Tower Bridge Anti Idling

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1. Introduction

The London Boroughs of Southwark and Tower Hamlets were awarded funding from the Mayor's Air Quality Fund (MAQF) to carry out an anti-idling project to improve air quality near Tower Bridge and the surrounding streets. This area had been declared an Air Quality Management Area (AQMA) for nitrogen dioxide (NO_2) and particulate matter (PM_{10}) due to the Air Quality Strategy objectives for these pollutants being exceeded.

Tower Bridge opens on average 900 times each year for approximately five minutes each time. This equates to 75 hours per year or less than 1% of the year. The Bridge currently carries 40,000 vehicles per day and so is busy for the majority of the day. Traffic queues build up near the bridge and on surrounding roads whilst the Bridge is open and then take a while to disperse once the road is open again. Vehicles queue with their engines running leading to increased emissions which could be reduced if drivers could be persuaded to turn their engines off. The aim of this project was to encourage drivers to turn their engines off and assess the effectiveness of this measure on air quality.

Variable Message Signs (VMS) were used to reduce the amount of idling by informing drivers of the road closure and the length of time before traffic is expected to move again.

The main objective of this trial was to establish the effects on air quality by using VMS to inform drivers of the bridge status and confirm whether less queuing traffic with engines running results in improved air quality.

The key success criteria were considered to be:

- An improvement in air quality.
- A reduction in traffic idling during bridge opening times by 60%.
- Improved satisfaction of drivers.

2. Background

2.1 Tower Bridge

Tower Bridge was built over 120 years ago to ease road traffic while maintaining river access to the busy Pool of London docks. It was built with giant moveable roadways that lift up for passing ships. Tower Bridge is still a busy crossing of the Thames; it is crossed by over 40,000 vehicles every day. The bridge is on the London Inner Ring Road, and is on the eastern boundary of the London Congestion Charging Zone.

2.1.1 Tower Bridge Lift Booking

Under the Corporation of London (Tower Bridge) Act 1885, the City of London Corporation is required to raise the bridge to provide access to and egress from the Upper Pool of London for registered vessels, at any time, day or night, 365 days a year. The service is provided free of charge subject to 24 hours' notice. Any vessel with a mast or superstructure of 10 meters or more wishing to enter or leave the Upper Pool of London can ask for a bridge lift.

The information regarding the bridge lift booking process is published on the http://www.towerbridge.org.uk website. In summary, the bridge lift requests have to be made in writing and received by the bridge operator at least 24 hours in advance of a lift. When a booking is made, the Tower Bridge operator will issue confirmation in the form of a numbered bridge lift order, and add the lift to the bridge lift schedule and published on the http://www.towerbridge.org.uk website.

2.1.2 Tower Bridge Operation

The bridge and control room will be staffed 30 minutes before the scheduled bridge lift time. The Tower Bridge staff track the progress of the vessels approach through visual, radio and a dedicated tracking system. Vessels can expect roughly five minutes leeway on a scheduled booking time. The bridge is not necessarily raised at the exact booked time but once the vessel is ready to pass in order to minimize any disruption to road traffic.

Once the vessel is prepared to pass, the bridge driver will initiate a sequence of operation (via the Bridge Control System) that will first turn the traffic signals on the bridge to red and then close the vehicle and pedestrian barriers. The bridge driver will then make an announcement over the loudspeaker system alerting pedestrian and road traffic that the bridge is about to be lifted.

The average time for the complete bridge lifting operation is on average 10-15 minutes. However, this can vary according to the type of vessel requiring a bridge lift. The height of the vessel dictates the degree to which the bridge is raised and the size of the vessel dictates how long the bridge remains lifted till it has passed. For example, a large cruise liner would require the bridge to be fully lifted for a longer period, increasing the time taken to complete the entire operation.

Maintenance lifts are also undertaken on a regular basis. However, these lifts are similar in duration (10-15mins) to bridge lifts for waterborne traffic.

The bridge driver indicated that the approaches to Tower Bridge on the Tower Hamlets side experience significant congestion regardless of Tower Bridge Lifts.

2.1.3 Traffic Equipment on Tower Bridge

There was a set of traffic signals and barriers located on both approaches to Tower Bridge to stop traffic prior to a bridge lift. These signals were initiated via a control panel by the bridge driver in the control room.

