MILL ROAD BRIDGE CLOSURE

SENSOR TRIALS FINAL REPORT

2019

smart CAMBRIDGE

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1 Executive Summary

In summer 2019, Mill Road Bridge was closed to vehicular traffic for a period of 8 weeks while crucial works were carried out by Govia Thameslink to improve rail services. In May 2019 in advance of the closure, Smart Cambridge took the opportunity to install 15 traffic count sensors in and around the area to monitor road usage before, during and after the works.

The key aims of the project included: trialling new technology; making city data available to the public; understanding whether closures affect travel behaviour and gaining a better understanding of the analysis that can be carried out on sensor data. Section three of the report details progress against these aims.

The project was expected to give us the opportunity to compare usage of Mill Road and the surrounding areas before, during and after the trial, but also to compare it seasonally with a 'normal' year in which the bridge was not closed. However, the Covid-19 pandemic has meant that the data gathered from March 2020 to date has been anything but normal, limiting our ability to offer comparisons and analysis of the closure impact as we had hoped.

Important learning has been gained from the trial itself which is already proving invaluable for the selection, deployment and usage of sensors. This learning is referenced throughout the document, but key learnings are discussed in both sections three and five. The work provided useful insights into ways in which traveller behaviour was affected by the bridge closure to vehicles which can be read in section four. Moreover, the project has increased the experience of the team in analysing sensor data and combining it with other datasets.

2 Introduction

The Mill Road Bridge was closed to vehicles for 8 weeks from 1st July 2019 while crucial works were carried out by Govia Thameslink to improve rail services. Smart Cambridge took this opportunity to install 15 traffic count sensors to monitor road usage before, during and after the closure to understand how it impacted traffic volumes on Mill Road itself and in other surrounding roads. Colleagues at Cambridge City Council installed 7 air quality sensors at similar locations to monitor air quality during and after the closure. They will be publishing a report on their findings in due course.

The project planned to leave the traffic sensors in place for up to eighteen months, giving the team a full year of data on which analysis could be carried out. This was expected to give us the opportunity to compare usage of Mill Road and the surrounding areas before, during and after the trial, but also to compare it seasonally with a 'normal' year in which the bridge was not closed between July and September.

The sensors have remained in place as planned, however the Covid-19 pandemic has meant that the data gathered from March 2020 to date has been anything but normal. While there are a number of ways in which this data has been extremely useful, the impact of the pandemic on the original goal of the report is significant, limiting the ability we have to offer comparisons and analysis of the closure impact as we had hoped.

With that said, valuable learning has been gained from the trial itself and insight can still be extracted from the data, albeit not quite as we had originally anticipated. This can be found in the following sections of the report.

3 Project Aims

At the start of the project in 2019, four main aims were identified. The four are listed below and the following sections of this chapter provide information on the extent to which each of these has been met over the twelve-month trial. Where it is relevant, each section also sets out what further knowledge we would hope to gain, or any improvements that we feel need to be made to support future use of similar technologies.

The four aims were as follows:

1. Trial new technology and the processes for its installation
2. Make city data available to the public via Cambridgeshire Insight (Shared research knowledge base for the County) and the Intelligent City Platform (an open data platform designed in collaboration with the University of Cambridge)
3. Understand whether closures affect travel behaviour and whether this is sustained
4. Gain a better understanding of the analysis that can be carried out on sensor data and what insights can be gathered from the use of multiple data sets.

3.1 Trial new technology and processes for its installation

One of the objectives of the Smart Cambridge programme is to trial emerging technologies, understanding their strengths and limitations, whether they are suitable for our purpose and how they might usefully be deployed to operations to support the Greater Cambridge Partnership (GCP) and other relevant organisations in delivering their aims for the area. In order to do this, evaluation of all trials is necessary and must include a review of how well technology performed, whether it gave us the expected results and what requirements there are of the local authority to ensure its accurate deployment and maintenance.

This report aims to cover a large range of findings but can be split into those relating to the technology itself, and those relevant to the process for installation.

Process for Installation

As mentioned in our Early Findings Report (here) installing the equipment to support this work provided insight into the process required to deploy sensors. Understanding the process for installing new technology and the requirements that this puts on the local authority is critical to assessing whether the technology has a useful and sustainable place in operational services.

- **Installation process and applications**
  The deployment of equipment in the public realm requires particular permissions to be obtained. In Cambridgeshire a number of the street lighting columns are owned and managed by a third party. As sensors are most often installed on lighting columns, this does lead to some further complexity in the installation process as permissions must be sought in advance. Through this project we have gathered generic information such as size and weight measurements for sensors that can easily be re-used reducing the time and effort needed to complete the necessary application forms. Project specific information is also required for each installation and through our knowledge of these processes, a checklist has been created to ensure officers know what information they will need before they submit applications

- **Sensor Placement – for installation**
  Our main partners in this project have been Vivacity and Balfour Beatty. Working closely with them has allowed us to gain experience in understanding the lighting columns most likely to be acceptable to both parties for installation of sensors. For example, those of the correct type and with few or no additional equipment installed on them. This allows us to carry out site assessments for the installation of sensors, reducing the need for Balfour Beatty or the supplier to visit site multiple times to agree the columns used for installation. This lowers the costs and allows us to confidently submit the required applications without having to have each location checked first, reducing the number of columns that are rejected for use.

- **Sensor Placement – for data collection**
  Knowledge has been gained on where best to locate sensors to collect the most accurate data for the specific scenario defined. For example, we know if you want to accurately collect information on cyclists and pedestrians, sensors are best located with a 'side on' view rather than 'front-on' which allows the outline of the object to be more clearly defined. However, Automated Number Plate Recognition (ANPR) sensors require a front-on view to obtain registration plate details. ANPR sensors were not tested in this trial but have been used to monitor subsequent schemes in order to capture journey time information.

All the information listed above has been captured in the process documents and flowcharts created as an output from the project and is available to all officers to guide them through sensor deployment.

<u>Technology</u>

One of the key elements of any Smart Cambridge trial is to better understand the technology being used. Gaining experience of its reliability, accuracy, strengths and limitations forms a critical part of the work and is used when assessing whether a solution is suitable for council purposes. During this trial the following observations have been made:

- **Reliability**
  Early in the trial a failure of the SIMs in the sensors occurred. This was identified and resolved quickly. Over the two-year period since their installation, there have been a small number of issues in which the sensors have malfunctioned or gone offline. In the event of software problems, the sensors can be accessed remotely and re-set, however if the problem is with the hardware, the supplier has attended site to resolve the issue with a fix or replacement. It should be noted that this has occurred only a small number of times and very few fixes have been needed since the early part of the trial. It should also be noted that the sensors are reliant on a power feed being available 24/7. Where there have been issues with this, Balfour Beatty have attended site to resolve them promptly as part of their contractual responsibility for the lighting columns.

  The early part of the trial also highlighted the need for a dashboard or process (owned by the supplier) to understand the status of all sensors, particularly whether they were offline. Vivacity understood that it is not necessarily feasible for a local authority customer to check in to each sensor each day and are developing processes to identify sensor status more easily. Provision of this type of functionality should be considered when evaluating maintenance/support agreements for any future procurements.

