Cambourne to Cambridge: In-Highway Proposals for High Quality Public Transport Scheme

Produced for Cambridge Past, Present & Future
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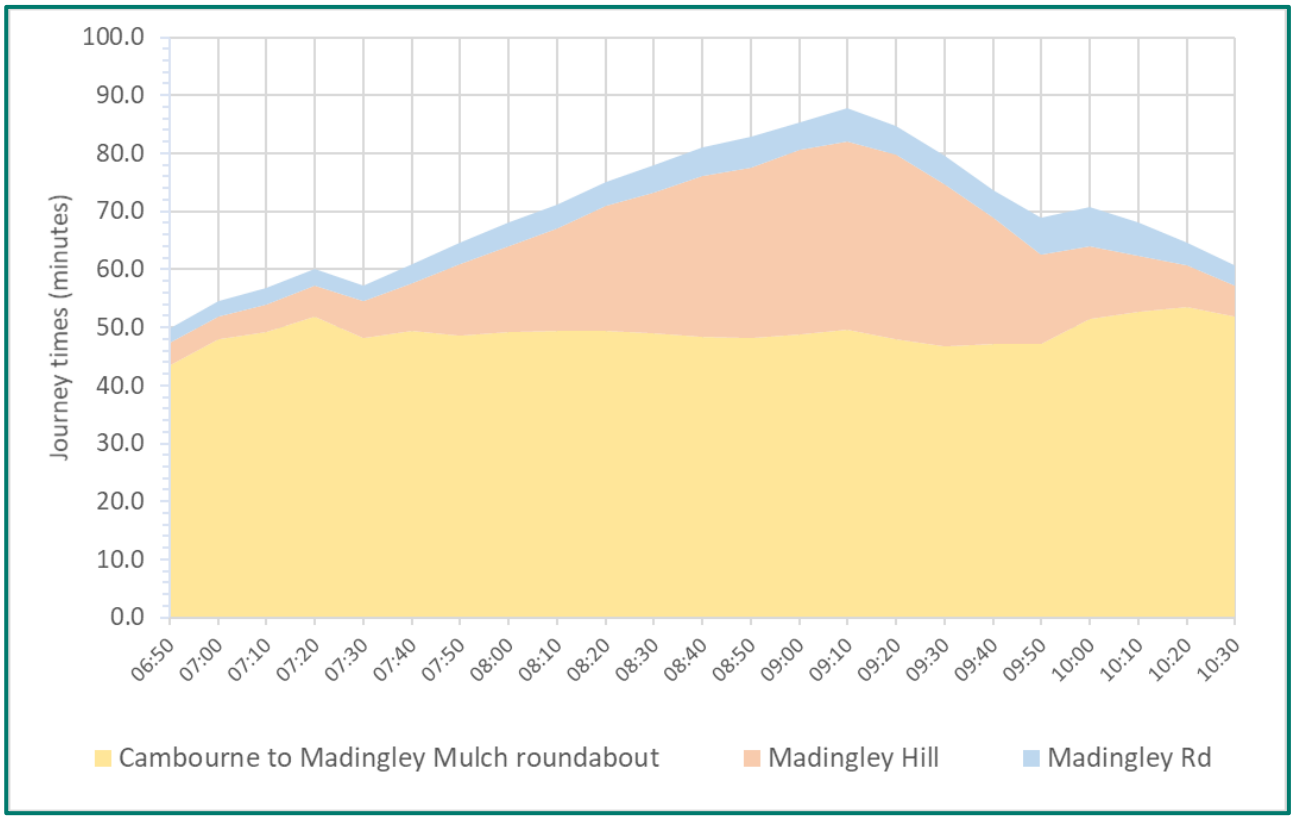

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Executive Summary

There remain serious flaws with the business case for the Greater Cambridge Partnership Cambourne–Cambridge busway, and significant uncertainties with other transport schemes that will affect the area to be served by the busway. Most notably, East West Railway, which is planned to run via a station at Cambourne, will abstract a significant portion of forecast users of the busway; and there is, as yet, no technical nor detailed geographical specification for the Cambridgeshire Autonomous Metro network, with which the design of this busway must comply.

Both East West Rail and CAM are able to provide a high-quality public transport scheme serving the Cambourne area in the medium and long-term. This creates the opportunity to consider in-highway improvements to bus services and active travel which could meet short-term needs and, in the medium and longer term, also provide access to locations that will not be served by the new railway or CAM. This report identifies some of these opportunities and estimates the bus journey time savings they could achieve.

Analysis of bus travel time data from 2019 reveals:

- There is no problem with outbound congestion west of the M11 junction: 99% of bus journeys are delayed by less than 2½ minutes.
- Congestion east of the M11 junction in both directions is typical for an urban road with multiple junctions, and tolerable until city-wide demand-management measures are implemented.
- There is minimal congestion inbound to Madingley Mulch roundabout (delays are mostly related to dwell times at bus stops).
- Congestion is a serious problem only inbound during the morning peak from Madingley Mulch roundabout to the M11 junction. Journey times are wildly erratic. Around 9am on the worst days, 5% (1 in 20) of inbound buses experience delays of 42 minutes or more.

We have therefore focused on measures that may be implemented relatively quickly to reduce delays to inbound buses from the Madingley Mulch roundabout to the Park & Ride junction. The package we recommend, which includes 1,135m of bus lanes and other technical interventions, would reduce a 42-minute delay to under 10 minutes.

We show that large improvements to bus journey times along Madingley Rd can be achieved relatively quickly with in-highway interventions. Buses to west, central and south Cambridge can run via any combination of the A428 and St Neots Rd to the Madingley Mulch roundabout, then take advantage of bus priority measures on Madingley Rd. Buses to north and east Cambridge can run via the A428 and A14, taking advantage of the bus priority measure on the approach to the Girton Interchange.

The interventions we propose would fully satisfy the requirements in the Local Plan to enable and support development of Bourn Airfield and Cambourne West. They therefore achieve most of the benefits of the GCP Busway at a fraction of the cost, and therefore with a significantly higher benefit-to-cost ratio. They would also have much less negative social and environmental impacts.

Our proposal is a subset of Options 'Low Cost a/b' in the Options Appraisal Report, with some additions. Option 1 had an estimated cost of £32.6m (in 2016 prices) and a Benefit-Cost Ratio of 1.22, five times higher than GCP's preferred option at that stage. The package we recommend is expected to cost well under £10m and to provide most of the same social benefits as the GCP option at a benefit–cost ratio in excess of 4.0, compared with 0.43 for GCP's option.

Therefore, we recommend this package of 'quick win' interventions to the Greater Cambridge Partnership and Combined Authority as an effective and low-cost interim solution while the details of longer-term infrastructure schemes, such as East West Rail, the CAM network and the Girton Interchange, are worked out.

Glossary

- **Madingley Mulch roundabout** refers to the junction between the A1303, A428 and St Neots Rd by Madingley Mulch, the garden building supplier.
- **Madingley Hill** refers to the A1303 between Madingley Mulch roundabout and the M11 Junction 13.
- **Madingley Rd** refers to the A1303 between the M11 Junction 13 and Queen's Rd.

The following reports are referenced:

- **CPIER:** Cambridge & Peterborough Independent Economic Review, Cambridgeshire and Peterborough Independent Economic Commission, September 2018
- **EC:** Outline Business Case: Economic Case, Mott MacDonald, 17 January 2020
- **NR**: C2C Technical Note: Northern Route, Mott MacDonald, 22 May 2019
- **NTSR**: Cambourne to Cambridge Better Public Transport Project Non-technical summary (Outline Business Case), Mott MacDonald, December 2019
- **OAR**: Outline Business Case Appendix B: Options Appraisal Report Part 2 & Part 3, Mott MacDonald, December 2018
- **OBC**: Outline Business Case, Mott MacDonald, 17 January 2020
- **QW:** C2C Technical Note: Madingley Road 'Quick-Win' Options Outline, Mott MacDonald, 14 May 2019
- **RFB:** A428 Cambourne to Cambridge Option Study: Rectory Farm Bridge Options Report, Atkins, 10 June 2016
- **SEN:** Outline Business Case Appendix J: Strategic Economic Narrative & Economic Impacts Report, Mott MacDonald, 17 January 2020
- **SOBC:** Strategic Outline Business Case, Atkins, 23 September 2016
- **TSCSC:** Transport Strategy for Cambridge and South Cambridgeshire, Cambridgeshire County Council, April 2014
- **TSM:** C2C Topographical Survey Maps, Cambridgeshire County Council, 24 November 2016

Other abbreviations used:

- **BCR:** Benefit-Cost Ratio
- **C2C:** Cambourne to Cambridge
- **EWR:** East West Rail
- **GCP:** Greater Cambridge Partnership
- **NMU:** non-motorised user (person walking, cycling or riding a horse)
- **RIS2:** Department for Transport Road Investment Strategy 2

Summary of proposed interventions

Phase 1 package

These measures may be implemented quickly:

- Lengthen the right-turn M11 filter lane.
- Add always-green signal for the existing eastbound bus lane.
- Configure traffic lights at P&R entrance to clear the eastbound filter lane when a bus is about to enter it. At other times, prioritise buses leaving the P&R.
- Optimise traffic lights along the rest of Madingley Rd and upgrade where necessary to be responsive to bus 'hurry calls'.

Phase 2 package

These measures have been selected to provide maximum benefit at modest cost and low environmental and heritage impact.

In-highway measures

- Insert an inbound bus lane through Madingley Mulch roundabout.
- Add traffic signals to Madingley Mulch roundabout.
- Insert a central eastbound bus lane between Madingley Mulch roundabout and Crome Lea Business Park junction, terminating at responsive traffic signals.
- Build central eastbound bus lane from the layby east of Mill Farm to Cambridge Rd junction, terminating at responsive traffic signals.
- Build a second eastbound general traffic lane between Madingley Mulch roundabout and Crome Lea Business Park junction to enable Inbound Flow Control.
- Install responsive traffic signals at the M11 entry junction.
- Create a layby at Cambridge Rd junction.
- Reassign hatched lane on A428 eastbound at Girton Interchange to create a 640m bus lane.

Complementary measures

- Upgrade NMU path between Cambridge Rd and Park & Ride junction.
- Build an NMU path along Cambridge Rd between Madingley village and Madingley Rd.
- Install a modal filter on Cambridge Rd at the American Cemetery.
- Extend Comberton Greenway west from Long Rd to Hardwick and Highfields Caldecote.
- Strike an agreement with the developer of Bourn Airfield to prioritise delivery of an NMU route between Cambourne and Highfields Caldecote.
- Build a bus station at Cambourne with appropriate facilities.
- Build a bus-only link between Sterling Way, Upper Cambourne, and Broadway.
- Integrate bus priority measures at Highfields Rd and Scotland Rd roundabouts.

Other interventions are also evaluated that could complement or replace some of these measures.

C2C Business case flaws

From the Outline Business Case (OBC), the Initial Benefit-Cost Ratio (BCR) of the preferred option is 0.43, implying that it will yield £67.5 million of social benefit for a budgeted outlay of £157 million. Even with less-certain benefits included, the Adjusted BCR is only 0.48. Normally such a poor return on public investment would have eliminated this scheme from consideration.

Wider Economic Impacts

The scheme is justified on the basis of its Wider Economic Impacts. These rely on two key assumptions (EC p40):

1. that "two housing developments, Cambourne West and Bourn Airfield, … are deemed 100% dependent upon the C2C project given the policy position set out in the adopted Local Plans", and hence that 100% of the land value uplift may be attributed to the C2C busway; and
2. that "44% of the jobs supported by the C2C project can be considered net additional at a UK level."

The first point is patently untrue as Cambourne West is being built out now and homes are already being marketed. Full planning consent has been granted this year for a business park on the Bourn Airfield site, and planning consent . There is therefore no sense in which development at Cambourne West or Bourn Airfield is "unlocked" by the C2C Busway or prevented by its absence. The additional value added to the land by the C2C Busway is a small fraction of the uplift from agricultural land values, as claimed in the OBC (SEN page 85, Table 14).

This is in large part because the sites are well connected by road: the A428 dual carriageway provides an almost direct route to the north of Cambridge, including the Science Park and other business parks, as well as other destinations further east. St Neots Rd provides a mostly congestion-free route as far as the Madingley Mulch roundabout. With a RIS2-funded plan to dual the A428 to the A1 now well advanced, there will be considerably more capacity available for travel to St Neots, Bedford and other destinations to the west.

The second point is based on a survey conducted as part of the CPIER report. This is summarised in SEN (page 74):

> *"As the Cambridge cluster is unique to the UK economy if a knowledge intensive company is forced to move away it is very likely to relocate to another cluster outside of the UK. In such a scenario the research uncovered that around 44% of those who would be likely or certain to move activity would move abroad, compared to just 25% who would stay in the UK."*

From this the OBC infers (SEN page 74):

> *"Given this the validation test, examining the UK level labour supply effects assumes that 44% of the jobs supported by the C2C project can be considered net additional at a UK level"*

This inference is based on an incomplete reading of the CPIER report, which summarises the survey (page 54) as follows:

> *For some of these knowledge-intensive sectors, Cambridge is the only viable cluster in the UK. In such a scenario they would be likely to move abroad. 35.4% of respondents to the qualitative survey said it was possible, likely, or certain that they would move activity abroad to elsewhere in Europe, and of those respondents who said they would likely or certainly move activity outside of the area, significantly more indicated that they would move abroad (44.2%) than elsewhere in the UK (25.0%). One commented: "Our reliance on a highly skilled work force, which could not easily be found elsewhere, would make relocation from the C&P*

area very difficult." This point serves to highlight the net additionality of the area to economic output in the UK, and once again shows that the success of Cambridgeshire and Peterborough is a project of national importance.

The 44.2% figure applies only to a subset of the 35.4% who responded that it was "possible, likely, or certain that they would move activity abroad". It is not possible to conclude from this that 44% of jobs in the Cambridge cluster are at risk of being relocated abroad. At the highest, it is 44% of a fraction of 35.4%, i.e. less than 15%.

The OBC makes two unwarranted inferences, that:

1. the entire risk of job relocation abroad falls on the delivery of the C2C Busway;
2. existing jobs being at risk is equivalent to new jobs being "net additional at a UK level".

The first inference is absurd, as it discounts not only other transport schemes, such as East West Rail, but also national government policies, such as post-Brexit trade agreements or tax treatment of R&D expenditure and venture capital.

The second inference is plain wrong. A job is only net-additional at a UK level if it is filled by someone who immigrates into the UK *and that post would not otherwise be filled*. Otherwise, only a fraction of the GVA associated with the job (SEN page 85, Table 14) may be counted towards the Wider Economic Impacts.

East West Rail

East West Rail will abstract a large proportion of travellers to south and central Cambridge, including the Biomedical Campus and CB1. Although technically the busway business case does not need to take into account the impacts of East West Rail as that is not yet a funded scheme, it is perverse to ignore it, given its wide strategic significance.

Decongestion benefits

Three quarters of the social benefit (£63.0/£83.8 million) attributed to the C2C busway derives from reduced congestion on the road network. Most of that is realised through modal shift from cars to buses, rather than removal of buses from the existing road network. If, as this study demonstrates, there are alternative interventions that can provide sufficient advantage to buses using the existing road network to stimulate modal shift, then those interventions will achieve similar benefits. Yet, the OAR attributes zero decongestion benefits to all the alternatives (OAR Part 2, page 78, 6.5.3).

Disaggregation of costs and benefits

There are three distinct components to the C2C Busway scheme: bus priority measures, a park-and-ride, and an NMU. These should be designed and appraised separately

Each of these can be provided independently of the other, with relatively small economies of co-delivery. The NMU path could be delivered as an extension of the Comberton Greenway much more quickly than as an adjunct to the busway. The park-and-ride has high lifetime operational costs, which depress the BCR of a low-cost bus-priority scheme more than a high-cost scheme.

Option comparators

Although OAR 'Low Cost a/b' options are similar to the scheme proposed here, they were not developed with the objective of optimising their BCR. They include expensive elements that are unlikely to deliver high benefit, such as a westbound bus lane over the M11 bridge, a separate NMU bridge, and a bus lane east of the M11 bridge. All of these require expensive engineering, including relocation of underground services.

Journey times between Grange Rd and the city centre

The OBC does not make clear what route buses will take between Grange Rd and the city centre, though it indicates in the NTSR (p58) that buses to the Biomedical Campus would run via Silver St and Pembroke St. Downing/Pembroke St is one-way eastbound. Which way will buses run westbound? Has the modelling taken into account congestion on Downing/Pembroke St and Lensfield Rd, and the westbound detour required from the city centre? (For reference, the Citi 4 service travels via Northampton St, Chesterton Rd, Victoria Ave and Emmanuel Rd in both directions.)

