Technical note 2

Project:	A428 Study	**To:**	Cambridgeshire County Council
Subject:	Tidal Bus lane Review	**From:**	Atkins
Date:	24 May 2016	**cc:**	

Introduction

As part of the A428 Corridor Study to improve the bus journey time between St Neots and Cambridge, Atkins put forward a feasibility option which includes the provision of new east-bound bus lane along part of A1303 Madingley Road between Madingley Mulch roundabout and M11 Junction 13 into Cambridge City.

Cambridgeshire County Council is, however, considering the possibility of introducing a tidal bus lane. In order to determine if a tidal bus lane would be feasible along this corridor, this technical note details existing schemes where tidal (or reversible) lanes have been implemented in the UK and other locations worldwide as a reference for further appraisal.

This note reviews the existing constraints along the corridor to determine the practicalities of introducing a bus lane, including its design and safety implications. The note then reviews the potential benefits of a tidal lane on this particular road section and provides recommendations.

Review of existing site constraints for A1303 Corridor

The existing site constraints which may be encountered for the A428 scheme proposals are divided into sections as follows.

Madingley Mulch Roundabout to Crome Lea Business Park

Madingley Road is 7.2m in width and when travelling eastbound the following features could be noted; access to Madingley Mulch Garden Supplies on the south side of Madingley Road along with accesses to residential properties. Following these property accesses there is one access to the north and one access to the south leading to agricultural land adjacent to Madingley Road.

A partially marked right turn area for eastbound traffic along Madingley Road leads to an access road to Crome Lea Business Park on the south side of Madingley Road which is approximately 5.2m in width.

Should a tidal flow lane be implemented at this location the main issue that would need to be considered is how traffic is managed when entering and exiting these side road / residential accesses.

Crome Lea Business Park to American Cemetery

Following the access to the Crome Lea Business Park there is a layby on the southern side of A1303 Madingley Road, the layby is approximately 65m in length and is partially utilised for a bus stop.

Approximately 100m after the layby the bus / coach entrance to the Cambridge American Cemetery is located on the north side of Madingley Road followed 75m later by the combined bus parking exit and the car park exit for all traffic. Directly opposite the Cemetery there are three residential property accesses on the south side of Madingley Road.

Should a tidal flow lane be implemented at this location the issue that would need to be considered is how traffic is managed when entering and exiting these side road / residential accesses, ensuring that the layby remains accessible to all traffic not dependant on the direction of the tidal lane, or whether provision of additional facilities are required on the opposite side of the A1303

Cambridge American Cemetery to Cambridge Road

A further 130m along Madingley Road there are three driveway accesses on the north side of the road, one of which is the exit from the American Cemetery car park, the other two appear to be to residential properties. The carriageway at this location is approximately 7.2m in width.

Technical note 2

Along this section of Madingley Road there is a layby on the northern side of Madingley Road, which is approximately 75m in length. Directly after the layby the carriageway widens to approximately 9.5m to provide an additional central right turn lane into a property access road on the southern side of Madingley Road, this turning lane is protected by traffic islands on both sides of the access possibly due to its location on the bend.

Madingley Road Straightens out as it approaches Cambridge Road where the carriageway is approximately 10.5m in width at this location. At the junction of Madingley Road and Cambridge Road right turn lanes are provided for both opposing directions of traffic.

Should a tidal flow lane be implemented at this location the issues that would need to be considered are; how traffic is managed when entering and exiting these side road / residential accesses, ensuring that the layby remains accessible to all traffic not dependant on the direction of the tidal lane, or whether provision of additional facilities are required on the opposite side of the A1303. The need for the hatched and protected right turn storage area on the bend approaching Cambridge Road would need to be assessed to determine its usage and necessity with regards to safety, and the implications of its removal to provide the required space for a tidal lane. Finally, as traffic approaches Cambridge Road the requirement for any bus facilities to be suitably terminated prior to the junction would need to be considered or the possibility that the junction may require signalisation in order to allow bus priority and time improvements.

Cambridge Road to M11 Junction 13

Following on from the Cambridge Road junction the carriageway narrows back to two lanes measuring approximately 7.2m over the length of approximately 120m where the carriageway widens once again to approximately 10.5m to provide a nearside bus lane for eastbound buses, this extends for 350m until the M11 overbridge where the bus lane terminates. At the junction with the off-slip from the M11 at Junction 13 the bus lane bypasses the junction and allows buses to continue eastbound unobstructed until after the junction where buses must then merge with normal traffic due to the width of the overbridge at this location.

For a tidal flow lane to be implemented along this section of the A1303 Madingley Road the main issue for consideration should be how the tidal lane should be terminated. The most feasible option would be to terminate the lane ahead of the M11 Junction to avoid confusion and the requirement to sign warnings of the tidal flow to motorists exiting the M11 at Junction 13. This would also enable to existing eastbound bus lane to be utilised on the approach to the junction.

M11 Junction 13 to Northampton Street

East of Junction 13 of the M11 Madingley Road becomes increasingly residential. The number of private accesses both to residences and educational centres increases. Similarly, the number of pedestrians and cyclists using and crossing the road also increases in this section. These characteristics make the introduction of a tidal bus flow lane along this section of the corridor impractical.