- **Accuracy of Sensors**
  Across the 15 sensors used in this trial, accuracy levels of 85% and above were achieved when classifying vehicles. For cars specifically, the accuracy level was consistently above 95%. The levels for pedestrians and cycles was originally lower than this due to the width of the roads and the efforts to capture the full roadway (including footpaths and cycle lanes) with a single sensor. In order to improve accuracy, countlines (the virtual line crossed by a vehicle/pedestrian etc. when it is counted by the sensor) for footpaths were separated out resulting in better identification of both cyclists and pedestrians. This has been recorded in the process for installation. Accuracy validation is carried out by recording short 15minute windows of footage from a sensor and comparing the system generated counts with manual counts completed by an operative. Footage is then deleted from the system. Videos are not captured or retained through use of these sensors. Data processing of images takes place at the edge (within the device) and then only the count data is transferred to systems and saved (where ANPR sensors are used, encrypted number plate data is also stored). This reduces the amount of data storage needed by the system, but also ensures that compliance with privacy policies is met as set out in the Data Protection Impact Assessment (DPIA) completed prior to the project start.

  A further independent test of accuracy was carried out over a longer period in which we used an alternative system to monitor traffic at the same points for twelve hours. The total counts of motorised vehicles were almost identical with a difference of just 0.2% on the counts towards the sensor and 3.9% away from the sensor. For cyclists and pedestrians this was somewhat lower, but still suggested that over 75% were correctly identified (note that the comparison was carried out before corrective countline measures were introduced improving the accuracy of pedestrian and cycle counts, as explained above).

- **Counts in hours of darkness**
  At the time of procurement, there was an element of concern over the accuracy of the sensors operating in dark or near dark conditions. While we have not specifically tested this, average counts appear to be as expected for traffic volumes during hours of darkness, this remains correct when comparing the average number of vehicles counted during hours that are brighter in summer and darker in winter (e.g. evening rush hours). In conclusion, the sensors operated well in the relatively well-lit areas in which we deployed them for this trial. As sensors are commonly installed on street lighting, this is not expected to be a significant issue. However, when installing sensors on alternative infrastructure and/or in more rural areas, this may need to be verified. Future procurements and trials may look to specifically request data on this from suppliers.

Through the points listed above and their inclusion in documentation available to all officers who wish to implement this type of monitoring in the future, the first objective of the trial has been achieved. The trial has understood the strengths of this technology (its accuracy and reliability) and the data proved its worth early in the trial. The detailed counts were shared with the signals team to determine the volume of traffic on one of the alternative routes to Mill Road allowing them to adjust the signals timings to reduce congestion caused by the higher number of vehicles using that route. A link to the case study explaining this scenario in more detail can be found in Appendix D.

Initially the limitations of the technology included poorer accuracy for pedestrians and cyclists. However, these levels have increased throughout the trial as we have learned the best ways to deploy the sensors. Rather than a limitation, cyclist/pedestrian accuracy is largely a decision officers must take when setting up the sensor systems. If capturing those particular types of traveller is considered most important, then the deployment must be completed with that in mind. This means additional count lines, or potentially reducing the accuracy of vehicle classifications to concentrate on the cycle and footpaths, or in some cases deploying additional sensors to achieve the required accuracy. There is a cost implication if the decision is made to deploy additional sensors to obtain the right level of accuracy for certain classes.

3.2 Make city data available to the public

Making city data available to the public has several benefits. For example, local residents can understand changes to their local area, businesses can use the data to design, build and test real-world solutions and local authorities are able to easily use the data for public engagement. Where possible and appropriate, Smart Cambridge aims to facilitate open data access through several projects, including this trial.

The data for this trial is collected in the Vivacity data platform (only accessible by officers) but has also been made available on the Cambridgeshire Insight platform. This shared research knowledge base is home to several county wide datasets and offered a logical home for this data. You can access the datasets here. Furthermore, we ensured that it is possible to feed the data into our Intelligent City Platform (ICP) available at smartcambridge.org.

In order to get the data into platforms other than the Vivacity data portal, it must be extracted and manipulated into the correct format. For Cambridgeshire Insight, this requires a manual download of the data which is carried out once per month. This means that even though the data is recorded in near real-time, it can be up to a month old by the time it is made publicly available. There is no system restriction on when the data is transferred, but resources must be available to carry out the extract and import and has been one of the limitations of this approach.

The Intelligent City Platform has been set up differently, allowing the platform to pull in the data in near real-time using an Application Programming Interface (API) which facilitates the flow of data. The ICP has been coded to periodically request information on changes to the data since its last check, this reduces the need for significant regular input from the team. However, it also means that any errors or issues are loaded directly into the platform. Considerable further work would be required to provide an automated check of the data and explain where there are particular anomalies for example. For this reason, the feed into the ICP is not currently publicly available.

In summary, several lessons have been learnt through this project objective:

- When you establish fixed methods for extracting/importing data, any changes in the raw dataset can cause complications – for example, in order to improve cyclist categorisation accuracy additional count lines were added to a sensor, this meant that in order to display a consistent set of data, the new count line totals had to be added to the existing ones before publication. Similar issues with consistency occur when a sensor is relocated.

- Automated processes are essential to pull data seamlessly into our platforms otherwise it is common that data quickly becomes out of date, people feel it is unreliable and/or there is confusion over the 'correct' or master data source

- When data is made publicly available, it must be correctly explained. The people consuming that data for whatever purpose, are unlikely to be data specialists, or may not have local knowledge therefore they need to be informed of what the data is reflecting. For example, a data set may have several days with no information, this may have been the result of an unexpected road closure, or a failure in the sensor. Some sensor networks may be collecting data every 5 minutes, others may be aggregating this into a full day. There are many examples of when an explanation of the data is essential if we are to make it publicly available

- Making raw data available is only useful to those with particular skills (such as advanced knowledge of MS Excel or a coding background). Often, and in the case of this project specifically, the majority of interested parties were unable to interpret the raw data. An element of analysis had to be undertaken by the team (and others) to visualise the data in a meaningful way for the audience, for example, producing graphs to allow easier comparison between sensor locations or periods

The conclusion of this objective is that making data publicly available is relatively straight forward, it is the effort required before and after this has been done that is significant. By understanding in each circumstance, what we hope to achieve by making the data public, we will be better able to plan the work required to support future projects and operational work.

3.3 Understand whether closures affect behaviour and whether this is sustained

The question posed in this objective appears simple initially, but further work has demonstrated that there are many considerations to be addressed. Some of these points are described further in the data analysis and summary of results (section 4).

The question is best reviewed in two parts:

<u>Do closures affect behaviour?</u>

In this question we were looking at whether the temporary closure of a main route caused changes in peoples travel behaviour. For example:

- Did they switch to other modes of transport such as walking, cycling or public transport or did they choose to keep the same mode of transport but take a different route?
- Were the patterns of road use different over the weekend and weekdays? For example, did more people cycle or walk to Mill Rd while the road was closed over the weekend and make use of new facilities such as street parks and outdoor dining.

The short answer is that a route closure will force a change in behaviour of some sort. Travellers must find a different solution to their regular journeys be that switching route or mode or both. Other factors (such as your reason for travel, the weather, traffic on other routes and your end destination) are also hugely important in these decisions and mean that making a clear analysis based only on quantitative data is difficult. Qualitative data and surveys to better understand what changes people had made to their behaviour and why would support the quantitative data.

The data that we collected appears to indicate that people chose to change route to avoid the closure, rather than changing mode. This suggests that for a relatively short, defined period and where the closure affects a single route only, people may prefer to find an alternative route than make significant changes to their behaviour pattern. The implication of this is that the perceived problems associated with major routes, such as congestion or poor air quality, could simply be moved to another location although further work is required to demonstrate this conclusively.

Are changes sustained?

By monitoring the before, during and after counts for all modes on and around Mill Road we were able to compare the figures in a straightforward way – an example of this was presented in our early findings report.