Unresolved questions

A great many strategically significant questions remained unanswered, making it risky to invest heavily in fixed transport infrastructure with a typical design life in excess of sixty years. For these reasons, we believe that the transport authorities should be prioritising infrastructure that delivers a high return over ten years. The Greater Cambridge Greenways fit the bill for cycling provision. This report seeks similarly high-return investment to reduce delays to bus services from west of Cambridge.

CAM

- Which part of Cambridge should the CAM connect to: West Cambridge or Girton Interchange?
- If West Cambridge, where will the tunnel portal be?
- How does CAM fit with the University of Cambridge's plans for West Cambridge?
- What is the CAM vehicle and guidance system?
- What are the route design constraints created by the vehicle (width, height clearance, corner radii, crossings, power supply, emergency access, etc)?
- What is the minimum level of segregation required for safe operation, with or without a driver?
- Does segregation require fencing or other means to restrict access (to people, livestock, wild animals)?
- How fast will CAM services be, including stopping times? How will journey times compare with East West Rail or travelling by car via the A428?
- How much demand will there be to use the CAM/busway to Cambridge from Cambourne and St Neots after allowing for abstraction by East West Rail?

East West Rail

- Where will the Cambourne station be?
- How close to St Neots will the railway line run? Will it be quicker for people to take the train or CAM to reach central Cambridge or the Science Park (allowing for the last 'mile' walk, cycle or bus journey from Cambridge or Cambridge North stations)?

Girton Interchange

- Direct connections between the A428 and M11 will relieve congestion on Madingley Hill, as 30% of traffic leaves Madingley Rd to join the M11 (see Figure 8).
- Direct connections between the A428, M11, A14 and A1307 will make the Girton Interchange the ideal location for a visitor transfer hub/coach station.
- Therefore, this should be a strategic objective of the local transport authorities.
- How and when will works on the Girton Interchange be funded?

Highways England is quoted in newspapers on 24 February 2021 that it will be re-evaluating the Girton Interchange as part of updating its route strategies in the East of England.

Baseline

We have analysed weekday bus journey times along Madingley Hill and Madingley Rd during the whole of 2019, as recorded in the Smart Cambridge Data Hub (see Figure 21). A small number of data points were omitted as unreliable or exceptional (including bank holidays and 12 March 2019, when delays were recorded over 1½ hours). The rest provide a clear picture of bus journey times along this critical route in and out of Cambridge.

As shown in Figure 3, severe delays are experienced by inbound traffic on Madingley Hill in the morning peak. Around 9am, 5% of bus journeys (i.e. on 1 day in 20) can be delayed by more than 32 minutes; 25% (1 in 4 days) by more than 25 minutes; and 50% (1 in 2 days) by more than 16 minutes. However, delays vary greatly: also around 9am, 5% of bus journeys (i.e. on 1 day in 20) are delayed less than 4 minutes.

As shown in Figure 4, there are no significant delays in the evening peak on Madingley Hill: 50% of outbound services are delayed less than a minute; and 99% less than 2.5 minutes. In other words, on only about two days a year are any buses delayed by more than 2.5 minutes.

ANPR data gathered in June 2017 showed that 30% of inbound traffic on Madingley Hill turns onto the M11 at Junction 13 (see Figure 8 and NR2.16).

Peak-time delays on Madingley Rd east of the Park & Ride are modest (see Figure 5): 95% of inbound journeys are delayed no more than 5 minutes; and 95% of outbound journeys are delayed no more than 7 minutes. In our view, these are insufficiently large to warrant large investment in advance of introducing demand-management measures and/or building CAM. As most of the delays are at signal-controlled junctions, there may be some gains to be made by dynamically optimising traffic signals along Madingley Rd.

It is clear from the data that the solution we are seeking can focus almost entirely on reducing the typically large delays experienced by inbound buses in the morning peak on Madingley Hill. Any measures that can significantly reduce delays in the morning peak on the worst 5% of days will reduce or eliminate delays on other days and at other times of day.

Objectives

We note that modal shift from solo-occupancy cars to buses and cycling can achieve two objectives at once:

- Increase road capacity, in terms of people moved per hour (which is what actually matters).
- Reduce congestion. One bus carrying 60 passengers (a less than full double-decker) is equivalent to 50 cars (at an average peak-time occupancy rate of 1.2 people per car). Travelling at 50mph, those cars occupy more than 2km of carriageway, or about the distance from Madingley Mulch roundabout to the Cambridge Rd junction.

The challenge is, and always has been, how to kick-start this virtuous cycle.

The objectives of this study have been to:

1. Determine the fastest, most reliable routes from west of Cambridge to main destinations in Cambridge:
    - **North** (Science Park, Cambridge North station): via A428, A14 Histon Interchange and Orchard Park busway, or A14 Milton Interchange.
    - **West** (University of Cambridge sites): via Madingley Rd.
    - **Central** (retail, cultural and social centre): via Madingley Rd (or via the A428, A14 Histon Interchange and Histon Rd?)
    - **South** (Biomedical Campus): via Madingley Rd, M11, Hauxton Rd and Addenbrooke's Rd.
    - **East** (Marshall businesses and retail sites): via A428, A14 Junction 34, Horningsea Rd.
2. Reduce bus journey times and delays on those routes:

- **West, Central:** Significantly reduce delays to buses on Madingley Hill.
- **North, East:** Optimise route for buses to north Cambridge via the A428.
- **South:** Reduce delays to buses on Madingley Hill, Hauxton Rd and Addenbrooke's Rd.

3. Be able to achieve these reductions within 6–24 months of sign-off.
4. Select bus priority schemes with positive net benefits over a reduced time frame of ten years (compared with sixty years for most infrastructure schemes, including the C2C busway).
5. Improve the safety and convenience of cycle routes from Cambourne into west Cambridge.
6. Increase transport capacity, in terms of people moved per hour, to accommodate future growth.

Pursuing this more tactical agenda will create breathing space to develop and deliver longer-term transport schemes in a coherent and cost-efficient way:

- **East West Rail**: the location of Cambourne station and the alignment of the railway line are yet to be determined. This will potentially provide a quarter-hourly, high-capacity service to Cambridge South station (the Biomedical Campus), Cambridge station (the city centre and CB1), Cambridge East (potentially a new business, residential and leisure/cultural hub on the site of the airport) and Cambridge North (Science Park, other business parks, and planned business, residential and leisure/cultural hub at NE Cambridge).
- **A428 dualling to the A1**: Funded as part of the current Road Investment Strategy (RIS2), the scheme to dual the A428 between the Black Cat Roundabout and Caxton Gibbet is progressing. The Development Consent Order is due to be published "at the end of February 2021."
- **CAM network:** The locations of tunnels, portals and segregated routes are yet to be determined; as are technical specifications for vehicles and track. This will potentially provide rapid and reliable access between all larger settlements in the Cambridge region.
- **Rural cycle network**: How the Greenway routes will be extended to connect more villages has yet to be determined. A dense and coherent network of cycleways that are attractive and safe for people of all ages and abilities (which, with the advent of affordable e-cycles and other micromobility innovations, includes most people) will greatly reduce the need for a car to make local trips.
- **Girton Interchange**: How and when connections between the A428, M11 and A1307 will be provided has yet to be determined. There is a clearly identified need for these connections, and a critical opportunity to build a coach station and visitor transfer hub at the interchange to serve tourists and other visitors to Cambridge.
- **Demand management**: What type or combination of demand management measures should be implemented is still being debated, but will most likely be based on some form of variable road pricing. This will provide a strong incentive to use of active and public transport instead of private cars, reducing congestion, carbon emissions and pollution. An essential component of any demand management measures will be generation of a reliable, long-term revenue with which to subsidise an expansion of bus services that people can depend upon in the same way that they depend upon railway services.

Outline of interventions considered

Interventions considered include:

- Realignment of lanes within the existing carriageway
- Widening of the road, mostly within the existing highway boundary
- Installation of new traffic lights
- Implementation of smart traffic management (flow control and bus 'hurry calls')
- Improvements for cycling and walking
- Other complementary measures

The recommended package of interventions is a subset of OAR options 'Low Cost a/b' with some additions. The estimated construction cost was £37 million in 2018 prices, which included a Park & Ride, traffic signals at the Madingley Mulch roundabout, and an eastbound bus lane from there to the Eddington Avenue junction except over the M11, where a westbound bus lane is included instead. The package proposed here involves the construction of only 1,135m of bus lane in two locations where the engineering costs are relatively low. It is expected to cost well under £10 million in 2021 prices.

Phase 1 ('quick win') interventions

The measures included here involve no construction work, and are therefore expected to be deliverable within six months of sign-off.

Items 1a, 1b and 1c will significantly increase bus speeds between the end of the existing bus lane just west of the M11 bridge to the Madingley Road P&R junction, with an expected time saving of 2.6 minutes at the slowest 95th percentile. A potential benefit of 1a is to increase the flow rate of traffic not joining the M11, which would increase the speed of all traffic on Madingley Hill. As this is an uncertain outcome and we lack data to model it, we have not quantified it. However, it could significantly benefit both buses and general traffic. The benefit of item 1d has also not been quantified as it would require detailed modelling of junction flows.

Reference	*Intervention*	*Section*
1a	Lengthen the right-turn M11 filter lane.	G
1b	Add always-green signal for the existing eastbound bus lane.	F
1c	Configure traffic lights at P&R entrance to clear the eastbound filter lane when a bus is about to enter it. At other times, prioritise buses leaving the P&R.	H
1d	Optimise traffic lights along the rest of Madingley Rd and upgrade where necessary to be responsive to bus 'hurry calls'.	J

Phase 2 in-highway interventions

The measures included here involve construction work or detailed agreement that could take up to two years from sign-off, though some items could be delivered within a year or eighteen months.

The combination of items 1a to 1c and 2a to 2f is expected to yield a time saving for buses of 21.4 minutes at the slowest 95th percentile, reducing delays from 42.1 to 20.7 minutes. At the slowest 75th percentile, the time saving is 16.5 minutes, reducing delays from 32.1 to 15.6 minutes.

We have chosen to locate the bus lane centrally within the carriageway on Madingley Hill so that it can also serve as a right-filter lane at junctions without further widening of the road. The junctions affected see only a small number of vehicles per day making right turns, so the impact on buses will be minimal.

Item 2g (described in more detail in the next section) increases the time saving at the slowest 95th percentile to 32.3 minutes, reducing delays to 9.8 minutes. At the slowest 75th percentile, the delay is reduced to 6.0 minutes.

The benefits of items 2h to 2j have not been quantified.

Reference	*Intervention*	*Section*
2a	Insert an inbound bus lane through Madingley Mulch roundabout.	A
2b	Add traffic signals to Madingley Mulch roundabout.	A
2c	Insert central eastbound bus lane between Madingley Mulch roundabout and Crome Lea Business Park junction.	B
2d	Add responsive traffic signals at the end of the bus lane.	B
2e	Build central eastbound bus lane from the layby east of Mill Farm to Cambridge Rd junction.	D
2f	Add responsive traffic signals to the Cambridge Rd junction.	D
2g	Build a second eastbound general traffic lane between Madingley Mulch roundabout and Crome Lea Business Park junction to enable Inbound Flow Control.	B
2h	Install responsive traffic signals at the M11 entry junction.	G
2i	Create a layby at Cambridge Rd junction (to replace the one lost in 2e).	E
2j	Reassign hatched lane on A428 eastbound at Girton Interchange to create a 640m bus lane.	

Phase 2 complementary interventions

We propose a westward extension of the already-agreed Comberton Greenway. From Hardwick it would go to Highfields Caldecote via an existing bridleway, and then to Cambourne via a new route through the Bourn Airfield site (Figure 16). We also propose an NMU path be built from Madingley, and upgraded east of the Cambridge Rd junction. A bus gate on Cambridge Rd behind the American Cemetery may be needed to stop drivers trying to bypass queues on Madingley Hill. Cambourne is long overdue a bus station.

The benefits of items 2k to 2r have not been quantified.

Reference	*Intervention*	*Section*
2k	Upgrade NMU path between Cambridge Rd and Park & Ride junction.	E–H
2l	Build an NMU path along Cambridge Rd between Madingley village and Madingley Rd.	
2m	Install a modal filter on Cambridge Rd at the American Cemetery.	
2n	Extend Comberton Greenway west from Long Rd to Hardwick and Highfields Caldecote.	
2o	Strike an agreement with the developer of Bourn Airfield to prioritise delivery of an NMU route between Cambourne and Highfields Caldecote.	
2p	Build a bus station at Cambourne with appropriate facilities.	
2q	Build a bus-only link between Sterling Way, Upper Cambourne, and Broadway.	
2r	Integrate bus priority measures at Highfields Rd and Scotland Rd roundabouts.	

Alternative or supplementary interventions

We have evaluated the benefits of building inbound bus lanes on the two sections not included above. We believe that Inbound Flow Control (2g) offers a more cost-effective solution with less environmental and social impact than building a bus lane past Madingley Wood, the American Cemetery, Mill Farm and Moor Barns Farm.

We have also included, but not evaluated, the addition of an outbound bus lane into the Madingley Mulch roundabout, for which currently there appears to be no need; and a bus lane on the A428 exit ramp, for which there may be a business case if and when St Neots Rd does not provide a congestion-free route from the Scotland Rd interchange.

Reference	*Intervention*	*Section*
3a	Build a nearside eastbound bus lane between Cambridge Rd junction and the start of the existing bus lane.	E
3b	Build a central eastbound bus lane between Crome Lea Business Park junction and the layby east of Mill Farm.	C
3c	Reconfigure the M11 (Rectory Farm) bridge to accommodate an eastbound bus lane.	G
3d	Build a nearside eastbound bus lane from the M11 bridge to the Park & Ride junction.	H
3e	Build a nearside westbound bus lane from east of Madingley Mulch roundabout to join directly with St Neots Rd.	A–B
3f	Build a bus lane on the A428 eastbound exit ramp.	A

Park & Ride

We have not included a Park & Ride in our proposal as it would perpetuate car dependency. Those who have access to a car will have a strong incentive to drive to the Park & Ride to pick up a cheaper and more frequent bus service into the city than they would catch closer to home. Services from Cambourne would therefore not see a significant increase in frequency. Worse, if Cambourne buses are diverted to the Park & Ride, that will extend journey times, further reducing the incentive to catch the bus from west of the Park & Ride.

However, our proposal is entirely compatible with a Park & Ride being built off Scotland Road, as proposed by GCP. Buses serving it could travel via St Neots Rd or the A428 to the Madingley Mulch roundabout and then take advantage of the bus priority measures on Madingley Hill and Madingley Rd.

Detail of interventions considered

The route is examined inbound from Madingley Mulch roundabout to Queen's Rd in sections (see Figure 7). The assessed benefits of recommended interventions, and how they are calculated, is set out in Table 1 towards the end of this document; other interventions warranting consideration, but not recommended, are set out in Table 2. See the glossary (above) for details of the reports referenced by abbreviations.

Section A: Madingley Mulch roundabout

Distance	110m / 190m
Speed limit	60mph
Bus lane position	Through centre of roundabout
Filter lane sections	n/a

2a. Bus bypass: An inbound bus lane could run from St Neots Rd through the middle of the roundabout. This would ensure buses could avoid any congestion on the roundabout, and reduce by 80 metres the distance travelled at slow speed around the roundabout.

2b. Signal controls: Signals would be required to enable use of the bus bypass. Signals could also reduce incidences of blocking back by regulating inflows to match outflows. (Reviewed in QW3.1.)

3e. Outbound bus lane: A westbound nearside bus lane could be accommodated within highway land to the south of Madingley Mulch roundabout (see Figure 12). This would provide buses with a congestion-free route if and when a queue builds on the approach to the roundabout (see Figure 13). (Reviewed in QW3.1.)

3f. A428 exit ramp bus lane: A bus lane on the A428 exit ramp was included in designs for a Park & Ride at the Waterworks site. There could be some benefit in this for express bus services using the A428 from Cambourne, St Neots or a Park & Ride at Scotland Rd. However, this needs to be weighed against buses using St Neots Rd from the Scotland Farm interchange. A number of interventions could be considered for St Neots Rd if that becomes congested, including a bus lane east of Hardwick, and a bus bypass through the southern roundabout at the Scotland Rd interchange.

Section B. Madingley Mulch Roundabout to Crome Lea Business Park junction

Distance	575m
Speed limit	50mph
Bus lane position	Central
Filter lane sections	Madingley Mulch, Jungle, Crome Lea Business park

2c. Inbound bus lane: This section can accommodate a central inbound bus lane with relatively low environmental and visual impact. The bus lane can incorporate right-turn filter lanes, including at the end, for the Crome Lea Business Park. There is space within the existing highway boundary to widen the road to the north without impacting the NMU path or people's homes to the south (see Figure 9).

2d. Signal controls: Traffic signals at the end of the new lanes would respond to bus 'hurry calls', and be linked to detector loops in the road behind (to monitor the length of the queue), and ahead (to monitor the flow rate). Even without a dedicated queuing lane, the lights can regulate traffic flow to some extent, optimising the flow rate to minimise delays on the next section (see *Inbound Flow Control* below).