There were 60 CCTV camera located on Tower Bridge. These were used by the bridge control room staff to monitor the bridge operation. There was no traffic counting equipment present on Tower Bridge.

2.2 Air Quality

2.2.1 Air Quality Legislation and Criteria

The key driver behind this project is the Environment Act 1995 and subsequent Air Quality Strategy which set out the requirement for local authorities in the UK to implement Local Air Quality Management (LAQM) and develop ameliorative local actions in areas of poor air quality.

The two pollutants of most concern are Nitrogen Dioxide (NO_2) and fine particulate matter (PM_{10}). Air Quality Management Areas have been declared for these pollutants by the London boroughs of Southwark and Tower Hamlets and the Corporation of the City of London. The objectives which are being exceeded are:

- Annual mean NO_2 objective set at 40 µg/m^3.
- Daily mean PM_{10} objective set at 50 µg/m^3 which can be exceeded 35 times per year.

Reducing concentrations in relation to these averaging periods is therefore important.

2.2.2 Background to the Study

Excessive idling of vehicles and especially heavy goods vehicles (HGVs) can significantly increase emissions in localised areas and key congestion hot spots. With modern vehicles, emissions are generally lower if the engine is turned off whilst the vehicle is queuing provided that the queue time is longer than a minute. A number of local authorities in the UK are now undertaking vehicle anti-idling projects as part of their LAQM work.

Vehicle idling has been recognised by local authorities throughout the UK as a potentially significant local source of atmospheric pollutants. Furthermore, it is sometimes an emission source that is within the scope of the authority to regulate and control as idling enforcement can be carried out using a Penalty Charge Notice (PCN) under Code 63. Therefore, it has been included as a defined action in air quality action plans and as a stand-alone policy in many regions.

2.2.3 Existing Monitoring

The London Boroughs undertake local air quality monitoring across their administrative areas using both passive and continuous monitoring techniques. Automatic continuous monitoring stations measure hourly concentrations using EU reference methods and provide the most accurate data but are expensive to operate. The majority of local authorities also measure NO_2 using the simpler and cheaper diffusion tubes. These tubes can be readily mounted on lamp-posts and do not require a power supply so can be used to obtain measurements over a wide area at a relatively low cost. The tubes measure average concentrations during the exposure period which is usually a month. Tubes are usually co-located with a continuous analyser so that the diffusion tube measurement can be compared with the continuous analyser and a bias adjustment factor applied to the diffusion tube reading to bring it in-line with the more accurate continuous analyser.

2.2.4 Electrochemical Sensor Trial

An air quality monitoring trial was undertaken in conjunction with Southwark Council, Future Cities Catapult and Intel for a period of 12 months beginning September 2014. An air quality monitoring unit consisting of various electrochemical sensors capable of measuring CO, CO_2, NO, NO_2 and SO_2 and reporting this data in real time was used. In addition to the functionality, the low cost and ease of deployment on street lighting columns enabling a large special distribution and collections of data were key factors in the choice of this unit.

Figure 2-1 Electrochemical Sensors and Enclosure

The electrochemical sensors were deployed at five locations along Tower Bridge Road listed in Table 2-1 and shown on a location plan in Figure 2-2 and an existing continuous monitoring station on Old Kent Road in September 2014.

Table 2-1. Electrochemical Sensor Monitoring Locations on Tower Bridge Road (Southwark Side)

Location ID	Lamppost Column ID	Location
1a	19	South of railway bridge on east side of Tower Bridge Road, near to junction with Tanner Street.
2	48	West side of Tower Bridge Road, near to junction with Druid Street.
3a	N/A (no column number)	Lamppost outside entrance to Tower Bridge Primary School
4	6315	South of St. John's Estate apartments on the north side of Druid Street, east of Tower Bridge Road.
5	56	West side of Tower Bridge Road, adjacent to One Tower Bridge Development.