We saw numbers of vehicles on Mill Rd decrease during the closure (at both ends) as expected. The number of cars on the surrounding roads increased as people changed the route they took to reach their destination. Looking at the total number of vehicles on Mill Road and the nearby potential alternative routes together, there appeared to be a slight decrease during the bridge closure. We considered whether this could have been an indication of mode shift. However, there was also a slight decrease on other 'control' sites in other parts of the city, indicating that the decrease on Mill Road and the nearby potential alternative routes might not be related to the closure. This supports the comments above that people did not seem to change mode but changed route instead. When the bridge re-opened, we soon saw traffic counts return to and, in some cases, exceed their pre-closure levels. This occurred over a more gradual period than the decrease observed when the road was closed to vehicles (see CEDAR Study in Appendix C). The two likely reasons for this are:

- people returning to their regular travel patterns following the summer holiday which ended one week into the post-closure period;
- Not all travellers were aware that the road had re-opened to vehicles at the same time.

This return to the original numbers in a short period demonstrates that the changed behaviours in this instance, were not sustained.

The data collected during the summer 2019 closure suggests that behaviour changes are not sustained when the imposed change to route (in this case the bridge closure) is known to be temporary. For future work, it will be interesting to evaluate the impact of a longer-term closure to some vehicle types to see if this statement remains true.

When looking at answers to both these questions (Do closures affect behaviour? and Are changes sustained?), it's important to note that other events also took place during the period of the bridge closure:

- A fire on Mill Road (over the night of 15th July), which may have impacted traffic figures and;
- major gas works being carried out in the street during the closure period.

Furthermore, this project was interested in how people travelled around or via the Mill Road area during the closure and does not aim to draw any conclusions on how the road space itself was re-appropriated for outdoor cafes or additional walking space for example.

In conclusion, the behaviour changes observed using these sensors suggest that habits were not changed by the relatively short closure of the Mill Road Bridge. While traffic numbers on the road fell, traffic in the surrounding areas increased proportionately and, following the re-opening, flows returned to their pre-closure levels. This supports the thinking that the closure of one main route is not sufficient reason for travellers to significantly alter their travel plans. This substantiates the view that a combination of measures is needed to successfully reduce congestion and improve air quality including the provision of alternatives to using the private car.

We had planned to compare 2019 data with the same period in 2020 to confirm this. However the summer of 2020 was not equivalent due to Covid-19, even though restrictions were less severe at that time, meaning that we did not have a comparable dataset. As the sensors remain in place on Mill Road and the surrounding areas, future analysis could be carried out when comparable time periods are available.

3.4 Improve understanding of analysis & insight gained from the use of multiple datasets

Having a rich data source such as those generated by these sensors offers many benefits. Being able to understand the type of vehicle as well as the number allows more detailed analysis to be carried out and a better understanding to be gained. However, further value still can be obtained when multiple complimentary datasets are analysed together. For example, rainfall recorded alongside classified vehicle counts may give you information on the number of cyclists that opt to switch mode and use their car on days of particularly heavy rainfall.

Colleagues at Cambridge City Council used the Mill Road Bridge Closure as an opportunity to test new lower cost air quality sensors on Mill Road, assessing how effective they were in comparison to the diffusion tubes and static air quality stations already in use. The sensors were co-located with the traffic sensors (where possible), providing a comparable dataset to be analysed alongside the traffic information. As mentioned in the introduction, a separate report on air quality in relation to the Mill Road Bridge closure in 2019 will be published by the City Council.

This objective was about understanding the process and value of capturing and analysing multiple datasets together. It is clear that there is a significant increase in the intelligence that can be gained when combining datasets, however, there are also a number of challenges:

- Data must be from comparable time periods
- Outside influences on all datasets must be known in order to understand any anomalies (i.e. the fire on Mill Road or a sensor being faulty and replaced).

While being able to analyse and compare datasets in one platform is very advantageous, the project has also demonstrated that analysis of multiple datasets can be carried out separately and when shown alongside comparable information can also give a wider understanding of a situation. For example, this year, data from the traffic sensors has been used alongside data captured by footfall sensors and car park data to give an understanding of the impact of Covid-19 on Cambridge over the course of the pandemic.

Overall, the trial has highlighted the challenges of comparing and maintaining multiple datasets, but also demonstrates the added value that can be achieved and that this can offer local authorities a more informed analysis of the impact of schemes and interventions put in place. Both on their intended and any additional or unintended, outcomes.

4 Data Analysis and Summary of Results

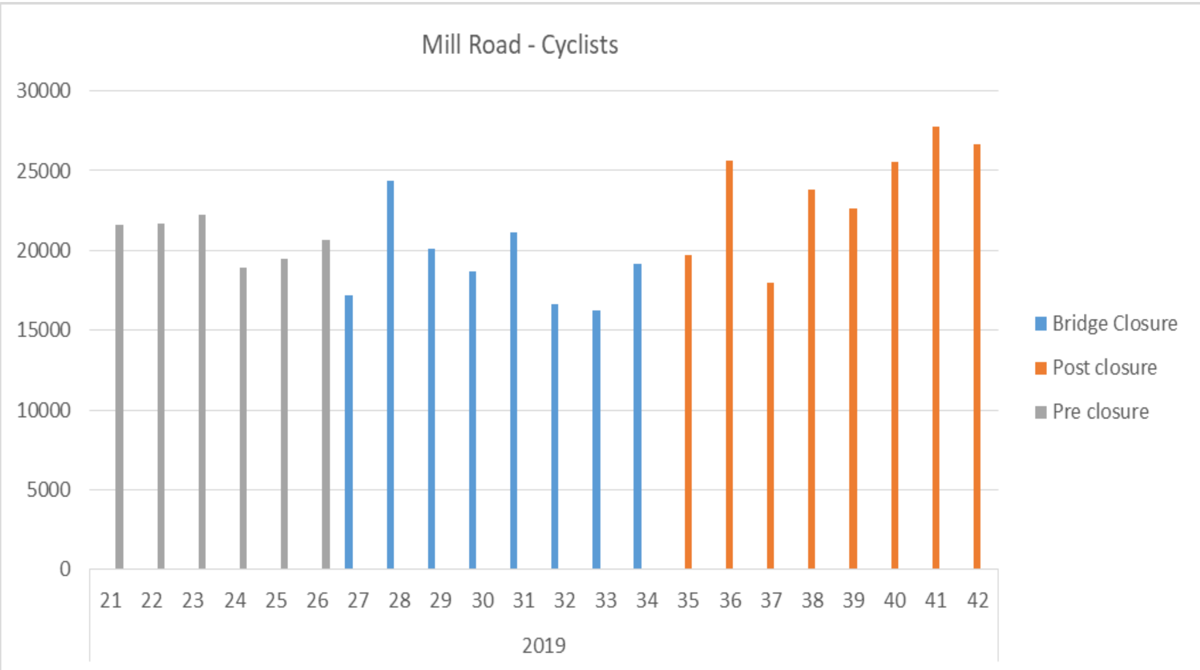
As explained in the sections above, data can be analysed and interrogated in several ways to provide insight on specific questions. We had hoped to be able to run comparisons between the usage of Mill Road during the closure and the summer of 2020. We have reviewed the data from 2020, and while the information is useful in its own right, the circumstances are so different that no meaningful comparison can be made of the two periods. Instead, we have used the 2019 data to analyse the closure itself and aim to provide insight on a number of key questions.

Please note, the following graphs show the total number of cyclists, pedestrians and vehicles counted by the two sensors on Mill Road between Monday and Friday, each week starting with Week 21 (which started Monday 20th May 2019). While more granular data is available, setting the figures at this level allows us to clearly see the general trend over the period. For ease of reference, a table showing the maximum, minimum and average counts are also displayed below each graph.