2g. Inbound Flow Control lane: A second lane may be added for general traffic to increase the queuing space. This would provide considerably more capacity to regulate traffic flow past the American Cemetery, providing similar benefit to building the Section B bus lane (3b).

At any time that the queue backs up to within 50m or so of the Madingley Mulch roundabout, the traffic management system would increase the rate at which general traffic is released so as to avoid blocking back to the roundabout and A428 exit lane.

Though there is space within the existing highway boundary to widen the road to the south and north (see Figure 9), it is likely to be preferable to acquire some of the farmland to the north in order to widen the road only on the north side, thereby limiting the loss of hedgerow and trees and the impact on people's homes.

Section C. Madingley Wood, American Cemetery and Mill Farm

Distance	918m
Speed limit	50mph
Bus lane position	None recommended
Filter lane sections	n/a

3b. Central bus lane (not recommended): This section is the most sensitive in terms of heritage, ecology and residential property which is why our preference is for Inbound Flow Control (2g). However, if Inbound Flow Control is not deemed to provide sufficient benefit and there is a preference for a bus lane along the entire length of Madingley Hill, then every effort should be made to minimise the impacts caused by the addition of a bus lane here. It would be possible to provide a bus lane within the existing highway without significant impacts on Madingley Wood (an SSSI site) and without the loss of trees outside the American Cemetery.

Section D. Mill Farm layby to Cambridge Rd

Distance	450m
Speed limit	50/40mph
Bus lane position	Central
Filter lane sections	Madingley Rise, Cambridge Rd (to Coton)

2e. Inbound bus lane: If the layby just east of Mill Farm is converted to a general traffic lane, and the central hatching east of that is converted to a central eastbound bus lane, interrupted by filter lanes at Madingley Rise and Cambridge Rd, there will be less than 100m of road requiring widening. There is sufficient land within the highway boundary to accommodate this (see Figure 6b). A replacement layby can be created in Section E just east of the Cambridge Rd junction (see 2i).

2f. Signal controls: Traffic signals at the Cambridge Rd junction would limit the rate at which vehicles can leave Cambridge Rd from Madingley and Coton, reducing delays to traffic on Madingley Hill. The signals woud also respond to bus 'hurry calls', prioritising inbound buses in the morning peak and outbound in the evening.

Section E. Cambridge Rd to existing bus lane

Distance	356m
Speed limit	40mph
Bus lane position	None recommended
Filter lane sections	n/a

3a. Inbound bus lane (not recommended): Constructing a bus lane on this section would be detrimental to Moor Barns Farm houses and would require removal of a number of mature trees. Although it could

provide significant benefit to buses, Inbound Flow Control (2g) offers a better balance of benefits to costs, and is therefore our recommendation.

2i. Layby: To replace the layby lost in Section D, a new layby can be created in the redundant part of the north side of the Cambridge Rd junction. The inter-green phases of the traffic lights would give vehicles a safe window in which to leave the layby. It would therefore be safer than the existing layby, which is in a 50mph zone.

Section F. Existing bus lane

Distance	384m
Speed limit	40mph
Bus lane position	Nearside
Filter lane sections	n/a

1b. Traffic signals: Add a traffic light at the M11 exit junction to give buses in the bus lane a green at all times. Reinstate lane markings between the bus lane and general traffic lane after the M11 exit junction. If necessary, install wands or other form of segregation to prevent drivers entering the bus lane.

Currently, a bus waiting in the bus lane is released at the same time as general traffic (see Figure 15). Most vehicles can accelerate faster than a bus, so several vehicles can pull ahead of the bus before it reaches the merge point 85m ahead. Allowing buses to run ahead of stopped traffic would allow them to take advantage of inter-green gaps in the traffic flow as the signals cycle between Madingley Rd and the M11 exit, reducing delays.

Section G. M11 (Rectory Farm) Bridge

Distance	170m
Speed limit	40mph
Bus lane position	n/a
Filter lane sections	n/a

1a. M11 filter lane: Extend the right-turn filter lane back to the traffic lights at the M11 exit junction. This will add 84m to the existing 66m filter lane, creating queuing space for at least thirteen more vehicles. By overlapping the bus lane and filter lane, buses will no longer be blocked by vehicles waiting to enter the filter lane. This can be achieved quickly with paint and minimal engineering. If necessary, the end of the bus lane can be pulled back a few metres to ensure a safe merge before the bridge.

Note that the planning application for Bourn Airfield (S/3440/18/OL) includes a similar proposal to segregate M11-bound traffic from city-bound traffic (see Figure 10). Both options should be modelled with accurate peak-time traffic volumes to determine which benefits buses more.

2h. Traffic signals: Signals could help accelerate the flow eastbound when there are insufficient gaps in outbound traffic to prevent blocking back at the entrance to the right-turn filter lane. Signals could also respond to a 'hurry call' from buses that use the filter lane (such as the 'H'), clearing the filter lane as a bus enters it. This is one of a set of interventions at this location that QW 3.4.2 assessed that could "potentially provide significant benefits to general traffic, as well as public transport vehicles."

Although we recommend this intervention, we have not quantified the potential benefits as we do not have access to data on the junction's performance. A manual traffic count at this time (during a COVID lockdown) would be uninformative.

3c. Bus lane (not recommended): Although RFB details in Option 2 (see Figure 14) how the bridge can accommodate four 3m-wide traffic lanes in addition to the existing NMU lane, the gain is relatively small once the filter lane is extended beyond behind the end of the existing bus lane (1a).

If the carriageway were widened, the estimated cost is £632,000 (2016 prices, RFB Appendix E p5), mostly to relocate below-surface services on the south side of the bridge. The lane allocation, north to south would be:

- Bi-directional NMU lane (unchanged)
- Eastbound bus lane
- Eastbound general traffic lane
- Eastbound M11 entry filter lane
- Westbound general traffic lane

Section H. M11 bridge to P&R entrance

Distance	202m
Speed limit	40mph
Bus lane position	n/a
Filter lane sections	n/a

1c. Responsive traffic signals: The signals at the P&R entrance could respond to a 'hurry call' from a bus approaching the start of the filter lane by cycling the filter lane lights to green, so that it is emptying as the bus enters it. At other times, buses exiting the P&R should be prioritised.

For inbound buses that do not call at the P&R, there may be advantage in permitting them to go straight on from the filter lane, taking advantage of the 'hurry call' prioritisation of filter-lane traffic. However, this would need to be synchronised with traffic exiting the P&R.

3d. Bus lane (not recommended): Adding a bus lane to this section is likely to be disproportionately expensive because of the need to relocate services buried in the verges, which is likely to include a gas main and foul sewer. Since the P&R filter lane is as long as the bus lane would be, a similar benefit could be achieved with previous intervention (1c).

Section I. P&R entrance to Northampton St

Distance	2,046m
Speed limit	40/30mph
Bus lane position	n/a
Filter lane sections	n/a

1d. Responsive traffic signals: All signals should be configured to respond to 'hurry calls' from approaching buses, and timings should be optimised to promote free-flow along Madingley Rd inbound in the AM peak and outbound in the PM peak.

We have not considered the relative merits of routing buses via Madingley Rd, West Cambridge or Eddington, or whether a new busway between West Cambridge and Grange Rd would be beneficial. In any case, options should be developed for redesigning the Eddington Avenue junction and Park & Ride to enable interchanging that is easy for bus users and efficient for bus operators.

We note that the University of Cambridge consulted in 2020 on extending the 'U' service to Girton, and running a complementary service to Milton Park & Ride (though Smarter Cambridge transport recommended that this instead terminate at Cambridge North station). These services could provide connections between Cambourne services and Cambridge North station, Cambridge Science Park,

Cambridge Regional College, Girton College, Eddington, West Cambridge, the Fitzwilliam Museum, Cambridge Station and the Biomedical Campus.

Cycle route

2n. Comberton Greenway extension: The most attractive route for active travel is through the villages to the south of the A428, not along St Neots Rd and Madingley Rd. For most people it is the more direct route; it avoids the relatively steep incline of Madingley Hill travelling west; it does not expose users to traffic noise, vehicle pollution and headlight glare; and it passes through attractive countryside.

With the Comberton Greenway now going ahead, the next step should be to design a continuation of that west through Hardwick to Highfields Caldecote, with the installation of an appropriate all-weather surface along the route of the Harcamlow Way bridleway (see Figure 16). An early agreement should be struck with the developer of Bourn Airfield to create an NMU path through the site, linking Highfields Caldecote with Cambourne (see Figure 17). This would comply with the draft Local Cycling and Walking Investment Plan, Appendix 3:

> *"A route should be provided through the southern end of the Bourn Airfield development which connects to Cambourne and the bridleway to Caldecote. Consideration should be given to providing a 3m hard surfaced path along the line of the bridleway to Hardwick, connecting to the [Comberton] Greenway." (South Cambridgeshire Item 2)*

GCP's preferred option of a busway includes an adjacent NMU route. Because of this, GCP has argued that if bus priority is provided instead along Madingley Road, then there must also be an upgrade to the shared footway along Madingley Road. However, once the route described above is completed, it is unlikely many people will choose to cycle along Madingley Rd west of Cambridge Rd junction, and therefore there would not be a case for widening it. Nevertheless, any safety improvements that can be made to the existing NMU path should be incorporated into the plan of works.

2k. Shared-use path east of Cambridge Rd junction: There is an urgent need to widen and repair the shared-use path alongside Madingley Rd between the Cambridge Rd junction and the start of the Madingley Road Cycling and Walking project (just west of the P&R junction). This can be done within the existing highway boundary (see Figure 9b). The parapet of the M11 overbridge needs to be raised to comply with current safety standards.

Cambridge Road

2l. Non-motorised user path: Cambridge Rd has a speed limit of 60mph and no footway, making it exceptionally unsafe as an active travel route. There is therefore an urgent need to build separate provision for walking and cycling between Madingley village and Madingley Rd, which would benefit village residents, parents using the Perse Nursery, people attending courses at Madingley Hall, and visitors to the American Cemetery and The Three Horseshoes gastropub.

2m. Modal filter: It may be worth considering a modal filter at the American Cemetery car park that is active in the morning peak. This would prevent drivers from detouring via Madingley and Cambridge Rd to bypass queues on Madingley Hill. An alternative is to phase the traffic signals at the Cambridge Rd junction (2f) to delay traffic from Madingley long enough to make this an unattractive route in the morning peak.

Girton Interchange

2j. Reassign hatched carriageway on A428: Moving the general traffic lane into the offside hatched area would free up the inside lane to be used by buses and coaches (and emergency vehicles). If the lanes merge before the M11 overbridge, this would provide a 640m bus lane to bypass congestion (see Figure 20).

As the 905 bus service demonstrates, the A428 and Orchard Park busway from Histon Rd offer a fast and direct route from Cambourne to north Cambridge, including the Science Park and Cambridge North station. However, traffic can become congested on the approach to the single-lane section of the A428 leading into the Girton Interchange.

Cambourne

2p. Bus station: Cambourne provides a poor experience for bus users: there is no bus station and few bus shelters. We recommend that consultation should start urgently to identify the best location for a bus station to serve express bus services to Cambridge and St Neots, and interconnecting local and demand-responsive services from Papworth, Elsworth, Caxton, Bourn and other villages. Facilities could include: shelters, cycle parking, a waiting room, toilets, refreshment kiosk, collection lockers, CCTV monitoring, helpdesk intercom, and WiFi.

2q. Bus link between Sterling Way and Broadway: The C2C Busway outline plan includes a bus-only link-road between Sterling Way in Great Cambourne and Broadway, at what will be one of the main entrances to the Bourn Airfield development (see Figure 18). However, this is not present on the technical drawings in OAR (see Figure 19).

This link is essential to reducing the travel time and mileage buses take to cover Lower, Great and Upper Cambourne (see Figure 2, which shows how convoluted the Citi 4 bus route is). It should be delivered as soon as possible, and not delayed until the Bourn Airfield Section 106 payments are transferred.

2r. Bus priority at Highfields Rd and Scotland Rd roundabouts: In advance of development of Bourn Airfield, measures should be put in place to minimise delays to buses at the roundabouts with Highfields Rd and Scotland Rd. The optimal configuration should be determined by modelling various combinations of lead-in bus lanes and central or peripheral bus bypass lanes.

Inbound Flow Control

The principle of Inbound Flow Control (or traffic 'gating' or 'queue relocation') is simple:

1. Add a bus lane and one (or more) general-traffic lanes in a location where it has the least equivalised cost (financial, social, ecological, carbon emissions, noise, etc).
2. Use traffic signals at the end of the lanes to hold some of the traffic back.
3. Release the traffic at the same rate (in vehicles/hour) as before, i.e. the rate at which it flows out of the road at the slowest junction further ahead.
4. The resulting reduction in traffic density (in vehicles/km) ahead of the traffic signals allows traffic, including buses, to travel at a higher speed than before.

With one bus lane (2c) and one general-traffic lane (2g), both running east from Madingley Mulch roundabout to the Crome Lea Business Park junction (Section B), there would be an additional 550m of space in which to queue traffic in the morning peak. That makes possible a large reduction in traffic density on the section past Madingley Wood and the American Cemetery (Section C). The speed at the worst-performing 95th percentile rises from 2.27mph to 8.01mph, reducing bus journey times through Section C by over 10 minutes, in addition to the almost 9 minutes saved by the bus lane through Section B.

The time penalty for general traffic is at most half a minute. This is much less than the gains likely to be realised for all traffic by the interventions around the M11 bridge (1a–c).

These timings are based on conditions where currently traffic would be queued all the way back to the Madingley Mulch roundabout. At other times, when the queue is significantly shorter, Inbound Flow Control can eliminate congestion beyond the queuing lanes by, in effect, relocating the queue to before the traffic signals, enabling buses to overtake it.

The detail of the speed, flow and density calculations is illustrated in Table 4. The impact on bus journey times is set out in Table 1, and on general traffic in Table 3. The relationship between traffic density and speed is illustrated in Figure 22.

To build an accurate model of Inbound Flow Control, we just need to monitor flow rates over the course of a period of time that includes maximum congestion. This could be achieved using single-lane automated traffic counters to count only eastbound traffic at the following locations:

- Just east of the Madingley Mulch junction
- Between the Cambridge Rd junction and the M11 exit junction
- On the M11 bridge
- Between the M11 entry junction and the Park & Ride junction
- Between the Park & Ride junction and the Eddington Ave junction

Comparison with GCP's preferred option

The current timetabled journey time for the Citi 4 bus service from the stop in Cambourne near the business park to Cambridge city centre is 26 minutes. On the worst days, at the height of the morning peak, buses experience negligible delay to Madingley Mulch roundabout, but one in twenty buses are delayed by 42 minutes or more on Madingley Hill and 5 minutes or more on Madingley Rd east of the Park & Ride junction. This is illustrated in Figure 1.

The scheme we propose would reduce the longest delays on Madingley Hill to under 10 minutes. This would mean that, at the height of the morning peak, 95% of buses would complete the journey in less than 41 minutes, and 75% in under 33 minutes. At other times, buses would experience minimal delay.

The forecast journey times via the C2C Busway from Cambourne to Cambridge city centre is 32 minutes during the morning peak. This is an average, and does not reflect variability in journey times where buses share the road with general traffic in Cambourne, Cambridge or accessing the proposed Park & Ride off Scotland Rd.

We can be reasonably confident therefore that, even at the height of the morning peak, our proposed scheme will enable 75% of buses achieve a similar journey time to the C2C busway. Commuters would experience a journey time nine or more minutes longer than on the C2C busway only once in four weeks.

The package we propose therefore offers most of the same benefits at a fraction of the cost (estimated at under £10 million) of the C2C busway (budgeted at £157 million). Even if the package we propose realised only half of the benefits of the GCP scheme, the standard BCR would still exceed 4.0, ranking it "Very High Value for Money".

The fact that on-highway measures can be implemented much more quickly than building a new busway means the benefits too may be realised more quickly. This is especially relevant for incentivising residents of the planned new homes to choose public transport rather than driving into Cambridge. Until bus services to east and south Cambridge are improved, driving will always be quicker. Therefore, most people who have the means to purchase a car will do so, committing themselves financially and psychologically to driving. The shorter delivery timeframe for the scheme we propose means that more of the planned new homes will be occupied *after* faster, more reliable bus services are running, substantially increasing the likelihood that occupiers will choose to take the bus rather than drive into Cambridge.

Previous objections to an on-line bus lane

Addressing the points made in SOBC page 79:

1. The lowest cost option (Option 1) is unlikely to offer a step change in capacity, connectivity and journey efficiency (i.e. combination of speed and reliability) in order to deliver a HQPT service on the corridor.

This assertion is both untrue and lacking evidence. As we have shown, the package of interventions we recommend will reduce delays to buses on the worst days by more than 30 minutes. That gives buses a significant advantage over the private car. The advantage will also be highly visible to people driving along Madingley Hill, which is not the case with a busway over the horizon.