Design Considerations

Appendix A contains a review of tidal flow schemes in the UK and internationally. Of these the majority make use of overhead signals to allow motorists to identify which lane can be used by which type of vehicle and when. They all have a central lane or lanes that switch directions at peak periods to provide increased capacity in one direction.

Schemes in the UK with tidal lanes have a continuous lane along the entire length of the scheme rather than allowing short sections of tidal flow, this enables motorists to identify the tidal flow sections and know when they begin and end.

The main constraint to a scheme of this type is controlling the movement of traffic at accesses along the route where right turn lanes are currently provided to allow the free flow of traffic continuing along the main line. Vehicles waiting in a normal traffic lane to turn right could cause traffic to back up behind them, which although temporary, could happen regularly at peak periods.

In addition to this, overhead lane designation signals would be required to provide all road users with the necessary information with regard to lane use, which could be visually intrusive on the surrounding area. A more modern design for the overhead mounting arrangement could improve the aesthetics of the scheme.

Technical note 2

For the effective implementation of a tidal bus lane along the A1303 Madingley Road the following features would most likely be required:

1. Road space available for a minimum of three continuous lanes;
2. The provision of overhead signals;
3. Removal of the provision of right turn lanes;
4. The junction of Madingley Road / Cambridge Road to be signalised; and
5. The provision of advanced signage.

Three continuous lanes

Of the three lanes, a central lane could be reversed at peak times. This could be in the form of a central bus lane which swaps directions (Table 1) or in the form of a nearside bus lane eastbound in the AM peak period and a nearside westbound bus lane in the PM peak period (Table 2). The latter would require more management of the lane switch over as this would most likely require an additional stage to the lane changeover.

Tables 1 and 2 show the potential arrangement of lanes along the A1303 and how a tidal lane could be operated.

Table 1 shows the centralised tidal bus lane option and where only buses can use the central lane, this lane switches direction to allow buses to flow freely during peak periods.

Table 2 shows the nearside bus lane option, where during peak periods the nearside lane in the busiest direction is a bus lane with the central lane being used for general traffic in the same direction. This is a more complicated option and requires a two stage changeover period as there would be need to be a period of time where the central lane is unused.

	AM	Changeover Period	PM
Lane 1	All Traffic (Eastbound)	All Traffic (Eastbound)	All Traffic (Eastbound)
Lane 2 (Tidal lane)	Buses (Eastbound)	Unused	Buses (Westbound)
Lane 3	All Traffic (Westbound)	All Traffic (Westbound)	All Traffic (Westbound)

Table 1. Central tidal flow bus lane option

	AM	Changeover Periods		PM
Lane 1	Buses (Eastbound)	All Traffic (Eastbound)	All Traffic (Eastbound)	All Traffic (Eastbound)
Lane 2 (Tidal lane)	All Traffic (Eastbound)	Unused	All Traffic (Westbound)	All Traffic (Westbound)
Lane 3	All Traffic (Westbound)	All Traffic (Westbound)	Unused	Buses (Westbound)

Table 2. Nearside bus lane option with tidal central lane

Technical note 2

Overhead signals

Overhead signals would be necessary to control the lane usage. These would need to span all three lanes to ensure drivers are informed of the lane designation / direction as it would not be practical to convey the tidal flow message to drivers effectively using only roadside signage.

Overhead signals are required to be between 5.5m and 9m in height, as per the Traffic Signs Regulations and General Directions (TSRGD) (2016). Gantries of this height which span three lanes are also likely to require large foundations.

Removal of right turn lanes

Removing right turn areas / lanes from minor junctions to free up road space for the additional tidal flow lane.

Signalisation of Madingley Road / Cambridge Road Junction

If the junction is not signalised, any bus lanes may need to terminate prior to the junction with enough distance for general traffic to be able to merge into the lane of their choice.

To ensure buses are able to approach the junction and pass through it with relative ease, signalisation may be necessary. This could depend on the method of tidal flow as shown in Tables 1 & 2.

Advance Signage

Providing signage in advance of the tidal flow lanes to ensure drivers are aware of the upcoming restrictions on lane use. Signs would need to inform drivers of the individual lane control in force and that there are restrictions on the type of vehicle that can use each lane. Variable Message Signs could be used in this instance to provide more information of the current status of the tidal flow.

AM and PM Peak Benefits

The sections above have established that subject to design and further investigation a tidal bus lane could be implemented along the 2.5km section of the A1303 Madingley Road from Madingley Mulch Roundabout to the junction with the M11.

However, doing so would require introduction of gantries and advance signage, restriction of right hand turns and could potentially lead to safety incidents. The potential benefits of implementing a tidal bus lane along this section will need to be considered against these issues.

Traffic Delays on Madingley Rise

The Cambridge Sub-Regional Model (CSRM) has been used to generate predictions of traffic delays to car users on this section of Madingley Rise in 2021. The AM peak and PM peak have been considered separately and are shown in Figures 1 and 2 below. It is worth noting that the model predicts traffic on a “typical” day (i.e. it cannot forecast variation due to route unreliability).

