converting the existing junction into an all movements junction. All options proposed to keep the existing northbound entry slip loop and avoid any impact on the commercial properties in the north west quadrant. They also sought to minimise the impacts on the residential properties on Withybridge Gardens. Because of this, all four options included at least one signalised slip road junction with the A4019.

9.2.3 A report produced by Aecom in February 2018 titled “Option Assessment Report – M5 Junction 10 and assess to the Cyber Park Access Road” identifies several options which included both improvements to Junction 10 and various different modelling scenarios.

9.3 West Cheltenham Link Road Options

9.3.1 Six outline options for a proposed West Cheltenham Link Road and improved/new M5 Junction 10 were developed by Amey Consulting in July 2018. These included various arrangements of a full movement Junction 10 located south, at, and north of the existing junction. A comparison of the options led to the development of three Concept Options included in the Homes England Business Case.

9.4 Homes England Business Case Concept Options

9.4.1 Amey Consulting developed three Concept Options from the previous six, which were included and assessed in the Homes England Business Case for funding in March 2019. These were:

- Concept Option 1 – Junction 10 moved north of its existing location
- Concept Option 2 – Upgrade to Existing Junction 10
- Concept Option 3 – Junction 10 moved south of its existing location

9.5 Options Identified at Options identification Stage

9.5.1 A workshop was held, attended by specialists in engineering, environmental and traffic modelling, to consider all previous options identified and to identify potential new options. The advantages and disadvantages of each option in relation to known constraints and were discussed and recorded. The options that were considered most likely to provide the benefits required and have the least impact on known constraints were identified. These were:

- Option 1A – As per Concept Option 1, but with J10 roundabout configuration amended to an elongated junction – New Junction North of Existing

- Option 2 – As per Concept Option 2 – Upgrade Existing Junction with Gyratory Roundabout
- Option 2A – As per Concept Option 2, but the junction moved slightly north to enable the retention of the existing bridge as the southern part of the gyratory carriageway.
- Option 3 – As per Concept Option 3 – New Junction South of Existing
- Option 4 – As per Concept Option 2, but with a dumbbell roundabout arrangement instead of a gyratory roundabout
- Option 5 –As per Concept Option 1, but with the junction located not as far north of the existing junction

9.6 Sifting of Options at Options identification Stage

9.6.1 A sifting exercise was undertaken on the above 6 concept options. A qualitative assessment was carried out using a range of Economic/Engineering, Environmental and Social/Cultural criteria and the options were scored on a seven-point scale.

9.6.2 Options 3 and 4 were considered to have less benefits or greater impacts that relative to the other options and were therefore sifted out at this stage.

9.6.3 As part of this process, it became apparent that there was a further sub-option of Option 2, which was similar to Option 2A, but moved the junction slightly south, to enable the retention of the existing bridge as the northern part of the gyratory carriageway. This layout was called Option 2B.

9.6.4 The options carried forward to the appraisal stage were therefore:

- Option 1A – New Junction North of Existing
- Option 2 – Upgrade Existing Junction with Gyratory Roundabout
- Option 2A - Upgrade Existing Junction with Gyratory Roundabout offset to the north
- Option 2B – Upgrade Existing Junction with Gyratory Roundabout offset to the south
- Option 5 - New Junction North of Existing (in alternative position to Option 1A)

A copy of the assessment table showing the relative scoring of each option is contained in Appendix C.

9.7 Description of Options carried forward for Appraisal

Option 1A – New Junction North of Existing

9.7.1 Option 1A proposes for a new M5 gyratory roundabout junction with two new overbridges, replacing the existing Hardwicke Elmstone Hard Bridge approximately 1250m north of the existing M5 Junction 10. This junction will provide access to the M5 in all directions, as a result the existing northbound on-slip and south bound off-slip at Junction 10 will no longer be required.

9.7.2 The Highway Layout with Engineering Constraints Option - 1A are shown on Drawing Nos GCCM5J10-ATK-HGN-OP1A_ML_Z-DR-CH-000001 to 000005 in Appendix B.

9.7.3 A new 50mph two-lane dual carriageway will connect the new M5 junction with the A4019 Tewkesbury Road by means of a new gyratory roundabout junction approximately 650m east of the M5. From this junction the new dual carriageway will continue south, passing over the River Chelt before tieing into the B4634 Gloucester Road approximately 300m east of the existing Withbridge Lane Junction. This section of dual carriageway provides continuity from the new M5 Junction while moving the traffic from Withybridge Lane.

9.7.4 In addition to the new sections of dual carriageway, it is proposed that the A4019 Tewkesbury Road, between the new gyratory roundabout and traffic signalised B4634 junction is widened to provide a two lane dualled carriageway. New signalised junctions will be required at the staggered crossroads of The Green and Moat Lane in Uckington and at Homecroft Drive junction.

9.7.5 As part of the improvement works, the existing Green Farm Access Bridge will be demolished and replaced at the same location with a new longer overbridge spanning the new slip road tapers. Another new bridge will be provided approximately 400m south to replace the demolished Hardwicke-Elmstone Hard Bridge.

9.7.6 This option would impact upon approximately 50% of a storage area at Bank Farm.

9.7.7

Option 2 – Upgrade Existing Junction with Gyratory Roundabout

9.7.8 Option 2 proposes for the existing M5 Junction 10 overbridge to be demolished and a new elongated oval shaped roundabout junction to be constructed over the M5, centred either side of the existing overbridge. To construct this roundabout and to tie into the existing A4019, the properties to the north and south of the A4019 carriageway will need to be demolished. Slip roads connect the junction to the M5, providing access in all directions.

9.7.9 The Highway Layout with Engineering Constraints Option - 2 are shown on Drawing Nos GCCM5J10-ATK-HGN-OP2_ML_Z-DR-CH-000001 to 000004 in Appendix B.

9.7.10 The connecting sections from the new junction to both the east and west are to be dualled, the west tying in approximately 250m west of the M5 Junction, while the east ties in to a new A4019 gyratory roundabout junction approximately 650m east of the junction. A connection stub to the north will be constructed for potential future development. From this roundabout a new 50mph dual carriageway will continue south, passing over the River Chelt before tying into the B4634 Gloucester Road with a new gyratory roundabout approximately 300m east of the existing Withbridge Lane Junction.

9.7.11 In addition to the new sections of dual carriageway, it is proposed that the A4019 Tewkesbury Road, between the new gyratory roundabout and traffic signalised B4634 junction is widened to provide a two lane dualled carriageway. New signalised junctions will be required at the staggered crossroads of The Green and Moat Lane in Uckington and at Homecroft Drive junction.

9.7.12 This option would impact upon all fourteen of the residential properties at Withybridge Gardens, the two properties on the A4019, a large proportion of the buildings at Sheldon Nurseries and the three properties nearby, and approximately a third of the Barn Farm storage area.

Option 2A – Upgrade Existing Junction with Gyratory Roundabout offset to the north

9.7.13 Option 2A proposes for the existing M5 Junction 10 to be upgraded to a gyratory roundabout junction, utilising the M5 overbridge and constructing one new overbridge north of the A4019. To construct the gyratory roundabout and tie the junction into the existing A4019, the properties to the north of the carriageway, both east of west of the M5 will need to be demolished. Slip roads connect the junction to the M5, providing access in all directions.

9.7.14 The Highway Layout with Engineering Constraints Option – 2A are shown on Drawing Nos GCCM5J10-ATK-HGN-OP2A_ML_Z-DR-CH-000001 to 000004 in Appendix B.

9.7.15 The connecting sections from the new junction to both the east and west are to be dualled, the west tying in approximately 250m west of the M5 Junction, while the east ties in to a new A4019 gyratory roundabout junction approximately 650m east of the junction. A connection stub to the north will be constructed for potential future development. From this roundabout a new 50mph dual carriageway will continue south, passing over the River Chelt before tying into the B4634 Gloucester Road with a new gyratory roundabout approximately 300m east of the existing Withbridge Lane Junction.

9.7.16 In addition to the new sections of dual carriageway, it is proposed that the A4019 Tewkesbury Road, between the new gyratory roundabout and traffic signalised B4634 junction is widened to provide a two lane dualled carriageway. New signalised junctions will be required at the staggered crossroads of The Green and Moat Lane in Uckington and at Homecroft Drive junction.

9.7.17 This option would impact upon four of the residential properties at Withybridge Gardens, the two properties on the A4019, a large proportion of the buildings at Sheldon Nurseries and the three properties nearby, and approximately a third of the Barn Farm storage area.

Option 2B – Upgrade Existing Junction with Gyratory Roundabout offset to the south

9.7.18 Option 2B proposes for the existing M5 Junction 10 to be upgraded to a gyratory roundabout junction, utilising the M5 overbridge and constructing one new overbridge south of the A4019. To construct the gyratory roundabout and tie the junction into the existing A4019, the properties to the south of the carriageway will need to be demolished. Slip roads connect the junction to the M5, providing access in all directions.

9.7.19 The Highway Layout with Engineering Constraints Option – 2B are shown on Drawing Nos GCCM5J10-ATK-HGN-OP2B_ML_Z-DR-CH-000001 to 000004 in Appendix B.

9.7.20 The connecting sections from the new junction to both the east and west are to be dualled, the west tying in approximately 250m west of the M5 Junction, while the east ties in to a new A4019 gyratory roundabout junction approximately 650m east of the junction. A connection stub to the north will be constructed for potential future development. From this roundabout a new 50mph dual carriageway will continue south, passing over the River Chelt before tying into the B4634 Gloucester Road with a new gyratory roundabout approximately 300m east of the existing Withbridge Lane Junction.

9.7.21 In addition to the new sections of dual carriageway, it is proposed that the A4019 Tewkesbury Road, between the new gyratory roundabout and traffic signalised B4634 junction is widened to provide a two lane dualled carriageway. New signalised junctions will be required at the staggered crossroads of The Green and Moat Lane in Uckington and at Homecroft Drive junction.

9.7.22 This option would impact upon all fourteen of the residential properties at Withybridge Gardens, a large proportion of the buildings at Sheldon Nurseries and two of the properties nearby, and approximately a third of the Barn Farm storage area.

Option 5 - New Junction North of Existing (in alternative position to Option 1A)

9.7.23 Option 5 proposes for a new M5 gyratory roundabout junction with two new overbridges, south of the existing Hardwicke Elmstone Hard Bridge which will be demolished, approximately 1000m north of the existing M5 Junction 10. This junction will provide access to the M5 in all directions, as a result the existing northbound on-slip and south bound off-slip at Junction 10 will no longer be required. To accommodate the new M5 junction, some buildings at Barn Farm will also have to be demolished and the existing access road to the farm realigned.

9.7.24 The Highway Layout with Engineering Constraints Option – 5 are shown on Drawing Nos GCCM5J10-ATK-HGN-OP5_ML_Z-DR-CH-000001 to 000005 in Appendix B.

9.7.25 A new 50mph two-lane dual carriageway will connect the new M5 junction with the A4019 Tewkesbury Road by means of a new gyratory roundabout junction approximately 650m east of the M5. From this junction the new 50mph dual carriageway will continue south, passing over the River Chelt before tying into the B4634 Gloucester Road approximately 300m east of the existing Withbridge Lane Junction. This section of dual carriageway provides continuity from the new M5 Junction while moving the traffic from Withybridge Lane.

9.7.26 In addition to the new sections of dual carriageway, it is proposed that the A4019 Tewkesbury Road, between the new gyratory roundabout and traffic signalised B4634 junction is widened to provide a two lane dualled carriageway. New signalised junctions will be required at the staggered crossroads of The Green and Moat Lane in Uckington and at Homecroft Drive junction.

9.7.27 As part of the improvement works, the existing Green Farm Accommodation Bridge will be retained.

9.7.28 This option would not impact upon any of the residential properties at Withybridge Gardens, the two properties on the A4019, Sheldon Nurseries and the three properties nearby. However it would affect all buildings and storage areas at Barn Farm.

9.8 Road Layout and Standards

Merge/Diverge Types and Spacing

9.8.1 The minimum merge/diverge types were identified by plotting traffic flow data for 2041 onto DMRB CD 122 Geometric design of grade separated junctions Figure 3.12b (Motorway merging diagram) and Figure 3.26b (Motorway diverging diagram). At this stage, a conservative approach has been taken and the next higher level of merge/diverge provision than the minimum has been included in the conceptual designs to account for any increases in traffic flows determined by traffic modelling in future stages of design. Merge/diverge types are to be revaluated as part of the preliminary design stage.

9.8.2 Table 9.1, 9.2 and 9.3 below summarise the merge/diverge types proposed for each option.

9.8.3 The distances between the proposed merges/diverges to M5 junctions 9 and 11 to the north and south respectively have also been summarised in the tables below. In accordance with CD 122, for spacings greater than 3 km the merges and diverges have been considered as separate entities and as such a weaving assessment was not required. Where the spacing was less than 3 km, the weaving section length has been determined and is provided in the tables below.

Table 9.9-1 – Proposed merge/diverge layout and spacing for Option 1A

Option	Location	Minimum Merge/Diverge Layout	Proposed Merge/Diverge Layout	Spacing
Option 1A	**NB Diverge**	**Layout A option 1** (Taper Diverge, 1 or 2 lanes on Slip Road)	**Layout B option 1** (Ghost Island Diverge, 2 lanes on Slip Road)	4.2 km from J11 NB merge > 3 km spacing satisfied
		Minimum layout identified from CD 122 Figure 3.26b using 2041 PM peak traffic flows (worst case)	*Next higher level of diverge provision than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	
	NB Merge	**Layout B** (Parallel Merge, 1 lane on slip road)	**Layout C** (Ghost Island Merge, 2 lanes on Slip Road)	5 km from J9 NB diverge > 3 km spacing satisfied
		Minimum layout identified from CD 122 Figure 3.12b using 2041 PM peak traffic flows (worst case). PM traffic flow value falls near the boundary line between Type A and Type B. Hence Type B is considered in a worst-case scenario.	*Next higher level of merge provision than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	
	SB Diverge	**Layout A option 1** (Taper Diverge, 1 or 2 lanes on Slip Road)	**Layout B option 1** (Ghost Island Diverge, 2 lanes on Slip Road)	5 km from J9 SB merge > 3 km spacing satisfied
		Minimum layout identified from CD 122 Figure 3.26b using 2041 AM peak traffic flows (worst case)	*Next higher level of diverge provision than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	
	SB Merge	**Layout A option 1** (Taper Merge, 1 lane on slip road)	**Layout C** (Ghost Island Merge, 2 lanes on Slip Road)	4.3 km from J11 SB diverge > 3 km spacing satisfied
		Minimum layout identified from CD 122 Figure 3.12b using 2041 AM peak traffic flows (worst case).	*Next higher level of merge provision (with two lanes on slip road) than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	

Table 9.2 – Proposed merge/diverge layout and spacing for Options 2, 2A and 2B

Option	Location	Minimum Merge/Diverge Layout	Proposed Merge/Diverge Layout	Spacing
Options 2, 2A and 2B	**NB Diverge**	**Layout A option 1** (Taper Diverge, 1 or 2 lanes on Slip Road)	**Layout B option 1** (Ghost Island Diverge, 2 lanes on Slip Road)	Option 2A satisfies 3 km spacing Option 2 and 2B approx. 2.95 km and 2.9 km from J11 NB merge respectively Weaving section length > 2 km for rural motorways satisfied
		Minimum layout identified from CD 122 Figure 3.26b using 2041 PM peak traffic flows (worst case)	*Next higher level of diverge provision than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	
	NB Merge	**Layout B** (Parallel Merge, 1 lane on slip road)	**Layout C** (Ghost Island Merge, 2 lanes on Slip Road)	Minimum 6.2 km from J9 NB diverge > 3 km spacing satisfied for all options
		Minimum layout identified from CD 122 Figure 3.12b using 2041 PM peak traffic flows (worst case). PM traffic flow value falls near the boundary line between Type A and Type B. Hence Type B is considered in a worst-case scenario.	*Next higher level of merge provision than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	
	SB Diverge	**Layout A option 1** (Taper Diverge, 1 or 2 lanes on Slip Road)	**Layout B option 1** (Ghost Island Diverge, 2 lanes on Slip Road)	Minimum 6.3 km from J9 SB merge > 3 km spacing satisfied
		Minimum layout identified from CD 122 Figure 3.26b using 2041 AM peak traffic flows (worst case)	*Next higher level of diverge provision than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	
	SB Merge	**Layout A option 1** (Taper Merge, 1 lane on slip road)	**Layout C** (Ghost Island	Option 2 and 2A

			Merge, 2 lanes on Slip Road)	satisfies 3 km spacing Option 2B 2.9 km from J11 SB diverge Weaving section length > 2 km for rural motorways satisfied
		Minimum layout identified from CD 122 Figure 3.12b using 2041 AM peak traffic flows (worst case).	*Next higher level of merge provision (with two lanes on slip road) than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	

Table 9.3 – Proposed merge/diverge layout and spacing for Option 5

Option	Location	Minimum Merge/Diverge Layout	Proposed Merge/Diverge Layout	Spacing
Option 5	**NB Diverge**	**Layout A option 1** (Taper Diverge, 1 or 2 lanes on Slip Road)	**Layout B option 1** (Ghost Island Diverge, 2 lanes on Slip Road)	Option 2A satisfies 3 km spacing Option 2 and 2B approx. 2.95 km and 2.9 km from J11 NB merge respectively Weaving section length > 2 km for rural motorways satisfied
		Minimum layout identified from CD 122 Figure 3.26b using 2041 PM peak traffic flows (worst case)	*Next higher level of diverge provision than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	
	NB Merge	**Layout B** (Parallel Merge, 1 lane on slip road)	**Layout C** (Ghost Island Merge, 2 lanes on Slip Road)	Minimum 6.2 km from J9 NB diverge > 3 km spacing satisfied for all options
		Minimum layout identified from CD 122 Figure 3.12b using 2041 PM peak traffic flows (worst case). PM traffic flow value falls near the boundary line between Type A and Type B. Hence Type B is considered in a worst-case scenario.	*Next higher level of merge provision than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	

	SB Diverge	**Layout A option 1** (Taper Diverge, 1 or 2 lanes on Slip Road)	**Layout B option 1** (Ghost Island Diverge, 2 lanes on Slip Road)	Minimum 6.3 km from J9 SB merge > 3 km spacing satisfied
		Minimum layout identified from CD 122 Figure 3.26b using 2041 AM peak traffic flows (worst case)	*Next higher level of diverge provision than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	
	SB Merge	**Layout A option 1** (Taper Merge, 1 lane on slip road)	**Layout C** (Ghost Island Merge, 2 lanes on Slip Road)	Option 2 and 2A satisfies 3 km spacing Option 2B 2.9 km from J11 SB diverge Weaving section length > 2 km for rural motorways satisfied
		Minimum layout identified from CD 122 Figure 3.12b using 2041 AM peak traffic flows (worst case).	*Next higher level of merge provision (with two lanes on slip road) than the minimum has been included in the conceptual design to account for any increases in traffic flows determined by traffic modelling in future stages of design.*	

Requirement for Gantries

9.8.4 A full sequence of gantry direction signing was previously considered essential for a Ghost Island diverge layout as specified in para 2.51 TD 22/06. This standard however has been superseded by CD 122 which does not make specific mention of the need for gantry signing for Ghost Island diverges.

9.8.5 CD 146 Positioning of signalling and advance direction signs sets out criteria to be met before using gantries for direction signs. The second criteria listed in paragraph 3.9 was considered to be the only applicable criteria for the proposed junction layout i.e.

9.8.6 “the carriageway has 3 running lanes and carries (or will carry within 15 years of opening) 33,000 vehicles per day (1-way) (high growth estimate) and the proportion of HGVs is greater than 20%”

9.8.7 Based on 2018 traffic data, the vehicles per day along the M5 northbound and southbound were 40,172 and 39,134 respectively, which is greater than the 33,000 criteria value. The percentage proportion of HGVs for the 2018 traffic count was 18% and the projection for the year 2041 is 17%. As this figure is below the 20% specified in the criteria above, gantries were not considered as part of the conceptual design options. However, the requirement for gantries will be reassessed during the preliminary design stage alongside finalisation of the merge/diverge types.

Highway Geometric Departures from Standard

9.8.8 No high-level highway geometric Departures from Standard (DfS) have been identified at this stage for any of the options due to the conceptual nature of the design done to date.

A more detailed DfS identification will be undertaken in future stages of the design as it is further developed.

Highway Cross-sections

9.8.9 The proposed M5 mainline will retain the existing 3 lanes plus hard shoulder cross-section in both directions in accordance with DMRB CD 127 Cross-sections and headrooms Figure 2.1.1N1a.

9.8.10 The slip road cross-sections will be provided in accordance with CD 127 Figure 2.1.1N1b Dimensions of cross-section components for rural motorway connector roads, being conservative at this stage and allowing for two lanes on all merge and diverge slip roads. The merges have therefore been designed as slip road type MG2C i.e. two lanes (3.65m) plus nearside hard shoulder (3.30m) and offside hard strip (1.00m). The diverges have been designed as slip road type DG2A i.e. two lanes (3.65m) plus nearside and offside hard strips (1.00m).

9.8.11 The minimum standard headroom will be provided at all new structures in accordance with CD 127 Table 4.1 and Table 4.3 i.e. 5.3m for overbridges with additional clearance for structures on a sag curve where necessary. For options where the existing J10 bridge would be retained, the minimum maintained headroom of 5.03m will be retained.

10 Traffic Analysis

10.1 Traffic Data Collection

10.1.1 As part of the M5 J10 HIF business case submission, an existing 2013 base year Central Severn Vale (CSV) traffic model previously developed by consultants Waterman Group was enhanced by Amey in 2019 while retaining the existing 2013 base year.

10.1.2 Full details of the model, including the traffic data collection undertaken is provided in the CSV Local Model Validation Reports produced by Amey:

- CSV LMVR 2013 IP Update Jan19 – Amey (2019 LMVR)
- CSV LMVR 2017_030317_ISSUE_a – Amey (2017 LMVR)

Note that the 2019 LMVR is materially the same as the 2017 LMVR with the addition of an Inter-peak model and its validation results.

10.1.3 For CSV base model update undertaken by Amey, all available data was collected, reviewed and processed to produce peak hourly traffic flows at key locations and journey times along key routes.

10.1.4 The principle sources of data used in the traffic model development stage were;

- Automatic traffic counts;
- Junction turning counts;
- Roadside interviews;
- Car park surveys;
- Journey time data from Strat-gis;
- Journey time data from the Basemap database;
- Telephonica mobile phone data;
- TEMPro growth factors;
- Address base data; and
- Census journey to work data.

10.1.5 The sources above have been used to produce trip matrices, which capture origin-destination movements within the model area and to independently validate the results of the highways assignment model.

10.1.6 Further details of the type of data and its specific application in the development on the CSV model can be found in the Atkins 'Transport Model Package Report (TR-000005), dated 24/09/19 and the CSV Local Model Validation Report produced by Amey as listed in section 10.1.2

10.1.7 Figure 10-1 below shows the location of the key traffic volume counts used to calibrate and validate the CSV base model. Individual counts have been aggregated into groups to form screenlines or cordons. Model flows are compared with observed at both individual count and screenline level to ensure that trip movements between sectors are well represented in the model. Further details on data collection are presented in the 'Transport Data Package Report' (GCCM5J10-ATK-HTA-XX-RP-TR-000004).

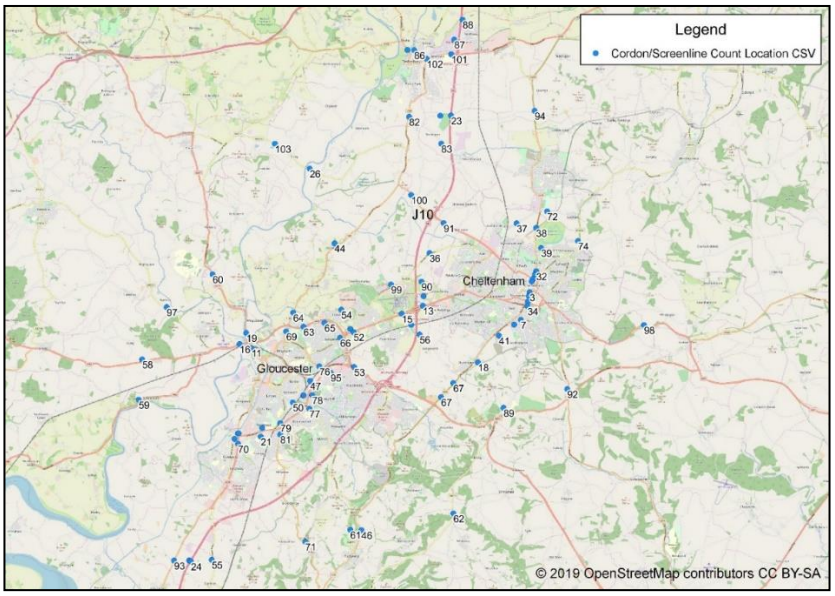


Figure 10-1 Screenline/Cordon Count Locations

10.2 Model Development

10.2.1 It was agreed with the client that the existing Central Severn Vale (CSV) model would provide the basis for developing traffic forecast scenarios for Stage 2. The CSV model was updated by Amey in 2019 to ensure that the model was appropriate to appraise transport interventions and policies, including the Joint Core Strategy and Gloucestershire Major Schemes like the M5 Junction 10 Improvements. Gloucestershire County Council (GCC) is already undertaking development of an enhanced 2015 base year model, which will available for use in Stage 3 assessment.

10.2.2 Some key features of CSV model are:

- 2013 base year for an average weekday in a neutral month;
- Modelled time periods;
  - AM Peak Hour: 08:00 – 09:00;
  - Inter-peak Average Hour: 10:00 – 16:00; and
  - PM Peak Hour: 17:00 – 18:00.
- The SATURN PASSQ functionality has been used to generate queues on the network for the peak hour assignments; and
- The CSV model comprises of five user classes which are:
  - Car Work
  - Car Commute
  - Car Other
  - LGV
  - HGV.

10.2.3 The base model development, calibration and validation are detailed in the Transport Model Package Report (GCCM5J10-ATK-HTA-XX-RP-TR-000005) and the results show that the model meets most of TAG criteria and is suitable for the purpose of developing traffic forecasts used to inform economic, environmental and operational appraisal of highway infrastructure schemes around M5 Junction 10.

10.2.4 Further, section 3.6.8 onwards present analysis to show that current traffic condition in 2019 is not much different to 2013 around A4019, though there is slight reduction in traffic on the motorway in AM/PM peak hours and increase in the average Inter-peak. Further

latest queue information from 2017 J10-J11 Paramics model shows southbound off-slip and Princess Elizabeth Junctions as main hotspots for the queues and rest of the networks in the vicinity operating well in 2019. Thus, overall the model base of 2013 and not expected to be too far from 2019. With a new Gloucestershire Countywide Traffic Model (GCTM v2.1) likely to be available in next stage of work, issues related to the age of the model would be addressed. This model is under development on behalf of GCC, has a 2015 base year and is derived from HE's South West Regional Model.

10.3 Model Forecasting

10.3.1 Full details of the traffic forecasting assessment work undertaken by Atkins for this Stage of the M5 Junction 10 Improvement Scheme can be found in the Transport Forecasting Package Report (GCCM5J10-ATK-HTA-XX-RP-TR-000006).

10.3.2 The purpose of developing a well validated base model that accurately represents current network conditions is to provide a robust basis for developing traffic forecasts. The M5 Junction 10 Improvement forecast scenarios have been developed using the CSV base model as a starting point to assess the environmental and economic impacts of the scheme options.

10.3.3 Atkins have retained three (2021, 2036 & 2041) of the five forecast years for Stage 2. A decision to omit 2026 and 2031 was taken to reduce the model run times as each modelled year adds a significant computational time and cost. Before doing so Atkins undertook a sensitivity test to determine the impact on the economic benefits resulting from three rather than five forecast years. The resulting Present Value of Benefits (PVB) calculated by TUBA was found to be nearly identical in both the cases.

10.3.4 Forecast year 2021 was used as a proxy for the scheme opening year. As the scheme opening year is likely to be 2023 which will have more traffic than 2021, using the 2021 forecast year will result in a conservative estimation of economic benefits.

10.3.5

10.3.6 Traffic modelling work considers three options which are variations of the Options carried forward for this appraisal. See Section 9.6 for full details of the schemes.

- Option 1: Junction 10 to be relocated approximately 1.25 km north of its current position;
- Option 2: Junction 10 to remain in its current position; and
- Option 5: As per Option 1, but with the junction located approximately 1.0 km north of the existing junction.

10.3.7 For traffic modelling purpose only one version of Option 2 was modelled, as the changes between options 2, 2A and 2B are unlikely to have any significant impact on the traffic modelling.

10.3.8 The model forecasts produced have two future demand scenarios. Full details of the forecasting approach and scenarios is provided in the Traffic Forecasting Report produced by Atkins.

10.3.9 Scenario Q is the baseline demand scenario using fixed trip demand forecasting techniques. Base year trips have been combined with new development trips and background growth and the resultant matrix constrained to be consistent with National Trip End Model (NTEM 7.2, March 2017) and the DfT Road Traffic Forecasts (RTF 2018).