2. The existing Park & Ride at Madingley Road allows traffic to be intercepted from both the A1303 / Madingley Road and from the M11.

This is true, but not relevant. The proposed Park & Ride off Scotland Rd can be served by buses using either the A428 or St Neots Rd. Buses to west and south Cambridge can use the bus priority measures proposed here for Madingley Rd; buses to north Cambridge can use the bus priority measure proposed here for the A428.

That said, we do not support Park & Ride as a sustainable, long-term transport solution. It makes highly inefficient use of land to benefit only people who have access to a car. Creating the conditions for a high-frequency, reliable bus service from Cambourne, Bourn Airfield and St Neots will benefit many more people, including proportionately more young, elderly and disabled people; reduce carbon emissions substantially; and reduce congestion on the wider road network, not just in Cambridge.

3. In increasing bus usage this option meets some, but not all, of the strategic criteria. Critically, the TSCSC aspires to deliver a HQPT service along the corridor, with increasing levels of segregation. As a fully online option with bus priority measures on the existing highway, has a limited ability to achieve this key strategic objective.

This objective will be met by a combination of East West Rail, CAM and improved on-road bus services. The integration of these services at the level of timetabling, fares and interchange hubs, is what will provide a high-quality public transport experience across Cambridgeshire, not just on a single route. The package of measures we recommend will buy time for East West Rail and the CAM network to be designed and built.

4. 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.

Bus tracking data proves that there is no congestion outbound, and therefore no need for bus priority. If that proved not to be the case in future, it would be possible to add a westbound bus lane into the Madingley Mulch roundabout (item 3e). In the medium term, the greatly improved reliability of bus services and improved provision for cycling will encourage modal shift away from cars.

5. This option does not provide improvements west of Madingley Mulch as there is little congestion expected there up to 2031 based on the modelling undertaken. This means that this option is not likely to fully achieve the aspirations (set out in the TSCSC) for providing 'busway / HQPT infrastructure' that connects Cambourne West and Bourn Airfield.

The longer-term increase in transport capacity will be met by East West Rail and/or CAM and/or additional connections at the Girton Interchange. CAM aims to provide an integrated, high quality public transport experience across Cambridgeshire, not just on a single route. The package of measures we recommend will buy time for East West Rail and the CAM network to be designed and built.

6. This option does not extend or interfere with cycling or pedestrian provision. In not doing so it does not support the aspirations of the TSCSC, which aims to provide more direct cycling and walking routes.

Madingley Rd is not on the most direct route for cycling from Cambourne, Bourn Airfield, Highfields Caldecote or Hardwick to west Cambridge. An extension to the Comberton Greenway (items 2n-o) will provide a much more convenient and attractive route.

Figures and tables

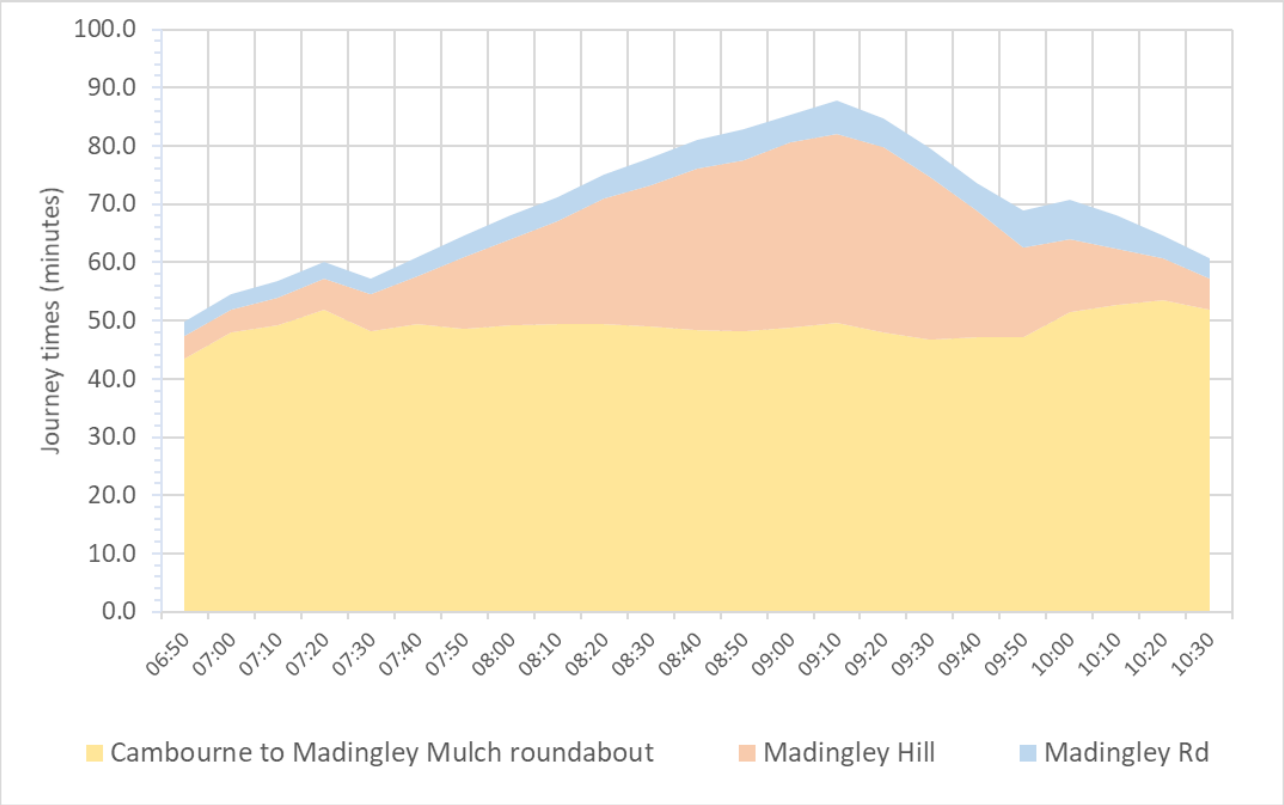

Figure 1: Citi4 inbound journey times during the weekday morning peak at the 95th percentile (1 in 20 bus journeys take this time or longer, including stopping times – which explains the peak after 10am in journey times to Madingley Mulch roundabout). Journey times are from the start point of the Citi4 route, as shown in Figure 2.

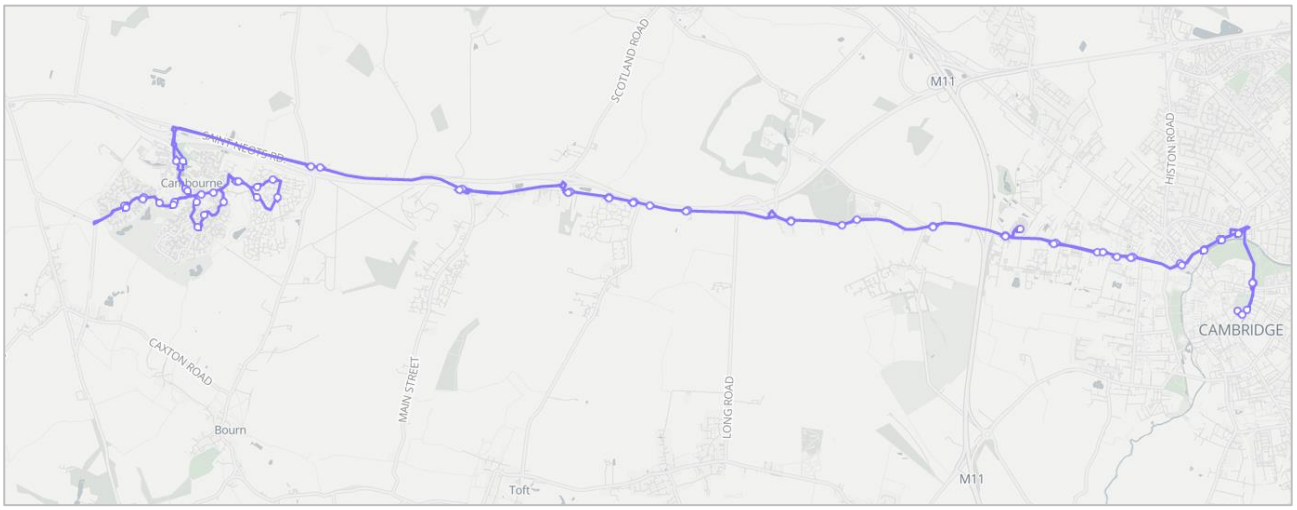

Figure 2: Citi 4 bus route from Cambourne to Cambridge

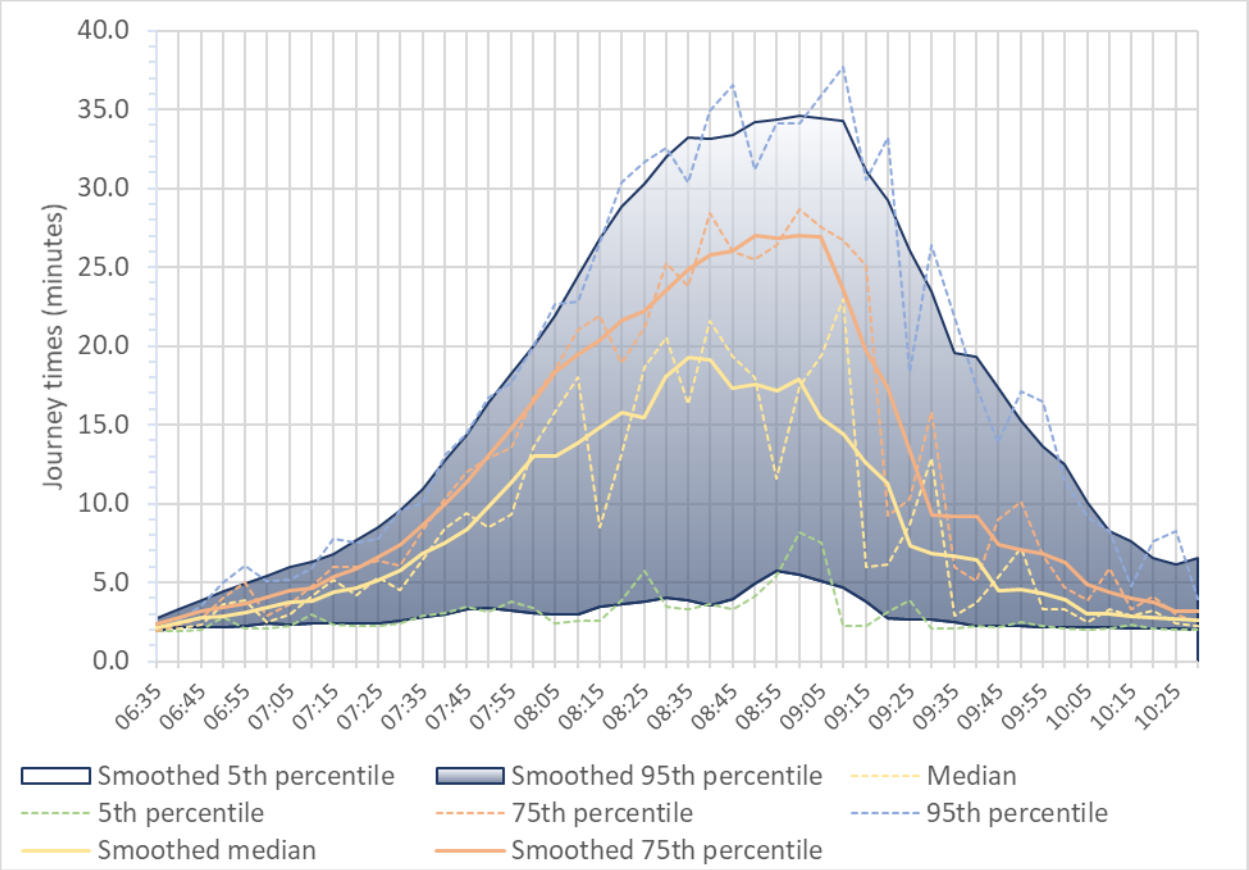

Figure 3: Inbound bus journey times on Madingley Hill (west of M11) in weekday morning peak

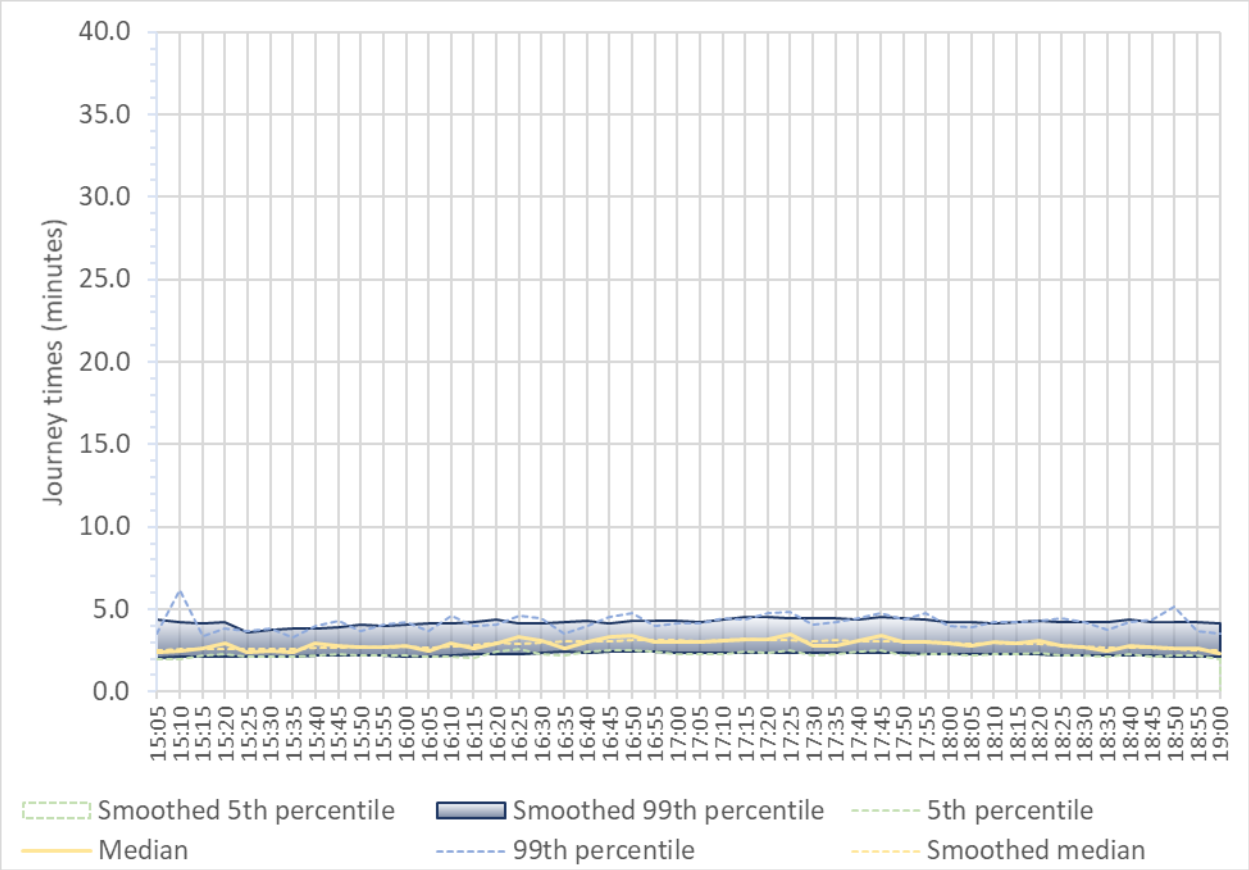

Figure 4: Outbound bus journey times on Madingley Hill (west of M11) in weekday evening peak (same vertical scale as Figure 3)