Did the closure impact the number of cyclists using Mill Road?

During the closure (shown in blue), there appears to be a small dip in the average number of cyclists on Mill Road, however there are also weeks in which the figures are higher than pre-closure. As we have previously mentioned, other works were carried out on Mill Road in parallel to the bridge closure (with the aim of reducing prolonged disruption). This may also have been a factor in deterring cyclists from using the road despite the drop in motorised vehicle traffic. As you can see from the graph, post closure figures (shown in orange) increase beyond those seen in the pre-closure period. No significant infrastructure changes were put in place for cyclists post closure, but there could be a number of other factors as to why there is an increase. The most likely of these are the return of students to the city for the start of the university terms and the return of schools/commuters after the summer holiday period in which changes to travel patterns across Cambridge are generally observed.

Overall, when looked at in isolation, these figures suggest that the number of people cycling on Mill Road was not particularly impacted by the closure.

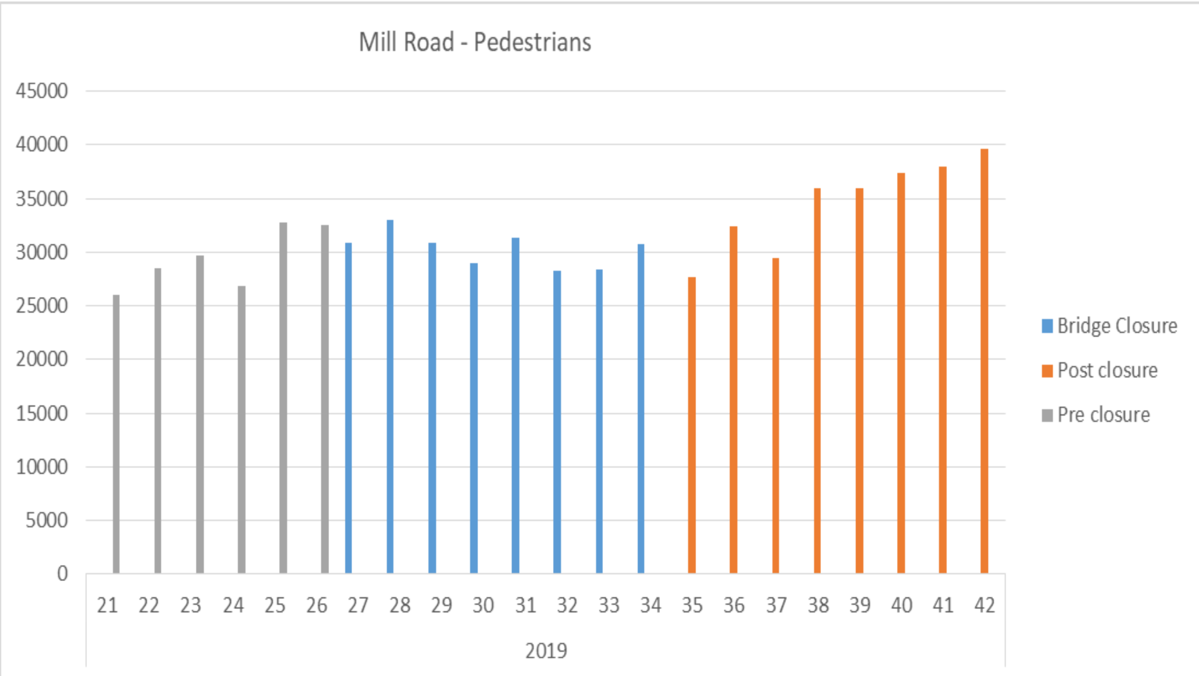


	Pre-Closure	During Closure	Post-Closure
Min. Cyclist Count	18,940	16,236	17,955
Average. Cyclist Count	20,768	19,196	23,721
Max. Cyclist Count	22,266	24,365	27,788

Did the closure impact the number of pedestrians on Mill Road?

Before and during the closure there were concerns over the impact that it would have on pedestrian numbers on Mill Road. When taking into consideration the gas works that were carried out in parallel, there was particular concern that the environment would not be pleasant for people to walk in therefore causing a number of outcomes including people driving rather than using sustainable modes of transport or a reduction in footfall for the traders on Mill Road.

The figures below show that between Monday and Friday each week, the flow of pedestrians changed very little. There were in fact increases in footfall in some weeks during the closure. Post closure numbers increase significantly, especially from week 38 onwards, again, this could be related to the return of students to the city.



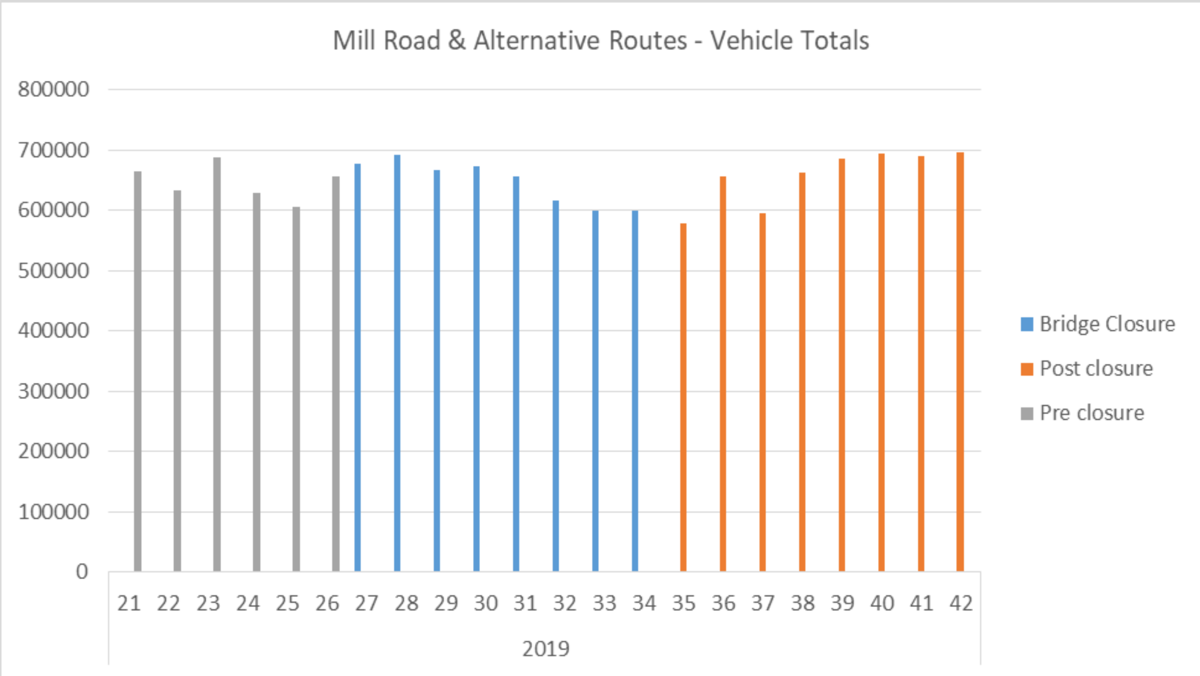
	Pre-Closure	During Closure	Post-Closure
Min. Ped. Count	26,032	28,230	27,650
Average Ped. Count	29,382	30,288	34,538
Max. Ped. Count	32,797	32,951	39,624

Overall, did the closure result in a change to the number of vehicles using the road network?