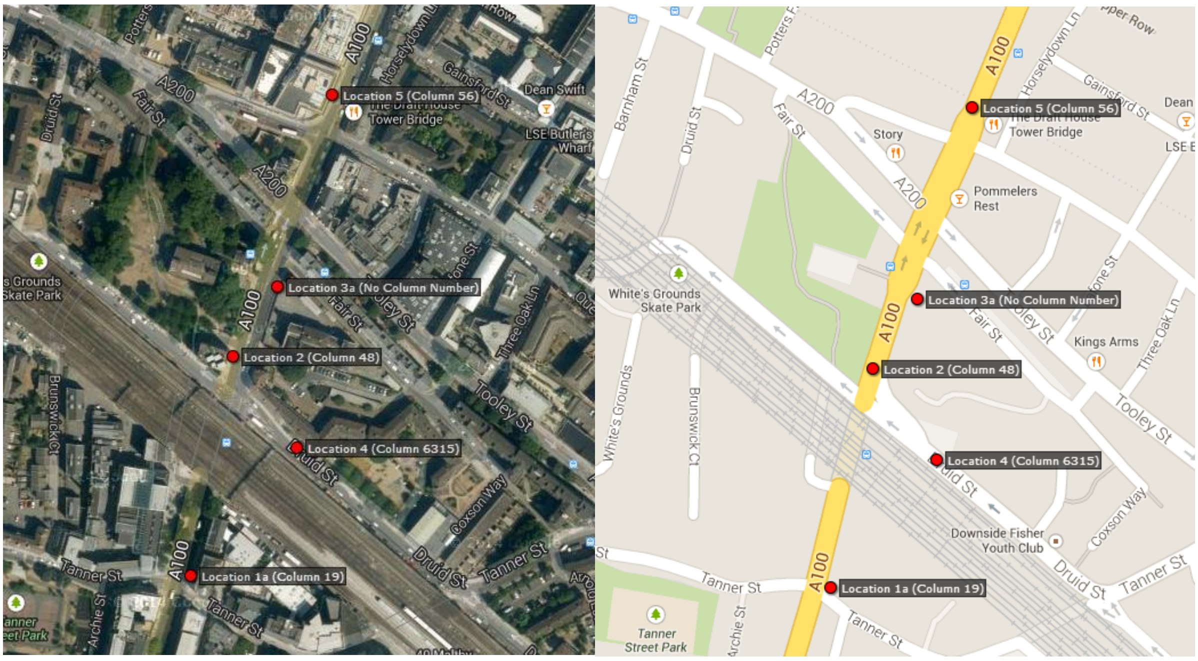


Figure 2-2 Electrochemical Sensor Monitoring Locations on Tower Bridge Road (Southwark Side)

The air quality monitoring experienced reliability and communication flaws during the trial including a fatal hardware fault in the devices that have been deployed in the field. This resulted in a period when no data was collected or recorded due to the hardware issue (modem). The faults equipment was replaced, however, the units continued to experience reliability issues.

The data from all the electrochemical sensors was analysed by Intel in conjunction with researchers at Kings College London. This processes involved validating the sensors against known NO_2 sources. The results of this analysis confirmed that the electrochemical sensors had not performed as expected and there data could not be verified. As NO and NO_2 were the primary focus for the anti-idling trial, the data from the electrochemical sensors was not used and the trial was not progressed further.

3. Anti-Idling Trial

This project aimed to reduce the amount of idling during bridge lifts through the use of portable Variable Message Signs (VMS) on the approach roads to Tower Bridge. They were situated where observed queuing for the bridge lift occurs and where there was sufficient space on the footway to accommodate the signs without inhibiting pedestrian flows or impacting negatively on safety. The VMS displayed messages during bridge lifts advising drivers to switch off engines.

The aim of the Tower Bridge anti-idling scheme was to encourage motorists to turn off their engines when they were waiting for the bridge to re-open, via messages displayed on a number of temporary VMS at strategic locations on the approaches to Tower Bridge.

The VMS on Tower Bridge Road were in operation from 10th February 2016 to 15th April 2016, and from 5th July 2016 to 9th September 2016 (VMS On). Between 15th April 2016 and 5th July 2016, and from 9th September 2016 to 21st November 2016, the VMS was not in operation (VMS Off).

Tower Bridge was lifted on 439 occasions between 13th February 2016 and 9th October 2016 for durations ranging from less than 1 minute to more than 41 minutes. The average bridge lift time was 8 minutes 30 seconds. The total duration of the bridge lifts was 62 hours 42 minutes.

3.1 Variable Message Signs (VMS)

VMS are electronic traffic control devices used to provide motorist en-route traveller information. VMS can be placed in a wide range of places like highways, major road junctions, and urban areas. Typically installed at the side or above the roadway, the VMS uses text and graphics in monochrome or colour to warn of traffic congestion, accidents, incidents, roadwork zones, or speed limits on a specific highway segment. The versatility of variable message signs makes them suitable for providing traffic information for a variety of situations in urban areas to warn of duration and location of the incidents or just inform of the traffic conditions.