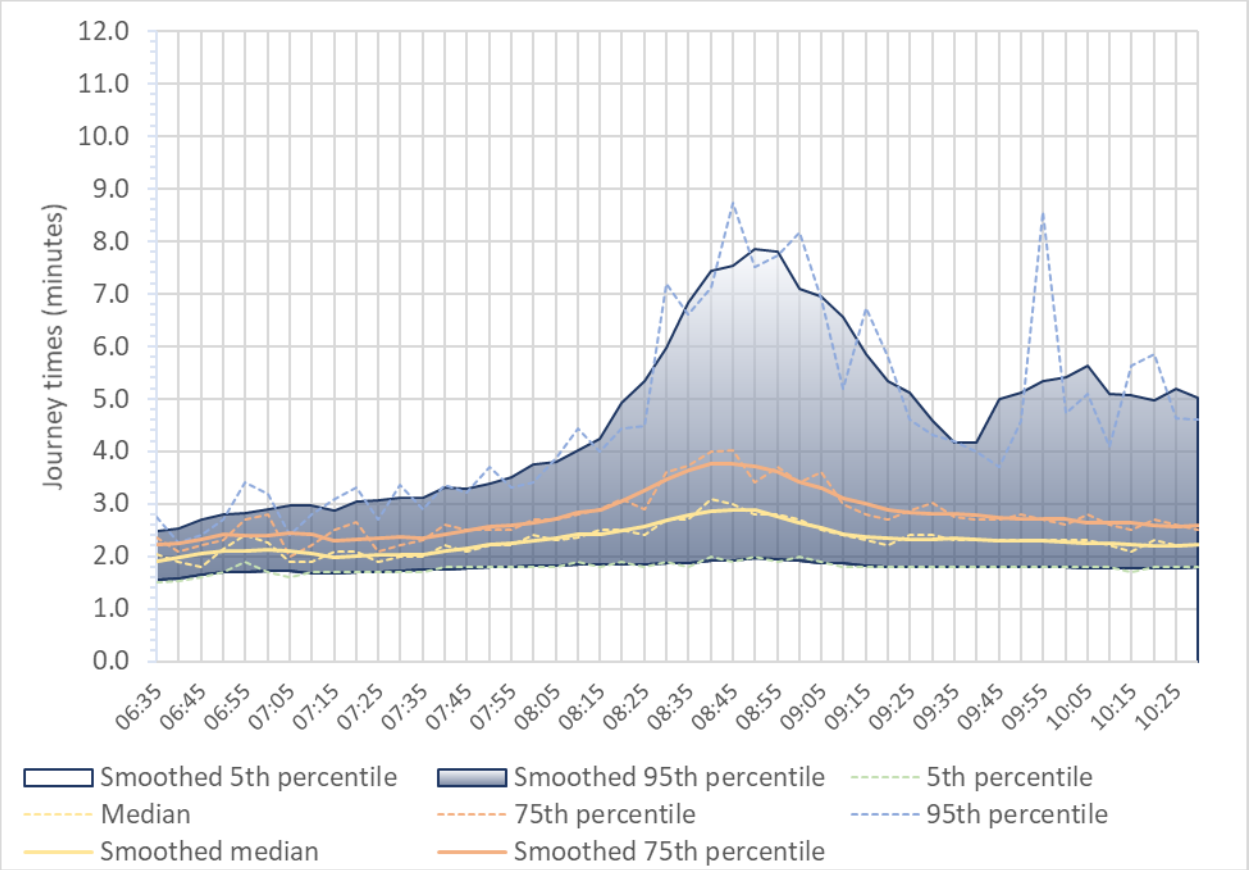

Figure 5: Inbound bus journey times on Madingley Road (east of P&R) in weekday morning peak

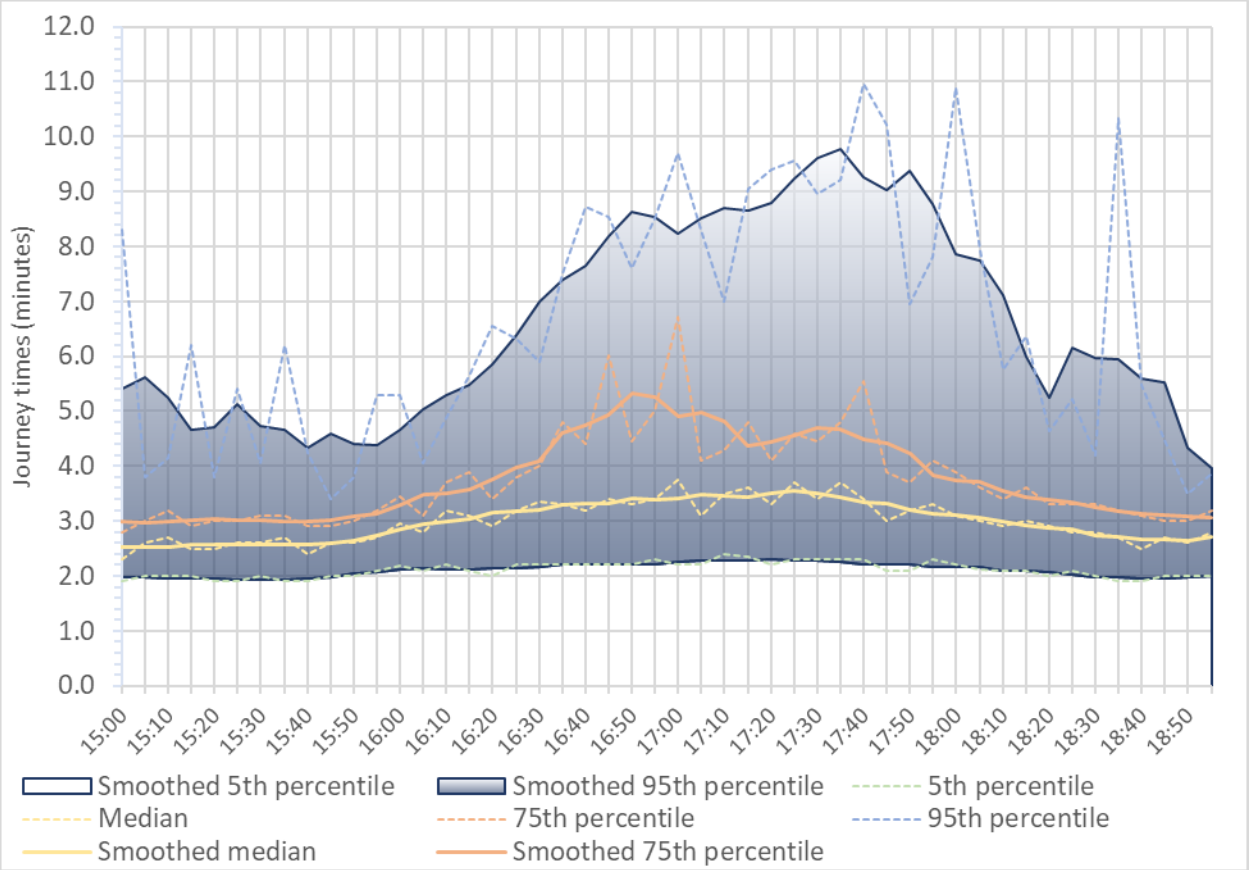

Figure 6: Outbound bus journey times on Madingley Rd (east of P&R) in weekday evening peak

Figure 7a: Annotated satellite map of proposed interventions on Madingley Rd (continued east on next pages)

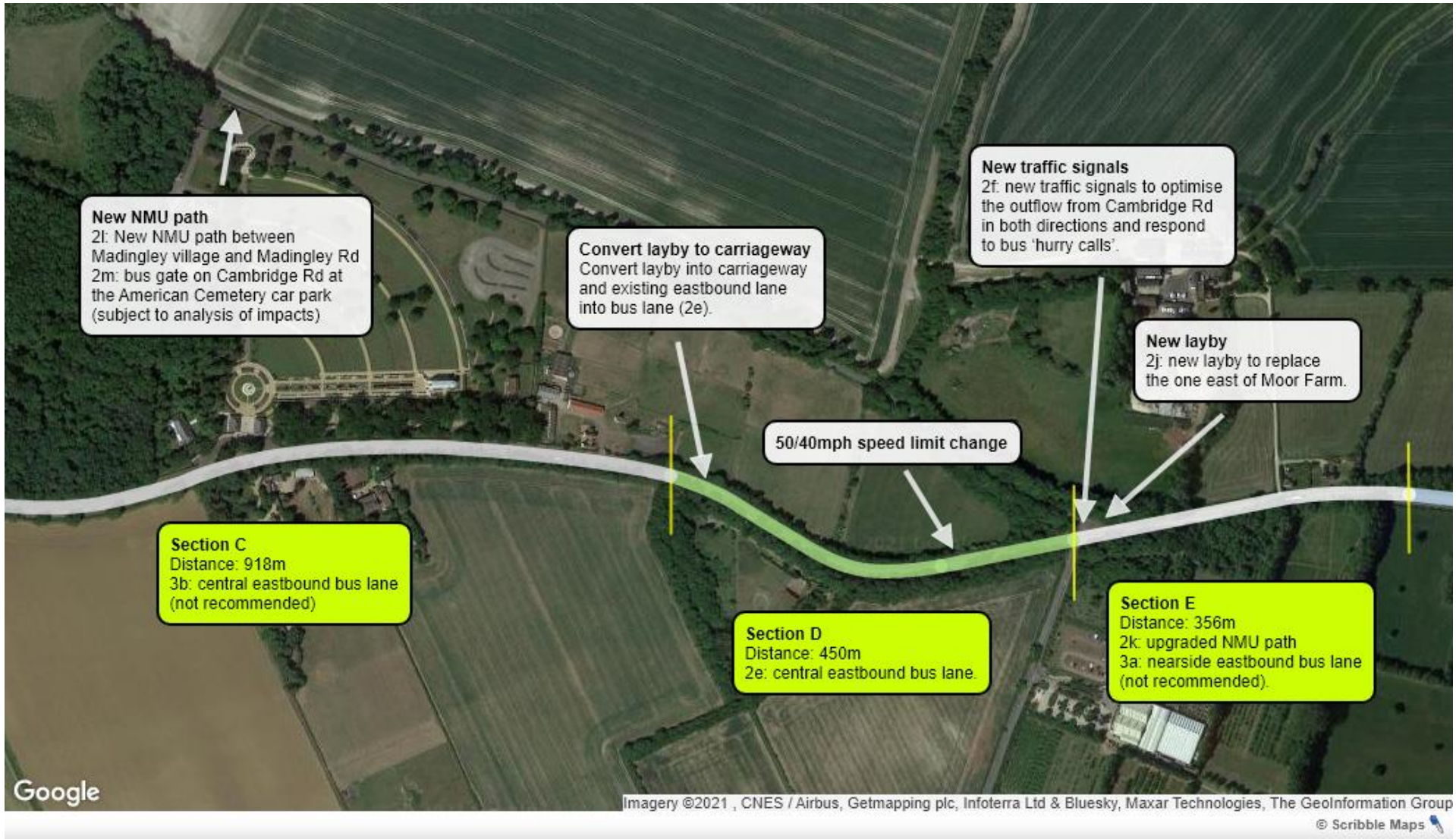

Figure 5b: Annotated satellite map of proposed interventions on Madingley Rd (continued east on next page and west on previous page)

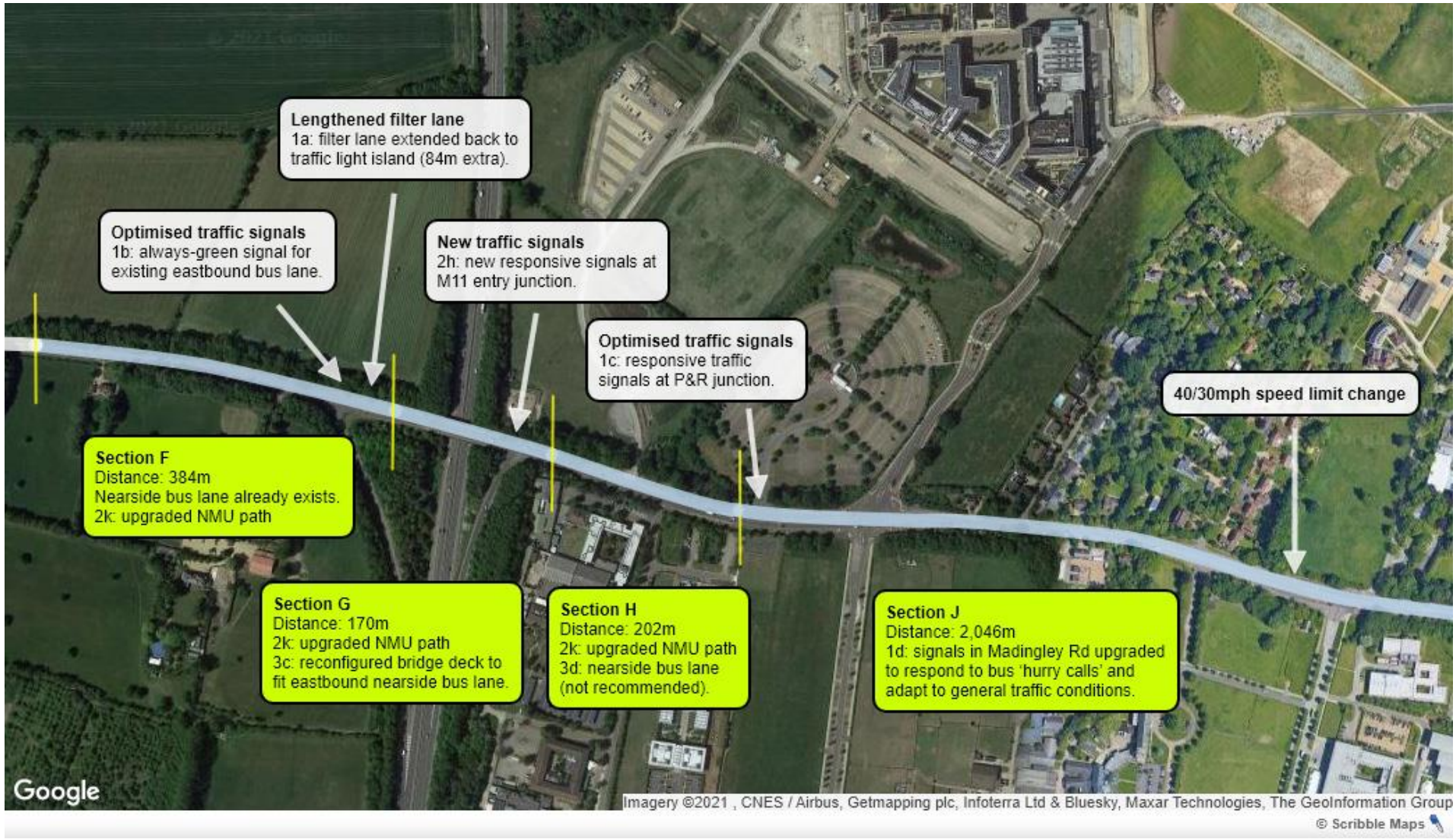

Figure 5c: Annotated satellite map of proposed interventions on Madingley Rd (continued west on previous pages)

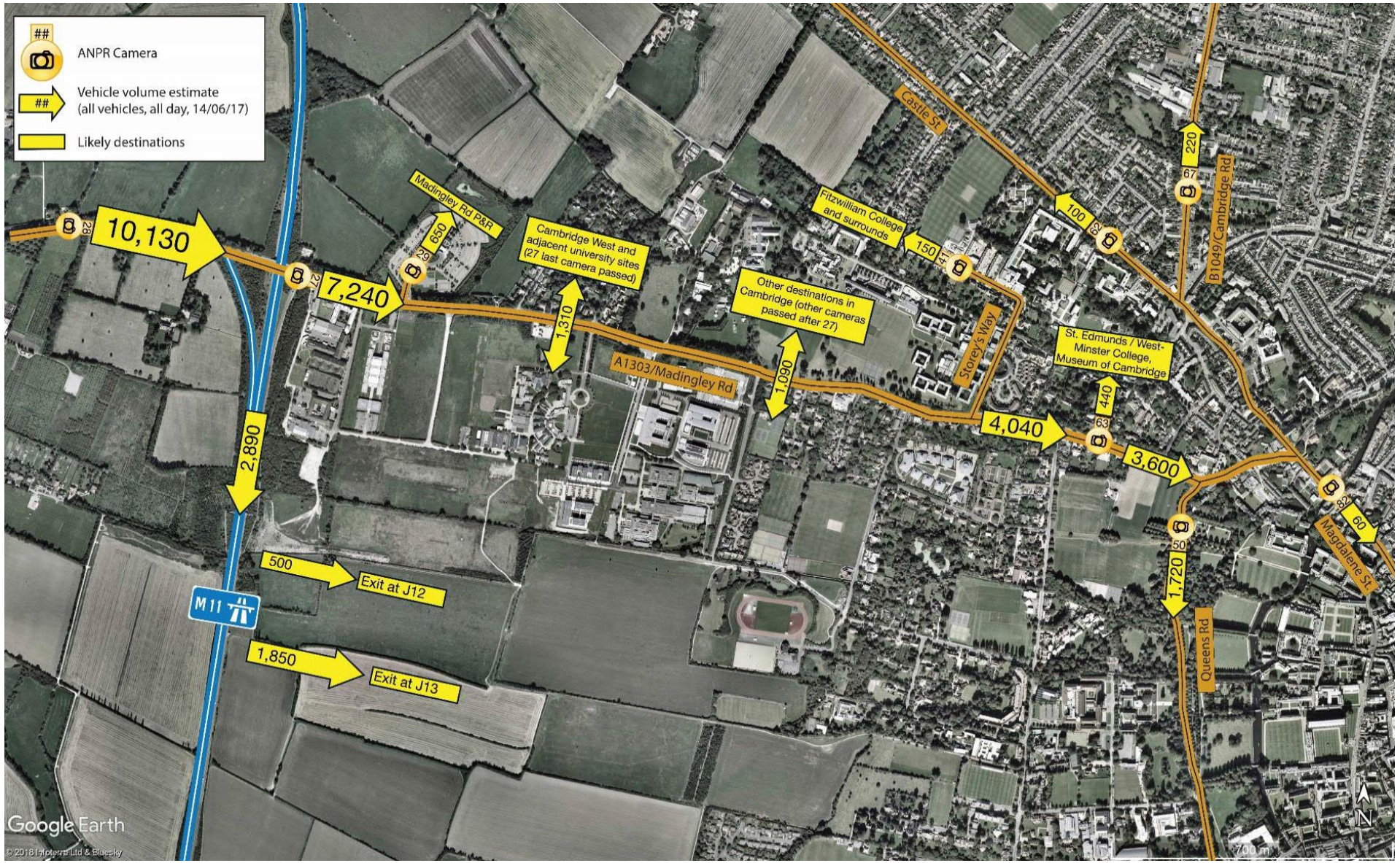

Figure 8: Whole-day (14 June 2017) traffic flow inbound on Madingley Rd and joining the M11 at Junction 13 (from NR page 8)

