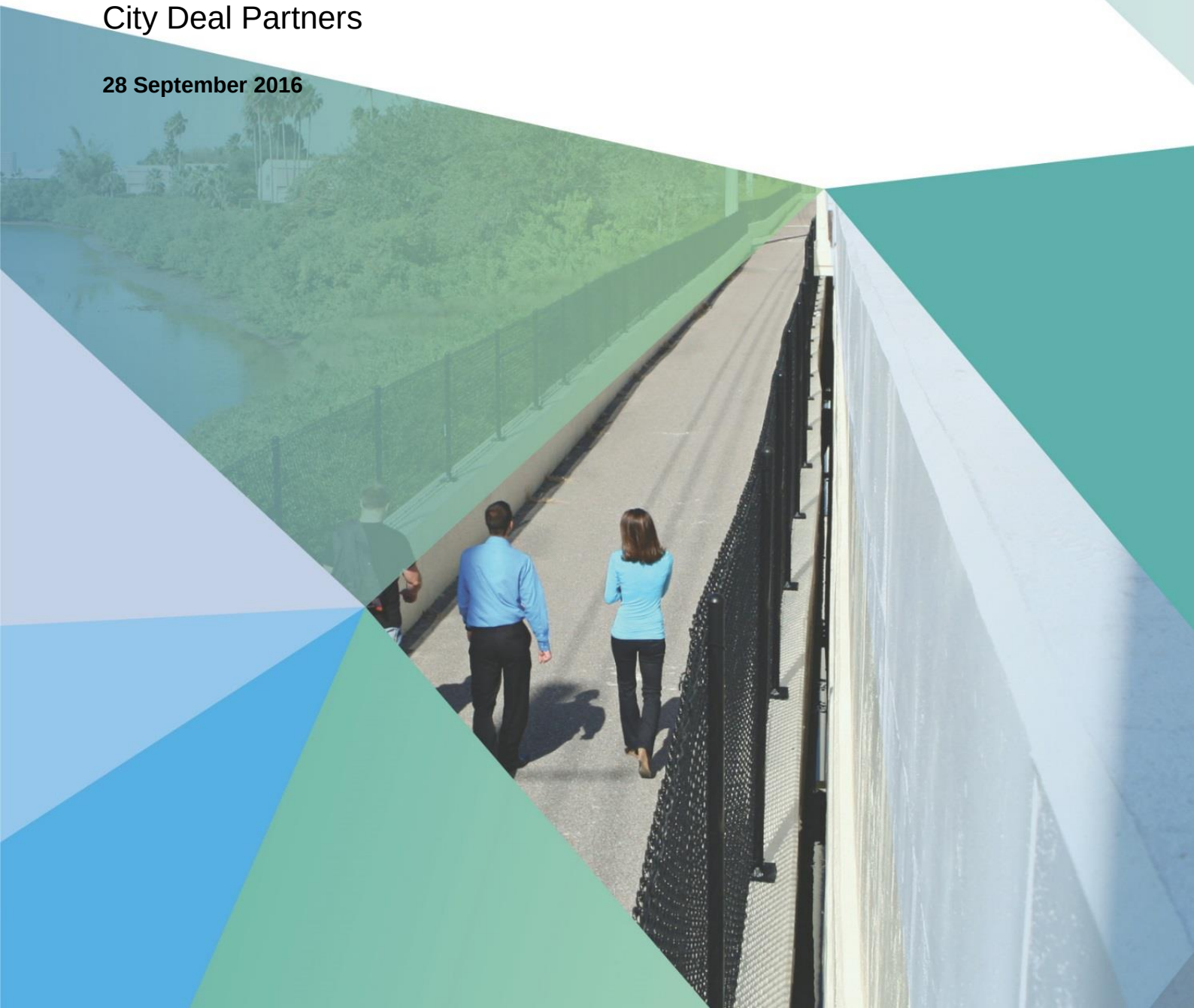
Cambourne to Cambridge Better Bus Journeys: Strategic Outline Business Case

Economic Case

City Deal Partners

28 September 2016



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Rev 2.0	Final for Issue	CW/JAH/TD/ SA/EM/TO/KQ	AL/LP	TD/CS	NC	28/09/16

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Summary

This economic case provides a proportionate, high level assessment of the five options considered for the A428 Cambourne to Cambridge Better Bus Journeys scheme. The five options are:

Option 1: Improvement to bus services running along existing roads with no infrastructure improvements to the west of Madingley Mulch. Online eastbound bus lanes from the A1303 / A428 junction along Madingley Rise and Madingley Road to Lady Margaret Road.

Option 2: A combination of offline infrastructure and online improvements, namely a new offline segregated bus route linking Cambourne and the proposed Bourn Airfield settlement; online on the St. Neot's road with bus priority measures in place to the A1303 / A428 junction; offline dedicated bus route going north-east from the A1303 / A428 junction, connecting to Madingley Road west of the M11. A further eastbound bus lane on Madingley Road provided as far as Lady Margaret Road.

Option 3: A new offline dedicated bus route connection between Cambourne and Bourn Airfield before running south of Hardwick to Madingley Mulch roundabout. From here a new offline dedicated bus route running north of Coton and parallel to Madingley Road and Madingley Rise to Grange Road, with a connection to the West Cambridge University site

Option 4: A new segregated bus route linking Cambourne and the proposed Bourn Airfield settlement; online along St Neots Road with bus priority measures in place to the A1303 / A428 junction; a new offline dedicated bus route going north-east from the A1303 / A428 junction, connecting in to Madingley Road just west of the M11. Services would use the existing bridge to cross the M11 and then enter the West Cambridge site, before continuing south and east to Grange Road on a new offline dedicated bus route running parallel to Madingley Road.

Option 5: A new segregated bus route linking Cambourne and the proposed Bourn Airfield settlement. The route continues along St Neots Road with bus priority measures in place to the A1303 / A428 junction. From here a new offline dedicated bus route running north of Coton and parallel to Madingley Road and Madingley Rise to Grange Road, with a connection to the West Cambridge University site.

The economic case documents the assessments of public transport economic efficiency, cost, environmental impact, wider economic benefits and social and distributional impacts. The analysis is undertaken in accordance with the Department for Transport's appraisal guidance (WebTAG). The economic case also contains a multi-criteria analysis of the performance of each option against a range of qualitative and quantitative economic and strategic criteria. The table below summarises the monetised impacts of the scheme.

The Benefit to Cost Ratios (BCRs) for all options are low or poor based on the modelling undertaken at this stage of scheme development, with initial BCRs ranging from 0.04 for Option 4 to 1.03 for Option 1 (the lowest cost option). Poor BCR performance is attributed both to low transport benefits based on the current phase of modelling and to the high costs associated with building offline infrastructure.

Low transport benefits currently identified reflect low modelled levels of demand for public transport along the A428 corridor which is due to relatively faster journey times of private car for local commuting and business trips and to the high levels of car dependency in Cambridgeshire. The mode share for public transport in the A428 corridor is approximately 21% across all user types but patronage is currently indicated to be dominated by education and leisure users, who have low values of time.

Economic appraisal summary table (all values NPV, 2010, £000s)[1]

Costs and Benefits	Option 1	Option 2	Option 3	Option 4	Option 5
Net PT Transport Benefits (£000s)	56,900	69,100	57,500	22,100	24,600
Environmental Impacts (£000s)	-6,400	-9,000	-11,200	-12,200	-12,200
Wider public finance (Indirect Tax Revenues)	-6,800	-7,800	-6,300	-3,700	-4,300
Total PVB (all monetised benefits, including wider public finance impacts and excluding wider economic impacts) (£000s)	43,600	52,300	40,100	6,200	8,100
Total PVC (£000s)	42,500	109,200	207,800	149,300	167,400
Initial BCR	1.03	0.48	0.19	0.04	0.05
Wider Economic Impacts (modelled in WITA and TUBA) (£000s)	8,200	1,500	1,400	-2,600	-2,500
Total PVB (all monetised benefits plus WebTAG Wider Economic Impacts) (£000s)	51,900	53,800	41,400	3,600	5,700
Adjusted BCR	1.22	0.49	0.2	0.02	0.03

While the options offer journey time improvements for public transport trips compared to current services, based on current modelling these improvements still do not enable PT journey times to compete with car journey times, and the low levels of demand for public transport means these journey time improvements translate into a relatively small level of transport benefits.

The environmental impacts are negative for all options, reflecting the negative impact in terms of noise and air quality that additional bus services could have on developments along the A428 corridor, however, mitigations will be identified and impacts designed-out where possible in further design development. The new offline bus routes proposed by the scheme options result in buses passing closer to households leading to increased noise and emissions disbenefits. In addition there are likely to be negative impacts on the landscape environment, heritage assets and biodiversity that, again, could be mitigated in some instances through further design development.

Comparing transport performance across options, Option 2 currently generates the highest level of transport benefits, which is particularly driven by it servicing both Madingley Mulch and Madingley road Park & Ride sites as it is the Park & Ride sites that generate much of the patronage for the options.

Options 4 and 5 have slightly higher average journey times than Options 1, 2 and 3 and furthermore, between them do not stop at both Caldecote and Coton. This may partially explain why Options 4 and 5 perform far more poorly in terms of generating transport benefits than the other options.

The WebTAG based wider impacts of the scheme options have also been assessed, namely agglomeration benefits; tax revenues arising from the labour market impacts of additional workers and the benefits resulting from output changes in imperfectly competitive markets. The wider economic impact assessment predominately accounts for the impact of an option on businesses and employees (commuters). Because current modelling indicates that patronage on the Cambourne to Cambridge Better Bus Journeys scheme is dominated by education and leisure users, the expected wider impacts are low.

To evaluate each option holistically against strategic and policy objectives a Multi-Criteria Assessment Framework (MCAF) was used to assess and score each option against a range of transport, economic,

[1] For presentation purposes monetised values in this case rounded to the nearest £100,000 unless stated

environmental and strategic fit criteria. The MCAF concludes, based on unweighted criteria that Option 3 scores highest as it proposes a fully segregated, high quality, reliable bus service on the corridor, which is assumed to provide best alignment with strategic objectives. Option 3 is, however, the most expensive option due to significant planning, design and construction costs and as such currently presents with a poor BCR as well as the highest deliverability risk given the likely public opposition to this offline development in the greenbelt.

At this stage of option design development and specification all the options assessed present a low or poor BCR. However, given the strategic long term vision for ambitious growth in Cambridgeshire it is expected that through further option development and optimisation the overall value for money of the scheme will improve.

1. Introduction

1.1. Overview

The purpose of a major scheme appraisal is to provide a balanced and evidence-based assessment of the costs and benefits of a project so that decision makers can understand how best to proceed. The scheme appraisal presents a range of evidence as to the costs and benefits, whilst all the time maintaining a focus on addressing key problems and meeting strategic objectives.

A Strategic Outline Business Case (SOBC) appraisal has five components:

- Strategic;
- Economic;
- Financial;
- Commercial; and
- Management.

The economic case section of the SOBC presents the appraisal of the **transport, environmental, wider economic and distributional impacts** of the proposed options for the Cambourne to Cambridge Better Bus Journeys scheme.

At the SOBC stage a key outcome is to make a case for change and outline options that could tackle the identified problem. This **Economic Case** follows the methodology set out in Department for Transport's transport appraisal guidance (DfT WebTAG) requirements for an **Economic Case** for options at this stage of design development. Table 1-1 identifies where in the **Economic Case** analysis is located.

Table 1-1 Economic Case according to WebTAG requirements

Requirement	Description	Location in report
Introduction	Outline approach to assessing Value for Money.	*This section*
Options appraised	A list of the options that have been appraised.	*Section 2*
Assumptions	Key assumptions used in the Cambourne to Cambridge Better Bus Journeys scheme that are considered in the **Economic Case**, in addition to those required by WebTAG.	*Sections 3, 6 & Appendix A*
Appraisal Summary Table	Appraisal summary tables based on WebTAG guidance.	*Section 9 & Appendix C*
Value for Money Statement	Value for Money assessments based on WebTAG guidance.	*Section 10*

In accordance with WebTAG, the Appraisal Summary Tables (ASTs) and Value for Money Statement are outlined with initial findings and will be completed with a full assessment at the Outline Business Case stage (OBC).

The economic case is structured as follows:

- Section 2 presents the shortlisted options selected for testing;
- Section 3 describes the transport modelling and appraisal methodology;
- Section 4 describes the baseline conditions;
- Section 5 presents the Do Minimum scenario against which the scheme options are compared;
- Section 6 shows the costs included in the appraisal;

- Section 7 presents the impacts of the options;
- Section 8 combines the costs and benefits and presents the cost benefit analysis outputs and comparison between options;
- Section 9 presents the Appraisal Summary Tables for the options ;
- Section 10 discusses the Multi-Criteria Assessment Framework used to assess all options against economic, environmental, strategic fit and deliverability criteria;
- Section 11 provides the value for money assessment of each option; and
- Section 12 concludes.

Detailed modelling assumptions and full WebTAG cost benefit analysis output tables are presented in the Appendices

1.2. Purpose and objectives of this Economic Case

The Economic Case assesses the *Value for Money* presented by each of the options considered. At this stage of design development and the decision making process the key requirement is to establish a robust strategic case for investment based on initial findings and to secure approval to proceed with development of option specification and design.

The Cambourne to Cambridge Better Bus Journeys scheme presents a range of bus-based interventions that seek to transform public transport connectivity between Cambourne, Bourn Airfield and villages to the West of Cambridge and Cambridge City Centre, Addenbrooke's and the Science Park. The options have a particular focus on improving the provision and connectivity of public transport between proposed housing developments, employment areas in the west of Cambridge and the city centre. The full problem description, vision, objectives, options and rationale for investment are described in detail in the **Strategic Case.**

The purpose of the **Economic Case** is to identify the monetised and non-monetised impacts as well as the costs for each option appraised and to report the Value for Money presented by each option.

The City Deal Assurance Framework sets out the requirements of Value for Money in which it states that, "Schemes with a **BCR of less than 2:1 will not normally be funded, unless wider appraisal evidence provides a compelling case for investment."**

The document goes on to state that a compelling case may be, "where a scheme is required **to unlock a barrier to growth, deliver wider economic benefits, environmental and or social/distributional impacts.** Where this occurs, scheme promoters will be required to justify the investment through provision of an evidence base and a proportionate quantitative analysis of benefits not included in the central benefit-cost analysis, and to demonstrate how these help deliver the policy objectives, to enable a comparative assessment of the economic case and comparison of the value for money with other schemes in the programme"[2].

At this stage of assessment for the SOBC, the key requirements are to establish the strategic case for investment, to demonstrate how this investment will further City Deal's aims and objectives and to secure approval to proceed with further development of option specifications and designs. Further detailed assessment is required in future stages of assessment to fully inform a preferred option in the Outline Business Case (OBC) and 'to continually align the progress of the project towards achieving…objectives'[3]. In that regard it could be expected that through option optimisation and improving the methods used to capture and assess scheme impacts that benefit-cost ratios could be developed in further stages of assessment.

The HM Treasury Green Book[4] recommends appraising schemes and options using Cost-Benefit Analysis, defined as "analysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible" so that they can be compared in a common unit of measurement.

[2] City Deal Assurance Framework
[3] DfT (2013). The Transport Business Cases.
[4] Her Majesty's Treasury (2003), The Green Book: Appraisal and Evaluation in Central Government

1.2.1. Costs and revenues

Section 6 of this **Economic Case** outlines the cost and risk estimation for each option. The **infrastructure delivery capital cost** estimates include the investment capital required for new infrastructure. The whole life cost estimates present the costs of maintenance, operation and renewals that will also need to be considered over the appraisal period.

Private sector costs and revenues are considered with reference to the peak vehicle requirement for the modelled bus services in each option. Consideration is also given to any subsequent grant / subsidy requirements that might be required to enable services to be operated. Any subsidy would be required over the whole appraisal period.

1.2.2. Benefits and Impacts

The economic case assesses a number of monetised and non-monetised benefits and impacts related to each option to allow for an objective comparison to take place. The monetised impacts captured using the transport modelling and appraisal methodology outlined in Section 3, are:

- Travel time;
- Vehicle operating costs;
- User charges (fares);
- Accidents;
- Air quality, noise and emissions (including greenhouse gases); and
- Wider Impacts.

The non-monetised impacts captured or discussed in this appraisal include:

- Potential reliability;
- Landscape, Biodiversity and Environment (including water) impact;
- Impact on physical activity;
- Journey quality;
- Accessibility; and
- Severance.

The variable demand Cambridge Sub-Regional Model (CSRM) was used to determine the transport economic impacts of each option. CSRM consists of a Land Use model, Transport Demand Model (TDM), PT / Active Travel assignment sub-model and a highway assignment sub-model. The impact assessment of monetised economic benefits was undertaken in TUBA (Transport Users Benefit Appraisal)[5].

1.2.3. Value for Money

The Benefit to Cost Ratio (BCR) is an indication of the return on public sector investment in a scheme. The BCR is the ratio of the Present Value of Benefits (PVB)[6] over the Present Value of Costs (PVC)[7], and indicates how much benefit is obtained for each unit of cost. A BCR greater than 1 indicating that the benefits outweigh the costs. Based on an assessment of the benefits and costs of each option an assessment of value for money is presented in Section 10 of this document comprising the BCR and the DfT Value for Money category for each of the options considered.

Based on the indicated costs and benefits currently indicated to be associated with each scheme, the Economic Case presents BCRs for each of the options considered alongside the wider social, economic and environmental impacts the ability of each scheme to meet strategic objectives.

[5] TUBA is an economic appraisal computer programme developed for the Department for Transport (DfT) for appraising multi modal transport studies.
[6] PVB is the present value of the future stream of estimated benefits of an option over 60 years discounted to the DfT's base year of 2010
[7] PVC is the present value of the future stream of estimated costs of an option over 60 years discounted to the DfT's base year of 2010

2. Shortlisted Options selected for testing

2.1. Background

Five options to provide Better Bus Journeys between Cambourne and Cambridge have been shortlisted for testing as part of this OBC. These options have been selected through an option assessment process carried out in previous phases of the work and described in detail in Section 8.2 of the **Strategic Case**.

2.2. Do Minimum Scenario

The five options being assessed as part of this SOBC have been compared against a Do Minimum future scenario. It is not realistic to assume that there will be no future changes in the corridor if no scheme is implemented (do nothing) and in order to provide a realistic comparison between two possible futures, the Do Something cases are compared to a Do Minimum (rather than Do Nothing) case. The Do Minimum scenario includes committed and expected developments, as well as programmed road improvements. The Do Minimum scenario therefore forms the expected future situation without the proposed bus scheme.

The Do Minimum scenario includes the following assumptions:

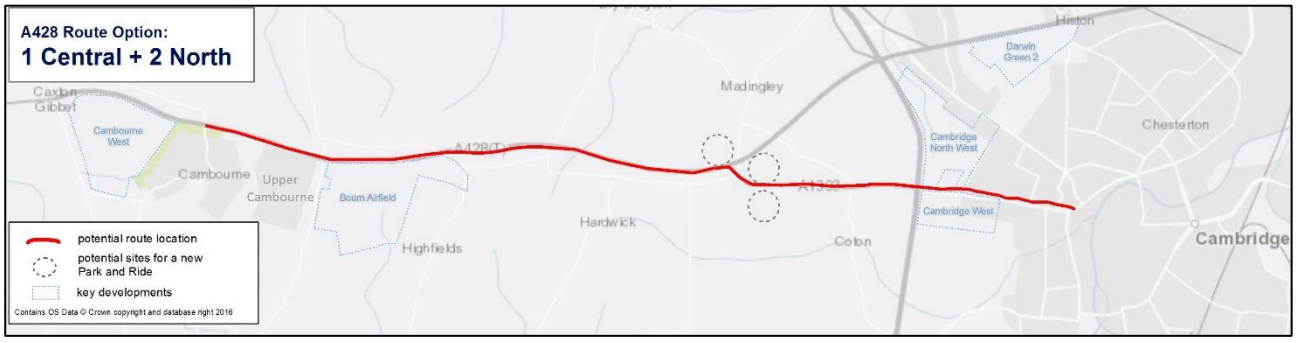
- Housing and employment growth as per the submitted Cambridgeshire and South Cambridgeshire Local Plans, according to guidance;
- Committed transport infrastructure away from the corridor, including schemes such as the A14 Upgrade from Cambridge to Huntingdon and other highway access related infrastructure for larger development sites such as Cambridge North West, Darwin Green and Northstowe; and
- Bus services on the corridor are maintained at current levels, frequency and stopping patterns. No new bus priority infrastructure is assumed.

2.3. Do Something Scenarios

Five options have been assessed in this SOBC. Summary descriptions are provided for reference below. Full details of each scheme, including service assumptions are provided in Section 8.4.1 of the **Strategic Case.** It should be noted that all alignments, including offline sections on greenfield and privately held land, would need significant stakeholder agreement and associated permissions and as such routes shown on the maps are indicative and subject to further design development. It is expected that as these option specifications and designs are optimised environmental highway impacts can be minimised and public transport benefits maximised to enhance the value for money of options and fully inform the decision making process for a preferred option.

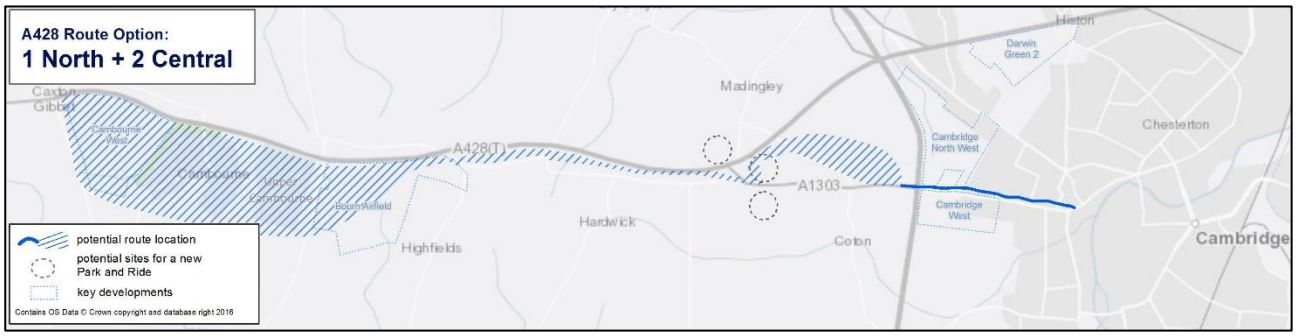
Option 1 - Improvement to bus services, which will run along existing roads with no infrastructure improvements to the west of Madingley Mulch. This option features online eastbound bus lanes from the A1303 / A428 junction along Madingley Rise and Madingley Road to Lady Margaret Road. All new services for Option 1 originate at the new Madingley Mulch Park & Ride.

Figure 2-1 Option 1: Potential route location



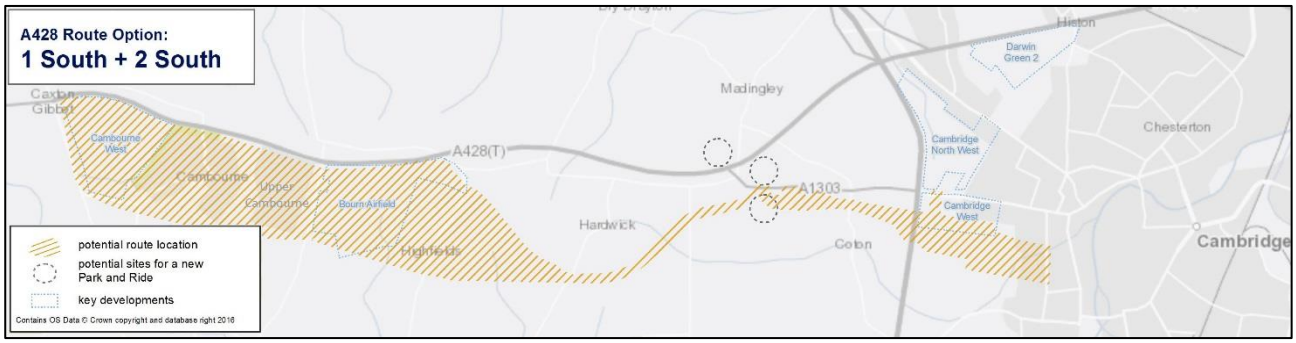
Option 2 – A new offline segregated bus route linking Cambourne and the proposed Bourn Airfield new settlement. The route continues along St Neots Road with bus priority measures in place to the A1303 / A428 junction; from here a new offline dedicated bus route going north-east from the A1303 / A428 junction, connecting to Madingley Road just west of the M11. A further eastbound bus lane on Madingley Road would be provided as far as Lady Margaret Road.

Figure 2-2 Option 2: Potential route location



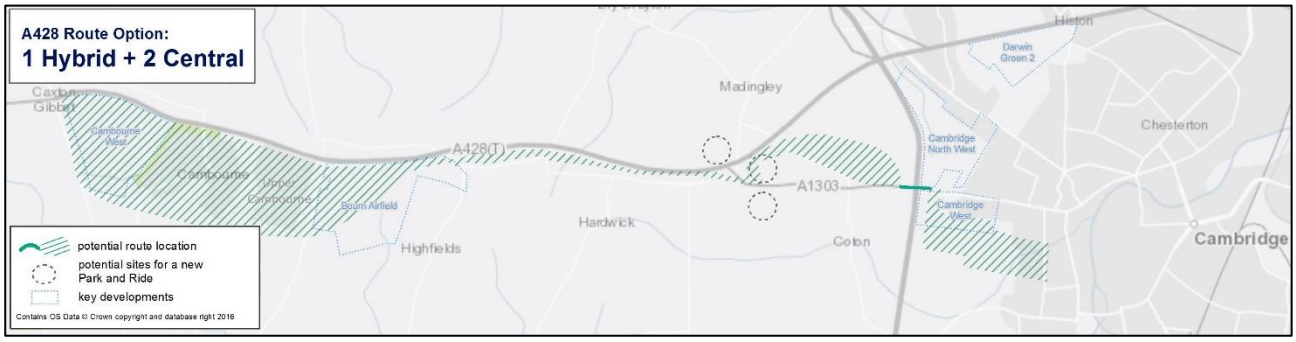
Option 3 – A new offline dedicated bus route connection between Cambourne and Bourn Airfield before running south of Hardwick to Madingley Mulch roundabout. From here a new offline dedicated bus route running north of Coton and parallel to Madingley Road and Madingley Rise to Grange Road, with a connection to the West Cambridge University site.

Figure 2-3 Option 3: Potential route location



Option 4 – A new segregated bus route linking Cambourne and the proposed Bourn Airfield new settlement. The route continues along St Neots Road with bus priority measures in place to the A1303 / A428 junction. From here a new offline dedicated bus route going north-east from the A1303 / A428 junction, connecting in to Madingley Road just west of the M11. Services would use the existing bridge to cross the M11 and then enter the West Cambridge site, before continuing south and east to Grange Road on a new offline dedicated bus route running parallel to Madingley Road.

Figure 2-4 Option 4: Potential route location



Option 5 – A new segregated bus route linking Cambourne and the proposed Bourn Airfield new settlement. The route continues along St Neots Road with bus priority measures in place to the A1303 / A428 junction. From here a new offline dedicated bus route running north of Coton and parallel to Madingley Road and Madingley Rise to Grange Road, with a connection to the West Cambridge University site.

Figure 2-5 Option 5: Potential route location

3. Transport modelling and appraisal methodology

3.1. Overview

As part of the transport study underpinning the **Economic Case**, the CSRM (a variable demand and multi-modal assignment model) was used to forecast the impact of the proposed options against a Do Minimum scenario. A description of the model and its limitations are described in this section.

3.2. The Cambridge Sub-Regional Model (CSRM)

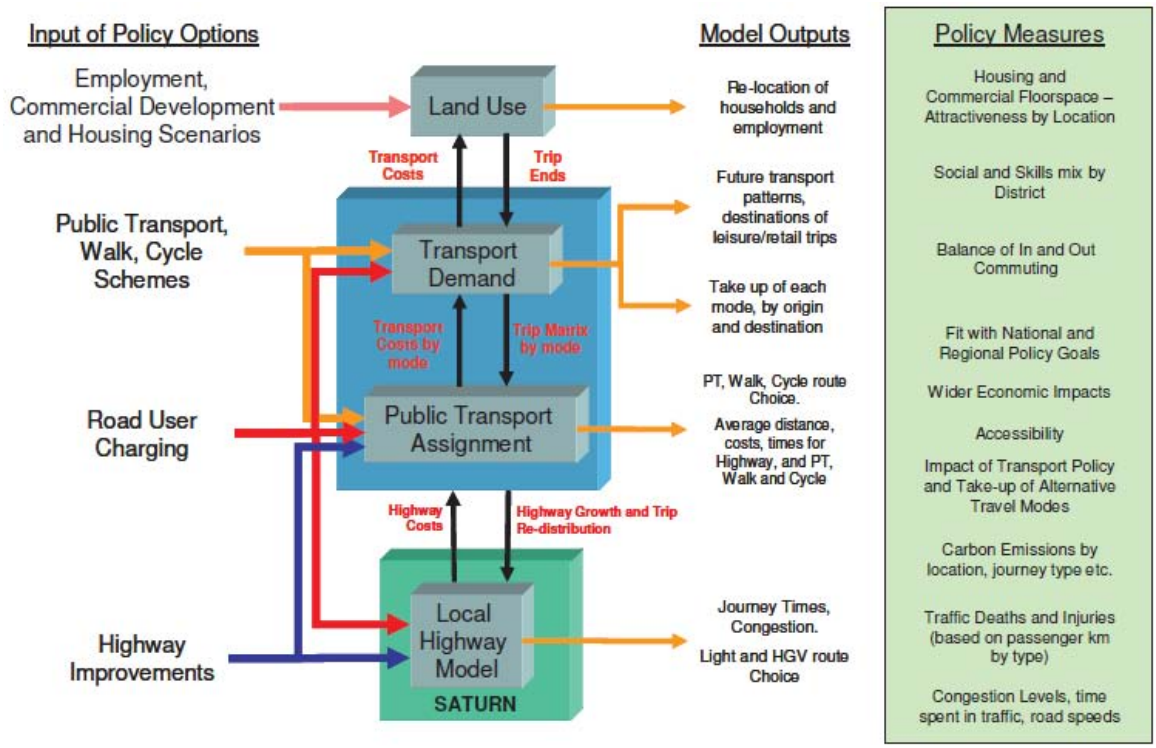
3.2.1. Model characteristics

The CSRM (**Figure** 3-1) is a multi-model, interactive land use and transport model which enables the assessment of road, public transport (PT), cycling and walking schemes. It allows standard economic benefit tests to take place and it can also be used for complex tests of strategic policy options. The model is, therefore, capable of assessing a variety of policy options, including road-pricing, new highway infrastructure and PT schemes.

The key features of the model, also shown in (**Figure** 3-1) are:

- A linked **land use** model to generate trip ends from forecast planning data and travel accessibilities (MENTOR);
- A **Transport Demand** Model (TDM);
- A **public transport, walk and cycle assignment sub-model** (MEPLAN), which includes bus, rail and guided bus; and
- A **local highway assignment sub-model** (SATURN).

Figure 3-1 CSRM Overview



The model is executed to assess policy option inputs:

- The land use model is setup to reflect the expected future land use scenarios as per policy plans, for example this includes the expected (planned) number of future housing units;
- The transport demand model is set up to reflect new schemes, in this case a new bus-based public transport scheme;
- Highway changes and improvements are reflected in the local highway model; and
- Road user charging does not form part of this scheme.

The elements of the model interact based on the inputs to assess the impact of the proposed bus scheme (**Figure** 3-1).

The strategic model covers the four districts in the Greater Cambridge area, namely:

- Cambridge;
- South Cambridgeshire;
- East Cambridgeshire; and
- Huntingdonshire.

The model incorporates all stages of the 'four-stage' modelling framework - trip generation, trip distribution, mode choice and route assignment[8] - and can be run with the Land Use model switched on or off as desired. It considers trips that start and end within the study area, as well as trips with an origin and/or destination in regions outside the study area.

The land use model generates average weekday trip ends (i.e. origins and destinations) based on population and employment data. Trip ends are segmented by trip purpose, household car availability and socio-economic group. The TDM aggregates these daily trip ends and carries out the trip distribution by time of day and mode. The assignment sub-models are implemented in the following time periods:

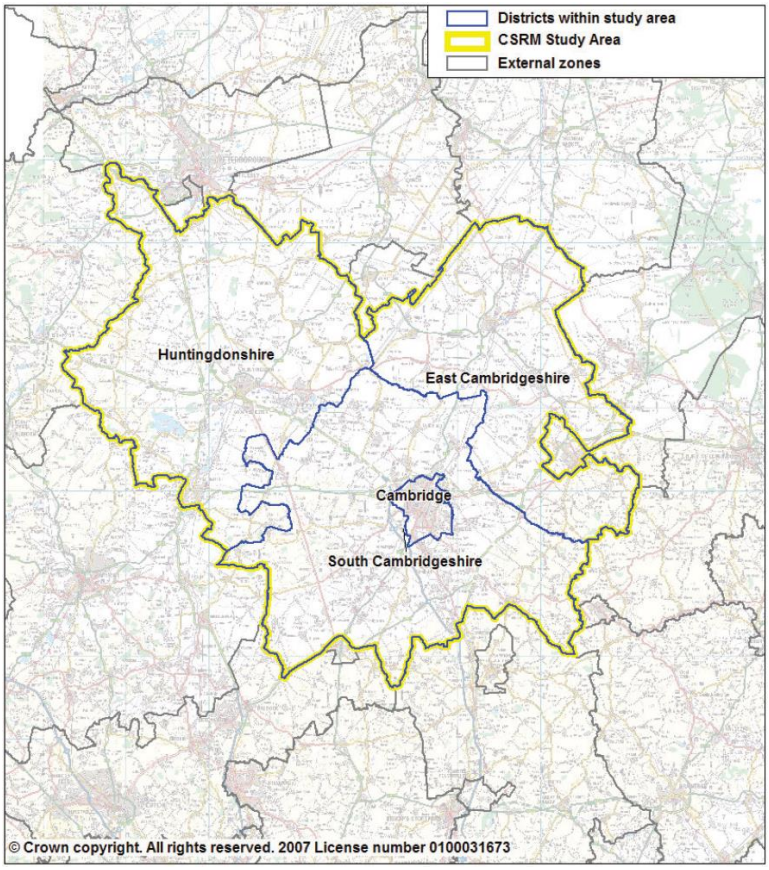
- **PT-Walk-Cycle:** AM Peak - 07:00-10:00, Inter-peak - 10:00-16:00, PM Peak - 16:00-19:00; and
- **Highway:** AM Peak - 08:00-09:00, Inter-peak - 14:00-15:00, PM Peak - 17:00-1800.

The TDM includes a large number of user modes which can be summarised as bus, rail, guided bus, Park & Ride, walk, cycle and highway. Within the highway model there are then 10 user classes[9], 8 of which represent light vehicles or varying purposes and income groups and the remaining two classes represent heavy vehicles.

The CSRM operates in 5 year increments from 2001 to 2031. Therefore the next modelled year (2021) represents the opening year for the scheme.

[8] WSP. (2009). *Cambridge Sub Regional Model Transport Demand and Public Transport Model Development and Validation Report*
[9] Ibid.

Figure 3-2 CSRM model coverage



Source: CSRM Model Development Report

The model was validated in 2006 and was based on 2001 census data and 2006 traffic flows and land-use assumptions which are now outdated. The CSRM is currently being updated and this update had not been finalised at the time of writing. As a result the original 2006-validated CSRM was used throughout this stage of assessment and business case generation. The one key upgrade made to the model for this current stage of the assessment was an update to the forecast land-use assumptions to those used in the 2015 Cambridgeshire Local Plan to ensure that key developments, including those on the A428 corridor (Cambourne and Bourn Airfield), are taken into account by the model in the Do-Minimum and Do-Something scenarios.

The CSRM is a strategic model and therefore is not designed to represent specific 'low-level' or localised characteristics of proposed schemes and nor does it consider traffic management. For example:

- The local highway element of the model assumes that all vehicles will utilise the lowest cost routes and have infinite network knowledge (i.e. the most efficient way in terms of distance and time to arrive at their destination). Therefore modelled congestion may be underestimated compared to reality as in the model all drivers attempt to divert away from congestion where possible to the lowest cost route, which is not always representative of real-life behaviour; and
- More generally, the model does not constrain the number of parking spaces available and this may cause a larger number of trips to be made by car compared a scenario where there are parking constraints.

Further investigation of localised issues and parking may be required at a later stage of business case development.

3.2.2. Highways modelling

TUBA calculates highways benefits from the SATURN assignment model outputs, using changes in flows and journey times to calculate the value of benefits seen by users. For this calculation to be useful, the

changes observed within the model should be primarily arising from the scheme being assessed. All assignment models include an element of variation, or 'noise', which is a result of the mathematical functions used to assign the traffic flows to individual roads in the model. In addition, traffic models respond to network conditions, routing traffic to avoid congestion hotspots. If future traffic growth in a particular location results in localised congestion, the model can experience difficulty in satisfying its internal mathematical checks. This is known as a lack of convergence, and leads to traffic changing routes between model runs in places unaffected by a scheme.

In the case of the A428 scheme the focus is on public transport and it is expected that the highway impacts are likely to be mainly incidental, particularly for options which are fully offline. Contrary to expectations it was observed that the model suggested large changes in forecast highway traffic in areas unaffected by the scheme. Testing with the model indicated that it is not currently possible to produce stable and consistent results under a range of conditions. Further, the TUBA calculations reported that the proportion of highway travel time benefits attributable to the scheme was extremely low – less than 0.05% of the total highway travel time in the model. This is equivalent to the effects of random daily variation in travel volumes and delays. Therefore, highway outputs arising from the model need to be considered carefully.