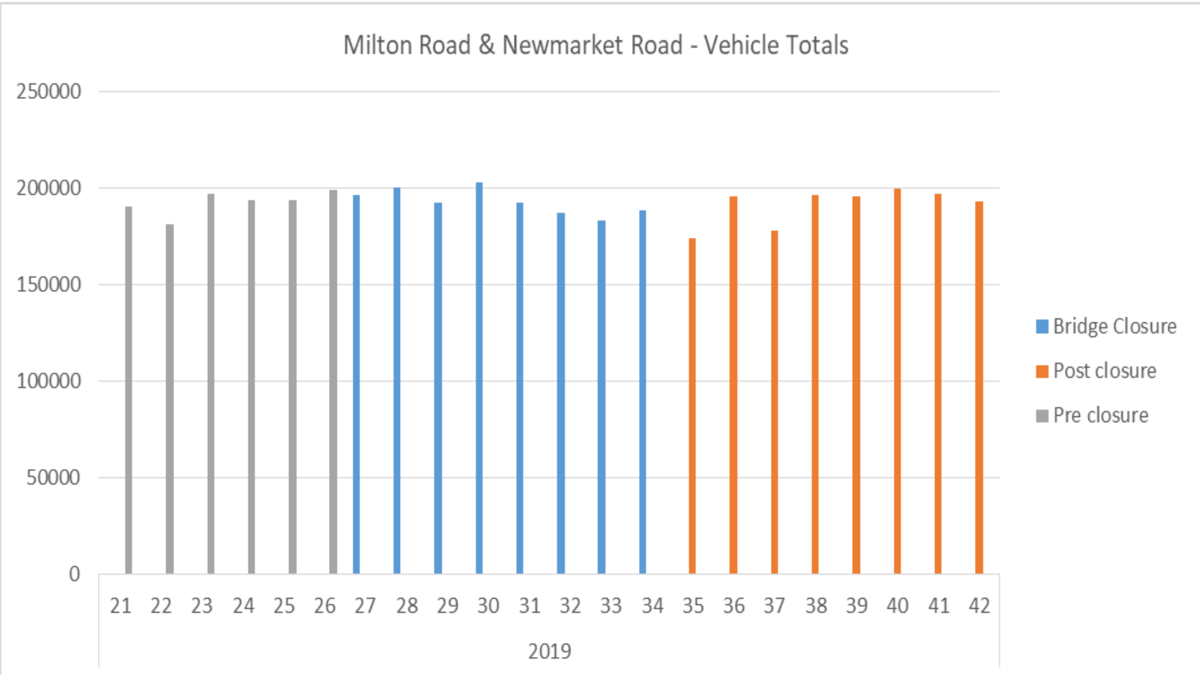
Using the sensors available, we were keen to understand whether the number of vehicles on the network decreased during the closure. If the number of vehicles in total reduced, this would suggest that travellers were using alternative modes of transport to complete their journeys during the closure.

Two graphs have been used to answer this question, the first showing data for Mill Road and the alternative routes, and the second showing 'control' routes, those less likely to have been impacted by the bridge closure (Milton Rd and Newmarket Rd).

The first graph appears to show a slight decrease in traffic volumes across Mill Rd and the alternative routes during the second half of the bridge closure period during weeks 31, 32 and 33. When viewed in isolation, this may suggest that fewer people used their car to make their regular journeys as a result of the closure during this period. However, by comparing this with the second graph, we can see that the decrease in traffic volume also occurred across the control routes in weeks 31, 32 and 33, which suggests that traffic flow across the whole city network decreased during this period. The most likely explanation for this is the start of the school holidays.



	Pre-Closure	During Closure	Post-Closure
Min. Vehicle Count	605,896	599,966	578,242
Average. Vehicle Count	646,206	647,418	657,226
Max. Vehicle Count	688,645	691,008	696,625



	Pre-Closure	During Closure	Post-Closure
Min. Vehicle Count	181,365	183,078	174,111
Average. Vehicle Count	192,528	192,914	191,356
Max. Vehicle Count	199,103	203,095	199,725

Further analysis carried out in conjunction with our partners GeoSpock, provided an alternative view of the data, also showing the potential results of traffic being diverting away from the Mill Road area during the closure. In the diagram below, the blue circles show positive correlations meaning that typically when there is less traffic on Mill Road, there will be less traffic at the locations of the blue circles. Conversely, the red circles indicate points of negative correlation meaning that more traffic was measured there when there was less traffic on Mill Road. This suggests that travellers found alternative routes to their usual journey on Mill Road as expected.

Are there any differences between weekday and weekend traffic patterns?

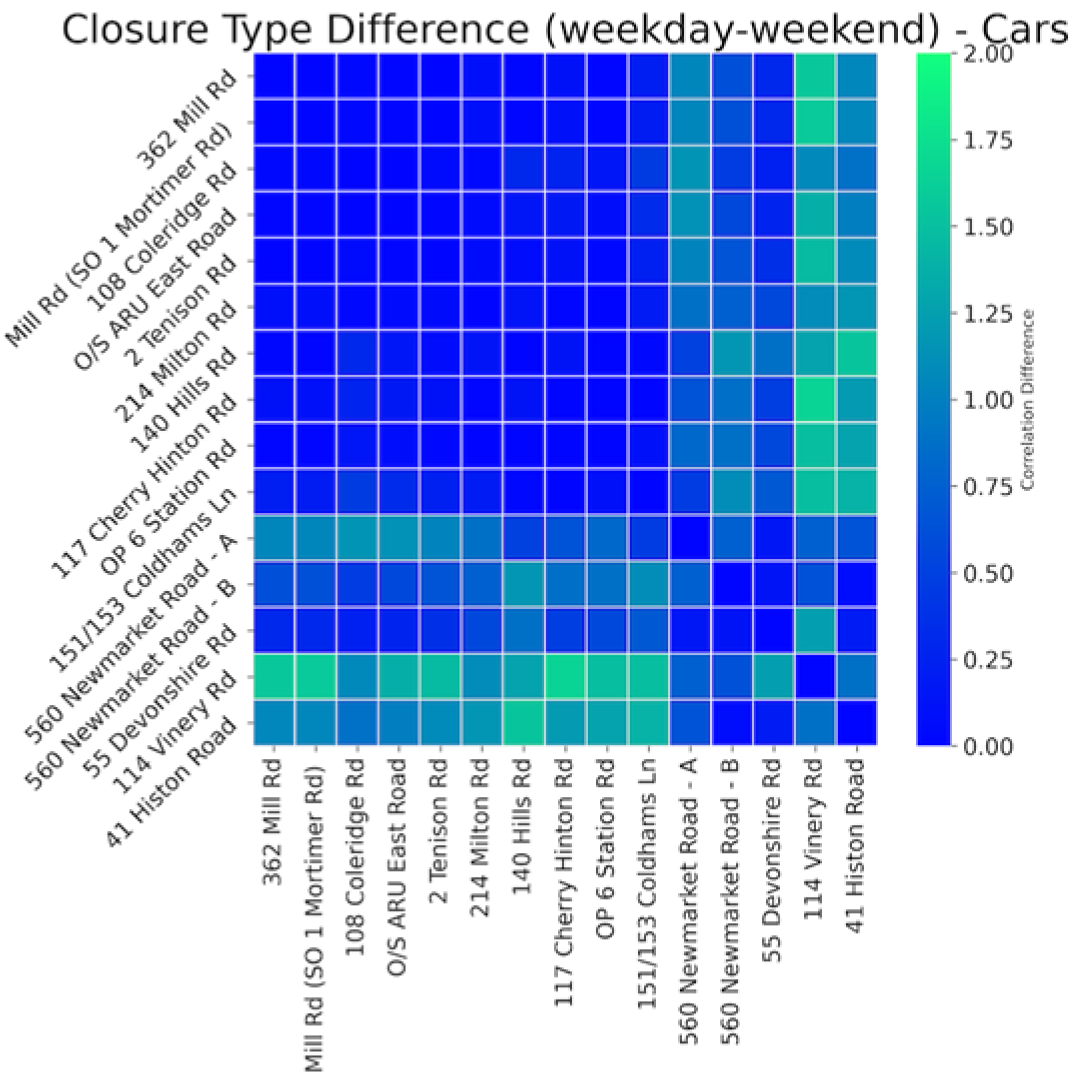
As mentioned early in this report, data can be used to review many different questions depending on how it is interpreted. In the final example in this report, the way that traffic used the roads during the week compared to the weekend was examined.