10.3.10 The future developments, their size, land use details and likelihood are detailed in the uncertainty log previously developed by Amey and is included in the Traffic Forecasting Report Section 5.3.

10.3.11 Scenario P is a hypothetical growth scenario and includes only the parts of dependent development sites that can be accommodated while maintaining an acceptable level of service on the road network without intervention.

10.3.12 Three model scenarios have been produced as follows;

- Scenario P (Do-Minimum): Do-Minimum Network + Scenario P Demand;
- Scenario R: Do Something Network + Scenario Q Demand; and
- Scenario S: Do Something Network + Scenario P Demand.

10.3.13 For economic and environmental assessment Scenario P is compared with Scenario S providing comparisons between two future scenarios with equal demand and different network configurations in order to assess the impacts of the scheme.

10.3.14 Table 10-1 and Table 10-2 below shows the year on year growth between the base year of 2013 and each of the forecast years. This is shown for all modelled user classes.

Table 10-1 – Scenario P Demand - Year on Year Growth

Time Period	Vehicle Type/ Trip Purpose	2013-to-2021	2013-to-2036	2013-to-2041
AM Peak	Car Work	10%	15%	18%
	Car Commute	6%	9%	11%
	Car Other	6%	16%	19%
	LGV	14%	28%	36%
	HGV	-2%	-2%	-1%
	Total	**6%**	**13%**	**16%**
Inter-peak	Car Work	7%	14%	17%
	Car Commute	4%	10%	12%
	Car Other	5%	18%	21%
	LGV	13%	29%	37%
	HGV	-2%	-3%	-2%
	Total	**5%**	**16%**	**19%**
PM Peak	Car Work	7%	13%	16%
	Car Commute	3%	7%	10%
	Car Other	5%	14%	17%
	LGV	14%	30%	38%
	HGV	-1%	-1%	1%
	Total	**5%**	**12%**	**15%**

Table 10-2 - Scenario Q Demand - Year on Year Growth

Time Period	Vehicle Type/ Trip Purpose	2013-to-2021	2013-to-2036	2013-to-2041
AM Peak	Car Work	10%	22%	25%
	Car Commute	6%	17%	21%
	Car Other	6%	23%	26%

Time Period	Vehicle Type/ Trip Purpose	2013-to-2021	2013-to-2036	2013-to-2041
	LGV	14%	35%	44%
	HGV	-2%	0%	1%
	Total	**7%**	**20%**	**23%**
Inter-peak	Car Work	7%	17%	20%
	Car Commute	4%	14%	16%
	Car Other	5%	23%	26%
	LGV	15%	36%	44%
	HGV	-1%	0%	1%
	Total	**5%**	**20%**	**24%**
PM Peak	Car Work	7%	19%	22%
	Car Commute	3%	13%	16%
	Car Other	5%	21%	25%
	LGV	14%	35%	44%
	HGV	-1%	1%	2%
	Total	**5%**	**18%**	**22%**

10.4 Model Results

10.4.1 The global network statistics provide information about the model network performance as a whole. The network statistics for each of the model scenarios are presented in Table 10-3, Table 10-4 and Table 10-5.

10.4.2 There are two key comparisons to be made using the presented results. The first, Do-Minimum (Scenario P) vs the Do-Something (Scenario S) is the typical DM vs DS comparison which is usually undertaken for scheme appraisal. This P vs S also forms the basis of the economic appraisal for the J10 Improvement scheme.

10.4.3 It can be seen from Table 10-3, Table 10-4 and Table 10-5. below that the network characteristics which indicate the presence of congestion (e.g. overcapacity queues) improve between scenario P to S. Travel times decrease, speeds increase and delay per vehicle decrease.

10.4.4 When scenario S is compared with scenario R (DS vs DS + Dependent Development) it's clear that there's more congestion in scenario R than in scenario S. This is to be expected given the additional demand present in the form of dependent developments.

10.4.5 Assignment statistics comparison between various scheme options for Scenario R shows similar results. This is not surprising considering that all the new options are designed to ensure enhanced capacity to cater for HIF demand without undue delays. Thus, these subtle differences in network performance aren't noticeable directly at the junction or adjacent networks but can be captured through journey time benefits captured and described in economics appraisal section of this report.

10.4.6 It is noted that despite the overall similarities between options, close inspection of the network statistics in Table 10-3 to Table 10-5 reveals that in Scenario R, Option 2 is marginally better. In particular the total travel times in Option 2 are lower in both time periods and across all three forecast years than Options 1 and 5.

Table 10-3 – Assignment Statistics – 2021

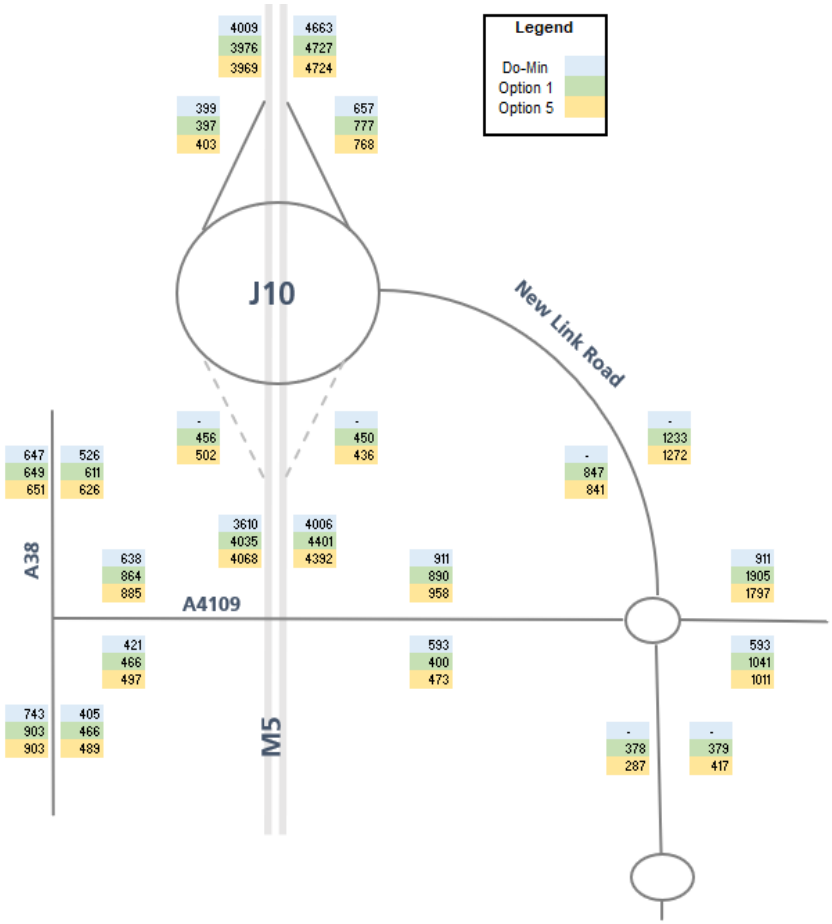
	Do-Min	Option 1A		Option 2		Option 5	
		S	R	S	R	S	R
AM Peak							
Transient Queues (PCU.hrs)	4,658	4,608	4,628	4,573	4,588	4,597	4,616
Over Capacity Queues (PCU.hrs)	388	381	381	375	382	374	378
Link Cruise Times (PCU.hrs)	46,777	46,749	46,817	46,739	46,807	46,752	46,816
Total Travel Times (PCU.hrs)	51,823	51,739	51,826	51,686	51,777	51,722	51,809
Travel Distance (PCU.kms)	3,280,337	3,279,982	3,283,718	3,280,496	3,284,244	3,280,395	3,284,007
Average Speed (km/h)	63.0	63.4	63.4	63.5	63.4	63.4	63.4
Total trips loaded (PCUs)	82,811.8	82,811.8	83,031.1	82,811.8	83,031.1	82,812	83,031
Simulation Queues (PCU/h) (Queue at End)	634.5	625.4	627.0	617.2	623.9	616	622
Delay / Vehicle(mins/Veh)	3.7	3.6	3.6	3.6	3.6	3.6	3.6
PM Peak							
Transient Queues (PCU.hrs)	4,374	4,339	4,353	4,320	4,334	4,335	4,348
Over Capacity Queues (PCU.hrs)	651	623	627	617	617	622	625
Link Cruise Times (PCU.hrs)	45,510	45,456	45,503	45,436	45,482	45,455	45,502
Total Travel Times (PCU.hrs)	50,535	50,418	50,482	50,372	50,433	50,411	50,474
Travel Distance (PCU.kms)	3,218,465	3,217,692	3,220,274	3,216,952	3,219,520	3,217,493	3,220,092
Average Speed (km/h)	63.7	63.8	63.8	63.9	63.8	63.8	63.8
Total trips loaded (PCUs)	78,832.8	78,832.8	79,012.8	78,832.8	79,012.8	78,833	79,013
Simulation Queues (PCU/h) (Queue at End)	670.3	624.5	629.9	615.1	615.4	624	626
Delay / Vehicle(mins/Veh)	3.8	3.8	3.8	3.8	3.8	3.8	3.8

Table 10-4 – Assignment Statistics – 2036

	Do-Min	Option 1A		Option 2		Option 5	
		S	R	S	R	S	R
AM Peak							
Transient Queues (PCU.hrs)	5,239	5,170	5,768	5,126	5,741	5,157	5,748
Over Capacity Queues (PCU.hrs)	595	578	659	575	682	576	657
Link Cruise Times (PCU.hrs)	50,501	50,469	52,173	50,458	52,141	50,472	52,174
Total Travel Times (PCU.hrs)	56,335	56,218	58,600	56,159	58,563	56,205	58,578
Travel Distance (PCU.kms)	3,521,803	3,522,098	3,614,532	3,522,238	3,612,896	3,522,461	3,614,449
Average Speed (km/h)	62.5	62.7	61.7	62.7	61.7	62.7	61.7
Total trips loaded (PCUs)	87,682.9	87,682.9	93,398.4	87,682.9	93,398.4	87,683	93,398
Simulation Queues (PCU/h) (Queue at End)	983.4	951.5	1,080.0	942.1	1,124.4	946	1,079
Delay / Vehicle(mins/Veh)	4.0	3.9	4.1	3.9	4.1	3.9	4.1
PM Peak							
Transient Queues (PCU.hrs)	4,983	4,922	5,396	4,894	5,388	4,919	5,397
Over Capacity Queues (PCU.hrs)	1,038	1,000	1,152	986	1,165	1,009	1,157
Link Cruise Times (PCU.hrs)	49,271	49,205	50,495	49,178	50,462	49,204	50,496
Total Travel Times (PCU.hrs)	55,292	55,128	57,043	55,058	57,014	55,132	57,049
Travel Distance (PCU.kms)	3,468,000	3,467,837	3,537,798	3,466,790	3,535,304	3,467,541	3,537,526
Average Speed (km/h)	62.7	62.9	62.0	63.0	62.0	62.9	62.0
Total trips loaded (PCUs)	83,948.2	83,948.2	88,835.3	83,948.2	88,835.3	83,948	88,835
Simulation Queues (PCU/h) (Queue at End)	1,066.3	994.0	1,106.3	996.0	1,157.2	998	1,111
Delay / Vehicle(mins/Veh)	4.3	4.2	4.4	4.2	4.4	4.2	4.4

Table 10-5 – Assignment Statistics – 2041

	Do-Min	Option 1A		Option 2		Option 5	
		S	R	S	R	S	R
AM Peak							
Transient Queues (PCU.hrs)	5,595	5,506	6,198	5,467	6,160	5,500	6,175
Over Capacity Queues (PCU.hrs)	781	758	896	750	925	758	887
Link Cruise Times (PCU.hrs)	52,243	52,211	54,074	52,207	54,048	52,213	54,074
Total Travel Times (PCU.hrs)	58,618	58,476	61,168	58,424	61,133	58,471	61,136
Travel Distance (PCU.kms)	3,631,997	3,632,286	3,731,837	3,632,174	3,730,394	3,632,511	3,731,773
Average Speed (km/h)	62.0	62.1	61.0	62.2	61.0	62.1	61.0
Total trips loaded (PCUs)	90,013.4	90,013.4	96,169.4	90,013.4	96,169.4	90,013	96,169
Simulation Queues (PCU/h) (Queue at End)	1,267.3	1,232.5	1,456.3	1,215.4	1,497.7	1,225	1,449
Delay / Vehicle(mins/Veh)	4.2	4.2	4.4	4.1	4.4	4.2	4.4
PM Peak							
Transient Queues (PCU.hrs)	5,287	5,225	5,771	5,197	5,765	5,225	5,775
Over Capacity Queues (PCU.hrs)	1,255	1,215	1,389	1,173	1,396	1,214	1,400
Link Cruise Times (PCU.hrs)	50,962	50,893	52,309	50,871	52,274	50,891	52,309
Total Travel Times (PCU.hrs)	57,504	57,334	59,469	57,241	59,435	57,330	59,484
Travel Distance (PCU.kms)	3,576,181	3,576,031	3,651,692	3,574,782	3,648,798	3,575,755	3,651,502
Average Speed (km/h)	62.2	62.4	61.4	62.5	61.4	62.4	61.4
Total trips loaded (PCUs)	86,167.8	86,167.8	91,453.6	86,167.8	91,453.7	86,168	91,454
Simulation Queues (PCU/h) (Queue at End)	1,269.1	1,188.8	1,295.7	1,168.6	1,358.1	1,183	1,303
Delay / Vehicle(mins/Veh)	4.6	4.5	4.7	4.4	4.7	4.5	4.7



10.4.7

10.4.8 Figure 10-2 to Figure 10-5 below show the modelled flows in vehicles for the AM and PM peaks in 2041 for the Do–Minimum (Scenario P, deadweight developments) and for each of the three Do-Something scheme options (Scenario R, deadweight plus dependent developments).

10.4.9 Generally, as would be expected given the additional demand present from the JCS developments in the Do-Something scenarios there is additional traffic both along the M5 corridor and the Gloucester and Cheltenham urban areas connecting slip roads.

10.4.10 All three options show a significant increase in flow along the M5 between J10 and J11 in both directions and in both peaks, implying that this section will be key to facilitating trips generated by the new housing developments which form the JCS allocations.

10.4.11 In the AM peak, all options results in a slight decrease in northbound traffic along the M5 towards Junction 9 when compared with DM, the largest decrease is seen in Option 2. In the PM peak, Option 2 also sees a decrease southbound along the M5 mainline towards J10.

10.4.12 It can be seen from the flow diagrams that the scheme primarily facilitates the traffic from the south and Gloucester.

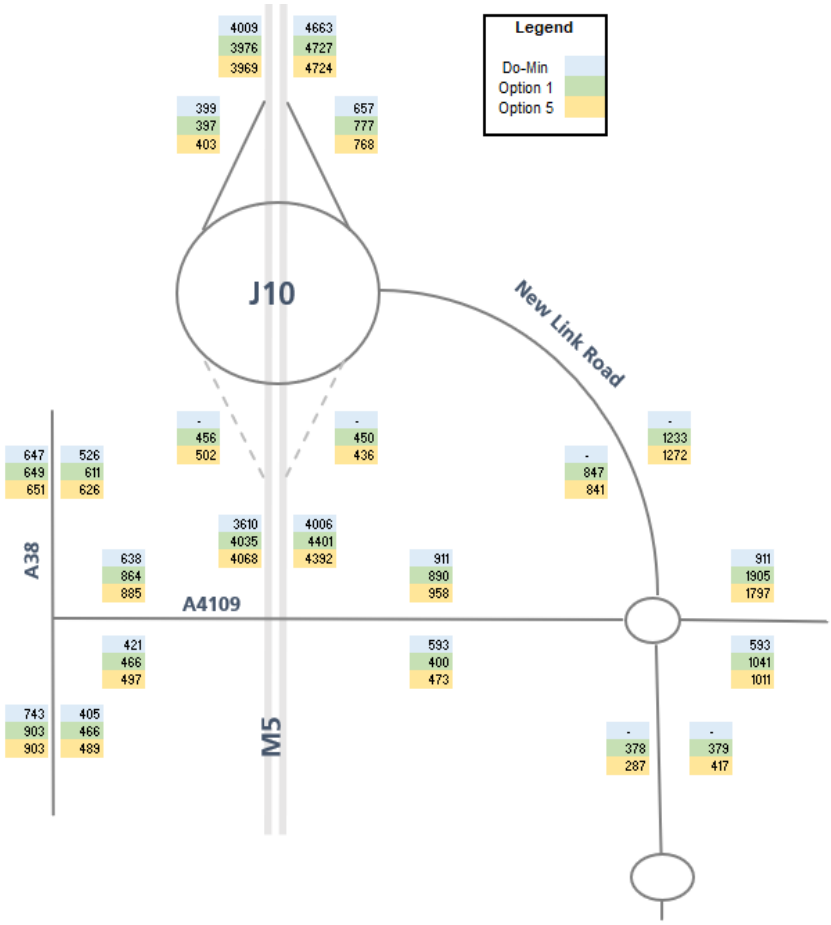


Figure 10-2 Option 1A&5 Modelled Flows (vehs) - 2041 AM Peak

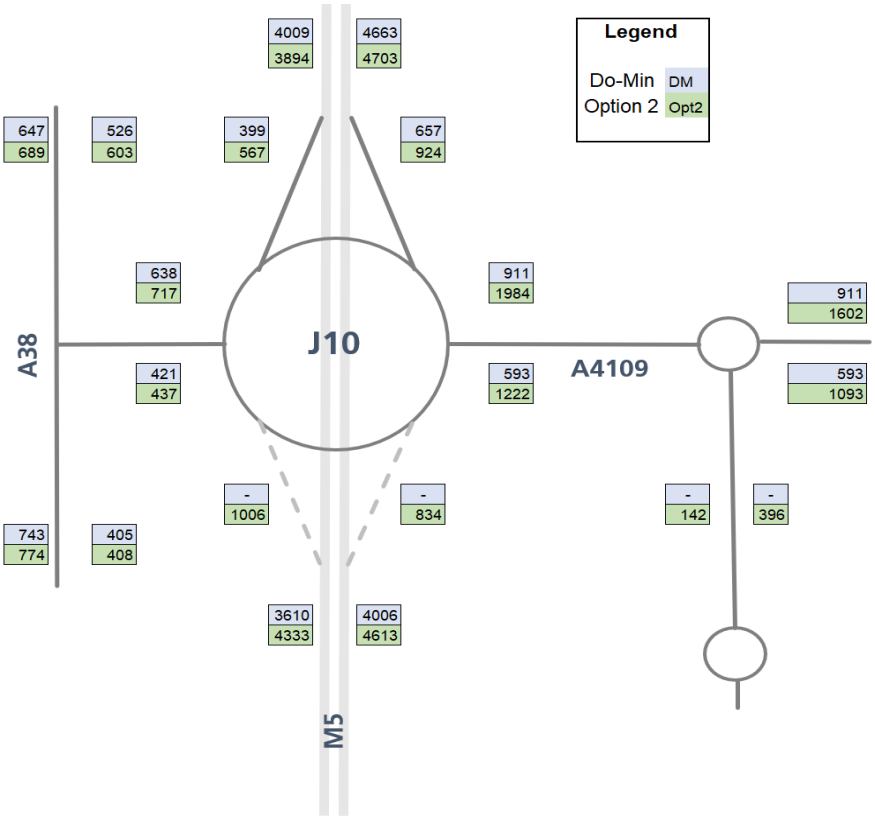


Figure 10-3 Option 2 Modelled Flows (vehs) – 2041 AM Peak

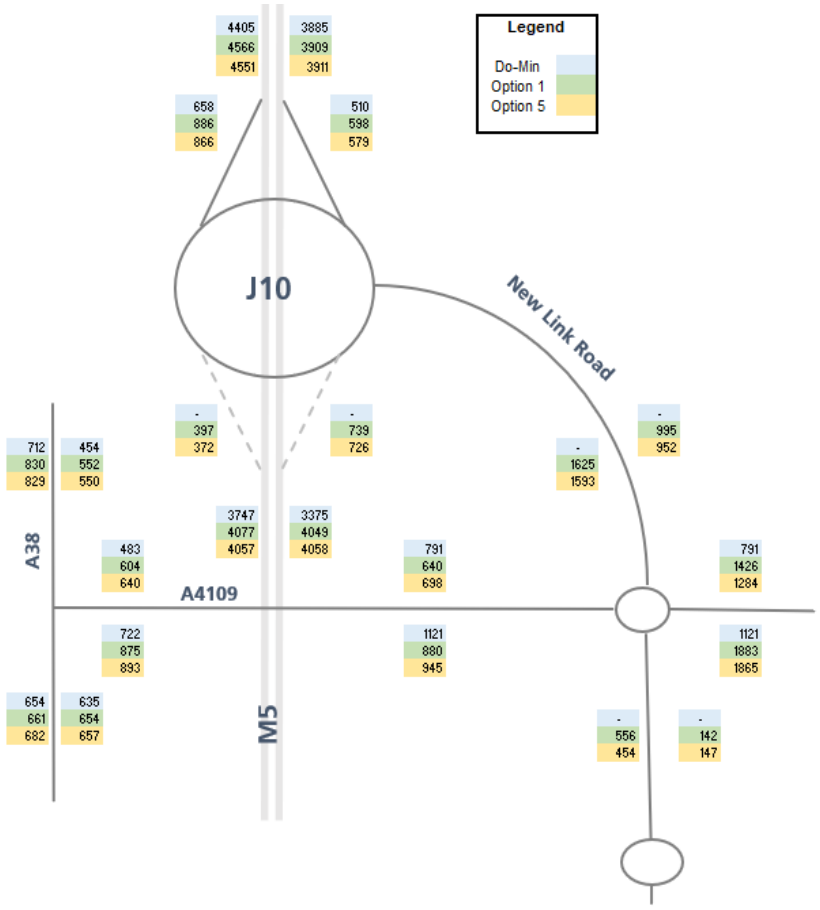


Figure 10-4 Option 1A&5 Modelled Flows (vehs) – 2041 PM Peak

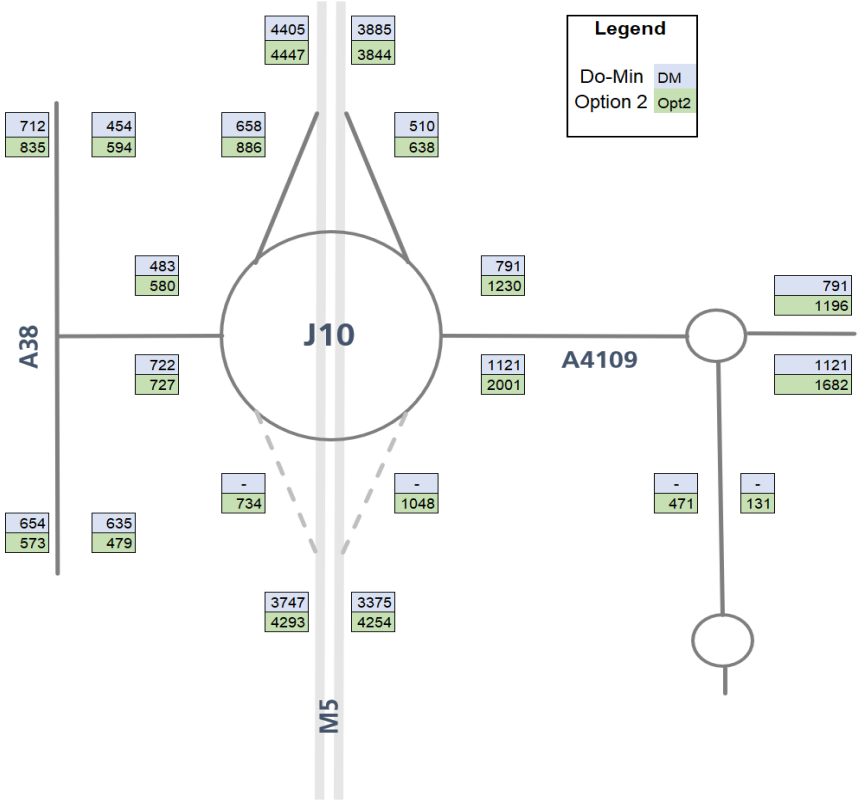


Figure 10-5 Option 2 Modelled Flows (vehs) - 2041 PM Peak

10.4.13 In addition to the vehicle flow diagrams presented above, flow difference plots have been produced using GIS software andare included below in Figure 10-6 to Figure 10-10 DS Option 5 (Scenario R) vs DM (Scenario P) – 2041 AM Peak

10.4.14 Flows differences are shown on the forecast network, though no flows are plotted along the new links as they don't exist in the Do-minimum modelling scenario. Similarly, on links where the network is changing due to addition or deletion on the node, flows are not plotted due to software limitation in matching the partial links. Such areas are marked within the dotted red circles in the plots.