Highway impacts of a scheme are of two types – traffic flow changes and journey time changes. Whilst there are undoubtedly some highway journey time impacts expected from this scheme, it could be assumed that they are likely to be small and not discernible from day-to-day variations in travel time. More significantly, testing with the model indicated that TUBA was unable to reliably and consistently indicate the scale of these benefits. It is anticipated that there is still likely to be some localised negative impact on the highway network, particularly adjacent to the new Park & Ride site, which could be mitigated by local schemes. Conversely, there are also likely to be areas of improved network performance as a result of decongestion due to mode shift to PT.

As a result, although we do not anticipate any significant changes in localised congestion, we do expect that changes in travel patterns as people shift to using the new services will result in changes in traffic flow on individual links, and an overall reduction in total travel time across all modes. In order to make sure that we capture these impacts correctly the model outputs have been used in the following way:

- TUBA (journey time) benefits are calculated from PT modes only, including Park and Ride;
- Environmental (noise and air quality) benefits use highway flow changes in addition to the impacts of the new busway; and
- Distributional Impact (DI) assessments are based on TUBA outputs and environmental assessment outputs.

The use of highway flows as inputs to the environmental and distributional impacts assessments may potentially limit the robustness of the results of these assessments. Further modelling work should be undertaken to further understand the anticipated impacts of the schemes on the highway network to inform a more robust assessment of all highway-related scheme impacts.

3.2.3. Potential under-estimation of demand

Given the strategic nature of CSRM, it is believed that it may be under-representing the congestion present in the A1303 and Madingley Road sections of the corridor, both in the current and forecast years. As a result the overall level of demand for High Quality Public Transport (HQPT) services may be understated as the benefits of public transport would be further amplified if the cost of private travel increases.

Demand may also be influenced by any future implementation of demand management measures to deter the use of private vehicles in order for the Sub-Region to meet its strategic obligations to maintain standards of living, improve the environment and to promote active modes / PT. For example the Transport Strategy for Cambridge and South Cambridgeshire (TSCSC) proposes a city-wide managed parking scheme and an extension to the Cambridge Core Traffic Scheme. These schemes are not committed or fully developed and,

therefore, have not been modelled. It is likely that any measures which reduce private vehicle use may increase demand for PT services.

3.2.4. Other Assumptions

Traffic modelling assumptions

The distribution and level of housing and employment across the study area has been taken from the SCDC and City Local Plan Preferred Strategy work that was undertaken in 2015. This includes detailed forecasts of the level of housing and employment growth across the sub-region up until 2031.

The modelling work has been undertaken assuming that the scheme would open in 2021, with further forecast years of 2026 and 2031. The 2021 and 2031 data has been used to feed in to the TUBA economic appraisal.

The Do Minimum scenario includes the following assumptions:

- Housing and employment growth as per the submitted Cambridgeshire and South Cambridgeshire Local Plans;
- Committed transport infrastructure away from the corridor, including schemes such as the A14 Upgrade from Cambridge to Huntingdon and other highway access related infrastructure for larger development sites such as Cambridge North West, Darwin Green and Northstowe;
- Bus services on the corridor are maintained at current levels, frequency and stopping patterns;
- No new bus priority infrastructure is assumed; and
- No other GCCD schemes have been considered within this modelling work at this time.

Housing and population

CSRM uses the level of housing units in Cambourne West and Bourn Airfield up to 2031 as per the housing trajectory published in the Annual Monitoring Report, January 2016, though this is a lower amount than the potential future capacity of the sites as shown in Table 3-1Se below.

Table 3-1 Modelled housing development to 2031 compared to future capacity (dwellings)

Example site	Dwellings considered in modelling up to 2031	Post-2031 capacity of site
Cambourne West	1200	Approximately 2350[10]
Bourn Airfield	1360	Approximately 3500

The modelling identifies that forecast transport demand by these new developments across the appraisal period can be accommodated on the dual carriageway section of the A428 corridor (based on the current planned levels of housing development and population forecasts assessed).

Consideration could be given to whether it is reasonable to begin planning for any additional demand on the Public Transport network, beyond the housing levels planned up to 2031 and to ascertain whether additional demand generated by development from 2031 to the end of the appraisal period would be sufficient to lead to a step-change in demand for public transport along the corridor. Further work could consider these longer term development assumptions in order to better articulate the vision for the sub-region based on potential future development growth.

Bus Service assumptions and mode constant

A number of bus services have been assumed to accompany the new infrastructure proposed in each of the modelled options. All of the new proposed services are included in the model, in addition to the existing Citi 4 service that currently runs along the corridor. A full list of modelled bus services for each option are presented in Table 11-2 in Appendix A. The service patterns and frequencies are assumed to be the same

[10] 2,350 dwellings are proposed in a planning application and does not reflect the submitted Local Plan

throughout the day within each option, although there are differences between options which are described fully in Section 8.2 of the Strategic Case.

Mode constant

It is important that the increased attractiveness of a HQPT service is captured as it is likely that these services may be more appealing to users compared to standard bus services, resulting in greater uptake. This increased attractiveness stems from a number of factors, including the high quality and comfort of vehicles and an improved ride quality on guided sections compared to standard bus services. All new services have been assumed to be akin to the existing Cambridgeshire Guided Busway and therefore operate as a HQPT service.

HQPT is represented within the model by factoring the In Vehicle Time by 0.9[11] to represent the increased attractiveness of these services. This has been applied to all of the proposed scheme related services for each option, irrespective of the infrastructure that they run on. All other services are factored by 1.0.

3.2.5. CSRM Summary

The CSRM has been used to assess the transport impacts of the options at this stage. Due the strategic nature of the model, key limitations include potential under-estimation of demand and variable highway benefits. Further work may be required in later phases of scheme development to gain a more detailed understanding of scheme specific localised transport constraints and benefits.

A strategic modelling exercise has been undertaken using the CSRM and the results from this inform the assessment of Value for Money for each option.

3.3. Economic Appraisal

The benefits associated with journey times, vehicle operating costs and indirect taxation has been assessed using the parameters from the DfT's WebTAG Databook (December 2015[12]) and the version of TUBA (1.9.6)[13] at the time of assessment. The key inputs for this TUBA analysis are discussed below.

3.3.1. Summary of outputs from CSRM

Information is extracted from CSRM covering the following for each time period:

- Number of trips between each origin and destination by mode (highway, bus, guided bus, Park & Ride and rail);
- Travel time between each origin and destination by mode (highway, bus, guided bus, Park & Ride and rail);
- Journey distance between each origin and destination for highway trips; and
- Average fare paid between each origin and destination for PT trips by mode (bus, guided bus, Park & Ride and rail).

Once the data is extracted, the PT modes are combined into a single representative PT mode. The process is required because of the way TUBA treats large changes in travel time, such as when a new guided bus service is introduced along the A428 corridor, and ensures that the Public Transport impacts for each option are accurately reflected.

3.3.2. Annualisation factors

TUBA uses annualisation factors to convert single day model outputs to benefits realised across a whole year. The results from the model were assumed to apply over 253 days, representing the standard number of working days in a year usually used for modelling and appraisal purposes.

[11] WSP. (2009). *Cambridge Sub Regional Model Transport Demand and Public Transport Model Development and Validation Report*

[12] WebTAG data book was updated in July 2016; this update includes changes to the Values of Time. Future iterations of the Business Case for this scheme will need to use the July 2016 WebTAG data book parameters to update the appraisal.

The outputs from the PT model cover 3 hours for each of the AM and PM periods and 6 hours for the inter peak. Therefore both the model and appraisal cover 12 hours of each weekday with no allowance for overnight or weekend traffic. Due to the nature of PT use in Cambridge, the benefits from the AM period were assumed to accrue over two hours (07:30-09:30), with the benefits from the Inter-peak period extended to cover 7 hours in order to maintain the 12 hour coverage. The annualisation factors in TUBA were adjusted accordingly to scale the benefit calculations appropriately.

Outputs from the highway model are for a single hour. For the AM and PM periods these represent specific hours on the road network, with the inter peak representing an average hour during the day. These are expanded to cover the AM, PM and inter peak periods using traffic counts obtained during the original construction of the model applying the calculation:

*factor = 253 * traffic_flow_in_period / traffic_flow_in_hour.*

Using the above information, benefits were calculated to show benefits for highway and PT users for both business and non-business users. Benefits include time savings, changes to vehicle operating costs, changes in charges (PT fares), revenue and changes in carbon emissions.

There may be additional benefits to be realised by late night and early morning bus services (i.e. outside the assumed 12 hour period), as well as weekends. However these have not been included in this assessment as the service patterns for these periods are not yet defined.

Each of the benefits is monetised a common base year, so that the PVB currently indicated to be generated by the options enables a comparison of the relative Value for Money presented.

Economic appraisal of each option was undertaken using TUBA to enable a comparison of the monetised benefits generated by each option using modelling undertaken at this stage of assessment.

3.4. Scheme Cost Methodology

A robust approach to cost estimation has been undertaken using expert input from quantity surveying experts from Faithful+Gould and Skanska. A further breakdown of construction cost estimation is presented in the **Financial Case** the Cost Appraisal in Section 6 of this report**.** Key assumptions are outlined below.

Construction costs: High level design drawings showing the potential alignment of each of the options provided by Atkins, were used by Faithful+Gould to estimate the appropriate infrastructure requirements and subsequent costs, based on historic data.

Operating costs: Indicative operating costs for the bus service provision has been estimated for each of the options. The operating costs take account of the route start and end points, along with key intermediate calling points. Bus service frequency, route length and journey time have been extracted from CSRM based on the 2021 future year scenario. The operating cost estimates include costs associated with operating the routes such as drivers' wage, depot overheads, depreciation and fleet size (as determined by peak vehicle requirement). Operating costs of the proposed Park & Ride site have been assumed based on consultation with CCC, with reference to other Park & Ride sites in Cambridgeshire.

Renewals: For the purposes of this appraisal indicative life cycle renewal cost estimates have been prepared by Faithful+Gould in accordance with requirements for TUBA. Life cycle renewal costs are costs associated with the renewal of infrastructure component(s), following the final disposal of the initial asset on completion of its life cycle. The estimates are based on high-level cost planning techniques and construction capital costs. The life cycle renewal costs do not include for planned and reactive maintenance, operation or end of life costs. The life cycle renewal costs utilise the descriptions, quantities and unit rates provided within the capital construction cost estimates, also provided by Faithful+Gould. A percentage scale of renewal has been applied to the assets considered to require life cycle renewal.

Maintenance costs: Maintenance costs, estimated by Skanska, are based on the high level preliminary designs used for the capital cost estimates. The maintenance cycle of each item has been estimated, and a

cost for the full 60 year appraisal period assumed. For the purposes of this appraisal, the total maintenance costs are assumed to have a flat spend profile, thereby providing a consistent annual maintenance cost.

Risk allowance: Details on the risk allowance register prepared for the scheme construction costs, by Faithful+Gould are presented in the **Financial Case**. Due to the number of options being considered, and the early conception stage of the scheme design, a percentage based approach to determining a weighted risk allowance has been taken in quantifying the risks to the potential schemes. The risk register summary indicates that an overall weighted allowance of 20% on the capital construction costs is appropriate at this stage. A 20% risk allowance has also been applied to the annual maintenance costs and lifecycle renewals estimates.

Inflation: Details on the application of inflation onto the base costs for the appraisal are provided in the **Financial Case**. Construction, capital renewal and infrastructure maintenance costs have all been estimated with a 2010 price base, and inflated to the point of expenditure based on either the All-in Tender Price Index (TPI) or the Retail Price Index (RPI), depending on the cost item.

For the purposes of appraisal only real inflation (i.e. the rate of inflation costs above the rate of background inflation) has been considered. The background inflation, based on the GDP deflator, has been deducted from the total rates of inflation derived from the TPI/RPI.

Optimism bias: Optimism bias is a factor added to scheme costs to account for the demonstrated systematic tendency for appraisers to be overly optimistic about the outcome of planned actions. This includes over-estimating the likelihood of positive elements of a scheme and/ or under-estimating the likelihood of negative elements of a scheme. Reference has been made to Table 8 in WebTAG unit A1.2, to determine the category, type and stage of the project. The Cambourne to Cambridge Better Bus Journeys scheme is considered to fall under Stage 1 of a road scheme, with the project type being Park & Ride, Bus lane schemes, Guided buses on wheels. Accordingly, a 44% optimism bias has been applied to risk-adjusted investment costs.

WebTAG is not prescriptive in providing guidance on a suitable level of optimism bias for capital renewals (traffic-related maintenance and vehicle fleet renewal). Based on experience from comparable schemes (bus based road schemes) across the UK, a 15% optimism bias has been applied for capital renewals expenditure. In line with standard practice, no optimism bias uplift has been applied to the operating and non-traffic related maintenance costs.

In accordance with WebTAG guidance the total costs are converted to 2010 values and prices using the rates included in TUBA to produce a PVC for each option, as outlined in section 6.

3.5. Wider Impacts in Transport Appraisal (WITA)

Agglomeration and labour market impacts have been assessed using time, distance and trip matrices from the public transport model with the DfT's WITA software to implement calculations in line with WebTAG Unit A2.1. The value of the increase in economic output in imperfectly competitive markets has been estimated as a 10% uplift on public transport business user benefits, again in line with guidance in WebTAG Unit A2.1. In line with the user benefit assessment, highway impacts were not included in the calculations due to the uncertainty over their scale and location.

The results of the wider impacts assessment are discussed in Sections 7.5.1 and 8.2.

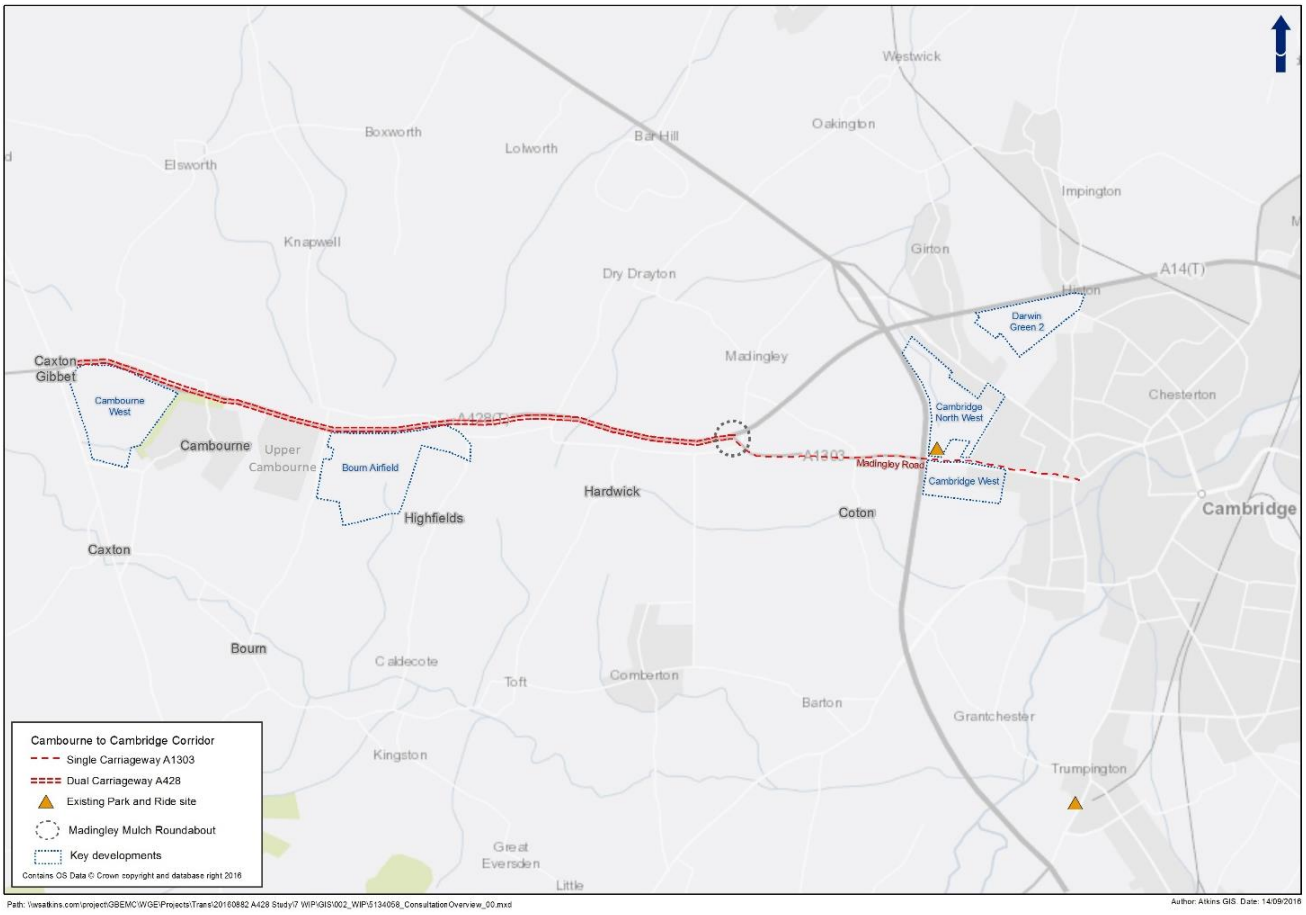
4. Baseline conditions

4.1. Current Highway performance of A428 corridor

The single carriageway sections of the A428 corridor currently exhibit congestion and reliability issues, particularly in the areas around Caxton Gibbet and Madingley Road.

The configuration of the A428 corridor, key features, development sites and Park & Ride locations are shown in Figure 4-1.

Figure 4-1 Configuration of the Cambourne to Cambridge corridor



Analysis of traffic data suggests that the journey times for travel along the A428 corridor, as a whole, is variable. This is recognised in local policy, with the need to address congested sections of the A428 corridor being identified within the LTP3, LTTS and the TSCSC.

Analysis of 2012/2013 TrafficMaster speed data indicates that there is good journey time reliability and limited congestion along the dual carriageway section of the A428 and it is, therefore, an attractive section of road for private car users. According to TRIS data[14] (Tues, Weds and Thurs in June 2016), the dual carriageway section of the A428 corridor currently carries in the region of 2,200 vehicles per hour in the AM Peak (07:00-08:00) travelling towards Cambridge and 1,800 vehicles per hour westbound in the PM Peak (17:00-18:00) travelling away from Cambridge. This is compared to an approximate capacity of 2,000 vehicles, per lane. As such there is a large amount of additional capacity on this duelled section to accommodate additional demand at this point in time.

[14] http://webtris.highwaysengland.co.uk/ (formerly called 'TRADs' data)

Conversely, the TrafficMaster journey time data shows that the single carriageway section of the A428 corridor has a higher variability of journey times indicating higher levels of congestion than the dual carriageway. This is evident along sections of the A428 between Caxton Gibbet and St Neots, and the A1303 approach into Cambridge.

The A1303 approach to Cambridge is shown to have greater levels of variability and congestion than the sections further west, with delays of up to 18 minutes travelling in to Cambridge in the AM peak, and 4 minutes travelling westbound in the PM peak. The problem can be seen to propagate from the combination of two significant traffic streams at the A1303 / M11 Junction as well as downstream junctions entering Cambridge itself when travelling eastbound, with up to 80% of the route experiencing queuing in the AM Peak. A further factor is the interaction of traffic entering and leaving the Madingley Road Park & Ride site, with the signalised junction contributing to variability and delay. This combination of different streams of traffic leads to the greatest level of flow between M11 Junction 13 and the Madingley Road Park & Ride Site, with peak direction traffic flows of up to 1,200 vehicles per hour.

Congestion in the outbound direction, which develops from M11 Junction 13 back towards Cambridge, is less significant.

Observed journey time data from TrafficMaster shows that car journeys from Cambourne to Cambridge in the AM peak took on average 28 minutes (from the Cambourne junction to Queens Road). The west-bound journey in the PM peak took on average 14 minutes. Future public transport schemes in the corridor need to attempt to offer services that are attractive in comparison or users will continue to prioritise private car trips over bus.

Figures from the 2011 census[15] suggest that the 1,096 workers living in Cambourne who commute to Cambridge City area are heavily reliant on cars with 80% of workers using a car or van to get to work (75% as drivers and 5% as passengers). The majority of those not using cars opt to use bus or coach (14%) with a small number (4%) choosing to walk and cycle. Of those using the bus to get from Cambourne to Cambridge, the majority of trips have a destination in one of three areas – the West Cambridge site / City Centre (54%), the Trumpington Road corridor (14%) and the Addenbrooke's / Hill's Road / Queen Edith's area (15%).

4.2. Current Performance of public transport services

St Neots is currently served by one bus service to and from Cambridge – the X5, with an AM peak frequency of two buses per hour. Between St Neots and Cambridge, the X5 follows the A428 and runs non-stop between Loves Farm, St Neots and Madingley Road Park & Ride.

Cambourne is currently served by five bus services to and from Cambridge. Of the five services, the Citi 4 service is the main Cambourne service, with a frequency of three buses per hour, running along the A428. The 3/X3 service provides a maximum of up to one bus per hour along the A428. In addition to these,

- Service 1 runs once per day, along the A428;
- Service 2 runs once per day on an indirect route to Cambridge via local villages of Caldecote, Toft, Hardwick, Drayton, Madingley and Coton; and
- Service 18 runs approximately 1 bus/hour, to the south of Cambourne along the B1046 toward Cambridge.

In the AM peak, the X5 service from St Neots Market Square to Madingley Road Park & Ride is timetabled to take between 26 and 33 minutes, with the Citi 4 service from Cambourne (De Le Warr Way) to Madingley Road Park & Ride[16] timetabled to take between 40 and 42 minutes (compared to 21 minutes by car, from observed TrafficMaster data).

There are additional services at the Park & Ride site on Madingley Road close to M11 Junction 13, which has shown consistent growth in patronage. Road Side Interview surveys conducted in 2013 suggest that the site captures up to 45% of the in-scope traffic passing the site (traffic that could use the Park & Ride to

[15] WU03EW - Location of usual residence and place of work by method of travel to work (MSOA level)
[16] Citi 4 bus stop nearest to Madingley Road Park & Ride is at British Antarctic Survey on Madingley Road.

complete their journey). There are however difficulties in accessing the site due to the existing congestion on the adjacent highway network, as explained above.

It should be noted that a current barrier to offering improved services along the A428 corridor is the lack of priority for bus services, with a short bus lane on the approach to M11 Junction 13 being the only significant measure along the corridor. PT therefore is able to offer little significant journey time benefit compared to car travel on the highway network. This is a significant factor that hinders mode shift as the attractiveness of PT on the corridor is unlikely to be sufficient (e.g. reduced journey times compared to car) to make users switch mode.

4.3. Current Performance of active modes

Walking and cycling facilities are provided locally to Cambridge, including off-road routes to Coton and between Hardwick and Caldecote, however these do not extend along the entire length of the corridor. There is the potential to walk or cycle along St Neots Road, however there is no dedicated cycling provision. The current level of service provision is unlikely to encourage more cyclists to make long distance trips into Cambridge, or shorter journeys between local towns and villages. Further data and analysis would be required to establish the current use of active modes along the A428 corridor.

5. Do Minimum scenario - 2031

5.1. Performance of A428 corridor in 2031 in the Do Minimum

5.1.1. Highway Network

Travel demand in the Greater Cambridge area is forecast to increase due to a combination of economic growth nationally, leading to a higher number of people accessing jobs and services, as well as due to a number of large development sites in the area. Demand forecasting has been undertaken using CSRM which takes into account the land-use growth proposals included in the submitted Local Plans.

CSRM forecasts that by 2031 car trips on the A428 corridor towards Cambridge could increase by 30% on the dual carriageway section in the AM Peak and 50% in the PM Peak heading westbound. On the single carriageway section flows remain fairly constant between 2011 and 2031 despite the demand for the corridor increasing which suggests that the single carriageway section of the corridor has already reached capacity and trips from the west will look to avoid Madingley Road (A1303). This theory is supported by the highway network analysis presented in Table 5-1 and Table 5-2, which show that junction are nearly at or even over capacity in 2031, which would lead to congestion and delays and therefore drivers are likely to redirect away from the A1303.

The highway model can be used to give an indication of the performance of key junctions along the single carriageway section of the corridor in terms of volume to capacity ratio (V/C). Table 5-1 and Table 5-2 present the V/C for specific traffic movements identified as being over capacity in 2031: a V/C of 0.85 or above is considered to indicate an area of high congestion.

Table 5-1 V/C at key junctions based on CSRM (2031 DM) AM Peak (08:00-09:00)

Junction	V/C
A1303 / M11 Off-Slip on the western approach from A1303 eastbound	1.05
A1303 / JJ Thomson Avenue on the right turn into JJ Thomson Avenue from the A1303 (West)	0.85
A1303 / Lady Margaret Road on the left turn from Lady Margaret Road onto A1303 (East)	0.96
A1303 / Lady Margaret Road on the ahead movement from A1303 (west) to A1303 (East)	0.85

Table 5-2 V/C at key junctions based on CSRM (2031 DM) PM Peak (17:00-18:00)

Junction	V/C
Madingley Mulch Roundabout on the eastern approach from A1303 westbound	0.91
A1303 / Coton village on all turns at the approach from Coton	1.07
A1303 / M11 Off-Slip on the eastern approach from A1303	1.03
A1303 / M11 Off-Slip on the M11 northbound off-slip	0.86
A1303 / Grange Road on the approach from Grange Road	1.0405
A1303 / Grange Road on the approach from the A1303 (W) to Grange Road	0.92
A1303 / Lady Margaret Road on the eastern approach from the A1303 westbound to Lady Margaret Road	0.98

5.1.2. Performance of public transport services

In the Do Minimum scenario, PT services are assumed to continue to use existing infrastructure. As previously described, there is minimal bus priority along the corridor and therefore it is likely that the reliability of bus journey times will continue to be affected by the forecast increase in traffic volumes and resultant congestion.

In the Do-Minimum scenario, using PT to travel from Cambourne to Madingley Mulch is forecast to take 29 minutes, and from Madingley Mulch to Northampton St/Bridge St 14 minutes in the 2031 AM Peak. PT journeys from Cambourne to Drummer Street in the AM peak are forecast to take approximately 52 minutes.

5.1.3. Performance of active modes

The intermittent nature of the pedestrian and cycle facilities along the A428 corridor means that cyclists are often required to share road space with general traffic. An increase in travel demand along the corridor will result in an increase in general traffic volumes, and most likely in the number of cyclists using the road. With this in mind, potential conflict between cyclists and private vehicles could increase in the Do Minimum scenario due to the lack of dedicated provision for cycling. There is also likely to be an increase in pedestrian trips locally along the corridor, associated with the new development sites. Further analysis is required to establish the rise in demand for cycling and pedestrian journeys, and the improvements to cycling and pedestrian journey times, as a result of the options for the Cambourne to Cambridge better bus journey schemes, to be undertaken for the recommended option in stage 3 of the business case development.

5.1.4. Rationale for Improvement

The Strategic Case identifies a case for change along the A428 / A1303 corridor. Increased employment, housing and therefore trips along the corridor may have a detrimental impact on the transport performance of the corridor, especially on single carriageway sections of the study corridor, unless transport improvements are forthcoming.

The potential consequences of a Do Minimum scenario, where no improvements to infrastructure are made, are summarised below:

- Traffic growth and congestion are likely to continue to increase, in line with expected housing and employment growth along the corridor, and people may spend more time in congestion, especially on single-carriageway elements of the study area;
- There are direct economic costs to users associated with congestion and this may also have indirect economic costs if the area becomes a less attractive place to live and work.

- As housing and employment development progresses, and without a step change in sustainable public transport provision, people may feel that they have little choice but to travel by car. In order to achieve mode shift from car to public transport, a more attractive public transport alternative to car than is currently available is required, that has comparable or better reliability, journey times, quality, cost and convenience of travel;

The remainder of this Economic Case presents the appraisal of the five options shortlisted for improving sustainable public transport along the corridor.

6. Option cost appraisal

6.1. Introduction

This chapter sets out the costs of the options that are captured in the appraised and explains the costs included and how they are manipulated following WebTAG guidance to provide Present Value of Costs (PVC). First the capital cost is presented for all options and then the whole life costs (maintenance and renewals) associated with the proposed schemes. The risk allowance for each scheme is presented and then the inflation and optimism bias assumptions are explained. The costs are brought together, adjusted and discounted for inclusion in the cost benefit analysis. Finally the costs are brought together into the PVC with the subsidy impact.

6.2. Infrastructure delivery capital cost estimates by option

The base construction cost estimates are presented in Table 6-1. The base costs have been provided in resource prices, and exclude allowances for VAT, inflation, risk and optimism bias. Further detail on the derivation of base costs are provided in the **Financial Case**.

Table 6-1 Breakdown of base investment costs for each option (2010 price base, undiscounted resource prices)

Cost item	Option 1 cost (£000s)	Option 2 cost (£000s)	Option 3 cost (000s)	Option 4 cost (000s)	Option 5 cost (000s)
Preparatory	£1,800	£4,000	£8,000	£4,700	£5,800
Construction	£16,400	£36,000	£73,100	£41,600	£50,400
Total	**£18,200**	**£40,100**	**£81,100**	**£46,300**	**£56,200**

6.3. Option infrastructure whole life cost estimates

Renewals

Renewals estimates for the 60-year appraisal period have been provided by Faithful+Gould based on high-level cost planning techniques and construction capital costs. The estimates are provided in Table 6-2.

Table 6-2 Breakdown of whole life renewals costs for each option (2010 price base, undiscounted resource prices)

Cost item	Option 1 cost (000s)	Option 2 cost (000s)	Option 3 cost (000s)	Option 4 cost (000s)	Option 5 cost (000s)
Highway	£4,800	£3,200	£1,900	£2,300	£1,900
Busway	-	£12,500	£28,700	£16,600	£17,300
Equipment and system	£800	£900	£1,100	£600	£600
Other infrastructure	£2,500	£2,800	£5,900	£2,800	£6,500
Total	**£8,200**	**£19,400**	**£37,500**	**£22,400**	**£26,200**

Annual maintenance

Annual maintenance, required for both general operation and repairs, has been estimated by Skanska, based on the capital construction items provided by Faithful+Gould. The annual maintenance figures are presented in Table 6-3.

Table 6-3 Breakdown of annual maintenance costs for each option (2010 price base, undiscounted resource prices)

Cost item	Option 1 cost (000s)	Option 2 cost (000s)	Option 3 cost (000s)	Option 4 cost (000s)	Option 5 cost (000s)
Highway	£10	£47	£64	£53	£55
Park & Ride site	£17	£17	£17	£17	£17
Total	**£26**	**£63**	**£80**	**£70**	**£71**

Note: Values in this table are rounded to the nearest £1,000

6.4. Risk Allowance

The risk allowance breakdown per option is presented in Table 6-4.

Table 6-4 Risk allowance breakdown per option (2010 price base, undiscounted resource prices)

Option	Risk allowance (000s)
Option 1	£5,100
Option 2	£11,800
Option 3	£23,300
Option 4	£13,500
Option 5	£16,500

6.5. Inflation and optimism bias

As described in Section 3.4, inflation and optimism bias has been added to the scheme costs based on WebTAG unit A1.2 guidance. The contribution of real cost inflation in addition to base costs are presented in Table 6-5, with the contribution of optimism bias presented in Table 6-6. Optimism bias has been added to the risk adjusted costs in accordance with WebTAG A1.2. The investment costs (including real cost increase) with optimism bias are presented in Table 6-7.

Table 6-5 Real cost inflation to be added (2010 price base, undiscounted resources prices)

Cost item	Option 1 cost (000s)	Option 2 cost (000s)	Option 3 cost (000s)	Option 4 cost (000s)	Option 5 cost (000s)
Construction costs	£5,100	£11,200	£22,600	£12,900	£15,700
Renewals	£4,400	£10,400	£20,200	£12,000	£14,100
Annual Maintenance	£800	£2,000	£2,600	£2,200	£2,300
Risk	£1,600	£3,700	£7,300	£4,200	£5,200
Total	**£11,900**	**£27,300**	**£52,700**	**£31,400**	**£37,200**

Table 6-6 Optimism bias to be added (2010 price base, undiscounted resources prices)

Cost item	Option 1 cost (000s)	Option 2 cost (000s)	Option 3 cost (000s)	Option 4 cost (000s)	Option 5 cost (000s)
Preparatory costs	£900	£2,000	£3,900	£2,300	£2,800
Construction costs	£9,400	£20,800	£42,100	£24,000	£29,100
Renewals	£1,900	£4,500	£8,700	£5,200	£6,100
Annual Maintenance	£0	£0	£0	£0	£0
Risk	£2,900	£6,800	£13,500	£7,800	£9,500
Total	**£15,100**	**£34,100**	**£68,200**	**£39,300**	**£47,500**

Table 6-7 Breakdown investment costs for each option with real-cost inflation and optimism bias (2010 price base, undiscounted resources prices)

Cost item	Option 1 cost (000s)	Option 2 cost (000s)	Option 3 cost (000s)	Option 4 cost (000s)	Option 5 cost (000s)
Preparatory costs	£2,800	£6,500	£12,900	£7,500	£9,200
Construction costs	£30,900	£68,000	£137,900	£78,500	£95,200
Renewals	£14,400	£34,300	£66,400	£39,600	£46,400
Annual Maintenance	£2,400	£5,800	£7,400	£6,400	£6,500
Risk	£9,600	£22,400	£44,000	£25,600	£31,200
Total	**£60,200**	**£136,900**	**£268,500**	**£157,700**	**£188,500**

6.6. Present Value of Appraisal Costs

Benefits of the scheme have been calculated at market prices (i.e. inclusive of taxes) and it is therefore necessary to adjust the cost estimates so that the benefits and costs are consistent. As specified in WebTAG unit A1.2, the average rate of indirect tax in the economy is currently 19%, and accordingly, the resource costs have been factored up by 1.19.

Discounting is an adjustment applied to both costs and benefits to represent the preference to receive benefits sooner rather than later and for costs to be paid later rather than sooner. This means that both costs and benefits occurring further into the future are valued lower. In line with WebTAG guidance, discount rates of 3.5% p.a. from 2016 to 2046 and 3.0% p.a. from 2047 onwards have been applied.

The tables below present the cost profile used in the appraisal, from the base cost (including full appraisal period maintenance and renewal costs), risk adjusted cost and Present Value Costs (PVC) market prices, discounted to 2010 price base.

Table 6-8 Appraisal Cost Profile

Option	Base costs 2010 resource prices, excluding risk (000s)	Risk adjusted 2010 resource costs, with real cost increase and Optimism Bias (000s)	Present Value Capital and Whole Life Costs, 2010 market prices discounted to 2010 (000s)
Option 1	£27,900	£60,200	£42,500
Option 2	£63,300	£136,900	£95,200
Option 3	£123,500	£268,500	£189,200
Option 4	£72,900	£157,700	£109,600
Option 5	£86,700	£188,500	£132,100

6.7. Bus service operating costs and revenue

Operating cost and revenue

The bus operating costs, estimated using CSRM outputs, have been re-based and discounted to 2010 market prices for input into TUBA. Fleet investment has been estimated with reference to the Peak Vehicle Requirement forecasts, derived using the CSRM.

To estimate the annual revenue from each of the options, a public transport fare matrix has been run through TUBA, in combination with the CSRM demand matrix. TUBA provides an estimation of the total fare paid in each option over the appraisal period, discounted to 2010.

The resulting fleet investment costs, bus operating costs and revenue are presented in Table 6-9.

Table 6-9 Fleet investment, bus operating costs and revenue (2010 market prices, discounted to 2010)

Option	Initial Fleet Investment (000s)	Operating Cost (000s)	Operating Revenue (000s)	Revenue-Cost (000s, excluding fleet investment)
Option 1	£3,600	£38,500	£45,900	£7,400
Option 2	£5,700	£60,500	£52,200	-£8,300
Option 3	£5,300	£55,300	£42,000	-£13,300
Option 4	£5,800	£58,100	£24,300	-£33,900
Option 5	£5,800	£57,700	£28,200	-£29,400

The results of the TUBA analysis indicate a shortfall in revenue for Options 2 to 5 of between £8 to 34 million over the full appraisal period compared to the operating costs. This difference between cost and revenue suggests a subsidy from the public sector is likely to be required to compensate for the shortfall caused to the private sector bus operator.

The economic analysis undertaken to date suggests that forecast model demand is not sufficient to commercially support the level of services currently assumed in the modelling. . Bus service provision for each option has not yet been optimised for the given level of modelled demand.[17]. A more detailed review of the service provision along the A428 corridor (including the Park & Ride) could inform a revised service

[17] As discussed in in section 3.2.1 above, CSRM may potentially be underestimating demand for high quality public transport but this can only be confirmed when further demand modelling is undertaken.

provision strategy that could allow a more commercially viable provision. It is not the expectation to set up commercially unviable services for the lifetime of the scheme.

The current analysis indicates that, on the basis of currently modelled bus service assumptions, the modelled demand does not generate sufficient revenue to commercially support the proposed level of bus service provision. Therefore a grant / subsidy to the private sector is likely to be required, which is included within the PVC in the cost benefit analysis.

6.8. Present Value Costs

For the purposes of this appraisal the full subsidy values need to be incorporated into the PVC, so that the benefit to cost ratio accounts for the potential discounted subsidy; Table 6-10 presents the full subsidy requirement in PVC terms, and resulting PVC that has been presented in the appraisal tables.