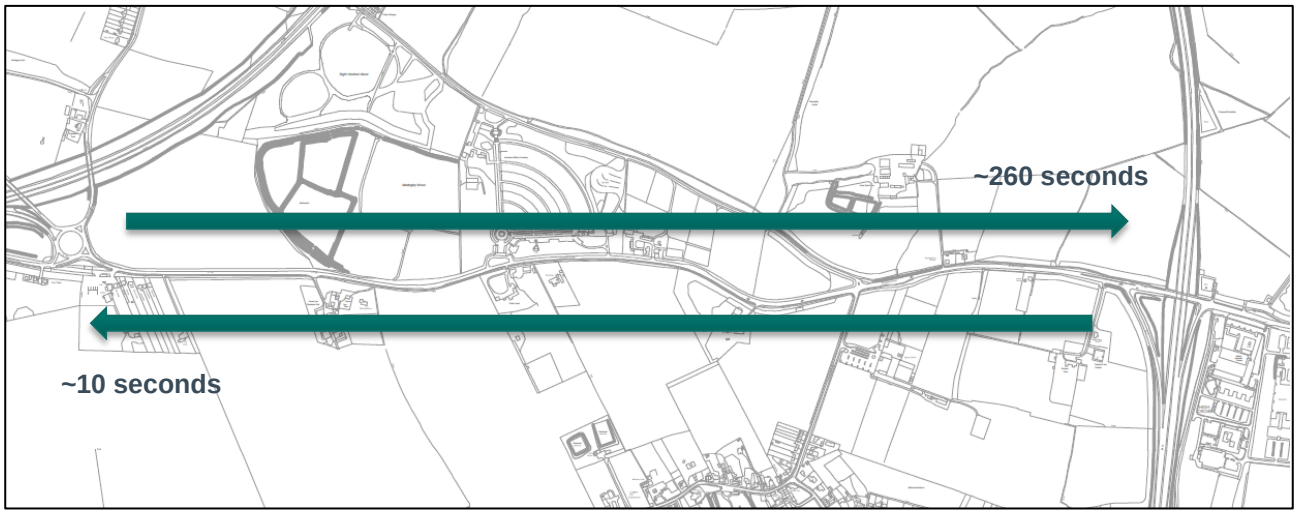

Figure 1: Predicted 2021 AM Peak Delays

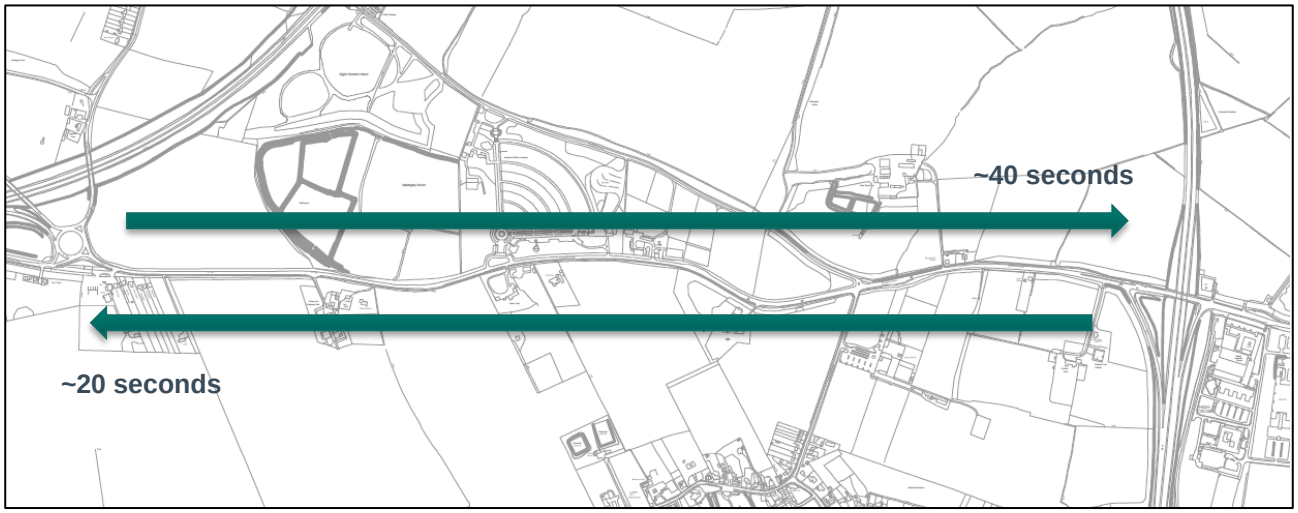

Figure 2: Predicted 2021 PM Peak Delays

These figures show that in the AM peak period the significant delay is eastbound approaching the M11 junction. The section already has a short section of bus lane on approach to the bridge, although the magnitude of the delay implies that the queue will be quite extensive; a longer section of bus lane to avoid that queue is likely to be beneficial.

The presence of this queue is likely to incentivise car users to park their car and switch to public transport if bus priority which bypasses the queue can be provided along this section. The proposed location of the Park and Ride at Madingley Mulch would facilitate this modal switch. However, it is worth noting that introduction of a Park and Ride and bus priority is unlikely to completely eliminate queues, as car users will likely only switch modes once the road is at capacity.