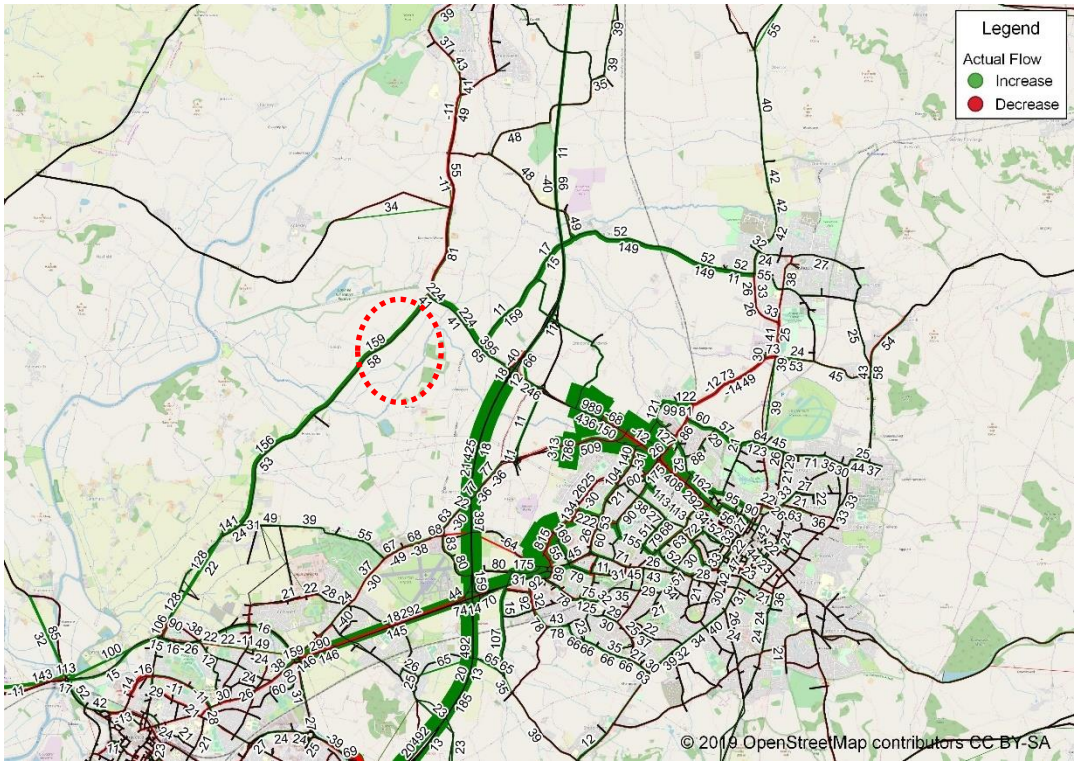


Figure 10-6 DS Option 1 (Scenario R) vs DM (Scenario P) - 2041 AM Peak

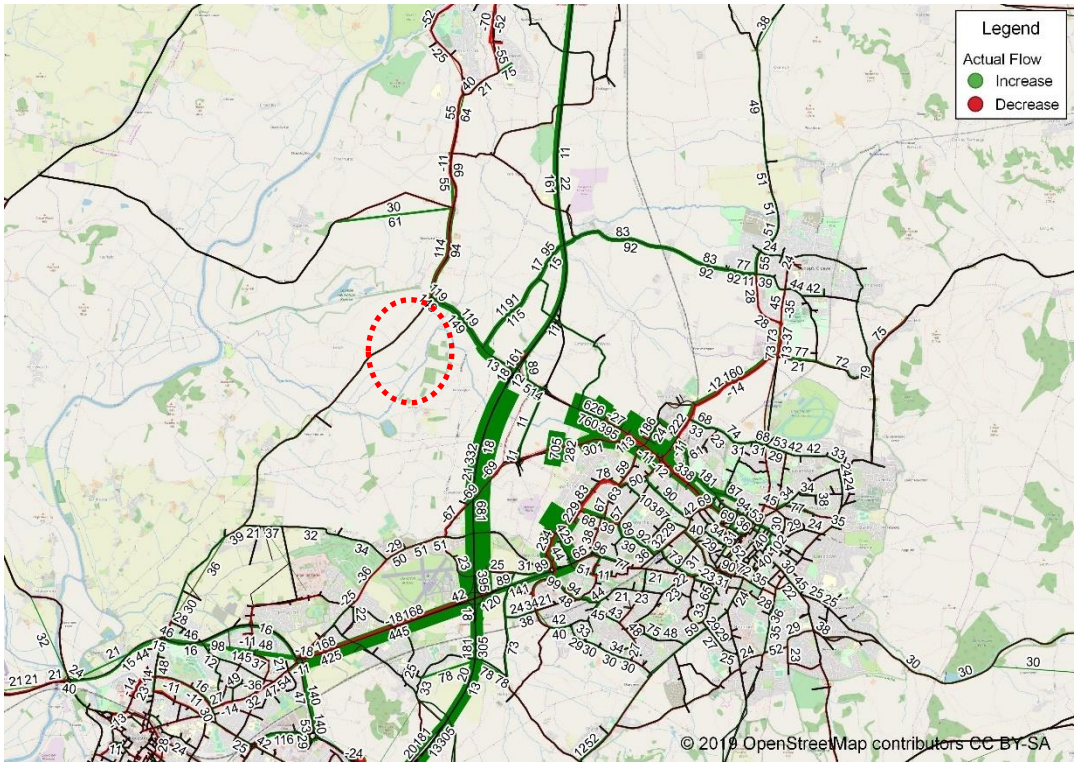


Figure 10-7 DS Option 1 (Scenario R) vs DM (Scenario P) - 2041 PM Peak

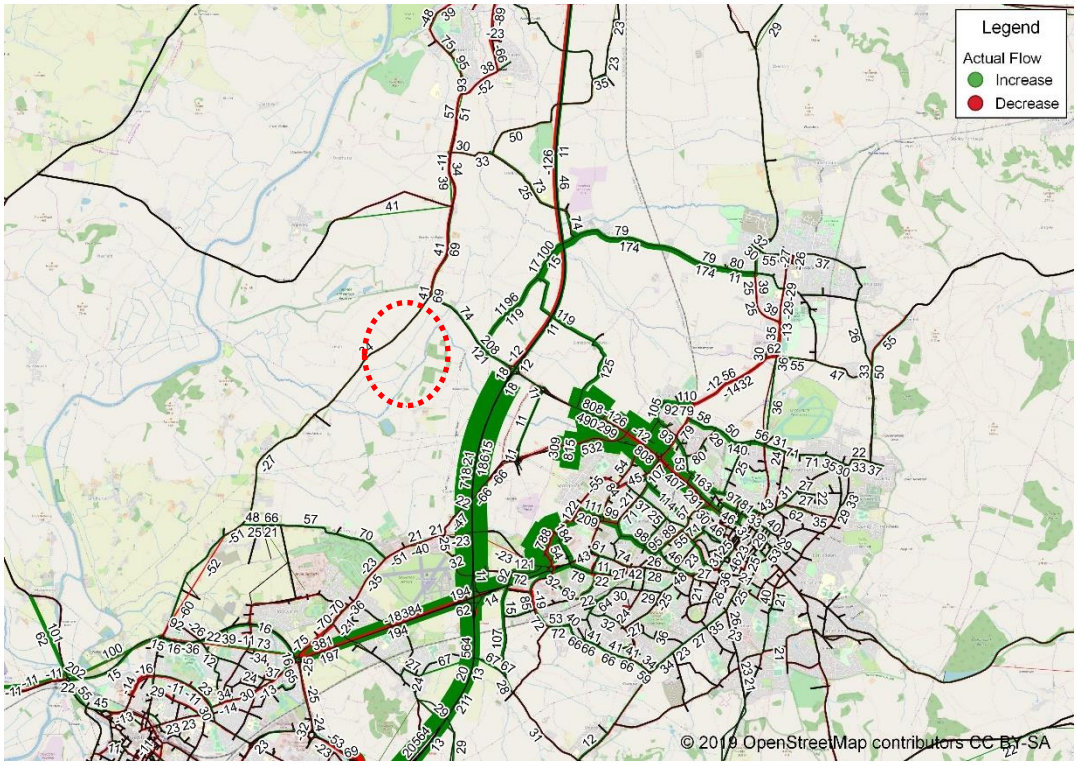


Figure 10-8 DS Option 2 (Scenario R) vs DM (Scenario P) - 2041 AM Peak

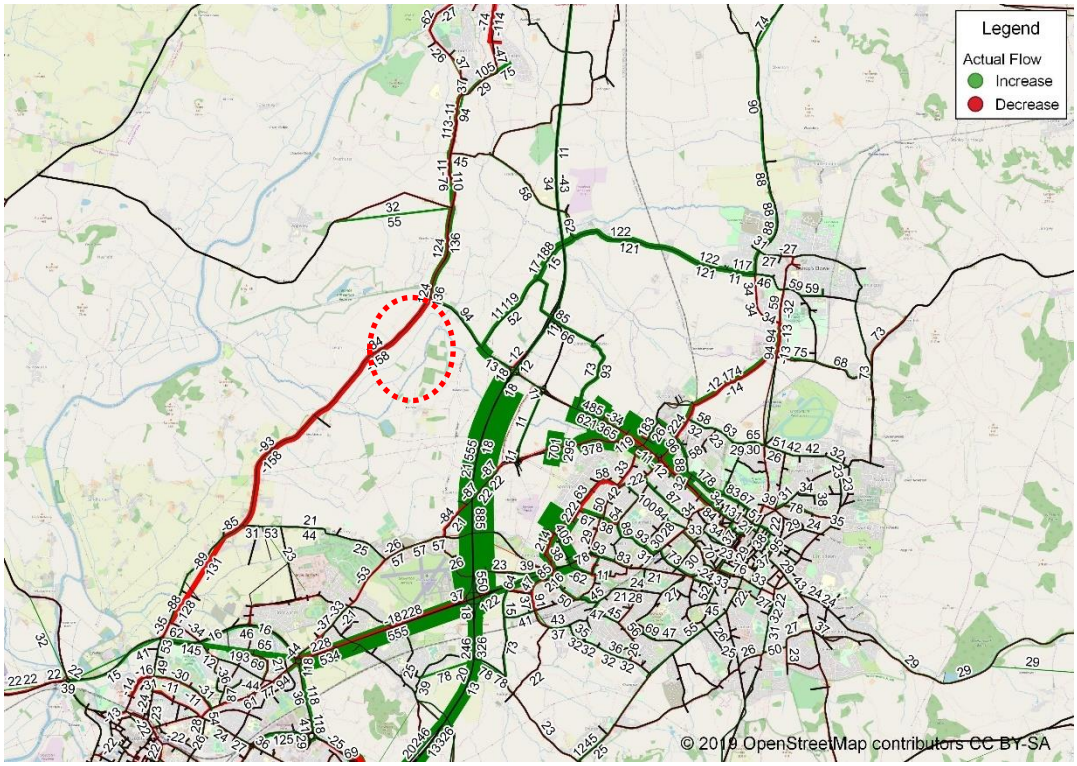


Figure 10-9 DS Option 2 (Scenario R) vs DM (Scenario P) - 2041 PM Peak

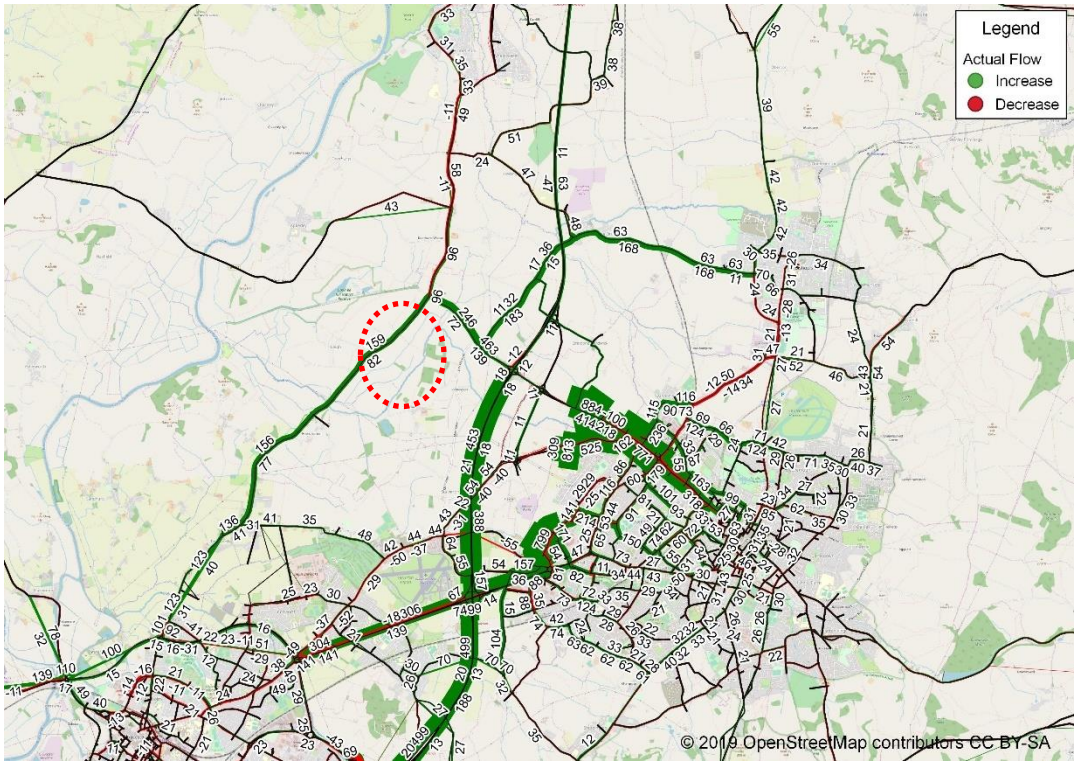


Figure 10-10 DS Option 5 (Scenario R) vs DM (Scenario P) - 2041 AM Peak

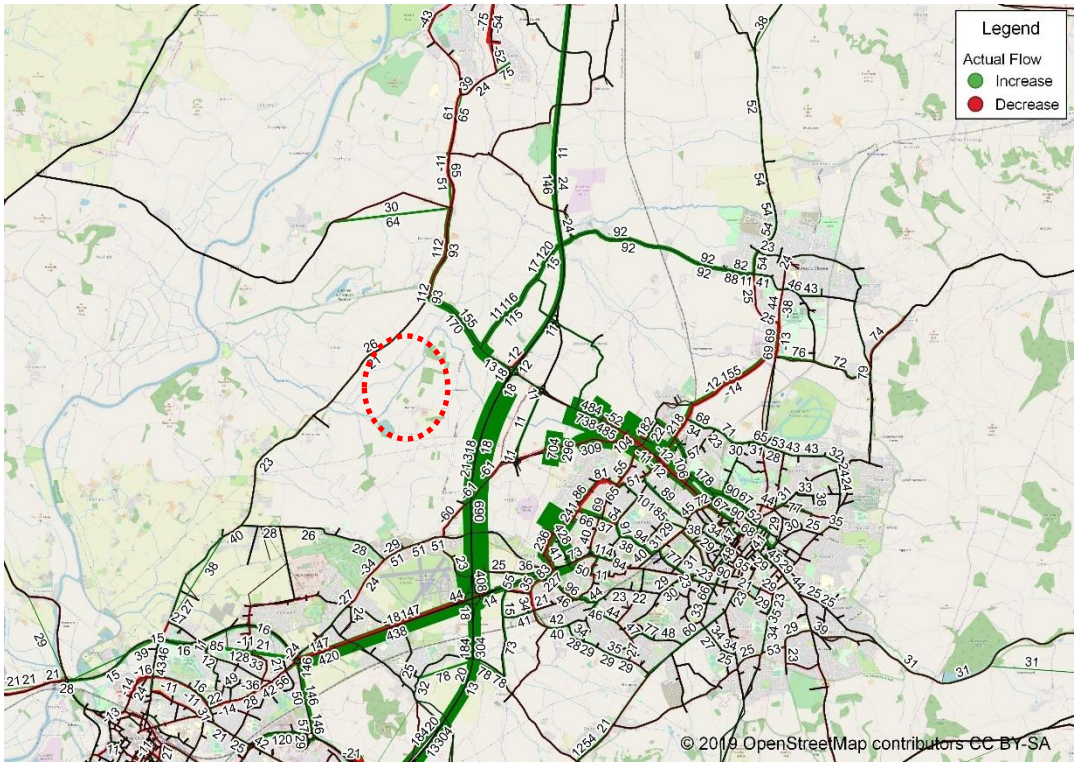


Figure 10-11 DS Option 5 (Scenario R) vs DM (Scenario P) - 2041 PM Peak

10.4.15 Generally, as would be expected given the additional demand present from the JCS developments in the Do-Something scenarios there is additional traffic both along the M5 corridor and the Gloucester/Cheltenham urban areas.

10.4.16 All three options show a significant increase in flow along the M5 between J10 and J11 in both directions and in both peaks, implying that this section will be key to facilitating trips generated by the new housing developments which form the JCS allocations.

10.4.17 In the PM peak, all three scheme options result in a slight decrease in northbound traffic along the M5 towards Junction 9, the largest decrease is seen in Option 2. In the AM peak, Option 2 also sees a decrease southbound along the M5 mainline towards J10. A portion of the southbound traffic favours Stoke Road over the M5 and The Green which runs through Elmstone Hardwicke to access Cheltenham from the north.

10.4.18 It can be seen from the flow difference plots that the JCS developments primarily draw traffic from the south and Gloucester, with a smaller number of trips present between the new developments and Bishops Cleeve to the north of Cheltenham.

10.5 Conclusion

10.5.1 From consideration of traffic patterns, volumes, differences in flows along the key links and the global network statistics, it can be interpreted that network performance doesn't differ significantly between scheme options. All the schemes options perform better than do-minimum and attracts more traffic from south and Gloucester. Flows between J9 and J10 are similar with or without the scheme, which is expected as slips to J10 are available in do-minimum scenario as well.

11 Economic Assessment

11.1 Introduction

11.1.1 The economic appraisal of the M5 J10 scheme consists of the appraisal of:

- Economic impacts on existing road users (Transport Economic Efficiency);
- Social impacts, specifically safety impacts; and
- Scheme Option costs.

11.1.2 These impacts were assessed on the basis of the modelling undertaken in Section 10.3.

11.1.3 This assessment was in addition to the Net Private Value of Housing and Net Private Value of Commercial Development, which are retained from the original HIF Economic Assessment. This is because these estimates, which were derived from the uplift in land value resulting from dependent development by specialist property consultant Bruton Knowles, were subject to ratification by Homes England as part of the HIF business case review process and as such these values were not revised. Environmental impacts (in terms of noise, air quality and greenhouse gas emissions) have not been re-quantified in monetary terms at this stage of appraisal – instead the values calculated in the HIF Economic Assessment have been carried forward. It should be noted that all Present Value Benefit (PVB) and Present Value Costs (PVC) values have been calculated in 2018 prices in line with HIF guidance requirements (rather than the standard 2010 price base for typical transport scheme appraisals).

11.1.4 Further details regarding the appraisal of the scheme are provided in the Economic Assessment Report (GCCM5J10-ATK-HTA-XX-RP-TB-000001) – which provides an update to the scheme appraisal originally presented in the HIF Economic Assessment.

11.2 Options Assessed

11.2.1 Given the transport scheme options set out in Section 9, and modelling scenarios set out in Section 10, the economic appraisal focussed on assessing the following options and scenarios.

Options

11.2.2 The options appraised were:

- Option 1A - New junction north of existing
- Option 2 - Upgrade existing junction with Gyratory Roundabout
- Option 2A - Upgrade existing junction with Gyratory Roundabout offset to the north
- Option 2B - Upgrade existing junction with Gyratory Roundabout offset to the south
- Option 5 - New junction north of existing (in alternative position to Option 1A)

11.2.3 From a transport modelling perspective, it was identified that Options 2, 2A and 2B could be modelled effectively as a single scenario due to their similarity – and hence the economic assessment presented in this report in terms of scheme benefits is consistent, but with different scheme costs affecting the overall Value for Money (VfM).

Scenarios

11.2.4 The following three scenarios were considered for this appraisal:

- Scenario P (no transport scheme and no dependent development); and
- Scenario S (including the transport scheme but without dependent development); and
- Scenario R (including the transport scheme and all residential and commercial development).

11.2.5 Comparisons of these options and scenarios formed the basis of the economic and social assessments undertaken.

11.3 Application of Assessment Software

Economic appraisal

11.3.1 The economic appraisal for M5 J10 was conducted using the most up-to-date version of the DfT's TUBA appraisal tool (v1.9.13), which estimates monetised user and provider benefits, in terms of travel time and vehicle operating cost savings.

11.3.2 Following the use of three modelled forecast years (2021, 2036 and 2041) for model forecasting as set out in 10.3, a sensitivity test was conducted to determine the difference in economic benefits resulting from the use of these three years, compared with using all model years (i.e. including 2026 and 2031). From the sensitivity test results, it was concluded that three forecast years is sufficient to appraise the M5 J10 scheme and no significant differences in the resulting VfM assessments would result from the omission of forecast years 2026 and 2031. As such the three appraisal years used for this stage of appraisal are:

- 2021;
- 2036; and
- 2041

11.3.3 In line with TAG guidelines, two separate comparisons of scenarios were made, for each of the M5 J10 scheme options. Scenario P (Without scheme and development) was compared against Scenario S (With scheme, without development), and Scenario S was compared against Scenario R (With scheme, with development - both housing and commercial).

Social appraisal

11.3.4 The assessment of social costs (in terms of accident rates) were carried out via the use of the DfT COBA-LT accident assessment software. COBA-LT presents results in the form of changes in the number of personal injury collisions (PICs) and disaggregates this further by severity of injury: fatal, serious and slight. A monetised value is assigned to the accidents, so that total accident costs can be calculated for the situation before (Scenario P) and after (Scenario R) the implementation of the scheme and developments, for each option. Accident costs are summed across the same project lifetime as used in the calculation of TEE benefits and discounted back to the 2018 (base year for the VfM assessment). The difference between the discounted accident costs represents the accident benefits related to the scheme.

11.4 Economic Impact

Transport Economic Efficiency

11.4.1 Table 11-1 summarises the total transport economic efficiency (TEE) resulting from the M5 J10 scheme on existing transport users, without, and with, the impact of the accompanying JCS dependent development.

11.4.2 This shows that, in terms of the impacts not considering the dependent development, Option 2 features higher TEE benefits than Options 1 and 5, with £145.1m of benefits. Option 1A and 5, being very similar in their design, feature similar levels of TEE benefits, with Option 1A featuring slightly greater TEE benefits overall, with £86.7m, compared with £79.8m of benefits under Option 5.

11.4.3 The impacts of the scheme including the dependent development are negative due to the impact of the additional traffic on the existing users on the network. This is evident in Table 11-1, which shows Option 2 to feature the greatest transport external costs, with £384.4m of costs (presented in terms of disbenefit). Option 1A features £374.1m of costs, and Option 5 sees the lowest level of costs overall, with £361.1m of transport external costs.

11.4.4 Hence overall, Option 2 performs strongest, with the least disbenefits out of the modelled options (-£239.3m). This can be attributed to Option 2 providing a quicker, more direct route than the other options between the higher volume movements on the network, for example trips to/from Gloucester to Cheltenham. Option 1A performs next best, with -£260.3m of benefits, and Option 5 performs worst, with -£281.3m of benefits.

11.4.5 These results feed into the VfM assessment shown in Section 11.5.

Table 11-1 – Total transport economic efficiency resulting from M5 J10 scheme

	Option 1A	Option 2	Option 5
Impact not incl. dependent development (Scenario P vs S)	£86,737,000	£145,064,000	£79,826,000
Impact incl. dependent development (Scenario S vs R)	-£374,078,000	-£384,411,000	-£361,121,000
Total transport economic efficiency	**-£260,341,000**	**-£239,347,000**	**-£281,295,000**

All values presented in 2018 prices discounted to 2018

Social Impact

11.4.6 The results of the COBA-LT assessment are presented in Table 11-2. As noted in paragraph 11.3.4, the comparison made is between Scenario P (no transport scheme and no dependent development) and Scenario R (with the transport scheme and additional dependent development) in line with TAG Unit A2.2. The assessment therefore includes the increase in accidents which would be expected from additional development traffic using the surrounding road network.

11.4.7 The analysis shows that Option 5 features the smallest increase in accidents, with 416 additional accidents resulting from the scheme, an increase of 7.8%. Option 2 has a slightly larger increase in modelled accidents, at 452 (8.5% increase), and Option 1A features 540 extra PICs as a result of the scheme and accompanying developments, an increase of 10.1%.

Table 11-2 – Personal injury collisions resulting from the M5 J10 scheme, across option

	Personal injury collisions		
	Option 1A	**Option 2**	**Option 5**
Scenario P (without scheme)	5,337	5,337	5,337
Scenario R (with scheme)	5,877	5,789	5,753
Difference (Absolute)	540	452	416

Difference (Percentage)	10.1%	8.5%	7.8%

11.4.8 Table 11-3 shows the total monetised accident costs resulting from the M5 J10 scheme and accompanying developments, for each modelled option. This shows that Option 5 has, marginally, the smallest increase in accident costs, with an increase of £26.4m. Option 2 features £26.5m additional costs, an increase of 7.33%, and Option 1A has the largest increase in accident costs, with an increase of £34.1m (9.43%).

11.4.9 Analysis of the COBA-LT outputs by severity showed Option 5 to have the lowest increase in slight accidents, and equal lowest increase in serious accidents. Option 2 features a lower increase in additional fatal and serious accidents (combined) than Option 5. By contrast, Option 1A had the greatest increase in fatal, serious and slight accidents.

11.4.10 The lower increase in monetised costs for Option 5 is driven by the lower number of additional slight accidents when compared with other options. Whilst Option 2 features a lower increase in combined serious and fatal accidents than Option 5, due to the slightly shorter travel distance for trips using the strategic road network to the south of Junction 10, the extra slight accidents across the modelled period, compared with Option 5, leads to the slightly greater monetised accident costs for Option 2.

11.4.11 These monetised results feed directly into the VfM assessment shown in Section 11.5

Table 11-3 – Total monetised accident costs resulting from M5 J10 scheme, across options

	Total monetised accident costs		
	Option 1A	**Option 2**	**Option 5**
Scenario P (without scheme)	£361,345,200	£361,345,200	£361,345,200
Scenario R (with scheme)	£395,405,100	£387,848,300	£387,745,200
Difference (Absolute)	£34,059,900	£26,503,100	£26,400,000
Difference (Percentage)	9.43%	7.33%	7.31%

*All values presented in 2018 prices discounted to 2018

11.5 Overall Results

Scheme costs

11.5.1 Table 11-4 shows the impact of the different assessed options on public finances (in terms of Present Value Costs, 2018 prices discounted to 2018), taking into account the impact on the broad transport budget after allowing for any change in indirect tax revenues accrued to the government. Note that the table displays the combined (summed) indirect tax revenues from scenarios P vs S and scenarios S vs R.

11.5.2 Several elements of the impact on the broad transport budget are consistent across each option. Local government funding, that takes the form of on-going (operating) maintenance over the project lifetime (from 2025 to 2077) and a £4m contribution to scheme design (investment), totals an £8.3m cost, after adjustment for optimism bias (assumed as 14% at this stage), real costs and discounting. At this stage, the assumed maintenance costs are consistent with the allowance for the Option 1 presented in the HIF bid. It should be noted that it is likely that actual maintenance costs for the other options would in fact be marginally lower as they involve less additional carriageway in comparison to Option 1 (and so the approach is conservative in a VfM context).

11.5.3 In addition, a commuted sum of £9.5m (£9.62m prior to adjustment), a lump sum paid in 2024 to Highways England to enable maintenance of the new roads, is included in the central government funding costs.

11.5.4 Option 2A features the lowest central government investment costs (£220.8m) and hence the lowest impact on the broad transport budget. The other Option 2 variants feature similar investment costs, with Option 2B at £237.5m, and Option 2 at £247.0m respectively. Option 5 features investment costs of £287.9m, and Option 1A has the highest investment costs, at £299.8m. In terms of indirect tax revenues, all options lead to a small increase in indirect tax revenues. This is comprised of a very small decrease in tax revenues in the case of the P vs S scenario, due to the reduction in congestion on the network, combined with a slightly larger increase in tax revenues in the case of the S vs R scenario, caused by the increase in congestion on the network.

Table 11-4 – Comparison of Present Value Costs (PVC) for M5 J10 assessed options (£000's)

Funding source	Category	Option 1A	Option 2	Option 2A	Option 2B	Option 5
Local Government Funding	Operating costs	£3,096	£3,096	£3,096	£3,096	£3,096
	Investment costs	£5,185	£5,185	£5,185	£5,185	£5,185
Central Government Funding	Operating costs	£9,448	£9,448	£9,448	£9,448	£9,448
	Investment costs	£299,831	£246,985	£220,886	£237,469	£287,870
	(Reduction in) Indirect Tax Revenue	-£5,130	-£2,947	-£2,947	-£2,947	-£5,125
	Broad Transport Budget	£317,560	£264,714	£238,615	£255,199	£305,600

All values presented in 2018 prices discounted to 2018

Value for Money Assessment

11.5.5 Table 11-5 combines the different elements which make up VfM assessment for the scheme options as presented in the Economic Appraisal Package. Overall comparison

11.5.6 For the Present Value Benefits, the recalculated economic impacts for TEE (both with and without dependent development) and social impacts (in terms of accidents as presented in section 11.4) are combined with the original land value impacts as calculated in the HIF submission. The environmental impacts have not been recalculated at this stage and are consistent with the HIF submission. Analysis of the overall VfM assessments is considered in 11.6.

VfM table

Table 11-5 – Scheme Option Value for Money Assessment Summary

Category	Source	Chpt.	Option 1A	Option 2	Option 2A	Option 2B	Option 5
(1) Net Social Val. of Developments	Sum (i)-(vi)	N/A	£488,095,610	£477,762,610	£477,762,610	£477,762,610	£501,052,610
(i) Net Private Val. of Housing	*HIF EAR*	N/A	£853,176,896	£853,176,896	£853,176,896	£853,176,896	£853,176,896
(ii) Net Private Val. of Commercial	*HIF EAR*	N/A	£42,210,751	£42,210,751	£42,210,751	£42,210,751	£42,210,751
(iii) Transport Ext. Costs	Scn S vs R	4	-£374,078,000	-£384,411,000	-£384,411,000	-£384,411,000	-£361,121,000
(iv) Environmental Ext. Costs	*HIF EAR*	N/A	-£16,159,573	-£16,159,573	-£16,159,573	-£16,159,573	-£16,159,573
(v) Amenity Ext. Costs (Housing)	*HIF EAR*	N/A	-£14,342,828	-£14,342,828	-£14,342,828	-£14,342,828	-£14,342,828
(vi) Amenity Ext. Costs (Comm.)	*HIF EAR*	N/A	-£2,711,636	-£2,711,636	-£2,711,636	-£2,711,636	-£2,711,636
(2) Transport Economic Efficiency	Scn P vs S	3	£86,737,000	£145,060,000	£145,060,000	£145,060,000	£79,826,000
(3) Transport Environmental Impact	*HIF EAR*	N/A	-£24,595	-£24,595	-£24,595	-£24,595	-£24,595
(4) Social Impact (Safety Impact)	COBALT	5	-£34,059,900	-£26,503,100	-£26,412,000	-£26,412,000	-26,400,000
(5) Affordable Housing Health Benefit	*HIF EAR*	N/A	£6,096,000	£6,096,000	£6,096,000	£6,096,000	£6,096,000
(a) Present Val. of Benefits (PVB)	Sum (1)-(5)	N/A	£546,844,115	£602,390,915	£602,482,015	£602,482,015	£560,550,015
(b) Present Val. of Costs (PVC)	Updated	6	£317,560,003	£264,714,229	£238,615,438	£255,198,625	£305,599,610
Net Present Val. (NPV)	(a)-(b)	N/A	£229,284,112	£337,676,686	£363,866,577	£347,283,390	£254,950,405
Benefit/Cost Ratio (BCR)	(a)÷(b)	N/A	1.72	2.28	2.52	2.36	1.83

All values presented in 2018 prices discounted to 2018

11.6 Comparison of options and summary

11.6.1 Table 11-5 show that all options, including the variants of Option 2, provide a positive Net Present Value (NPV). In all five cases, this positive NPV results from a significantly positive Net Social Value of Developments (Housing and Commercial), largely driven by very high Net Private Values of Development. Each option also features positive Transport Economic Efficiency results, relating to the transport scheme-only impacts on existing transport users (2), although these are offset by the significant negative Transport External Costs resulting from the dependent developments (1.iii).

11.6.2 Table 11-6 presents a summary comparison of the PVB, PVC, NPV and BCR for each of the five options assessed.

11.6.3 Option 2A provides the greatest VfM, with an NPV of £363.8m, and a BCR of 2.52. The option has both the (equal) highest PVB, at £602.4m, and the lowest PVC (£238.6m). More generally, the Option 2 variants display significantly better value for money than Option 1A and Option 5, with both the highest PVB and lowest three PVCs across Option 2, 2A and 2B. Option 2B, with an identical PVB and slightly higher PVC than Option 2A, has the second best BCR (2.36), while Option 2, with a PVC of £264.7m, features the third highest BCR, at 2.28.