Table 6-10 Potential level of subsidy and PVC

Option	Potential subsidy value, inclusive of fleet investment, 2010 market prices, discounted to 2010 (000s)	Adjusted PVC 2010 market prices discounted to 2010 (000s)
Option 1	N/A	£42,500
Option 2	-£14,000	£109,200
Option 3	-£18,700	£207,800
Option 4	-£39,700	£149,300
Option 5	-£35,300	£167,400

The economic analysis undertaken to date suggests that forecast model demand is not sufficient to commercially support the level of services currently assumed in the modelling to be provided by the Cambourne to Cambridge Better Bus Journey Scheme.

The subsidy calculated in Table 6-10 is the difference between modelled revenue (as reported by TUBA, using CSRM model inputs) and operating costs (as reported by TUBA, based on high level bus operations calculations) for each option. Modelled revenue is calculated by multiplying patronage by an average fare, the fare being calculated by distance. Revenue does not include concessionary fares as concessionary fares are not included in the average fares input to the model.

A fully specified operational model is needed to accurately calculate the operational commercial viability of services, something that could be developed in further stages of the scheme. For the current assessment, the outcome of the revenue and cost calculations is a high level indication that it is worth considering, more carefully, whether there is sufficient demand for the number of services currently specified (9-12 bph over 3 route variants (Cambourne to Science Park; Cambourne to Addenbrooke's, Cambourne to Cambridge City Centre). It is not expected that a bus scheme would be designed that ab initio requires subsidy for the lifetime of the scheme, instead scheme design and specification should be refined in order to achieve commercial viability as well as overall value for money.

A more detailed review of the service provision along the A428 corridor (including the Park & Ride) should explore:

- The optimal number of additional buses per hour assumed on the option, or reduction of current services being offered on existing routes so that passengers are spread less thinly between buses;
- The optimal route of the option to maximise patronage from villages along the alignment or diversion of buses onto more commercial routes;
- The optimal fare;

- Various sources of subsidy, not all of which would necessarily be funded by local councils. Part of the subsidy includes paying for concessionary passengers for instance, which may be central government funded; and

- Diversion of buses onto more commercial routes.

7. Option Impacts

7.1. Transport Economic Efficiency

The transport impacts of a scheme are made up of changes to journey times, user chargers and vehicle operating costs, separated out by user type (commuting, business and all other users). The monetised public transport impacts of each option are summarised in Table 7-1 below.

Full TEE Tables are shown in Appendix A.

Table 7-1 Transport Economic Efficiency – Public Transport

	Transport Economic Efficiency - Bus only (totals)				
All values in £000s, discounted to 2010 prices	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Non-business: Commuting					
User benefits					
Travel time	£11,200	£12,200	£12,900	£5,000	£5,300
User charges[18]	£190	-£40	-£310	-£480	-£480
NET NON-BUSINESS BENEFITS: COMMUTING	£11,400	£12,100	£12,500	£4,500	£4,800
Non-business: Other					
User benefits					
Travel time	£40,200	£55,300	£45,600	£18,600	£20,700
User charges	£900	£1,200	-£900	-£800	-£800
NET NON-BUSINESS BENEFITS: OTHER	£41,100	£56,400	£44,700	£17,800	£19,900
Business					
User benefits					
Travel time	£900	£800	£500	£4[19]	£100
User charges	-£200	-£200	-£200	-£200	-£200
Subtotal	£700	£600	£300	-£200	-£100
Private sector provider impacts					
Revenue	£45,900	£52,200	£42,000	£24,300	£28,200
Operating costs	-£38,500	-£60,500	-£55,300	-£58,100	-£57,700
Investment costs	-£3,600	-£5,700	-£5,300	-£5,800	-£5,800
Grant/subsidy	£0	£14,000	£18,700	£39,700	£35,300
Subtotal	£3,800	£0	£0	£0	£0
Other business impacts					
Developer contributions	£0	£0	£0	£0	£0
NET BUSINESS IMPACT	£4,400	£600	£300	-£200	-£100
TOTAL					
Present Value of Transport Economic Efficiency Benefits (TEE)	£56,900	£69,100	£57,500	£22,100	£24,600
	Notes: Benefits appear as positive numbers, while costs appear as negative numbers.				
	All entries are discounted present values, in 2010 prices and values				

As discussed in Section 3, highway impacts are excluded from the analysis at this initial stage of assessment, although it should be noted again that all options are expected to generate mixed highway impacts; benefits from congestion relief associated with mode-shift offset by disbenefits associated with

[18] Values in this row rounded to nearest £10,000.
[19] Option 4 has not been rounded for presentation due to the low value.

capacity reduction for other vehicles caused by online running, additional buses and the concentration of trips in congested areas around Park & Ride sites. Due to the very detailed nature of the interactions it isn't possible to model the impacts accurately in the strategic CSRM model, but the net impacts are expected to be negative because the disbenefits are focussed in particularly congested areas. Further option design and specification development would allow for the option to be optimised to mitigate the congestion disbenefits as far as possible.

7.2. Strategic Model assessment of demand and journey times

Strategic modelling of the Cambourne to Cambridge Better Bus Journeys Scheme indicates that it has only a modest impact on demand for public transport along the A428 corridor, and the options are not forecast to realise significant monetised benefits.

Despite the journey time improvements that result from the options, commuting and business trips taken by car along the A428 corridor are much faster than those taken by public transport and as such there is minimal modelled mode shift to public transport, despite an allowance having been made in the modelling for improved attractiveness of HQPT provision. Demand management measures (such as those envisaged by the Cambridge Access Study) have not been included in the model, the inclusion of which may increase the attractiveness of public transport as compared to private car users.

Public transport (bus and park & ride) mode share along the A428 corridor is approximately 21%, however, the total modelled number of trips along the corridor is relatively small. The majority of public transport trips are taken by Education and Other (that is non-business and non-commuting, including leisure) users who have lower values of time than commuters and business travellers and, therefore, generate lower monetised transport benefits per trip than business travellers or commuters.

7.2.1. Summary findings of overall demand

In the Greater Cambridgeshire area public transport is forecast to continue to account for a relatively small proportion of all trips to 2031 (8.2% in the Do Minimum scenario), as can be seen in Table 7-2. Travel in the study area is dominated by car due to car journey times being, on average, much lower than public transport journey times (see tables Table 7-3 and Table 7-4).

Along the A428 corridor itself the modelled mode share of public transport is higher than that of Greater Cambridgeshire as a whole (about 21% across all options in 2031), however, the corridor only accounts for about 8% of the total trips made in the study area. As a result of the overall low demand for public transport, the PT journey time improvements generated by the Cambourne to Cambridge Better Bus Journeys scheme options are only experienced by a small number of users and this translates to a low level of transport benefits.

Table 7-2 summarises the numbers and proportions of total users and public transport users in the Greater Cambridge study area and on the A428 corridor specifically, by option for 2031.

Table 7-2 Forecast daily public transport usage in Greater Cambridgeshire and along the A428 corridor[20], total daily trips in 2031

Options	Do Min	Option 1	Option 2	Option 3	Option 4	Option 5
Total daily trips (car and public transport) in Greater Cambridgeshire	1,395,935	1,396,282	1,396,309	1,396,309	1,396,101	1,396,106
Total daily PT trips in Greater Cambridgeshire	115,157	118,821	119,265	118,207	116,809	117,130
Daily PT trips as proportion of total daily trips in Greater Cambridgeshire	8.2%	8.5%	8.5%	8.5%	8.4%	8.4%
Total daily trips on A428 corridor	114,599	115,195	115,167	115,026	114,856	114,881
A428 corridor total daily trips as proportion of Greater Cambridgeshire total daily trips	8.2%	8.3%	8.2%	8.2%	8.2%	8.2%
Total daily PT trips on A428 corridor	23,462	25,109	25,504	25,080	24,367	24,448
A428 corridor daily PT trips as a proportion of A428 corridor total daily trips	20.5%	21.8%	22.1%	21.8%	21.2%	21.3%

Table 7-2 shows that the Cambourne to Cambridge Better Bus Journeys options for intervention are forecast to increase absolute numbers of PT trips along the A428 corridor compared to the do-minimum in 2031, but from a relatively low base demand. The small absolute increase in demand[21] translates into relatively modest monetised user benefits associated with each option.

7.2.2. Demand by user type

Table 7-3 and Table 7-4 show the difference in weighted average journey time between public transport and car journeys across Greater Cambridgeshire for all user types in the AM peak period (in minutes in Table 7-3 and as a percentage in Table 7-4). User types are:

- **Business** – Business users are those travelling as part of business, or during business time;
- **Commuter** – Users travelling to or from work; and
- **Other** - includes leisure travellers, those travelling for medical purposes and all other purposes that are not commuting or business. This excludes education users because this is a large sub-group and is disaggregated from 'Other' in this analysis.
- **Education** – Education users are those travelling to/from Education sites (excluding home-based education).

[20] 'A428 Corridor': West Cambridgeshire, Cambourne, Bourn, Bourn Airfield, Caldecote, Coton, Hardwick and St Neots) to the City Centre, Addenbrooke's and the Science Park.

[21] As discussed in in Section 3.2.1 above, CSRM may potentially be underestimating demand for high quality public transport but this can only be confirmed when further demand modelling is undertaken.

Table 7-3 Difference between Average PT Journey Time (Minutes) and Average Car Journey Time (Minutes) in the Greater Cambridgeshire area, AM Peak, 2031

Options	Do Min	Option 1	Option 2	Option 3	Option 4	Option 5
Business	33.4	33.7	33.8	34.0	33.7	33.7
Education	22.0	22.0	21.6	21.6	21.7	21.7
Commuter	27.0	26.3	26.0	26.1	26.3	26.3
Other[22]	9.3	8.2	8.0	8.5	8.6	8.6

Table 7-3 indicates that business users have an average PT journey time that is around 33 to 34 minutes longer than the same journey by car across all options. Journey times taken by Other users are on average only 8 to 9 minutes longer than the same journey taken by car. Table 7-4 represents these journey time differences as proportions.

Table 7-4 PT Average Journey Time (Minutes) As Percentage of Car Journey Time in the Greater Cambridgeshire area, AM Peak, 2031

Options	Do Min	Option 1	Option 2	Option 3	Option 4	Option 5
Business	153%	154%	154%	155%	154%	154%
Education	180%	180%	179%	179%	179%	179%
Commuter	153%	152%	151%	152%	152%	152%
Other	123%	120%	119%	120%	121%	121%

On the A428 corridor, the largest share of public transport users is “Other” users, followed by Education users (Table 7-5). Business users only make up approximately 1% of public transport trips on the A428 corridor in 2031.

Table 7-5 A428 Corridor percentage PT trips by user type 2031

Options	Do-Min	Option 1	Option 2	Option 3	Option 4	Option 5
Business	1%	1%	1%	1%	1%	1%
Education	38%	36%	37%	37%	37%	38%
Commuter	21%	22%	22%	22%	22%	22%
Other	40%	42%	41%	40%	40%	40%

Analysis indicates that Other users experience, on average across all Other trips, only 9 minutes additional journey time when using public transport as opposed to car. In contrast the initial findings indicate that Business user experience, on average across all business trips, 33 minutes additional journey time when using public transport as opposed to car. Other users of public transport have, on average, a much closer journey time to cars which means they have less disincentive to use public transport and the number of trips taken by this user group is expected to be higher than commuters and business users as a result.

Education users may have a lower car ownership rate than business travellers and commuters making the use of public transport necessary, while the leisure proportion of Other users may have an incentive (due to congestion and lack of parking) to travel into Cambridge Centre by Public Transport rather than car (the evidence on Park & Ride patronage discussed in Section 7.2.3.1 suggests this). Other and Education users

[22] **Note:** Further investigation is required to understand why Other users have on average a far smaller difference in journey time compared to car journeys than other users, but it is expected that the explanation has to do with the average length of journeys undertaken for leisure purposes and the use of Park & Ride for leisure trips.

have a lower Value of Time than commuters and business travellers and while they are likely to account for a higher proportion of PT trips, the monetised transport benefits achieved per trip by Other and Education users are lower than for commuters and business users.

Transport benefits for all options are relatively low due to low demand for public transport[21] on the A428 Corridor and patronage dominated by Other and Education users who have a low Value of Time.

7.2.3. Transport Economic Efficiency by Option

Transport benefits are derived from an increase in demand and journey time improvements. Table 7-6 summarises the net present value of transport economic benefits accruing to each option.

Table 7-6 Public Transport[23] Benefits by option (all values NPV, 2010, £'000s)

Benefits	Option 1	Option 2	Option 3	Option 4	Option 5
Net PT Transport Benefits (£'000s)	56,900	69,100	57,500	22,100	24,600

Option 2 generates the highest level of public transport benefits, followed by Option 3. This is due to a combination of Option 2 generating higher patronage than other options and having the highest average journey time savings (along with Option 3).

7.2.3.1. Demand and Park & Ride

As noted earlier, the overall scheme impact on demand for public transport in the study area is relatively small. The change in demand is driven largely by additional Park & Ride journeys. Options 1 and 2 generate significantly more additional Park & Ride journeys than the other options. This is primarily because Options 1 and 2 route new bus services via the new Park & Ride at Madingley Mulch as well as the existing Park & Ride on Madingley Road.

Table 7-7 shows the breakdown of demand changes compared to the Do Minimum by option and mode. As discussed in Table 7-2 above, there are approximately 1.3 million car trips in the study area in the Do Minimum, compared to 115,000 PT trips (of which 11,000 are Park & Ride trips). With the options, Park & Ride trips increase by between 10.9% and 33.7% above the Do-Minimum, however, as a proportion of total trips (excluding active modes) the contribution to the overall change in total demand is small.

Table 7-7 Study area demand changes compared to Do Min, excluding active modes (all time periods, 2031)

	Option 1	Option 2	Option 3	Option 4	Option 5
Car	-0.3%	-0.3%	-0.2%	-0.1%	-0.1%
Park & Ride	33.7%	31.5%	21.3%	10.9%	13.8%
Public Transport	0.0%	0.7%	0.7%	0.4%	0.5%
Total demand change (Car, Park & Ride, PT)	**0.02%**	**0.03%**	**0.03%**	**0.01%**	**0.01%**

Figure 7-1 to Figure 7-5 show option bus patronage in the AM Peak. From the figures it can be seen how much patronage increases on routes after the Park & Ride locations and the lower levels of patronage for Options 3 to 5. Blue arrows on the maps indicate the approximate location of Park & Ride facilities.

[23] Excludes Highways Impacts

Figure 7-1 Option 1 route and demand Map, AM Peak 2031

Figure 7-2 Option 2 route and demand Map, AM Peak 2031

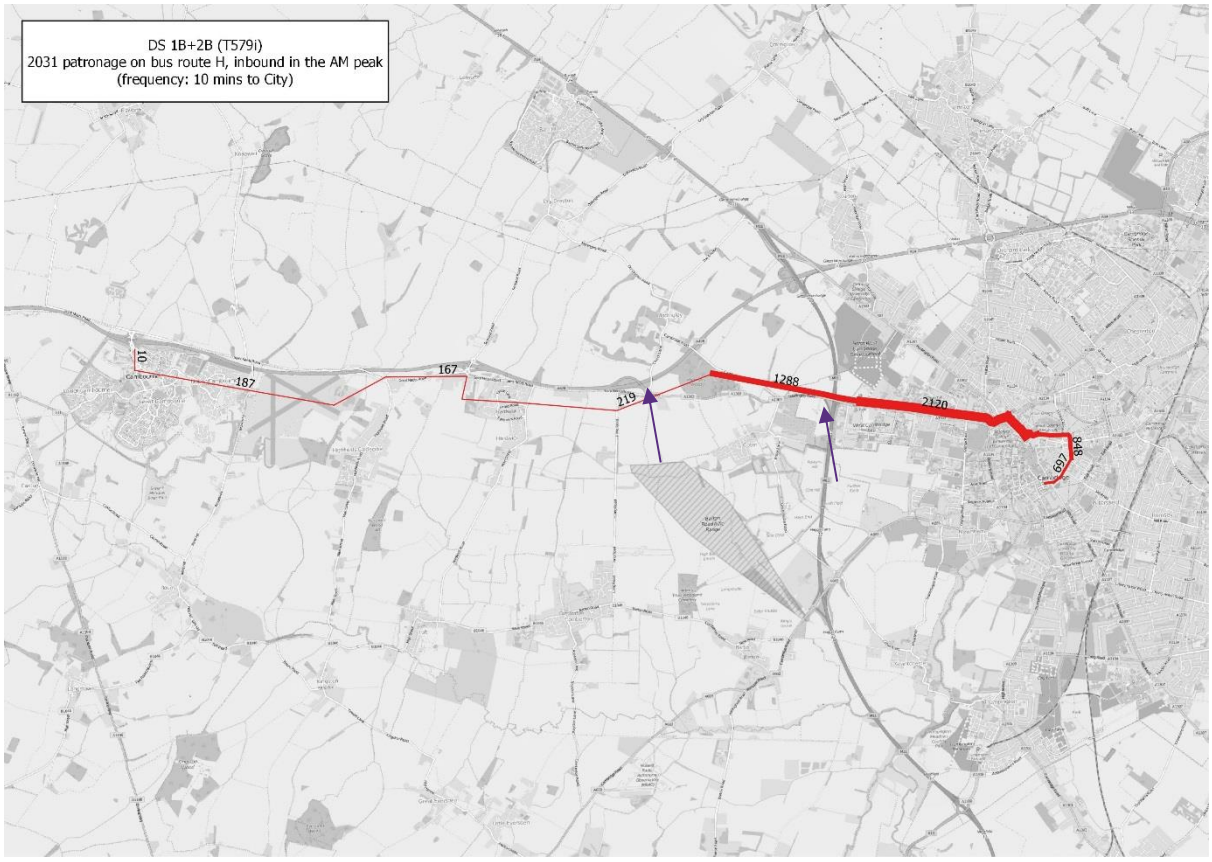


Figure 7-3 Option 3 route and demand Map, AM Peak 2031

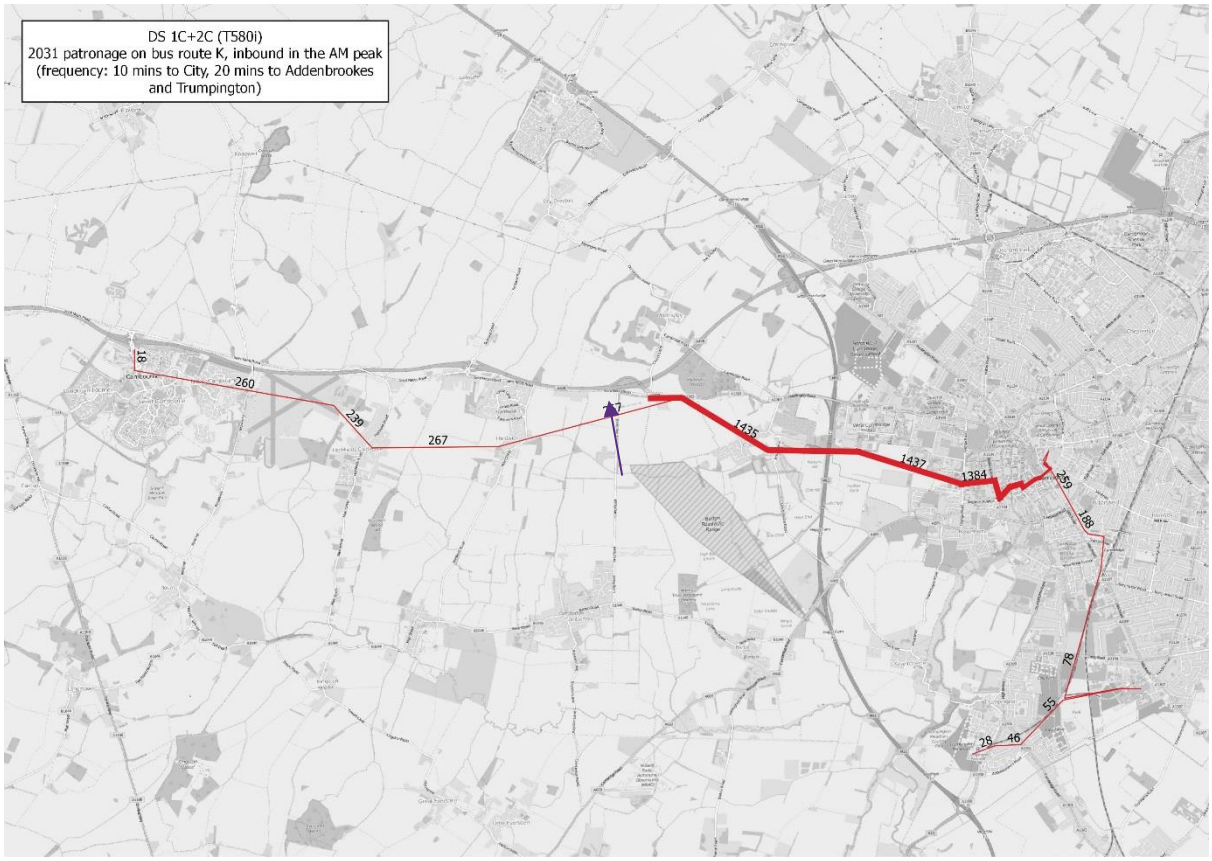


Figure 7-4 Option 4 route and demand Map, AM Peak 2031

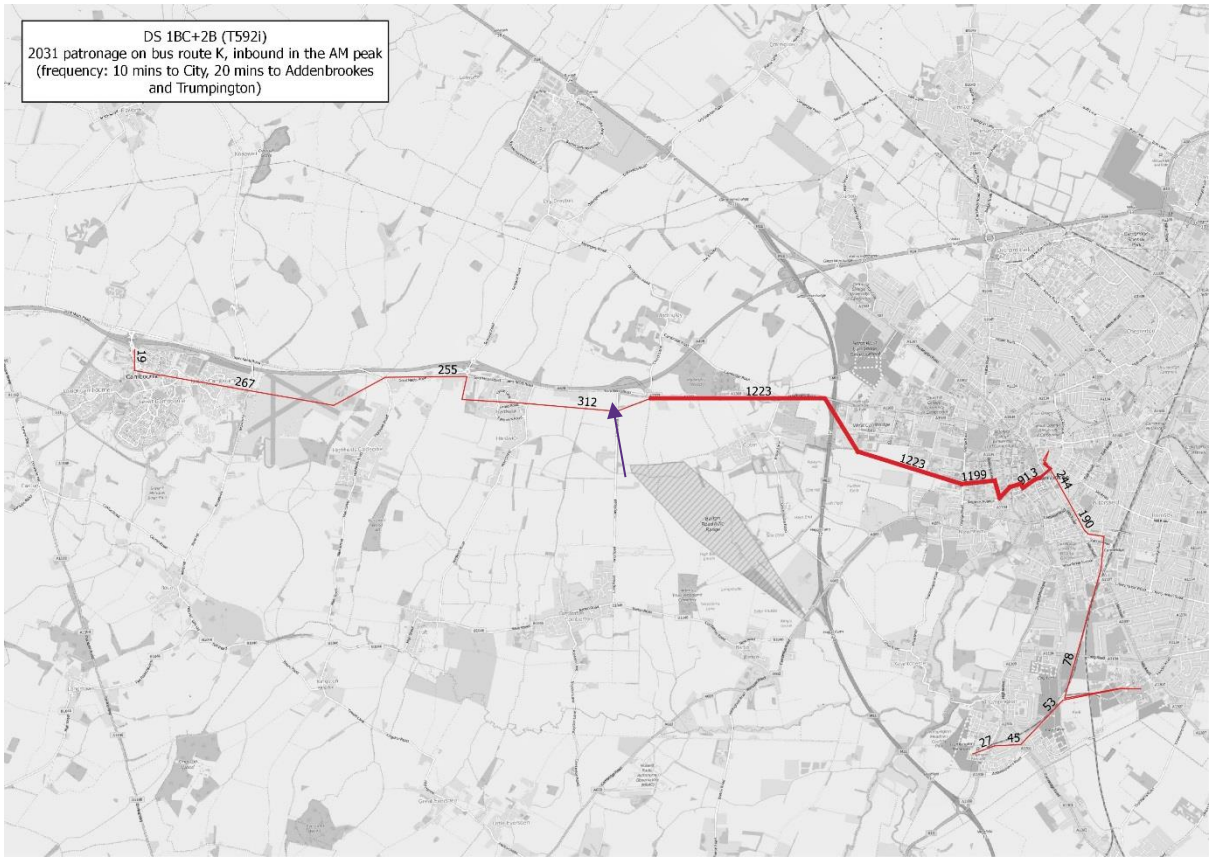
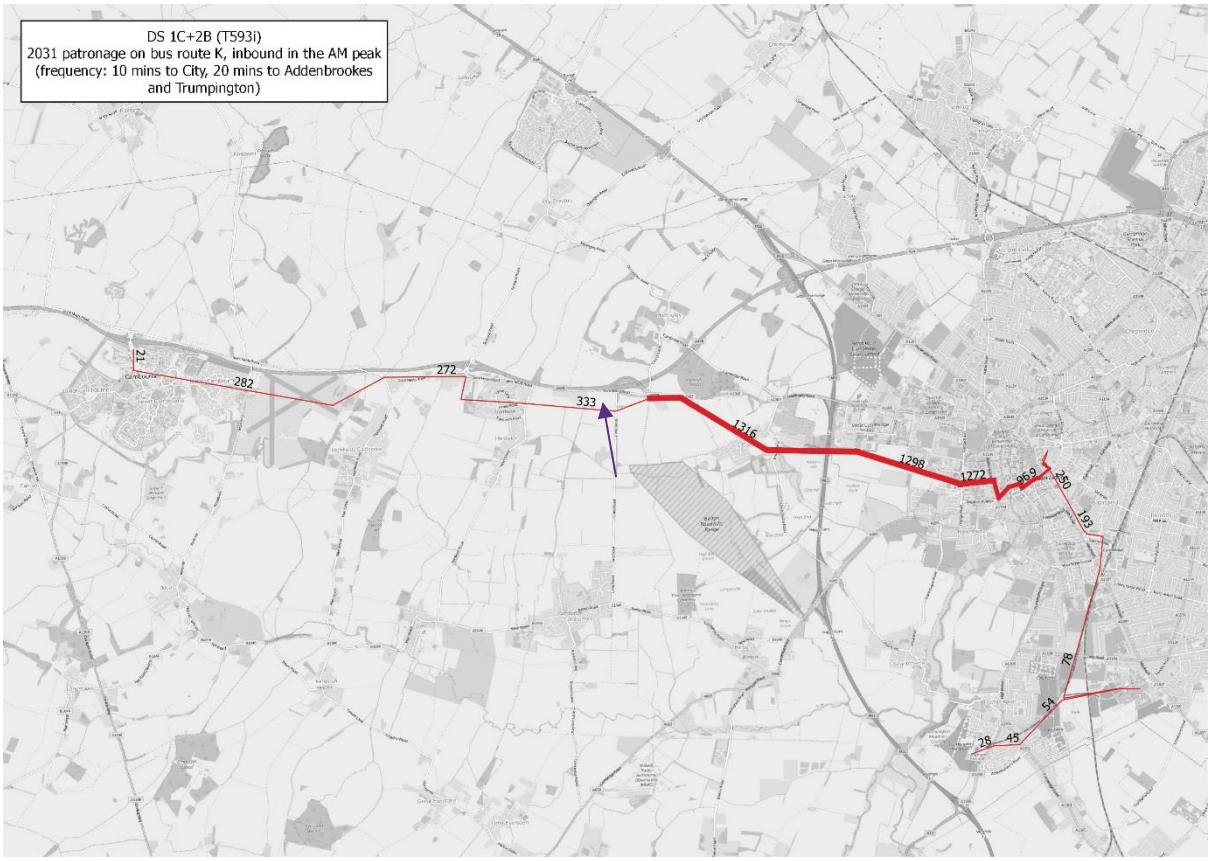


Figure 7-5 Option 5 route and demand Map, AM Peak 2031



Across all options, patronage is concentrated on the eastern sections of the alignment, (east of Madingley Mulch). Aside from the option alignments to Park & Ride, there are several other factors that might be contributing to the variation in total benefits accruing to each option, including the differences in bus service routes that mean some options pass through more populated areas, and the slight differences in journey times. Further investigation at a later stage of option optimisation and development is required to establish the extent to which each of these factors influence the differential performance of options.

7.2.3.2. Public Transport Journey Time Savings

All options provide improved average public transport journey times over the Do-Minimum, with Options 2 and 3 showing the best average improvements. This difference is illustrated in Table 7-8, which shows the AM Peak average Journey Times for Public Transport users along the A428 corridor.

Table 7-8 AM Peak 2031 Journey Times (minutes) on the A428 corridor[20] for Public Transport users

	Do-Min	Option 1	Option 2	Option 3	Option 4	Option 5
Business	50.4	46.0	44.8	45.1	46.9	46.7
Education	66.4	63.8	58.1	56.6	59.1	59.0
Commuter	56.4	50.7	47.9	48.4	49.8	49.5
Other	48.8	43.8	41.8	42.4	43.1	42.8
Total	59.0	53.6	50.4	50.4	52.2	51.9

The proposed route for Option 3 passes through more built up areas, such as the village of Coton and Caldecote, than do the proposed routes for Options 4 and 5. This means the total prospective patronage

pool for Option 3 is higher than 4 or 5, which could potentially contribute to Options 3's superior relative performance on total transport benefits compared to Options 4 and 5.

Further investigation is required to fully understand the reasons driving the benefits attributed to each option and it is possible that further design development and optimisation could lead to improved option benefits. It is not possible to confirm at this stage whether the BCRs for any option would change as a result of further design development and analysis.

Public transport journey times are slower compared to car, especially for business usage. Other users have, on average, the closest public transport journey time to the private car. The analysis thus indicates that all options have a low, positive present value of transport user benefits (PVB). Current modelled demand and revenue do not cover the expected operating costs of running the number of services provided by Options 2 to 5 and private sector operators are expected to require subsidies.

7.3. Benefits to cyclists

All options with offline sections of busway will be designed to provide parallel, segregated cycling facilities. In this regard Option 3 will provide cyclists with a relatively convenient, well-connected and segregated cycle route from Cambourne to Cambridge City Centre via the Bourn Airfield development, free from motor vehicle traffic. It is likely that the level of perceived and actual safety of cyclists, quality of infrastructure and continuity of routes will be highest on segregated elements of infrastructure. Other options are likely to be able to provide a more direct route, on or parallel to the A428, however the level of segregation from general traffic will be highest in Option 3.

Option 1 does not provide any additional cycling facilities, although cyclists may benefit from improvements to bus facilities that they are permitted to use, the key limitation being that they will not be offered segregation from buses or general traffic and the quality of the infrastructure will be affected by buses or general traffic. Options 2, 4 and 5 are all proposed elements of busway with segregated cycling facilities and therefore provide benefits, however the level of continuity is unlikely to be comparable to Option 3.

Benefits from increased cycling and walking trips generated by cycling infrastructure extend to health improvements (and a resultant reduction in costs to health services) and a lower motor vehicle emissions if mode-shift from cars and increased cycling uptake occurs[24]. In addition, there are likely to be wider productivity benefits due to improved health from cycling which can reduce employee absenteeism[25]. Further work would be required to fully assess and quantify these potential impacts.

The monetised benefits to cyclists have not been assessed as part of this appraisal, however the costs of infrastructure are accounted for as part of the cost of busways (see Section 6).

Option 3 will present the largest level of cycling infrastructure improvements, with segregated infrastructure from Cambourne to the City Centre. Options 2, 4 and 5 all propose new infrastructure on offline elements and there are no additional facilities proposed for Option 1. Where mode-shift to cycling occurs, it is likely that there will be health benefits for those switching mode along with emissions benefits. Additional benefits to the economy as a result of increased cycling, in the form of reduced employee absenteeism, may also be realised and can be monetised and included in the appraisal at the next stage of scheme development.

[24] http://www.sustrans.org.uk/policy-evidence/related-academic-research/economic-benefits-active-travel
[25] Grous. (2011). The British cycling economy: 'gross cycling product' report. Sky and British Cycling.

7.5. Safety impacts, Accident reduction

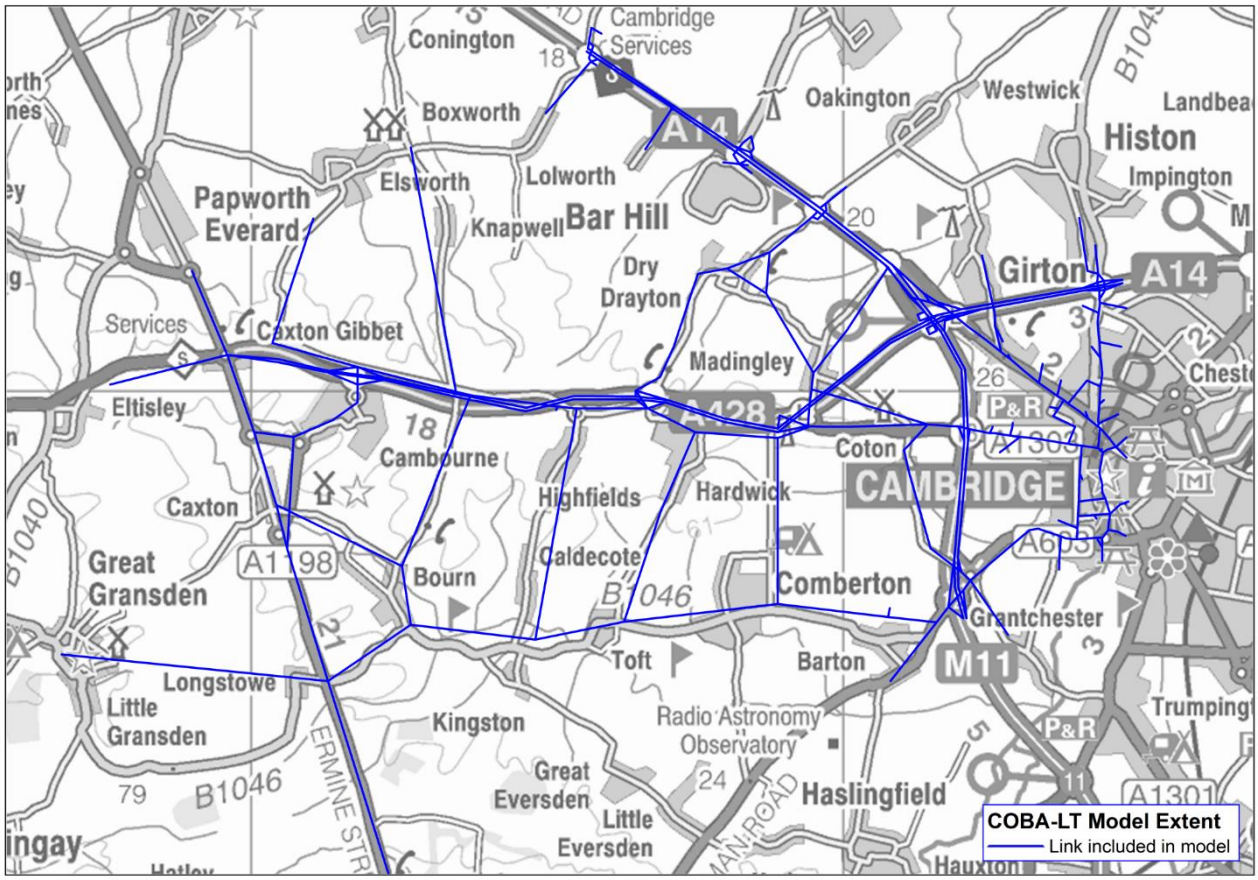
7.5.1. Approach

The likely impact on accidents was measured using the industry standard COBA-LT software, which uses flows and typical accident rates for different road types to estimate future accident rates. The COBA-LT model used for this study has been configured as follows:

- COBA-LT run with links and junctions combined, rather than with links and junctions considered separately;
- COBA-LT runs based on SATURN model outputs, using a base year of 2016 and forecast years of 2021 and 2031;
- Modelled flows converted to AADTs using nearby count sites to adjust modelled periods;
- Observed accident rates used for key routes in study area, using 2010-2014 collision data from the DfT (see data.gov.uk website); and
- Default accident rates used for other routes in study area, based on assigning each route to a road class and standard.

It was considered that the full traffic model was too broad to be included within the COBA-LT model, and so only a sub-section of the model was coded into COBA-LT. The area covered was chosen to represent the roads most likely to experience flow change due to the scheme. The COBA-LT network extent is demonstrated in Figure 7-6.

Figure 7-6 Option 5: COBA-LT model area



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7.5.2. Outcomes

The COBA-LT run outputs are summarised in Table 7-9 for the five options considered. COBA-LT provides an estimate for the 60 year total cost of accidents in the baseline (Do Minimum) and with scheme (Do Something) scenarios; the difference between these can be considered the impact of the scheme on accidents.

Table 7-9 Summary Results of the modelled impacts on accidents

Option	Do Minimum 60 Year Cost of Accidents (000s)	Do Something 60 Year Cost of Accidents (000s)	60 Year Benefits (£000s) discounted to 2010 prices
1	£451,800	£449,900	£1,900
2	£451,800	£450,500	£1,300
3	£451,800	£451,600	£200
4	£451,800	£451,600	£200
5	£451,800	£452,000	-£200

The table demonstrates that the total impact of each of the schemes based on the current stage of assessment range from a £1.92m benefit and a £0.14m dis-benefit over 60 years. Four of the options provide some level of benefits, with Option 5 the only one to provide a negative impact. The most beneficial scenario is Option 1 which is forecast to provide a £1.92m benefit over 60 years.

This assessment has provided confidence that the impact of all options will be non-negative or near neutral. None of the impacts are predicted to be substantial. The schemes do not change the current road classes or standards and so the impacts are almost entirely driven by flow changes. Analysis of the traffic model indicates that changes in traffic flows are minimal, and hence the accident analysis shows only minor changes in the cost of accidents. None of the options have a significant impact, with three of the five options (Options 3, 4 and 5) having negligible impact. Even the largest impact of £1.92m relates to a change of less than half of an accident per year, therefore, monetised benefits are not included in the BCR or ASTs.