The plot below compares two data sets: car traffic before, during and after the closure at each location on weekdays with car traffic before, during and after the closure at weekends. This visualisation uses colours to show the difference between those two pieces of information. The larger the difference in correlation, the further towards the green shades the cell turns.

Where there is little difference in road use (traffic volume) between the week and the weekend, the values are low and therefore the cells are blue. As you will see, one road clearly has more green cells when compared to the others. Vinery Road experiences different road use during the weekdays than the weekends.

Location pairs which are green (such as Vinery Road and Mill Road) suggest that over the period of Jun – Sep 19, people's decisions about how/whether to re-route their journeys involving Vinery Road during the closure were made differently at weekends compared to during the week.

No evidence was gathered to explain why this appears to be the case, but it could suggest that this was related to people travelling less for business at the weekend but more for shopping/leisure (potentially at the Beehive Centre and Newmarket Rd Retail) and therefore using Vinery Road as a suitable cut through when the bridge was closed. Potentially during the week this is a less suitable alternative as people may be travelling to work in the city centre or to commute from the train station.



Understanding data in this way supports planning for future works. By demonstrating how people use the roads, we are better able to understand the impact that various works or closures would have on traffic flow during the week or weekend periods. This helps to determine the best time to carry out works with minimal impact to the public.

5 Key Learnings

The trial has provided us with valuable lessons on the deployment, limitations and operation of the technology as well as the ways in which data can be collected, stored and analysed. Our understanding of the wide range of scenarios in which data can be used to monitor the impact of schemes, the building of an evidence base and in support of operational decisions has increased. The key learnings are detailed below.

Working closely with partners in this case offered mutual benefit

Working closely with our technology partner (Vivacity) has been mutually beneficial. This is a philosophy that the Smart Cambridge team have used for some time, making sure that the relationships we build with suppliers and potential suppliers offer benefit to both sides, in this case, it has been particularly effective. We have had the luxury of being able to learn how their processes work and how the placement of sensors affects the outcome of data. This is knowledge that we are now able to share internally to help our operational teams. By doing so, we are less reliant on suppliers to provide the consultancy or lengthy initial set ups phases for our projects. By understanding what is needed, our internal teams can suggest suitable locations for sensors, quickly verify these with the supplier and move directly to obtaining the relevant permissions. This has offered us the benefit of being able to reduce the cost of projects, but more significantly in this instance, reducing the lead times required to get monitoring projects up and running smoothly.

Vivacity have had the opportunity to trial the products and services with a team that are using them in 'real world' scenarios to answer operational queries. Our team have fed into the design and development of their data platform, based on how we use the data. This has allowed them to develop specific tools within the data platform useful to a range of clients. We have also worked with Vivacity to outline use-cases for their tools based on our experiences and this knowledge can be shared with other users to further develop and expand the platform.

Changes to route rather than mode

The data that we have collected and analysis undertaken both by Smart Cambridge, GeoSpock and the Centre for Diet and Activity Research (CEDAR) who also collaborated with us on this project (see Appendix C for their summary report) suggests that a closure such as that of Mill Road Bridge, which is relatively short in duration and has a pre-determined end date, is more likely to result in short term changes of routes than changes (long or short term) of mode.

While the closure of the route caused an increase in the number of vehicles seen on alternative routes, there was no evidence to suggest a modal shift had been experienced. In particular, the total volume of traffic on the network did not significantly decrease and the number of cyclists/pedestrians did not significantly increase. This suggests that in order to achieve a sustained shift from the private car to alternative transport modes, more significant and coordinated changes across the city would be required, for example changes to multiple roads and improvements to bus and cycling provision to incentivise a modal shift. It is acknowledged this is a wide-reaching supposition made on a relatively small dataset so before assuming that this is a statement of fact, further investigation is advised.

Placement of Sensors and Uses of Data

As this report has demonstrated, data can be displayed and utilised in a huge variety of ways to inform the reader. As mentioned in section 1.1, placement of sensors is critical to collecting the data you need to assess or analyse a specific outcome, volume or impact. By understanding the primary purpose of collecting the data, you can select locations that offer the best opportunity to gather the right data for that purpose.

This trial has also proven that data collection can often be used to answer un-planned questions or help to support decisions made in response to unexpected changes. For example, our primary purpose for collecting data in this instance was to monitor changes in road usage across the network as a result of the closure. However, as you can read in the case study in Appendix D, we were also able to support colleagues in the signals team. They received complaints of extended queues at the Cherry Hinton Rd/Clifton Road junction causing congestion on associated routes during the closure period. Using the data we had collected, we were able to confirm that the volume of traffic had increased significantly, impacting the length of time needed to exit Clifton Road. This information allowed the signals team to adjust the traffic signal timings at that junction, reducing congestion in the area.

More recently, the data we have been collecting has been used in support of the Covid-19 recovery dashboards produced by the Business Intelligence team. Data has been used to review footfall and traffic volumes as part of the sensor network across the city.

Finally, the data has also been used to support our Streetworks team. By providing accurate figures on road usage during a specific period, the team are able to determine when streetworks permits can potentially have conditions relaxed and if there is a benefit in allowing work to take place at a particular time e.g. weekends, allowing works to be carried out with minimal disruption to the public.

Time periods required for comparison

As mentioned throughout this report, our intention has always been to gather an extended dataset to enable comparison of the closure period with the same timeframe the following year. By investigating and analysing data in this way, it is possible to understand trends more effectively and to determine whether changes seen in the data are impacted by particular influences such as seasonality or weather.

The pandemic was a completely unexpected event, which meant that we were unable to carry out these comparisons and draw further intelligence from the data we were able to collect. However, it highlights the importance and usefulness of having access to data from extended periods and locations. Data can be stored effectively in data platforms such as SmartCambridge.org or the County Councils Cambridgeshire Insight platform and is then available for future analysis and comparison with other datasets as needed. Having a robust, county wide, sensor network will enable the local authority partners to understand the way the cities and towns are moving, where there are issues and success of schemes implemented, with the goal of improving mobility across the region.

6 Conclusions

When this project was initiated in May 2019, our hope was that we would be able to collect data on the expected bridge closure over the summer, learn more about the challenges and benefits of this type of technology and, using data from Summer 2020, provide a comparison with a ‘normal’ year.

While we have been unable to complete the last project objective as a result of the impact of the Covid-19 pandemic, this project has been extremely useful and all other aims have been addressed. The project will now be formally closed down and the key learnings that have been captured in documentation and processes will continue to be used and revised through further sensor deployments.