11.6.4 Option 5 features a PVB £41.8m lower than Option 2, and a PVC £40-70m higher. The resulting NPV (£255.0m) and BCR (1.83) were thus the fourth highest of the different options. Option 1A features the lowest PVB of the five options due to transport related impacts, at £546.8m, and also the highest PVC, at £317.6m. As a result, the NPV (£229.3m) and BCR (1.72) are the lowest of the options appraised.

Table 11-6 – Comparison of Value for Money for M5 J10 assessed options

Category	Option 1A	Option 2	Option 2A	Option 2B	Option 5
PVB	£546,844,115	£602,390,915	£602,482,015	£602,482,015	£560,550,015
PVC	£317,560,003	£264,714,229	£238,615,438	£255,198,625	£305,599,610
NPV	£229,284,112	£337,676,686	£363,775,477	£347,192,290	£254,950,405
BCR	**1.72**	**2.28**	**2.52**	**2.36**	**1.83**

12 Safety Assessment

12.1 Impact on Road User – Strategic Safety Action Plan

12.1.1 All five design options introduce a new major junction and new sections of carriageway. The existing junction restricts vehicle movements with northbound traffic on the M5 unable to leave the motorway at the junction and eastbound traffic on the A4019 unable to access the M5 at the junction. These restricted movements are likely to supress the number of collisions occurring at the junction. The introduction of a new junction which allows all movements is likely to lead to an increase in the number of collisions occurring. Similarly, the new sections of carriageway linked to the B4634 are likely to lead to an increase in the number of collisions within the scheme extents as a whole.

12.1.2 All options involve the introduction of a roundabout on the A4019. Although more collisions occur at junctions than along links due to the number of turning movement increasing the number of conflict points the improvements along the A4019 could see fewer link collisions. Option 5 does not involve the introduction of any improvements to the section of the A4019 to the east of the existing junction until the new roundabout east of Withybridge Lane. The collision hotspot at this location is therefore not addressed although the new roundabout may help to reduce vehicle speed along this section.

12.1.3 The introduction of a roundabout to allow new movements at the junction is likely to displace the traffic which had previously left or joined the M5 at junction 11 to the new junction. This displacement of traffic could lead to a reduction in collisions at junction 11 but an increase in collisions at junction 10.

12.1.4 In setting a safety baseline and objective it will be important to take into consideration the wider effects of the scheme. Safety benefits are likely to be realised at neighbouring junctions on the M5 and on the local GCC network, as traffic is routed through the new junction. The safety baseline and objective will be set at the options stage and reviewed as the project progresses. For the purposes of setting a safety baseline it is important that collision/casualty data is updated to allow the numerical input to be made for the safety baseline.

12.1.5 The baseline and objective will refer to Fatal and Weighted Injuries (FWI), which is a formula used to reflect the approximate ratios between the costs of fatal, serious and slight injuries as given by DfT's Web Technical Advisory Group (TAG) and is defined as:

12.1.6 (Number of fatalities) + 0.1 x (number of serious casualties) + 0.01 x (number of slight casualties).

12.1.7 It is important to consider the characteristics and nature of the scheme before deciding on safety objectives. Where a scheme is targeted at relieving congestion for instance, this can make a reduction in the overall number of collisions particularly challenging and in these circumstances, it is important to consider the rate of collisions or casualties, to allow for impacts of traffic growth.

12.1.8 There is no numerical objective or target for road worker accidents for major schemes and the risk must be managed in accordance with the 'as low as reasonably possible' principle. This is a legal requirement.

12.1.9 Through its National Incident and Casualty Reduction Plan, Highways England sets out how it is working to ensure that no one should be harmed whilst travelling or working on the strategic road network. This plan supports the Health and Safety Five Year Plan which details how we will deliver wider improvements in health, safety and wellbeing for Highways England's staff, suppliers and road users.

12.2 Construction (Design and Management) Regulations 2015

12.2.1 The objective of the Construction Design and Management (CDM) Regulations 2015 is to ensure that the systematic management of projects from conception through to completion with hazards are identified, reduced and controlled and where possible eliminated.

12.2.2 The Hazard Plans with Existing Utilities are shown on Drawing Nos GCCM5J10-ATK-HGN-XX_ML_Z-DR-CH-000001 to 000005 in Appendix A.

12.2.3 The following measures will need to be considered to ensure a robust management of all hazards during construction;

- Use of speed enforcement to protect workforce and road users during periods of temporary traffic management;
- Use of narrow lanes to ensure that sufficient working space is provided to enable safe completion of the works and provide sufficient traffic capacity.
- Use of temporary vehicle restraint systems to prevent incursions into the works area by errant vehicles, maintaining safety to the construction work force and pedestrians.
- Work at night when additional space is required and the M5 will be reduced to single traffic or closed to generate adequate safe working areas.

12.2.4 A risk register for each option has been produced which identify hazards and assess their risk prior to construction, during construction and during the maintenance period. These risk registers should be developed further as the scheme progresses through future stages. The hazards identified are shown on the Hazard Identification drawings.

12.2.5 All options have similar risks in respect of construction over high-pressure gas mains, construction adjacent to live traffic and under high voltage electrical cables. However, Option 2A and 2B do not require the need to demolish any existing bridges over the M5 motorway compared to one bridge demolishment for Option 2 and two for Options 1A and 5, and therefore have a lesser amount of risk.

12.2.6 Identifying areas that can be constructed off-line, such as large structural elements reduces the risk of constructing adjacent to and over live traffic. This is key especially where site confinements and large haulage vehicle movements are limited. Constructing offline will also reduce the traffic management restrictions, reducing the exposure to construction workers and traffic management operatives and the public.

During Construction, Operation and Maintenance

12.2.7 The options that have been considered throughout the Technical Appraisal Report will have the same operation and maintenance requirements as would be expected by an all-purpose trunk road, dual carriageway or motorway and as currently experienced with the existing layout. The provision of the following in addition to the measures outlined in Chapter 7 would enable the operation and maintenance requirements to be optimised.

- Existing access arrangements to fields and housing to be maintained or improved, dependent on which option is taken forward
- Existing access to verges and central reserves is to be maintained or relocated dependant in which option is taken forward
- Existing access to footways and bridleways are to be maintained or improved dependent on which option is taken forward

12.2.8 Off network access is to be considered to enable assets to be maintained, reducing the need to implement temporary traffic management. The reduction of temporary traffic

management required has a significant impact on reducing risk to both road workers and road users.

13 Operational Assessment

13.1.1 The Operational Assessment outlines how the design of the scheme will impact on the operating regime and driver compliance.

13.2 Scheme's Operating Regime

13.2.1 The Combined Operations product, produced at the preliminary design stage will be drafted in consultation with key operational stakeholders including Highways England Regional Control Room, Traffic Officer Service and the emergency services. The document will outline the scheme's operating regime, it will:

- Outline the ways in which the scheme is expected to impact the operation of the network and set out any constraints that the scheme creates with regard to operating the network;
- Set out the compliance strategy for the scheme, where applicable, (taking account of national guidance), to help ensure that motorists comply with signs, signals, or other instructions that are fundamental to the operation of the scheme. This will ensure that the scheme can be operated safely and effectively.
- Provide an overview of any proposed core responder engagement about the implications of the scheme and update of any relevant agreements, for example for access to incidents.
- Clarify any Traffic Officer training requirements

13.2.2 The Engineering Constraints Drawings are shown on Drawing Nos GCCM5J10-ATK-HGN-XX_ML_Z-DR-LP-000001 to 000002 in Appendix A.

13.2.3 The junction currently operates with no roundabout which restricts traffic movements to the extent that northbound traffic on the M5 cannot leave the motorway at the junction and eastbound traffic on the A4019 cannot directly access the motorway.

13.2.4 The M5 is a standard dual carriageway with three lanes and hard shoulder in each direction (D3M). The current M5 on-slip is two lanes with hard shoulder and the M5 southbound off-slip is a single lane with hard strip. The A4019 is single carriageway east of Withybridge Lane and becomes dual carriageway with two lanes in each direction through the junction. To the west of the junction the route narrows down to single carriageway.

13.2.5 Under the current arrangement the residential properties and traveller's site on the north side of the A4019 to the east of the existing junction are accessed via a crossover on the A4019 and an informal hardened verge along the north side of the route where vehicles travel against the flow of traffic.

13.2.6 All five options involve the removal of the existing M5 northbound on-slip loop and M5 southbound off-slip and the creation of a new large grade separated roundabout. And, all five options involve the construction of new sections of carriageway running parallel to the M5 and linked to the B4634. Option 2B addresses the access arrangements to residential properties and traveller's site.

13.2.7 The construction of new carriageway will impact on winter maintenance services with additional quantities of salt required. This may impact on the winter maintenance depot's requirements to store the additional salt required. Additional depot requirements due to this improvement scheme have not yet been confirmed by either Highways England or GCC.

13.2.8 The incorporation of roundabouts into the scheme options creates turnaround areas for gritters should this be required to avoid maintenance vehicles travelling extended distances to turn around.

13.2.9 The Traffic Officer Service (TOS) patrols the M5 but does not cover the remaining elements of the scheme. It is not envisaged that their operations will change or that more resource will be required as a result of the improvements scheme.

13.2.10 Although there is no MIDAS equipment operating within the scheme extents there is a MIDAS site located to the south of the scheme at Junction 11. Should Option 2, 2A or 2B become the preferred option and MIDAS equipment be required at the new junction, it may be necessary to join the MIDAS sites together to avoid a gap between the two along the M5.

13.2.11 An existing CCTV camera is located on the M5 northbound at marker post 77/4 to the north of Junction 10. CCTV will be required at the new motorway junction at strategic points around the roundabout (in whatever form it takes depending on which is the preferred option).

13.2.12 During construction of the new junction the different options present their own separate issues. Considering options 2, 2A and 2B which involve the provision of a new junction at the same location as the old junction the Temporary Traffic Management (TTM) required would be more onerous as the junction would need to be closed to allow works to take place. However, where the junction is to be provided at a new location as in Options 1 and 5 some of the construction works could take place without requiring a motorway closure and whilst keeping junction 10 open.

13.3 Driver Compliance

13.3.1 The M5 is subject to the national speed limit and this will remain the case under all five options. The A4019 is subject to a 50mph speed limit reducing to 40mph at the eastern extents of the scheme. A 50mph speed limit operates along the B4634.

13.3.2 The new A4019 on-slips will be subject to a 50mph speed limit while the new M5 on-slips will be subject to national speed limit. The speed limit through the roundabout will be 50mph. There are currently no proposals to change the speed limit along the A4019 and B4634 or to provide camera enforcement. The new sections of carriageway providing links to the B4634 will be subject to a 50mph speed limit.

13.3.3 Any consideration for provision of traffic enforcement cameras will be in conjunction with Highways England's Regional Enforcement Coordinator and the Gloucester Safety Camera Partnership.

13.3.4 The number of collisions occurring along the A4019 is higher than would be expected along an 'A' Road. The presence of private driveways and uncontrolled junctions has been identified as a possible cause of the unusually high number of collisions. A reduction in speed limit along this route should seek to reduce road user risk and improve safety.

14 Structures Assessment

14.1 Basis of Structures Assessment

14.1.1 This section explains the approach taken in assessing the proposed highway alignments for the five scheme options to determine indicative details of required structural alterations and new structures.

14.2 Highway Cross Sections and Long Sections

14.2.1 The first step of the Structures Assessment was the production of proposed highway cross sections and long sections, for each scheme option, at the location of the existing and proposed structures within the project limits.

14.2.2 The highway Cross Sections and Long Sections sketches used in the Structures Assessment are listed in the table below.

Table 14-1 – Highway Cross Sections and Long Sections

Sketch Number	Version	Title / Description
GCCM5J10-ATK-HGN-OP1A-SK-CH-000001	P01.1	Cross Sections and Long Sections at Structure Locations for Option 1A
GCCM5J10-ATK-HGN-OP2-SK-CH-000001	P01.1	Cross Sections and Long Sections at Structure Locations for Option 2
GCCM5J10-ATK-HGN-OP2A-SK-CH-000001	P01.1	Cross Sections and Long Sections at Structure Locations for Option 2A
GCCM5J10-ATK-HGN-OP2B-SK-CH-000001	P01.1	Cross Sections and Long Sections at Structure Locations for Option 2B
GCCM5J10-ATK-HGN-OP5-SK-CH-000001	P01.1	Cross Sections and Long Sections at Structure Locations for Option 05

14.3 Modification of Existing Structures

14.3.1 For the purposes of reporting, the existing structures that may be affected by the scheme are categorised into four sub-types. The categorisation is shown in Table 14-2.

Table 14-2 – Existing Structures Categorisation

Existing Structure Type	Structure Name	HE Structure Key
M5 Overbridges	Green Farm Access Bridge	1657
	Hardwicke-Elmstone Hard Bridge	1658
	Piffs Elm Interchange Bridge	1659
M5 Culverts	Barn Farm Culvert	34462
	Piff Elms Service Culvert	13574
	Piff Elms Culvert	34468
	River Chelt Culvert	1660
	Staverton Twin Culvert	34477
M5 Minor Structures	CCTV Mast 00041 47774 NB	26968
	MS4 Cantilever Gantry 12	26925

Existing Structure Type	Structure Name	HE Structure Key
	Minor retaining walls (Comcab R/W)	22295, 22296, 22297, 2 x unknown
A4019 Structures	Withybridge Gardens Retaining Wall	N/A

14.3.2 Details of the existing structures (construction type, geometry, condition, etc.) are included in section 3.4 of this Technical Appraisal Report.

Existing M5 Overbridges

14.3.3 Overbridges are defined as bridges crossing over the M5 motorway. In most instances the highway alignment for the scheme option being assessed indicated the obvious retention or demolition of an M5 overbridge.

14.3.4 Where this was not obvious, the highway cross sections were interrogated to determine the extent of the proposed carriageway widening at the location of the M5 overbridge. Reduced offsets to the bridge piers were then determined, informing a decision on structure retention.

Existing M5 Culverts

14.3.5 The highway alignments for the five scheme options were scrutinised to identify the existing culverts affected by any proposed M5 carriageway widening. The feasibility of modifications to identified culverts, such as extensions, was then considered.

14.3.6 If modifications were considered feasible, the highway cross sections were interrogated to determine the required extension length. The required extension length was derived by comparison of the existing culvert length, square to the M5 carriageway, with the proposed M5 carriageway and verge width at the location of the culvert.

Existing M5 Minor Structures

14.3.7 The highway alignments were reviewed to determine where proposed carriageway widening clashes with the minor structures. Where clashes occur, relocation of the minor structures has been assumed.

A4019 Structures: Withybridge Gardens Retaining Wall

14.3.8 The highway alignments including earthworks were reviewed to assess the impact on the Withybridge Gardens Retaining Wall.

14.4 New and Replacement Structures

New and Replacement M5 Overbridges

14.4.1 The indicative design approach and issues applicable to all new and replacement M5 overbridges are considered under this heading.

14.4.2 Multi-span overbridge arrangements with bank seat abutments in the approach embankments and side spans spanning over sloped revetments have been chosen to promote an open appearance, which matches the existing overbridges along this section of the M5. This layout avoids substantial concrete or reinforced earth abutments and wing walls.

14.4.3 The decision was taken to avoid locating bridge supports in the central reserve of the M5 to avoid hazardous construction and maintenance works in the central reserve. The decision necessitated each overbridge to have a large central span over the M5 mainline carriageways.

14.4.4 Typically bridge supports were located in the verge at 5m offsets from the edge of the motorway's overall paved width. This was done to avoid collision loading, as BD 60/04 requires supports within 4.5m of the paved edge to be designed for collision loading. This decision could be reconsidered during preliminary design, but it is considered sufficient for concept design and has been applied consistently across the scheme options. Where there was an additional contribution to the overall paved width from slip road and nosing arrangements, consideration was given to whether the resultant span length was achievable. Where span lengths were becoming excessive, intermediate bridge supports were located in the nosing width.

14.4.5 For three-span overbridge arrangements, the proposed central spans were significantly larger than the side spans. The side spans were equally sized to provide a symmetrical arrangement. The side span lengths were determined considering headroom provision in conjunction with the assumption of a 1 in 3 embankment slope up to the bridge bank seat abutment level. This resulted in a typical side span length of 17m for standard headroom, which was used consistently across the proposed overbridges for concept design purposes.

14.4.6 Similarly, where overbridges had more than three spans, an attempt was made to rationalise the arrangement to return a symmetrical arrangement with equal approach spans.

14.4.7 The available overbridge construction depths were determined considering minimum headroom requirements, and proposed road over and motorway levels. Span arrangements were then reviewed to check the span to depth ratios were within acceptable limits (typically < 25) based on past experience.

14.4.8 To determine the proposed bridge deck widths, the proposed carriageway widths were measured from the highway alignment plans. 2m wide paved verges/footways and 0.5m wide parapet upstands were typically assumed. Exceptions are covered in the specific scheme option sections further below.

14.4.9 Integral prestressed concrete and steel-concrete composite construction types are considered the most appropriate for the proposed overbridge span arrangements. Road over levels, deck depths and construction types will be considered in more detail at the preliminary design stage.

Link Road Structures

14.4.10 The indicative structures design approach and constraints relating to the proposed link road between the new M5 junction 10 with the A4019 Tewkesbury Road (for Option 1A and 5) and the West Cheltenham Link Road (between the new A4019 gyratory roundabout junction to the B4634 Gloucester Road) are considered under this Section.

14.4.11 New viaduct structures are required where the link road between M5 junction and the A4019 crosses Leigh Brook and its bordering floodplain, and where West Cheltenham Link Road crosses the River Chelt floodplain to the south of the A4019. For the purposes of the indicative design, viaduct lengths have been determined based on the corresponding route extent of the 1 in 25-year Environment Agency floodplain modelling data. This approach was agreed in an email exchange in January 2019 between John Foulds (Environment Agency) and Andrew Padden (then Amey, now Atkins). The email chain is provided in Appendix D.

14.4.12 For the West Cheltenham Link Road crossing of the River Chelt, the indicative design bridge length includes allowance for a minimum 8m set-back from the river banks, an Environment Agency requirement notified in the January 2019 email exchange.

14.4.13 The scheme option crossing locations have the potential to increase flood risk where they restrict flood flows or change floodplain dynamics. Hydraulic models with the proposed scheme included will be produced at a later design stage. The models should be used to evaluate the impact of the proposed scheme on flood risk and to derive peak flood water levels relative to the proposed structures.

14.4.14 Subsequent to the link road structure span lengths being estimated in autumn 2019 based on the Environment Agency flood mapping, new flood mapping has been obtained from an alternative datasource. The new flood zone extents have been reproduced in the scheme options drawings contained in Appendix B. Given that the flood zone extents will likely change again when scheme-specific hydraulic models are produced at the next design stage, and to avoid delaying the delivery of this Technical Appraisal Report, it has been decided not to update the link road structure span lengths on the drawings (Appendix B) and Structures Schedule (Appendix D) at this stage. The span lengths will need to be updated when the new hydraulic modelling is available, and it is expected that the proposed River Chelt floodplain viaduct will need to be extended.

14.5 Scheme Options Structure Requirements

14.5.1 This section provides indicative details of required structural alterations and new structures for the five scheme options.

14.5.2 In addition, a Structures Schedule (document ref. GCCM5J10-ATK-SGN-XX-SH-CB-000002) has been prepared listing structure requirements and key data for the five scheme options. The document is contained in Appendix D.

14.5.3 The identified existing and proposed structures are not exhaustive. There may be additional existing small culverts that could be picked up following the topographical survey and site visits, particularly in the fields along the alignment of the proposed link roads. New retaining walls and environmental barriers have not been considered at this stage, excepting possible alteration of Withybridge Gardens Retaining Wall. The indicative locations and dimensions of the structures that have been identified may not be exhaustive and should be subject to locational and dimensional verification at later design stages.

14.6 Option 1A Structure Requirements

14.6.1 The structural alterations and new structures that have been identified for Option 1A are listed below.

14.6.2 The justification for the identified structural alterations and derivation of indicative dimensions is set out in ‘Proposed Bridge Layouts Option 1A’ (document ref. GCCM5J10-ATK-SGN-OP1A-SH-CB-000001) contained in Appendix D.

Alterations to Existing M5 Overbridges

- Demolition of the existing Green Farm Access Bridge (Str. Key: 1657) at M5 kilometrage 75.9 to enable construction of the new north facing Junction 10 slip roads.
- Demolition of the existing Hardwicke-Elmstone Hard Bridge (Str. Key: 1658) at M5 kilometrage 76.7 to enable construction of a new Junction 10 interchange.

Alterations to Existing M5 Culverts

- Extension of the existing Barn Farm Culvert (Str. Key: 34462) by approximately 2m to both sides of the M5 motorway. The extension construction form will be twin precast concrete pipes to match existing.

Alterations to Existing M5 Minor Structures

- Demolition and replacement of the existing Communication Cabinet Retaining Wall Number 3 (Str. Key: 22295) at M5 kilometrage 75.9.
- Demolition and replacement of two existing retaining walls at M5 kilometrages 76.4 and 76.9. Highways England SMIS information is not available for these structures. They are believed to be additional communication cabinet retaining walls.
- Relocation of the existing CCTV Mast 00041 47774 NB (Str. Key: 26968) at M5 kilometrage 77.4. A new foundation for the mast would need to be constructed.

Alterations to Existing A4019 Structures

- Withybridge Gardens Retaining Wall is unaffected by the Option 1A highway alignment.

Proposed New M5 Overbridges

- A three-span prestressed concrete or steel-concrete composite replacement for Green Farm Access Bridge along the same line at M5 kilometrage 75.9. The proposed structure is 89m in length and 6m wide. The proposed 89m length comprises a 55m central span and 17m side spans. The proposed 6m deck width is based on a single track and narrow paved verges, similar to the existing bridge. It is assumed there would be no requirement to future-proof this bridge for a wider two-lane carriageway, but this would need to be confirmed during preliminary design.
- A five-span prestressed concrete or steel-concrete composite replacement for Hardwicke-Elmstone Hard Bridge at M5 kilometrage 76.3, constructed north of the existing bridge to maintain access for local traffic over the M5 between the villages of Hardwicke and Elmstone Hardwicke. The proposed structure is 114m in length and 12m wide, comprising a central span of 40m, inner side spans of 20m and outer side spans of 17m. The inner piers are located in the nosing widths between the mainline carriageways and the slip roads.
- A three-span prestressed concrete or steel-concrete composite bridge 79m in length and 17m wide to carry the north side of the Option 1A Junction 10 roundabout over the M5 motorway. The proposed span arrangement comprises a 45m central span and 17m side spans.
- A three-span prestressed concrete or steel-concrete composite bridge 79m in length and 17m wide to carry the south side of the Option 1A Junction 10 roundabout over the M5 motorway. The proposed span arrangement comprises a 45m central span and 17m side spans.

Proposed Structure on M5 J10 to A4019 Link Road

- A multi-span viaduct of precast beam or precast arch construction 100m in length and 28m wide to carry the link road across Leigh Brook and the bordering floodplain.

Proposed West Cheltenham Link Road Structures

- A multi-span viaduct of precast beam or precast arch construction 200m in length and 28m wide to carry West Cheltenham Link Road across the floodplain south of the A4019.

- A single span prestressed concrete or steel-concrete composite bridge 30m in length and 28m wide to carry West Cheltenham Link Road over the River Chelt.

Option 1A Structure Requirements Appraisal

14.6.3 Option 1A requires the demolition of two existing M5 overbridges, the construction of two replacement M5 overbridges and two new junction roundabout M5 overbridges, and the construction of three river and floodplain crossings to carry the M5 J10 to A4019 link road and West Cheltenham Link Road. Barn Farm Culvert requires short extensions.

14.6.4 In considering Option 1A, thought should be given to the impact of required sequencing of the M5 overbridge demolition and construction works on the construction period. It is assumed to be necessary to ensure the existing routes across the M5 are maintained throughout the construction period. To facilitate this, it is envisaged that the replacement for Hardwicke-Elmstone Hard Bridge, at M5 kilometrage 76.3, would be constructed prior to the demolition of both the existing Hardwicke-Elmstone Hard Bridge to the south and the existing Green Farm Access Bridge to the north. The permanent diversion of the unclassified road carried by the existing Hardwicke-Elmstone Hard Bridge over the replacement bridge would also need be installed prior to demolition.

14.6.5 To maintain access to Green Farm during the demolition and replacement of Green Farm Access Bridge, a temporary diversion route would be provided for the farmer via the re-routed unclassified road over the newly constructed replacement for Hardwicke-Elmstone Hard Bridge. This would allow an on-line replacement of Green Farm Access Bridge, minimising earthworks and loss of trees and ecology associated with the existing approach embankments. The proposed Green Farm Access Bridge foundations have been positioned to avoid clashes with the existing foundations, which would be demolished to ground level with the rest left buried.

14.6.6 Demolition of both overbridges, the existing Hardwicke-Elmstone Hard Bridge and the existing Green Farm Access Bridge, requires careful consideration. The construction form is the same for these bridges, being three-span continuous haunched voided post-tensioned concrete slab with integral tapered rectangular column pier supports. There are Freyssinet type hinges at the bases of the columns. Weekend closures of the M5 motorway would be necessary. A Severn Trent water distribution main and a Gigaclear broadband service are carried across the M5 motorway by the existing Hardwicke-Elmstone Hard Bridge. They would require diversion prior to demolition.

14.6.7 The proposed replacement for Hardwicke-Elmstone Hard Bridge has inner piers located in the proposed nosings that would require traffic management during construction and maintenance. The proposed northbound nosing is only 3.6m wide at the bridge location, meaning the pier would be built close to the existing hard shoulder. It is unlikely that a hard shoulder closure alone would provide sufficient working space to construct the pier, so narrow lanes would perhaps be needed on the M5 northbound carriageway. The pier would have to be designed for impact loading, as the set-back would be less than 4.5m and approach/departure safety barriers would need to tie into the pier faces on the mainline and slip road sides. 1.2m set-back is required to the pier faces on both sides, meaning the pier width would be limited to approximately 1.2m, which is slender for a pier required to resist impact loading. This could be looked at during preliminary design and the bridge location could perhaps be shifted slightly south where increased nosing width is proposed, but that would increase the span length.

14.6.8 Existing local road access in the vicinity of the Option 1A demolition and construction sites is limited, being a network of narrow lanes passing through small villages. It would therefore be essential to establish a suitable haul road to enable access for heavy plant, equipment and materials, and in the process minimise disruption and disturbance to local residents. A further temporary haul road would be required to enable early commencement of construction of the link road structures. A temporary crossing over the River Chelt would be required.

14.6.9 The existing Withybridge Gardens Retaining Wall is unaffected by the Option 1A highway alignment.

14.7 Option 2 Structure Requirements

14.7.1 The structural alterations and new structures that have been identified for Option 2 are listed below.

14.7.2 The justification for the identified structural alterations and derivation of indicative dimensions is set out in 'Proposed Bridge Layouts Option 2' (document ref. GCCM5J10-ATK-SGN-OP2-SH-CB-000001) contained in Appendix D.

Alterations to Existing M5 Overbridges

- Demolition of the existing Piff Elms Interchange Bridge (Str. Key: 1659) at M5 kilometrage 77.9 to enable construction of a new Junction 10 interchange.

Alterations to Existing M5 Culverts

- Extension of the existing Barn Farm Culvert (Str. Key: 34462) by approximately 6m to both sides of the M5 motorway. The extension construction form will be twin precast concrete pipes to match existing.
- Proposed abandonment of the existing Piffs Elm Service Culvert (Str. Key: 13574) at M5 kilometrage 77.9. The existing manhole accesses to the culvert would be buried by the earthworks arrangement associated with the Option 2 Junction 10 alignment. At its shortest point the distance across the outer limits of the interchange earthworks is approximately 280m, following the line of the existing route of the services.
- Extension of the existing Piffs Elm Culvert (Str. Key 34468) at M5 kilometrage 78.1 by approximately 45m to both sides of the M5 motorway. The extension construction form will likely be corrugated steel pipe sections to match existing.
- Extension of the existing buried concrete box River Chelt Culvert (Str. Key 1660) at M5 kilometrage 78.8 by approximately 4m to both sides of the M5 motorway.

Alterations to Existing M5 Minor Structures

- Relocation of the existing CCTV Mast 00041 47774 NB (Str. Key 26968) at M5 kilometrage 77.4. A new foundation for the mast would need to be constructed.
- Demolition and replacement of the existing Communication Cabinet Retaining Wall Numbers 4 and 5 (Str. Keys 22296 and 22297) at M5 kilometrages 78.3 and 78.7 respectively.

Alterations to Existing A4019 Structures

- Demolition of the existing Withybridge Gardens Retaining Wall in its entirety.

Proposed New M5 Overbridges

- A three-span prestressed concrete or steel-concrete composite bridge 78m in length and 17m wide to carry the north side of the Option 2 Junction 10 roundabout over the M5 motorway. The proposed span arrangement comprises a 44m central span and 17m side spans.
- A three-span prestressed concrete or steel-concrete composite bridge 78m in length and 17m wide to carry the south side of the Option 2 Junction 10 roundabout over the M5 motorway. The proposed span arrangement comprises a 44m central span and 17m side spans.