Based on the analysis undertaken the impact on accidents is likely to be both limited in nature and similar across all options based on the strategic level assessment undertaken. Further work would be required to understand scheme-specific safety issues at a localised level.

7.6. Environmental Impacts

The SOBC environmental assessments of the five options have been undertaken in accordance with the DfT's WebTAG guidance[26], to determine an overall qualitative environmental assessment score using the standard seven point textual scale: large/moderate/slight beneficial and adverse, neutral, score thresholds based on Design Manual for Roads and Bridges (DMRB) and professional judgement.

Where a scheme is under continuing development and refinement, it is possible (or even probable) that the assessment score will change. The scoring categories described for each environmental topic should not be considered as comparable with those determined for other environmental topics, due to qualitative differences between them. It should also be recognised that the scoring definitions are not fixed and finite. This open flexibility is necessary to accommodate the complexity of environmental appraisal in general.

This phase of work is intended to identify a preferred overall option at which point further evaluation will be undertaken for that option. This will include surveys to understand in more detail the nature of the environment likely to be affected and the potential impacts. This work will inform a detailed business case.

[26] DfT December 2015 Transport Appraisal Guidance (TAG) Unit A3 Environmental Impact Appraisal.

It is anticipated that the scheme will be considered to be Environmental Impact Assessment (EIA) development by the competent authority and that an Environmental Statement (ES) will be required to support any consent application. Much of the further work to inform the detailed business case will also inform the ES although this will be determined through a formal scoping process.

7.6.1. Impact on air quality

The proposed infrastructure will have an impact on air quality with the potential to:

- Improve air quality where mode shift the private car to public transport or active modes;
- Worsen air quality where there are increased emissions from buses; and
- Worsen air quality where there is increased congestion to general traffic.

The analysis undertaken includes an assessment of local air quality, regional pollution and greenhouse gas emissions indicated as a result of scheme development at this stage of assessment.

The Proposed Scheme and associated air quality study area lie within the boundaries of Cambridge City Council and South Cambridgeshire District Council areas. There is one AQMA within the air quality study area, covering Cambridge city centre, declared for exceedances of the annual mean NO_2 UK AQS objective. Defra PCM mapping of roadside NO_2 concentrations in 2014 indicates no roadside exceedances of the annual mean NO_2 EU limit value and UK AQS objective within the air quality study area.

Monitoring data from surveys undertaken by Cambridge City Council in 2014, South Cambridgeshire District Council in 2013[27] and Highways England in 2013[28] (undertaken to inform the A14 Cambridge to Huntington Improvement Scheme environmental impact assessment), indicates that there are no exceedances of the annual mean NO_2 UK AQS objective at roadside locations adjacent to the Proposed Scheme.

There were exceedances of the annual mean NO_2 UK AQS objective at two diffusion tubes adjacent to the affected road network (ARN) in Cambridge city centre in 2014 (local authority site number S18 and S22), however, the exceedances are at kerbside (S18) and within a confined street canyon (S22) and therefore not representative of sensitive receptors in the wider study area.

There is one statutory designated ecological site within 200 metres of the ARN. The Madingley Wood Site of Special Scientific Interest (SSSI), located adjacent the A1303, contains broad-leaved, mixed and yew woodland habitat, which is sensitive to nitrogen deposition. The impact of the Proposed Scheme on the SSSI is not required within the TAG assessment, however consideration of the impact of the Proposed Scheme on the SSSI is recommended as further work at the next appraisal stage.

The Proposed Scheme has been assessed in general accordance with the Department for Transport's Transport Analysis Guidance (TAG)[29] ,Unit A3 Environmental Impact Assessment (December 2015) and associated worksheets with to referenced methodologies within the Highways Agency Design Manual for Roads and Bridges ,Volume 11 section 3, part 1, Air Quality, revision May 2007 (DMRB HA207/07)[30].

The TAG assessment includes:

- an assessment of the overall change in exposure to concentrations of nitrogen dioxide (NO_2) and fine particulate matter (PM_{10}) in the opening year;
- an assessment of the change in mass emissions of total oxides of nitrogen (NO_x) in tonnes per year for the opening year and a future year;
- an assessment of the overall change in exposure to concentrations of PM_{10} in a future year; and
- monetisation of changes in air quality.

[27] 2013 is the latest available year of monitoring data for South Cambridgeshire District Council
[28] 2013 Highways England survey data is based on annualised six month diffusion tube survey https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010018/TR010018-000768-A14%206.3%20ES%20Appendix%2008.01.pdf
[29] https://www.gov.uk/transport-analysis-guidance-webtag
[30] http://www.standardsforhighways.co.uk/dmrb/vol11/section3/ha20707.pdf

The assessment has been undertaken using daily average traffic flows, the proportion of heavy duty vehicles (HDV), daily average vehicle speeds, and road link lengths were utilised for the base year (2016) and for the opening year (2021) and the future year (2031), for both the Do-Minimum and Do-Something scenarios for five Proposed Scheme Options. Estimates of the daily bus movements associated with the Proposed Scheme Options were assigned to relevant roads in the Do-Something Scenario.

The air quality study area for the Proposed Scheme has been defined based on changes in traffic data as a result of the Proposed Scheme Options (i.e. the Do-Something scenario compared to the without Do-Minimum scenario). The change criteria used for defining the ARN for local air quality assessments are provided in DMRB HA207/07 (paragraph 3.12).

OS Address point data was used to determine the location and the number of sensitive properties within 200m of the ARN

7.6.1.1. Local Air Quality Assessment

NO2 and PM10 concentrations were estimated in distance bands (20 metres, 70 metres, 115 metres and 175 metres) away from the centreline of roads in the ARN using the DMRB air quality screening tool version 1.03c. Total NO2 was calculated from the modelled road NOx and background NO2 using the 'NOx to NO2 conversion spreadsheet' Version 4.1 available on the Defra UK-AIR website[31]. Total PM10 was calculated by adding the modelled road PM10 to the background PM10.

In order to ensure confidence in the estimated results, modelled concentrations were compared with monitored concentrations in the base year. It was only possible to undertake this comparison for NO2 as data for PM10 was not available in the study area.

The properties in each band were counted for the Do-Minimum and Do-Something scenarios and then multiplied by the pollutant concentration calculated for that band to give property weighted NO_2 and PM_{10} concentrations. This was carried out for each of the four bands and the results added together to give a total for each Proposed Scheme Option. To avoid double counting, properties were assigned to the nearest ARN link only.

The Do-Minimum value was deducted from the Do-Something value for each affected road link. The overall assessment score (Table 7-10) was calculated by summing values over all ARN road links, with an improvement (decrease in concentrations) having a negative value and a deterioration (increase in concentrations) having a positive value.

Diffusion tube monitoring sites[32], located adjacent to the A1303 and A1309, selected as representative of the air quality study area, were compared with modelled concentrations. Measured concentrations of annual mean NO_2 were compared with those estimated using the DMRB air quality screening tool. The comparison indicated the modelled concentrations were tending to under predict annual mean NO_2, with some locations experiencing a difference greater than 25% of those monitored, indicating that the model did not have acceptable performance in accordance with Defra's local air quality management (LAQM) technical guidance[33] (LAQM.TG(16)). Following guidance in LAQM.TG(16) a comparison and adjustment of the road NO_x was undertaken and subsequent adjusted modelled total NO_2 concentrations calculated. Following adjustment, modelled results were within 25% of the monitored concentrations, indicating acceptable model performance. PM_{10} concentrations were not adjusted as there was no monitoring data available to enable a comparison with the modelled concentrations.

There are not expected to be any exceedances of the annual mean NO_2 or PM_{10} UK AQS objectives[34] in either the Do-Minimum or Do-Something scenarios in the opening year 2021 for all Proposed Scheme Options. The assessment showed that there is expected to be an overall worsening in exposure to annual

[31] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc
[32] Highways England diffusion tubes 10 (542845, 259281) and 11 (539606, 259424) and Cambridge City Council diffusion tube S27 (544575, 255307)
[33] http://laqm.defra.gov.uk/technical-guidance/
[34] The EU limit value and UK Air Quality Strategy (AQS) objective for annual mean NO_2 and annual mean PM_{10} is 40 $\mu g/m^3$.

mean NO_2 and PM_{10} with the Proposed Scheme in the opening year (2021), as indicated by the positive assessment scores for all options.

The worsening of local air quality across all options is driven by an increase in HDVs on road links with new or increased bus traffic. Assessment scores are worse for the options with offline sections, as properties are affected by the introduction of a new pollutant source.

Madingley Wood SSSI, adjacent the A1303, is within 200m of the Proposed Scheme Options. The impact of changes in pollutant concentrations (NO_x and N deposition) due to Proposed Scheme on this site should be considered at future stages of assessment.

Table 7-10 Overall assessment scores[35], summary of Air Quality Assessment

Option	NO_2	PM_{10}
1	743	18
2	1,450	102
3	1,122	105
4	1,354	125
5	1,538	89

7.6.1.2. Regional Air Pollution Assessment

Emissions of NO_x were calculated for the opening year (2021) and future year (2031), both with and without the Proposed Scheme Options. The emissions were calculated using the latest emission factors available from DEFRA's emissions factors toolkit (EFT) v6.0.2[36]. The EFT only provides emission factors up to 2030, therefore 2031 emissions were calculated using 2030 emission factors. All ARN roads within Cambridge City Council were classified as 'urban (not London)' and those within South Cambridgeshire Council area were classified as 'rural (not London)' for the calculation of regional emissions. Results are presented as the change in mass emissions of NO_x in tonnes per year.

The regional air pollution assessment (Table 7-11) shows that an increase in emissions of NO_x is expected as a result of all Proposed Scheme Options in both 2021 and 2031, compared to the Do-Minimum. The difference between the five options is relatively small. The largest change with the Proposed Scheme is calculated for Option 4 and Option 5 at 5.3 tonnes per year whereas the smallest change is 2.6 tonnes per year for Option 1. Changes are driven both by the overall increase in traffic flows across the ARN and the increase in distance travelled. Increases in pollutant emissions are greater for options with offline sections, as vehicles on these routes travel a greater total distance.

[35] The methodology for Local Air Quality TAG Assessment returns a score value that defines the magnitude of change in concentrations due to each option. A positive value indicates that there is an overall increase in pollutant concentrations and therefore a general detrimental effect upon air quality due to that option. The 'score' is derived from combining property count data and pollutant concentration data. There is no 'unit' attached to this score.
[36] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

Table 7-11 Summary Results of the Regional NOx Emissions

Option	Total NO_x Emissions with Proposed Scheme in Opening Year (tonnes)	Change in NO_x Emissions with Proposed Scheme in Opening Year compared to Do-Minimum (tonnes)	Change in NO_x Emissions with Proposed Scheme over 60 year appraisal period compared to Do-Minimum (tonnes)
1	76.2	2.6	54
2	78.4	4.8	98
3	78.4	4.8	100
4	78.9	5.3	118
5	78.9	5.3	117

7.6.1.3. Economic Valuation of Air Pollution

Air quality impacts were monetised using the approach as documented in the TAG guidance which considers an appraisal period of 60 years from the opening year of the Proposed Scheme. The valuation is undertaken for PM_{10} concentrations and NO_x emissions. The costs are derived from analysis by the Inter Departmental Group on Costs and Benefits (Air Quality) (IGCB(A)) of the typical health impacts arising from changes in air pollution. The values calculated for the 60 years of the appraisal period were discounted at standard HM Treasury rates to give a present value for that particular year. This was then summed over the appraisal period, to give the net present value (NPV) of the change in air quality. The change in PM_{10} concentrations were assumed to be constant from 2021 for the 60 year appraisal period. For NO_x emission the change in emissions is calculated by linear interpolation for the opening year (2021) to future year (2031) and then assumed to be constant for the remainder of the 60 year appraisal period. There were no areas where the NO_2 EU limit value[37] was expected to be exceeded, as determined by reviewing 2014 roadside concentrations given in DEFRA's Pollution Climate Mapping (PCM) model and available monitoring data, hence the damage cost approach was followed for NO_x emissions rather than the marginal abatement cost (MAC) approach[38].

The analysis undertaken (Table 7-12) indicates that there is expected to be an overall increase in annual mean PM_{10} concentrations with the Proposed Scheme in the opening year. The change in annual mean PM_{10} concentrations were assumed to be constant beyond this year. In addition there is an overall increase in NO_x emissions with the Proposed Scheme over the 60 year appraisal period. There is an overall net disbenefit as shown by the negative NPV for all Proposed Scheme Options. The largest NPV of the worsening in air quality has been calculated for Option 4 whereas the smallest NPV is associated with Option 1. The base year for monetisation of air quality impacts has been taken as 2010.

Table 7-12 Summary Results of the Air Quality Valuation[39]

Option	Present value of change in NO_x emissions (£000s)	Present value of change in PM_{10} concentrations (£000s)	Total value of change in air quality (£000s)
1	-42	-56	-98
2	-76	-314	-391
3	-77	-323	-400
4	-89	-387	-477
5	-89	-276	-365

[37] The EU limit value and UK Air Quality Strategy (AQS) objective for annual mean NO_2 is 40 µg/m^3.
[38] Given that a section of the ARN lies within Cambridge Air Quality Management Area (AQMA), a proportion of the modelled links has been assumed to be exceeding the limit value for NO_2 .This is based on the "urban" option within the TAG Air Quality Valuation spreadsheet, which assumes a proportion of urban PCM links
[39] Values in this table are rounded to the nearest £10,000

7.6.1.4. Greenhouse gas emissions

The Proposed Scheme has been assessed in general accordance with the Department for Transport's Transport Analysis Guidance (TAG)[40] ,Unit A3 Environmental Impact Assessment (December 2015) and associated worksheets with to referenced methodologies within the Highways Agency Design Manual for Roads and Bridges ,Volume 11 section 3, part 1, Air Quality, revision May 2007 (DMRB HA207/07)[41].

The TAG assessment includes:

- An assessment of the change in equivalent tonnes of carbon dioxide for the whole appraisal period; and
- Monetisation of changes in greenhouse gases.

The ARN determined local air quality traffic change criteria have also been used for the regional air pollution and greenhouse gas assessments.

Emissions were calculated for 2021 and 2031 for both the Do-Minimum and Do-Something scenarios. The EFT only provides emission factors up to 2030, therefore 2031 emissions were calculated using 2030 emission factors. Emissions were linearly interpolated for the interim years. Post 2031, emissions were assumed to remain the constant.

The results of the assessment were expressed as a set of mass emissions (tonnes of pollutant per year) for each year of the 60 year appraisal period (Table 7-13). The difference in emissions, expressed in tonnes of CO_2 per annum, between the Do-Something and Do-Minimum scenario was calculated for each year. Monetary values are then applied to the changes in greenhouse gas emissions according to guidance by the Department for Energy and Climate Change (DECC). The value per tonne of CO_2 emissions was applied to the difference in emissions in each year. This value was then discounted at standard HM Treasure Rates and summated to give the NPV of the change in non-traded CO_2 emissions over the 60 year appraisal period using the TAG Greenhouse Gases Workbook.

Emissions of CO_2 were calculated using the latest emission factors available from the DEFRA Emissions Factors Toolkit (EFT) v6.0.2.

The greenhouse gases TAG workbooks present the change in estimated emissions of carbon dioxide in the Do-Something scenario when compared to the Do-Minimum scenario in the opening year 2021 and over the whole 60 year appraisal period. The NPV of the change in CO2 emissions as a result of the Proposed Scheme is also calculated. Overall the Proposed Scheme is expected to have a disbenefit resulting in an increase in CO2 emissions and a negative NPV for all Proposed Scheme Options. The smallest negative NPV is for Option 1 whereas the largest negative value is for Option 4.

Table 7-13 Summary of Estimated Change in Emissions of Carbon Dioxide (Tonnes) and the Associated Net Present Value

Option	Change in CO2 Emissions with Proposed Scheme in Opening Year compared to Do-Minimum (tonnes)	Change in CO2 Emissions with Proposed Scheme over 60 year appraisal period compared to Do-Minimum (tonnes)	NPV (£000s)
1	2,882	139,432	-6,400
2	3,900	153,654	-7,000
3	4,187	189,901	-8,700
4	4,166	187,349	-8,600
5	4,082	181,938	-8,300

[40] https://www.gov.uk/transport-analysis-guidance-webtag
[41] http://www.standardsforhighways.co.uk/dmrb/vol11/section3/ha20707.pdf

The assessment suggests that all schemes will have a negative impact on air quality, with NOx, PM10 and C02 emissions all having been assessed to increase as a result of the options. The worsening of local air quality across all options is likely driven by an increase in bus traffic especially on offline sections, as properties are affected by the introduction of a new pollutant source.

7.6.2. Noise impacts

The Proposed Scheme has been assessed in general accordance with the Department for Transport's Transport Analysis Guidance (TAG)[42] ,Unit A3 Environmental Impact Assessment (December 2015) and associated worksheets with reference to methodologies within the Highways Agency Design Manual for Roads and Bridges ,Volume 11 section 3, part 7, Noise and Vibration, revision November 2011 (DMRB HD213/11)[43].

The TAG assessment includes:

- an assessment of the predicted change in noise in the opening year, when comparing the Do Minimum situation with each of the Options;
- an assessment of the predicted change in noise in the design year (ten years later), when comparing the do minimum situation with each of the Options; and
- monetisation of changes in noise.

In accordance with the guidance from within DMRB, the study area was defined within 600m of the route of the physical works associated with the road project, as well as any roads being bypassed or improved by the schemes; this is the affected road network (ARN). For the purposes of this assessment, the wider area was not considered. The noise levels calculated in this assessment are indicative.

OS Address point data was used to determine the location and the number of noise sensitive residential properties within 600m of the ARN. The study area was the same for all Options. This data does not include any permitted developments.

Where AAWT traffic flows were greater than 1000 vehicles, Noise levels were predicted using 'Calculation of Road Traffic Noise' (CRTN)[44]. For the offline bus routes, the Noise Advisory Council's 'Guide to Measurement and Prediction of Equivalent Continuous Sound Level Leq'[45] was used.

The $L_{A10\text{-}18hr}$ Noise Levels were predicted at 10m from each road, and then interpolated further back in bands by doubling the distance and reducing the levels by 3dB. The noise at each band was predicted at the midpoint, e.g. noise predicted at 10m for the 0-20m band, meaning that two adjacent houses in different bands would be predicted to be 3dB different. Therefore, in order to simplify the calculations further, noise levels were rounded to the nearest decibel.

The assessment did not account for individual screening measures, topography, structures or soft ground corrections. However, for properties more than 60m from each road, it was considered likely that there would have been some degree of screening or soft ground absorption. Therefore, at distances greater than 60m from a road, a correction of -15dB was included to account for soft ground and screening The noise levels were also adjusted for façade reflections (+2.5dB).

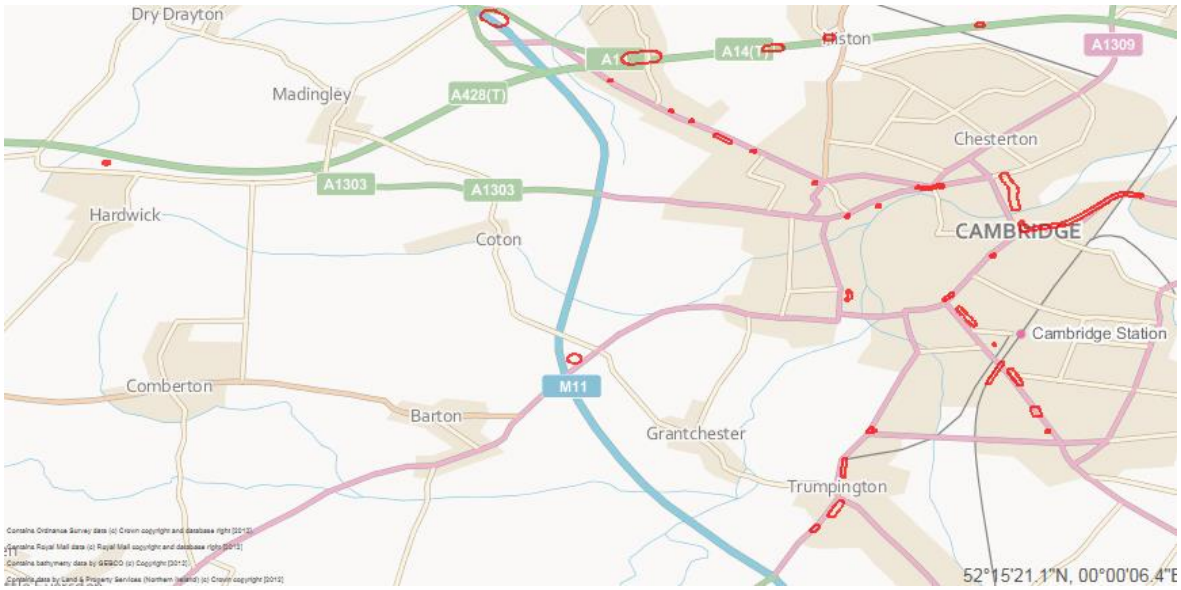
The residential properties within each band were determined using MapInfo Pro 15 software, and allocated the predicted noise level from that band for each road within 600m. The highest predicted noise level from any road, at each property, was used to determine the noise levels for each scenario.

The data for each property were input into the WebTAG workbook for noise, which used this data to determine the impact of each of the Options.

[42] https://www.gov.uk/transport-analysis-guidance-webtag
[43] http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/hd21311.pdf
[44] Calculation of Road Traffic Noise – The Department of Transport - 1988 (ISBN 978-0115508479)
[45] A Guide to Measurement and Prediction of Equivalent Continuous Sound Level Leq – The Noise Advisory Council - 1980

The Proposed Scheme is sited within the boundaries of Cambridge City Council and South Cambridgeshire District Council areas. There are a number of Noise Important Areas in and around the noise study area, as shown in red in Figure 7-7.

Figure 7-7 Noise Important Areas



Noise monitoring has not been carried out as part of this project, and the measured noise levels at some of the properties away from modelled road links may actually be greater than predicted due to other factors. The impact of new bus links in these areas may be over-predicted.

Traffic flows in 18hr AAWT, the percentage of HDVs and daily average vehicle speeds (kph) were utilised for the base year (2016) and for the opening year (2021) and the future year (2031), for both the Do-Minimum and Do-Something scenarios for five Proposed Scheme Options. Estimates of the daily bus movements associated with the Proposed Scheme Options were assigned to relevant roads in the Do-Something Scenario.

The assessment showed that due to traffic changes on existing links, as well as introducing new bus links for the five options, there is the potential to increase noise levels within the study area. The base year for monetisation of noise impacts is 2010.

The summary of the noise assessment is shown in Table 7-14, with the online Option 1 having the lowest impact, with Option 3, Option 4, and Option 5 having the greatest impact due to the greatest number of offline sections in areas where there are fewer modelled road links, and therefore lower predicted Do Minimum noise levels. Baseline noise levels on an online alignment are already high and the introduction of new services does not significantly increase noise levels at properties close to these links. For the offline sections of the alignment, proposed sections of bus links introduce a new noise source to a quieter area, and therefore increases the negative noise impact of the option.

Table 7-14 Summary of Noise Assessment for all Options

Option	Households experiencing increased daytime noise in 2031	Households experiencing reduced daytime noise in 2031	NPV (£000's)
1	88	146	£52,[46]
2	469	147	-£1,600
3	845	377	-£2,100
4	949	326	-£3,100
5	949	173	-£3,500

These predicted noise levels are indicative; with noise levels predicted in 3dB bands for each road, to the nearest 1dB, and with the effects of screening ignored. Most of the predicted increases and decreases in noise were found to be just 1dB.

At some receptors which are less than 60m from a new bus link, but away from modelled road links, the impact may be over predicted. If all road links were modelled, the predicted Do Minimum noise levels would likely be greater at the properties near these links, and the impact would be reduced.

Based on current modelling, the noise assessment shows that there would likely be negative noise impacts as a result of all options, in particular 3 to 5. It is expected that further assessment of the noise impact on new bus links will result in a reduced impact and resulting NPV due to refinement of option design and attendant modelling.

7.6.3. Water environment

A desktop exercise has been undertaken. The spatial scope of the assessment includes as a minimum, features of the water environment within 1km of the options.

The options have been ranked based on the following criteria:

- The number of new river/drain watercourse crossings (principal criteria);
- Groundwater status (aquifer status);
- Flood risk; and
- Proximity to designated sites.

The method of assessing the importance, magnitude and significance of effects is stated within tables in WebTAG unit A3[47] and has not been reproduced in this section.

At this stage, a high level desk-based assessment has been undertaken using the following publicly available data (largely web-based):

- Ordnance Survey (OS) open data (10k) in conjunction with latest design drawings (May 2015) A428-ATK-HML-ZZ-DR-D-0001 1of3, A428-ATK-HML-ZZ-DR-D-0001 2of3 and A428-ATK-HML-ZZ-DR-D-0001 3of3;
- Environment Agency online - Catchment Data Explorer;
- Environment Agency online - What's In Your Backyard; and
- Magic' website, via Natural England website.

[46] Value rounded to nearest £1,000.
[47] DfT December 2015 Transport Appraisal Guidance (TAG) Unit A3 Environmental Impact Appraisal (Chapter 10 Tables 13 - 17)

The following assumptions have been made:

- The assessment considers the most recent option corridors;
- All rivers/drains have been assigned an equal weighting in the assessment;
- The assessment is based on existing data sources and has not been verified through a site walkover survey;
- It is assumed that the provision of mitigation or compensation for any effects will be equally effective for each option. To date, no investigations have been made of potential opportunities to mitigate scheme effects which may only be associated with particular routes;
- The feasibility of adapting drainage infrastructure to derive benefits to the water environment has not been investigated;
- The vulnerability of the Principal Aquifer is assumed to be consistent between the options; and
- It is assumed that cumulative effects will be comparable for each route option.

Features of the water environment within 1km of the options have been identified. These include the following Main WFD designated Rivers:

- Bin Brook (WFD ID GB105033042680) – located south of the existing A428 alignment
- Bourn Brook (WFD ID GB105033042690) – located south of the existing A248 alignment
- River Cam (WFD ID GB105033042750) – located to the east of the existing A428 alignment

There are also numerous un-named watercourses (not WFD designated), however all fall within the Cam and Ely Ouse catchment.

Table 7-15 sets out a summary of the appraisal results. They are shown in order of potential damage for the water environment (noted in the Rating Score column), with the least potentially damaging option shown first.

The AST is also provided. This score is in line with the method of assessing the importance, magnitude and significance of effects of the options on the Transport Appraisal Guidance (TAG) Unit A3 (Department for Transport, December 2015) (Chapter 10 Tables 13 - 17).

Potential impacts from the scheme include (but not limited to) the following:

Water quality

The proposed construction works have the potential to impact water quality in any of the receiving surface or groundwater receptors. This may be due to:

- The excavation, and the subsequent deposition of soils, sediment, or other construction materials
- The spillage of fuels or other contaminating liquids
- The mobilisation of contamination following disturbance of contaminated ground or groundwater, or through uncontrolled site runoff.

Providing adherence to best practice mitigation during the construction period, there should be no significant effects to the water environment.

During operation there would be potential impacts to water quality from discharge of polluting runoff through drainage outfalls.

Flood risk

Potential impacts on flood risk include the storage of materials and temporary impermeable areas at site compounds which could increase flood risk. Providing adherence to best practice mitigation during the construction period, there should be no significant effects to the flood risk.

The proposed works have the potential to impact on flood flows in the rivers and on the floodplain because of new or altered watercourse crossings and earthworks on the floodplain. If required, mitigation measures such as floodplain compensation storage should be designed to reduce the impact on flood risk.

The increase in impermeable area would need to be mitigated so as not to increase the risk of surface water flooding.

Channel morphology

Direct morphological changes to the watercourses (such as new culverts or realignments) and changes in drainage patterns may arise which could affect WFD status. Since the watercourses directly affected by are both Main and non-Main Rivers, the lead local flood authority has a duty to ensure the works comply with the WFD.

Groundwater

The most significant potential effects of the proposed improvements are associated with the new road alignment, which could include includes cuttings and piling. Drainage during both construction and once operational may include SUDS such as soakaways. These works may affect the flow of groundwater, indirectly affecting surface water features and abstractions which are dependent upon groundwater inputs. The works may introduce new pollutant pathways to the underlying aquifer. The inherent risks of contamination during construction presents a further risk to the underlying aquifer groundwater.

Option 3 crosses more watercourses than the other options and impacts Bin Brook WFD waterbody twice so at the time of reporting this is potentially the most environmentally damaging for the water environment

Option 1 is the least environmentally damaging for the water environment as with the exception of the Park & Ride, proposed works are within the existing highway boundary

All options are subject to the same issues with respect to groundwater, as the area for the ground works is underlain by Principal Aquifer and both construction and operational discharges may lead to more interaction with groundwater and therefore may introduce a new pollutant pathway. A summary of the appraisal results is shown in Table 7-15.

Table 7-15 Appraisal Results

Option	Environmental concerns/commentary	Ranking Score*	AST Score
Option 1	• No new watercourse crossings • Issues with respect to groundwater - as the area for the ground works is underlain by Principal Aquifer and operational discharges may lead to more interaction with groundwater • Impacts from the Park & Ride are assumed to be from drainage and with mitigation through sustainable drainage solutions, these should be reduced to a negligible level • Potential operational issues and an increase in spillage risk. The reliance on existing junctions and road infrastructure will potentially increase spillage risks relative to other options.	1	Neutral
Option 2	• 10 new watercourse crossings • Groundwater issues are as per Option 1 • Park & Ride issues are as per Option 1 • Surface water flooding issues to consider associated with the unnamed watercourses • There are potential cumulative effects with the Bourn Airfield site which will also impact on the water environment (e.g. increased runoff or morphological change).	2	Slight Adverse

Option	Environmental concerns/commentary	Ranking Score*	AST Score
Option 5	• One new crossing over WFD waterbody Bin Brook • Nine new watercourse crossings • Groundwater issues are as per Option 1 • Park & Ride issues are as per Option 1 • Transverses across high risk flood zone from Bin Brook • Surface water flooding issues to consider on unnamed watercourses • There are potential cumulative effects with the Bourn Airfield site which will also impact on the water environment.	3	Slight Adverse
Option 4	• One new crossing over WFD waterbody Bin Brook • 11 new watercourse crossings • Groundwater issues are as per Option 1 • Park & Ride issues are as per Option 1 • Transverse across high risk flood zone from Bin Brook • Surface water flooding issues to consider • There are potential cumulative effects with the Bourn Airfield site which will also impact on the water environment.	4	Slight Adverse
Option 3	• Two new crossings over WFD waterbody Bin Brook • 11 new watercourse crossings • Groundwater issues are as per Option 1 • Park & Ride issues are as per Option 1 • Transverses across high risk flood zone from Bin Brook • Surface water flooding issues to consider • Potential cumulative effects with the Bourn Airfield site • A greater number of potential river/drain crossings leads to more likelihood of interaction with the water environment and greater impacts to water bodies as a whole	5	Slight Adverse
*Ranking Score Key: 1 = Least environmental impact; 5 = most environmental impact. Main driver is the number of new river/drain watercourse crossings			

The impact on the Water Environment is expected to be neutral for Option 1 and Slight Adverse for all other options. Option 3 is likely to have the largest water environment impact due to the option having the most watercourse crossings.

The AST scores are a function of the environmental features present along the alignment (for example aquifers, ponds, ground water, protected sites etc.), their quality, scale, rarity, importance and substitutability and the likely impact of the option on each of the water features.

The options' ranking of 1 to 5 for the water environment assessment is based on a finer granularity than the overall AST score is able to reflect as it averages over a broad 7point scale (from major beneficial, moderate, slight, neutral to major adverse) which is why, despite options 2 to 5 having a an AST score of slightly adverse, the ranking shows option 1 to have the least water environment impact.

7.6.4. Landscape and visual impact

The assessment follows the five step approach to appraising 'environmental capital' described in TAG Unit A3, Environmental Impact Appraisal, December 2015, Chapter 5. As stated in Chapter 6 of TAG Unit A3 "the level of detail to which landscape character assessment and appraisal is undertaken depends very much on the purpose of the exercise and the scale of the landscape in question".

The Landscape Appraisal Worksheet has been used to capture the assessment. A separate Townscape Appraisal Worksheet has not been completed, this is due to the type and location of the proposal within the

landscape. Any impacts on the townscape environment have been considered and reported within the Landscape Appraisal Worksheet.

A wide study area of around 2km from the route options has been used to identify the 'key environmental resources' that may be affected by the proposals. The Worksheet describes the landscape elements of the environment that provide qualities and functions which are considered by the community (local, regional, national or international) to be of particular value. This analysis has been informed by a range of data sources described below.

The Worksheet then describes what matters, why it is important and how that may change over time in the absence of the proposal. Step 2 and 3 of the worksheets are consistent for all options to allow a comparison of the effects of each on the landscape resource of the area to be made. The proposed location for a Park & Ride is similar for each option, therefore this has been addressed specifically within the Worksheet text to enable the impact of the wider corridors, which are different for each option, to be compared more easily. For each option, an overall assessment score has been derived using the seven point textual scale provided in Table 4 of TAG Unit A3.

The following broad assumptions have been made to inform the assessment at this stage:

- Potential visibility of the proposals from sensitive receptors has been derived on the basis of professional judgement made on the basis of desk-study only and assumed requirements for vegetation removal. Actual visibility of the proposals may be lesser or greater than anticipated and would need to be verified through site visits or mitigation proposals;

- The potential level of some impacts described could be reduced through careful coordinated landscape/engineering design and mitigation of the proposal at later stages; and

- The potential level of impact described is undertaken on the basis of the overall landscape resource of the area and not specific landscape and visual receptors. Impacts on specific receptors may be lesser or greater than those identified for the overall landscape resource.

The following information sources have been used to inform this stage of the desktop study:

- Ordnance Survey Terrain 50;

- CPRE Tranquility Map, 2007;

- Mapping data from Natural England including Country Parks, Local Nature Reserves, Common Land, Ancient and Semi-Natural Woodland, Planted Ancient Woodland Sites, Sites of Specific Scientific Interest, Traditional Orchards and Special Areas of Conservation;

- Mapping data from Historic England including Listed Buildings, Registered Parks and Gardens and Scheduled Monuments;

- The South Cambridgeshire Local Plan, February 2004 (Adopted), Core Strategy DPD, January 2007 (Adopted) and South Cambridgeshire Local Plan 2014 (proposed but not adopted);

- The Cambridge Local Plan, July 2006 (adopted) and Cambridge Local Plan 2014 (proposed but not adopted);

- Cambridge Green Belt Study 2002;

- Cambridgeshire Landscape Guidelines 1991;

- Cambridge Landscape Character Assessment 2003;

- National Character Area profile: 88. Bedfordshire and Cambridgeshire Claylands (NE555), Natural England, April 2014;

- Cambridge Landscape Character Assessment, Cambridge City Council, April 2003;
- Cambridgeshire County Council Conservation Areas and Public Rights of Way;
- South Cambridge District Council Tree Preservation Orders; and
- Google Earth.

The summary assessment score for each of the options on the overall landscape resource of the study area is set out below:

- **Option 1** – Slight adverse;
- **Option 2, 4 and 5** – Slight to moderate adverse; and
- **Option 3** – Moderate adverse.

7.6.4.1. Option 1

Option 1 is judged to result in the lowest impact on the landscape resource due to its focus around existing transport corridors, however the design of the approach into Cambridge would need to be carefully considered to avoid or minimise loss of mature street trees and TPOs alongside the existing road. In terms of the American Cemetery, the landscape impact assessment takes into account that the existing setting includes a thick buffer of trees separating it from the busy A1303, widening the road to accommodate the new bus services will not substantially change the character of the Cemetery.

7.6.4.2. Option 2

On the basis of the information and level of study undertaken at this stage, the Scheme is judged to result in a slight to moderate adverse effect on the landscape. This is due to the fact that:

- It cuts across a section of public open space west of Cambourne;
- It may result in some visual intrusion on the Grade I Listed American Military Cemetery; and
- Some TPO's may be lost along the A3103 in the western side of Cambridge.

7.6.4.3. Option 3

Option 3 is judged to result in the largest impact on the landscape resource due to the alignment across the public open space east of Cambourne and the extent to which it creates new infrastructure that transects the agricultural field pattern, passes through a traditional orchard and is situated in close proximity to the Conservation Areas of Coton and Hardwick.

7.6.4.4. Option 4

On the basis of the information and level of study undertaken at this stage, the Scheme is judged to result in a slight to moderate adverse effect on the landscape. This is due to the fact that:

- It cuts across a section of public open space west of Cambourne;
- It may result in some visual intrusion on the Grade I Listed American Military Cemetery; and
- Transects the agricultural landscape and its existing field pattern.

7.6.4.5. Option 5

On the basis of the information and level of study undertaken at this stage, the Scheme is judged to result in a moderate adverse effect on the landscape. This is due to the fact that:

- It cuts across a section of public open space west of Cambourne;

- Passes through a traditional orchard and nearby the Conservation Area at Coton; and

- Transects the agricultural landscape and its existing field pattern.

For all options the proposed Park & Ride at Madingley Mulch roundabout would result in small scale, localised effects on the overall landscape character and there are opportunities to mitigate these to some degree and integrate the proposal into the landscape through careful consideration of the layout, design, retention of boundary vegetation and limiting the height of lighting proposals.

The landscape and visual impact of a scheme is likely to be greatest where there is new infrastructure that crosses open space, in particular conservation areas. Option 3, with the largest amount of new, offline infrastructure is, therefore, likely to have the largest landscape and visual impact.