Trailer-mounted VMS are used to warn traffic of incidents in urban areas where it is not feasible to install permanent VMS. These VMS can be operated using sustainable energy through solar panels and battery packs integrated on the trailer. This avoids expensive fixed power supply installations, enables the signs to be completely self-sufficient and standalone and promotes a greener environment.

The messages displayed on the sign can be programmed locally on the unit's control panel, or units equipped with a cellular modem can be programmed remotely via computer or phone.

The objective of the VMS was to allow the motorist time to prepare for unavoidable conditions with the goal to have a positive impact on the local air quality.

Figure 3-1 Variable Message Signs

3.2 VMS Locations

In order to identify where the VMS should be placed, on site observations were carried out. These combined with still images of surrounding streets during bridge lift times, provided by Transport for London (TfL), provided a picture of where queues build and therefore where to place the signs. The initial site observation included an assessment:

a. Available space
- Footway width
- Street furniture
- Utilities
- Other
  - Dropped kerbs
  - Bus stops
  - Cycle lanes
  - Parking/loading bays
  - Building access

b. Sightlines
- Street furniture
- Trees
- Road alignment

Considerations were given to junctions, as the idea was not to re-route drivers on to alternative routes.

As a result of the initial site assessment a total of ten sites had been identified around the Tower Bridge area for locating the VMS. A number of the sites had been presented with two location options. The site locations were divided equally between the north and south of the river, some of which were utilised for deployment of VMS during the London Olympics in 2012.

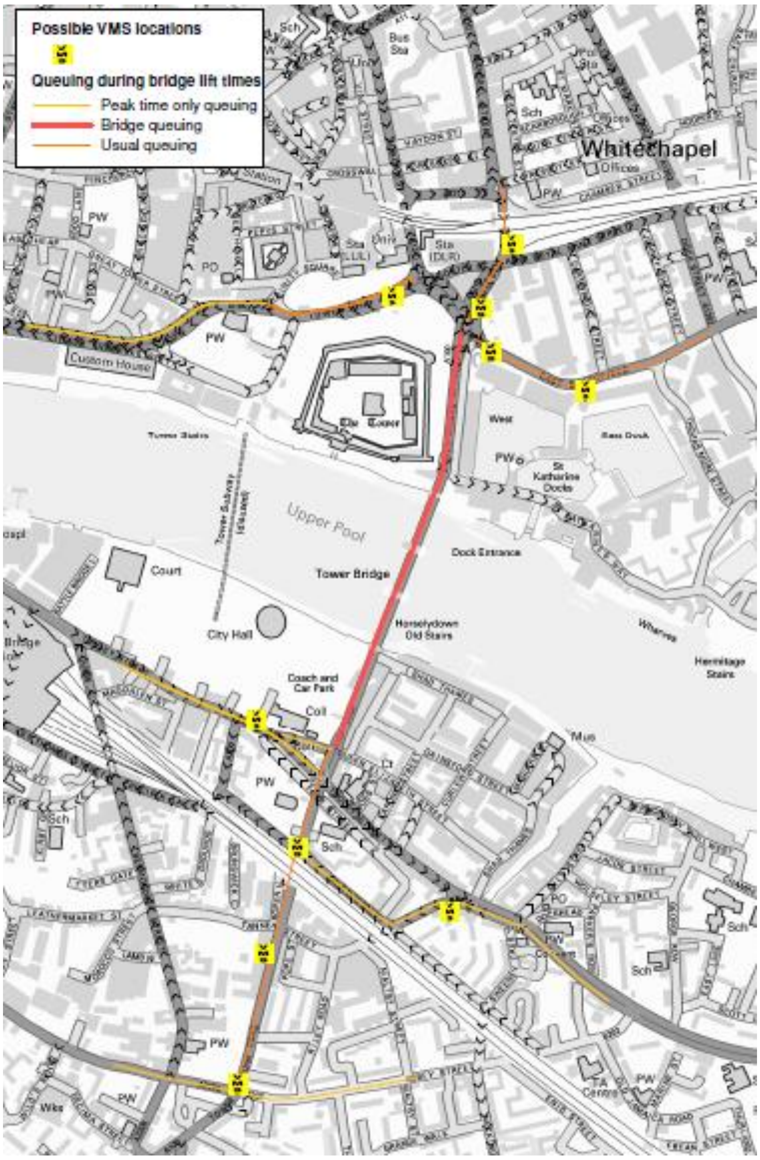


Figure 3-2 Preliminary VMS Locations

A Stage1/2 Road Safety Audit (RSA) was carried out for all the proposed sites identified during the initial site assessment. The audit reported each of the problems identified together with recommendations to solve or mitigate the problems. Following a review of the audit report and consultation with the stakeholders, the final proposed VMS deployment locations were approved with Southwark Council and Transport for London. These locations are displayed in Figure 3-3 and Figure 3-4