Figure 9a: Highway boundary from Madingley Mulch roundabout to Cambridge Rd junction – Sections B-D (from TSM © Crown)

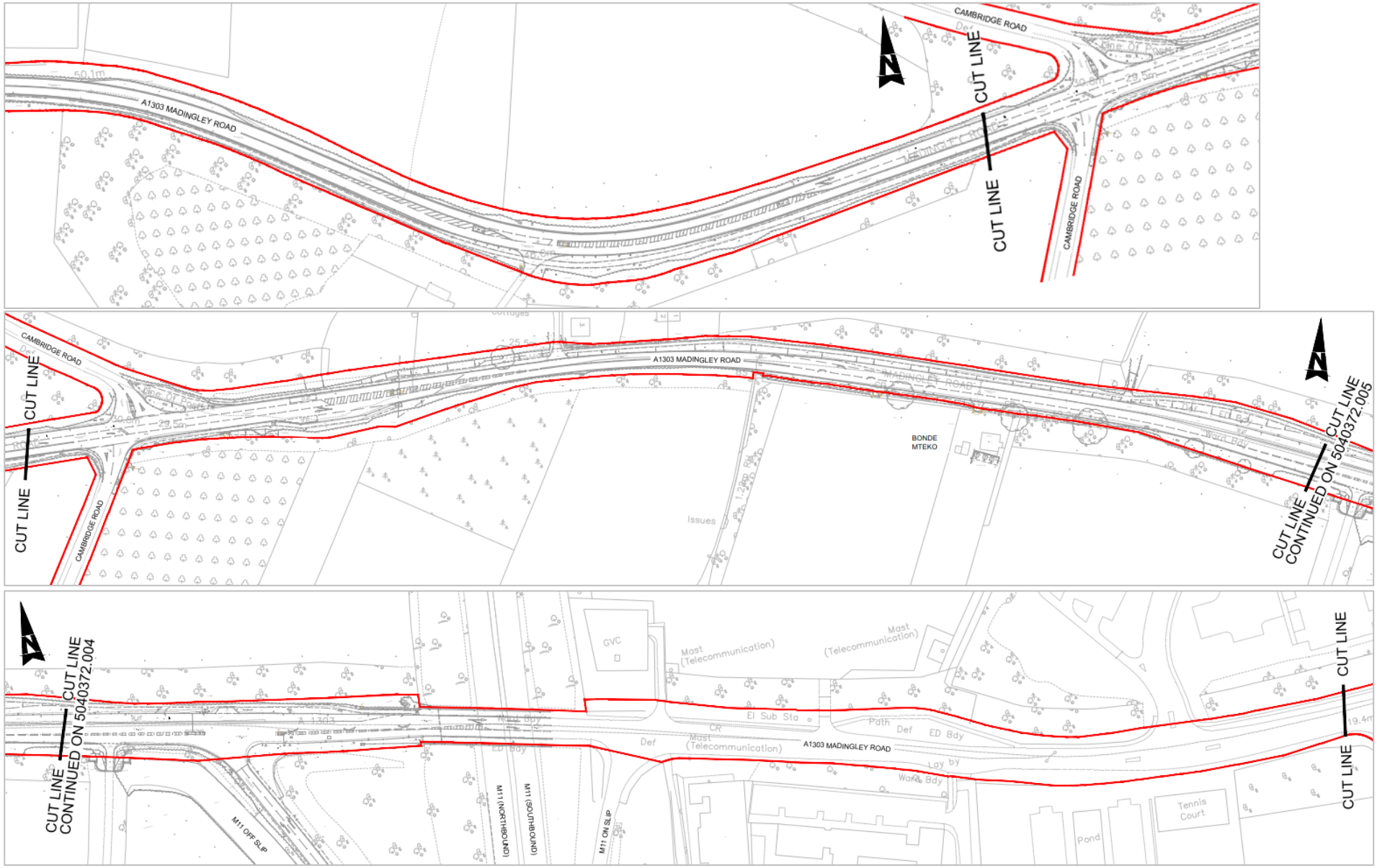

Figure 6b: Highway boundary between Mill Farm and Madingley Rd Park & Ride – Sections D–H (from TSM © Crown)

Figure 10: Changes proposed to A1303 at M11 junction as part of Bourn Airfield planning application (S/3440/18/OL)

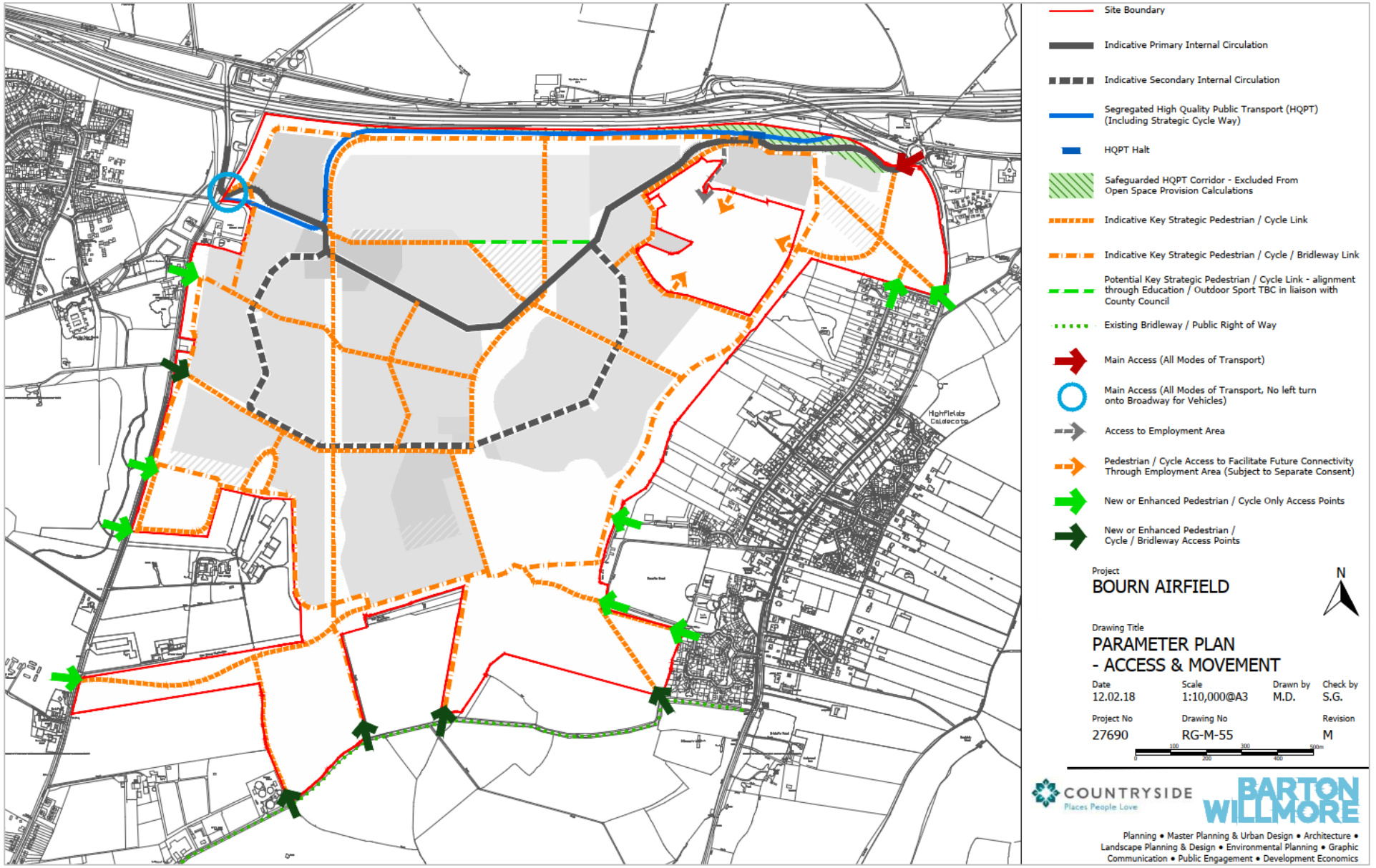

Figure 11: Proposed NMU routes through the Bourn Airfield site proposed in the outline planning application (S/3440/18/OL)

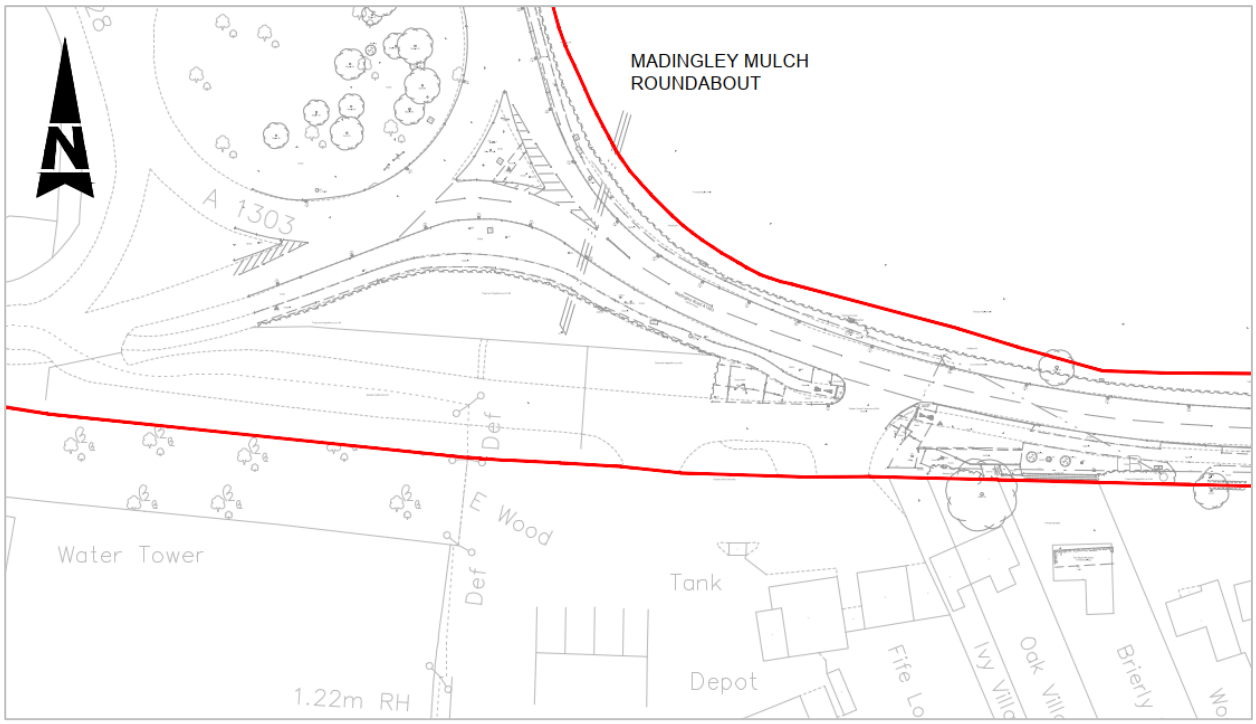

Figure 12: Highway boundary south of Madingley Mulch roundabout – Section A (from TSM © Crown)

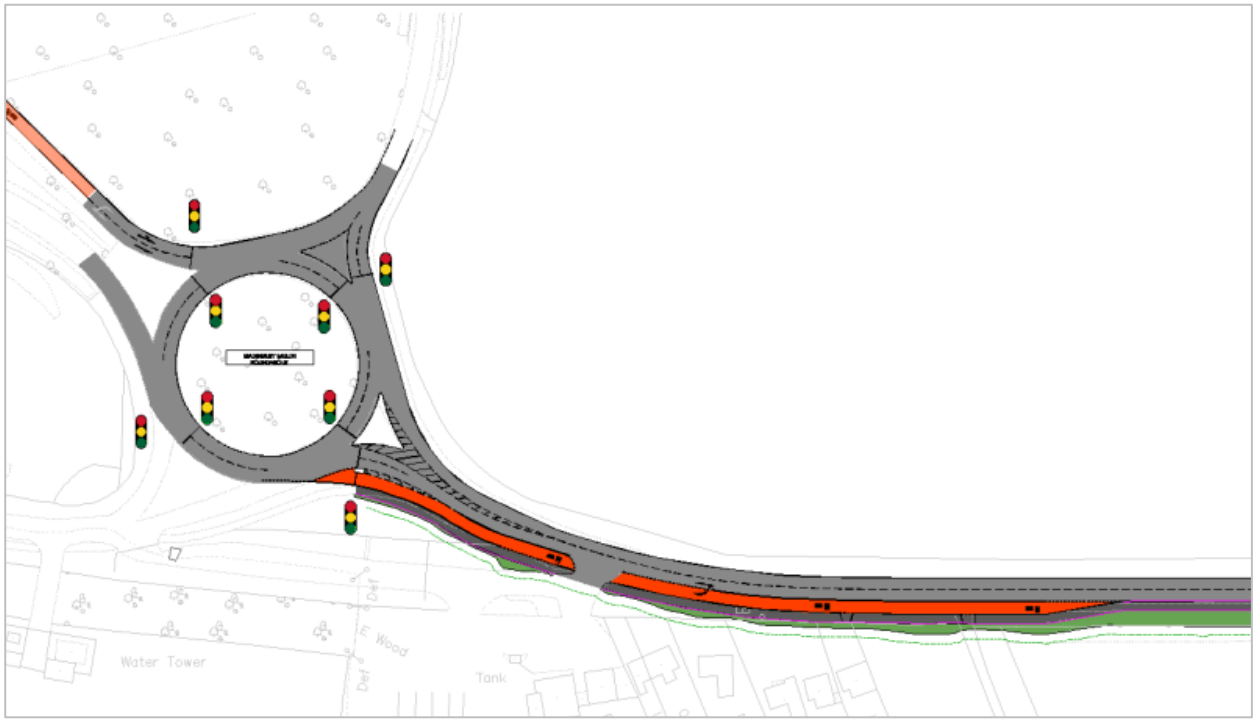

Figure 13: Westbound bus lane into Madingley Mulch roundabout (from QW 3.1/Mott MacDonald)

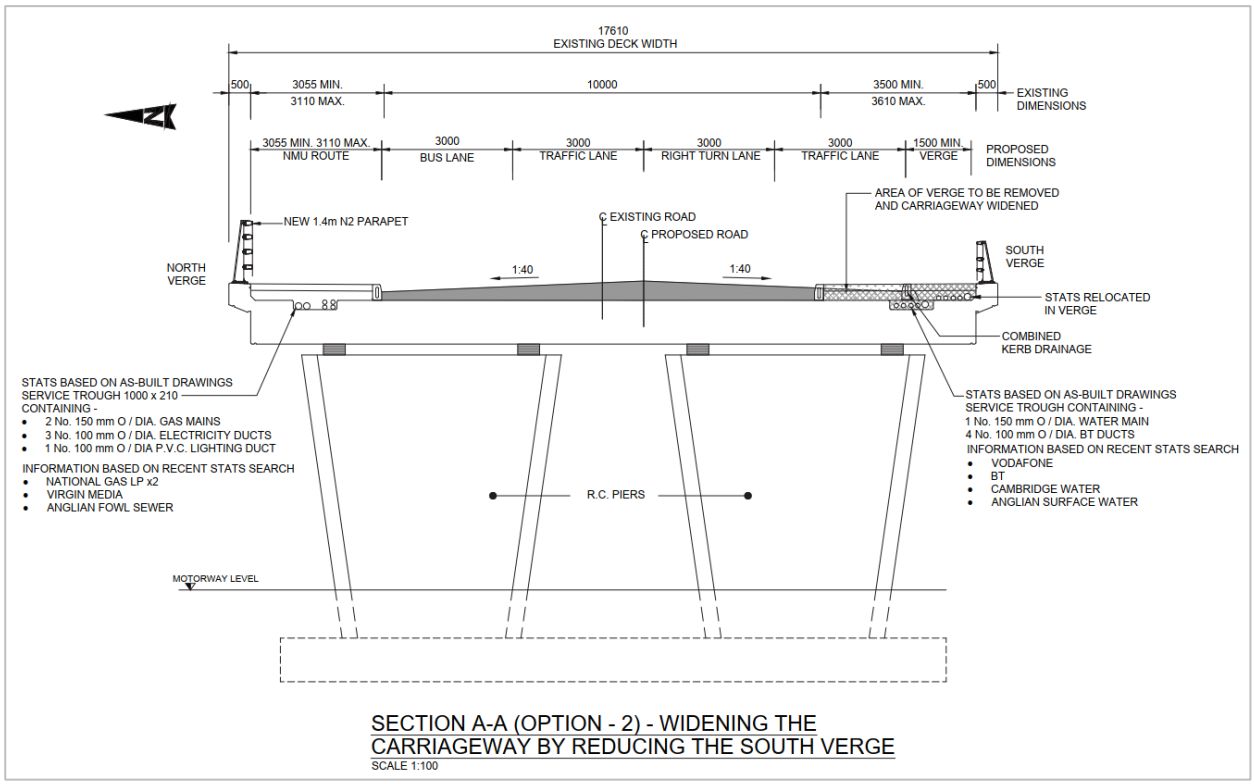

Figure 14: Four-lane configuration of M11 "Rectory Farm" bridge (from RFB page 33 © 2016 Atkins Ltd)