7.6.5. Heritage of historic resources

The impacts appraisal for Historic Environment has been carried out in accordance with:

- HA208/07: Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 2 Cultural Heritage; Highways Agency, 2009; and
- Department for Transport, TAG unit A3 Environmental Impact Appraisal, December 2015.

The features of key historic environment assets within a study area 200m either side of the proposed route options have been described in Historic Environment Appraisal Worksheets. A separate worksheet has been completed for each route option. The form, survival, condition, complexity, context and period of the historic environment assets within the study area are described within each worksheet. This includes description of the setting of historic environment assets under definition of 'context'. Assessment has then been carried out in accordance with the Appraisal guidance (DfT 2015), and a score has been determined based on the criteria in Table 8 of the guidance.

Historic environment assets identified for the appraisal comprise the following:

- Historic buildings;
- Areas, such as parks and gardens, Conservation Areas, the rural historic landscape and designed spaces; and
- Archaeological sites, both upstanding monuments and sites where only below ground remains survive.

Data on the nature and extent of these assets has been obtained from the Cambridgeshire Historic Environment Record in Spring 2016, which includes information from aerial photographic analysis, investigations already carried out within the study area, and from spot finds of archaeological material from the plough soil or retrieved through metal detection.

Appraisal has been carried out based on the presence of known assets, as well as an assessment of potential for below ground archaeological remains to be present in areas of new land take. These remains are not known certainly to exist, but their presence is assumed based on data from within the Study Area. In establishing the appraisal scores three considerations have influenced the results above all others:

- The amount of offline development required, which may affect both the form and character of the historic landscape;

- The likelihood of destroying below ground archaeological remains in areas of new land take; and

- The proximity of options to key assets, such as Conservation Areas or Listed Buildings, whose settings may be affected by the presence of high quality bus priority infrastructure.

Option 1: This option is currently indicated to have a neutral effect on the historic environment. It will result in the loss of archaeological remains in any areas of new land take, but will not affect the fabric or setting of other historic environment assets to such an extent that significance will be lost. The American Cemetery, a grade II registered park and garden, is the only American World War 2 cemetery in Britain and contains a listed grade II* building, the memorial chapel. Option 1 will have a slightly adverse impact on the setting of

the American Cemetery due to widening of the A1303 adjacent to it, and may also impact on as yet unknown archaeological assets. The impact on the overall historic environment is neutral as the option will not result in the loss in significance of any historic asset.

Option 2: This is currently indicated to have a slight adverse effect on historic environment assets, resulting from the loss of possible archaeological remains of low value and their context, but where suitable mitigation could be carried out to provide better understanding of these assets. The new lanes across the airfield and north of the American Cemetery will diminish the form and character of the current historic landscape to a minor degree if following current pathways and boundaries as proposed, but will not affect appreciation and understanding of the historic environment significantly, or lead to the loss of any significance of the settings of valuable historic environment assets.

Option 3: This option is currently indicated to have a moderate adverse effect on the historic environment. The new lanes south of Hardwick and north of Coton will be intrusive in the rural setting of the villages and at odds with the pattern and form of the historic landscape. There will also be a loss of possible archaeological remains of low value and their context, but suitable mitigation could be carried out to provide better understanding of these assets.

Option 4: This option is currently indicated to have a slight adverse effect on historic environment assets, resulting from the loss of possible archaeological remains of low value and their context, but where suitable mitigation could be carried out to provide better understanding of these assets. The new lanes across the airfield and north of the American Cemetery will diminish the form and character of the current historic landscape to a minor degree if following current pathways and boundaries as proposed, but will not affect appreciation and understanding of the historic environment significantly, or lead to the loss of any significance of the settings of valuable historic environment assets.

Option 5: This option is currently indicated to have a moderate adverse effect on the historic environment. The new lane north of Coton will be intrusive in the rural setting of the village and at odds with the pattern and form of the historic landscape. There will also be a loss of possible archaeological remains of low value and their context, but suitable mitigation could be carried out to provide better understanding of these assets.

The impact on historical resources is predicted to range from neutral to moderate adverse. Both Options 3 and 5, which have new lanes south of Hardwick and north of Coton are likely to be intrusive in the rural setting of the villages and at odds with the pattern and form of the historic landscape, which when combined with the possible loss of archaeological remains, increases their impact to moderate adverse.

7.6.6. Biodiversity

This section presents the findings of a qualitative assessment of the potential biodiversity impacts of the five proposed route options. The biodiversity appraisal has been undertaken in accordance with the 'Biodiversity' sub-objective from the Department for Transport WebTAG Environmental objective.

A desk based study was undertaken in June 2016 to review existing information available in the public domain and to obtain relevant information held by statutory and non-statutory consultees for each scheme option, as recommended in the Institute of Environmental Assessment's 'Guidelines for Baseline Ecological Assessment' (1997).

Information was requested from the Cambridgeshire and Peterborough Environmental Record Centre, where a request for the following data was made:

- Designated sites (statutory and non-statutory)[48].

The following meta-databases were also searched for protected habitats and species:

- MAGIC (Multi-Agency Geographic Information for the Countryside); and

[48] All data that was received can be provided upon request. Please note that protected species data was not requested at this stage of the process.

- National Biodiversity Network.

Ordnance Survey (OS) base maps and aerial photography publicly available from the Google website were reviewed in order to identify the potential ecological and nature conservation features within the Study Corridor for each of the five routes, including features that could be impacted upon both during the construction and operational phases of the development.

During the desk based study particular attention was paid to the presence (or potential presence) of the following within the Study Corridor for each route option:

- Internationally statutory designated sites (including Special Areas of Conservations (SAC) etc.) – search radius of up to 10km;
- Statutory designated sites (including Sites of Special Scientific Interest (SSSI) etc.) – search radius of up to 2km;
- Non-statutory sites – search radius of up to 2km;
- Watercourses (including rivers, canals, ditches / drains and streams) – search radius of up to 50m;
- Waterbodies– search radius of up to 50m;
- Woodland – search radius of route and directly adjacent;
- Hedgerows– search radius of route and directly adjacent;
- Other habitats– search radius of route and directly adjacent;
- Great crested newts;
- Otter;
- Water vole;
- Badger;
- Reptiles;
- Bats;
- Birds;
- Hazel dormouse; and
- Other mammals.

For this desk based options appraisal, the ecological features along a particular route option have been grouped by habitat type unless a site is afforded a designation in which case their potential importance has been stated based upon the potential importance of the site given its nature conservation status (assuming its ability to support populations of protected species).

With the exception of ponds and watercourses, ecological features have been described where the potential route options pass through (or over) or are immediately adjacent to the feature. Watercourses and water bodies have been described where they fall within 50m of the route option to consider the potential impacts that each route option could have upon water quality and associated ecosystems.

The findings of the above study have been used to identify the biodiversity impacts associated with each of the five route options, the results of which are presented in the WebTAG worksheets.

Key assumptions are as follows:

- No protected species data was collected from the Cambridgeshire and Peterborough Environmental Record Centre, who may hold additional information that could support further assessments;

- The ecological appraisal of the route options has been based wholly upon information obtained during a desk study; no field work has been undertaken as part of the ecological constraints appraisal.

- The indicative baseline conditions for the five route options have been determined based upon OS base maps and aerial photographs at the time of the assessment. It was not possible to confirm the date that these photographs were taken and therefore the conditions that they present, which are described within this report, may differ from those which are actually present within the study corridor of the route options.

- Due to the scale of the OS base maps and aerial photographs used during the appraisal it is possible that ecological features such as smaller ponds, drains and streams have been missed when determining the indicative baseline conditions. It is also difficult to determine the classification of grassland from aerial photographs; therefore valuable neutral and semi-improved grassland may have been missed when determining the indicative baseline conditions.

- The likely potential for protected and notable species to be present within habitats along the three scheme options has been determined from aerial photographs and would require confirmation through field walkover surveys which may be required as part of more detailed future assessment.

All of the options currently have the summary assessment score of large adverse, based on the current information available. **All of the routes have received this categorisation under the principal of 'most adverse category',** where each scheme is assessed to reflect the most adverse assessment of the affected resources, even if it does not occur across the whole route.

For example route Option 1 is primarily located within the existing A428 road network, and therefore impacts are overall considered to be lower in comparison to the other routes (as can be seen in Table 1 above). However, in the worst case scenario there could be a large adverse impact on Madingley Wood SSSI, as the works are located directly adjacent to this habitat. It is considered that standard mitigation measures could potentially be incorporated into the scheme design and programme to ensure only a slight adverse impact on this habitat, which would bring the entire route in line with a slight adverse impact. However, until confirmation that such mitigation measures could defiantly be adopted, large adverse impacts must be assumed.

In contrast Option 3 is primarily located within a rural setting and will affect significant areas of habitat, and subsequently could isolate the largest proportion of terrestrial species from the surrounding habitats.

As with route Option 1, in the worst case scenario there could be a large adverse impact on Madingley Wood SSSI (as the works are directly adjacent), however in addition there could also be a large adverse impact on the Eversden and Wimpole Woods SAC, as the works may impact on this Annex II bat species' flight lines.

It is considered that standard mitigation measures could potentially be incorporated into the scheme design and programme for the recommended option, however the majority of the residual impacts on habitat and species in the Eversden and Wimpole Woods SAC perceived from this route and not covered by the standard mitigation measures, are moderate adverse. With appropriate mitigation some of these levels may be reduced, however as the route will cross 7 woodlands and 20 drains / ditches (5 of which will be directly crossed by the route where no road network currently exists), it is very likely that the moderate adverse summary assessment score will remain. This is especially true if combined with the number of protected / notable species that could also be moderately adverse affected by this route.

The remaining three routes were considered to be similar in that there is an overall large adverse impact, which could potentially be reduced with mitigation to moderate adverse, however these assessments would be very unlikely to go as far as being reduced to slight adverse.

The principal of 'most adverse category' means that the overall impact category assigned to a scheme is based on the most adverse assessment of an affected resource. All options have an assessment of large adverse, as a result of this method, as the impact on at least one resource for each option as classed in the large adverse category. Further work to define mitigation measures will determine the overall impact of each option.

7.7. Distributional Impacts

Distributional impacts relate to the extent to which there are differences in the way impacts affect different groups in society. For example, the noise impacts of an intervention will affect different groups of households, with some experiencing increases, and others decreases. Depending on the geographical locations of different groups of people, these groups will each experience varying impact. This section outlines the key option-specific findings of the SDI assessment undertaken.

The approach outlined in the DfT's guidance ensures that the DI appraisal is proportionate to the scale of the issue and follows a process to ascertain whether a full appraisal is required. Table 7-16 shows this process, detailing key decision-making points as illustrated by the three identified steps.

Table 7-16 DI Process

Step	Description	Output
1	Screening Process: • Identification of likely impacts for each indicator.	Screening Proforma
2	Assessment: • Confirmation of the area impacted by the transport intervention (impact area); • Identification of social groups in the impact area; and • Identification of amenities in the impact area.	DIs social groups statistics and amenities affected within the impact area.
3	Appraisal of Impacts: • Core analysis of the impacts; and • Full appraisal of DIs and input into AST.	Appraisal worksheets and AST Inputs.

7.7.1. Assessment methodology

7.7.1.1. Screening (Step 1) – Approach

The initial screening assessment considered the likely positive and negative impacts of the Scheme using the eight DI indicators in relation to specific vulnerable groups, including children, older people, people with a disability, Black and Minority Ethnic (BME) communities, people without access to a car and people on low incomes.

A number of key questions are posed in a Screening Proforma published by the DfT which are considered during the initial screening. The questions cover the following:

- Is the option being considered likely to have negative or positive impacts on specific groups of people, including children, older people, disabled people, Black and Minority Ethnic (BME) communities, people without access to a car and people on low incomes?
- Can the likely impacts be eliminated or mitigated through re-design or amendment?
- Are the impacts either significant or concentrated?

The remaining sections present the findings from the DI screening process and approach for the full appraisal (Steps 2 & 3) in accordance with WebTAG.

7.7.1.2. Screening (Step 1) – Key Findings

The screening proforma for this DI appraisal details the reasoning behind the analysis undertaken in this report. The findings from the screening are summarised in Table 7-17.

Table 7-17 Summary of Proforma

Indicator	Likely DI Impact	Recommendations
User Benefits	Yes	Proceed to Steps 2 and 3
Noise	Yes	Proceed to Steps 2 and 3
Air Quality	Yes	Proceed to Steps 2 and 3
Accidents	Yes	Proceed to Steps 2 and 3
Security	No	No further appraisal required
Severance	Yes	Proceed to Steps 2 and 3
Accessibility	Yes	Proceed to Steps 2 and 3
Affordability	Yes	Proceed to Steps 2 and 3

7.7.1.3. Assessment (Steps 2) – Approach

Following on from the screening proforma (Step 1), the steps to complete the full DI appraisal, where required for each indicator, are described below.

7.7.1.4. Step 2a – Confirmation of the area impacted by the intervention

The screening provides a broad understanding of the areas likely to experience impacts as a result of the Scheme. Within Step 2a, a more detailed examination is required to investigate the spatial impacts of the Scheme. The area affected is likely to vary depending on the individual DI indicator being appraised.

7.7.1.5. Step 2b – Identification of the social groups in the impact area

Step 2b requires the analysis of socio-economic and demographic characteristics to develop a profile of:

- The **transport users** that will experience changes in travel generalised costs resulting from the intervention;
- **People living in those areas** identified as likely to be affected by the intervention; and
- **People travelling in areas** identified as likely to be affected by the intervention.

The analysis uses a common dataset and plots the proportions of vulnerable groups within the impacted area for each indicator. Table 7-18 sets out the groups of people to be identified in the analysis for each indicator.

Table 7-18 Scope of Socio-Demographic Analysis for DIs (Step 2b)

Social Group	User Benefits	Noise	Air quality	Accidents	Security	Severance	Accessibility	Affordability
Income Distribution	✓	✓	✓				✓	✓
Children: <16		✓	✓	✓	✓	✓	✓	
Young adults: aged 16-25				✓			✓	
Older people: aged 70+				✓	✓	✓	✓	
Population with a disability					✓	✓	✓	
Population of BME origin					✓		✓	
Households without access to a car						✓	✓	

7.7.1.6. Step 2c – Identification of amenities in the impact area

The concentration of social groups is based not only on the resident population but also on trip attractors/amenities that are within the impact area. Using desktop analysis, the local amenities which are likely to be used by the identified social groups for each DI indicator are identified. Amenity data allows qualitative assessments / statements to be made to add value to the DI appraisal and provides a wider assessment than just that of the resident population.

The output of Step 2 is summarised and presented in order to provide evidence for the appraisal of impacts in Step 3.

7.7.1.7. Appraisal of Impacts (Step 3)

This step examines information collated in the previous steps to assess the potential impacts of the intervention on each indicator's social groups.

7.7.1.8. Step 3a – Core analysis of impacts

An assessment score is given for each indicator and each of the social groups under consideration. The seven-point scoring system follows the standard DfT appraisal measures:

- Large beneficial;
- Moderate beneficial;
- Slight beneficial;
- Neutral;
- Slight adverse;
- Moderate adverse; or
- Large adverse.

7.7.1.9. Step 3b: Full appraisal of DIs

The analysis undertaken in Step 3a provides an assessment score for each indicator and each of the social groups under consideration. In addition, a qualitative assessment will be provided for each indicator to

describe the key impacts in each case. These will be summarised in the DI appraisal matrix. The scores and qualitative assessment are summarised in the DI appraisal matrix of Distributional Impacts with key findings presented in the 'key impacts' column.

7.7.2. User benefits

User benefits are those that accrue to the population as a result of the scheme in terms of time and cost. In the majority of cases, there are user benefits associated with a transport intervention but these are generally net outcomes. Within the net outcome, some people may experience disbenefits, for example through longer journey times or lower public transport service frequencies.

In the case of user benefits, it is necessary to understand the income distribution of potential users in the impact area. This has been undertaken by mapping variations in income deprivation using data from the Indices of Deprivation (IoD 2015) Income Domain[49] at Lower Super Output Area (LSOA) level, according to their national rank.

As shown in Table 7-19, just under 1% of residents within the impact area are within the most deprived income quintile (quintile 1 – the 20% most deprived LSOAs nationally), while 42% of the residents are within quintile 5, making them amongst the 20% least income deprived in England. Representation of residents in quintile 2 is lower than national levels, while the proportions of residents in quintiles 3 and 4 are close to national levels.

Table 7-19 Proportions of each income quintile within study area

Income group	% Impact area	% England
Quintile 1 (most deprived)	0.9%	20.0%
Quintile 2	9.7%	20.0%
Quintile 3	21.1%	20.0%
Quintile 4	26.7%	20.0%
Quintile 5 (least deprived)	41.7%	20.0%

The user benefits assessment considers the change in the cost of travel (including time and financial based costs) for users of the transport network using private vehicles and public transport.

Table 7-20 presents all the five options UB appraisal result. Options range from slight adverse (Option 5) to moderate beneficial (Options 1, 2 and 4) with net benefits from -£2.9m (Option 4) to £56.1m (Option 2).

[49] The Index of Deprivation measures relative deprivation at LSOA level in England. The Income Deprivation Domain measures the proportion of the population in an area experiencing deprivation relating to low income. The definition of low income used includes both those people that are out-of-work, and those that are in work but who have low earnings (and who satisfy the respective means tests). Various indicators (e.g. recipients of Income Support, Job Seekers' Allowance, Pension Credit etc) are combined to rank LSOAs from most to least deprived, and the ranked LSOAs are divided into five equal groups (quintiles) for ease of reference.

Table 7-20 User Benefits Appraisal Options Summary

Options	Income Quintile					User Benefits appraisal	Overall net benefits (000's)
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5		
Option 1	✓✓	✓✓	✓	✓	✓✓✓	Moderate beneficial	£53,000
Option 2	✓✓	✓✓	✓	✓	✓✓✓	Moderate beneficial	£56,100
Option 3	✓	✓✓	✓	×××	✓✓✓	Slight beneficial	£36,900
Option 4	✓✓	✓✓	✓	×××	✓✓✓	Moderate beneficial	£1,700
Option 5	×	✓✓✓	×	×××	×××	Slight adverse	-£3,000

Key: ✓✓✓ Large Beneficial, ✓✓ Moderate Beneficial, ✓ Slight beneficial, 0 Neutral
× Slight adverse, ×× Moderate adverse, ××× Large adverse.

Full results can be seen in the accompanying report in Appendix X.

Options 1 and 2 are the most beneficial in terms of user benefits, as all quintiles experience a benefit, and the least deprived quintiles experience a proportion of benefits in line with their proportion of the population.

7.7.3. Personal affordability

Any intervention that changes transport costs may give rise to impacts on personal affordability, and may have disproportionate effects where there are few or no travel alternatives, especially where low income households preclude car ownership and use. Changes to transport costs can include public transport fares, parking charges, road user charges or impacts to the road network that impacts on the operating costs of cars.

7.7.3.1. Affordability benefits Appraisal Options Summary

The DI appraisal demonstrates whether the affordability impacts are distributed evenly across the vulnerable groups and identifies the 'winners' and 'losers' of affordability benefits as a result of the proposed scheme. An examination of the distribution of benefits and disbenefits compared to what might be expected from the overall distribution of benefits across the populations within each income quintile is shown Figures 3-27 – 3-31.

A proportionate distribution of affordability benefits should see the benefits and disbenefits mirror the overall distribution of the population within each income group in the assessment area (green column on the graphs). For all options, residents in the most deprived income quintiles (1 and 2) experience fair, or a higher proportion of benefits than would be expected. For all options apart from 1, a higher proportion of residents in quintile 5 (the least deprived) experience disbenefits compared to what would be expected from a fair distribution.

Table 7-21 presents all the five options affordability DI appraisal result. Options range from slight adverse (Options 3, 4 and 5) to moderate beneficial (Options 1 and 2) with net benefits from -£2.1m (Option 4) to £12.1m (Option 1).

Table 7-21 Affordability benefits Appraisal Options Summary

Options	Income Quintile					Affordability benefits appraisal	Overall net benefits (000's)
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5		
Option 1	✓✓	✓✓	✓	✓	✓✓	Moderate beneficial	£12,100
Option 2	✓✓	✓✓	✓	✓	✓✓✓	Moderate beneficial	£9,200
Option 3	✓✓	✓✓	×	××	×××	Slight adverse	-£1,500
Option 4	✓✓	✓✓✓	×	××	×××	Slight adverse	-£2,100
Option 5	✓✓	✓	×	××	×××	Slight adverse	-£1,900

Options 1 and 2 are the most beneficial in terms of affordability, as all quintiles experience a benefit, and the least deprived quintiles experience a proportion of benefits in line with their proportion of the population.

7.7.4. Noise

Any intervention that increases traffic levels and/or speeds or reduces physical distances between people and traffic will give rise to noise impacts within a localised area. It should be noted that the Social and Distributional Impacts for noise are based on an early iteration of a noise assessment, and will be updated as further work is carried out on this project. The assessment in this section is likely to be an overestimation of the noise impacts.

The noise assessment has examined the level of noise before scheme implementation and the noise levels expected as a result of the Scheme options, in accordance with DI WebTAG Units A4.1 and A4.2. Following WebTAG A4.2, the area impacted by the intervention is defined as a 600m buffer of links forecast to experience a change in noise as a result of each Scheme option.

The assessment indicates that for Options 1 and 2, all properties are likely to receive a negligible impact or no change to noise levels.

The majority of properties also have a negligible noise impact as a result of Options 3, 4 and 5. However Options 3, 4 and 5 do have an adverse impact on some residential properties. For all three options, properties in Cambourne are likely to experience a negative noise impact, particularly in the south east, where there is a small concentration of major adverse noise impacts. Options 4 and 5 also have a number of properties to the west of the Cambridge City Centre that are likely to receive moderate or minor adverse noise impacts, these are located along Sidgwick Avenue, Pembroke Street and Tennis Court Road.

Option 4 and 5 are the only options that are likely to reduce noise for a (small) number of properties, however these are insignificant as they only account for 11 and 7 properties respectively, out of a total of 24,863 properties. For both Option 4 and 5 these benefits are experienced north of Comberton. Furthermore, quintiles 4 and 5 had more properties that are likely to experience an increase in noise than a decrease.

A summary of the assessment undertaken is shown in Table 7-22. Full details can be seen in the accompanying report.

Table 7-22 Noise impacts income distribution summary

Population Group		Option 1	Option 2	Option 3	Option 4	Option 5
Children		0	0	0	0	0
Income deprivation quintile	5 (20% least deprived nationally)	0	0	×	×	×
	4	0	0	×××	×××	×××
	3	0	0	×	×	×
	2	0	0	0	0	0
	1 (20% most deprived nationally)	0	0	0	0	0
Overall score		0	0	×	×	×

Key: ✓✓✓ Large Beneficial, ✓✓ Moderate Beneficial, ✓ Slight beneficial, 0 Neutral
× Slight adverse, ×× Moderate adverse, ××× Large adverse.

Table 7-22 summarises the noise impact for all five options by income deprivation and children. It shows that there is a negligible impact or no change to noise levels as a result of both Option 1 and 2. Therefore, overall a **neutral** noise distributional impact is considered for these options, and **slight adverse** for Options 3, 4 and 5.

Overall Options 1 and 2 have a neutral impact on Noise distributional impact. Options 3, 4 and 5 have a slight adverse impact, affecting the middle and upper income deprivation quintiles (less deprived) more than the lower deprivation quintiles.

7.7.5. Air Quality

Any intervention that increases traffic levels, increases the amount of slow moving traffic, or reduces physical distances between people and traffic may give rise to impacts on air quality. The air quality assessment has been undertaken following WebTAG A4.2.

Analysis of the demographic profile of the areas likely to be affected has been undertaken using the Indices of Deprivation 2010 (IoD) income data and the proportions of children under 16 years of age (census 2011 data). The outputs from this analysis have been used to assess the impacts of air quality changes on vulnerable groups and complete a matrix of DI findings on air quality. This assessment focuses on nitrogen dioxide (NO_2) and particulate matter 10 (PM10) impacts.

During operation, there are likely to be some impacts associated with increased bus service frequencies for all five options, however a reduction in car use from users switching to bus may result in small improvement in air quality.

Across all five options, the DI appraisal demonstrates that there are no receptors within the two most deprived quintiles, for both NO_2 and PM10.

Option 1, 2 and 3 are likely to increase NO_2 levels for properties in quintiles 4 and 5, with the least deprived quintile receiving the majority of the adverse impact. Properties in quintile 3 on the other hand are likely to experience a decrease in NO_2. Quintiles 3, 4 and 5 are all expected to receive an adverse NO_2 impact as a result of Option 4 and 5. All options have a higher number of properties likely to experience an increase in NO_2 than a decrease or no change. Consequently, all five options have been scored as **slight adverse** for NO_2.

Option 1 is likely to decrease PM10 for residents in quintile 3, however this is for very few properties (12). However, it is also expected to increase PM10 for a small number of residents (123) in quintile 4 and for almost 400 residents in quintile 5.

Option 2, 3, 4 and 5 are also all likely to decrease PM10 for residents living in quintile 3, and increase PM10 for quintiles 4 and 5. The number of properties likely to experience an increase in PM10 as a result of Option 3, 4 or 5 is approximately three times those that are likely to experience a decrease.

As the air quality receptors are showing no change in NO_2 or PM10 adjacent to the school for Option 1, the impact on children for Option 1 has been scored as **neutral**. The impact for Option 2, 3, 4 and 5 however, have been scored as **slight adverse** as receptors adjacent to the school are forecast to receive an increase in NO_2 and PM10. Overall, as can be seen in Table 7-23 and Table 7-24, the DI appraisal has assessed both NO_2 and PM10 levels to be **slight adverse** for all five options.

Table 7-23 NO2 Air quality impacts

Population Group		Option 1	Option 2	Option 3	Option 4	Option 5
Children		0	×	×	×	×
Income deprivation quintile	5 (20% least deprived nationally)	×××	×××	×××	××	×
	4	×	××	××	××	××
	3	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓	××	××
	2	0	0	0	0	0
	1 (20% most deprived nationally)	0	0	0	0	0
Overall score		×	×	×	×	×

Table 7-24 PM10 Air quality impacts

Population Group		Option 1	Option 2	Option 3	Option 4	Option 5
Children		0	×	×	×	×
Income deprivation quintile	5 (20% least deprived nationally)	×××	××	××	××	××
	4	×	××	××	××	××
	3	✓	✓	✓	✓	✓
	2	0	0	0	0	0
	1 (20% most deprived nationally)	0	0	0	0	0
Overall score		×	×	×	×	×

Key: ✓✓✓ Large Beneficial, ✓✓ Moderate Beneficial, ✓ Slight beneficial, 0 Neutral
× Slight adverse, ×× Moderate adverse, ××× Large adverse.

Air quality is predicted to be slight adverse for all options. The largest benefits are seen for the middle income deprivation quintile. The largest dis-benefits are seen in the upper deprivation quintile (least deprived nationally).

7.7.6. Accessibility impacts

Different transport options will often have differentiated impacts on accessibility for different groups of people. Particularly vulnerable groups in terms of accessibility impacts are young people, older people, disabled people, and black and minority ethnic (BME) groups. Different accessibility impacts result from a range of social and distributional factors including differences in travel needs and places of residence.

Impacts of accessibility can include effects associated with changes to services, routings and timings. Changes to waiting facilities, rolling stock and changes to accessibility of services due to relocation can also have impacts on accessibility levels.

Calculations undertaken provide the bus public transport journey times from the key villages (Cambourne; Bourn; Highfields Caldecote; Hardwick; Madingley and Coton) to all three key destinations (Cambridge City Centre; Cambridge Science Park and Addenbrooke's Hospital).

The accessibility modelling outputs are illustrated in the accompanying report. These demonstrate the Do-Minimum scenario and the five scheme options. These calculations provide the bus public transport journey times from the key villages (Cambourne; Bourn; Highfields Caldecote; Hardwick; Madingley and Coton) to all three key destinations (Cambridge City Centre; Cambridge Science Park and Addenbrooke's Hospital).

These calculations are high level and the outputs have been calculated using the default TRACC software parameters, including:

- Maximum walking distances of 500m between the point of journey origin and the first bus stop, a maximum 500m walk for an interchange and a maximum 500m walk between alighting the bus and the journey destination point;
- Default walking (4.6km/hr) and traffic speeds (set to kmph);
- The accessibility software does not take into account peak travel times or expected traffic delays;
- The origin points used in the model include the postcode centre points for the key population centres listed above;
- A maximum journey time of 90 minutes was used in the model;
- The bus journeys ran in the model were to all three destinations in the destination set; and
- The model does not take into account other factors which may influence how easy it is for residents to access the road network and bus stops. For example, older people, people with children or people with a disability may struggle to walk as far as the maximum distance the model allows.

Furthermore, people may experience severance as a result of having to walk uphill or if they have to cross busy roads as part of their journey. These impacts could all mean increases in journey time for those affected, which have not been picked up by the accessibility assessment. Conversely, some people may be willing to walk further than the maximum modelled distance to a bus stop, which may mean they are categorised as having poor or no access.

The analysis undertaken demonstrates almost 100% of the population of the impact area have access to the destination set, within an hour's bus journey. Option 1 is demonstrating the largest improvements in journey times. All of the options are demonstrating accessibility improvements in comparison to the Do-Minimum.

However, it should be noted that although a significant number of people are now demonstrating shorter journey times (i.e. they are now placed in shorter journey time categories), their journey times may have decreased by as little as a minute. It should also be taken into account that although sections of this route will be along a bus route not amongst other traffic, there may still be an impact from other traffic, particularly during peak time. Overall, the bus journey times remain similar for all options.

A summary of the accessibility impacts can be seen in Table 7-25. Although this analysis has highlighted there are improvements in terms of accessibility to the three key destinations, travel will not become more accessible to the population without ensuring services, stations and information materials are accessible for all users.

Table 7-25 Summary of accessibility DIs

	Option 1	Option 2	Option 3	Option 4	Option 5
Children (under 16)	✓✓	✓✓	✓✓	✓✓	✓✓
Older people (70+)	✓	✓	✓	✓	✓
BME	✓	✓	✓	✓	✓
Disability Living Allowance	✓	✓	✓	✓	✓
No car households	✓	✓	✓	✓	✓
Overall appraisal	✓	✓	✓	✓	✓

Key: ✓✓✓ Large Beneficial, ✓✓ Moderate Beneficial, ✓ Slight beneficial, 0 Neutral
× Slight adverse, ×× Moderate adverse, ××× Large adverse

As approximately 10% of children will benefit from reduced bus journey times across all five options, the impact is **moderate beneficial** for this group. However, the result to bus journey time for all five options is **slight beneficial** for accessibility to the destination set considered within this accessibility appraisal for all vulnerable groups, with the exception of children.

Accessibility is predicted to be slight beneficial overall for all options, with the largest benefits predicted to be assigned to children under 16 who will benefit from reduced bus journey times.

7.7.7. Severance

Severance is often an unintended consequence of a measure intended to address other problems. Severance issues may be identified at an early stage and in many cases a design solution may reduce or eliminate impacts. The DI guidance (Unit A4.2) recommends the impact area for severance to include any location with physical changes in road alignment or where links on the road network will experience significant changes in traffic flows and or speeds (>10%).

The main physical changes in road alignment are likely to include areas that the new off-line bus routes will be located. These new routes include:

- A route running from south east Cambourne across Bourn airfield. This route crosses Broadway Road, which connects Bourn to the A428. This route is proposed in Options 2, 3, 4 and 5;
- A route running east-west to the south of Hardwick. This route crosses Main Street, which connects a small village (Toft) to the A428 to the north of Hardwick. This route is proposed by Option 3;
- A route running east-west to the north of the existing A428, between the proposed Park & Ride site at Madingley Mulch, north of Madingley wood to Junction 13 of the M11. This route is proposed by Options 4 and 2;
- A route running east-west to the south of the existing A428, between the proposed Park & Ride site at Madingley Mulch, north of cotton to the M11 (south of Junction 13). This route is proposed by Options 3 and 5; and
- A route running east-west to the south of High Cross, to Grange Road. This route is proposed by Options 3, 4 and 5.

The assessment undertaken in this distributional impact appraisal has been based on an examination of the area adjacent to the main physical changes in road alignment, and road links with an expected change in traffic flow above or below 10% of the do-minimum scenario.

Option 1 – neutral – due to it running on the existing on-line route.

Option 2 – slight adverse - due to the possibility of it severing PRoWs near Bourn Airfield, and public footpaths and a bridleway near Madingley.

Option 3 – slight adverse - due to the possibility of it severing PRoWs near Bourn Airfield, and public footpaths and a bridleway in Caldecote, Hardwick and Coton.

Option 4 – slight adverse - due to the possibility of it severing PRoWs near Bourn Airfield and a bridleway near Caldecote, Hardwick and Madingley.

Option 5 – slight adverse - due to the possibility of it severing PRoWs near Bourn Airfield and public footpaths in Coton and a small bridleway route in Coton.

Option 1 has neutral severance impacts, due to it using the existing on-line infrastructure. Options 2-5 all include new infrastructure that may sever public right of ways, resulting in a slight adverse impact.

7.8. Wider Impacts

7.8.1. WebTAG Wider impacts

DfT guidance (WebTAG Unit A2.1) defines wider impacts as the impacts of transport interventions on welfare at a national level that are not captured by a conventional appraisal of transport user benefits. These impacts are omitted because the conventional appraisal assumes theoretical 'perfectly competitive' transport-using markets, whereas in reality markets are imperfect, leading to the potential for additional benefits (or disbenefits).

The three key wider impacts identified in WebTAG are:

- **Agglomeration**, meaning the concentration of economic activity over an area that is affected by accessibility resulting from transport schemes. Agglomeration impacts reflect productivity benefits experienced by businesses as a result of improved connections to other businesses and to potential employees thus improving interaction, knowledge exchange and access to markets, including labour markets. The assessment in this economic case considers static agglomeration only (i.e. where the improved connections are brought about by reduced travel costs rather than physical relocation of employment). The latter impact is termed dynamic agglomeration and can only be estimated with input from a land use transport model or equivalent. The WebTAG approach to estimating agglomeration focuses on intra-urban connectivity, with agglomeration levels most affected by reductions in travel costs within urban areas. Commuters and business users are the focus of agglomeration impacts.

- **Labour market impacts (tax effects),** refers to the tax revenue changes arising from labour supply impacts and from moves to more or less productive jobs. A reduction in commuting costs equates to a net increase in wages for those commuting and therefore can be sufficient to make it worthwhile for some who weren't previously working to take a job. Whilst the direct benefits to the commuter are included within the standard estimate of time savings, the benefit to the government of any additional tax paid is not captured because commuters consider benefits net of tax. The tax impacts are therefore included as a wider impact. Additionally, labour market tax impacts could be derived from a transport intervention leading to jobs relocating to more productive locations. This impact has not been considered in this assessment as, along with the dynamic agglomeration impacts, estimates require inputs from a land use transport interaction model.

- **Benefit of increased output in imperfectly competitive markets**, capture the output change in imperfectly competitive markets driven by a change in transport costs as a result of a transport intervention, reflecting the fact that the benefits to businesses of increasing production in response to travel cost savings will be underestimated by the estimate of user benefits of the travel cost savings alone. In imperfectly competitive markets, businesses are able to make additional profit on each unit

produced, reflecting the fact that the prices that consumers are willing to pay exceed the cost of production.

Wider impacts are driven by the scale and location of business and commuting user benefits, but are not influenced by benefits for Other journey purposes (leisure and education). Agglomeration impacts are influenced by both business and commuting travel cost savings, labour market impacts are influenced by commuter cost savings and the benefit of increased output in imperfectly competitive markets is influenced by business time savings.

The results of the wider impacts assessment for all the Cambourne to Cambridge Better Bus Journey scheme options are dominated by agglomeration effects and impacts of increased output in imperfectly competitive markets. Labour market impacts are more minor, as is typical for schemes of this type where the scale of change in commuting cost is such a small proportion of wages and therefore does not have a very significant impact on people's decisions on whether to work or not.

In each option, agglomeration impacts focus particularly on the district of Cambridge, reflecting the focus of impacts on trips to and from the city, influencing the level of agglomeration experienced in the district. The productivity impacts of any agglomeration changes within Cambridge are also accentuated by the fact that Cambridge has an above average productivity per worker and above average proportion of employment in consumer and producer services, both sectors which show an above average response to agglomeration. Strong agglomeration impacts are also evident in Huntingdonshire and South Cambridge but for each option the impacts in East Cambridgeshire are minimal, in keeping with the location and focus of the options.

Overall the wider impacts for each option are relatively minor. This is partly because the majority of user benefits for each option are accrued from journeys by Other users (leisure and education users, accounting for 78% to 80% of the benefits for each option), whilst commuter and business trips typically experience more limited benefits from the options due to the much greater disincentives commuters and business users face when considering switching mode from car to bus given the much higher journey times associated with public transport journeys as compared to car and the preference for cars in the region.

Table 7-26 shows the user benefits derived from TUBA and the wider impacts due to public transport that have been derived from WITA. WITA is a software tool that calculates wider impacts in accordance with the methods set out in WebTAG guidance. It shows a range of Wider Impacts ranging from £8.2 million for Option 1 and -£2.6 million for Option 4, in direct proportion to the transport benefits to commuters and business travellers discussed in Section 7.1 but including highways impacts.