Westbound the delays are not as significant, and amount to a predicted 8 seconds in the AM peak and 17 seconds in the PM peak. A tidal bus lane which switches to westbound operation in the PM peak is therefore likely to have only minor journey time benefits compared to the benefits obtained in the AM peak period.

Reliability

As explained above, it is not possible to use CSRM to predict the reliability of car or bus journeys in future. However the various infrastructure solutions being considered by the scheme can be ranked in terms of their reliability, as shown in Table 3.

Greater reliability

Infrastructure	Comments
Uni-directional bus lane	Provides a certain level of reliability, but buses are still subject to obstructions such as stopped cars, or may need to travel slowly whilst waiting to overtake cyclists
Bi-directional bus lane	As above, but would offer greater reliability in the PM peak too
Segregated bus route	Greatest reliability. No interaction with other modes (except for discrete incidents).

Table 3. Reliability of different infrastructure types

Bi-directional bus lanes would offer reliability benefits both in the eastbound and westbound directions, but the most reliable solution is to provide a completely segregated route for the bus. This infrastructure has the advantage of being bi-directional and eliminates the possibility of interference from other road users (e.g. turning vehicles or cyclists), providing the greatest reliability.

Options 1 North and 1 South, which are being tested as part of the continued assessment of the A428 route options, both offer the possibility of achieving completely segregated routes to bypass queues on Madingley Rise while achieving a high level of reliability.

Conclusion

Following initial assessment of the road characteristics from Madingley Mulch roundabout to Northampton Street, it would be possible to implement a tidal lane along the 2.5km section of A1303 Madingley Road between Madingley Mulch roundabout and the M11. This is providing there is suitable redesign of this section of the route, in particular its junction with Cambridge Road. This would most likely be in the form of overhead signal controlled lanes similar to that of the Lincoln and Sheffield schemes.

However, the road section from the M11 to Northampton Street contains many junctions and residential accesses to be accommodated restricting a tidal bus lane to be practical.

Introduction of a tidal bus lane is likely to have significant safety implications and would require alterations to the road environment. These dis-benefits should be assessed against the potential benefits of providing bi-directional priority along this section.

Examination of predicted traffic flows in 2031 in the AM and PM peak has shown that delays are more severe during the AM peak on Madingley Rise and in the section approaching the M11. Car users would therefore be incentivised to leave the car at a Park and Ride site further upstream, if a scheme with east-bound priority allowed them to bypass these queues (therefore forcing them to travel back to the Park and Ride by bus in the evening).

Delays during the PM peak are not as severe as those in the AM peak, and therefore the journey time benefits of providing bus priority in the westbound direction are not as significant.

Some reliability benefits could be obtained from the introduction of tidal bus lanes, but these will be less than those provided by a completely segregated bus route, which is being explored by some of the other project options.

Given the engineering considerations and safety implications of a tidal bus scheme and the high-level assessment of journey time benefits likely to be achieved in the eastbound and westbound directions, it is recommended that an east-bound only bus lane is provided on Madingley Rise. Introduction of a tidal bus lane would have significant safety, maintenance and townscape impacts for a limited benefit to journey times during PM periods.

Technical note 2

Appendix A. Review of Tidal Flow Schemes

Existing tidal flow schemes in the UK

A38(M) Aston Expressway (Birmingham)

The A38(M) Aston Expressway in Birmingham links the A38 at its junction with A4045 at Dartmouth Circus to the north of Birmingham City Centre to the M6 Motorway at the Gravelly interchange (Junction 6, Spaghetti Junction).

The tidal flow section of the A38(M) is 1.6 miles in length and at its widest is a seven lane carriageway. Of these seven lanes, the central lane highlighted with red surfacing has a prohibition of motorcyclists at all times due to the centrally located drainage system which would be dangerous to motorcyclists. This central lane acts as a "buffer" lane, when 3 lanes of traffic can travel in each direction with a lane between them. During AM and PM peaks this typically changes to four lanes in one direction and two lanes in the opposite direction maintaining the one lane "buffer".

The lanes are managed with overhead gantries with lane indicator signals to TSRGD Diagrams 5001.1, 5003 & 5005, these are located at regular intervals ranging between 250m and 400m apart. Visually these are similar to gantry lane signage found on a number of motorways and is not out of place in this location.