Proposed West Cheltenham Link Road Structures

- A multi-span viaduct of precast beam or precast arch construction 200m in length and 28m wide to carry West Cheltenham Link Road across the floodplain south of the A4019.
- A single span prestressed concrete or steel-concrete composite bridge 30m in length and 28m wide to carry West Cheltenham Link Road over the River Chelt.

Option 2 Structure Requirements Appraisal

14.7.3 Option 2 requires the demolition of one existing M5 overbridge, the construction of two new junction roundabout M5 overbridges, and the construction of two river and floodplain crossings to carry West Cheltenham Link Road. The culvert extensions to Piffs Elm Culvert and River Chelt Culvert would be fairly significant works, the former being long pipe extensions and the latter being a large box culvert. Barn Farm Culvert requires moderate extensions.

14.7.4 Significant works were undertaken on Piffs Elm Interchange Bridge in 2015: the pier footings were replaced with piled foundations placed between the existing spread footings as part of remedial measures to prevent deterioration caused by Thaumasite Sulphate Attack (TSA). The demolition of this bridge under Option 2, several years after costly and disruptive works were undertaken, could lead to bad publicity. However, it is noted that other parts of the structure are in poor condition with defects including concrete cracking, spalling and TSA affecting the east abutment. Demolition of this bridge would remove an ongoing maintenance liability.

14.7.5 The Option 2 Junction 10 interchange arrangement enabling works would include the full demolition of Withybridge Gardens Retaining Wall, and the diversion of the statutory undertaker apparatus currently routed under the M5 motorway via the Piff Elms Service Culvert. The existing manhole accesses to the culvert would be buried by the Option 2 Junction 10 earthworks arrangement. It is assumed the service culvert would be abandoned and possibly infilled, but this would need to be investigated further at preliminary design. Directional drilling under the M5 motorway and routing services over the new bridge carrying the south side of the Junction 10 roundabout should be considered as options for the necessary permanent service diversions.

14.7.6 During construction of the proposed Junction 10 interchange arrangement, the A4019 route over the M5 motorway would be maintained by the temporary retention of the existing Piffs Elm Interchange Bridge. The existing northbound on slip road would need to be closed to facilitate construction of the two new roundabout M5 overbridges. The southbound off slip road could be kept open while the bridges are being built, then closed when the remainder of the roundabout and earthworks are being built up. On completion of the new interchange works and connection to the A4019, the existing Piff Elms Interchange Bridge could be demolished.

14.7.7 Partial and full closures of the M5 motorway would be necessary to make possible the Option 2 overbridge construction and demolition works.

14.7.8 A temporary haul road would be required to enable early commencement of construction of the West Cheltenham Link Road structures. A temporary crossing over the River Chelt would be required.

14.8 Option 2A Structure Requirements

14.8.1 The structural alterations and new structures that have been identified for Option 2A are listed below.

14.8.2 The justification for the identified structural alterations and derivation of indicative dimensions is set out in ‘Proposed Bridge Layouts Option 2A’ (document ref. GCCM5J10-ATK-SGN-OP2A-SH-CB-000001) contained in Appendix D.

Alterations to Existing M5 Overbridges

- The structural components of the existing M5 overbridges are unaffected by the Option 2A highway alignment. The existing Piff Elms Interchange Bridge (Str. Key: 1659) would be retained to carry the south side of the Option 2A Junction 10 roundabout over the M5 motorway.

Alterations to Existing M5 Culverts

- Extension of the existing Barn Farm Culvert (Str. Key: 34462) by approximately 8m to both sides of the M5 motorway. The extension construction form would be twin precast concrete pipes to match existing.
- Proposed abandonment of the existing Piffs Elm Service Culvert (Str. Key: 13574). The existing manhole accesses to the culvert would be buried by the earthworks arrangement associated with the Option 2A Junction 10 alignment.
- Extension of the existing Piffs Elm Culvert (Str. Key: 34468) by approximately 35m to both sides of the M5 motorway. The extension construction form would likely be corrugated steel pipe sections to match existing.
- Extension of the existing buried concrete box River Chelt Culvert (Str. Key: 1660) by approximately 4m to both sides of the M5 motorway.

Alterations to Existing M5 Minor Structures

- Relocation of the existing CCTV Mast 00041 47774 NB (Str. Key: 26968) at M5 kilometrage 77.4. A new foundation for the mast would need to be constructed.
- Demolition and replacement of the existing Communication Cabinet Retaining Wall Numbers 4 and 5 (Str. Keys: 22296 and 22297) at M5 kilometrages 78.3 and 78.7 respectively.

Alterations to Existing A4019 Structures

- Demolition of approximately a 50m length of the western end of the existing Withybridge Gardens Retaining Wall and replacement on a new line.

Proposed New M5 Overbridges

- A three-span prestressed concrete or steel-concrete composite bridge 78m in length and 17m wide to carry the north side of the Option 2A Junction 10 roundabout over the M5 motorway. The proposed span arrangement comprises a 44m central span and 17m side spans.

Proposed West Cheltenham Link Road Structures

- A multi-span viaduct of precast beam or precast arch construction 200m in length and 28m wide to carry West Cheltenham Link Road across the floodplain south of the A4019.
- A single span prestressed concrete or steel-concrete composite bridge 30m in length and 28m wide to carry West Cheltenham Link Road over the River Chelt.

Option 2A Structure Requirements Appraisal

14.8.3 Option 2A requires construction of one new junction roundabout M5 overbridge, and the construction of two river and floodplain crossings to carry West Cheltenham Link Road. The culvert extensions to Piffs Elm Culvert and River Chelt Culvert would be fairly significant works, the former being long pipe extensions and the latter being a large box culvert. Barn Farm Culvert requires moderate extensions.

14.8.4 The existing Piffs Elm Interchange Bridge would be retained under Option 2A. Parts of the structure are in poor condition with defects including concrete cracking, spalling and Thaumasite Sulphate Attack affecting the east abutment. Retaining this bridge would present an ongoing maintenance liability. The minimum headroom is 5.03m over the southbound hard shoulder, which equals the minimum allowable headroom according to standards. This would leave no scope for overlaying surfacing on the M5 motorway and remain at risk of bridge strikes. The existing pier in the central reserve would remain a risk to maintenance workers who are forced to work in the central reserve under traffic management. The existing pier in the northbound verge could hamper the renewal and landscaping of the redundant northbound on slip road area.

14.8.5 The Option 2A Junction 10 interchange arrangement enabling works would include the demolition of an approximate 50m length of the west end of the existing Withybridge Gardens Retaining Wall and replacement on a new line. They would also include the diversion of the statutory undertaker apparatus currently routed under the M5 motorway via the Piff Elms Service Culvert. The existing manhole accesses to the culvert would be buried by the Option 2A Junction 10 earthworks arrangement. It is assumed the service culvert would be abandoned and possibly infilled, but this would need to be investigated further at preliminary design. Directional drilling under the M5 motorway and routing services over the existing Piffs Elm Interchange Bridge should be considered as options for the necessary permanent service diversions. The existing bridge has service bays in the verges that are believed to be largely empty.

14.8.6 During construction of the proposed Junction 10 interchange arrangement to the north of the A4019, the A4019 route over the M5 motorway would be maintained by the permanent retention of the existing Piffs Elm Interchange Bridge. The existing northbound on slip road would need to be closed to facilitate construction of the new roundabout M5 overbridge. The southbound off slip road could be kept open whilst the bridge is being built, then closed when the remainder of the roundabout and earthworks are being built up.

14.8.7 Closures of the M5 motorway would be necessary to make possible the Option 2A overbridge construction works.

14.8.8 A temporary haul road would be required to enable early commencement of construction of the West Cheltenham Link Road structures. A temporary crossing over the River Chelt would be required.

14.8.9 It is assumed that the existing Uckington Transmission Station, located in the M5 southbound verge approximately 100m north east of Piffs Elm Interchange Bridge, would need to be relocated to make way for the proposed north roundabout bridge. The proposed structure may be clear of the transmission station, but the side span earthworks would conflict with it. A retaining wall solution to avoid relocating the transmission station could be considered at a later design stage.

14.9 Option 2B Structure Requirements

14.9.1 The structural alterations and new structures that have been identified for Option 2B are listed below.

14.9.2 The justification for the identified structural alterations and derivation of indicative dimensions is set out in ‘Proposed Bridge Layouts Option 2B’ (document ref. GCCM5J10-ATK-SGN-OP2B-SH-CB-000001) contained in Appendix A.

Alterations to Existing M5 Overbridges

- The structural components of the existing M5 overbridges are unaffected by the Option 2B highway alignment. The existing Piff Elms Interchange Bridge (Str. Key: 1659) would be retained to carry the north side of the Option 2B Junction 10 roundabout over the M5 motorway.

Alterations to Existing M5 Culverts

- Extension of the existing Barn Farm Culvert (Str. Key: 34462) by approximately 8m to both sides of the M5 motorway. The extension construction form would be twin precast concrete pipes to match existing.
- Proposed abandonment of the existing Piffs Elm Service Culvert (Str. Key: 13574). The existing manhole accesses to the culvert would be buried by the earthworks arrangement associated with the Option 2B Junction 10 alignment.
- Extension of the existing Piffs Elm Culvert (Str. Key: 34468) by approximately 60m to both sides of the M5 motorway. The extension construction form would likely be corrugated steel pipe sections to match existing.
- Extension of the existing buried concrete box River Chelt Culvert (Str. Key: 1660) by approximately 6m to both sides of the M5 motorway.

Alterations to Existing M5 Minor Structures

- Relocation of the existing CCTV Mast 00041 47774 NB (Str. Key: 26968) at M5 kilometrage 77.4. A new foundation for the mast would need to be constructed.
- Demolition and replacement of the existing Communication Cabinet Retaining Wall Numbers 4 and 5 (Str. Keys: 22296 and 22297) at M5 kilometrages 78.3 and 78.7 respectively.

Alterations to Existing A4019 Structures

- Demolition of the existing Withybridge Gardens Retaining Wall in its entirety.

Proposed New M5 Overbridges

- A three-span prestressed concrete or steel-concrete composite bridge 78m in length and 17m wide to carry the south side of the Option 2B Junction 10 roundabout over the M5 motorway. The proposed span arrangement comprises a 44m central span and 17m side spans.

Proposed West Cheltenham Link Road Structures

- A multi-span viaduct of precast beam or precast arch construction 200m in length and 28m wide to carry West Cheltenham Link Road across the floodplain south of the A4019.
- A single span prestressed concrete or steel-concrete composite bridge 30m in length and 28m wide to carry West Cheltenham Link Road over the River Chelt.

Option 2B Structure Requirements Appraisal

14.9.3 Option 2B requires construction of one new junction roundabout M5 overbridge, and the construction of two river and floodplain crossings to carry West Cheltenham Link Road. The culvert extensions to Piffs Elm Culvert and River Chelt Culvert would be fairly significant works, the former being long pipe extensions and the latter being a large box culvert. Barn Farm Culvert requires moderate extensions.

14.9.4 Like Option 2A, the existing Piffs Elm Interchange Bridge would be retained under Option 2B. Parts of the structure are in poor condition with defects including concrete cracking, spalling and Thaumasite Sulphate Attack affecting the east abutment. Retaining this bridge would present an ongoing maintenance liability. The minimum headroom is 5.03m over the southbound hard shoulder, which equals the minimum allowable headroom according to standards. This would leave no scope for overlaying surfacing on the M5 motorway and remain at risk of bridge strikes. The existing pier in the central reserve would remain a risk to maintenance workers who are forced to work in the central reserve

under traffic management. The existing pier in the northbound verge could hamper the renewal and landscaping of the redundant northbound on slip road area.

14.9.5 The Option 2B Junction 10 interchange arrangement enabling works would include the demolition of the existing Withybridge Gardens Retaining Wall, and the diversion of the statutory undertaker apparatus currently routed under the M5 motorway via the Piff Elms Service Culvert. The existing manhole accesses to the culvert would be buried by the Option 2B Junction 10 earthworks arrangement. It is assumed the service culvert would be abandoned and possibly infilled, but this would need to be investigated further at preliminary design. Directional drilling under the M5 motorway and routing services over the new bridge carrying the south side of the Junction 10 roundabout or the existing Piffs Elm Interchange Bridge should be considered as options for the necessary permanent service diversions. The existing bridge has service bays in the verges that are believed to be largely empty.

14.9.6 During construction of the proposed Junction 10 interchange arrangement to the south of the A4019, the A4019 route over the M5 motorway would be maintained by the permanent retention of the existing Piffs Elm Interchange Bridge. The existing northbound on slip road would likely need to be closed to facilitate construction of the new roundabout M5 overbridge, although it could be possible to keep the nearside lane open until the west abutment is backfilled. The southbound off slip road could be kept open whilst the bridge and roundabout are being built, then closed when the approach earthworks are being built up.

14.9.7 Closures of the M5 motorway would be necessary to make possible the Option 2B overbridge construction works.

14.9.8 A temporary haul road would be required to enable early commencement of construction of the West Cheltenham Link Road structures. A temporary crossing over the River Chelt would be required.

14.10 Option 5 Structure Requirements

14.10.1 The structural alterations and new structures that have been identified for Option 5 are listed below.

14.10.2 The justification for the identified structural alterations and derivation of indicative dimensions is set out in ‘Proposed Bridge Layouts Option 5’ (document ref. GCCM5J10-ATK-SGN-OP5-SH-CB-000001) contained in Appendix D.

Alterations to Existing M5 Overbridges

- Demolition of the existing Hardwicke-Elmstone Hard Bridge (Str. Key: 1658) at M5 kilometrage 76.7 to enable construction of the new north facing Junction 10 slip roads.

Alterations to Existing M5 Culverts

- Extension of the existing Barn Farm Culvert (Str. Key: 34462) by approximately 5m to both sides of the M5 motorway. The extension construction form would be twin precast concrete pipes to match existing.

Alterations to Existing M5 Minor Structures

- Demolition and replacement of two existing retaining walls at M5 kilometrages 76.4 and 76.9. Highways England SMIS information is not available for these structures. They are believed to be additional communication cabinet retaining walls.
- Relocation of the existing CCTV Mast 00041 47774 NB (Str. Key: 26968) at M5 kilometrage 77.4. A new foundation for the mast would need to be constructed.

Alterations to Existing A4019 Structures

- Withybridge Gardens Retaining Wall is unaffected by the Option 5 highway alignment.

Proposed New M5 Overbridges

- A three-span prestressed concrete or steel-concrete composite replacement for Hardwicke-Elmstone Hard Bridge at M5 kilometrage 76.3, constructed north of the existing bridge to maintain access for local traffic over the M5 between the villages of Hardwicke and Elmstone Hardwicke. The proposed structure is 89m in length and 12m wide, comprising a central span of 55m and side spans of 17m.
- A three-span prestressed concrete or steel-concrete composite bridge 78m in length and 17m wide to carry the north side of the Option 5 Junction 10 roundabout over the M5 motorway. The proposed span arrangement comprises a 44m central span and 17m side spans.
- A three-span prestressed concrete or steel-concrete composite bridge 78m in length and 17m wide to carry the south side of the Option 5 Junction 10 roundabout over the M5 motorway. The proposed span arrangement comprises a 44m central span and 17m side spans.

Proposed Structure on M5 J10 to A4019 Link Road

- A multi-span viaduct of precast beam or precast arch construction 100m in length and 28m wide to carry the link road across the Leigh Brook and bordering floodplain.

Proposed West Cheltenham Link Road Structures

- A multi-span viaduct of precast beam or precast arch construction 200m in length and 28m wide to carry West Cheltenham Link Road across the floodplain south of the A4019.
- A single span prestressed concrete or steel-concrete composite bridge 30m in length and 28m wide to carry West Cheltenham Link Road over the River Chelt.

Option 5 Structure Requirements Appraisal

14.10.3 Option 5 requires the demolition of one existing M5 overbridge, the construction of one replacement M5 overbridge and two new junction roundabout M5 overbridges, and the construction of three river and floodplain crossings to carry M5 J10 to A4019 link road and West Cheltenham Link Road. Barn Farm Culvert requires moderate extensions.

14.10.4 The Option 5 highway alignment is a variant of the Option 1A highway alignment. The difference being the location of the M5 J10 roundabout; the Option 5 roundabout (approximate M5 kilometrage 77.0) is approximately 250m south of the Option 1A roundabout (approximate M5 kilometrage 76.7). The extent of the Option 5 M5 widening associated with the northbound on slip and southbound off slip roads is therefore shifted southwards in comparison with the Option 1A M5 widening extent. This has two consequences for the Option 5 structures requirements. Firstly, the demolition and replacement of Green Farm Access Bridge, and associated farm access diversion works, are not required. Secondly, the proposed Option 5 replacement for Hardwicke-Elmstone Hard Bridge is a three-span 89m long structure, offering a reduction on the five-span 114m long structure required for Option 1A. Option 5 would not require bridge piers in the slip road nosings.

14.10.5 The requirement to construct the replacement for Hardwicke-Elmstone Hard Bridge prior to the demolition of the existing bridge remains. With regards to the service diversions and new haul roads, the Option 5 requirements are the same as those described previously

for Option 1A, except there would be no requirement to extend a haul road to Green Farm Access Bridge.

14.10.6 The existing Withybridge Gardens Retaining Wall is unaffected by the Option 5 highway alignment.

14.11 Summary of Structures Assessment

14.11.1 This section discusses a few issues that are common to all scheme options and provides a summary of the advantages and disadvantages of each option.

14.11.2 Thaumasite Sulphate Attack is known to be a problem for substructures in this area, and it has already led to remedial works to Piffs Elm Interchange Bridge. All new structures will need to be designed with this risk in mind. Protective measures such as additional concrete cover to bridge foundations shall be considered following the ground investigation.

14.11.3 Works to demolish existing and construct new bridges over the M5 motorway are inherently hazardous and disruptive to traffic. Measures to minimise risks and disruption, including precast elements and off-site fabrication, should be considered at preliminary design. Simultaneous works on multiple bridges could help to make effective use of traffic management and full closures of the M5 motorway.

14.11.4 The link road structures will need to be discussed with the Environment Agency, taking account of updated flood modelling as it becomes available. It is assumed they would be constructed in the summer months when flood risk is lowest.

14.11.5 Table 14-3 provides a relative comparison of the advantages and disadvantages of the options in regard to structures. Green shading represents a relative advantage, amber is neutral and red represents a relative disadvantage. Costs, environmental impacts and other non-structures issues (e.g. land take) are considered elsewhere in this Technical Appraisal Report.

14.11.6 It is not appropriate to make an overall scheme option recommendation based on structures alone. The table below shows the relative merits that should be factored into choosing the overall preferred scheme option.

Table 14-3 – Structures Comparison of the Scheme Options[7]

Topic	Option 1A	Option 2	Option 2A	Option 2B	Option 5
Extent of major structures works	Two overbridges demolished, four new overbridges and three new Link Road structures.	One overbridge demolished, two new overbridges and two new Link Road structures. Culvert extensions.	No overbridge demolition, one new overbridge and two new Link Road structures. Culvert extensions.	No overbridge demolition, one new overbridge and two new Link Road structures. Culvert extensions.	One overbridge demolished, three new overbridges and three new Link Road structures.
Safety during construction, maintenance and operation	Piers in slip road nosings hazardous for maintenance. Demolition of post-tensioned concrete and Freyssinet hinges.	Demolition of post-tensioned concrete	No particular issues	No particular issues	Demolition of post-tensioned concrete and Freyssinet hinges.
Traffic Management	Temporary diversion required for Green Farm Access Bridge. Possible M5 narrow lanes to construct piers in slip road nosings.	Junction 10 northbound slip road to be closed during roundabout bridge works	Junction 10 northbound slip road to be closed during north roundabout bridge works	Junction 10 northbound slip road to be closed (perhaps partially) during south roundabout bridge works	No particular issues
Services (utilities)	Water main and comms diversions at Hardwicke-Elmstone Hard Bridge	Significant service diversions at Piffs Elm Service Culvert	Significant service diversions at Piffs Elm Service Culvert	Significant service diversions at Piffs Elm Service Culvert	Water main and comms diversions at Hardwicke-Elmstone Hard Bridge
Piffs Elm Interchange Bridge	Retention of Piffs Elm Interchange Bridge; ongoing maintenance liability, borderline headroom and hampers renewal of redundant NB on slip road area	Removal of Piffs Elm Interchange Bridge as an ongoing maintenance liability and bridge strike risk	Retention of Piffs Elm Interchange Bridge; ongoing maintenance liability, borderline headroom and hampers renewal of redundant NB on slip road area	Retention of Piffs Elm Interchange Bridge; ongoing maintenance liability, borderline headroom and hampers renewal of redundant NB on slip road area	Retention of Piffs Elm Interchange Bridge; ongoing maintenance liability, borderline headroom and hampers renewal of redundant NB on slip road area

[7] Note on colours: Green shading represents a relative advantage, amber is neutral and red represents a relative disadvantage.

15 Road Pavement Assessment

15.1 The impact of the options identified for appraisal

15.1.1 All route options will involve new pavement construction, potential use of existing pavement and widening to the existing pavement.

15.1.2 All route options will involve various new pavement construction options depending on the ground conditions and design traffic levels.

15.1.3 Where the existing pavement is widened, all options will have areas of narrow widening and where required, existing pavement will be cut-back to locate the longitudinal joints away from the wheel track zones in accordance with SHW 903.21 and DMRB HD 27/15.

15.1.4 For all the route options, assessment of the existing pavement condition will be required in order to determine its suitability to form part of the proposed carriageway taking into account the highway alignment.

15.1.5 All route options provide new pavement construction of the two-lane dual carriageway that starts from a new gyratory roundabout junction, to be constructed approximately 650m east of the M5 along the A4019 Tewkesbury Road, and ties into the B4634 Gloucester Road approximately 300m east of the existing Withybridge Lane Junction.

15.1.6 In addition, all options include widening to the A4019 Tewkesbury Road, between the new gyratory roundabout and traffic signalised junction near Cheltenham.

15.1.7 Option 2 offers the maximum potential to re-use the existing pavement as part of the proposed carriageway and at the same time has the least length of new pavement construction. This is subject to confirmation of suitability of the existing pavement to be used as part of the proposed carriageway through pavement investigations. Therefore, Option 2 could provide the most cost-effective option with programme benefits.

15.1.8 Options 2A and 2B also utilises the existing pavement between the new gyratory roundabout and the existing M5 junction 10. However, both options will introduce more longitudinal joints between the existing pavement and the proposed pavement compared to Option 2. This may result in reconstruction to parts of the existing pavement to ensure the joints are located outside the wheel tracks zones. Moreover, there is likely to be narrower pavement widening sections as a result of the proposed alignment changes.

15.1.9 Options 1A and 5 involves new pavement construction between the new roundabout on A4019 and the new M5 Junction 10 gyratory, north of the existing M5 Junction 10. This increases the extent of pavement works relative to the other proposed options.

15.1.10 Option 1A has more pavement works than Option 5 as the new M5 gyratory roundabout junction in Option 1A is shifted further toward the North.

15.1.11 The pavement design standards adopted for the project will vary depending on the requirements of the Overseeing Authority (Highways England or Gloucestershire County Council).

15.1.12 For the M5 mainline and slip roads, the pavement design will be carried out in accordance with the relevant Highway England standards and guidance, e.g. the Design Manual for Roads and Bridges (DMRB) and Manual of Contract Documents for Highway Works (MCHW).

15.1.13 For the road sections managed by Gloucestershire County Council (GCC), where specified and required, the pavement design will be carried out in accordance with the

guidance given in the Gloucestershire Technical Specification for New Streets and associated appendices. The roads managed by GCC include the new link road from J10 to West Cheltenham, the A4019 to the East of the link road, A38/A4019 junction at Coombe Hill; and the extension to Arle Court Park and Ride.

15.1.14 The surfacing type requirement for the Highways England and GCC road sections are likely to be different as Highways England requires Thin Surface Course System (TSCS) and GCC requires Hot Rolled Asphalt (HRA).

15.1.15 For the works on the main road carriageways, GCC technical specification specifies two types of HRA, HRA 55/14F Surf and HRA 35/14 F Surf with pre-coated chippings, depending on the traffic speed.

15.1.16 Pavement material selection will be carried out during PCF Stage 3 and will be subject to the following:

- Whole life cycle cost analysis;
- Scheme's high-level requirements including environmental requirements (i.e. noise levels);
- Consultation with the client/maintenance service provider.

16 Technology Assessment

16.1 General

16.1.1 All considered options for improvement will create a new junction that should meet current standards for technology provision. The technology implications focus on meeting these standards and ensuring that existing ITS systems are operable, and provide a similar level of service, during and following construction of the selected scheme. This will result in:

- Relocation of existing equipment impacted by changes to the highway layout;
- Provision of new equipment as required by revised highway layout to meet current standards of provision and/or operational assessments within this report;
- Preservation of Uckington Transmission Station (TS) facilities during construction works along with maintenance access on a 24/7 basis;
- Provision of a temporary bypass cable route to protect the operation of the NRTS network during construction;
- Provision of new cable, cabinets, ducts, chambers, electrical interfaces and associated hardstanding and access facilities where required to facilitate new and/or relocated technology equipment.

16.1.2 The following sections identify common and specific requirements for each option under consideration within the report.

16.2 Common Impact

16.2.1 The following impacts are common to all options:

- Removal of MS1s deployed in the central reserve at MP79/2B (single sided), MP77/4A & B (double sided) and associated cabinets to meet current requirements that MS1s shall not be deployed in the central reserve. The customer information provided by these will be replaced (and enhanced) by Variable Message Signs (VMS) as below;
- VMS will be required on the approaches to the new junction. In accordance with CD146, a primary, secondary and final VMS will be required on both the southbound (A) and northbound carriageway (B). The location of the primary and secondary VMS will be related to the location of ADS'. The final VMS will be within the junction, downstream from the exit slip on that carriageway. The VMS will be verge mounted MS4s;
- MIDAS (Motorway Incident Detection and Automatic Signalling) between approximately MP75/0 and MP79/0. This will require installation of loop detectors in the carriageways (A&B) or radar detectors adjacent to the carriageway. Detectors will be at approximately 500m intervals;
- Existing CCTV camera at MP77/4 and associated cabinets will need to be relocated to an appropriate position;
- New CCTV will be required around the junction in accordance with the operational assessment given within of Section 15 of this report;
- New Electrical Interfaces (EI) will be required to provide power for relocated and new equipment;
- Local cabling and associated ducts, chambers, cabinets and associated hardstanding and access facilities for all new ITS equipment inclusive of VMS/CCTV bases and/or any required retaining walls;

- NRTS (longitudinal) cable and associated ducts, chambers, cabinets and associated hardstanding and access facilities will require relocation and re-routing. This will include crossing new slip roads and routing through the new junction. The approximate extents of the relocation for each option are stated within the specific analysis;
- Access will need to be preserved to Uckington TS. An alternative temporary facility may be possible;
- Temporary NRTS bypass cable route will be required to enable the existing NRTS network to operate as usual during construction. The approximate extents for each option are stated within the specific analysis.
- Temporary power supply solutions may be required if the construction method will result in the interruption of existing supplies. The approximate extents for each option are stated within the specific analysis.
- Changes to SWRCC control systems data will be required to reflect on road changes.

16.3 Option 1A Specific Analysis

16.3.1 The specific technology impact of Option 1A is as follows:

- NRTS cables and associated facilities between approx. MP75/4 and MP77/8 will require relocation and re-routing;
- ERT at MP75/9A & B and associated cabinets will require temporary removal during demolition of the Green Farm Access Bridge. Relocation of the ERT to approx. MP75/4A & B will enable the requirements of TD73/16 for ERT on approaches to junctions to be met. Replacement at MP75/9A & B may require a departure;
- A pair of new ERT will be required within the new Junction 10 at approx. MP76/7A & B to meet the requirements of TD73/16 for ERT within junctions;
- No impact to existing Uckington Transmission Station;
- Temporary NRTS bypass cable route will be required between approx. MP75/7 and MP77/5;
- Temporary power supply solutions may be required between approx. MP75/7 and MP77/5.

16.4 Option 2 Specific Analysis

16.4.1 The specific technology impact of Option 2 is as follows:

- NRTS cables and associated facilities between approx. MP76/4 and MP79/2 will require relocation and re-routing.
- Existing ERT at MP77/4A & B and associated cabinets will require removal during construction work. Subsequent replacement of the ERT should be at approx. MP77/0A & B to meet the requirements of TD73/16 for ERT on approaches to junctions;
- Existing ERT at MP78/2A & B and associated cabinets will require removal during construction work. Subsequent replacement of the ERT should be at approx. M77/9A & B to meet the requirements of TD73/16 for ERT within junctions;
- Provision of entry stop signals on the southbound entry slip to provide for continuity and queue protection associated with the MIDAS scheme on the M5 southbound approach to Junction 11;
- If the design and construction of the proposed new interchange bridges cannot accommodate Uckington TS remaining in situ, a new TS will need to be constructed in the locality of the current TS complete with parking space and safe access for maintainers (on or off motorway). Ideally this will be on the M5 southbound facilitating

ready access to the longitudinal NRTS cabling. If construction and commissioning of a new TS cannot be achieved before the existing one is demolished a temporary facility may be required;

- If the TS does not need to be removed, then during construction of the new interchange bridges its functionality and access will need to be preserved or an alternative temporary facility may be required;
- Temporary NRTS bypass cable route will be required between approx. MP76/4 and MP79/2. The bypass will need to connect into Uckington TS or any new or temporary TS;
- Temporary power supply solutions may be required between approx. MP76/4 and MP79/2.