Table 7-26 Wider Impacts: Public Transport

A) User Benefits						
PT User Benefits (£000 discounted present value in 2010 prices and values)		Option 1	Option 2	Option 3	Option 4	Option 5
	Commuter User Benefits	£11,400	£12,100	£12,500	£4,500	£4,800
	Other User Benefits	£41,100	£56,400	£44,700	£17,800	£19,900
	Business User Benefits	£4,400	£600	£300	-£200	-£100
B) Wider Impacts - PT only						
	Imperfect Competition[50]	£70	£60	£30	-£20	-£10
	Labour Market (welfare)	£300	-£700	-£1,500	£1,000	£500
	Agglomeration	£7,800	£2,100	£2,900	-£3,600	-£3,000
	Total	£8,200	£1,500	£1,400	-£2,600	-£2,500

[50] Values rounded to the nearest £10,000.

7.8.2. Indirect wider economic impacts: welfare benefits

Mott MacDonald was appointed in April 2016 to provide a strategic economic appraisal of the A428-A1303 Cambourne to Cambridge Better Bus Journeys scheme[51]. The purpose of this work was to provide an initial assessment of the potential of scheme options to deliver indirect Wider Economic Benefits (WEBs) over and above those captured in conventional appraisal.

The strategic economic appraisal assessed the net UK level welfare benefits of the scheme (in addition to the UK level GVA benefits described in the Strategic Case[52]). UK level welfare benefits include benefits from:

- land utilisation;
- labour supply;
- move to more productive jobs;
- reductions in spatial inequalities and structural unemployment – the welfare benefits associated with any jobs in areas with high levels of deprivation and reductions in long term structural unemployment. These benefits are largely only applicable to schemes that have direct welfare reduction goals and objectives though any scheme that supports employment growth and labour mobility will have some effect on improving access to employment for disadvantaged groups. This can be via either residents directly accessing the jobs unlocked through the scheme, or through existing employees in the GCCD transferring to these new jobs, freeing up opportunities for those in the deprived areas/areas of long term unemployment and;
- option and non-use values. Option values are the values residents place on having access to opportunities, both social and economic (e.g. jobs) in case they need to use them at some point in the future. Thus they reflect the value that someone in an affected community may place on having access to the Cambridge job market, not because they currently work there, but because they may wish to have the choice of working there at some point in the future.
  Non-use values represent the value a household may place on a transport service even if they never intend to use it (e.g. they may wish the service to be available for other people to use). Option values are always additional to transport user benefits in an appraisal, whilst only some non-use values (those with an altruistic motive) are additional to transport user benefits.

These impacts can be considered supplementary to the conventional benefits presented in the Economic Case, and are presented in Table 7-27.

[51] Mott MacDonald. (2016). *Strategic Economic Appraisal of A428-A1303 Bus Scheme. Wider Economic Benefits.*

[52] Welfare benefits and GVA benefits are not additive, they represent alternative perspectives on the impacts of the scheme.

Table 7-27 UK indirect wider economic benefits welfare impacts (£m in 2010 discounted values and market prices) over a 60-year period[53]

Benefit	Option		
Welfare benefits – UK Level (£m in discounted 2010 market prices)	Low – On highway (Option 1)	Medium – Hybrid (Option 4)	High – Segregated (Option 3)
Land Utilisation – net additional jobs to the UK	13.4	45.3	58.5
Move to more productive jobs within the UK	4.2	13.9	18.0
Reduction in spatial inequalities	0.5	1.5	1.9
Alleviation of unemployment	0.1	0.2	0.3
Option and Non-use values[54].	0.0	29.8	29.8
Welfare Benefits[55]	**18.1**	**90.7**	**108.5**

The strategic economic appraisal assessed welfare benefits for three options differentiated by the level of segregation of buses from general traffic; 'low' (on-highway only), 'medium' (hybrid option with some on-highway and some segregated elements) and 'high' (fully segregated) and these are broadly comparable with Options 1, 4 and 3 respectively. As options 2 and 5 were not assessed separately, welfare benefits have not been included in the adjusted BCR calculation of any of the options.

7.9. Reliability Benefits

Differing levels of infrastructure provision will give rise to different levels of service performance. One key aspect of a HQPT service is the reliability of that service (in terms of how closely the service runs to timetables times) and the increased reliance that the end user is therefore able to place upon the service.

Analysis of data recorded from Real Time Passenger Information (RTPI) systems in Cambridge for all school term days in November 2015 across a range of different infrastructures (On-street with no bus infrastructure provision, on-street with bus lane provision, segregated busway in a rural context and segregated busway in a urban context) demonstrated that in the AM peak there was a significant reduction in the level of variation in journey times (-72% in a rural context, -29% for an urban context) when a fully segregated section of infrastructure was provided for bus service. The provision of bus lanes did show a marginal improvement in levels of variation of -14%.

The level of improvement for a bus lane became more marginal during both the Inter and PM peak periods, where there was less than 5% difference between the variation levels for services that do and do not use a bus lane. However, the level of reliability of a service running on fully segregated infrastructure remains at the same level as the AM peak.

Based on the above high level analysis those options which contain the greatest lengths of dedicated infrastructure are likely to yield the highest levels of reliability benefits, both in terms of bi-directional benefits but also significantly lower levels of variation from timetabled times throughout the day compared to those

[53] Mott MacDonald. (2016). *Strategic Economic Appraisal of A428-A1303 Bus Scheme. Wider Economic Benefits.*

[54] The valuation of option and non-use values reported in the Mott MacDonald Strategic Economic Appraisal is based on an interpretation of the guidance that considers that option and non-use values would only apply where a new scheme provides fixed infrastructure (where it does not previously exist).
If an alternative interpretation of the guidance is taken that new transport options of any type would generate option and non-use values, the Low alternative would accrue similar levels of option and non-use value benefits to the Medium and High alternatives.

[55] The value of the benefits is also strongly dependent on the assumption on catchment area size. The benefits reported in the Strategic Economic Appraisal assume 500m for non-Park &Ride stops and stations and 5km for Park & Ride sites, adjusting these assumptions would alter the scale of estimated benefits.

services that are using on-line infrastructure. This would enable the end user to have a greater reliance upon the service provided.

Detailed modelling of reliability has not been undertaken, however based on professional judgement and the current scheme specifications (specifically the amount of segregation in each option) it is expected that with further work, the options would be ranked in the following order in terms of their anticipated reliability:

1. Option 3 – this provides fully segregated infrastructure for the overwhelming majority of the route;
2. Option 5 – this provides online bus priority on the western section with fully segregated infrastructure for the eastern section of the route;
3. Option 4 – this provides online bus priority on the western section with fully segregated infrastructure for the majority eastern section of the route, but does have interaction with general traffic to cross the M11 and travel through the West Cambridge Site;
4. Option 2 – this provides online bus priority on the western section, a section of fully segregated infrastructure linking to an inbound bus lane on the eastern section; and
5. Option 1 – this provides no provision on the western section and an inbound bus lane on the eastern section. There is no outbound provision.

Although a modelled assessment of reliability benefits has not been undertaken, a high-level analysis of baseline data indicates that increasing levels of segregation provides increasing levels of journey time reliability. Option 3 has the highest level of segregation and it is therefore likely that this option would provide a higher level of journey time reliability than other options that might experience more congestion on online elements.

8. Cost Benefit Analysis

8.1. Cost benefit analysis outputs by option

This Section brings together the costs and the benefits and compares the benefit to cost ratios (BCRs) across the options being considered.

In accordance with WebTAG guidance both an ‘initial’ and ‘adjusted’ BCR is estimated. The adjusted BCR includes WebTAG based Wider Impacts. This section presents the initial BCR and the Adjusted BCR is presented in Section 8.2.

The focus of the “initial” Benefit-Cost Ratio (BCR) is to reflect core transport specific impacts compared to costs. These impacts include:

- Transport User Impacts;
  - Journey time impacts to all modes;
  - Operating cost changes;
  - Fares, tariffs, tolls incurred by users;
- Transport Provider impacts, public and private sector;
  - Infrastructure costs - construction, maintenance, operation and renewal;
  - Service delivery costs – fleet, operating and maintenance costs;
  - Revenues – fares/ticket receipts, advertising, retail;
  - Taxes – impact on tax receipts to Government;
- Environmental impacts;
  - Noise;
  - Local Air Quality; and
  - Greenhouse Gasses.

Table 8-1 shows a summary of the outputs from the analysis of monetised costs and benefits. These need to be considered alongside the full breakdown of costs and benefits, presented in Appendix B.

Table 8-1 Analysis of Monetised Costs and Benefits (£'000 discounted present value in 2010 prices and values)

	Option 1	Option 2	Option 3	Option 4	Option 5
Noise	£52[56]	-£1,600	-£2,100	-£3,100	-£3,500
Local Air Quality[57]	-£98	-£391	-£400	-£477	-£365
Greenhouse Gases	-£6,400	-£7,000	-£8,700	-£8,600	-£8,300
Journey Quality					
Physical Activity					
Accidents					
Economic Efficiency: Consumer Users (Commuting)	£11,400	£12,100	£12,500	£4,500	£4,800
Economic Efficiency: Consumer Users (Other)	£41,100	£56,400	£44,700	£17,800	£19,900
Economic Efficiency: Business Users and Providers	£4,400	£600	£300	-£200	-£100
Wider Public Finances (Indirect Taxation Revenues)	-£6,800	-£7,800	-£6,300	-£3,700	-£4,300
Present Value of Benefits (see notes) (PVB)	£43,600	£52,300	£40,100	£6,200	£8,100
Cost to Broad Transport Budget	£42,500	£109,200	£207,800	£149,300	£167,400
Present Value of Costs (see notes) (PVC)	£42,500	£109,200	£207,800	£149,300	£167,400
OVERALL IMPACTS					
Net Present Value (NPV)	£1,100	-£56,900	-£167,800	-£143,100	-£159,300
Benefit to Cost Ratio (BCR)	1.03	0.48	0.19	0.04	0.05

Note: Table 8-1 includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals. There may also be other significant costs and benefits, such as reliability benefits, landscape and visual impacts, journey quality, physical activity amongst others which cannot be presented in monetised form at this stage and are shown greyed out in the table. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions. We have developed a bespoke Multi Criteria Assessment Framework to assess a broad range of relevant criteria for optioneering decision making, see Section 10. The exclusion of Accident data is described in Section 7.5.

Option BCRs currently range from 0.04 for Option 4 to 1.03 for Option 1. These BCRs exclude the impact of highways (see Section 3.2.2). The poor BCRs are a result of the combination of high costs of construction of offline infrastructure and the modest modelled transport benefits reflecting low demand for public transport by commuters and business travellers due to the relatively faster journey times of car and high levels of car dependency in Cambridgeshire, as discussed in Section 7.1.

[56] Value rounded to the nearest £1,000
[57] All values in this row rounded to the nearest £1,000

The BCRs are based on early stage option design development based in initial findings for the SOBC. The costs and benefits are subject to change through more detailed analysis that may allow for design and benefits optimisation and thereby increase the ratio of benefits to costs. Areas for further work are discussed in section 10.9.

8.2. Adjusted BCR

The adjusted BCR (Table 8-2) for each option includes wider impacts (see Section 7.5.1) along with scheme costs and benefits. Adjusted BCRs seek to account for the impacts an option has on economic welfare at a national level by identifying the additional economic benefits from agglomeration, additional tax revenues and increased output in imperfectly competitive markets that are associated with the option. Wider impacts were calculated based on public transport impacts of each option and accounting for wider impacts the BCRs presented by each option remain low or poor.

Table 8-2 Adjusted BCR for options accounting for Wider Impacts

	Option 1	Option 2	Option 3	Option 4	Option 5
Initial BCR	**1.03**	**0.48**	**0.19**	**0.04**	**0.05**
Wider Economic Impacts (modelled in WITA and TUBA) (£000s)	8,200	1,500	1,400	-2,600	-2,500
Total PVB (all monetised benefits plus Wider Economic Impacts) (£000s)	51,900	53,800	41,400	3,600	5,700
Adjusted BCR	**1.22**	**0.49**	**0.20**	**0.02**	**0.03**

It is evident that based on the transport and wider economic analysis undertaken all options provide poor value for money and therefore, based on the assurance framework, there must be wider strategic and appraisal evidence that provides a compelling case for investment. Additional rationale for this investment is presented through the Multi-Criteria Assessment Framework in Section 10, which also summarises the Value for Money assessment within the context of strategic fit.

9. Appraisal Summary Tables

The Appraisal Summary Tables for each option, using the format determined in WebTAG, are presented in Appendix C. The purpose of these tables is to present a comprehensive summary of the results of the option appraisals undertaken covering both monetised and non-monetised impacts.

Where applicable, non-monetised assessments use the seven-point scoring system follows the standard DfT appraisal measures:

- Large beneficial;
- Moderate beneficial;
- Slight beneficial;
- Neutral;
- Slight adverse;
- Moderate adverse; or
- Large adverse.

Note that all assessments undertaken at the SOBC stage present initial findings based on the current stage of modelling and option development. In addition, the following assessments have not been undertaken with a modelled or formal assessment at this stage (although they may have been commented on qualitatively):

- Reliability impact on business users;
- Regeneration;
- Impact on Townscape;
- Reliability impact on commuting and other users;
- Physical activity;
- Journey quality;
- Security;
- Affordability; and
- Option and non-use values.

In addition accidents have not been included in the BCR due to the limited variation in terms of accident impact between options.

A discussion of the specific and comparative performance of options is discussed in Section 10.

10. Multi-Criteria Assessment Framework

The Multi-Criteria Assessment Framework has been undertaken to provide a broad assessment of each option against strategic fit, transport economic, environmental, and delivery criteria to indicate the extent to which each option demonstrates a compelling case for investment.

Option 3 has the highest combined score of all the options as it aligns most closely with the strategic objectives for the scheme, namely the provision of a segregated and thus reliable high quality public transport service that connects the housing developments in Cambourne and Bourn Airfield with employment sites in Cambridge, Addenbrooke's and the Science Park.

10.1. Introduction

A bespoke Multi Criteria Assessment (MCAF) has been developed in order to appraise each scheme option against a range of criteria such that the overall performance of each option can be taken into account based on a wider range of evidence than economic cost benefit analysis alone.

The assessment criteria fall into the following categories:

- Overall strategic fit;
- Scheme costs and benefits;
- Transport impacts;
- Risks;
- Accessibility;
- Environmental impacts; and
- Stakeholder support.

The framework is developed from the strategic and policy objectives outlined in full in the **Strategic Case** and aims to make an assessment of the extent to which each scheme achieves specific, measurable outcomes, as reiterated in Table 10-1 below.

Table 10-1 MCAF: Goals, outcomes and metrics

Strategic Objectives	Corridor goals within scheme bounds	Measurable outcomes	Metrics considered in the MCAF
• Nurture the conditions necessary to enable the potential of Greater Cambridge to create and retain the international high-tech businesses of the future. • To markedly improve connectivity and networks between clusters and labour markets so that the right conditions are in place to drive further growth. • To better target investment to the needs of the Greater Cambridge economy by ensuring those decisions are informed by the needs of businesses and other key stakeholders such as the universities. • Source: City Deal Assurance Framework	• Focus on bus and addressing issues that prevent a good service being delivered. • Segregated links or offline alignments on the A428 and M11. • Bus priority measures • Outer ring of Park & Ride • Busway / HQPT infrastructure to serve Bourn Airfield / Cambourne • Walking and cycling improvements, including direct links • Highway capacity improvements • Source: TSCSC	• Value for Money • Increased transport capacity • Improved transport connectivity • Improved journey times • High Quality Public Transport	• High Quality Public Transport Attributes (vehicle quality / ride quality / RTPI / branding / ticketing) • Level of quality bus service that segregation of buses from general vehicular traffic provides • Improvements in walking infrastructure • Improvements in cycling infrastructure • Disruption to existing traffic during construction • Deliverability risk (planning/permissions) • PVC • PVB • Journey times (2031, Cambourne - Drummer Street, Inbound, AM Peak) • Bus frequency (AM Peak, Buses Per Hour, Inbound) • Bus and Park & Ride mode share • Car mode share • Agglomeration • Constructability risk (complexity of delivery) • Operability risk • Reliability • Sub-total • Accessibility • Total change in air quality over the 60 year appraisal period • Change in C02 emissions (£,NPV) • Change ion noise impacts on households (£,NPV)

Strategic Objectives	Corridor goals within scheme bounds	Measurable outcomes	Metrics considered in the MCAF
			• Impact on the water environment • Landscape and visual impact • Heritage impact • Biodiversity impact • Reduction in road traffic accidents • Stakeholder feedback from public consultation

The MCAF is an unweighted assessment of the qualitative and quantitative scores for the criteria for each option. For all qualitative metrics (e.g. High Quality Public Transport attributes), each option was assigned an integer score from 1-5, with a score of five representing the 'best performing' scheme and one the 'worst performing'. The rational for the scores against qualitative measures is outlined in Table 10-2 and is based on a comparison of each scheme specification against its potential ability to perform against each of the metrics. For example in terms of delivery of High Quality Public Transport, it would be envisaged that a scheme with the highest levels of segregation would provide a higher quality ride for passengers and offer more reliability than a scheme with the least level of segregation, where buses are travelling with general traffic on the highway. In this regard a fully 'offline' option would score 5 (best performing) and a fully online option would score 1 (less comparative ability for the option to achieve the goal).

Where quantitative metrics were used, then the best performing option was given a score of five and this was then scaled proportionally based on the underlying data for each option. Using journey times as an example, the fastest journey time would score 5 (best performing). If the fastest time was (hypothetically) 10 minutes from the origin to destination, then a scheme that took twice as long (20 minutes) would be allocated half of the top score, in this example 2.5.

The scores are summed across all metric and the total score provides an overall indication of performance against a range of strategic fit, transport economic, environmental, social and delivery criteria. Note that further iterations of the MCAF assessment could be weighted to account for local authority and city deal priorities, where evidence supports doing so.

The relative performance of each option against the criteria defined in the MCAF is shown in Table 10-2, and the remaining sections of this chapter discuss the performance of each option in more detail, incorporating the value for money assessment into the discussion in order to reflect the fact that while performance of all options on transport value for money grounds may be poor, when due consideration is given to strategic alignment the option selection decision can become more focused on a single option to be taken forward for further design and specification. The Value for Money assessment provide a concise and formal summary of the economic, social, environmental and public account impacts of each option in order to reflect the emerging economic case for the option, and at this stage of option design development must be considered along with strategic alignment of the option with the City Deal vision.

10.2. Multi- criteria option Performance: value for money assessment and strategic fit

The MCAF assessment in table 10-2 shows that the unweighted MCAF scores range from 62 for Options 4 and 5 to 72 for Option 3 (higher indicates a better performing option against a range of economic, environmental and delivery metrics).

The alignment of options to the vision for public transport for Cambridge is represented by the level of segregation and potential for HQPT to be provided by each option. The rationale for this includes the fact that a segregated alignment is likely to provide a more reliable bus service that does interact with general traffic; that has higher levels of protection from interruption for utilities or maintenance works and that has infrastructure that is constructed to a higher quality and better specification and which is designed to accommodate high quality guided buses.

With this in mind Option 3 has the best strategic fit as it is a fully offline option and Option 1 has the poorest strategic fit as it is a fully online option. Option 1 does not address the requirement of connectivity of development in Cambourne and Bourn Airfield with employment centres in Central Cambridge, Addenbrooke's and the Science Park, because it does not provide improvements to infrastructure or services west of the Madingley Mulch Park & Ride.

Option 1 has the lowest costs and environmental impacts compared to other options and thus scores better on these criteria than Options 2 to 5. However it is expected that through optimisation of option designs and specifications as well as through environmental mitigations that the performance of the other options against these criteria could be substantially improved.

Table 10-2 Multi Criteria Assessment of Options

MCAF Analysis Cambourne to Cambridge Better Bus Journeys Scheme Options	**Key**										
	Qualitative scoring				**Quantitative scoring**						
	Best performing option	5			Best performing option		5				
	Worst performing option	1			All other options		Proportion based on the best performing option				

			Ranking										
			Option 1		**Option 2**		**Option 3**		**Option 4**		**Option 5**		
	Outcomes	**Metric for scoring outcomes**	**Assessment**	**Score**	**Assessment**	**Score**	**Assessment**	**Score**	**Assessment**	**Score**	**Assessment**	**Score**	**Rationale**
Strategic Goals (City Deal Assurance Framework)	**Value for Money, increased transport capacity, improved transport connectivity, improved journey times, High Quality Public Transport**	**High Quality Public Transport Attributes (vehicle fleet/ride quality/RTPI/branding/ticketing)**	Lowest	1	Medium	3	Highest	5	Medium	3	Medium	3	Option 1 has no dedicated infrastructure and therefore the high quality ride expected to be achieved with a HQPT scheme could deteriorate over-time. Options 2, 4 and 5 have some dedicated infrastructure, but lower control overall when compared to option 3 which is offline and can maintain both ride quality and start/stop frequency. Branding is also expected to be lower on an online scheme.
		Level of service that segregation provides	No segregation	1	Partially segregated	2	Fully segregated	5	Partially segregated	3	Partially segregated	3	More segregation will be indicative of greater route control and fewer permissions issues e.g. utilities / general highway maintenance works that could be undertaken during operation.
		Improvements in walking infrastructure	No segregation	1	Partially segregated	2	Fully segregated	5	Partially segregated	3	Partially segregated	3	Where busway sections are provided, direct walking infrastructure will be included within the scheme.
		Improvements in cycling infrastructure	No segregation	1	Partially segregated	2	Fully segregated	5	Partially segregated	3	Partially segregated	3	Where busway sections are provided, direct cycling infrastructure will be included within the scheme.
		Disruption to existing traffic during construction	Highest	1	High	2	Lowest	5	Medium	3	Medium	3	No full assessment of construction disruption has been undertaken, however construction impacts will be greatest where infrastructure is proposed on Madingley Road / Madingley Rise. Option 1 has an eastbound bus lane proposed, east of Madingley Mulch roundabout. Option 2 has works on Madingley Road, east of the M11 bridge. Diversion options for traffic using Madingley Road are very limited.
		Deliverability risk (planning/consents)	Lowest	5	Medium-high	2	Highest	1	Medium-high	2	Medium-high	2	Deliverability risk (in terms of planning requirements and permissions) is expected to be lowest where schemes are based on upgrades to existing infrastructure. New infrastructure on greenfield sites is expected to have the highest risk. Any relevant environmental / statutory consents would be required.
		PVC (Bus Only)	£42,500,000	5.0	£109,200,000	3.4	£207,800,000	1.0	£149,300,000	2.4	£167,400,000	2.0	Results from modelling undertaken.

To better target investment to the needs of the Greater Cambridge economy by ensuring those decisions are informed by the needs of businesses and other key stakeholders such as the universities.

To markedly improve connectivity and networks between clusters and labour markets so that the right conditions are in place to drive further growth.		**PT Benefits**	£43,600,000	4.2	£52,300,000	5.0	£40,100,000	3.9	£6,200,000	1.0	£8,100,000	1.2	Results from modelling undertaken. Does not include environmental disbenefits (see below)
		GVA benefits - UK Level - (PVB over 30 years, 2010 prices, Source: Mott MacDonald)	£45,400,000	-	Not assessed	-	£198,100,000	-	£153,400,000		Not assessed	-	Mott MacDonald assessment of Wider Economic Benefits. Work assessed Options 1,3 and 4 only and therefore option-specific performance is not scored as part of this MCAF assessment. Source: Mott MacDonald (2016) Strategic Economic Appraisal of A428-A1303 Bus Scheme: Wider Economic Benefits.
		Journey times (2031, Cambourne - Drummer Street, Inbound, AM Peak)	46	1.0	23	4.5	20	5.0	22	4.7	22	4.8	Results from modelling undertaken.
		Bus frequency (AM Peak, Buses Per Hour, Inbound)	6	1.0	12	5.0	9	3.0	9	3.0	9	3.0	Reported as number of buses per hour. For Option 1 divide by two as it is 12 buses per hour, but not on the full route
		Bus and Park & Ride mode share	21%	1.0	23%	3.0	25%	5.0	22%	2.0	21%	1.0	Results from modelling undertaken.
		Wider Impacts (PVB over 60 years, 2010 prices)	£8,200,000	5.0	£1,500,000	2.5	£1,400,000	2.5	-£2,600,000	1.0	-£2,500,000	1.1	Results from modelling undertaken.
		Constructability risk (complexity of delivery)	Medium	2	Medium	2	Highest	1	Medium	3	Highest	1	Delivery will be most complex where the route options include a new bridge over the M11. In addition, Madingley Road has traffic management restrictions in peak periods, so construction windows are likely to be restricted, increasing the complexity of construction.
		Operability risk	Highest	1	Medium-high	2	Lowest	5	Medium	3	Medium	3	Bus operations are easier where 2-way priority is given to buses. This gives operators more consistent and reliable journey times to enable easier planning for turn-around.
		Reliability	No segregation	1	Partially segregated	2	Fully segregated	5	Partially segregated	4	Partially segregated	4	Expected that offline options will offer a more reliable service than those that run online.
		Relative Strategic Fit Sub-total	31		42		57		41		38		
	More Housing	**Accessibility**	Lowest	1	Medium	3	Medium	3	Medium	3	Medium	3	Based on qualitative assessment of accessibility plots, which rely on journey times.
		Relative Housing impact Sub-total	1		3		3		3		3		
Nurture the conditions necessary to enable the potential of Greater	Environmental Impacts	**Total change in air quality over the 60 year appraisal period**	-£98,000	5.0	-£391,000	1.9	-£400,000	1.8	-£477,000	1.0	-£365,000	2.2	These figures are partly based on highway modelling that is not being presented fully due to the model being overly sensitive to changes in network conditions, which don't totally represent changes due to the scheme.
		Change in C02 emissions (£,NPV)	-£6,400,000	5.0	-£7,000,000	3.9	-£8,700,000	1.0	-£8,600,000	1.2	-£8,300,000	1.6	
		Change in noise impacts on households (£,NPV)	£52,000	5.0	-£1,600,000	3.2	-£2,100,000	2.5	-£3,100,000	1.4	-£3,500,000	1.0	
		Impact on the water environment	Neutral	5.0	Slight adverse	4.0	Slight adverse	1.0	Slight adverse	2.0	Slight adverse	3.0	Based on environmental assessment undertaken
		Landscape and visual impact	Slight adverse	5	Slight/Moderate adverse	2	Moderate adverse	1	Slight/Moderate adverse	2	Slight/Moderate adverse	2	Based on environmental assessment undertaken
		Heritage impact	Neutral	5	Slight adverse	4	Moderate adverse	3	Slight adverse	4	Moderate adverse	3	Based on environmental assessment undertaken

		Biodiversity impact	Large adverse	1	Large adverse	1	Large adverse	1	Large adverse	1	Large adverse	1	Based on environmental assessment undertaken, based on the principal of 'most adverse category'. Mitigation options to be explored during design development.
		Reduction in road traffic accidents	Neutral	0	Neutral	0	Neutral	0	Neutral	0	Neutral	0	Minimal change across all options, compared to do-minimum
		Relative environmental impact Sub-total	31		20		11		13		14		
	Stakeholder support	**From public consultation**	Most support	5	Some support	4	Most opposition	1	Some support	3	Some opposition	2	Based on assessment of consultation responses.
		Relative stakeholder Sub-total	5		4		1		3		2		
		TOTAL Relative MCAF SCORE	68		69		73		60		57		
MCAF Table: Atkins (2016) with UK-level GVA impacts supplied by Mott MacDonald (2016). Strategic Economic Appraisal of A428-A1303 Bus Scheme: Wider Economic Benefits.													

10.3. Option 1: Performance summary

Option 1 performs reasonably well on cost and environmental impacts criteria but performs poorly on strategic fit.

10.3.1. Monetised Value for Money assessment

Based on the transport modelling forecasts, Option 1 is indicated to generate economic benefits valued at £43.65m over the 60-year appraisal period (2010 prices, discounted to 2010). The total cost of the scheme over 60 years is £42.52m (2010 prices, discounted to 2010). This results in an initial BCR of 1.03. If Wider Economic Impacts are included within the overall scheme benefits, the resulting adjusted BCR is 1.22. Taking these monetised benefits into account the scheme represents low[58] value for money.

10.3.2. Multi criteria assessment

Option 1 is the lowest cost option but is unlikely to offer a step change in connectivity and journey efficiency (i.e. combination of speed and reliability) in order to deliver a HQPT service on the corridor. In increasing public transport capacity this option meets some, but not all, of the strategic criteria. Critically, the TSCSC aspires to deliver a High Quality Passenger Transport (HQPT) service along the corridor, with increasing levels of segregation. As a fully online option with bus priority measures on the existing highway, the option has a limited ability to achieve the key strategic objective to deliver HQPT services. The restrictions of the online alignment on the A1303 also mean that bus priority provision can only be accommodated in an inbound (eastbound) direction, meaning that there is no priority for services travelling away from Cambridge.

Option 1 does not provide infrastructure or service improvements west of Madingley Mulch. This means that this option is not likely to achieve the aspirations (set out in the TSCSC) for providing 'busway / HQPT infrastructure' that connects Cambourne West and Bourn Airfield. In addition, this option does not extend cycling or pedestrian provision as there is inadequate space along the A1303 to widen the alignment to expand provision for cycling and walking. In not doing so it does not support the aspirations of the TSCSC, which aims to provide more direct cycling and walking routes.

The public transport benefits generated by Option 1 are driven mostly by the benefits provided to the users of the existing Madingley Park & Ride site, east of the M11 J13 Bridge. The existing Park & Ride at Madingley Road allows traffic to be intercepted from both the A1303/Madingley Road and from the M11. Whilst journey time improvements related to the existing Park & Ride as a result of this option are relatively low, the volume of trips that have been generated for bus travel combined with the benefits provided to users of the Madingley Road Park & Ride site, result in the large transport benefits.

Option 1 generates the lowest impacts in terms of noise, air quality and emissions as well as wider environmental impacts (such as impacts on the historic environment and biodiversity) and this is primarily because the scheme will run on existing roads.

In summary, from the MCAF and economic analysis undertaken it is evident that while Option 1 generates higher PT benefits and lower costs compared to other options (and, therefore, demonstrates the best value for money) it also demonstrates a significantly lower strategic fit than options that deliver a highly segregated HQPT route.

[58] Initial Value for Money categories are identified based on the Benefit Cost Ratio (BCR) of the scheme, using monetised impacts in line with WebTAG guidance. These categories are:

- poor VfM if the BCR is less than 1.0;
- low VfM if the BCR is between 1.0 and 1.5;
- medium VfM if the BCR is between 1.5 and 2.0;
- high VfM if the BCR is between 2.0 and 4.0; and
- very high VfM if the BCR is greater than 4.0.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/255126/value-for-money-external.pdf

Table 10-3 Option 1: Performance Summary

	Option 1
Initial BCR	**1.03**
Wider Economic Impacts (modelled in WITA and TUBA) (£000s)	8,200
Total PVB (all monetised benefits plus Wider Economic Impacts) (£000s)	51,900
Adjusted BCR	**1.22**
MCAF Score (unweighted)	**68**

10.4. Option 2: Performance summary

Option 2 produces the highest level of transport economic benefits (PVB) but is only partially segregated, while running fully online along Madingley Road and as such scores relatively less well on strategic fit.

10.4.1. Monetised Value for Money assessment

Based on the transport modelling forecasts, Option 2 generates economic benefits valued at £52.56m over the 60-year appraisal period (2010 prices, discounted to 2010). The total cost of the scheme over 60 years is £109.19m (2010 prices, discounted to 2010). This results in an initial BCR of 0.48. If Wider Economic Impacts are included within the overall scheme benefits, the resulting adjusted BCR is 0.49. Taking these monetised benefits into account the scheme represents poor value for money.

10.4.2. Multi criteria assessment

The PVB of Option 2 is driven by servicing both the existing Madingley Road Park & Ride (located east of the M11 J13) as well as the new Madingley Mulch Park & Ride. The BCR of 0.48, which is lower than Option 1 despite the higher benefits (due to much higher costs), could be improved through option design optimisation to capture more benefits, while the negative environmental impacts of the scheme could be mitigated.

The MCAF assessment identifies that this option addresses some of the strategic goals of the scheme. The option is offline to the west of Madingley Mulch, between Cambourne and Bourn Airfield, which directly addresses the objective in the TSCSC to provide HQPT services free from general traffic congestion to serve Cambourne and Bourn Airfield. This segregation, however, does not extend throughout the scheme. Further, offline infrastructure increases the cost of the Option compared to Option 1. The restrictions of the online alignment on the A1303 mean that bus priority provision can only be accommodated in an inbound direction, meaning that there is no priority for services travelling away from Cambridge on what is expected to continue to be a congested section of the study area.

The option offers a compromise between costs, connectivity, accessibility and HQPT provision. The option broadly addresses strategic objectives for the western section of the scheme. In addition this option provides segregated walking and cycling infrastructure along the offline section of the route, addressing walking and cycling objectives for this section of the route, however not along the entire corridor.

Because this scheme includes new, offline sections, there will be noise impacts to additional households that were previously less exposed to noise, air quality impacts through increased vehicle kilometres and a related increase in GHG emissions. In addition there will be increased landscape, historic environment and biodiversity impacts due to the fact that the option includes a section of offline busway through greenbelt land. Further design development could mitigate some of these impacts in future stages of the analysis.

Modelling indicates that this option provides the highest level of public transport benefits of the options considered and it is partially aligned to the strategic objectives and vision for the corridor and wider sub-region. Importantly, by not providing segregation along the entire corridor, the option does not provide the level of segregation that is aspired to within the region, nor are pedestrians and cyclists catered for on a

corridor-wide basis. It is expected that design optimisation and environmental mitigation could improve the value for money of this option in further stages of assessment.

Table 10-4 Option 2: Performance Summary

	Option 2
Initial BCR	**0.48**
Wider Economic Impacts (modelled in WITA and TUBA) (£000s)	1,500
Total PVB (all monetised benefits plus Wider Economic Impacts) (£000s)	53,800
Adjusted BCR	**0.49**
MCAF Score (unweighted)	**69**

10.5. Option 3: Performance summary

This option currently presents the highest strategic fit (given that buses are separated from general traffic congestion on the entirety of the route in line with the vision and strategic objectives for Cambridgeshire). However, based on current scheme specification and modelling results, Option 3 has a poor initial BCR of 0.19, driven mainly by the cost of providing segregated infrastructure along the whole alignment. The adjusted BCR is 0.20.

It is expected that environmental mitigations and option optimisation could improve the PVB of the option, while reducing the costs and the impact on the environment. In addition it is important to note that the MCAF assessment undertaken has not used weighted criteria to assess option performance. If the MCAF was weighted and if a key priority was the provision of segregation and high quality public transport services then it is possible that the strategic fit of Option 3 would be stronger. Further assessment would be required to determine a weighted MCAF based on prioritisation and weighting of objectives.

10.5.1. Monetised Value for Money assessment

Based on our transport modelling forecasts, Option 3 is currently indicated to generate economic benefits valued at £41.32m over the 60-year appraisal period (2010 prices, discounted to 2010). The total cost of the scheme over 60 years is £268.5m (2010 prices, discounted to 2010). This results in an initial BCR of 0.19. If Wider Economic Impacts are included within the overall scheme benefits, the resulting BCR is 0.20. Taking these monetised benefits into account the scheme represents poor value for money.

10.5.2. Multi criteria assessment

Option 3 provides segregated busway along the entire A428 corridor. This option looks to build on the success of the current Guided Busway in addressing Cambridge's ambitious long term vision as a fast growing highly productive City that maintains a high quality standard of living, in terms of accessibility of housing to employment, the promotion of public transport, increasing sustainable growth and encouraging use of active modes. As a result, Option 3 performs best in terms of strategic fit, mainly because the fully offline route provides the highest level of connectivity, capacity and journey efficiency through the provision of a HQPT service and segregated walking and cycling infrastructure. However, as a result the option is the most costly due to significant conception, design and construction costs.

Option 3 does not fully serve the existing Madingley Road Park & Ride, which based on the current analysis is a main generator of benefits for Options 1 and 2. Option 3 could be designed to call at an optimally sited additional Park & Ride. Further detailed development and assessment of the access arrangements, and the preferred location of the Park & Ride site, will need to be undertaken alongside the detailed development of the preferred option.

A significant aspect of this option is that it avoids Madingley Road and is segregated, therefore, the eastern section of the route does not add to congestion on Madingley road (nor is it impacted by congestion). This

indicates a good strategic fit in this area in that it addresses strategic HQPT objectives whilst also addressing congestion issues in this part of the corridor.

This option has the largest negative environmental impacts, primarily driven by the implementation of a fully offline route, some of which is on greenbelt land. Noise, Air Quality and GHG impacts are all expected to increase as a result of the new routes and additional buses. The impact on the landscape, historic environment and biodiversity is likely to be the largest as this scheme includes the most new infrastructure.

Table 10-5 Option 3: Performance Summary

	Option 3
Initial BCR	**0.19**
Wider Economic Impacts (modelled in WITA and TUBA) (£000s)	1,400
Total PVB (all monetised benefits plus Wider Economic Impacts) (£000s)	41,400
Adjusted BCR	**0.20**
MCAF Score (unweighted)	**73**

10.6. Option 4: Performance summary

10.6.1. Monetised Value for Money assessment

Based on our transport modelling forecasts, Option 4 is currently indicated to generate economic benefits valued at £6.51m over the 60-year appraisal period (2010 prices, discounted to 2010). The total cost of the scheme over 60 years is £149.27m (2010 prices, discounted to 2010). This results in an initial BCR of 0.04. If Wider Economic Impacts are included within the overall scheme benefits, the resulting BCR is 0.03. Taking these monetised benefits into account the scheme represents very poor value for money.

10.6.2. Multi criteria assessment

This option is offline between Cambourne and Bourn Airfield, which partially addresses the strategic objective to create a HQPT service to link Cambourne and Bourn Airfield with central Cambridge, Addenbrooke's and the Science Park. However, this option's alignment, in the approach to central Cambridge, does not include a bridge over the M11 and instead re-joins the main carriageway where the buses will integrate with general traffic which severely undermines the HQPT offering on this portion of the alignment. Having utilised the existing bridge, the services will continue on dedicated bus infrastructure which is also consistent with the strategic requirement for segregation along the corridor.