Figure 15: M11 exit junction with Madingley Rd (© 2020 Edward Leigh)

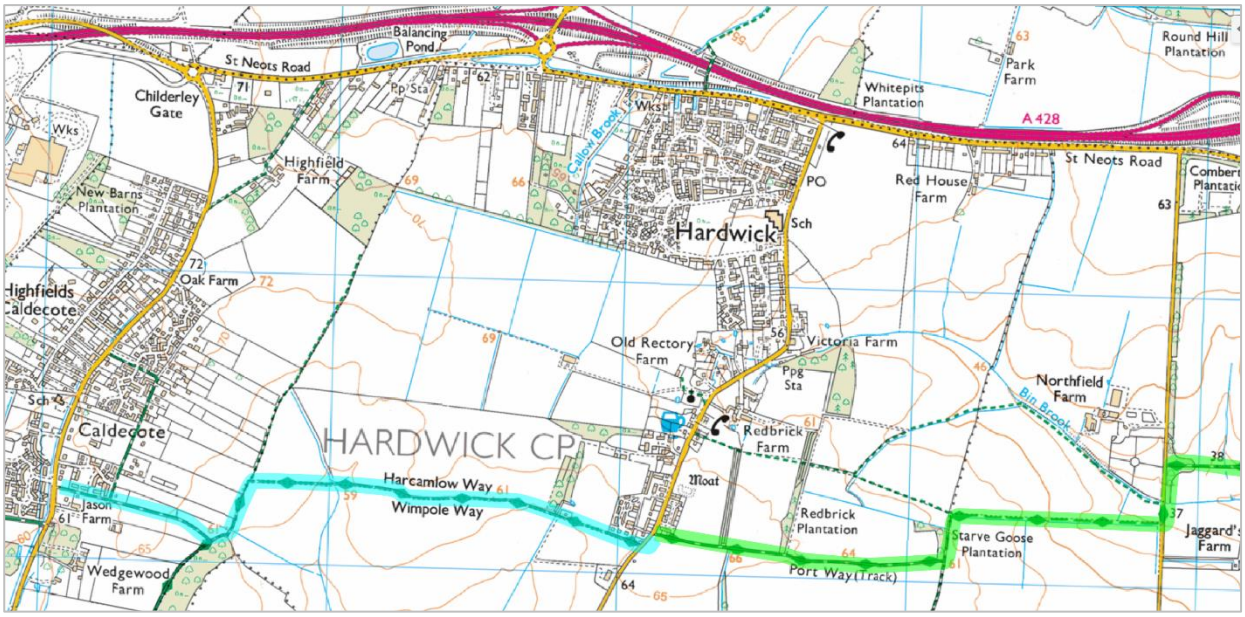

Figure 16: The Comberton Greenway (green) could be extended (blue) via the Harcamlow Way bridleway to Highfields Caldecote (shown here on the Ordnance Survey map)

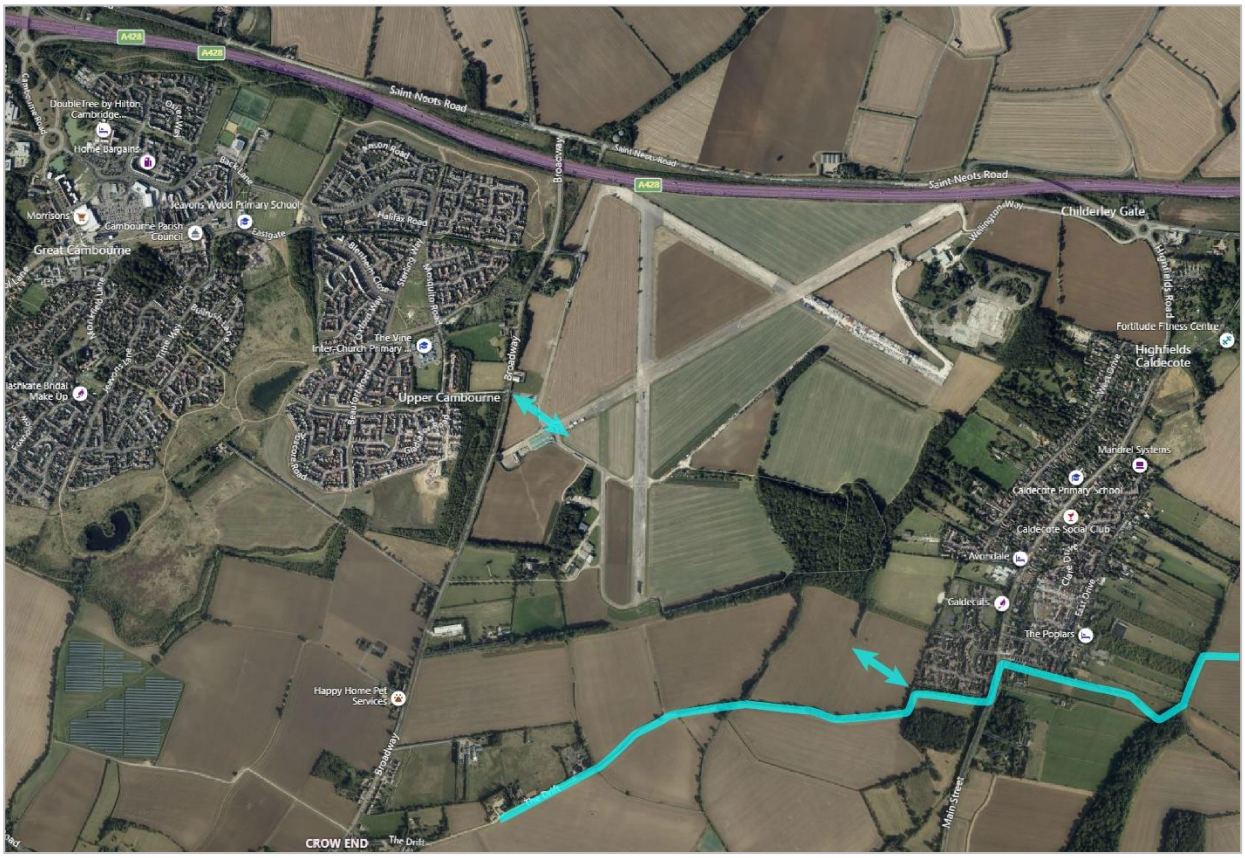

Figure 17: Indicative connection points for an NMU route through the Bourn Airfield development, connecting Cambourne to Highfields Caldecote and a westward extension of the Comberton Greenway, as shown in Figure 16 (Ordnance Survey imagery)

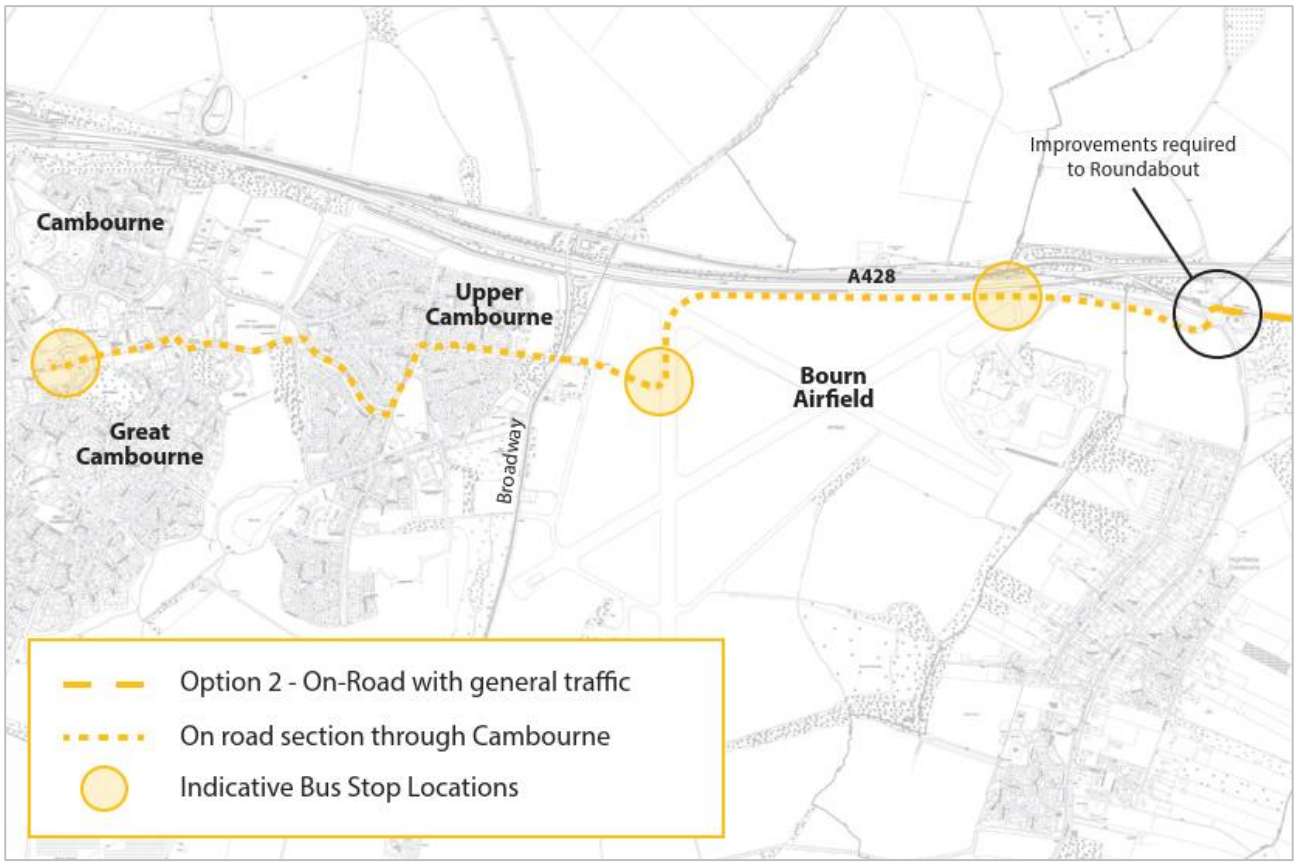

Figure 18: Indicative bus route as part of C2C Busway (from NTS page 38)

Figure 19: Technical drawing showing junction on Broadway with Bourn Airfield western access point (from OAR Part 3, page 70)

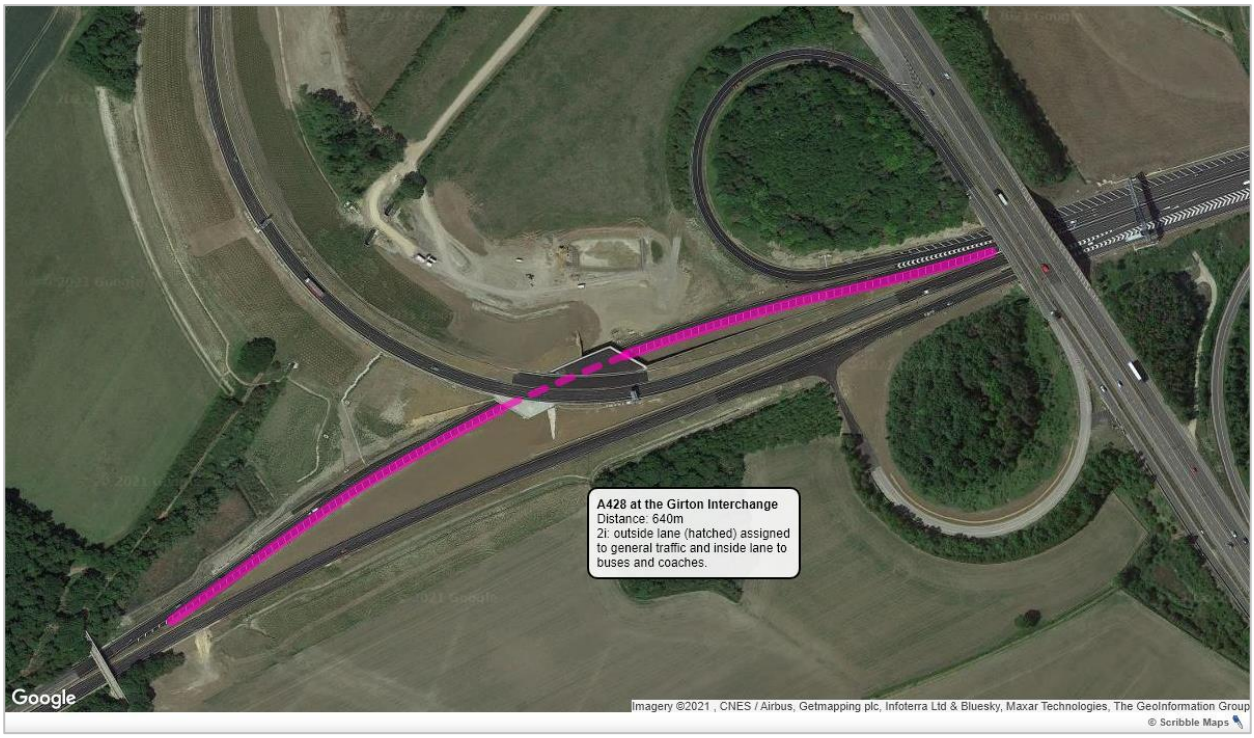

Figure 20: Reassignment of hatched outside lane on A428 at the Girton Interchange to create a 640m long bus and coach lane

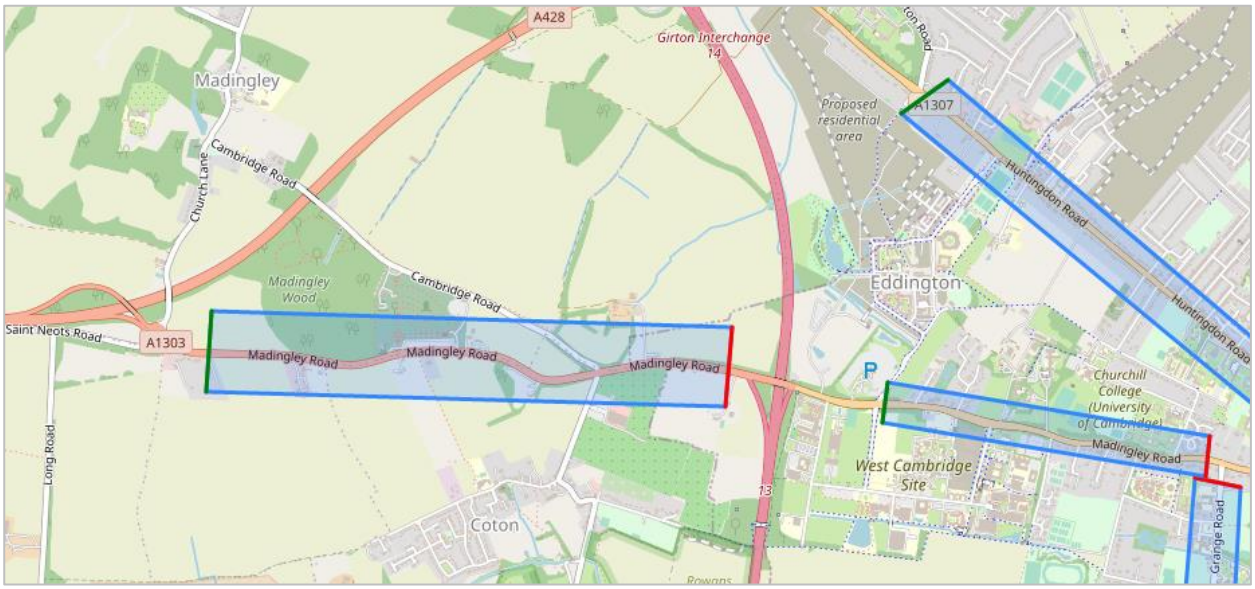

Figure 21: Bus tracking zones on Madingley Rd (from Smart Cambridge data hub)