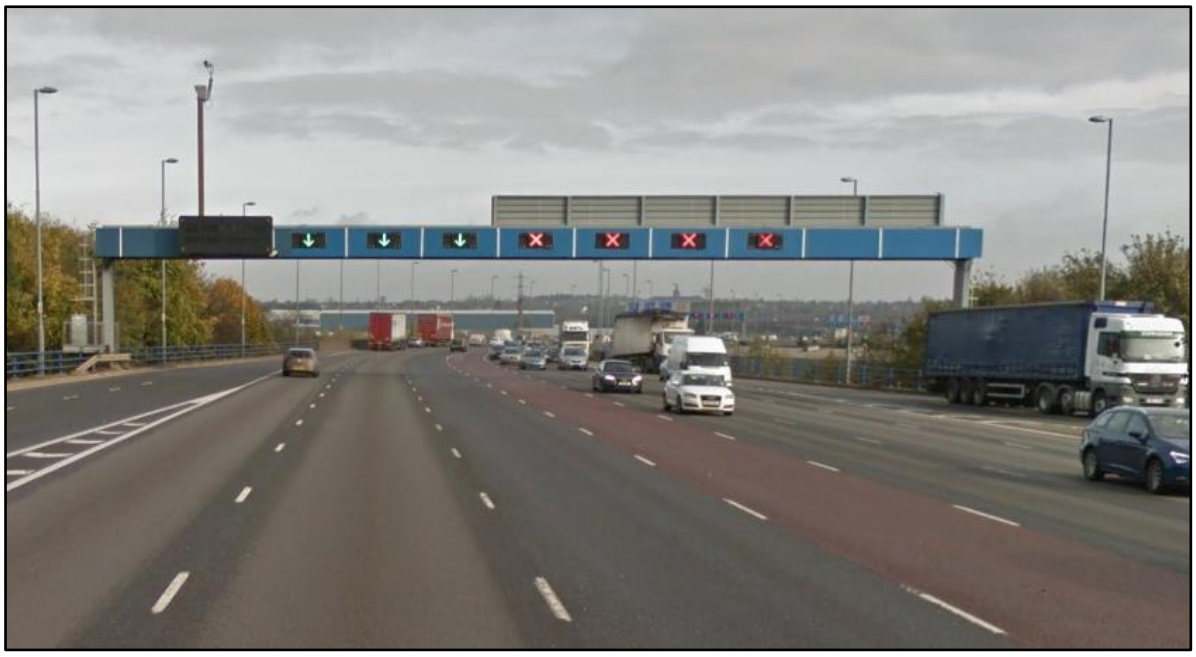

Figure 1: Northbound view of A38(M) Aston Expressway

A15 Canwick Road (Lincoln)

This tidal flow all traffic lane begins on the A15 Canwick Road at the junction of A15 Canwick Road / A15 South Park Avenue and B1188 Canwick Road. This scheme is approximately 420m in length comprising of three normal traffic lanes using nine Gantry / Cantilever mounted lane indicator signals to TSRGD Diagrams 5001.1, 5003 & 5005 to control the direction of flow at peak periods.

Both approaches have signage to TSRGD Diag. 5011 indicating the use of lane control signals on the road ahead. The central lane on this road section is not highlighted on the carriageway and all lane designation signals are of the same size. The existing lane designation signs without any backing board could have

visibility issues under certain light conditions. The overhead gantries reduce footway space on both sides of the carriageway however they are less visually intrusive in this partly industrial area.

Recent improvements at the junction of A15 Canwick Road / A15 South Park Avenue & B1188 Canwick Road have seen new cantilever mounted signal equipment replacing the previous gantry structures. These have only been replaced in locations where the signals span two lanes rather than three, it is unknown if there is a limitation.