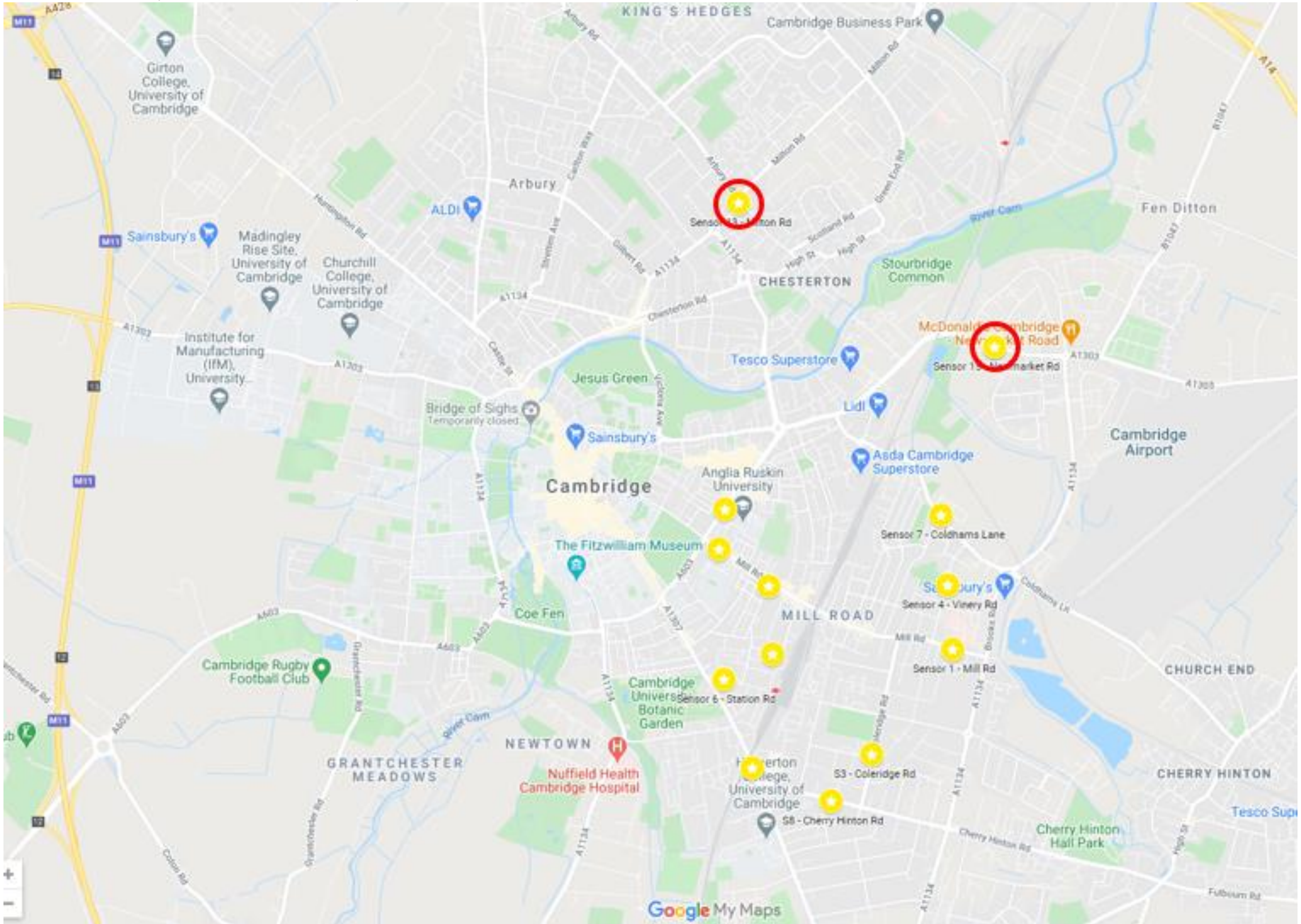
7 Appendix

The following items can be found in this section:

- Map of sensor locations
- List of key dates for the Mill Road Bridge closure
- CEDAR Mill Road Bridge closure report
- Links to other documents and information

7.1 Appendix A: Map of sensor locations

Sensor Locations marked with a yellow star on the map. Red circles at Newmarket Rd & Milton Rd indicate the 'control' sites (those distant from Mill Road).



7.2 Appendix B: List of key dates for Mill Road Bridge closure

The Govia Thameslink works took place between 01/07/2019 and 25/08/2019.

Throughout this period, the Mill Road Bridge was closed to all motorised traffic. Pedestrians and cyclists were still able to cross the bridge.

On the following dates the bridge was completely closed to **ALL** modes of traffic, including pedestrians and cyclists:

- 11th – 12th July 2019
- 28th – 31st July 2019
- 3rd – 5th August 2019

Three other events to note during the closure period were:

- 6th July 2019: Extinction Rebellion protests
- 15th July 2019: Mill Road Fire (23:20)
- 16th and 17th July: Closed at Mawson Road to the bridge

7.3 Appendix C: CEDAR Mill Road Bridge closure report

MRC | Epidemiology Unit   UNIVERSITY OF CAMBRIDGE   CEDAR Centre for Diet and Activity Research

Traffic data findings - Mill Road Closure summer 2019

Dr Richard Patterson, Dr David Ogilvie and Dr Jenna Panter, MRC Epidemiology Unit, University of Cambridge

What we did

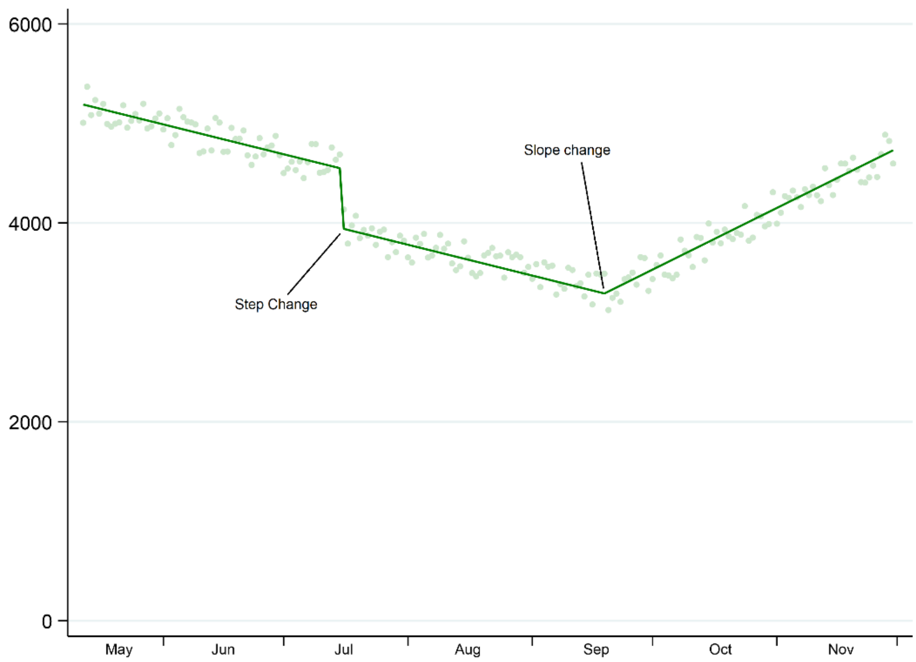
We evaluated the impact of the closure of Mill Road Bridge on the numbers of motorised vehicles, pedestrians and cyclists by examining the impacts on proximate roads and in comparison areas using sensor data.