16.5 Option 2A Specific Analysis

16.5.1 The technology impact of Option 2A will generally be as per Option 2 however under Option 2A proposals the Uckington Transmission Station will require relocation.

16.5.2 The new TS will need to be constructed in the locality of the current TS with parking space and safe access for maintainers (on or off motorway). Ideally this will be on the M5 southbound facilitating ready access to the longitudinal NRTS cabling. If construction and commissioning of a new TS cannot be achieved before the existing one is demolished a temporary facility may be required.

16.5.3 The temporary NRTS bypass cable route will need to connect into the new or temporary TS.

16.6 Option 2B Specific Analysis

16.6.1 The technology impact of Option 2B will generally be as per Option 2 however under Option 2B proposals the Uckington Transmission Station is unlikely to require relocation although this will need to be confirmed at later design stages.

16.6.2 During construction of the new interchange bridges its functionality and access will need to be preserved or an alternative temporary facility may be required

16.6.3 The temporary NRTS bypass cable route will need to connect into the new or temporary TS.

16.7 Option 5 Specific Analysis

16.7.1 The technology impact of Option 5 is as follows:

- NRTS cables and associated facilities between approx. MP75/4 and MP77/8 will require relocation and re-routing;
- ERT at MP77/5A&B and associated cabinets may require temporary removal during construction;
- New ERT will be required within the new Junction 10 at approx. MP76/9A & B to meet the requirements of TD73/16 for ERT within junctions;
- No impact to existing Uckington Transmission Station;
- Temporary NRTS bypass cable route will be required between approx. MP75/4 and MP77/8 to enable the existing NRTS network to operate as usual during construction;
- Temporary power supply solutions may be required between approx. MP76/4 and MP79/2 if the construction method will result in their interruption.

16.8 Further considerations

16.8.1 Under all considered options Highways England will consider the new junction should meet current standards for technology provision and the implications described above align with this. The following might also require further consideration:

- Both M5 J9 and M5 J11 have MIDAS queue protection and associated variable message signs (MS4s at Junction 11 and MS2s at Junction 9). MIDAS will also be implemented at M5 Junction 10. Infill MIDAS may be required between Junction 10 and the adjacent junctions to be in keeping with standards (TD45);
- Additional CCTV above and beyond that detailed above;
- Provision of entry stop signals on all new entry slips. Entry slip signals are not provided at existing junction 10;
- Replacement of any ITS equipment in the area of the scheme that is approaching or is beyond its expected life with new equipment and this may require implementation of MS4 as above.

16.8.2 Each of the above would require associated new power supplies, interface cabinets, ducts, chambers, hardstanding and access facilities.

17 Public Utilities Assessment

17.1.1 The following information provides details on which and where each statutory undertaker will be affected by the varying options. It should be noted that the statutory utility plant identified as being affected for each option has been based on the plans provided by the statutory undertaker as part of the C2 enquiry undertaken. Details of any diversionary or protective works to statutory utility plant and associated budgetary estimates will be requested as part of stage C3, to be undertaken once a preferred option is identified.

17.2 Option 1A – New M5 Junction and A4019 Link Road

17.2.1 Utilities that will be affected by the construction of Option 1A include;

- Existing overhead Western Power; The existing overhead Western Power 11KV network is shown to pass over the proposed M5 junction northbound on-slip and southbound off-slip before continuing to over the proposed side road to the east of the junction. Within close proximity to the slip road is and existing LV overhead, this will not be affected by the works.
- Communication Network; An existing GIGACLEAR Fibre Optic network is shown to be running to the west of the M5 northbound carriageway up to Harwicke Elmstone Hard Bridge. At this location the network continues up the embankment to the side road. From this point the network continues east, passing over the Harwicke Elmstone Hard Bridge, continue to the properties to the east of the M5. As a result of the existing bridge proposed for demolition, the fibre optic network would need to be diverted.
- Water and Sewers; A Severn Trent Water main is shown to be crossing the M5 at the existing Hardwicke-Elmstone Hard Bridge continuing south to Elmstone Hardwicke. The main is passing through the centre of the proposed M5 J10 junction so will be affected by the works possibly requiring diversion or protection. Water mains are also shown running along A4019 Tewkesbury Road and B4634 Old Gloucester Road so may be affected by the new roundabouts of the proposed link road between the A4019 and B4634.
- British Telecom Network; Underground BT cabling is shown running along the A4019 Tewkesbury Road and B4634 Old Gloucester Road so may be affected by the new roundabouts of the proposed link road between the A4019 and B4634.
- Gas; A High Pressure (HP) main crosses the proposed link road between the A4019 and B4634. A Medium Pressure (MP) main is shown running along the A4019 Tewkesbury Road so may be affected by the new roundabout proposed on Tewkesbury Road.

17.2.2 No Statutory Undertakers are identified to be affected for the new dual carriageway between the proposed M5 junction and the A4019.

17.3 Options 2, 2A and 2B Upgrade of Existing M5 Junction 10

17.3.1 Options 2, 2A and 2B provide alternate options for the upgrade of the existing M5 Junction 10.

17.3.2 The following list provides details of where and how the utilities will be affected by the upgrade of both the M5 junction A4019 Tewkesbury Road.

- British Telecom Network; Underground BT cabling runs to both the north and south of the existing A4019, crossing the M5 through the existing structure. Throughout the section of carriageway there are a number of overhead and underground crossing which provide connection to the surrounding housing.

- Gas; Throughout the A4019 there are Low (LP) and Medium (MP) pressure gas mains run along verges to both the north and south of the existing carriageway. A High Pressure (HP) main crosses the existing Tewkesbury Road and proposed link road between the A4019 and B4634.
- Water and Sewers; water mains and sewers run the full length of the A4019 with connections to houses on both sides of the existing carriageway.
- Electricity: Throughout the A4019 the electrical network predominately runs overhead, with underground network connecting to the neighbouring houses. There are a number of high voltage cross carriageway overhead crossings within close proximity of the junction.
- Through the alignment there are several comms companies which have been installed underground through the length of the A4019.

17.4 Option 5 – New M5 Junction and A4019 Link Road

17.4.1 Utilities that will be affected by the construction of Option 5 include;

- Existing overhead Western Power; The existing overhead Western Power 11KV network is shown to pass over the proposed M5 junction northbound on-slip and southbound off-slip before continuing to over the proposed side road to the east of the junction. Within close proximity to the slip road is and existing LV overhead, this will not be affected by the works.
- Communication Network; An existing GIGACLEAR Fibre Optic network is shown to be running to the west of the M5 northbound carriageway up to Harwicke Elmstone Hard Bridge. At this location the network continues up the embankment to the side road. From this point the network continues east, passing over the Harwicke Hard Elmstone Bridge, continue to the properties to the east of the M5. As a result of the existing bridge proposed for demolition, the fibre optic network would need to be diverted.
- Water and Sewers; A Severn Trent Water main is shown to be crossing the M5 at the existing Hardwicke-Elmstone Hard Bridge continuing south to Elmstone Hardwicke. The main is passing through the slip roads to the north of the proposed M5 J10 junction so will likely be affected by the works possibly requiring diversion or protection. Water mains are also shown running along A4019 Tewkesbury Road and B4634 Old Gloucester Road so may be affected by the new roundabouts of the proposed link road between the A4019 and B4634.
- British Telecom Network; Underground BT cabling is shown running along the A4019 Tewkesbury Road and B4634 Old Gloucester Road so may be affected by the new roundabouts of the proposed link road between the A4019 and B4634.
- Gas; A High Pressure (HP) main crosses the proposed link road between the A4019 and B4634. A Medium Pressure (MP) main is shown running along the A4019 Tewkesbury Road so may be affected by the new roundabout proposed on Tewkesbury Road.

17.4.2 No Statutory Undertakers are identified to be affected for the new dual carriageway between the proposed M5 junction and the A4019.

17.5 A4019 Carriageway Improvements

17.5.1 The upgrade of the A4019 to a two-lane dual carriageway from the proposed roundabout junction to B4634 Hayden Road will be carried out as part of all the design options.

17.5.2 The A4019 is the main route into Chelmsford from the M5 and therefore the main arterial route for all utilities. Situated along the A4019, to both the north and south side of the

carriageway are both overhead and underground utilities with numerous carriageway crossings throughout.

17.5.3 The following list provides details of where and how the utilities will be affected by the upgrade of the A4019 Tewkesbury Road.

- British Telecom Network; Overhead and underground BT cabling runs predominately to the north of the existing A4019. Throughout the section of carriageway there are a number of overhead and underground crossing which provide connection to the surrounding housing.
- Gas; Throughout the A4019 there is Low (LP) Medium (MP) and High (HP) pressure gas. Prominently medium pressure with low pressure branching out to the surrounding housing. There is a High-Pressure gas main crossing the A4019 approximately 200m west of the junction with Homecroft Drive.
- Water and Sewers; water mains and sewers run the full length of the A4019 with connections to houses on both sides of the existing carriageway.
- Electricity: Throughout the A4019 the electrical network predominately runs overhead, with underground network connecting to the neighbouring houses. There are a number of cross carriageway overhead crossings, these range in from Low Voltage up to 132KV within 50m west of the junction with Homecroft Drive.
- Through the alignment there are several comms companies which have been installed underground through the length of the A4019.

17.6 B4634 Old Gloucester Road and New Link Road to A4019 Tewkesbury Road

17.6.1 The upgrade of the B434 Old Gloucester Road includes a new gyratory junction which connects the new link road with the A4019 Tewksbury Road and existing carriageway. The new link road and junction are located approximately 160m east of the existing junction with Withybridge Lane.

17.6.2 The following list provides details of where and how the existing utilities will be affected by the new junction and link road

- British Telecom Network; within the extents of the works, there is a small section of the overhead BT network connecting the neighbouring properties at both the west and east tie-in sections that will be affected by the works. No BT networks will be affected by the new link road
- Gas; There is an existing high pressure (HP) gas main which crosses the link road approximately 220m north of the existing carriageway. No Gas pipelines will be affected by the upgrade and new junction of the B4634.
- Water and Sewer; To the east of the extent of main highway works there are existing sewer connections which connect to the neighbouring properties. Water mains run the extent of the limit of highway works. The link road will not affect the existing sewer or water main network.
- Electricity; Two 132KV electrical networks cross the realigned B4634 Gloucester Road and proposed link road near the new gyratory junction. No pylons will need to be relocated.
- Throughout the existing B4634 Gloucester Road there are existing underground comms networks running to both the north and south sides of the carriageway.

18 Drainage Assessment

18.1 Proposed drainage strategy

18.1.1 The proposed junction upgrades represent an increase in the impermeable footprint of the highway, which will create greater amounts of surface water runoff compared to the current situation. Therefore, the proposed surface water drainage strategy will seek to replicate the site's existing hydrology through SuDS principles, where feasible. The drainage design for the upgraded and new carriageway sections will consist of gravity drainage networks, which will convey flows to suitable outfalls.

18.1.2 It is the intention to re-use as much as possible of the existing drainage, including outfalls. Ongoing design in subsequent stages would involve reviewing the existing drainage within the scheme and confirm its compliance with current design standards. It may be necessary to replace or make improvements to the existing assets.

18.1.3 The drainage design will be undertaken in accordance with the latest DMRB standards and IANs.

18.1.4 Key constraints and assumptions identified at this stage are:

- Works within flood zones and safeguarded areas.
- Access tracks to ponds are indicative and detailed analysis including turning heads and vehicular track analysis are to be made at further design stages.
- Pre-earthwork ditches have not been designed at this stage. However, land required for the ditches needs to be considered. Ideally a corridor of 13m from the toe of embankment should be kept reserved for the ditches plus a maintenance track.
- Ponds have been sized to store all generated runoff from the catchments for a 1 in 100-year event plus 40% for climate change, with a safety factor of 2. This will be revisited at later stages once further site information is obtained.
- Other relevant constraints shall be identified and included on the GA drawings as they become known.

18.1.5 Risks to the drainage design identified at this stage are:

- Lack of information or incomplete information regarding the existing drainage, attenuation, pollution control and/or ground conditions may result in an incomplete drainage design.
- HAWRAT assessments undertaken during the later design stages may require changes to be made to the design strategy.

18.1.6 Preliminary design of ponds has been carried out and included on the general arrangement drawings. The following tables provide details for each highway design option:

Table 18-1 – Drainage Strategy for Option 1A

Catchment	Impervious Area (Ha)	Outfall location	SUDs	Required Pond Top area (sq.m)	Pond Volume at 1.2m depth (cu.m)	Pond Depth (m)
1	0.57	390772.4443, 226186.4640	Pond	2061	1983	1.5
2	4	391491.1987, 227123.0033	Pond	12360	13587	1.5
3	1.4	391094.2485, 227064.6982	Pond	4677	4859	1.5
4	1.3	391389.0654, 226613.8015	Pond	4348	4492	1.5
5	2.8	391456.3372, 226281.7836	Pond	8891	9617	1.5
6	3.9	390998.3777, 225078.8126	Pond	12144	13339	1.5
7	3.4	390442.2442, 224194.3709	Pond	11788	12931	1.5

Table 18-2 – Drainage Strategy for Option 2

Catchment	Impervious Area (Ha)	Outfall location	Outfall	Required Pond Top area, (sq.m)	Pond Volume at 1.2m depth (cu.m)	Pond Depth (m)
1	0.2	389996.3593, 224969.5749	Pond	988	856	1.5
2	0.5	390778.5222, 226183.4228	Pond	2000	1918	1.5
3	0.1	390169.7917, 225764.3412	Pond	490	365	1.5
4	1.2	390865.6695, 225240.1453	Pond	3934	4036	1.5
5	2.7	391007.6872, 225073.5745	Pond	8781	9493	1.5
6	3.4	390447.3982, 224180.6563	Pond	10685	11667	1.5

Table 18-3 – Drainage Strategy for Option 2A

Catchment	Impervious Area (Ha)	Outfall location	Outfall	Required Pond Top area (sq.m)	Pond Volume at 1.2m depth (cu.m)	Pond Depth (m)
1	0.8	389968.3496, 224964.2691	Pond	2659	2630	1.5
2	1.1	390747.1097, 226211.7006	Pond	3766	3845	1.5
3	1.2	390099.9191, 225754.1717	Pond	4052	4163	1.5
4	0.9	390829.0601, 225273.7309	Pond	3012	3015	1.5
5	2.7	391007.2517, 225084.3990	Pond	8782	9493	1.5
6	3.4	390450.0732, 224184.8303	Pond	10685	11667	1.5

Table 18-4 – Drainage Strategy for Option 2B

Catchment	Impervious Area (Ha)	Outfall location	Outfall	Required Pond Top area (sq.m)	Pond Volume at 1.2m depth (cu.m)	Pond Depth (m)
1	0.7	389986.8999, 224970.1722	Pond	2541	2501	1.5
2	1.6	390788.7384, 226248.2333	Pond	5298	5553	1.5
3	1.9	390044.0558, 225759.3624	Pond	6081	6432	1.5
4	0.9	390852.0791, 225308.4591	Pond	3187	3208	1.5
5	2.7	391009.9375, 225086.0503	Pond	8781	9493	1.5
6	3.4	390447.7087, 224182.0613	Pond	10794	11791	1.5

Table 18-5 – Drainage Strategy for Option 5

Catchment	Impervious Area (Ha)	Outfall location	Outfall	Required Pond Top area (sq.m)	Pond Volume at 1.2m depth (cu.m)	Pond Depth (m)
1	0.4	390772.2868, 226198.6401	Pond	1442	1326	1.5
2	3.9	391019.4307, 226592.3606	Pond	12306	13525	1.5
3	1.3	391110.2722, 227124.1696	Pond	4223	4353	1.5
4	1.6	391372.3108, 226577.2430	Pond	5297	5553	1.5
5	3.3	391308.2517, 226215.3922	Pond	10360	11295	1.5
6	2.9	391006.4701, 225084.1238	Pond	9381	10177	1.5
7	3.4	390450.5381, 224183.4255	Pond	10685	11667	1.5

19 Lighting Assessment

19.1 Options 1A and 5

M5 Junction 10

19.1.1 There is no existing lighting within the extents of the proposed highway works. If consideration were to be given to providing lighting to the proposed junction an assessment would be required in accordance with TA 49/07. If required, lighting should be designed in accordance with TD 34/07.

M5 J10 to A4019 Link Road and West Cheltenham Link Road

19.1.2 The proposed the link roads will require lighting to be considered. The link roads are not a motorway or trunk road, therefore an assessment under TA 49/07 would not be appropriate, but a similar methodology should be employed to assess the need to light.

B4634

19.1.3 There is no existing lighting within the extents of the proposed highway works. As with the M5, if lighting is to be considered, an assessment should be carried out to determine the need to light in accordance with TA 49/07. If required, lighting should be designed in accordance with TD 34/07. The B4634 is not a motorway or trunk road, therefore an assessment under TA 49/07 might not be appropriate, but a similar methodology should be employed to assess the need to light.

A4019

19.1.4 The proposed dualling of the A4019 will require replacement of the existing road lighting. Consideration should be given to increasing the lighting extents to include the currently unlit gap between Homecroft Drive and Hayden Road, and extending the lighting westwards to tie-in with any lighting that may be proposed for the West Cheltenham link road roundabout. The A4019 is not a motorway or trunk road, therefore an assessment under TA 49/07 might not be appropriate, but a similar methodology should be employed to assess the need to light.

19.2 Options 2, 2A and 2B

M5 Junction 10

19.2.1 The proposed works would require removal of the single lighting column at junction 10. If consideration were to be given to providing lighting to the proposed junction an assessment would be required in accordance with TA 49/07. If required, lighting should be designed in accordance with TD 34/07.

West Cheltenham Link Road

19.2.2 The proposed the link road will require lighting to be considered. The link road is not a motorway or trunk road, therefore an assessment under TA 49/07 would not be appropriate, but a similar methodology should be employed to assess the need to light.

B4634

19.2.3 There is no existing lighting within the extents of the proposed highway works. As with the M5, if lighting is to be considered, an assessment should be carried out to determine the need to light in accordance with TA 49/07. If required, lighting should be designed in accordance with TD 34/07.The B4634 is not a motorway or trunk road, therefore an assessment under TA 49/07 might not be appropriate, but a similar methodology should be employed to assess the need to light.

A4019

19.2.4 The proposed dualling of the A4019 will require replacement of the existing road lighting. Consideration should be given to increasing the lighting extents to include the currently unlit gap between Homecroft Drive and Hayden Road, and extending the lighting westwards to tie-in with any lighting that may be proposed for the West Cheltenham link road roundabout. The A4019 is not a motorway or trunk road, therefore an assessment under TA 49/07 might not be appropriate, but a similar methodology should be employed to assess the need to light.

20 Maintenance Assessment

20.1.1 Maintenance of assets along the M5 will not change significantly. Where new assets are provided their maintenance demand will be evaluated to minimise road worker exposure and risk and steps taken to provide off-network access where possible. The hard shoulder will continue to be used as and when required for maintenance purposes.

20.1.2 Where new technology is implemented on the motorway, safe access will be provided inclusive of any necessary access steps and handrails. If safe access cannot be provided from the hard shoulder (or off-motorway) it may also be necessary to provide parking areas. Under Option 2A (and possibly Option 2B) the Uckington Transmission Station (TS) will require relocation. The new TS will need to be constructed in the locality of the current TS with parking space and safe access for maintainers (on or off motorway).

20.1.3 During the construction phase technology maintainers may require access to operational technology (inclusive of TS) on a 24-hour basis.

20.1.4 New signing and lighting will be required on the slip roads and at the roundabout and the maintenance of these items will need to be considered. Laybys are likely to be required both on the slip roads and on the roundabout, which could be used to maintain multiple assets grouped together where possible.

20.1.5 The new sections of carriageway providing links to the B4634 will require maintenance and the maintenance of new assets such as new lighting and signs along these routes will need to be considered. Off-network access will be provided wherever possible and laybys or areas of hardstanding incorporated into the scheme. Any new assets will be designed to minimise maintenance demand.

20.1.6 Where new structures such as bridges are being provided consideration will be given to the types of material used in construction to minimise weathering and maintenance requirements. Two new bridges will be required for four out of the five options along the new section of carriageway (south of A4019) linking to the B4634. Option 1A also involves the construction of a viaduct over a floodplain to the north of the A4019.

20.2 Maintenance and Repair of Civil Infrastructure

20.2.1 The purpose of inspection, testing and monitoring is to verify that highway structures are safe and fit for purpose and to provide the data required to support effective maintenance management and planning.

20.2.2 To keep the structure in a good state of repair and to avoid the need to replace items and employ specialist services it is necessary to frequently perform basic maintenance. Routine maintenance is minor work carried out on a regular or cyclic basis that helps to maintain the condition and functionality of the structures and reduce the need for other maintenance works.

20.2.3 Preventative maintenance (planned or unplanned) is work carried out to keep the infrastructure open and safe to use and maintain the condition of the structure by protecting it from deterioration or slowing down the rate of deterioration. By timely intervention, preventative maintenance reduces the need for essential work and/ or the likelihood of essential work arising prematurely in the future.

20.2.4 Major overhauls and refurbishment of structural elements are undertaken on a basis that ensures the long-term preservation of investment by acting on the agreed recommendations of the Principal Inspection reports.

20.2.5 All of the options being considered involve some civil infrastructure and technology works and would require comprehensive monitoring, inspection and maintenance plans to be developed if they are to remain in service for their expected design life and beyond.

20.2.6 The options all involve lengths of new highways, new junctions, earthworks, drainage and other items of highways infrastructure including structural and electrical systems. All of these would require a programme of maintenance and periodic renewals.

21 Environmental Assessment

21.1.1 The assessments outlined in this section provide summaries of the Preliminary Environmental Assessment of Options undertaken to produce Preliminary Environmental Assessment of Options Report (PEAOR). For further detail about the assessment of options, please refer to the PEAOR (GCCM5J10-ATK-EGN-RP-LM-000002).

21.2 Noise and Vibration

Option Comparison

21.2.1 All options result in perceptible changes in noise level in the short and long term. Traffic data provided for Option 2 covers both option 2A and 2B assessments.

21.2.2 The table below summarises the impacts, significant effects and Net Present Value change.

Table 21-1 – Summary Results

		Option 1A	Option 2	Option 5
Short Term	Perceptible Decreases	282	1670	266
	Perceptible Increases	768	345	704
	Significant effects - policy	28	14	27
	Significant increases - EIA	3	2	1
	Significant decreases - EIA	2	523	4
Long Term	Perceptible Decreases	3	239	3
	Perceptible Increases	257	20	257
	Significant effects - policy	209	75	192
	Significant increases - EIA	0	1	0
	Significant decreases - EIA	1	4	3
Net Present Value Change due to Noise (£)		£3,039,907	£5,682,658	£3,209,051

21.2.3 Of the 3 options considered, Option 2 results in the fewest perceptible increases and the most perceptible decreases. Due to this, Option 2 has a positive Net Present Value of change in noise, demonstrating a net improvement. Option 2 also has the greatest potential for significant decreases in noise in EIA terms. Options 2A and 2B are likely to have similar results.

21.2.4 Both Option 1A and Option 5 introduce a new road to the north of A4019 which has impacts at a number of properties around Elmstone Hardwicke. Option 2 does not introduce this new road and therefore there are fewer impacts in this area. Option 1A and Option 5 have negative Net Present Value changes in noise, demonstrating a net disbenefit.

21.2.5 Based on this assessment Option 2 is recommended from a noise perspective.

Mitigation

21.2.6 Mitigation measures have not been considered as part of this assessment however, a short summary on the likely efficacy of mitigation for each option is discussed below. In all instances, more detailed investigation of mitigation should be undertaken at a later design stage.

21.2.7 With all options, significant effects are predominantly along A4019 and A40. It may be possible to mitigate these receptors with the use of noise barriers; however, this would be dependent on access to the receptor not being directly from the main highway.

21.3 Air Quality

Option Comparison

21.3.1 All the scheme options have the potential to affect local air quality pollutant concentrations at sensitive receptors, both during construction and operation.

21.3.2 A preliminary assessment of inter option differences has been conducted for operational phase traffic data provided for Options 1A, 2 and 5. A qualitative comparison of road links defined as ARN (increase or decrease) for each option has been used to infer areas where changes in air quality pollutant concentrations may occur. All three options followed a similar pattern of traffic change distribution; however, some notable differences are observable from the traffic changes expected with the Scheme.

21.3.3 Analysis of the traffic data showed that the with Scheme traffic change distribution for Options 1A and 5 were broadly similar. A reduction of AADT is expected on roads near to the M5 J11 which are currently used to access north western areas of Cheltenham Spa (including B4063, A40 East of M5 J11 and Fiddlers Green Lane/Hesters View). An increase in AADT was observed in locations near to the revised M5 J10 layout, the A40 West of M5 J10 and key routes through central areas of Cheltenham Spa. This includes both areas within the designated AQMA and at locations where monitored nitrogen dioxide (NO2) concentrations have recently exceeded the annual mean Air Quality Strategy objective of 40 µg/m3, including on the A4019 and St Margaret's Street

21.3.4 A notable difference was observed for Option 2 which had fewer ARN links classified due to increases in traffic in 2021. The option is expected to result in fewer ARN links (those with an increase in traffic movements) in central areas of Cheltenham Spa, within the AQMA. This is of particular importance when considering options as these areas are likely to be the most sensitive to changes to air quality.

21.3.5 The 2036 options analysis shows a similar pattern, with the majority of the ARN classified links showing an increase in AADT with the Scheme. In all three options, the only major links which were classified as an ARN due to a decrease in traffic levels were the B4063 and B4634. The only notable difference between the options was that in Option 2, a large section of the A38 was shown to have a reduction in AADT meeting the ARN change criteria. Conversely, in Option 1A and Option 5, the same A38 link was included in the ARN due to an expected increase in AADT.

21.3.6 It must be noted that this qualitative assessment has only determined whether a link is defined as within the ARN or not. No quantitative air quality assessment has been conducted as to the magnitude of change above the assessment criteria or the number of sensitive receptors adjacent to ARN road links. As such, the conclusions can only be used to allow a comparative assessment of the options rather than consideration of environmental effects of the Scheme.

Mitigation

21.3.7 No mitigation is proposed at this stage for minimising air quality and dust from the construction and operational phase. Mitigation, proportional to the expected magnitude of the effects will be determined based on the full impact assessment of the preferred option.

21.4 Greenhouse gases

Option Comparison

21.4.1 Irrespective of the route option selected, the Scheme will lead to a negative effect on climate through the generation of greenhouse gas emissions in the construction phase. However, the National Policy Statement (NPS) for National Networks states that this type of scheme is unlikely to produce a significant effect in comparison to UK total emissions. It is therefore considered unlikely that any of the options will produce a significant negative effect on climate.

21.4.2 Initial assessment suggests that in the construction phase, Option 2A is likely to lead to the lowest emissions and is therefore the preferable route option in terms of the Scheme's effects on climate. Options 1A and 5 are likely to lead to the highest emissions.

Mitigation

21.4.3 Although the Scheme is unlikely to produce a significant effect on climate (as a consequence of its scale), it is recommended that design and mitigation measures are put in place to reduce emissions in line with national policy. Emissions will be mitigated by applying Highways England's carbon reduction hierarchy:

- Avoid / prevent
  - Maximise the potential for re-using and / or refurbishing existing assets to reduce the extent of new construction required; and
  - apply alternative lower carbon options to deliver the project objectives (i.e. shorter route options with smaller construction footprints).
- Reduce
  - apply low carbon solutions (including technologies, materials and products) to minimise resource consumption during the construction, operation, user's use of the project, and at end-of-life; and
  - construct efficiently, using techniques (e.g. during construction and operation) that reduce resource consumption over the life cycle of the project.
- Remediate
  - after addressing steps 1 and 2 projects will identify, assess and integrate measures to further reduce carbon through on or off-site offsetting or sequestration.

21.4.4 Specific potential mitigation measures relevant to the construction and operational phases of the Scheme are suggested below. The defined measures are consistent with PAS 2080:2016 'Carbon Management in Infrastructure', which is the technical standard for measuring and managing emissions from infrastructure.