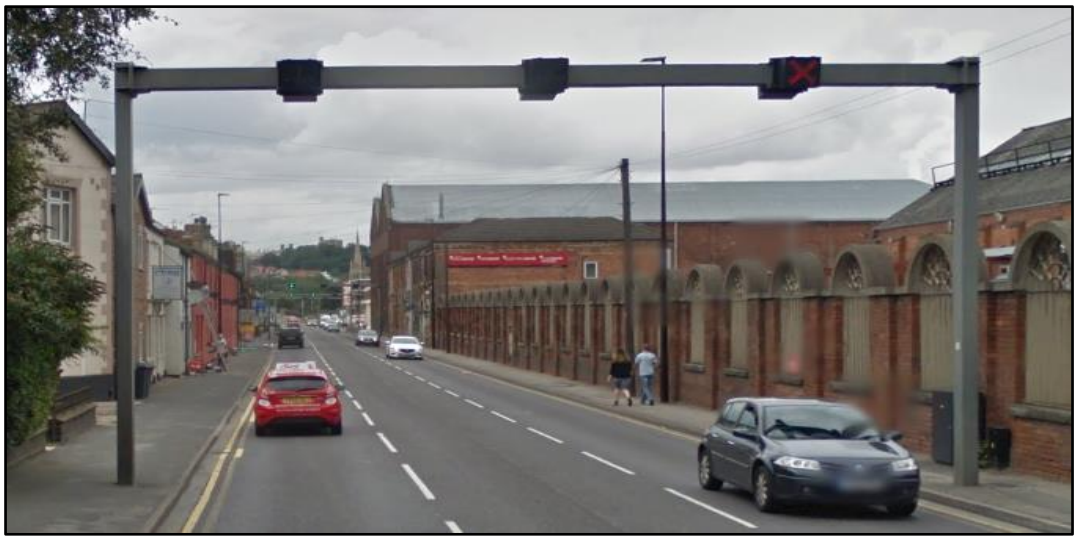

Figure 2: Northbound view of A15 Canwick Road

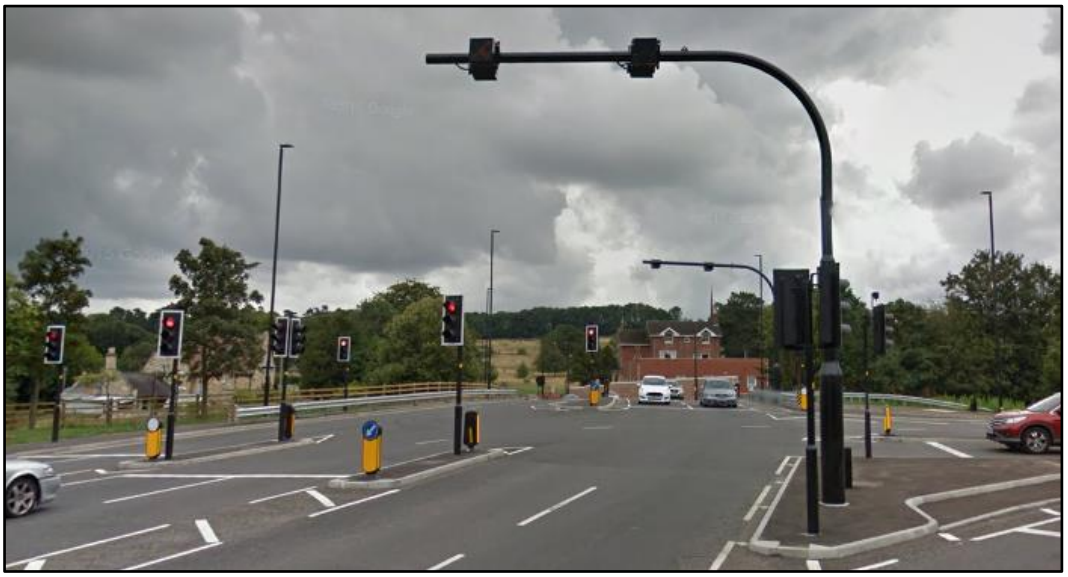

Figure 3: Southbound view of A15 Canwick Road

A61 Queens Road / A61 London Road (Sheffield)

This central tidal flow all traffic lane begins on the A61 Queens Road at the junction of A61 Queens Road / Alderson Road and continues until the junction of A61 London Road / Broadfield Road.

It is approximately 400m in length and varies between three and four traffic lanes with one lane highlighted in red to identify the tidal flow lane. This is controlled using five gantries with lane indicator signals to TSRGD Diagrams 5001.1, 5003 & 5005. This allows the direction of traffic in the tidal flow lane to be controlled at busy periods.

Technical note 2

Four signalised junctions are located along the length of this scheme along with one controlled pedestrian crossing, at each location there are opposing stop lines on the central tidal lane to be compliant with regulations. The majority of these junctions have yellow box markings to TSRGD Diagrams 1044. At Cookes pet store and Halfords on A61 Queens Road yellow boxes to TSRGD Diagram 1043 are used to allow right turning traffic into and out of the car park / access road without blocking the tidal flow lane.

The tidal flow lane signage for the central lane at this location is larger than the two normal traffic lanes not having any backing to the lane designation signal could make the signal difficult to see under some light conditions, however the signals have been covered with a hood to reduce the glare from sunlight.

The overhead gantries take up valuable footway space on both sides of the carriageway, however they are less visually intrusive in this largely industrial area