As for all the segregated or partially segregated options (Options 2 through 5) there will be negative noise and air quality impacts to additional households that were not previously as close to bus routes. These negative impacts can be mitigated, a more detailed environmental assessment in future stages of the analysis would identify what mitigations are most appropriate.

While the exclusion of a new bridge does reduce costs, the costs still remain high compared to the associated benefits currently forecast for the route and as such the initial BCR of this scheme is 0.04.

Table 10-6 Option 4: Performance Summary

	Option 4
Initial BCR	**0.04**
Wider Economic Impacts (modelled in WITA and TUBA) (£000s)	-2,600
Total PVB (all monetised benefits plus Wider Economic Impacts) (£000s)	3,600
Adjusted BCR	**0.02**
MCAF Score (unweighted)	**60**

10.7. Option 5: Performance summary

The option runs offline between Cambourne and Bourn Airfield and unlike Option 4 does include a bridge over the M11 and continuous busway infrastructure east of Madingley Mulch Park & Ride. This option therefore directly addresses the strategic objective to create HQPT infrastructure and services to serve Cambourne and Bourn Airfield as set out in the TSCSC.

10.7.1. Monetised Value for Money assessment

Based on our transport modelling forecasts, Option 5 is currently indicated to generate economic benefits valued at £8.42m over the 60-year appraisal period (2010 prices, discounted to 2010). The total cost of the scheme over 60 years is £167.42m (2010 prices, discounted to 2010). This results in an initial BCR of 0.05. If Wider Economic Impacts are included within the overall scheme benefits, the resulting BCR is 0.03. Taking these monetised benefits into account the scheme represents very poor value for money.

10.7.2. Multi criteria assessment

Because this option includes new, offline sections, there will be noise impacts to additional households that were previously not exposed to the levels of noise, air quality impacts and GHG emissions associated with bus services running close-by. As is the case for all offline options, the impacts on landscape, historic environment and biodiversity are adverse and further design development is required to mitigate these impacts in future stages of the analysis.

This option does not serve the existing Madingley Road Park & Ride as buses would need to significantly divert from this route to do so, as such this option has lower transport economic benefits than Options 1 and 2. Options 4 and 5 have slightly longer journey times than Option 3, and do not stop at Caldecote and Coton which suggest why Option 3 significantly outperforms Options 4 and 5.

The costs associated with this scheme, compared with the associated benefits leads to an initial BCR of 0.05.

Table 10-7 Option 5: Performance Summary

	Option 5
Initial BCR	**0.05**
Wider Economic Impacts (modelled in WITA and TUBA) (£000s)	-2,500
Total PVB (all monetised benefits plus Wider Economic Impacts) (£000s)	5,700
Adjusted BCR	**0.03**
MCAF Score (unweighted)	**57**

10.8. Comparative performance

At this stage of design concept all options represent poor value for money on transport economic grounds. Further option design work concentrated on benefits optimisation and environmental impact avoidance or mitigation would likely improve the transport economic performance of options, however, it is not possible to determine at this stage whether this would have an impact on option BCRs.

If an option is taken forward, despite the lack of evidence of value for money in terms of transport economic grounds, a possible indicator to consider is the strategic fit of the option with the vision and policy directives of Cambridge and South Cambridgeshire. Option 3 currently scores highest for strategic fit in the analysis undertaken, though the design requires further work to reduce costs, optimise transport benefits and alleviate concerns of stakeholders about building through the greenbelt. It is not possible to confirm at this stage whether the BCR for Option 3 (or indeed any option) would change significantly with further design development and analysis. Therefore, decision makers need to be confident that the option taken forward could gain funding approval and endorsement without a strong BCR. This would be on the foundation of the strategic aim to meet the Vision for Cambridgeshire, despite there being a lack of proven transport need along the entirety of the route at this stage. Note that the strategic fit is not consistent with the transport appraisal and as a result there is not a clear preferred option at this stage.

10.9. Further work

The value for money assessment at this stage is based on high level option designs and further work will allow optimisation of the design and option performance. Both general design optimisation and environmental mitigations will be considered in order to improve the transport benefits and economic efficiency, whilst planning to reduce identified environmental impacts. The costs and benefits presented in this report are subject to change through more detailed analysis in the following areas. These may optimise the design and thereby increase the ratio of benefits to costs:

- Refinement of design and bus service specifications and routing to inform optimal bus service provision and potentially improve commercial performance of the services proposed in the options, which under current modelled specifications are expected to require a substantial subsidy;
- In addition to those route options set out within this report, one possible refinement Atkins has been commissioned by CCC to investigate at a high level is the feasibility of providing segregated high quality public transport infrastructure along the existing St Neots Road corridor. Initial investigations suggest this is feasible from an engineering perspective. The transport or wider economic impacts of this option (referred to as option 3a in CCC's Options Assessment Report) have not been assessed;
- Operational modelling of the interaction between buses and cars for all options to inform mitigation of highways dis-benefits;
- Assumptions relating to locations of Park & Ride sites, including the future of the existing Madingley Road site[59];
- Enhancements to the M11 J13 bridge to relieve heavy congestion on the approach to Cambridge City Centre by providing a bus lane or bus priority on the bridge;
- Demand management in Cambridge City Centre to encourage and incentivise mode shift to public transport;
- Running sensitivity tests including consideration of demand generated beyond 2031 to the end of the appraisal period, in line with the vision for the sub-region;
- Environmental impact avoidance or mitigation (e.g. through landscaping, habitat management and design measures) which may improve the environmental impacts of the scheme;
- Capture monetised reliability benefits;
- Capture monetised dependent development benefits; and
- Capture of monetised active mode benefits for walking and cycling.

[59] For this appraisal it was assumed that the existing Park & Ride site at Madingley Road would remain open until 2031 when the existing site lease expires. Therefore, this site is present within the Do Minimum scenario. However, more recent discussions have suggested that the site may not remain in use should another site be constructed along the corridor ahead of 2031, such as that proposed at Madingley Mulch Park & Ride site. During the next phase of the project the impact of when the existing Park & Ride site at Madingley Road is likely to close will need to be assessed and what the strategy would be for any replacement for this site.

11. Conclusions

Cambridgeshire has an aspiring vision for growth and City Deal ambitious sustainable growth targets to achieve and the Cambourne to Cambridge better bus journey scheme is an important transport infrastructure component in this growth strategy in that it aims to deliver substantial public transport capacity that is of high quality in order to compete with car, currently the predominant and preferred mode for commuting and business travel in Cambridgeshire. The purpose of this Strategic Outline Business Case is to present initial assessments of each of the options considered for the scheme, to identify their impacts and the resulting value for money and broader performance outcome of each option based on the current stage of option development and modelling.

Along with the level of option development and assessment it is recognised that the growth prospects for Cambridge are not adequately reflected in the future modelled scenario of 2031, due to demand volumes from the developments of Cambourne and Bourn Airfield likely being understated and to demand management strategies, such as those suggested in the draft Cambridge Access study, not yet incorporated into the modelling. The strategic model CSRM itself is being updated to incorporate updated growth forecasts for Cambridgeshire.

At this stage of option design development the key requirement is to establish the strategic case for investment and to secure approval to proceed with development of option specifications and designs. The strategic case for investment has been presented and provides a description of the rationale for consideration of investment. This economic case provides initial evidence that could be used to inform decision makers with regards to which option(s) to take forward for further design and specification development, in order to optimise transport economic and environmental performance.

It is important to account for the fact that the current strategic assessment and economic appraisal present conflicting recommendations. Further detailed assessment is required in order to fully understand option impacts and to optimise the option specifications and designs. This will allow a preferred option to be confirmed and will better align the progress of the project towards achieving City Deal's objectives. It is possible that through option optimisation and improving the methods used to capture and assess scheme impacts that benefit-cost ratios could improve in further stages of assessment, however this cannot be confirmed without further work.

Based on the results of this current analysis, Option 3 achieves the highest strategic fit on the basis that segregation and a higher degree of HQPT best meets the Vision and Strategic Objectives and Goals. However, the analysis undertaken shows that there are significant benefits to be gained from providing improvements to infrastructure and services which intercept the existing Park & Ride site at Madingley Road. This option cannot be practically routed through the existing site, and therefore the option achieves lower public transport benefits compared to other options which do serve the Park & Ride. Option 3 is the highest cost option and is most likely to have strong public opposition. Due to the Option having high costs, high environmental impacts and relatively low benefits, the Option presents with poor value for money in its current configuration.

Options 4 and 5 achieve very low public transport benefits, partially explained by slightly longer journey times and not serving both of Caldecote and Coton along the western alignment. These options provide very poor value for money and only partially address strategic requirements.

The benefits generated by Option 1 are driven by patronage from both Park & Ride sites. This option does not align well with the strategic objectives of segregated and high quality public transport provision to the developments of Cambourne and Bourn Airfield as this option does not improve infrastructure or services from the developments. It is not possible in this option to enhance existing cycling or pedestrian provision (a key objective) as it is constrained by the width of Madingley Road. Further, the approach to Cambridge along the A1303 and Madingley Road is currently extremely congested and forecast to remain that way and making any changes to the existing highway will likely be highly disruptive during construction and future maintenance. This option scores relatively highly in the MCAF assessment undertaken, driven by the low costs and low impacts of the scheme rather than the strategic fit. The option presents low value for money.

Option 2 generates the highest level of public transport benefits of all options, driven in part by servicing both the existing Madingley Road Park & Ride (located east of the M11 J13) as well as the new Madingley Mulch Park & Ride. It presents lower value for money than Option 1 despite the higher benefits, due to much higher costs. Value for Money could potentially be improved through option design optimisation to capture more benefits, while some of the negative environmental impacts of the scheme could be mitigated. The MCAF assessment identifies that this option addresses some of the strategic goals of the scheme, however it does not align fully with the longer term aspiration and visions of the sub-region to provide corridor-wide segregation for buses, pedestrians and cyclists.

The analysis of the transport problem indicates that the approach to Cambridge, east of Madingley Mulch, may be better served offline. The greatest transport need in the corridor lies in the A1303 and Madingley Road sections of the route, which currently suffer from congestion and are forecast to remain congested to 2031 so and as such requires intervention. In contrast, the dual carriageway section of the A428 is forecast to remain un-congested to 2031 (based on current development assumptions). The MCAF analysis shows that options which address the transport needs of the corridor by providing segregated bus only infrastructure on the approach to Cambridge better align with the vision for Cambridgeshire.

Appendix A. Key Appraisal Assumptions

Table 11-1 Key appraisal assumptions

Issue	Assumption	Source
Appraisal Period	2021 to 2080	WebTAG Unit A1.1 and A1.2
Model Years	2021 and 2031	-
Demand Cap?	Demand is forecast to 2031 in line with Cambridgeshire Local Plan predictions	WebTAG Unit A5.3 (i.e. 20 years from current appraisal date i.e. 2015)
GDP Deflator	TUBA default	WebTAG Data Book, December 2015 Annual Parameters
RPI	TUBA default	OBR July 2015
Market Price Adjustment	TUBA default	WebTAG Data Book, December 2015
Fares on buses	Calculated from average fares in 2006 with growth factors applied to future years	CSRM Forecasting Report
Tax Rate on Fares	TUBA default	WebTAG Data Book, December 2015
Value of Time - Business		
Value of Time - Commuting		
Value of Time - Leisure		
Car Occupancy - Business		
Car Occupancy - Commuting		
Car Occupancy - Leisure		
Car Occupancy Annual Change to 2036 - Business		
Car Occupancy Annual Change to 2036 - Commuting		
Car Occupancy Annual Change to 2036 - Leisure		
Fuel Prices and Components		
Fuel consumption parameter values		
Proportion of cars, LGV & other vehicle kilometres using petrol, diesel or electricity		
Forecast Assumed Vehicle Fuel Efficiency Improvements to 2035		
Forecast Non-Fuel Resource Vehicle Operating Costs		
Carbon Dioxide Emissions per litre of fuel burnt/kWh used		
Non Traded Carbon Price		
Traded Carbon Price		
Optimism Bias: Construction	*44%*	*WebTAG A1.2 Table 8, based on standard highway improvement scheme at Programme Entry level of development*

Issue	Assumption	Source
Optimism Bias: Maintenance and Renewals	*15%*	*Based on risk analysis carried out on similar types of scheme*
Optimism Bias: bus opex costs (fleet investment, maintenance and renewal)	*15%*	*Based on risk analysis carried out on similar types of scheme*
Optimism Bias: Mileage driven opex	*0%*	*WebTAG A1.2, with costs based on existing unit rates for bus operation it is considered equally likely that costs will increase or reduce, so no OB uplift is applied.*

Table 11-2 Bus service definitions

Service	Route	Type (Offline = busway, online = on-street)	Frequency
Do Minimum – SCHEME NAMES			
Citi 4	Cambourne - Hardwick - City Centre	Fully online standard bus service	20 min
Option 1			
Citi 4	Cambourne - Hardwick - City Centre	Fully online standard bus service	20 min
A	Madingley Mulch Park & Ride – Madingley Road Park & Ride – Science Park – Chesterton Station	High-quality service. Online from Madingley Mulch Park & Ride to Histon Road, existing busway from Histon Road to Chesterton Station	20 min
B	Madingley Mulch Park & Ride – Madingley Road Park & Ride – City Centre	Fully online high-quality service	10 min
C	Madingley Mulch Park & Ride – M11 – Trumpington Park & Ride - Addenbrooke's	High-quality service. Online from Madingley Mulch Park & Ride to Trumpington Park & Ride, existing busway from Trumpington Park & Ride to Addenbrooke's	20 min
Option 2			
Citi 4	Cambourne - Hardwick - City Centre	Fully online standard bus service	20 min
G	Cambourne – Bourn Airfield – Hardwick – Madingley Mulch Park & Ride – Madingley Road Park & Ride – Science Park – Chesterton Station	High-quality service. Offline from Cambourne to M11, online from M11 to Histon Road, offline from Histon Road to Chesterton Station	20 min
H	Cambourne – Bourn Airfield – Hardwick – Madingley Mulch Park & Ride – Madingley Road Park & Ride – City Centre	High-quality service. Offline from Cambourne to M11, online from M11 to City Centre	10 min
I	Cambourne – Bourn Airfield – Hardwick – Madingley Mulch Park & Ride – M11 – Trumpington Park & Ride - Addenbrooke's	High-quality service. Offline from Cambourne to M11, online from M11 to Trumpington Park & Ride, offline from Histon Road to Addenbrooke's	20 min
Option 3			
Citi 4	Cambourne - Hardwick - City Centre	Fully online standard bus service	20 min
J	Cambourne – Bourn Airfield – Caldecote - Hardwick – Madingley Mulch Park & Ride – Coton – Cambridge West -	High-quality service. Offline from Cambourne to Bourn Airfield, online from Bourn Airfield to Madingley Mulch Park & Ride, offline from Madingley Mulch Park	20 min

	Madingley Road Park & Ride – Science Park – Chesterton Station	& Ride to Cambridge West, online from Cambridge West to Histon Road, existing busway from Histon Road to Chesterton Station	
K	Cambourne – Bourn Airfield – Caldecote - Hardwick – Madingley Mulch Park & Ride – Coton – Cambridge West - Grange Road – City Centre – Railway Station - Addenbrooke's – Trumpington Park & Ride	High-quality service. Offline from Cambourne to Bourn Airfield, online from Bourn Airfield to Madingley Mulch Park & Ride, offline from Madingley Mulch Park & Ride to Grange Road, online from Grange Road to City Centre, online from City Centre to Cambridge Railway Station, existing busway from Cambridge Railway Station to Trumpington Park & Ride	10 min between Cambourne and City Centre 20 min between City Centre and Trumpington
Option 4			
Citi 4	Cambourne - Hardwick - City Centre	Fully online standard bus service	20 min
J	Cambourne – Bourn Airfield – Hardwick – Madingley Mulch Park & Ride – Cambridge West - Madingley Road Park & Ride – Science Park – Chesterton Station	High-quality service. Offline from Cambourne to Bourn Airfield, online from Bourn Airfield to Madingley Mulch Park & Ride, offline from Madingley Mulch Park & Ride to Cambridge West, online from Cambridge West to Histon Road, existing busway from Histon Road to Chesterton Station	20 min
K	Cambourne – Bourn Airfield – Hardwick – Madingley Mulch Park & Ride – Cambridge West - Grange Road – City Centre – Railway Station - Addenbrookes – Trumpington Park & Ride	High-quality service. Offline from Cambourne to Bourn Airfield, online from Bourn Airfield to Madingley Mulch Park & Ride, offline from Madingley Mulch Park & Ride to Grange Road, online from Grange Road to City Centre, online from City Centre to Cambridge Railway Station, existing busway from Cambridge Railway Station to Trumpington Park & Ride	10 min between Cambourne and City Centre 20 min between City Centre and Trumpington
Option 5			
Citi 4	Cambourne - Hardwick - City Centre	Fully online standard bus service	20 min
J	Cambourne – Bourn Airfield – Hardwick – Madingley Mulch Park & Ride – Coton – Cambridge West - Madingley Road Park & Ride – Science Park – Chesterton Station Road Park & Ride – Science Park – Chesterton Station	High-quality service. Offline from Cambourne to Bourn Airfield, online from Bourn Airfield to Madingley Mulch Park & Ride, offline from Madingley Mulch Park & Ride to Cambridge West, online from Cambridge West to Histon Road, existing busway from Histon Road to Chesterton Station	20 min
K	Cambourne – Bourn Airfield – Hardwick – Madingley Mulch Park & Ride – Coton – Cambridge West - Grange Road – City Centre – Railway Station - Addenbrookes – Trumpington Park & Ride	High-quality service. Offline from Cambourne to Bourn Airfield, online from Bourn Airfield to Madingley Mulch Park & Ride, offline from Madingley Mulch Park & Ride to Grange Road, online from Grange Road to City Centre, online from City Centre to Cambridge Railway Station, existing busway from Cambridge Railway Station to Trumpington Park & Ride	10 min between Cambourne and City Centre 20 min between City Centre and Trumpington

Appendix B. DfT compliant appraisal tables

B.1. Transport Economic Efficiency (TEE) Tables

B.1.1. Option 1: TEE Table

Non-business: Commuting	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	11,200		11,200
Vehicle operating costs	-		-
User charges	190		190
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: COMMUTING	11,400	*(1a)*	11,400
Non-business: Other	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	40,200		40,200
Vehicle operating costs	-		-
User charges	900		900
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: OTHER	41,100	*(1b)*	41,100
Business			
User benefits			Passengers
Travel time	900		900
Vehicle operating costs	-		-
User charges	- 200		- 200
During Construction & Maintenance	-		-
Subtotal	700	*(2)*	700
Private sector provider impacts			
Revenue	45,900		45,900
Operating costs	- 38,500		- 38,500
Investment costs	- 3,600		- 3,600
Grant/subsidy	-		-
Subtotal	3,800		3,800
Other business impacts			
Developer contributions	-	*(4)*	-
NET BUSINESS IMPACT	4,400	*(5) = (2) + (3) + (4)*	
TOTAL			
Present Value of Transport Economic Efficiency Benefits (TEE)	56,900	*(6) = (1a) + (1b) + (5)*	

Notes: Benefits appear as positive numbers, while costs appear as negative numbers
All entries are discounted present values, in 2010 prices and values

B.1.2. Option 2: TEE Table

Non-business: Commuting	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	12,200		12,200
Vehicle operating costs	-		-
User charges	- 40		- 40
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: COMMUTING	12,100	*(1a)*	12,100
Non-business: Other	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	55,300		55,300
Vehicle operating costs	-		-
User charges	1,200		1,200
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: OTHER	56,400	*(1b)*	56,400
Business			
User benefits			Passengers
Travel time	800		800
Vehicle operating costs	-		-
User charges	- 200		- 200
During Construction & Maintenance	-		-
Subtotal	600	*(2)*	600
Private sector provider impacts			
Revenue	52,200		52,200
Operating costs	- 60,500		- 60,500
Investment costs	- 5,700		- 5,700
Grant/subsidy	14,000		14,000
Subtotal	-	*(3)*	-
Other business impacts			
Developer contributions	-	*(4)*	-
NET BUSINESS IMPACT	600	*(5) = (2) + (3) + (4)*	
TOTAL			
Present Value of Transport Economic Efficiency Benefits (TEE)	69,100	*(6) = (1a) + (1b) + (5)*	

Notes: Benefits appear as positive numbers, while costs appear as negative numbers.

All entries are discounted present values, in 2010 prices and values

B.1.3. Option 3: TEE Table

Non-business: Commuting	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	12,900		12,900
Vehicle operating costs	-		-
User charges	- 310		- 310
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: COMMUTING	12,500	*(1a)*	12,500
Non-business: Other	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	45,600		45,600
Vehicle operating costs	-		-
User charges	- 900		- 900
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: OTHER	44,700	*(1b)*	44,700
Business			
User benefits			Passengers
Travel time	500		500
Vehicle operating costs	-		-
User charges	- 200		- 200
During Construction & Maintenance	-		-
Subtotal	300	*(2)*	300
Private sector provider impacts			
Revenue	42,000		42,000
Operating costs	- 55,300		- 55,300
Investment costs	- 5,300		- 5,300
Grant/subsidy	18,700		18,700
Subtotal	-	*(3)*	-
Other business impacts			
Developer contributions	-	*(4)*	-
NET BUSINESS IMPACT	300	*(5) = (2) + (3) + (4)*	
TOTAL			
Present Value of Transport Economic Efficiency Benefits (TEE)	57,500	*(6) = (1a) + (1b) + (5)*	

Notes: Benefits appear as positive numbers, while costs appear as negative numbers.

All entries are discounted present values, in 2010 prices and values

B.1.4. Option 4: TEE Table

Non-business: Commuting	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	5,000		5,000
Vehicle operating costs	-		-
User charges	- 480		- 480
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: COMMUTING	4,500	*(1a)*	4,500

Non-business: Other	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	18,600		18,600
Vehicle operating costs	-		-
User charges	- 800		- 800
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: OTHER	17,800	*(1b)*	17,800

Business			
User benefits			Passengers
Travel time	4		4
Vehicle operating costs	-		-
User charges	- 200		- 200
During Construction & Maintenance	-		-
Subtotal	- 200	*(2)*	- 200
Private sector provider impacts			
Revenue	24,300		24,300
Operating costs	- 58,100		- 58,100
Investment costs	- 5,800		- 5,800
Grant/subsidy	39,700		39,700
Subtotal	-	*(3)*	-
Other business impacts			
Developer contributions	-	*(4)*	-
NET BUSINESS IMPACT	- 200	*(5) = (2) + (3) + (4)*	

TOTAL		
Present Value of Transport Economic Efficiency Benefits (TEE)	22,100	*(6) = (1a) + (1b) + (5)*

Notes: Benefits appear as positive numbers, while costs appear as negative numbers.

All entries are discounted present values, in 2010 prices and values

B.1.5. Option 5: TEE Table

Non-business: Commuting	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	5,300		5,300
Vehicle operating costs	-		-
User charges	- 480		- 480
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: COMMUTING	4,800	*(1a)*	4,800

Non-business: Other	ALL MODES		BUS and COACH
User benefits	TOTAL		Passengers
Travel time	20,700		20,700
Vehicle operating costs	-		-
User charges	- 800		- 800
During Construction & Maintenance	-		-
NET NON-BUSINESS BENEFITS: OTHER	19,900	*(1b)*	19,900

Business			
User benefits			Passengers
Travel time	100		100
Vehicle operating costs	-		-
User charges	- 200		- 200
During Construction & Maintenance	-		-
Subtotal	- 100	*(2)*	- 100
Private sector provider impacts			
Revenue	28,200		28,200
Operating costs	- 57,700		- 57,700
Investment costs	- 5,800		- 5,800
Grant/subsidy	35,300		35,300
Subtotal	-	*(3)*	-
Other business impacts			
Developer contributions	-	*(4)*	-
NET BUSINESS IMPACT	- 100	*(5) = (2) + (3) + (4)*	

TOTAL		
Present Value of Transport Economic Efficiency Benefits (TEE)	24,600	*(6) = (1a) + (1b) + (5)*

Notes: Benefits appear as positive numbers, while costs appear as negative numbers.

All entries are discounted present values, in 2010 prices and values

B.2. Public Accounts (PA) Tables

B.2.1. Option 1: PA Table

	ALL MODES		ROAD	BUS and COACH
Local Government Funding	TOTAL		INFRASTRUCTURE	
Revenue	-		-	
Operating Costs	4,700		4,700	
Investment Costs	37,800		37,800	
Developer and Other Contributions	-		-	
Grant/Subsidy Payments	-		-	-
NET IMPACT	42,500	*(7)*	42,500	
Central Government Funding: Transport				
Revenue	-		-	
Operating costs	-		-	
Investment Costs	-		-	
Developer and Other Contributions	-		-	-
Grant/Subsidy Payments	-		-	-
NET IMPACT	-	*(8)*	-	-
Central Government Funding: Non-Transport				
Indirect Tax Revenues	6,800	*(9)*		6,800
TOTALS				
Broad Transport Budget	42,500	*(10) = (7) + (8)*		
Wider Public Finances	6,800	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as
All entries are discounted present values in 2010 prices and values.

B.2.2. Option 2: PA Table

	ALL MODES		ROAD	BUS and COACH
Local Government Funding	**TOTAL**		**INFRASTRUCTURE**	
Revenue	-		-	
Operating Costs	10,800		10,800	
Investment Costs	84,400		84,400	
Developer and Other Contributions	-		-	
Grant/Subsidy Payments	14,000		-	14,000
NET IMPACT	109,200	*(7)*	109,200	
Central Government Funding: Transport				
Revenue	-		-	
Operating costs	-		-	
Investment Costs	-		-	
Developer and Other Contributions	-		-	-
Grant/Subsidy Payments	-		-	-
NET IMPACT	-	*(8)*	-	-
Central Government Funding: Non-Transport				
Indirect Tax Revenues	7,800	*(9)*		7,800
TOTALS				
Broad Transport Budget	109,200	*(10) = (7) + (8)*		
Wider Public Finances	7,800	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.

All entries are discounted present values in 2010 prices and values.

B.2.3. Option 3: PA Table

	ALL MODES		ROAD	BUS and COACH
Local Government Funding	**TOTAL**		**INFRASTRUCTURE**	
Revenue	-		-	
Operating Costs	19,400		19,400	
Investment Costs	169,800		169,800	
Developer and Other Contributions	-		-	
Grant/Subsidy Payments	18,700		-	18,700
NET IMPACT	207,800	*(7)*	207,800	
Central Government Funding: Transport				
Revenue	-		-	
Operating costs	-		-	
Investment Costs	-		-	
Developer and Other Contributions	-		-	-
Grant/Subsidy Payments	-		-	-
NET IMPACT	-	*(8)*	-	-
Central Government Funding: Non-Transport				
Indirect Tax Revenues	6,300	*(9)*		6,300
TOTALS				
Broad Transport Budget	207,800	*(10) = (7) + (8)*		
Wider Public Finances	6,300	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.

All entries are discounted present values in 2010 prices and values.

B.2.4. Option 4: PA Table

	ALL MODES		ROAD	BUS and COACH
Local Government Funding	**TOTAL**		**INFRASTRUCTURE**	
Revenue	-		-	
Operating Costs	12,300		12,300	
Investment Costs	97,300		97,300	
Developer and Other Contributions	-		-	
Grant/Subsidy Payments	39,700		-	39,700
NET IMPACT	149,300	*(7)*	149,300	
Central Government Funding: Transport				
Revenue	-		-	
Operating costs	-		-	
Investment Costs	-		-	
Developer and Other Contributions	-		-	-
Grant/Subsidy Payments	-		-	-
NET IMPACT	-	*(8)*	-	-
Central Government Funding: Non-Transport				
Indirect Tax Revenues	3,700	*(9)*		3,700
TOTALS				
Broad Transport Budget	149,300	*(10) = (7) + (8)*		
Wider Public Finances	3,700	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.

All entries are discounted present values in 2010 prices and values.

B.2.5. Option 5: PA Table

	ALL MODES		ROAD	BUS and COACH
Local Government Funding	**TOTAL**		**INFRASTRUCTURE**	
Revenue	-		-	
Operating Costs	14,100		14,100	
Investment Costs	118,100		118,100	
Developer and Other Contributions	-		-	
Grant/Subsidy Payments	35,300		-	35,300
NET IMPACT	167,400	*(7)*	167,400	
Central Government Funding: Transport				
Revenue	-		-	
Operating costs	-		-	
Investment Costs	-		-	
Developer and Other Contributions	-		-	-
Grant/Subsidy Payments	-		-	-
NET IMPACT	-	*(8)*	-	-
Central Government Funding: Non-Transport				
Indirect Tax Revenues	4,300	*(9)*		4,300
TOTALS				
Broad Transport Budget	167,400	*(10) = (7) + (8)*		
Wider Public Finances	4,300	*(11) = (9)*		

Notes: Costs appear as positive numbers, while revenues and 'Developer and Other Contributions' appear as negative numbers.

All entries are discounted present values in 2010 prices and values.

B.3. Analysis of Monetised Costs and Benefits (AMCB) Tables

B.3.1. Option 1: AMCB Table

			PT
Noise	£ 52	*(12)*	£ 52
Local Air Quality	-£ 98	*(13)*	-£ 98
Greenhouse Gases	-£ 6,400	*(14)*	-£ 6,400
Journey Quality	£ -	*(15)*	
Physical Activity	£ -	*(16)*	
Accidents	£ -	*(17)*	
Economic Efficiency: Consumer Users (Commuting)	£ 11,400	*(1a)*	£ 11,400
Economic Efficiency: Consumer Users (Other)	£ 41,100	*(1b)*	£ 41,100
Economic Efficiency: Business Users and Providers	£ 4,400	*(5)*	£ 4,400
Wider Public Finances (Indirect Taxation Revenues)	-£ 6,800	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*	-£ 6,800
Present Value of Benefits (see notes) (PVB)	£ 43,600	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*	£ 43,600
Broad Transport Budget	£ 42,500	*(10)*	£ 42,500
Present Value of Costs (see notes) (PVC)	£ 42,500	*(PVC) = (10)*	£ 42,500
OVERALL IMPACTS			
Net Present Value (NPV)	£ 1,100	NPV=PVB-PVC	£ 1,100
Benefit to Cost Ratio (BCR)	1.03	BCR=PVB/PVC	

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

B.3.2. Option 2: AMCB Table

			PT
Noise	-£ 1,600	*(12)*	-£ 1,600
Local Air Quality	-£ 391	*(13)*	-£ 391
Greenhouse Gases	-£ 7,000	*(14)*	-£ 7,000
Journey Quality	£ -	*(15)*	
Physical Activity	£ -	*(16)*	
Accidents	£ -	*(17)*	
Economic Efficiency: Consumer Users (Commuting)	£ 12,100	*(1a)*	£ 12,100
Economic Efficiency: Consumer Users (Other)	£ 56,400	*(1b)*	£ 56,400
Economic Efficiency: Business Users and Providers	£ 600	*(5)*	£ 600
Wider Public Finances (Indirect Taxation Revenues)	-£ 7,800	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*	-£ 7,800
Present Value of Benefits (see notes) (PVB)	£ 52,300	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*	£ 52,300
Broad Transport Budget	£ 109,200	*(10)*	£ 109,200
Present Value of Costs (see notes) (PVC)	£ 109,200	*(PVC) = (10)*	£ 109,200
OVERALL IMPACTS			
Net Present Value (NPV)	-£ 56,900	NPV=PVB-PVC	-£ 56,900
Benefit to Cost Ratio (BCR)	0.48	BCR=PVB/PVC	

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

B.3.3. Option 3: AMCB Table

Noise	-£ 2,100	*(12)*	-£ 2,100
Local Air Quality	-£ 400	*(13)*	-£ 400
Greenhouse Gases	-£ 8,700	*(14)*	-£ 8,700
Journey Quality	£ -	*(15)*	
Physical Activity	£ -	*(16)*	
Accidents	£ -	*(17)*	
Economic Efficiency: Consumer Users (Commuting)	£ 12,500	*(1a)*	£ 12,500
Economic Efficiency: Consumer Users (Other)	£ 44,700	*(1b)*	£ 44,700
Economic Efficiency: Business Users and Providers	£ 300	*(5)*	£ 300
Wider Public Finances (Indirect Taxation Revenues)	-£ 6,300	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*	-£ 6,300
Present Value of Benefits (see notes) (PVB)	£ 40,100	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*	£ 40,100
Broad Transport Budget	£ 207,800	*(10)*	£ 207,800
Present Value of Costs (see notes) (PVC)	£ 207,800	*(PVC) = (10)*	£ 207,800
OVERALL IMPACTS			
Net Present Value (NPV)	-£ 167,800	NPV=PVB-PVC	-£ 167,800
Benefit to Cost Ratio (BCR)	0.19	BCR=PVB/PVC	

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

B.3.4. Option 4: AMCB Table

			PT
Noise	-£ 3,100	*(12)*	-£ 3,100
Local Air Quality	-£ 477	*(13)*	-£ 477
Greenhouse Gases	-£ 8,600	*(14)*	-£ 8,600
Journey Quality	£ -	*(15)*	
Physical Activity	£ -	*(16)*	
Accidents	£ -	*(17)*	
Economic Efficiency: Consumer Users (Commuting)	£ 4,500	*(1a)*	£ 4,500
Economic Efficiency: Consumer Users (Other)	£ 17,800	*(1b)*	£ 17,800
Economic Efficiency: Business Users and Providers	-£ 200	*(5)*	-£ 200
Wider Public Finances (Indirect Taxation Revenues)	-£ 3,700	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*	-£ 3,700
Present Value of Benefits (see notes) (PVB)	£ 6,200	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*	£ 6,200
Broad Transport Budget	£ 149,300	*(10)*	£ 149,300
Present Value of Costs (see notes) (PVC)	£ 149,300	*(PVC) = (10)*	£ 149,300
OVERALL IMPACTS			
Net Present Value (NPV)	-£ 143,100	NPV=PVB-PVC	-£ 143,100
Benefit to Cost Ratio (BCR)	0.04	BCR=PVB/PVC	

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

B.3.5. Option 5: AMCB Table

Analysis of Monetised Costs and Benefits

			PT
Noise	-£ 3,500	*(12)*	-£ 3,500
Local Air Quality	-£ 365	*(13)*	-£ 365
Greenhouse Gases	-£ 8,300	*(14)*	-£ 8,300
Journey Quality	£ -	*(15)*	
Physical Activity	£ -	*(16)*	
Accidents	£ -	*(17)*	
Economic Efficiency: Consumer Users (Commuting)	£ 4,800	*(1a)*	£ 4,800
Economic Efficiency: Consumer Users (Other)	£ 19,900	*(1b)*	£ 19,900
Economic Efficiency: Business Users and Providers	-£ 100	*(5)*	-£ 100
Wider Public Finances (Indirect Taxation Revenues)	-£ 4,300	*- (11) - sign changed from PA table, as PA table represents costs, not benefits*	-£ 4,300
Present Value of Benefits (see notes) (PVB)	£ 8,100	*(PVB) = (12) + (13) + (14) + (15) + (16) + (17) + (1a) + (1b) + (5) - (11)*	£ 8,100
Broad Transport Budget	£ 167,400	*(10)*	£ 167,400
Present Value of Costs (see notes) (PVC)	£ 167,400	*(PVC) = (10)*	£ 167,400
OVERALL IMPACTS			
Net Present Value (NPV)	-£ 159,300	NPV=PVB-PVC	-£ 159,300
Benefit to Cost Ratio (BCR)	0.05	BCR=PVB/PVC	

Note : This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals, together with some where monetisation is in prospect. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

Appendix C. Appraisal Summary Tables

This Appendix presents the Appraisal Summary Tables for the Cambourne to Cambridge Better Bus Journeys Scheme (Options 1 to 5).

11.2. Option 1

Appraisal Summary Table

Date produced:	23/09/2016

Contact: Cambridgeshire County Council

Name of scheme:	Camborne to Cambridge Better Bus Journeys: Strategic Outline Business Case – Option 1
Description of scheme:	Option 1 - Improvement to bus services, which will run along existing roads with no infrastructure improvements, such as offline busways.