Each proposed VMS location has a unique reference number and is represented in one of two different colours indicating its approval status. The colours are explained in the following key.

Conditional Agreement by TfL	Subject to satisfying conditions stated in the Stage 1/2 RSA
Approved by TfL	Location Approved

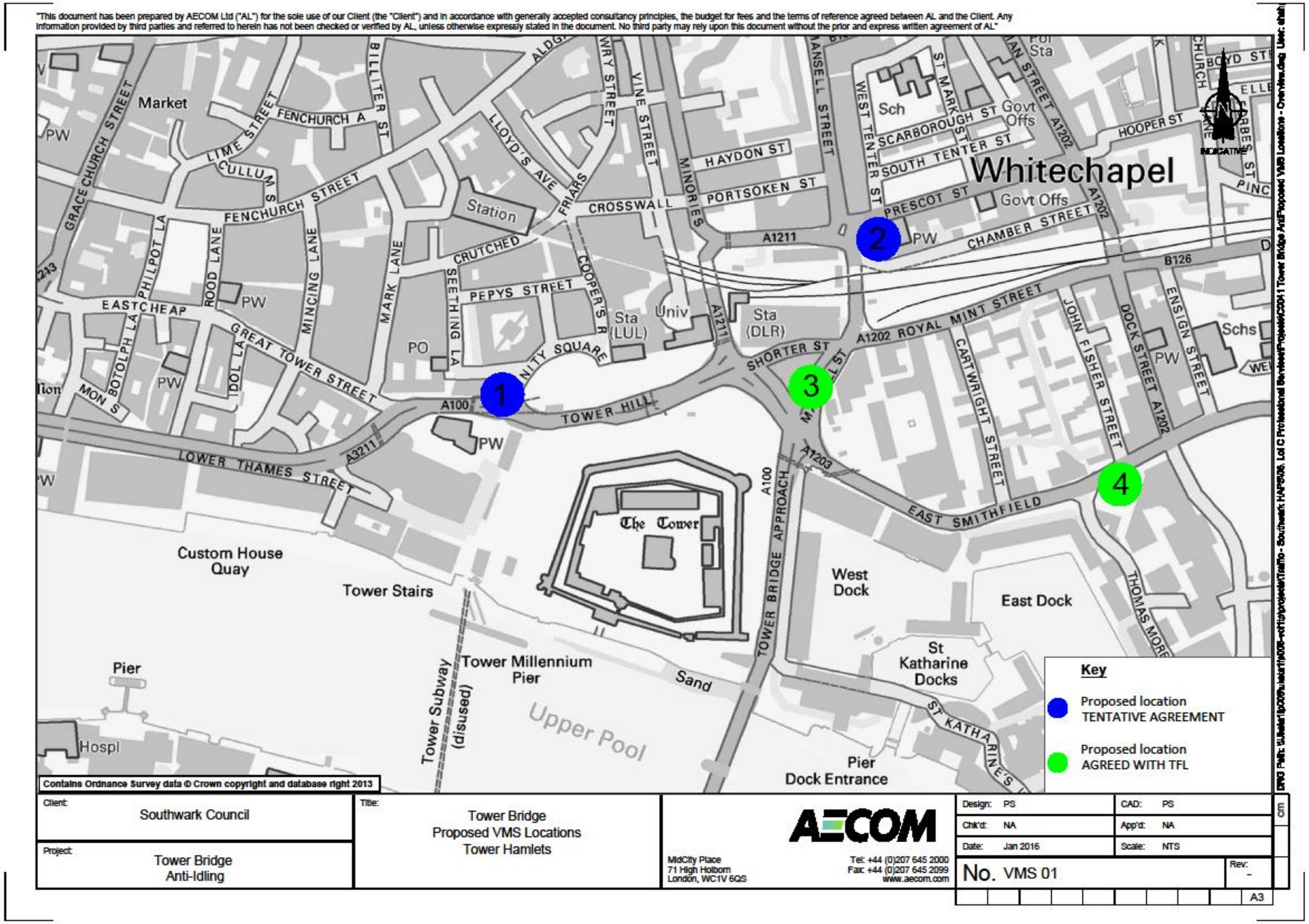


Figure 3-3 Proposed VMS Locations – Tower Hamlets

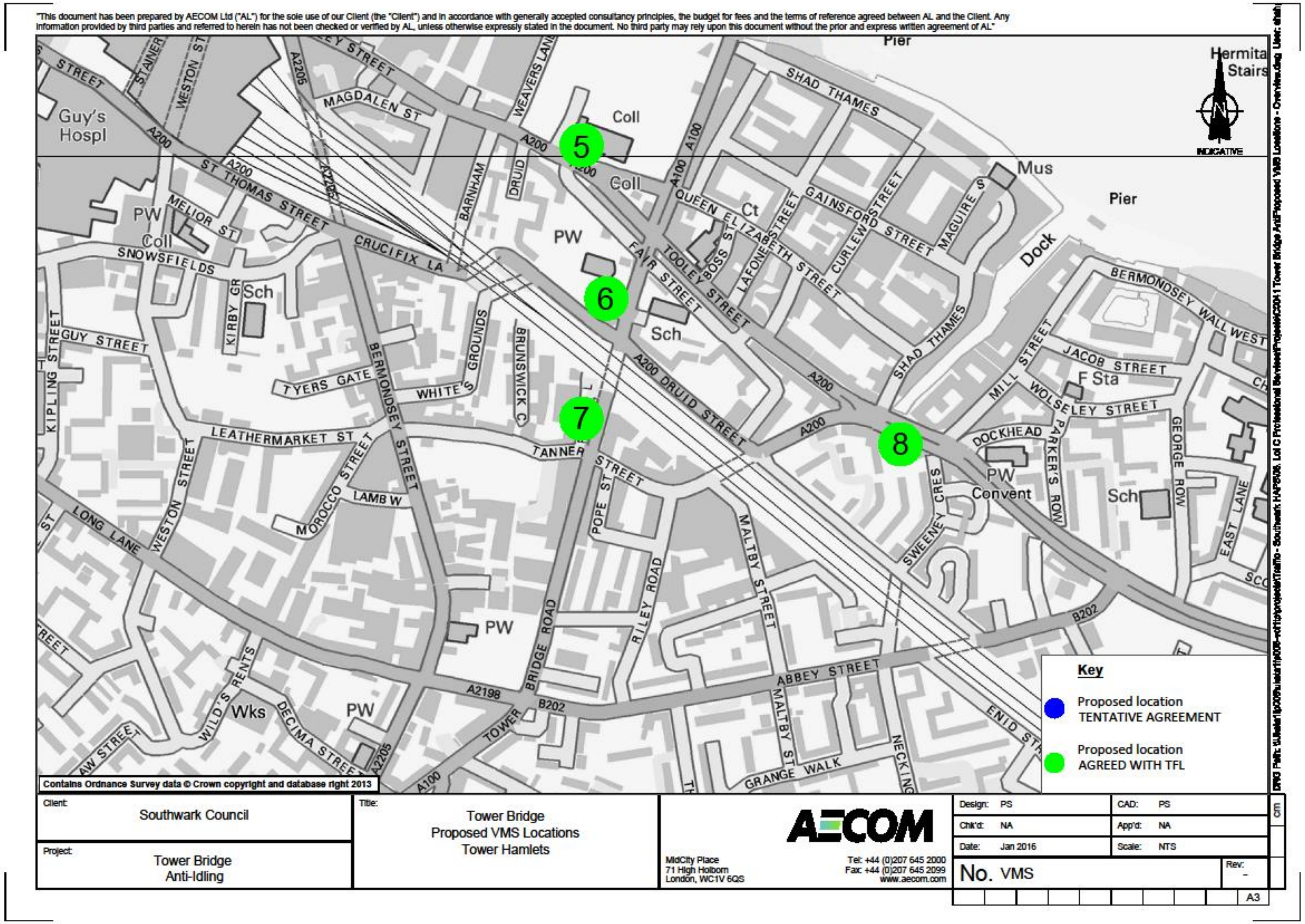


Figure 3-4 Proposed VMS Locations – Southwark

3.3 Anti-Idling Trial Operation

This section provides details of the provisions made to enable the VMS to activate relevant messages for the road users.