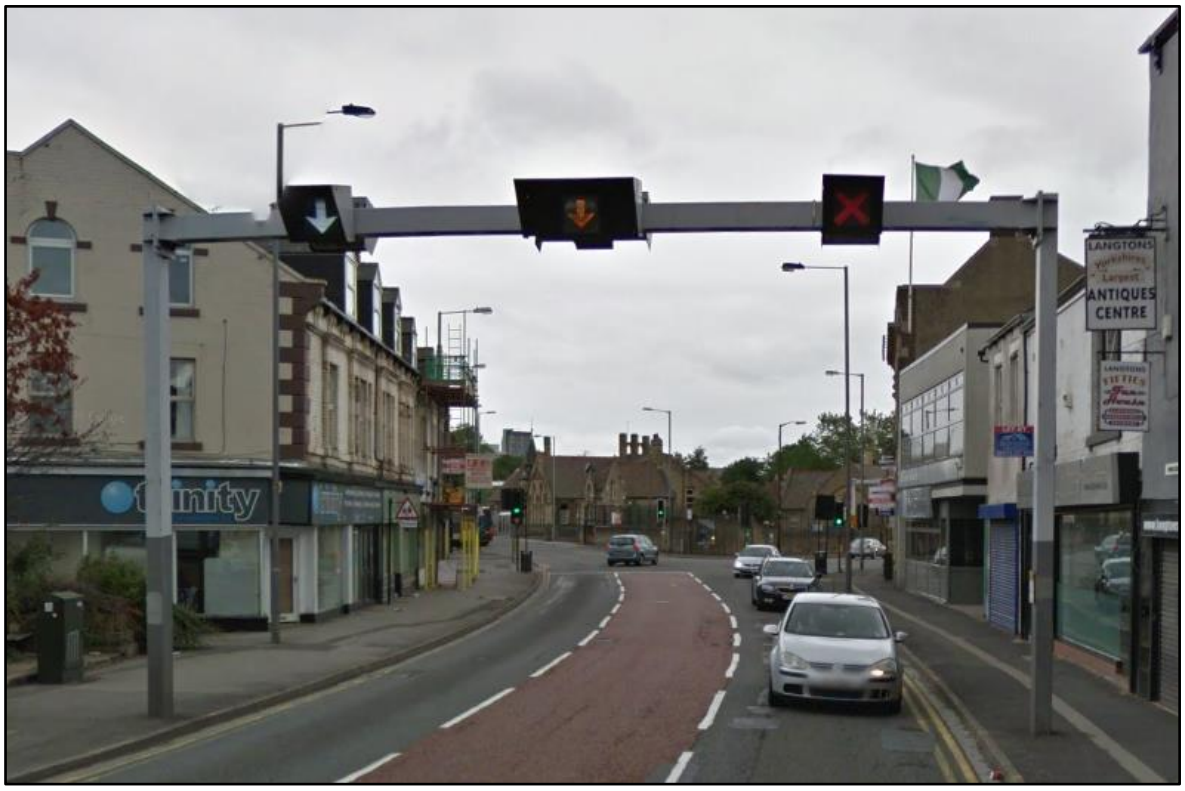

Figure 4: Northbound view of A61 London Road

Existing tidal flow schemes overseas

Coronado Bridge (San Diego – US) – "Road Zipper" moveable barrier system

This tidal "reversible" lane utilises a moveable concrete barrier system extending along the entire length of the 1.6 miles Coronado Bridge. This system uses a specially constructed vehicle which can be driven along the route and reposition the interlocked one metre barriers from one edge of a lane to the opposite edge. This can be easily undertaken whilst all lanes are open providing the traffic in the central lane is moving. This system has been in place for almost 20 years and was installed following a spate of head on collision accidents in the mid 1990's.

This system allows a central traffic lane across the bridge to have its direction of flow altered at any point and provides a clear indication to motorists when the lane is available due to the nature of the barrier. This also means that there is no need for additional signalisation to provide motorists with lane designation information.