Table 21-2 – Construction mitigation measures

Life Cycle Module	Potential Mitigation Measures
Materials production	Selection of route based on which option has the lowest/lower material consumption requirement, with preference given to shorter routes which require less new major infrastructure. Where possible, existing infrastructure should be re-used and refurbished preferentially, over new infrastructure. Reduction of materials consumption should be carried out in accordance with the mitigation measures outlined in the Materials and Waste Chapter. Consideration should be given to alternative low-carbon materials e.g. recycled aggregates, cement substitution etc.
Materials transport	Materials transportation should be avoided / reduced by minimising the quantity of materials required, as per the above, and procuring from primary manufacturers, as locally as possible. Where possible, detailed design and procurement measures should be specified to enable local sourcing of materials.
Construction processes	**Construction Plant Use** Construction plant emissions should be minimised by designing for efficient construction processes as part of design development. During construction, plant emissions should be managed via the Construction Environmental Management Plan (CEMP), which should specify plant operator efficiency requirements. **Construction Water Use** Construction water consumption should be minimised by designing for efficient construction processes as part of design development. During construction, mains water consumption will be managed via the CEMP, which should specify reduction and reuse measures. **Construction Waste Transportation** Reduction of waste generation should be carried out in accordance with the mitigation measures outlined in the Materials and Waste Chapter. **Construction Waste Offsite-Processing** Appropriate waste treatment / disposal should be carried out in accordance with the mitigation measures outlined in the Materials and Waste Chapter. **Employee Commuting** Local contractors should be used where possible, reducing the distance driven by employees.

21.4.5 Operational emissions can be mitigated by designing a Scheme which minimises emissions from traffic and operational energy use. Potential specific mitigation measures that will reduce in-use emissions include;

- route selection and design for efficient operation of vehicles, including shorter, flatter routes with fewest at-grade junctions to reduce stop-start traffic;
- inclusion of Walking, Cycling and Horse Riding routes to encourage the utilisation of alternative means of transport, and help to achieve the goal of creating a more integrated and sustainable transport network, whilst reducing emissions; and
- operational energy use should be minimised by designing for use of low energy lighting and traffic management systems, specification of controls that minimise on-time, and use of low-carbon energy sources where practicable.

21.5 Landscape and Visual Amenity

Option Comparison - Landscape character

21.5.1 Although there would be increased presence of roads and accommodation bridges these would essentially be in keeping with the existing landscape character of the area which does include roads aligned north/south as characteristic aspects. Similarly, adjustments to the M5 Junction itself, for any Option, would not be out of place in the existing context.

21.5.2 The Scheme would include requirement for attenuation ponds. Although there are ponds within the study area, they are typically not of the scale suggested by the indicative design, particularly for Options 1A and 5, which have the most and largest attenuation ponds. It should be noted that the attenuation pond design is indicative, and it is anticipated that design development would include exploring "naturalistic" formations, utilising underground storage features and well considered landscaping, which would help to integrate the ponds and mitigate any significant adverse effect on the character of the landscape.

21.5.3 Impacts on the Cotswold AONB are considered to be negligible due to the distance. Overall the impact on Landscape Character is expected to be negligible to minor for all options and not significant.

Visual impacts

21.5.4 All Scheme route options have the potential to cause visual impacts on the PRoW in the land to the south-east of the existing M5 J10 between A4019, Withybridge Lane and West Cheltenham Link Road. The link road would sever/shorten all these PRoW; although new access would be provided.

21.5.5 All Scheme route options also have the potential to cause impacts for property visual receptors between the A4019, Withybridge Lane and B4634 due to the proximity of the proposed West Cheltenham Link Road; and for properties along the A4019 frontage due to the effects of widening this road. Careful design and mitigation would be essential to avoid significant effects arising from these landscape and visual impacts on PRoW and properties.

21.5.6 Option 1A has the potential to cause impacts for the bridleway running north-east of the A4019 due to severance; and for Barn Farm and properties to north-east of the Elmstone/Hardwicke road due to the new M5 slip road and the new Elmstone/Hardwicke access bridge respectively. Eight other PRoW Groups and Visual Groups may also experience impacts.

21.5.7 Option 2 has the potential to cause impacts for three visual groups around the existing M5 Junction 10, due to the new junction slip roads and roundabout. Five properties from the property group immediately to south-east of M5 Junction 10 and possibly three, plus the nurseries from the property group immediately to north-west of M5 Junction 10 would also require demolition.

21.5.8 Option 2A requires demolition of four properties immediately to south-east of M5 Junction 10; three properties plus the nurseries immediately to north-west of M5 Junction 10 and two properties to north-east of M5 Junction 10. There would potentially be visual impacts for the remaining properties to immediate south-east and north-west, due to the new junction slip roads and roundabout.

21.5.9 Option 2B would require the demolition of all properties to immediate south-east of M5 Junction 10 and two properties from those to north-west, with some encroachment into the nurseries' land. Significant effects from visual impacts for remaining properties could be avoided with good design and mitigation planting. There is also the potential for Option

2B to have a beneficial effect on the two properties to immediate north-east of M5 J10, due to the impact of the A4019 being moved away from these properties.

21.5.10 Option 5 has the potential to cause impacts for the bridleway running north-east of the A4019 due to intersection with this route; and for properties to north-east of the Elmstone/Hardwicke road, due to new Elmstone/Hardwicke access bridge. Eight other PRoW Groups and Visual Groups may also have impacts. Barn Farm would require demolition.

21.5.11 In conclusion, all options have the potential to cause significant visual effects. The least number of additional effects for are expected for Option 2B, followed by 2A, 2 and 5, with the greatest number of additional effects expected for Option 1A.

Mitigation

21.5.12 Detailed mitigation measures would be worked up as part of the overall preferred route design to ensure significant effects are avoided.

21.5.13 Vegetation removal should be kept to that necessary for the works and where possible new road alignments should be adjusted during design development to avoid mature trees and hedgerows.

21.5.14 Consideration of colour, scale and form are important and good quality junction, road, viaduct and associated infrastructure design is essential to embed these features into the landscape and ensure they do not dominate any view or appear out of place.

21.5.15 Design of the attenuation ponds would include exploring “naturalistic” formations, utilising underground storage features and well considered landscaping, which would help to integrate the ponds into the landscape.

21.5.16 Well considered mitigation planting is important to provide adequate screening in appropriately sized banks of planting and avoid the introduction of uncharacteristic large blocks of woodland.

21.5.17 Enhancement of the environment along the A4019 to improve the experience for residents, pedestrians, cyclists and vehicles users is also recommended.

21.6 Heritage and historic resources

Option Comparison

21.6.1 All options have the potential to have adverse impacts on the historic environment. These include direct physical impacts to known archaeological remains and indirect impacts to listed buildings as a result of changes to their settings. Options 1A and 5 would result in more physical impacts to known archaeology due to their impacts to GHER 48029. As such, these options can be said to have the potential for having a greater impact on the historic environment than of Options 2, 2A, and 2B.

21.6.2 All options have the potential for also directly impacting on as-yet unknown archaeological remains. These are assessed at likely relating to local and regional research goals and would be considered to be of low to medium value. Options 1A and 5, due to the need for greater areas of new construction north of the A4019, are considered to have the potential for a greater number of impacts to these archaeological remains.

21.6.3 None of the options present potential impacts to cultural heritage that are considered to rise to the level of “significant harm” under the National Planning Policy Framework (NPPF), provided a suitable programme of mitigation, evaluation, and recording is undertaken.

Mitigation

21.6.4 For all Options, a programme of archaeological works is recommended to further identify, characterise and evaluate both the known and unknown impacts to heritage assets. Such a programme would include:

- A desk-based assessment of the known baseline, including review of published archaeological investigations undertaken in the area and archival sources to understand impacts from previous developments, such as the construction of the M5;
- Setting assessments for the designated heritage assets that may be impacted by the chosen option, focusing on how the setting of each asset contributes to its significance to understand its capacity for changes to the setting;
- Geophysical surveys of the selected option to identify as-yet unknown buried archaeological remains;
- Evaluation trenching to understand the nature and significance of buried archaeological remains that would be impacted by construction of the chosen option;
- Area excavations or other recording programmes to off-set the impacts of construction and preserve by record the significant information associated with the remains.

21.7 Biodiversity

Option Comparison

21.7.1 All of the Scheme options have the potential to have significant impacts on the identified ecological features. Further survey work is required and/or under way to enable assessment of those impacts.

21.7.2 While an attempt has been made below to make a preliminary comparison of the options at this stage, it must be noted that, in the absence of complete survey information, such a comparison could be skewed by the exclusion or inaccurate prediction of impacts for particular options, especially in relation to bats, dormouse, birds, reptiles and invertebrates.

21.7.3 Based on the information that is currently available, the most adverse ecological effects are predicted for Options 1A and 5 (the northern options). These include potential moderate adverse construction impacts on the CFHN and terrestrial invertebrates and potential moderate adverse operation impacts on the CFHN, otter and great crested newt, plus a slight adverse operation impact on common toad. There are also construction impacts that are predicted to be significant for all the options, but that would potentially be worst for Options 1A and 5, including impacts on great crested newt, common toad, Leigh Brook and ponds.

21.7.4 There are also some impacts that are predicted to be worse for Options 2, 2A and 2B. A slight adverse impact is predicted due to loss/degradation of aquatic habitat on the Unnamed Tributary of the River Chelt, which is only associated with Options 2A and 2B. Also, significant impacts on the River Chelt and the Unnamed Tributary of Leigh Brook are predicted for all options but are predicted to be worst for Options 2, 2A and 2B.

21.7.5 All the options are currently predicted to have very large adverse impacts on bats during construction and operation. All would result in the loss and fragmentation of foraging and commuting habitats, particularly through the construction of the new highway link between the A4019 and B4634 (option wide). However, there are differences between the options in the number and type of bat roosts and potential roost features that would be affected (see Table 2). Based on what has been surveyed to date, generally more potential tree roosts would be lost with the northern options and more confirmed and potential building roosts would be lost with Options 2, 2A and 2B.

Table 21-3 – Confirmed bat roosts and potential bat roost

Roost Status	Option Wide	Option 1A	Option 2	Option 2A	Option 2B	Option 5
Buildings						
Confirmed Roost	0	0	+2	+2	+2	+1
High Roost Potential	0	0	0	0	+1	+1
Moderate Roost Potential	0	0	+4	+7	+7	0
Low Roost Potential	0	0	+2	+6	+6	0
Trees						
Confirmed Roost	0	0	0	+1	+1	0
High Roost Potential	4	+6	0	+2	+1	+3
Moderate Roost Potential	7	+5	+8	+11	+9	+6
Low Roost Potential	3	+26	+6	+14	+11	+16

Confirmed bat roosts and potential bat roost features that would be lost for all Scheme options (Option Wide) and additional losses associated with each individual option (note that these values are based on incomplete survey data)

Mitigation Measures

21.7.6 The overarching aims of the mitigation will be to ensure legal compliance and deliver a net gain for biodiversity, in accordance with national and local planning policy.

21.7.7 In accordance with the mitigation hierarchy[8], the primary mitigation measure will be avoidance of impacts via option selection and Scheme design (e.g. alteration of the Scheme footprint to avoid loss of a particular habitat). The next step will be to minimise effects that cannot be avoided. Generic measures that will be employed to minimise ecological effects include:

- Design amendments to minimise habitat loss;
- Design amendments to incorporate habitat connectivity features, such as habitat corridors, wildlife underpasses and/or green bridges;
- Establishment of an appropriately sized, resourced and experienced site environmental management team (including at least one Ecological Clerk of Works (ECoW)) to ensure effective implementation of all environmental mitigation;
- Ecological briefings / toolbox talks for all site operatives to make them aware of relevant constraints and requirements prior to commencing work on the Scheme;
- Clear demarcation (i.e. fencing) of retained habitats and no allowance of vehicles or storage of materials within these areas;
    - Timing works to avoid exposure of soil during autumn/winter;
    - Seeding/planting exposed topsoil at earliest opportunity;
    - Use of silt fencing, drainage ditches, attenuation ponds, etc;
- Use of pollution control measures during construction, such as:
    - Use of low emission plant;
    - Regular maintenance and inspection of machinery;

[8] The 'mitigation hierarchy' seeks as a preference to avoid impacts then to mitigate unavoidable impacts, and, as a last resort, to compensate for unavoidable residual impacts that remain after avoidance and mitigation measures (The British Standards Institution (2013). *BS 42020:2013. Biodiversity — Code of practice for planning and development*.)

- Use of designated, bunded areas away from sensitive ecological features for fuel storage and refuelling (i.e. following EA Pollution Prevention Guidance (PPGs)[9] and the Construction Industry Research and Information Association (CIRIA) guidance on the control of water pollution from construction sites[10]);

- Location of haul roads away from sensitive features and use of dust suppression measures during dry periods;
- Covering excavations overnight or incorporating features such as ramps to prevent animals getting trapped;
- Designing the construction and operation drainage to maintain or enhance[11] the existing hydrological conditions; and
- Designing the operation drainage to minimise the risk of pollution from the road surface coming into contact with sensitive habitats.

21.7.8 In addition to the generic measures set out above, specific mitigation strategies are likely to be needed for bats, dormouse, badger, otter, water vole, breeding birds, reptiles and great crested newt, including provision of compensatory habitats, disturbance avoidance measures and adoption of sensitive habitat clearance methods (under Natural England licences where appropriate) to avoid harm during construction. Specific measures will also be required to prevent the spread of invasive non-native species of plant, such as Himalayan Balsam.

21.8 Geology and Soils

Land contamination, geology and geomorphology

21.8.1.1 Option Comparison: Options 1A and 5

21.8.2 With respect to land contamination, the assessment of baseline conditions, and the magnitude of the potential impact (change) of the Option 1A and Option 5 scheme layout has been assessed not significant (neutral to minor beneficial) following implementation of mitigation measures during construction phase. The operational phase has been assessed as having a neutral to minor beneficial effect and has therefore been assessed as not significant.

21.8.3 With respect to geology / geomorphology the assessment indicated that the construction phase and the operational phase will have a neutral to minor beneficial effect, this has been assessed as not significant.

21.8.3.1 Option Comparison: Options 2, 2A and 2B

21.8.4 With respect to land contamination, the assessment of baseline conditions, and the magnitude of the potential impact (change) of the Option 2, 2A and 2B scheme layout has

[9] Note that a review of the PPGs is currently underway, resulting in a replacement guidance series for Scotland, Northern Ireland and Wales (Guidance for Pollution Prevention (GPPs)). In the absence of the new guidance in England the existing (withdrawn) PPGs provide appropriate guidance to be followed. If individual PPGs have been superseded with a GPP, it is recommended that the newer guidance is used despite not being compiled by the Environment Agency and the https://www.gov.uk/guidance/pollution-prevention-for-businesses website is consulted.
[10] The CIRIA documents are a series of publications developed by the Construction Industry Research and Information Association. Each document is targeted at a particular type of business or activity and covers environmental good practice to minimise pollution. Particular attention should be given to CIRIA C532 (Control of water pollution from construction sites, 2001).
[11] Enhancement in this context means the enhancement of one or more features' ecological condition or value, without detriment to other ecological features.

been assessed not significant (neutral to minor beneficial) following implementation of mitigation measures during construction phase. The operational phase has been assessed as having a neutral to minor beneficial effect and has therefore been assessed as not significant.

21.8.5 With respect to geology / geomorphology the assessment indicated that the construction phase and the operational phase will have a neutral to minor beneficial effect, this has been assessed as not significant.

21.8.5.1 Mitigation

21.8.6 A summary of the proposed measures to be incorporated into the design of the proposed Scheme in relation to soils and geology are likely to include:

- A ground investigation would be undertaken to inform the Scheme design and confirm the ground conditions and contamination status of the site, with subsequent remediation of soil and groundwater undertaken prior to construction if the investigations and risk assessment deem necessary;
- and
- Gas protection measures would be incorporated within proposed structures if monitoring and risk assessments deem them to be necessary.

21.8.7 Standard mitigation measures based on current guidance and regulations would be incorporated into the construction process via a Construction Environmental Management Plan (CEMP). These are not repeated here.

21.8.8 It has been assumed that hardstanding will be placed across the majority of the proposed works associated with the carriageway, except for soft landscaping along embankments and cuttings, which will minimise the generation of dust, direct contact and ingestion pathways and minimise infiltration during the operational phase. If soil contamination is identified, laying of a clean capping layer may be required in areas of proposed soft landscaping.

21.8.9 Drainage design will consider the risks from any residual contamination and designers may be required to use lined drainage systems in areas of contamination that may be left in situ. If soil and / or groundwater contamination is identified during the ground investigation which poses a risk to sensitive receptors, appropriate remediation will be undertaken.

21.8.10 Design of the road and the selection of construction materials would be in accordance with DMRB, British Standards and best practice guidance at the time of the design. The design would be required to take into account the ground conditions including the potential for ground movement, compaction, ground gas and ground aggressivity.

21.8.11 Furthermore, pollution prevention measures incorporated within drainage design will mitigate the risk of contamination to controlled waters. The principles of drainage design for the proposed development are summarised in Chapter 8 Road Drainage and the Water Environment.

Agricultural Land

21.8.12 The main agricultural impacts of all five options are:

- Loss of agricultural land and its potential impact on the viability of farms;
- Severance of agricultural land and its potential impact on the viability of farms; and
- Loss of BMV land as a national resource,

21.8.13 At this stage the calculations of agricultural land-take are close approximations, based on measurements taken from Google Earth. Where the size and shape of a drainage pond would render a field or part of a field unusable for agricultural purposes, the area of measured land-take has been extended beyond the red line boundary to include those unusable areas. Most significant to this assessment are the relative amounts of land-take.

21.8.13.1 Option 1A (North) Specific

21.8.14 The impacts on agricultural land without mitigation are:

- Loss of agricultural land – 32.5 ha;
- Linear severance –3.0 km; and
- Loss of BMV land – 8.5 ha.

21.8.14.1 Option 2 (On Junction) Specific

21.8.15 The impacts on agricultural land without mitigation are:

- Loss of agricultural land – 15.5 ha;
- Linear severance – 1.5 km; and
- Loss of BMV land – 6.0 ha.

21.8.15.1 Option 2A and 2B (On Junction) Specific

21.8.16 The impacts on agricultural land without mitigation are:

- Loss of agricultural land – 17.0 ha;
- Linear severance – 1.5 km; and
- Loss of BMV land – 7.0 ha.

21.8.16.1 Option 5 (South)

21.8.17 The impacts on agricultural land without mitigation are:

- Loss of agricultural land – 30.0 ha;
- Linear severance – 2.6 km; and
- Loss of BMV land – 9.0 ha.

21.8.17.1 Agricultural Land Summary

21.8.18 Options 1A and 5 have the greatest impacts on agricultural land in terms of land-take, severance and loss of BMV land. Option 1A would take 2.5 ha more agricultural land than Option 5. Without mitigation, these impacts would be moderate adverse (significant) in terms of their effects on farm holdings and loss of high-quality land.

21.8.19 Option 2, 2A and 2B have the least impacts on agricultural land in terms of land-take, severance and loss of BMV land. Without mitigation, these would be minor adverse (not significant) in terms of their effects on farm holdings and moderate (significant) for loss of high-quality land.

21.8.20 After mitigation of severance, Options 1A and 5 would still have the greatest impact on agricultural land because of total land-take and loss of BMV land. Option 1A would take 2.5 ha more agricultural land than Option 5. These land-take impacts are assessed as moderate adverse (significant), while that of severance would be reduced to minor adverse (not significant).

21.8.21 Option 2, 2A and 2B ha have minor impacts (not significant) on agricultural land in terms of land-take and severance and moderate impacts (significant) for loss of BMV land.

21.9 Water Environment

Option Comparison

21.9.1 All options have the potential to have impact upon the water environment the extent to which depends upon whether the overall driving purpose is surface water quality, hydromorphology or flood risk; as summarised below:

Surface water

21.9.2 Option 1A is the least preferred option as this has the largest scheme footprint. Option 1A hence has the largest contributing impermeable area discharging to water receptors and the larger area gives the higher risk of a potential spillage occurring. Option 2 is the most preferred as this option has the smallest scheme footprint, followed by options 2A, 2B and 5.

21.9.3 Based on the proximity of the surface water receptors from the options, in conjunction with an understanding of well-known flood risk issues in the vicinity, it is assumed the following receptors (from highest risk to least risk) are at most potential risk. The River Chelt is considered to be the highest risk, due to the new embankment for the new section of road linking the A4019 and Old Gloucester Road, which crosses the flood plain of the River Chelt. It is also presumed, potential impacts to Hyde Brook and Wymans Brook could be more acute as there are no existing crossing points at this location at present.

- River Chelt
- Leigh Brook
- Hyde Brook
- River Swilgate
- Dean Brook
- Wymans Brook
- Hatherley Brook

21.9.4 Without appropriate mitigation, and any supporting quantitative details on the proposed drainage, the works could result in changes to the WFD status (should water standards be breached). The potential overall effect on surface water (without mitigation) has therefore been assessed as large adverse and is considered to be significant.

21.9.5 Subject to the correct implementation of all mitigation measures, the overall residual effect on surface water has been assessed as neutral which is not considered significant.

Hydromorphology

21.9.6 Options 1A and 5 are the preferred options in this study as they do not require culvert extensions over the River Chelt for the two existing M5 crossing points. The river at these two points has higher ecological and geomorphological quality than at the locations where new crossings are proposed for all the options. Options 2, 2A and 2B include culvert extensions at the two existing M5 crossing points on the River Chelt as well as new crossing points, so are less favourable options

21.9.7 A further assessment of the impacts on the WFD should be undertaken once a preferred option has been chosen, together with consultation with the Environment Agency

Flood risk

21.9.8 Option 2B entails the most construction in the floodplain and will therefore likely require the most mitigation. Option 1A entails the least and is most preferred from a flood risk perspective

21.9.9 Subject to the implementation of all mitigation measures, the construction and operation of all options is not likely to have an adverse impact on flood risk.

21.9.10 More detailed flood modelling is required to understand this potential risk of this.

21.9.11 Further assessment of groundwater flood risk should also be undertaken.

Mitigation

21.9.12 All design, construction and operation work would be carried out in accordance with a number of standard mitigation measures and follow best practice and guidelines, including DMRB, that would prevent damage or loss to the water environment and prevent harm to human health.

21.9.13 Specific note should be made in that single span structures are the preferred type of watercourse crossing because they minimise impact on the water environment if designed appropriately. They should be designed and constructed in such a way as to minimise disruption to the river and riparian zone. Abutments should be set well back from the bank edge to allow the river to function naturally and to maintain a wildlife corridor along the banks.

21.10 Materials and Waste Impacts

21.10.1 Due to the minimal impact anticipated, materials and waste during operation has been scoped out of the assessment.

Construction Phase Materials

21.10.2 The material volumes for the Scheme are shown in and the assessment based on those volumes is shown in Table 21-4. Volumes of materials to be used have been sourced from the emerging design detail and are currently limited to aggregates for embankments/earthworks and asphalt.

21.10.3 It is likely the Scheme will use more material types and volumes and this detail will be available at later design stages.

Table 21-4 – Material Volumes

Material	Option 1A (m^3)	Option 2 (m^3)	Option 2A (m^3)	Option 2B (m^3)	Option 5 (m^3)
Aggregates	393,134	352,835	338,789	404,871	411,412
Asphalt	9,644	7,644	7,816	8,409	9,233

Table 21-5 – Material Assessment

Option	Material	Material Baseline (tonnes)	Estimated Material Use (tonnes)*	Percentage Impact	Effect Category
Option 1A	**Aggregates**	**29,400,000**	**428,516**	**1.46**	**Slight**
Option 2			**384,590**	**1.31**	**Slight**

Option 2A			**369,280**	**1.26**	**Slight**
Option 2B			**441,309**	**1.50**	**Slight**
Option 5			**448,439**	**1.53**	**Slight**
Option 1A	**Asphalt**	**2,100,000**	**7,908**	**0.38**	**Slight**
Option 2			**6,268**	**0.30**	**Slight**
Option 2A			**6,409**	**0.31**	**Slight**
Option 2B			**6,895**	**0.33**	**Slight**
Option 5			**7,571**	**0.36**	**Slight**

**Converted from m^3 to tonnes using indices from WRAP

21.10.4 Data in the table above shows that although all Options will have a slight effect, for aggregates Option 5 will have the greatest impact and Option 2A will have the least impact. For asphalt Option 1A will have the greatest impact and Option 2 will have the least impact.

21.10.4.1 Recycled Aggregate Assessment

21.10.5 It is not currently known how much recycled material will be used within the Scheme. This will be assessed at a later stage.

21.10.5.1 Waste Infrastructure Capacity Assessment

21.10.6 There is currently limited data on the volumes of waste that may be generated by the Scheme. At present the quantifiable amount is that which will be generated from excavating ponds, required for the runoff from the Scheme. The table below summarises these volumes.

Table 21-6 – Pond Excavation Volumes

Waste	Option 1A (m3)	Option 2 (m3)	Option 2A (m3)	Option 2B (m3)	Option 5 (m3)
Soil	77,401	36,228	44,495	49,765	73,723

21.10.7 The table above indicates that Option 1A will have the greatest impact and that Option 2 will have the least impact.

21.10.8 The other main waste stream from the Scheme will be that generated from demolition. There are currently no quantities for this however, based on a review of the summary details of the Scheme it is assumed, using professional judgment, that Option 2b will have the greatest impact due to the number of buildings and structures requiring demolition and Option 2 will have the least impact.

Summary of CD&E significant effects

21.10.9 Due to limited information on materials and waste for the Scheme at this design stage, none of the Options are considered likely to have a significant impact.

21.10.10 Based on a ranked scoring system (high score – lower impact) Option 5 currently has the greatest impact overall for materials and waste and Option 2 has the lowest impact overall.

Table 21-7 – Summary of Effects

Ranking	Option 1A	Option 2	Option 2A	Option 2B	Option 5
Asphalt	1	5	4	3	2

Aggregate	3	4	5	2	1
Excavation waste	1	5	4	3	2
Demolition waste	4	5	2	1	3
Total	**529**	**929**	**730**	**399**	**398**

Potential Mitigation Measures

21.10.11 Mitigation measures are necessary to reduce the environmental effects of both the CD&E and operational phases of the Scheme. The following sections detail the mitigation measures that should be implemented. Many of the measures outlined in both the CD&E and operational sections for waste are also mitigation measures for materials and as such a separate section is not included.

21.10.11.1 Construction Phase

21.10.12 There are several measures that can be utilised throughout the construction phase of the Scheme which will reduce the impact of materials and waste. These are detailed in the sections below.

21.10.13 An overarching measure is the implementation of the waste hierarchy, which is also beneficial for material use.

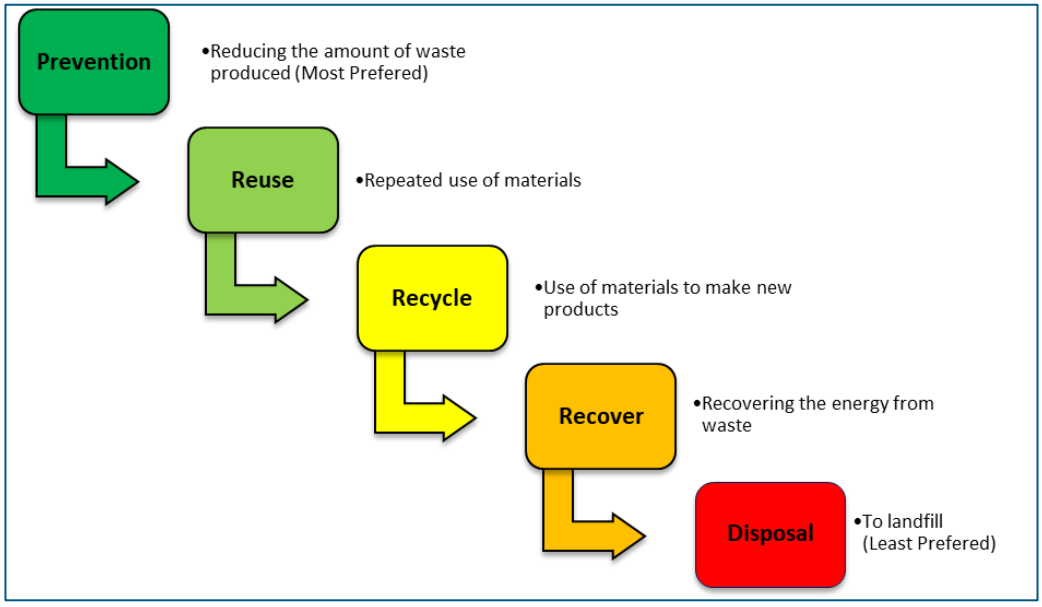


Figure 21-1 Waste Hierarchy

21.10.13.1 Designing Out Waste

21.10.14 Within the design process of the Scheme, materials use and waste generation should be minimised as early as is practicable.

21.10.15 The UK's Waste Resources Action Programme (WRAP) has produced guidelines for design teams, which should be considered during the Scheme, under the following headings:

- Re-use and recovery;
- Off-site construction;
- Materials optimisation;

- Waste efficient procurement; and
- Deconstruction and flexibility.

21.10.15.1 On-Site Management

21.10.16 Best practice waste management, which should be considered include:

- Setting targets for waste recovery and recycling, communicating these to those working on the Scheme with a clear understanding of what is expected;
- Preparation and maintenance of an Operational Environmental Management Plan (OEMP) and a Site Waste Management Plan (SWMP) so that waste generation and management can be logged and audited;
- Using precast concrete and other materials that can be prepared off-site to minimise waste generation on-site;
- Using recycled materials wherever practicable;
- Not over ordering materials and using materials brought to site as efficiently as possible;
- Organising deliveries so materials arrive on-site as they are needed to reduce the possibility of damage and wastage occurring;
- Having clearly defined and separated skips on-site and a clearly demarked waste area(s); and
- Training staff to understand how they should sort any waste and providing regular reminders and updates.