How we did it

The Mill Road Bridge closed to vehicles from July 1st to August 25th 2019 due to building works, however, it remained open to pedestrians and cyclists for most of this period. Data from six sensors were used in our analysis. Those located on Mill Road East and Mill Road City were used to capture changes on the affected road section. Cherry Hinton Road, Hills Road and Devonshire Road cycle and foot bridge were used as potential alternative routes for displaced traffic. Finally, the Milton Road sensor was included as a comparison site as it is remote from the road closure and unlikely to be affected.

Sum of daily counts in both directions were calculated for each sensor for motor vehicles (cars and LGV), pedestrians and cyclists. Our statistical analyses took account of any step changes (changes in the absolute levels of traffic after the re-opening) and slope changes (changes in the gradient after the reopening) and other events occurring in a similar time period, such as school holidays (see below).

We adjusted for differences in traffic that would be expected at weekends, concurrent gas main works, the days the bridge was completely closed (to pedestrians and cyclists) and weather conditions including rainfall and temperature which may all influence numbers of motor vehicles.



What we found

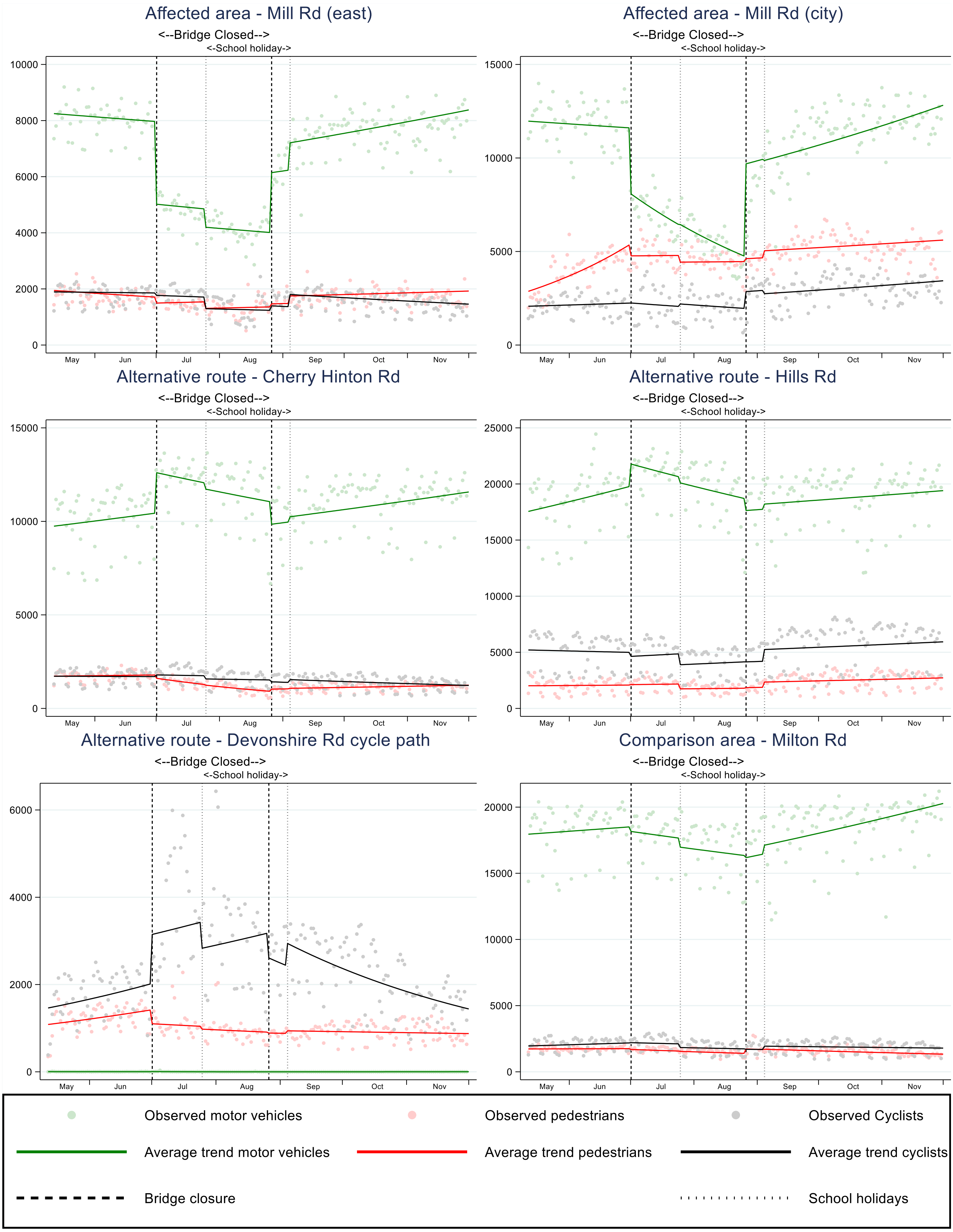
- As expected, both ends of Mill Road experienced reduced numbers of motor vehicles when the road was closed to through traffic.
- Alternative routes saw an increased traffic counts during the closure of Mill Road
- Walking and cycling changed less than motor vehicle traffic on both Mill Road and alternative routes, probably reflecting their continued access to the bridge
- When the Mill Road Bridge reopened, traffic levels took some time to return to their previous levels
- Some evidence for decreasing motorised traffic throughout the closure period, which might reflect the summer holiday period but may be drivers adapting their behaviour
- As expected, the control site at Milton Road saw little change in counts during the closure period

Caveats

- Full seasonal adjustment not possible due to insufficient pre-intervention data and Covid-19 making 2020 invalid for comparison
- Without seasonal adjustment firm conclusions are not possible
- Difficult to disentangle the summer holiday period from the road closure due to overlap
- Events on nearby roads, such as gas works and building fire contribute to problems attributing changes to the closure

Learnings

- Comparison sensors located remote from intervention areas are useful to understand the effects of the intervention and to increase our confidence in the results seen
- Long-term data collection is helpful to control for seasonal trends
- Controlling for all eventualities is not possible and there might be other factors that explained the changes that are not captured here



Affected area - Mill Rd (east)
<--Bridge Closed-->
<-School holiday->
10000
8000
6000
4000
2000
0
May
Jun
Jul
Aug
Sep
Oct
Nov
Affected area - Mill Rd (city)
<--Bridge Closed-->
<-School holiday->
15000
10000
5000
0
May
Jun
Jul
Aug
Sep
Oct
Nov
Alternative route - Cherry Hinton Rd
<--Bridge Closed-->
<-School holiday->
15000
10000
5000
0
May
Jun
Jul
Aug
Sep
Oct
Nov
Alternative route - Hills Rd
<--Bridge Closed-->
<-School holiday->
25000
20000
15000
10000
5000
0
May
Jun
Jul
Aug
Sep
Oct
Nov
Alternative route - Devonshire Rd cycle path
<--Bridge Closed-->
<-School holiday->
6000
4000
2000
0
May
Jun
Jul
Aug
Sep
Oct
Nov
Comparison area - Milton Rd
<--Bridge Closed-->
<-School holiday->
20000
15000
10000
5000
0
May
Jun
Jul
Aug
Sep
Oct
Nov
Observed motor vehicles
Observed pedestrians
Observed Cyclists
Average trend motor vehicles
Average trend pedestrians
Average trend cyclists
Bridge closure
School holidays

7.4 Appendix D: Useful Links

The following are a list of links to documents and information referenced or relevant to this report:

- The case study for Cambridgeshire County Council Signals Team use of traffic data is available on the Smart Cambridge website here.
- The Early Findings Report published for the project is available on the Smart Cambridge website here.
- The GCP Covid19 Transport Dashboard compared modal split in October 2019, April 2020 and November 2020 across our wider Vivacity sensor network. You can review this data on page 120 here.