Name	Public Transport Projects, Cambridgeshire County Council
Organisation	Cambridgeshire County Council
Role	Project Sponsor

Impacts (PT impacts only. All monetary values reported in £000s.)		**Summary of key impacts**	**Assessment** – **Quantitative**	**Qualitative**	**Monetary** £000s (NPV)	**Distributional** 7-pt scale/ vulnerable grp
Economy	Business users & transport providers	The total quantified impact to business users and transport providers is £4.4m. This is made up of Journey time benefits for business users of £0.9m,private sector provider impacts of £3.8m and user charges of -£0.2m.	**Value of journey time changes(£000s)**: 870 **Net journey time changes (£000s)**: 0 to 2min: 100; 2 to 5min: 220; > 5min: 550		4,400	
	Reliability impact on Business users	A modelled assessment of reliability impacts has not been undertaken	Not assessed quantitatively for this Strategic Outline Business Case as outside of scope given the high-level of design development			
	Regeneration	Not assessed for this outline business case as region not considered a regeneration area				
	Wider Impacts	Wider impacts of £8.2m comprise agglomeration benefits of £7.8m; tax revenues from labour market impacts of £0.3m and imperfect competition impacts of -£70k			8,200	
Environmental	Noise	Changes in noise are due to redistribution of traffic and the additional buses. Summary values are indicative and based on rounded figures. Indications that impacts are expected to be no worse than 'Minor Adverse impact' as this Option is mainly online.	Households experiencing increased daytime noise in forecast year: 88 Households experiencing reduced daytime noise in forecast year: 146	Not used for noise (ref: Unit A3, para 2.4.2)	52	Neutral
	Air Quality	Overall deterioration in local air quality with the scheme option due to the increase in bus traffic on existing routes. Regional emission increase as a result of traffic growth and overall increase in vehicle kilometres. The scheme option does not result in any exceedances of annual average UK AQS objective and EU limit value thresholds.	` PM10: +18 NO2: +743 Emissions NOx (60 year period): +54 tonnes Value of change in PM10 concentration: NPV -£0.056m Value of change in NOx emissions: NPV -£0.042m Total value of change in air quality: NPV -£0.098m		- 98	Slight Adverse
	Greenhouse gases	There is an expected increase in CO2 emissions with this option over the 60 year appraisal period. The non-traded carbon dioxide emissions in 2021 = +0.0029 MtCO2e indicating an increase in CO2 emissions in opening year. Change in emissions in MtCO2e for 2021-2022 = +0.0057, Change for 2023-2027 = +0.0132	Change in non-traded carbon over 60y (CO2e): 139 kT Change in traded carbon over 60y (CO2e): N/A	N/A	- 6,400	
	Landscape	This option is expected to result in a slight adverse effect on the landscape due to the fact that although not very visually intrusive to new receptors and landscape features, it may increase the prominence of the A1303 impact on views, affect the setting of areas of recognised landscape quality in the form of the American Military Cemetery and Madingley Hall Registered Parks and Gardens and result in the potential loss of trees with tree preservation orders.		Slight adverse	-	
	Townscape	Not assessed at this stage of the design process. Subject to assessment as part of the advanced design development and business case process.		Not Assessed	-	
	Historic Environment	This option may have a neutral effect on the historic environment. It may result in the loss of archaeological remains in any areas of new land take, but may not affect the fabric or setting of other historic environment assets to such an extent that significance may be lost.		Neutral	-	
	Biodiversity	This route may have a large adverse impact on Madingley Wood SSSI. It is considered that standard mitigation measures could potentially be incorporated into the scheme design and programme to ensure only a slight adverse impact, however until confirmation, large adverse impact is assumed. The scheme also has the potential to have a slight adverse impact on other sites.		Large adverse	-	
	Water Environment	Impacts to principal aquifer, Madingley Wood (changes in drainage, water levels, tables and water utilisation) and surface watercourse. The additional impermeable area caused by the Park & Ride site may need to be mitigated so as not to increase the risk of surface water flooding and potential pollution runoff. Spillage risk could change.		Neutral	-	
Social	Commuting and Other users	The combined quantified impact to commuting and other users from this option is £52.5m. This is made up of Journey time benefits for commuting and other users of £51.4m (commuting journey time benefits of £11.2m and other user time benefits of £40.2m) and combined user charges of £1.1m (Commuting: £0.2m, Other: £0.9m)	**Value of journey time changes(£000s)**: 51,400 **Net journey time changes (£000s)**: 0 to 2min: 4,900; 2 to 5min: 4,800; > 5min: 41,700		52,500	Moderate Beneficial
	Reliability impact on Commuting and Other users	A modelled assessment of reliability benefits has not been undertaken				
	Physical activity	Options with the potential to generate high mode shift will have a higher impact on physical activity as more people would walk or cycle to a bus stop. This option makes no specific additional provision for cyclists. A modelled assessment has not been undertaken.				
	Journey quality	Options that provide high quality public transport are likely to have a better journey quality. It is expected that schemes with greater segregation will have the best opportunity to positively benefit journey quality. This option does not provide segregation for bus services. A modelled assessment has not been undertaken.				

	Accidents	Accident analysis shows only minor changes in the cost of accidents for this option. Accident benefits of this option are assessed to be positive though not substantial. Accident data has not been considered in the BCR calculations.				
	Security	An assessment of security has not been undertaken at this stage of design and business case development				
	Access to services	Improvements in terms of accessibility to the population require ensuring services, stations and information materials are accessible for all users. The specific accessibility impacts of this option at this stage of design development have been a assessed as moderate beneficial.		Slight		Slight Beneficial
	Affordability	All quintiles experience a benefit, and the least deprived quintiles experience a proportion of benefits in line with their proportion of the population.				Moderate beneficial
	Severance	Neutral due to running on the existing on-line route		Neutral		Neutral
	Option and non-use values	An assessment of option and non-use values has not been undertaken at this stage of design and business case development				
Public Accou	Cost to Broad Transport Budget	-			42,500	
	Indirect Tax Revenues	-	Central Government Funding = Wider Public Finances		- 6,800	

11.3. Option 2

Appraisal Summary Table

Date produced:	23/09/2016

Contact: Cambridgeshire County Council	
Name	Public Transport Projects, Cambridgeshire County Council
Organisation	Cambridgeshire County Council
Role	Project Sponsor

Name of scheme:	Camborne to Cambridge Better Bus Journeys: Strategic Outline Business Case – Option 2
Description of scheme:	Option 2 - Mixed online and offline HQPT provision for the A428 Corridor.

Impacts PT impacts only. All monetary values reported in £000s.		**Summary of key impacts**	**Assessment** **Quantitative**	**Qualitative**	**Monetary** **£000s (NPV)**	**Distributional** **7-pt scale/ vulnerable grp**
Economy	Business users & transport providers	The total quantified impact to business users is £0.6m. This is made up of journey time benefits to business users of £0.8m, user charges of -£0.2m, revenue of £52.2m Opex of -£60.5m, private sector investment of -£5.7m and a public sector subsidy of £14m.	**Value of journey time changes(£000s)** 800 **Net journey time changes (£000s)** 0 to 2min: - / 2 to 5min: 200 / > 5min: 600		600	
	Reliability impact on Business users	It could be expected that schemes with greater segregation could provided higher reliability for business users. As a scheme with some segregation, it is likely that this option will perform better than Option 1, but worse than Option 3.	Not assessed quantitatively for this Strategic Outline Business Case case as outside of scope given the high-level of design development			
	Regeneration	Not assessed for this outline business case as region not considered a regeneration area				
	Wider Impacts	Wider impacts of £1.5m comprise agglomeration benefits of £2.1m; tax revenues from labour market impacts of -£0.7m and imperfect competition impacts of £60k			1,500	
Environmental	Noise	Changes in noise are due to redistribution of traffic and the additional buses. New bus routes mean buses passing closer to households that were previously exposed to low levels of noise. Summary values are indicative and based on rounded figures. Indications that impacts are expected to be no worse than 'Moderate Adverse impact' near online sections, and as much as 'Major Adverse impact' near offline sections.	Households experiencing increased daytime noise in forecast year: 469 Households experiencing reduced daytime noise in forecast year: 147	Not used for noise (ref: Unit A3, para 2.4.2)	- 1,600	Neutral
	Air Quality	Overall deterioration in local air quality with the scheme option due to the increase in bus traffic on existing and new offline routes. Regional emission increase as a result of traffic growth and overall increase in vehicle kilometres. The scheme option does not result in any exceedances of annual average UK AQS objective and EU limit value thresholds.	**Assessment Score (2021)** PM10: +102 NO2: +1450 Emissions NOx (60 year period): +98 tonnes Value of change in PM10 concentration: NPV -£0.314m Value of change in NOx emissions: NPV -£0.076m Total value of change in air quality: NPV -£0.391m		- 391	Slight Adverse
	Greenhouse gases	Overall increase in CO2 emissions with scheme option over 60 year appraisal period. Calculated using non-TUBA method. The non-traded carbon dioxide emissions in 2021 = +0.0039 MtCO2e indicating an increase in CO2 emissions in opening year. Change in emissions in MtCO2e for 2021-2022 = +0.0077, Change for 2023-2027 = +0.0166	Change in non-traded carbon over 60y (CO2e): 154 kT Change in traded carbon over 60y (CO2e): N/A	N/A	- 7,000	
	Landscape	On the basis of the information and level of study undertaken at this stage, the Scheme is judged to result in a slight to moderate adverse effect on the landscape. This is due to the fact that: • It cuts across a section of public open space west of Cambourne • It may result in some visual intrusion on the Grade I Listed American Military Cemetary • Some TPO's may be lost along the A3103 in the western side of Cambridge.	N/A	Slight to Moderate adverse	N/A	
	Townscape	N/A	N/A	N/A	N/A	
	Historic Environment	This option may have a slight adverse effect on historic environment assets, resulting from the loss of possible archaeological remains of low value and their context, but where suitable mitigation could be carried out to provide better understanding of these assets. The new lanes across the airfield and north of the American Cemetery may diminish the form and character of the current historic landscape to a minor degree if following current pathways and boundaries as proposed, but may not affect appreciation and understanding of the historic environment significantly, or lead to the loss of any significance of the settings of valuable historic environment assets.	N/A	Slight adverse	N/A	
	Biodiversity	This route may have a large adverse impact on Eversden and Wimpole Woods SAC and Madingley Wood SSSI. It is considered that after a full suite of surveys impacts of the SAC may be reduced if barbastelle are not using the route for flight line(s), however for now it is assumed that barbastelle flight lines could be affected and the SSSI could be impacted by the adjacent works. The scheme also has the potential to have a slight adverse impact on four designated sites: Madingley Slip Road RSV, CWS, Bird Sanctuary CiWS, Conduit Head CiWS and Scrub East of M11 Verge CiWS. The scheme may also have moderate adverse impacts on 19 drains / ditches (6 of which will be directly crossed by the route where no road network currently exists) and 4 woodland habitats that will be intersected by the route. It also may have slight adverse impacts on Callow Brook, 18 ponds within 50m of the route, 14 intersected hedgerows and large areas of pasture / arable field. Protected species along the route that may also be moderately affected include: great crested newts, otter, water vole, badger, reptiles, bats, birds, hazel dormouse and other mammals including harvest mouse, brown hare and hedgehog (though it should be noted that at this stage of the assessment these species have not been confirmed as present). It is considered that standard mitigation measures for these habitats and species are feasible and could be incorporated into the scheme design and programme. Mitigation would aim to avoid impacts where possible. Where avoidance is not possible, mitigation to reduce the impacts, and compensation to	N/A	Large adverse	Slight to Moderate adverse	

		address residual effects may be implemented as part of the works. At this stage it is not possible to confirm whether all potential impacts could be mitigated for, resulting in no residual effects, considering that just under half of the route is being situated in a rural landscape where no road network is currently present. Further ecological assessment may be required to determine specific impacts on habitats and species and the mitigation required to undertake the works.				
	Water Environment	• Potentially moderate significant adverse impacts including pollution of a principal aquifer during construction and operational should discharge from the option not be mitigated • The route runs adjacent to the Madingley SSSI • The additional impermeable area caused by the Park & Ride site may need to be mitigated so as not to increase the risk of surface water flooding and potential pollution runoff, the implementation of attenuation and pollution prevention measures in the form of SuDs may be required to mitigate the impacts. • Spillage risk could change given the road geometry and character is being altered. • Six additional/new crossing of watercourses	N/A	Slight adverse	N/A	
Social	Commuting and Other users	The combined quantified impact to commuting and other users from this option is £68.5m. This is made up of Journey time benefits for commuting of £12.2m and other user time benefits of £55.3m, along with user charges for commuting of -£0.04m and Other of £1.2m)	**Value of journey time changes(£000s)** 67,400 **Net journey time changes (£000s)** 0 to 2min: 2,600 / 2 to 5min: 4,200 / > 5min: 60,500		68,500	Moderate Beneficial
	Reliability impact on Commuting and Other users	A modelled assessment of reliability benefits has not been undertaken				
	Physical activity	Options with the potential to generate high mode shift will have a higher impact on physical activity as more people would walk or cycle to a bus stop. This option makes provision for cyclists on any offline section. A modelled assessment has not been undertaken.				
	Journey quality	Options that provide high quality public transport are likely to have a better journey quality. It is expected that schemes with greater segregation will have the best opportunity to positively benefit journey quality. This option does provide some segregation for bus services. A modelled assessment has not been undertaken.				
	Accidents	Accident analysis shows only minor changes in the cost of accidents for this option. Accident benefits of this option are assessed to be positive though not substantial. Accident data has not been considered in the BCR calculations.				
	Security	An assessment of security has not been undertaken at this stage of design and business case development				
	Access to services	Improvements in terms of accessibility to the population require ensuring services, stations and information materials are accessible for all users. The specific accessibility impacts of this option at this stage of design development have been a assessed as slight beneficial		Slight Beneficial		Slight Beneficial
	Affordability	All quintiles experience a benefit, and the least deprived quintiles experience a proportion of benefits in line with their proportion of the population.				Moderate beneficial
	Severance	Slight adverse - due to the possibility of it severing PRoWs near Bourn Airfield, and public footpaths and a bridleway near Madingley.		Slight adverse		Slight Adverse
	Option and non-use values	An assessment of option and non-use values has not been undertaken at this stage of design and business case development				
Public Accounts	Cost to Broad Transport Budget	-	Out of the £109.2m approximately £14m comes from the local government subsidy.		109,200	
	Indirect Tax Revenues	-	Central Government Funding = Wider Public Finances		- 7,800	

11.4. Option 3

Appraisal Summary Table

Date produced:	23/09/2016

Contact: Cambridgeshire County Council

Name	Public Transport Projects, Cambridgeshire County Council
Organisation	Cambridgeshire County Council
Role	Project Sponsor

Name of scheme:	Camborne to Cambridge Better Bus Journeys: Strategic Outline Business Case – Option 3
Description of scheme:	Option 3 - Fully offline HQPT provision for the A428 Corridor.

Impacts PT impacts only. All monetary values reported in £000s.		**Summary of key impacts**	**Assessment** **Quantitative**	**Qualitative**	**Monetary** **£000s (NPV)**	**Distributional** **7-pt scale/ vulnerable grp**
Economy	Business users & transport providers	The total quantified impact to business users is £0.3m. This is made up of journey time benefits to business users of £0.5m, user charges of -£0.2m, revenue of £42m Opex of -£55.3m, private sector investment of -£5.3m and a public sector subsidy of £18.7m.	**Value of journey time changes(£000s)** 500 **Net journey time changes (£000s)** 0 to 2min: 100 / 2 to 5min: 100 / > 5min: 300		300	
	Reliability impact on Business users	It could be expected that schemes with greater segregation could provided higher reliability for business users. As the scheme with a fully offline route, it is likely that this option will perform better than all other options.	Not assessed quantitatively for this Strategic Outline Business Case as outside of scope given the high-level of design development			
	Regeneration	Not assessed for this outline business case as region not considered a regeneration area			1,400	
	Wider Impacts	Wider impacts of £1.4m comprise agglomeration benefits of £2.9m; tax revenues from labour market impacts of -£1.5m and imperfect competition impacts of £30k				
Environmental	Noise	Changes in noise are due to redistribution of traffic and the additional buses. New bus routes mean buses passing closer to households that were previously exposed to low levels of noise. Summary values are indicative and based on rounded figures. Indications that impacts are expected to be no worse than 'Moderate Adverse impact' near online sections, and as much as 'Major Adverse impact' near offline sections.	Households experiencing increased daytime noise in forecast year: 845 Households experiencing reduced daytime noise in forecast year: 377	Not used for noise (ref: Unit A3, para 2.4.2)	- 2,100	Slight Adverse
	Air Quality	Overall deterioration in local air quality with the scheme option due to the increase in bus traffic on existing and new offline routes. Regional emission increase as a result of traffic growth and overall increase in vehicle kilometres. The scheme option does not result in any exceedances of annual average UK AQS objective and EU limit value thresholds.	**Assessment Score (2021)** PM_{10}: +105 NO2: +1122 Emissions NOx (60 year period): +100 tonnes Value of change in PM10 concentration: NPV -£0.323m Value of change in NOx emissions: NPV -£0.077m Total value of change in air quality: NPV -£0.400m	N/A	- 400	Slight Adverse
	Greenhouse gases	Overall increase in CO2 emissions with scheme option over 60 year appraisal period. Calculated using non-TUBA method. The non-traded carbon dioxide emissions in 2021 = +0.0042 MtCO2e indicating an increase in CO2 emissions in opening year. Change in emissions in MtCO2e for 2021-2022 = +0.0083, Change for 2023-2027 = +0.0187	Change in non-traded carbon over 60y (CO2e): 190 kT Change in traded carbon over 60y (CO2e): N/A	N/A	- 8,700	
	Landscape	On the basis of the information and level of study undertaken at this stage, the Scheme is judged to result in a moderate adverse effect on the landscape. This is due to the fact that: • It cuts across a section of public open space west of Cambourne • Passes through a traditional orchard and nearby the Conservation Area at Coton • Transects the agricultural landscape and its existing field pattern	N/A	Moderate adverse	N/A	
	Townscape	N/A	N/A	N/A	N/A	
	Historic Environment	This option may have a moderate adverse effect on the historic environment. The new lanes south of Hardwick and north of Coton may be intrusive in the rural setting of the villages and at odds with the pattern and form of the historic landscape. There may also be a loss of possible archaeological remains of low value and their context, but suitable mitigation could be carried out to provide better understanding of these assets.	N/A	Moderate adverse	N/A	
	Biodiversity	This route may have a large adverse impact on Eversden and Wimpole Woods SAC. It is considered that after a full suite of surveys this impact may be reduced, however for now it is assumed that barbastelle flight lines could be affected. The scheme also has the potential to have a moderate adverse impact on Coton Path Hedgerow CWS, and slight adverse impact on four designated sites: Madingley Wood SSSI, Hedgerows East of M11 CWS, Bin Brook CiWS and Scrub East of M11 Verge CiWS. The scheme may also have moderate adverse impacts on 20 drains / ditches (5 of which will be directly crossed by the route where no road network currently exists) and 7 woodland habitats that will be intersected by the route. It also may have slight adverse impacts on Callow Brook, 15 ponds within 50m of the route, 27 intersected hedgerows and large areas of pasture / arable field. Protected species along the route that may also be moderately affected include: great crested newts, otter, water vole, badger, reptiles, bats, birds, hazel dormouse and other notable mammal species including harvest mouse, brown hare and hedgehog (though it should be noted that at this stage of the assessment these species have not been confirmed as present). It is considered that mitigation measures for these habitats and species may be feasible and could be incorporated into the scheme design and programme Mitigation would aim to avoid impacts where possible. Where avoidance is not possible, mitigation to reduce the impacts, and compensation to address residual effects may be implemented as part of the works. At this stage it is not possible to confirm whether all potential impacts could be mitigated for, resulting in no residual effects, considering that the majority of	N/A	Large adverse	N/A	

		the route is being situated in a rural landscape where no road network is currently present. Further ecological assessment may be required to determine specific impacts on habitats and species and the mitigation required to undertake the works.				
	Water Environment	• Potentially moderate significant adverse impacts including pollution of a principal aquifer during construction and operational should discharge from the option not be mitigated • The route runs adjacent to the Madingley SSSI • The additional impermeable area caused by the Park & Ride site may need to be mitigated so as not to increase the risk of surface water flooding and potential pollution runoff, the implementation of attenuation and pollution prevention measures in the form of SuDs may be required to mitigate the impacts. • Spillage risk could change given the road geometry and character is being altered. • 2 new WFD crossings - on same WFD river - Bin Brook • 12 additional/ new crossings	N/A	Slight adverse	N/A	
Social	Commuting and Other users	The total quantified impact is £57.3m - This is made up of journey time benefits commuters of £12.9m and other user time benefits of 45.6m, along with user charges for commuting of -£0.3m and other of -£0.9m.	**Value of journey time changes(£000s)** 58,500 **Net journey time changes (£000s)** 0 to 2min: 5,400 / 2 to 5min: 4,700 / > 5min: 48,400		57,300	Slight Beneficial
	Reliability impact on Commuting and Other users	A modelled assessment of reliability benefits has not been undertaken				
	Physical activity	Options with the potential to generate high mode shift will have a higher impact on physical activity as more people would walk or cycle to a bus stop. This option makes provision for cyclists throughout as it is considered to be a fully offline route. A modelled assessment has not been undertaken.				
	Journey quality	Options that provide high quality public transport are likely to have a better journey quality. It is expected that schemes with greater segregation will have the best opportunity to positively benefit journey quality. This option provides the highest level of segregation. A modelled assessment has not been undertaken.				
	Accidents	Accident analysis shows only very minor changes in the cost of accidents for this option. Accident benefits of this option are assessed to be slightly positive though not substantial. Accident data has not been considered in the BCR calculations.				
	Security	An assessment of security has not been undertaken at this stage of design and business case development				
	Access to services	Improvements in terms of accessibility to the population require ensuring services, stations and information materials are accessible for all users. The specific accessibility impacts of this option at this stage of design development have been a assessed as slight beneficial		Slight Beneficial		Slight Beneficial
	Affordability	The two most deprived quintiles experience a benefit, and least deprived quintiles experience a disbenefit, and in line with their proportion of the population.				Slight adverse
	Severance	Slight adverse - due to the possibility of it severing PRoWs near Bourn Airfield, and public footpaths and a bridleway in Caldecote, Hardwick and Coton.				Slight Adverse
	Option and non-use values	An assessment of option and non-use values has not been undertaken at this stage of design and business case development				
Public Accounts	Cost to Broad Transport Budget		Out of the £207.8m approximately £19m comes from the local government subsidy.		207,800	
	Indirect Tax Revenues		Central Government Funding = Wider Public Finances		- 6,300	

11.5. Option 4

Appraisal Summary Table

Date produced:	23/09/2016

Contact: Cambridgeshire County Council

Name of scheme:	Camborne to Cambridge Better Bus Journeys: Strategic Outline Business Case – Option 4
Description of scheme:	Option 4 – Mixed online and offline HQPT provision for the A428 Corridor.

Name	Public Transport Projects, Cambridgeshire County Council
Organisation	Cambridgeshire County Council
Role	Project Sponsor

Impacts PT impacts only. All monetary values reported in £000s.		**Summary of key impacts**	**Assessment**			
			Quantitative	**Qualitative**	**Monetary** £000s (NPV)	**Distributional** 7-pt scale/ vulnerable grp
Economy	Business users & transport providers	The total quantified impact to business users and transport providers is -£200k. This is made up of Journey time benefits for business users of £4k, user chargers of -£0.2m, revenue of £24.3m, OPEX of -£58.1m, fleet investment of -£5.8m, and a government subsidy of £39.7m.	**Value of journey time changes(£000s)** 4 **Net journey time changes (£000s)** 0 to 2min: 47 / 2 to 5min: 29 / > 5min: -72		- 200	
	Reliability impact on Business users		Not assessed quantitatively for this Strategic Outline Business Case as outside of scope given the high-level of design development			
	Regeneration					
	Wider Impacts	Wider impacts of -£2.6m comprise agglomeration benefits of -£3.6m; tax revenues from labour market impacts of £1m and imperfect competition impacts of -£20k.			- 2,600	
Environmental	Noise	Changes in noise are due to redistribution of traffic and the additional buses. New bus routes mean buses passing closer to households that were previously exposed to low levels of noise. Summary values are indicative and based on rounded figures. Indications that impacts are expected to be no worse than 'Moderate Adverse impact' near online sections, and as much as 'Major Adverse impact' near offline sections.	Households experiencing increased daytime noise in forecast year: 949 Households experiencing reduced daytime noise in forecast year: 326	Not used for noise (ref: Unit A3, para 2.4.2)	- 3,100	Slight Adverse
	Air Quality	Overall deterioration in local air quality with the scheme option due to the increase in bus traffic on existing and new offline routes. Regional emission increase as a result of traffic growth and overall increase in vehicle kilometres. The scheme option does not result in any exceedances of annual average UK AQS objective and EU limit value thresholds.	**Assessment Score (2021)** PM_{10}: +125 NO2: +1354 Emissions NOx (60 year period): +118 tonnes Value of change in PM10 concentration: NPV -£0.387m Value of change in NOx emissions: NPV -£0.089m Total value of change in air quality: NPV -£0.477m	N/A	- 477	Slight Adverse
	Greenhouse gases	Overall increase in CO2 emissions with scheme option over 60 year appraisal period. Calculated using non-TUBA method. The non-traded carbon dioxide emissions in 2021 = +0.0042 MtCO2e indicating an increase in CO2 emissions in opening year. Change in emissions in MtCO2e for 2021-2022 = +0.0082, Change for 2023-2027 = +0.0185	Change in non-traded carbon over 60y (CO2e): 187 kT Change in traded carbon over 60y (CO2e): N/A	N/A	- 8,600	
	Landscape	On the basis of the information and level of study undertaken at this stage, the Scheme is judged to result in a slight to moderate adverse effect on the landscape. This is due to the fact that: • It cuts across a section of public open space west of Cambourne • It may result in some visual intrusion on the Grade I Listed American Military Cemetary • Transects the agricultural landscape and its existing field pattern	N/A	Slight to Moderate adverse	N/A	
	Townscape	N/A	N/A	N/A	N/A	
	Historic Environment	This option may have a slight adverse effect on historic environment assets, resulting from the loss of possible archaeological remains of low value and their context, but where suitable mitigation could be carried out to provide better understanding of these assets. The new lanes across the airfield and north of the American Cemetery may diminish the form and character of the current historic landscape to a minor degree if following current pathways and boundaries as proposed, but may not affect appreciation and understanding of the historic environment significantly, or lead to the loss of any significance of the settings of valuable historic environment assets.	N/A	Slight adverse	N/A	
	Biodiversity	This route may have a large adverse impact on Eversden and Wimpole Woods SAC and Madingley Wood SSSI. It is considered that after a full suite of surveys impacts on the SAC may be reduced if barbastelle are not using the route for flight line(s), however for now it is assumed that barbastelle flight lines could be affected and the SSSI could be impacted by the adjacent works. The scheme also has the potential to have a moderate adverse impact on Coton Path Hedgerow CWS, and slight adverse impacts on four designated sites: Madingley Slip Road - RSV, CWS, Hedgerows East of M11 CWS, Bin Brook CiWS and Scrub East of M11 Verge CiWS. The scheme may have moderate adverse impacts on 19 drains / ditches (6 of which will be directly crossed by the route where no road network currently exists) and 5 woodland habitats that will be intersected by the route. It also may have slight adverse impacts on Callow Brook, 15 ponds within 50m of the route, 14 intersected hedgerows and large areas of pasture / arable field. Protected species along the route that may also be moderately affected include: great crested newts, otter, water vole, badger, reptiles, bats, birds, hazel dormouse and other notable mammal species including harvest mouse, brown hare	N/A	Large adverse	N/A	

		and hedgehog (though it should be noted that at this stage of the assessment these species have not been confirmed as present). It is considered that standard mitigation measures for these habitats and species are feasible and could be incorporated into the scheme design and programme. Mitigation would aim to avoid impacts where possible. Where avoidance is not possible, mitigation to reduce the impacts, and compensation to address residual effects may be implemented as part of the works. At this stage it is not possible to confirm whether all potential impacts could be mitigated for, resulting in no residual effects, considering that over half of the route being situated in a rural landscape where no road network is currently present. Further ecological assessment may be required to determine specific impacts on habitats and species and the mitigation required to undertake the works.				
	Water Environment	• Potentially moderate significant adverse impacts including pollution of a principal aquifer during construction and operational should discharge from the option not be mitigated • The route runs adjacent to the Madingley SSSI • The additional impermeable area caused by the Park & Ride site may need to be mitigated so as not to increase the risk of surface water flooding and potential pollution runoff, the implementation of attenuation and pollution prevention measures in the form of SuDs may be required to mitigate the impacts. • Spillage risk could change given the road geometry and character is being altered. • 1 new WFD crossing - Bin Brook • 10 additional/ new crossings of watercourses including two crossings of WFD assessed waterbodies.	N/A	Slight adverse	N/A	
Social	Commuting and Other users	The combined quantified impact to commuting and other users from this option is £22.3m. This is made up of Journey time benefits for commuting of £5m and other user time benefits of £18.6m, along with user charges for commuting of -£0.5m and Other of -£0.8m)	**Value of journey time changes(£000s)** 23,500 **Net journey time changes (£000s)** 0 to 2min: 3,200 / 2 to 5min: 3,200 / > 5min: 17,000		22,300	Moderate beneficial
	Reliability impact on Commuting and Other users	A modelled assessment of reliability benefits has not been undertaken				
	Physical activity	Options with the potential to generate high mode shift will have a higher impact on physical activity as more people would walk or cycle to a bus stop. This option makes provision for cyclists on any offline section. A modelled assessment has not been undertaken.				
	Journey quality	Options that provide high quality public transport are likely to have a better journey quality. It is expected that schemes with greater segregation will have the best opportunity to positively benefit journey quality. This option does provide some segregation for bus services. A modelled assessment has not been undertaken.				
	Accidents	Accident analysis shows only very minor changes in the cost of accidents for this option. Accident benefits of this option are assessed to be slightly positive though not substantial. Accident data has not been considered in the BCR calculations.				
	Security	An assessment of security has not been undertaken at this stage of design and business case development				
	Access to services	Improvements in terms of accessibility to the population require ensuring services, stations and information materials are accessible for all users. The specific accessibility impacts of this option at this stage of design development have been a assessed as slight beneficial		Slight beneficial		Slight Beneficial
	Affordability	The two most deprived quintiles experience a benefit, and least deprived quintiles experience a disbenefit, and in line with their proportion of the population.				Slight adverse
	Severance	Slight adverse - due to the possibility of it severing PRoWs near Bourn Airfield and a bridleway near Caldecote, Hardwick and Madingley.				Slight Adverse
	Option and non-use values	An assessment of option and non-use values has not been undertaken at this stage of design and business case development				
Public Accounts	Cost to Broad Transport Budget		Out of the £149.3m approximately £40m comes from the local government subsidy.		149,300	
	Indirect Tax Revenues		Central Government Funding = Wider Public Finances		- 3,700	

11.6. Option 5

Appraisal Summary Table

Date produced:	23/09/2016

Contact: Cambridgeshire County Council

Name	Public Transport Projects, Cambridgeshire County Council
Organisation	Cambridgeshire County Council
Role	Project Sponsor

Name of scheme:	Camborne to Cambridge Better Bus Journeys: Strategic Outline Business Case – Option 5
Description of scheme:	Option 5 – Mixed online and offline HQPT provision for the A428 Corridor.

Impacts (PT impacts only. All monetary values reported in £000s.)		**Summary of key impacts**	**Assessment** – **Quantitative**	**Qualitative**	**Monetary** £000s (NPV)	**Distributional** 7-pt scale/ vulnerable grp
Economy	Business users & transport providers	The total quantified impact to business users and transport providers is -£0.1m. This is made up of Journey time benefits for business users of £0.05m, user chargers of -£0.2m, revenue of £28.2m, OPEX of -£57.7m investment of -£5.8m, and a government subsidy of £35.3m.	**Value of journey time changes(£000s)** 51 **Net journey time changes (£000s)** 0 to 2min: 83 / 2 to 5min: 45 / > 5min: - 77		- 100	
	Reliability impact on Business users					
	Regeneration					
	Wider Impacts	Wider impacts of -£2.5m comprise agglomeration benefits of -£3m; tax revenues from labour market impacts of £0.5m and imperfect competition impacts of -£10k			-2,500	
Environmental	Noise	Changes in noise are due to redistribution of traffic and the additional buses. New bus routes mean buses passing closer to households that were previously exposed to low levels of noise. Summary values are indicative and based on rounded figures. Indications that impacts are expected to be no worse than 'Moderate Adverse impact' near online sections, and as much as 'Major Adverse impact' near offline sections.	Households experiencing increased daytime noise in forecast year: 949 Households experiencing reduced daytime noise in forecast year: 173	Not used for noise (ref: Unit A3, para 2.4.2)	- 3,500	Slight Adverse
	Air Quality	Overall deterioration in local air quality with the scheme option due to the increase in bus traffic on existing and new offline routes. Regional emission increase as a result of traffic growth and overall increase in vehicle kilometres. The scheme option does not result in any exceedances of annual average UK AQS objective and EU limit value thresholds.	**Assessment Score (2021)** PM_{10}: +89 NO2: +1538 Emissions NOx (60 year period): +117 tonnes Value of change in PM10 concentration: NPV -£0.276m Value of change in NOx emissions:NPV -£0.089m Total value of change in air quality: NPV -£0.365m	N/A	- 365	Slight Adverse
	Greenhouse gases	Overall increase in CO2 emissions with scheme option over 60 year appraisal period. Calculated using non-TUBA method. The non-traded carbon dioxide emissions in 2021 = +0.0041 MtCO2e indicating an increase in CO2 emissions in opening year. Change in emissions in MtCO2e for 2021-2022 = +0.0080, Change for 2023-2027 = +0.0181	Change in non-traded carbon over 60y (CO2e): 182 kT Change in traded carbon over 60y (CO2e): N/A	N/A	- 8,300	
	Landscape	On the basis of the information and level of study undertaken at this stage, the Scheme is judged to result in a moderate adverse effect on the landscape. This is due to the fact that: • It cuts across a section of public open space west of Cambourne • Passes through a traditional orchard and nearby the Conservation Area at Coton • Transects the agricultural landscape and its existing field pattern	N/A	Slight to Moderate adverse	N/A	
	Townscape	N/A	N/A	N/a	N/A	
	Historic Environment	This option may have a moderate adverse effect on the historic environment. The new lane north of Coton may be intrusive in the rural setting of the village and at odds with the pattern and form of the historic landscape. There may also be a loss of possible archaeological remains of low value and their context, but suitable mitigation could be carried out to provide better understanding of these assets.	N/A	Moderate adverse	N/A	
	Biodiversity	This route may have a large adverse impact on Eversden and Wimpole Woods SAC. It is considered that after a full suite of surveys this impact may be reduced, however for now it is assumed that barbastelle flight lines could be affected. The scheme also has the potential to have a moderate adverse impact on Coton Path Hedgerow CWS, and slight adverse impact on four designated sites: Madingley Wood SSSI, Madingley Slip Road - Roadside Verge (RSV), CWS, Hedgerows East of M11 CWs, Bin Brook CiWS and Scrub East of M11 Verge CiWS. The scheme may also have moderate adverse impacts on 17 drains / ditches (2 of which will be directly crossed by the route where no road network currently exists) and 5 woodland habitats that will be intersected by the route. It also may have slight adverse impacts on Callow Brook, 15 ponds within 50m of the route, 10 intersected hedgerows and large areas of pasture / arable field. Protected species along the route that may also be moderately affected include: great crested newts, otter, water vole, badger, reptiles, bats, birds, hazel dormouse and other notable mammal species including harvest mouse, brown hare and hedgehog (though it should be noted that at this stage of the assessment these species have not been confirmed as present). It is considered that standard mitigation measures for these habitats and species are feasible and could be	N/A	Large adverse	N/A	

		incorporated into the scheme design and programme. Mitigation would aim to avoid impacts where possible. Where avoidance is not possible, mitigation to reduce the impacts, and compensation to address residual effects may be implemented as part of the works. At this stage it is not possible to confirm whether all potential impacts could be mitigated for, resulting in no residual effects, considering that over half of the route being situated in a rural landscape where no road network is currently present. Further ecological assessment may be required to determine specific impacts on habitats and species and the mitigation required to undertake the works.				
	Water Environment	• Potentially moderate significant adverse impacts including pollution of a principal aquifer during construction and operational should discharge from the option not be mitigated • The route runs adjacent to the Madingley SSSI • The additional impermeable area caused by the Park & Ride site may need to be mitigated so as not to increase the risk of surface water flooding and potential pollution runoff, the implementation of attenuation and pollution prevention measures in the form of SuDs may be required to mitigate the impacts. • Spillage risk could change given the road geometry and character is being altered. • 1 new WFD crossing - Bin Brook • 8 additional/ new crossings	N/A	Slight adverse	N/A	
Social	Commuting and Other users	The combined quantified impact to commuting and other users from this option is £24.7m. This is made up of Journey time benefits for commuting of £5.3m and other user time benefits of £20.7m, along with user charges for commuting of -£0.5m and Other of -£0.8m)	**Value of journey time changes(£000s)** 26,000 **Net journey time changes (£000s)** 0 to 2min: 4,400 / 2 to 5min: 3,100 / > 5min: 18,500		24,700	Slight adverse
	Reliability impact on Commuting and Other users	A modelled assessment of reliability benefits has not been undertaken				
	Physical activity	Options with the potential to generate high mode shift will have a higher impact on physical activity as more people would walk or cycle to a bus stop. This option makes provision for cyclists on any offline section. A modelled assessment has not been undertaken.				
	Journey quality	Options that provide high quality public transport are likely to have a better journey quality. It is expected that schemes with greater segregation will have the best opportunity to positively benefit journey quality. This option does provide some segregation for bus services. A modelled assessment has not been undertaken.				
	Accidents	Accident analysis shows only minor changes in the cost of accidents for this option. Accident benefits of this option are assessed to be very slightly negative though not substantial. Accident data has not been considered in the BCR calculations.				
	Security	An assessment of security has not been undertaken at this stage of design and business case development				
	Access to services	Improvements in terms of accessibility to the population require ensuring services, stations and information materials are accessible for all users. The specific accessibility impacts of this option at this stage of design development have been a assessed as slight beneficial		Slight beneficial		Slight Beneficial
	Affordability	The two most deprived quintiles experience a benefit, and least deprived quintiles experience a disbenefit, and in line with their proportion of the population.				Slight adverse
	Severance	Slight adverse - due to the possibility of it severing PRoWs near Bourn Airfield and public footpaths in Coton and a small bridleway route in Coton.				Slight Adverse
	Option and non-use values	An assessment of option and non-use values has not been undertaken at this stage of design and business case development				
Public Accounts	Cost to Broad Transport Budget		Out of the £167.4m approximately £35.3m comes from the local government subsidy.		167,400	
	Indirect Tax Revenues		Central Government Funding = Wider Public Finances		- 4,300	

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