21.10.17 Best practice waste management not only reduces the environmental effects of a Scheme through reducing waste to landfill or incineration, but also offers cost benefits, as the cost of disposal to landfill or incineration is not needed.

21.10.17.1 Treatment and Disposal

21.10.18 The contractor should aim to achieve at least a 70% recycling / recovery rate for all CD&E waste generated on–site, as per the Waste Framework Directive target. This can be achieved by arranging for the source segregation of recyclable waste and the provision of appropriate recycling facilities. Achieving a high recycling rate will minimise the environmental burden in terms of pollution, energy consumption and emissions of CO_2 equivalent associated with the production of products from virgin material.

21.10.19 Only waste contractor(s) who are registered with the Environment Agency as a waste carrier should be used on the Scheme. Completed waste transfer notes and/ or hazardous waste consignment notes must be provided by the contractor. These should be kept for a minimum of two and three years respectively. Any site that waste is transferred to must also have either a permit or exemption that allows it to receive and manage the waste being transferred.

21.10.19.1 Operational Phase

21.10.20 Although the operational phase is not being assessed, there is still an opportunity for mitigation measures to be considered where practicable, the measures that should be considered include:

- Any materials required for planned/unplanned maintenance should be managed in accordance with the best practice procedures outlined in the above sections;
- Recyclable waste should be source segregated. This can be achieved through the provision of clearly marked and/or colour-coded containers to enable easy

identification of where waste should be placed during planned/unplanned maintenance;

- Hazardous waste should also be source segregated. An area should be set aside, at maintenance depots, for hazardous waste storage which should include appropriate containers, for example Waste Electrical and Electronic Equipment (WEEE) cages; and
- Regular training should be provided for staff and/or sub-contractors. The training should focus on the practices necessary to minimise waste and to facilitate good practice whilst undertaking litter picking and planned/unplanned maintenance.

Summary

21.10.21 Limited data on materials and waste is available at this design stage, therefore a mix of qualitative and quantitative approaches to assessment have been taken. Based on this, it is likely that Option 5 currently has the greatest negative impact overall for materials and waste and Option 2 has the lowest negative impact overall.

21.10.22 A lower negative impact is envisaged during the operational stage of the Scheme compared to the construction stage, due to minimal material use and waste generation, so this has been scoped out of further assessments.

21.11 Population and Human Health

Option Comparison

21.11.1 There is no material distinction between any of the route options with respect to community assets, access to work and training, green space, social cohesion, noise pollution, soil and water pollution, vehicle travelers and risk of injury and death.

21.11.2 All five route options will result in improved access for residents in the study area as a result of reduced congestion. This also applies to access to businesses. This constitutes a significant positive effect on access for residents.

21.11.3 All five route options will result in improved lighting and crossing provision, which in turn will reduce the likelihood of accidents which occur. Improvement works will also result in a positive effect on journey times, amenity and driver stress.

21.11.4 All five route options have the potential to result in increased noise levels resulting from changes in traffic conditions.

21.11.5 Option 2A (On Junction North) will have a slighter greater adverse impact on pedestrians, cyclists and horse riders due to the stopping up of the bridleway linking Church Lane Farm with Withybridge Gardens, on top of the stopping up of the two footpaths located at Withybridge and Millhouse Farm.

21.11.6 Due to Option 1A (North) and Option 5 (North) heavily encroaching on safeguarded land east of M5 Junction 10, these options will have greater adverse impacts than Option 2 (On Junction), Option 2A (On Junction North) and Option 2B (On Junction South).

21.11.7 Option 2 (On Junction), Option 2A (On Junction North) and Option 2B (On Junction South) require the demolition of private dwellings at Withybridge Gardens. Furthermore, Option 5 (North) will result in the demolition of Barn Farm. Therefore, Option 1A (North) is the preferred options from a population and human health perspective.

Mitigation

21.11.8 The extent of direct, permanent land take affecting identified individual receptors should be minimised.

21.11.9 Users of affected PRoW, footpaths and cycleways should be notified of planned diversions, and closures, with signs along sections to be closed during construction, at least one month prior to the works.

21.11.10 Appropriate compensation measures should be provided to residents where their properties are the subject of severance and / or demolition.

21.11.11 Construction works should be programmed so that affected PRoW, footpaths or cycleways remain open for part, or the duration, of the construction period, and also that other routes can act as a diversion route for those affected.

21.11.12 Clear signage and provision of access information for all users during construction and before operation should be provided.

21.12 Social Assessments

Accidents

21.12.1 In terms of monetised accident costs, an assessment using the DfT's COBA-LT has been undertaken. The assessment examines the type of accidents that could occur, the costs associated with an accident and the resulting casualties.

21.12.2 The assessment is based on Options 1A, 2 and 5 due to the availability of traffic modelling. The absolute and percentage difference in types of accidents is shown in Figure 21-2

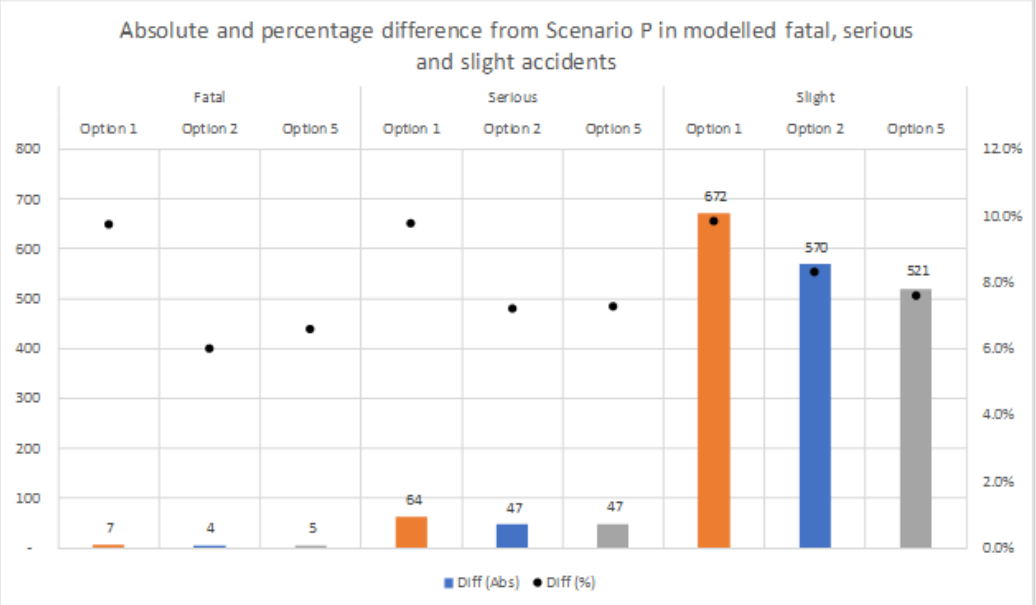


Figure 21-2 Absolute and percentage difference in modelled fatal, serious and slight accidents

- For Option 1A, the assessment predicts a total accident cost increase of £34.0m (9.47%). This cost also incorporates the largest increases in all three types of accidents.
- For Option 2, the assessment predicts a total accident cost increase of £26.4m (7.33%). This cost is derived from the same number of serious accidents and one

additional fatality compared to Option 5, but a considerably larger number of slight accidents than Option 5.

- For Option 5, the assessment predicts a total accident cost increase of £26.3m (7.32%). This cost is similar in value to Option 2; however, the overall predicted increases in fatalities is lower and slight accidents is considerably lower than both Options 2 and 1A.

21.12.3 Option 5 represents, marginally, the smallest increase in accident costs. This difference is driven by the significantly lower number of additional slight accidents when compared with other options

Physical Activity

21.12.4 All Scheme route options involve the temporary stopping up of the footpath linking the B4634 and Hayden Farm during construction. However, as the usage of this PRoW is considered to be low, it is considered that the temporary closure will not result in a significant adverse effect on physical activity.

21.12.5 For all Scheme route options, during the construction phase the two footpaths at Withybridge and Millhouse Farm will remain open under the viaduct/bridges in place over the floodplain, encouraging active travel and physical activity.

21.12.6 For Options 1A and 5, the demolition of the Hardwicke Elmstone Hard Bridge and the construction of the replacement overbridge may result in reduced amenity for users of nearby PRoWs and discourage physical activity. However, due to the impacts being temporary in duration it is considered that any resultant effects on physical activity will be negligible. As a result, there is little to distinguish between the five Scheme route options in terms of impacts on physical activity and each are considered to have a neutral effect on physical activity.

Security

21.12.7 For all Scheme route options there are unlikely to be any significant changes in security over existing conditions once operational. However, during the construction phase, the use of the two footpaths under the viaduct/bridges over the floodplain may reduce security, although the effects will be temporary.

Severance - Option 1A

21.12.8 Public Footpaths AEH20 and AEH23 are situated to the west of the M5 and connect at their northern ends with a small network of PRoW at Hardwicke. The west embankment of the overbridge will sever the two footpaths. The severance impact is considered to have a moderate negative effect.

21.12.9 Bridleway AUC1 runs southwest from Elmstone Hardwicke to the A4019 where PRoW access to Withybridge Lane is severed by the single carriageway A4019. The dualling of this section of the A4019 will increase PRoW severance for users of AUC1. Unless mitigated, the effects of the change are considered moderate negative. Public Footpath AUC8 crosses agricultural land north of the A4019 and joins the undesignated footpath running alongside the road. No change in severance is considered. There is the opportunity for AUC8 to be connected to a roadside footpath as part of the design.

21.12.10 Option 1A proposes an all-movement Junction 10 to the north of the existing junction with a link road to the east of the M5 joining the A4019. Option 1A would sever Bridleway AUC1; although, a grade-separated PRoW crossing would be incorporated into the bridge proposed over the adjacent watercourse. This would require the partial redirection of the Bridleway; and no change in severance impact is considered likely.

21.12.11 At present the undesignated pedestrian footpath crossing the M5 at Junction 10 is incomplete. As such, pedestrians crossing Withy Bridge must walk in the highway verge of the eastbound carriageway on the unpaved section. There is an opportunity to reduce severance and improve pedestrian safety by including within the design a section of path to connect with existing sections of footpaths along the westbound carriageway. If taken, this opportunity would be considered a beneficial change resulting in a moderate positive effect on severance.

21.12.12 The West Cheltenham Link Road will sever Public Footpaths AUC11 and ABO24, which pass through agricultural land, running east to west either side of the River Chelt. The footpaths would be partially redirected and grade-separated crossings provided beneath the proposed River Chelt bridge. This would mitigate the impact of severance and so no change in the residual effect on severance is considered.

21.12.13 The proposed roundabout on the B4634 would sever a short section of Public Footpath ABO26, which currently stops at the B4634 in this location. The change is not considered likely to increase severance and is assessed as having a neutral effect.

21.12.14 The existing footway along the A4019 would be re-provided as part of its widening. A crossing of the dual carriageway at the West Cheltenham Link Road roundabout would be required. The opportunity also exists to formalise the footway over the existing Junction 10 bridge, filling the existing gap in provision. Consideration could also be given to upgrading the whole length of footway along the A4019 within the scheme limits to a combined footway/cycleway.

Severance - Option 2

21.12.15 As with Option 1A, Option 2 will sever PRoW access to Withybridge Lane from Bridleway AUC1 by the single carriageway A4019. Unless mitigated this would be considered a negative change in severance, resulting in a moderate negative effect.

21.12.16 Public Footpath ABO14 crosses through agricultural land west of the M5 and ends at the A4019 immediately west of the existing Junction 10 slip road. The A4019 in this location is an existing dual carriageway and the Option 2 is not expected to increase severance of the footpath. No change in severance is considered. Option 2 includes junction improvements that would tie into the A4019 carriageway in the immediate proximity of ABO14 and consideration should be given to how the footpath is incorporated into the design.

21.12.17 Similarly to Option 1A, there is potential for a reduction in severance on Withy Bridge through the provision of a section of dedicated footpath to complete the footpath along the eastbound side of the A4019. If taken, this opportunity would be considered a beneficial change resulting in a moderate positive effect on severance.

21.12.18 The West Cheltenham Link Road will sever Public Footpaths AUC11 and ABO24, which pass through agricultural land, running east to west either side of the River Chelt. There is an opportunity for these footpaths to be partially redirected and grade-separated crossings integrated into the proposed River Chelt bridge. This would mitigate the impact of severance and so no change in the residual effect on severance is considered.

21.12.19 The existing footway along the A4019 would be re-provided as part of its widening. The opportunity also exists to provide footways over the new Junction 10 bridges, filling the existing gap in provision. Crossings of the north facing slip roads at the roundabout would be required. Consideration could also be given to upgrading the whole length of footway along the A4019 within the scheme limits to a combined footway/cycleway.

Severance - Option 2A

21.12.20 As with Option 2, Option 2A will sever PRoW access to Withybridge Lane from Bridleway AUC1 by the single carriageway A4019. Unless mitigated this would be considered a moderate negative change in severance. Unlike Option 2, Option 2A could increase severance of Public Footpath AUC8 due to the dualling of the A4019, although the design could incorporate a connection to a roadside footpath. Regardless, no change in severance is considered. Otherwise, Option 2A would have similar affects to Option 2.

Severance - Option 2B

21.12.21 Option 2B would have similar effects to those described for Option 2A.

Severance - Option 5

21.12.22 Option 5 would have similar affects to those described for Option 1A.

Conclusion

21.12.23 Options 1A and 5 would likely result in moderate negative changes in severance at two locations, while Options 2, 2A and 2B are predicted to result in a moderate negative change in severance at one location. All five options have the potential for a moderate positive change in severance at Withy Bridge through the provision of a section of footpath to connect existing footpaths along the eastbound carriageway of the A4019.

21.12.24 Options 1A and 5 would likely result in an overall slight increase in severance. The number of people affected per day is considered to be low and so a slight adverse change in severance is assessed.

21.12.25 With an equal number of positive and negative changes in severance, Options 2, 2A and 2B are assessed to have an overall balance. The change in severance is assessed as neutral.

Journey Quality

21.12.26 There are not likely to be any significant changes in traveller views as a result of the Scheme. Therefore, no further assessment of this topic has been undertaken at this stage.

21.12.27 For all Scheme route options, increased driver stress and route uncertainty is likely to be limited to the construction phase of the Scheme as the construction works and diversions take place. This will be effectively mitigated through appropriate signage and temporary traffic management, therefore avoiding any significant residual adverse effects.

21.12.28 All Scheme route options are likely to reduce driver stress for vehicles not using the M5, due to the reduction in rat-running and congestion on the roads surrounding M5 Junction 10 resulting from the proposed all-movements junction.

Option Values and Non-Use Values

21.12.29 The five Scheme route options do not involve the introduction of any new transport modes, nor do they involve the loss of any existing transport modes. The dualling of the A4019 will require the replacement of existing bus stops and existing bus routes may be temporarily disrupted during the construction of the Scheme.

21.12.30 The Scheme does not include any measures that will substantially change the availability of transport services within the study area and so option and non-use values are not assessed.

21.12.31 The eight bus stops situated along the A4019 within the footprint of Options 1A, 2A, 2B and 5, and the two bus stops situated within the footprint of Option 2, would be temporarily removed during the construction phase to facilitate the construction of the dual carriageway. Temporary disruption to the local bus services serving these bus stops may result; however, each Scheme route option would replace the bus stops and no permanent effects to these services are expected following the completion of construction.

Accessibility Impacts

21.12.32 None of the five Scheme route options considered would directly affect any public transport infrastructure or services beyond the temporary closure and/or relocation of bus stops during construction. Consequently, access to current public transport services and facilities would remain unchanged following the implementation of any of the five Scheme route options.

21.12.33 The provision of improved all-movement access to the M5 at Junction 10 provides the opportunity for national bus service providers to alter and improve their existing routes.

21.12.34 The allocated sites to the north west and west of Cheltenham currently comprise rural agricultural land. Existing access to these areas from the local and strategic road network is limited. Future inhabitants and workers of these sites will likely include vulnerable social groups who have a greater reliance on public transportation. The West Cheltenham Link Road will provide the highways infrastructure to improve access to these sites and which, in the future, local bus services that will serve the planned developments can operate on.

Personal Affordability

21.12.35 For all Scheme route options, it is likely that adverse impacts to affordability will occur. This is because all Scheme route options are likely to increase the vehicle operating costs (VOC) for road users, due to the fact that speeds would increase on the M5 resulting from decreased congestion and the introduction of an all-movements junction.

Table 21-8 – Outcome by indicator for each option

	Option 1A	Option 2	Option 2A	Option 2B	Option 5
Accidents	Adverse	Adverse	Adverse	Adverse	Adverse
Physical Activity	Neutral	Neutral	Neutral	Neutral	Neutral
Security	Neutral	Neutral	Neutral	Neutral	Neutral
Severance	Slight adverse	Neutral	Neutral	Neutral	Slight adverse
Journey Quality	Large beneficial	Large beneficial	Large beneficial	Large beneficial	Large beneficial
Option Values and Non-Use Values	Neutral	Neutral	Neutral	Neutral	Neutral
Accessibility	Large beneficial	Large beneficial	Large beneficial	Large beneficial	Large beneficial
Personal Affordability	Slight adverse	Slight adverse	Slight adverse	Slight adverse	Slight adverse

22 Assessment Summary

22.1 Appraisal Summary Tables (ASTs)

22.1.1 Appraisal Summary Tables have been produced in accordance with the DfT's Transport Analysis Guidance (WebTAG). The summary tables can be found in Appendix C.

22.1.2 For this current option identification stage, only a qualitative assessment has been determined. No quantitative assessment has been conducted except criteria's that have available quantitative information. The conclusions can only be used to allow a comparative assessment of the options rather than consideration of quantitative effects of the Scheme.

23 Programme

23.1 Scheme Level Programme

23.1.1 The project programme shows the key dates for the scheme as shown in Table 23-1

Table 23-1 – Key Programme Dates

Milestone	Date
Non-statutory Public Consultation	Sep 2020
Preferred Route Announcement	Early 2021
Commencement of Statutory Planning process	Early 2022
Determination of Statutory Planning	Late 2022
Start of Construction	Late 2022
Completion	Early 2025

23.1.2 It is anticipated that the construction period will be approximately 2 years

24 Detailed Cost Estimate

24.1 Option Cost Comparison

24.1.1 Table 24-1 below provides a summary of the detailed cost estimate for each option.

24.1.2 Cost estimates for the scheme will be subject to change in future stages, when more detailed assessments and design developments are undertaken

Table 24-1 - Summary of Detailed Cost Estimates for Each Options

Description	Option 1A	Option 2	Option 2A	Option 2B	Option 5
Direct Construction Works Costs	£101,932,933	£79,426,522	£73,425,671	£76,020,922	£97,654,784
Construction Cost	£149,994,311	£116,876,127	£108,045,875	£111,864,787	£143,699,015
Employer Indirect Costs	£45,268,720	£44,297,129	£36,310,322	£43,169,577	£43,852,278
Risk/ Uncertainty	£40,976,606	£34,158,651	£30,795,239	£32,930,873	£39,434,259
Inflation	£59,719,306	£49,782,818	£44,880,982	£47,993,454	£57,471,489
Total Scheme Cost	**£305,578,943**	**£254,734,725**	**£229,652,417**	**£245,578,691**	**£294,077,040**

All figures shown in pounds, in Q1 2018 prices

25 Conclusion and Recommendations

25.1 Options for Public Consultation

25.1.1 The five options (1, 2, 2A, 2B and 5) presented in this report have been assessed under the following headings:

- Brief summary description of each option
- Environmental Impact
- Buildability and Programme
- Compatibility with Key Design Considerations
- Option Cost
- BCR and VfM

25.2 Brief summary description of each option

Option 1A – Main design elements

- New grade-separated interchange with two overbridges to be constructed north of the existing junction 10. The new junction will provide free flowing movement in all directions of the M5.
- Local road connectivity to the M5 junction is provided via a new link road, connecting an at-grade gyratory junction from the A4019 Tewksbury road to the new grade-separated junction.
- A new dual carriageway will connect the A4019 Tewksbury Road the B4634.
- The existing A4019, heading towards Cheltenham from the new at-grade roundabout will be upgraded to a two-lane dual carriageway.

Option 2 – Main design elements

- Roundabout to replace the existing junction with a new grade-separated gyratory. Replacing the existing structure with two new structures over the M5.
- A new dual carriageway will connect the A4019 Tewksbury Road the B4634.
- The existing A4019, heading towards Cheltenham from the new at-grade roundabout will be upgraded to a two-lane dual carriageway.

Option 2A – Main design elements

- Roundabout to replace the existing junction with a new grade-separated gyratory. Utilising the existing structure and constructing a new structure to the north of the existing.
- A new dual carriageway will connect the A4019 Tewksbury Road the B4634.
- The existing A4019, heading towards Cheltenham from the new at-grade roundabout will be upgraded to a two-lane dual carriageway.

Option 2B – Main design elements

- Roundabout to replace the existing junction with a new grade-separated gyratory. Utilising the existing structure and constructing a new structure to the south of the existing.
- A new dual carriageway will connect the A4019 Tewksbury Road the B4634.
- The existing A4019, heading towards Cheltenham from the new at-grade roundabout will be upgraded to a two-lane dual carriageway.

Option 5 – Main design elements

- New grade-separated interchange with two overbridges to be constructed north of the existing junction 10. The new junction will provide free flowing movement in all directions of the M5.
- Local road connectivity to the M5 junction is provided via a new link road, connecting an at-grade gyratory junction from the A4019 Tewksbury road to the new grade-separated junction.
- A new dual carriageway will connect the A4019 Tewksbury Road the B4634.
- The existing A4019, heading towards Cheltenham from the new at-grade roundabout will be upgraded to a two-lane dual carriageway.

25.3 Environmental Impact

25.3.1 Chapter 21 of this report summarises the findings of the Environmental Study, which considered the environmental effects of each scheme option. Please note that these findings are not definitive and will be subject to review as more detailed, quantitative assessments are undertaken in the future stages. This may change the potential effects, and their significance identified throughout this document.

25.3.2 Table 25-1 summarises the potential effects associated with each option during the operational phase. It uses the seven-point scale from WebTAG and assumes normal mitigation measures. Where several different effects arise from a DMRB topic, or the receptors are affected to a differing degree, the score in Table 25-1 presents the most significant associated with that topic.

Table 25-1 – Potential Environmental Impact for each option

DMRB Topic	Option 1A	Option 2	Option 2A	Option 2B	Option 5
Air Quality	Slight Adverse	Minor Beneficial	Minor Beneficial	Minor Beneficial	Slight Adverse
Cultural Heritage	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
Landscape	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
Nature Conservation/	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse	Moderate Adverse
Geology and Soils	Neutral/Minor Beneficial	Neutral/Minor Beneficial	Neutral/Minor Beneficial	Neutral/Minor Beneficial	Neutral/Minor Beneficial
Materials and Waste	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
Noise and Vibration	Slight Adverse	Slight Beneficial	Slight Beneficial	Slight Beneficial	Slight Adverse

DMRB Topic	Option 1A	Option 2	Option 2A	Option 2B	Option 5
People and Communities	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial	Large Beneficial
Road Drainage and Water Environment	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse

25.3.3 The table shows that all five options are likely to have a positive impact on people and communities, three of the options will be benefit from air quality, noise and vibration and while all options will have a negative impact on road drainage and water environment, cultural heritage, landscape and nature/conservation.

25.4 Buildability and Programme

25.4.1 All options will require the existing entry and exit to and from the M5 to be removed.

25.4.2 In terms of buildability, all options will require for at least one structure to be constructed over the M5.

25.4.3 Options 1A, 2 and 5 require the demolition of a structure currently crossing the M5

25.4.4 All of the options require the link road between the A4019 and B4634 to be constructed. This link road requires the construction over the existing high-pressure gas main and under the 132kv electric cables.

25.4.5 All of the options, both during construction and in completion of the A4019 will maintain the existing Walking, Cycling and Horse Riding routes and facilities along the A4019 Tewksbury Road.

25.4.6 Additional land take will be required for all options to accommodate the revised junction and associated slip roads. For options 2, 2A and 2B these require properties adjacent to the existing junction to be demolished.

25.5 Compatibility with Scheme Objectives

25.5.1 All options are considered to be compatible with the scheme objectives as set out within the in the brief provided by Gloucestershire County Council.

25.6 Option Cost

Table 25-2 – Expected Option Costs

Option	Total Scheme Cost (£)
Option 1A	305,578,943
Option 2	254,734,725
Option 2A	229,652,417
Option 2B	245,578,691
Option 5	294,077,040

25.7 BCF and VfM

25.7.1 Table 25-3 summaries the BCR and corresponding VFM category for each option. The stated VFM is based on definition set out within WebTAG guidance, as follows

- Poor VfM if BCR is less than 1.0
- Low VfM if BCR is between 1.0 and 1.5
- Medium VfM if BCR is between 1.5 and 2.0
- High VfM if BCR is between 2.0 and 4.0
- Very High VfM if BCR is greater than 4.0

Table 25-3 – Summary Comparison of BCR and VfM Assessments

Option	BCR, with benefits from accident savings applied	VfM Category
Option 1A	1.72	Medium
Option 2	2.28	High
Option 2A	2.52	High
Option 2B	2.36	High
Option 5	1.83	Medium

25.8 Options to be taken forward

25.8.1 Whilst Option 1A and 5 have remained part of the assessment within the TAR, for completeness and comparison with other options, it has been concluded that these options should not be taken any further forward due to the complexities and affordability issues

25.8.2 It is recommended that Options 2, 2A and 2B are taken forward for further development, having all achieved a “High” VfM category, albeit with the aforementioned caveats. The economic analysis supporting this outcome will be continuously refined during subsequent development Stages to give GCC and stakeholders a continued confidence in the economic justification for the scheme.

25.8.3 Although all options meet the scheme objectives fully, there is marginal difference in overall benefits or disadvantage of these three options when compared with each other. Due to the varying degrees the options comply with the scheme objectives and marginal difference in benefits and disadvantages it is not possible to confirm a preferred solution at this stage. Therefore, it is proposed that Options 2, 2A and 2B are taken forward in to next stage for public consultation.

26 Glossary

Abbreviation	Term
AADT	Annual Average Daily Traffic
ALC	Agricultural Land Classification
AONB	Area of Outstanding Natural Beauty
AQMA	Air Quality Management Area
ARN	Affected Road Network
ASR	Appraisal Specification Report
AST	Appraisal Summary Table
BCR	Benefit/Cost Ratio
BMV	Best and Most Versatile
CBC	Cheltenham Borough Council
CCTV	Close Circuit Television
CDM	Construction Design Management
CEMP	Construction Environmental Management Plan
CFHN	Colman's Farm Habitat Network
CO2e	Carbon Dioxide Equivalent
CSV	Central Severn Vale
DCO	Development Consent Order
DEFRA	Department for Environment Food and Rural Affairs
DfT	Department for Transport
DMRB	Design Manual for Road and Bridges
EA	Environmental Agency
ELPV	Enhanced Longitudinal Profile Variance
ERTs	Emergency Response Telephones
ES	Environmental Statement
ESR	Environmental Study Report
GCC	Gloucestershire County Council
GHG	Green House Gases
HE DDMS	Highways England Drainage Data Management System
HAPMS	Highways Agency Pavement Management System
HE	Highways England
HIF	Housing Infrastructure Fund
INNS	Invasive Non-native Species
IP	Inter-Peak
IPPC	Integrated Pollution Prevention and Control
ITS	Intelligent Transport Systems

Abbreviation	Term
JCS	Joint Core Strategy
LAPPC	Local Authority Pollution Prevention and Control
LCA	Landscape Character Area
LGF	Local Growth Fund
LWS	Local Wildlife Site
MIDAS	Motorway Incident Detection and Automatic Signalling
NIA	Noise Important Area
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NRSWA	New Roads and Streetworks Act
NPV	Net Present Value
NTM	National Transport Model
OEMP	Operational Environmental Management Plan
PEAOR	Preliminary Environmental Assessment of Options Report
PICs	Personal Injury Collisions
PRoW	Public Right of Way
PVB	Present Value of Benefits
PVC	Present Value of Costs
RofSW	Risk of Flooding from Surface Water
SAC	Special Area of Conservation
SCOOT	Split Cycletime Offset Optimisation Technique
SGAR	Stage Gate Assessment Review
SPA	Special Protection Area
SRN	Strategic Road Network
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage System
SWMP	Site Waste Management Plan
TAR	Technical Appraisal Report
TBC	Tewkesbury Borough Council
TEE	Transport Economic Efficiency
TS	Transport System
TTM	Temporary Traffic Management
VfM	Value for Money
WebTAG	WebTAG (DfT's on line) Transport Analysis Guidance
WEEE	Waste Electrical and Electronic Equipment
WFD	Water Framework Directive

Appendices – Refer to Volume 2

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