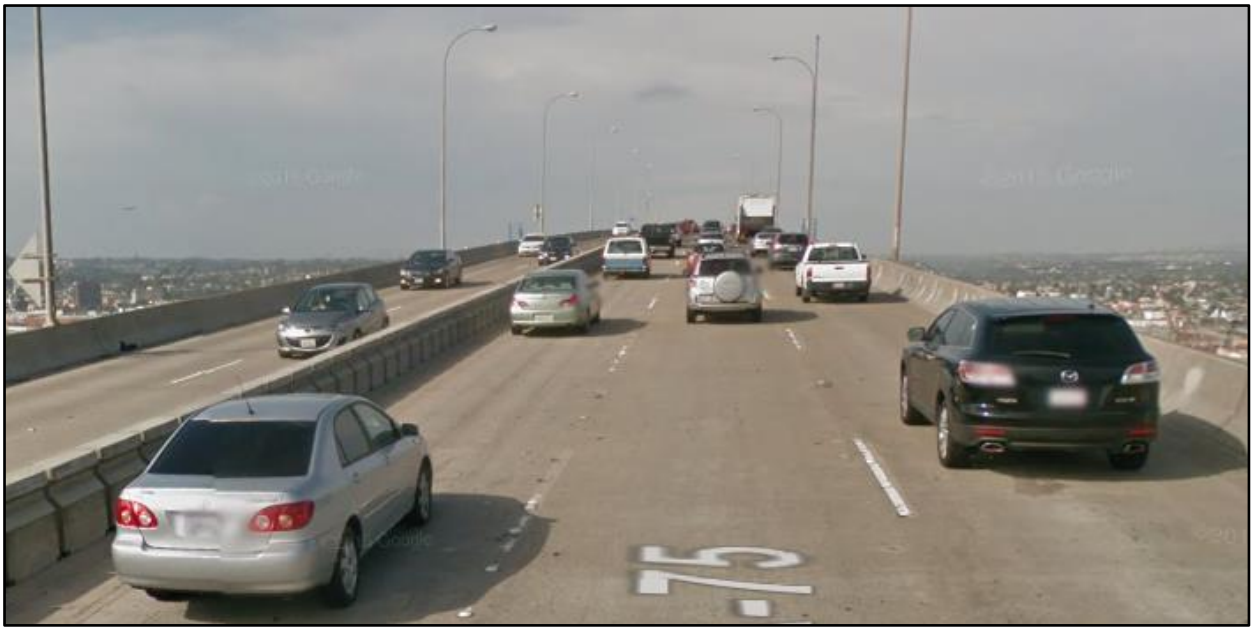

Figure 5: Northbound view of CA-75 on the Coronado Bridge

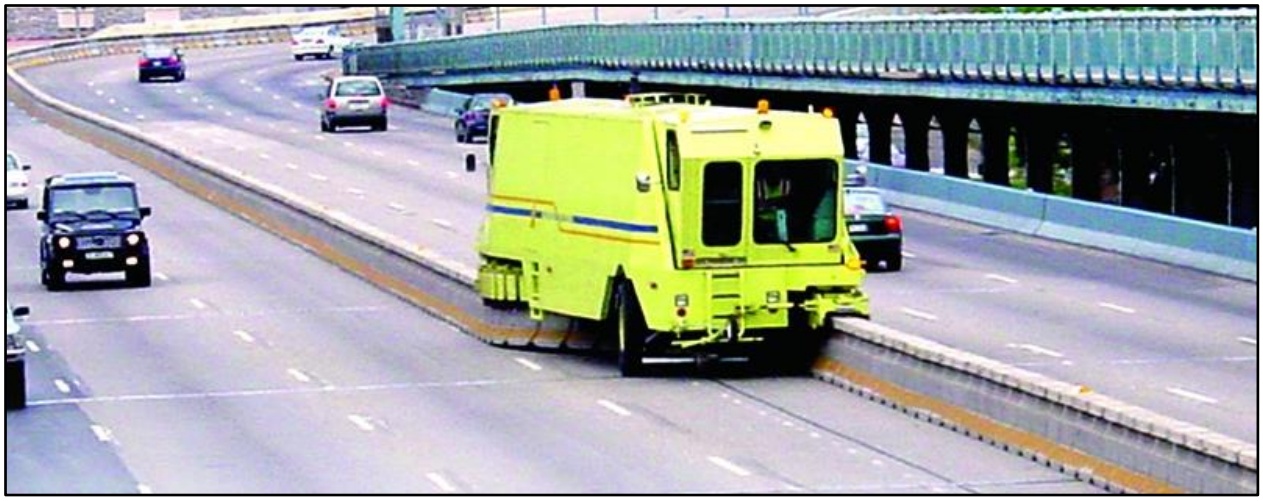

Figure 6: Moveable barrier system in operation

Tidal Busway – (Eugene Oregon - US)

This tidal (or reversible) lane is a partially segregated central busway utilising overhead light rail type signals, at signalised junctions these are integrated into the existing overhead cantilever traffic signal.

The bus services in Eugene utilise central bus stops similar to that of light rail stops. These are located within wider central reservations which can be accessed via the central tidal bus lane from either direction or from either of the normal traffic lanes adjacent when required.

This system utilises a combination of traffic signal controls and strategically located bus lanes to provide buses with the required priority at junctions when not using the tidal bus lane.

The layout of a centralised bus lane which is segregated from the main carriageway works due to the availability of road space between property boundaries; the space for the centralised bus stops is easily

achieved by utilising large central reserve spaces. The space taken up by this scheme would be on par with a light rail system in the UK.

Figure 7: Eastbound on E 11th Ave. at Dad's Gates Station

Proposed tidal flow schemes in the UK

A40 Eynsham to Oxford tidal bus lane proposal (3.8 miles)

A tidal bus lane has been proposed along a stretch of the A40 between Eynsham and Oxford. This part of the A40 is approximately 3.8 miles in length. Along this section of road there are two junctions where traffic can enter and leave the A40.

During the morning peak hour it would allow buses to bypass eastbound traffic between Eynsham and Oxford, switching to the opposite direction in the evening peak hour.

The proposals for this scheme have not been finalised and are still being reviewed with further option appraisals to be undertaken. Potentially, there are two options in which this could be achieved; either by having a single reversible bus lane segregated from normal traffic and controlled by entry signals, or by having three lanes with restrictions on direction of flow and use, which can be adjusted throughout the day.

For the first option, control would be through entry restrictions (which would probably need to be traffic signal controlled) and separation, either physical or through regulation, of the reversible lane from the remaining carriageway.

For the second option, the control of traffic would be via overhead gantries which would restrict traffic from travelling in a particular direction in each lane and prohibit the use of the central lane except to a particular class of vehicle (e.g. buses & coaches). Gantries in this location would increase the visual intrusion on the surrounding landscape.

The majority of discussions on these options suggest that a central tidal bus lane would be the most likely choice, utilising overhead gantries and road markings to show which direction the lane is running and which type of vehicles are able to use the lane. At locations where the carriageway is narrow for three lanes, bus gates could be provided to give priority to buses.

Technical note 2

Implications for the A1303 Madingley Road

The bus rapid transit scheme in Eugene would be the most ideal option for improving public transport as this segregates buses from general traffic as much as possible, whilst still providing fully functioning junctions which cross its path. However the road space required to provide this is significantly more than is available along the A1303 Madingley Road.

The “Road Zipper” system used in San Diego has a proven track record for improving traffic flows at peak periods however this system is best suited to locations where there is no requirement to turn left (right in the UK) across the mainline of the carriageway such as along bridges. This system would not be suitable along the A1303 due to the number of side road / residential accesses and junctions.

The two schemes which have similar constraints to that of the A1303 Madingley Road are the A15 in Lincoln and the A61 in Sheffield. Both of these schemes have property boundaries and pedestrian areas which limit the road space available for the scheme. The signage methods used would also be similar as both schemes are in the UK. In places, side roads along the length of these schemes have been altered to provide safer movement of traffic, i.e. banned / restricted turns.