Table 1: Assessed effects of recommended interventions on bus journey times

						Recommended interventions					
Slowest 95th percentile		**Fastest possible**		**2019**		**1a-c**		**1a-c, 2a-f**		**1a-b, 2a-g**	
	Distance (m)	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*
Section A.a (around roundabout)	190			2.27	3.1	2.27	3.1				
Section A.b (through roundabout)	110	20	0.2					20	0.2	20	0.2
Section B	208	50	0.2	2.27	3.4	2.27	3.4	50	0.2	50	0.2
Section B	367	50	0.3	2.27	6.0	2.27	6.0	50	0.3	50	0.3
Section C (American Cemetery)	918	50	0.7	2.27	15.1	2.27	15.1	2.27	15.1	8.01	4.3
Section D.1	308	50	0.2	2.27	5.1	2.27	5.1	35	0.3	45	0.3
Section D.2	142	40	0.1	2.27	2.3	2.27	2.3	40	0.1	40	0.1
Section E	356	40	0.3	2.27	5.8	2.27	5.8	2.27	5.8	2.27	5.8
Section F.1 (existing bus lane)	204	40	0.2	30	0.3	30	0.3	30	0.3	30	0.3
Section F.2 (existing bus lane)	180	40	0.2	30	0.2	35	0.2	35	0.2	35	0.2
Section G (M11 bridge)	170	40	0.2	2.27	2.8	10.97	0.6	10.97	0.6	10.97	0.6
Section H	202	40	0.2	10.97	0.7	20	0.4	20	0.4	20	0.4
Total	**3165.0**		**2.7**		**44.8**		**42.3**		**23.4**		**12.5**
Comparison with historic data	*2295.0*		*1.8*		*34.6*		*34.6*		*21.9*		*11.0*
Delay relative to fastest possible			0.0		42.1		39.6		20.7		9.8
Time saving relative to 2019			42.1				2.6		21.4		32.3
Slowest 75th percentile		**Fastest possible**		**2019**		**1a-c**		**1a-c, 2a-f**		**1a-b, 2a-g**	
	Distance (m)	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*
Section A.a (around roundabout)	190			2.92	2.4	2.92	2.4				
Section A.b (through roundabout)	110	20	0.2					20	0.2	20	0.2
Section B	208	50	0.2	2.92	2.7	2.92	2.7	50	0.2	50	0.2
Section B	367	50	0.3	2.92	4.7	2.92	4.7	50	0.3	50	0.3
Section C (American Cemetery)	918	50	0.7	2.92	11.7	2.92	11.7	2.92	11.7	15.76	2.2
Section D.1	308	50	0.2	2.92	3.9	2.92	3.9	35	0.3	45	0.3
Section D.2	142	40	0.1	2.92	1.8	2.92	1.8	40	0.1	40	0.1
Section E	356	40	0.3	2.92	4.5	2.92	4.5	2.92	4.5	2.92	4.5
Section F.1 (existing bus lane)	204	40	0.2	30	0.3	30	0.3	30	0.3	35	0.2
Section F.2 (existing bus lane)	180	40	0.2	30	0.2	40	0.2	40	0.2	40	0.2
Section G (M11 bridge)	170	40	0.2	2.92	2.2	22.52	0.3	22.52	0.3	22.52	0.3
Section H	202	40	0.2	22.52	0.3	30	0.3	30	0.3	30	0.3
Total	**3165.0**		**2.7**		**34.8**		**32.7**		**18.3**		**8.7**
Comparison with historic data	*2295.0*		*1.8*		*27.0*		*27.0*		*17.3*		*7.6*
Delay relative to fastest possible			0.0		32.1		30.0		15.6		6.0
Time saving relative to 2019			32.1				2.0		16.5		26.1
With bus lane											
With flow controls applied											

*Table 2: Assessed effects of non-recommended interventions on **bus** journey times*

						Alternative or complementary interventions							
Slowest 95th percentile		**Fastest possible**		**2019**		**1a-c, 2a-f, 3a**		**1a-c, 2a-g, 3a**		**1a-c, 2a-f, 3a-b**		**1a-c, 2a-f, 3a-c**	
	Distance (m)	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*
Section A.a (around roundabout)	190			2.27	3.1								
Section A.b (through roundabout)	110	20	0.2			20	0.2	20	0.2	20	0.2	20	0.2
Section B	208	50	0.2	2.27	3.4	50	0.2	50	0.2	50	0.2	50	0.2
Section B	367	50	0.3	2.27	6.0	50	0.3	50	0.3	50	0.3	50	0.3
Section C (American Cemetery)	918	50	0.7	2.27	15.1	2.27	15.1	8.01	4.3	50	0.7	50	0.7
Section D.1	308	50	0.2	2.27	5.1	40	0.3	45	0.3	40	0.3	40	0.3
Section D.2	142	40	0.1	2.27	2.3	40	0.1	40	0.1	40	0.1	40	0.1
Section E	356	40	0.3	2.27	5.8	40	0.3	40	0.3	40	0.3	40	0.3
Section F.1 (existing bus lane)	204	40	0.2	30	0.3	40	0.2	40	0.2	40	0.2	40	0.2
Section F.2 (existing bus lane)	180	40	0.2	30	0.2	35	0.2	35	0.2	40	0.2	40	0.2
Section G (M11 bridge)	170	40	0.2	2.27	2.8	10.97	0.6	10.97	0.6	10.97	0.6	40	0.2
Section H	202	40	0.2	10.97	0.7	20	0.4	20	0.4	20	0.4	40	0.2
Total	**3165.0**		**2.7**		**44.8**		**17.8**		**7.0**		**3.4**		**2.8**
Comparison with historic data	*2295.0*		*1.8*		*34.6*		*16.3*		*5.5*		*1.9*		*1.9*
Delay relative to fastest possible			0.0		42.1		15.1		4.2		0.7		0.1
Time saving relative to 2019			42.1				27.0		37.9		41.5		42.1
Slowest 75th percentile		**Fastest possible**		**2019**		**1a-c, 2a-f, 3a**		**1a-c, 2a-g, 3a**		**1a-c, 2a-f, 3a-b**		**1a-c, 2a-f, 3a-c**	
	Distance (m)	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*
Section A.a (around roundabout)	190			2.92	2.4								
Section A.b (through roundabout)	110	20	0.2			20	0.2	20	0.2	20	0.2	20	0.2
Section B	208	50	0.2	2.92	2.7	50	0.2	50	0.2	50	0.2	50	0.2
Section B	367	50	0.3	2.92	4.7	50	0.3	50	0.3	50	0.3	50	0.3
Section C (American Cemetery)	918	50	0.7	2.92	11.7	2.92	11.7	15.76	2.2	50	0.7	50	0.7
Section D.1	308	50	0.2	2.92	3.9	40	0.3	50	0.2	40	0.3	40	0.3
Section D.2	142	40	0.1	2.92	1.8	40	0.1	40	0.1	40	0.1	40	0.1
Section E	356	40	0.3	2.92	4.5	40	0.3	40	0.3	40	0.3	40	0.3
Section F.1 (existing bus lane)	204	40	0.2	30	0.3	40	0.2	40	0.2	40	0.2	40	0.2
Section F.2 (existing bus lane)	180	40	0.2	30	0.2	40	0.2	40	0.2	40	0.2	40	0.2
Section G (M11 bridge)	170	40	0.2	2.92	2.2	22.52	0.3	22.52	0.3	22.52	0.3	40	0.2
Section H	202	40	0.2	22.52	0.3	30	0.3	30	0.3	30	0.3	40	0.2
Total	**3165.0**		**2.7**		**34.8**		**14.0**		**4.4**		**3.0**		**2.8**
Comparison with historic data	*2295.0*		*1.8*		*27.0*		*12.9*		*3.3*		*1.9*		*1.9*
Delay relative to fastest possible			0.0		32.1		11.3		1.7		0.3		0.1
Time saving relative to 2019			32.1				20.8		30.4		31.8		32.0
With bus lane													
With flow controls applied													
With non-recommended bus lanes													

*Table 3: Assessed effects of recommended interventions or a continuous bus lane on **general traffic** journey times*

						Recommended interventions					
Slowest 95th percentile		**Fastest possible**		**2019**		**1a-c**		**1a-b, 2a-g**		**1a-c, 2a-f, 3a-c**	
	Distance (m)	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*
Section A.a (around roundabout)	190	20	0.4	2.27	3.1	2.27	3.1	2.27	3.1	2.27	3.1
Section A.b (through roundabout)	110										
Section B.1	208	50	0.2	2.27	3.4	2.27	3.4	1.04	7.5	2.27	3.4
Section B.2	367	50	0.3	2.27	6.0	2.27	6.0	1.04	13.2	2.27	6.0
Section C (American Cemetery)	918	50	0.7	2.27	15.1	2.27	15.1	8.01	4.3	2.27	15.1
Section D.1	308	50	0.2	2.27	5.1	2.27	5.1	2.27	5.1	2.27	5.1
Section D.2	142	40	0.1	2.27	2.3	2.27	2.3	2.27	2.3	2.27	2.3
Section E	356	40	0.3	2.27	5.8	2.27	5.8	2.27	5.8	2.27	5.8
Section F.1 (existing bus lane)	204	40	0.2	2.27	3.4	2.27	3.4	2.27	3.4	2.27	3.4
Section F.2 (existing bus lane)	180	40	0.2	2.27	3.0	2.27	3.0	2.27	3.0	2.27	3.0
Section G (M11 bridge)	170	40	0.2	2.27	2.8	10.97	0.6	10.97	0.6	10.97	0.6
Section H	202	40	0.2	10.97	0.7	10.97	0.7	10.97	0.7	10.97	0.7
Total	**3165.0**		**2.9**		**50.7**		**48.5**		**48.8**		**48.5**
Comparison with historic data	*2295.0*		*1.8*		*37.7*		*37.7*		*34.0*		*37.7*
Delay relative to fastest possible			0.0		47.8		45.6		46.0		45.6
Time saving relative to 2019			47.8				2.2		1.9		2.2
Slowest 75th percentile		**Fastest possible**		**2019**		**1a-c**		**1a-b, 2a-g**		**1a-c, 2a-f, 3a-c**	
	Distance (m)	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*	*Speed (mph)*	*Time (mins)*
Section A.a (around roundabout)	190	20	0.4	2.92	2.4	2.92	2.4	3.46	2.0	2.92	2.4
Section A.b (through roundabout)	110										
Section B.1	208	50	0.2	2.92	2.7	2.92	2.7	1.5	5.2	2.92	2.7
Section B.2	367	50	0.3	2.92	4.7	2.92	4.7	1.5	9.1	2.92	4.7
Section C (American Cemetery)	918	50	0.7	2.92	11.7	2.92	11.7	15.76	2.2	2.92	11.7
Section D.1	308	50	0.2	2.92	3.9	2.92	3.9	3.46	3.3	2.92	3.9
Section D.2	142	40	0.1	2.92	1.8	2.92	1.8	3.46	1.5	2.92	1.8
Section E	356	40	0.3	2.92	4.5	2.92	4.5	3.46	3.8	2.92	4.5
Section F.1 (existing bus lane)	204	40	0.2	2.92	2.6	2.92	2.6	3.46	2.2	2.92	2.6
Section F.2 (existing bus lane)	180	40	0.2	2.92	2.3	2.92	2.3	3.46	1.9	2.92	2.3
Section G (M11 bridge)	170	40	0.2	2.92	2.2	22.52	0.3	22.52	0.3	22.52	0.3
Section H	202	40	0.2	22.52	0.3	22.52	0.3	22.52	0.3	22.52	0.3
Total	**3165.0**		**2.8**		**39.2**		**37.3**		**32.0**		**37.3**
Comparison with historic data	*2295.0*		*1.8*		*29.3*		*29.3*		*22.2*		*29.3*
Delay relative to fastest possible			0.0		36.3		34.5		29.1		34.5
Time saving relative to 2019			36.3				1.9		7.2		1.9
Flow controls applied											
Flow control queueing											

Table 4: Inbound Flow Control effect at the slowest 95th and 75th percentile speeds

	2019		With Inbound Flow Control	
Speed percentile	*95th*	*75th*	*95th*	*75th*
Section B				
Speed (mph)	**2.27**	**2.92**	**1.04**	**1.50**
Flow rate (veh/hour)	512	718.8	514	715.6
Traffic density (veh/km)	140.1	129.1	153.5	148.2
Distance (m)	575	575	1125	1125
Number of vehicles	81	74	173	167
Section C				
Speed (mph)	**2.27**	**2.92**	**8.01**	**15.76**
Flow rate (veh/hour)	512	718.8	512	718.8
Traffic density (veh/km)	140.1	129.1	39.7	28.3
Distance (m)	918	918	918	918
Number of vehicles	129	119	36	26
Total number of vehicles	209	193	209	193

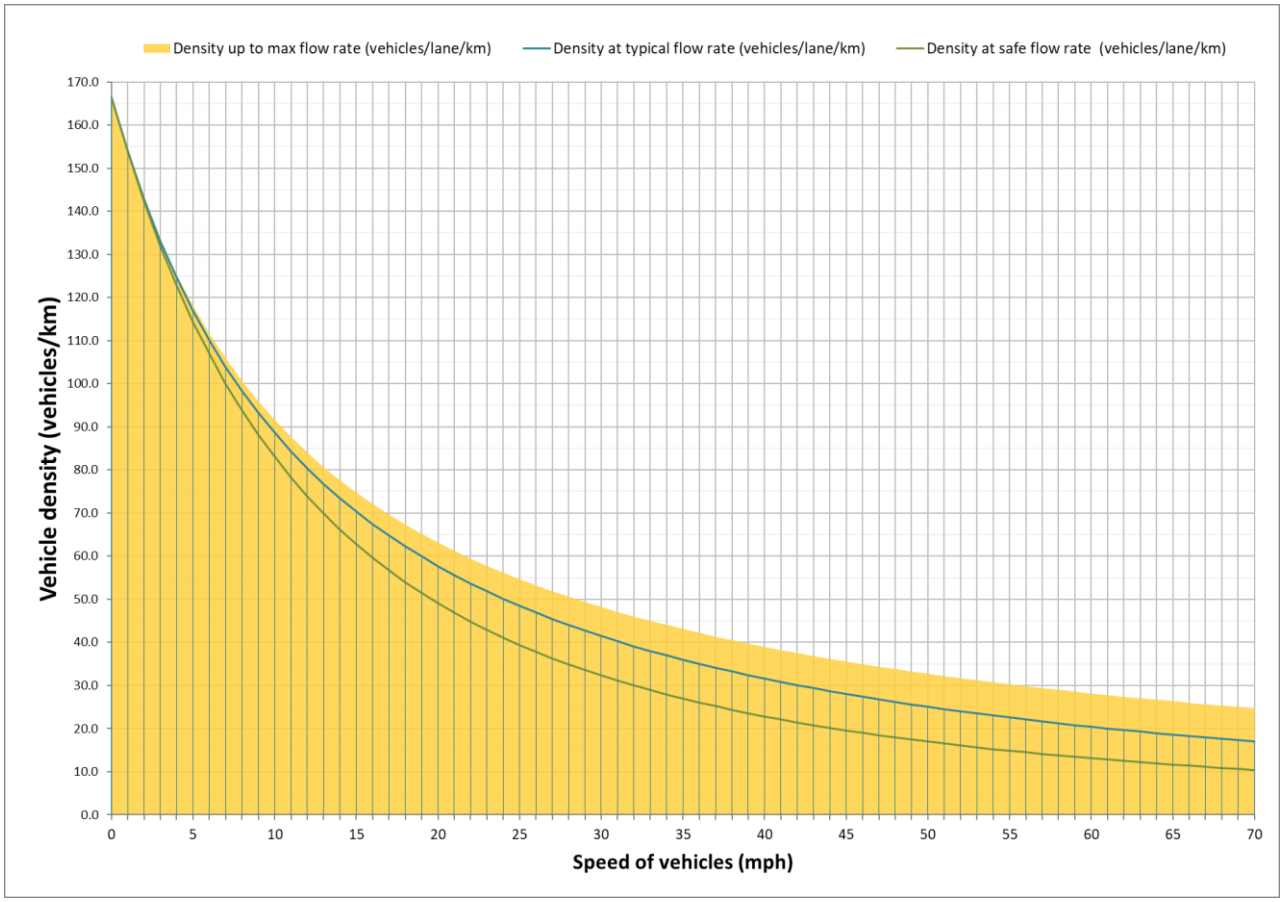

Figure 22: Relationship between traffic speed and density