The Traffic Signal Controller at the junction of the approaches to Tower Bridge (e.g. TOWER BRIDGE APP. / MANSELL ST / EAST SMITHFIELD / TOWER HILL) receives a data feed from a relay on Tower Bridge, via a communications cable, which signal Bridge down and Bridge up and initiates traffic signal plans accordingly.

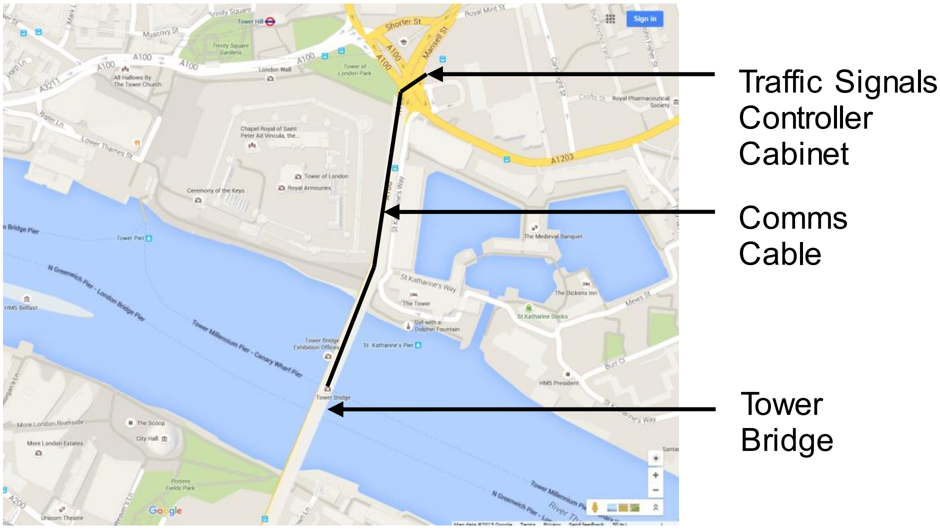


Figure 3-5 Map of Tower Bridge and controller cabinet location with physical cable shown.

TfL had provided a parallel output of the data feed from the relay on Tower Bridge in a feeder pillar cabinet located adjacent to the Traffic Signal Controller cabinet. This feeder pillar cabinet was used by the scheme to house communications equipment required to activate messages on the VMS when a bridge lift is in operation.

Figure 3-7 View of transmission cabinet location.

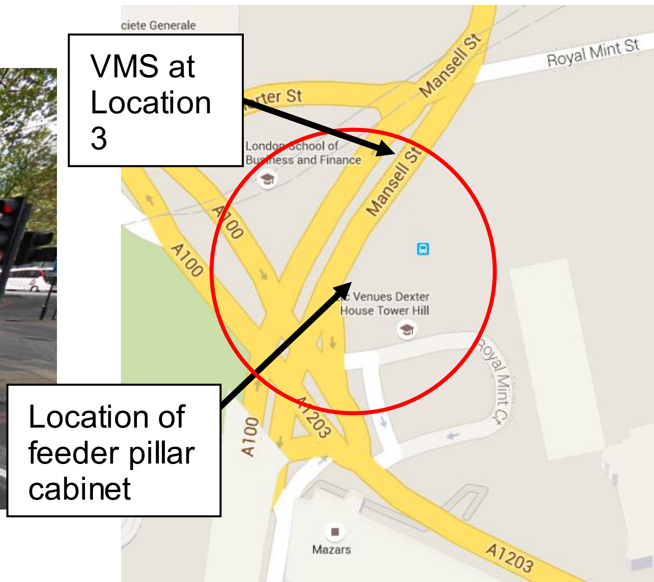


Figure 3-7 VMS Location 3 in relation to feeder pillar cabinet

3.4 VMS Legends

The following legends were displayed on the VMS at all locations when a Bridge Lift was in operation. Each cycle described below uses a combination of legends to display a specific message. The legends transitioned consecutively as specified below until the bridge lift was complete.

<u>Bridge in operation</u>

Cycle 1

Cycle 2

Once the Bridge Lift had been completed the "Bridge Lift Complete" message was displayed on the VMS at all locations for a minimum period of thirty seconds followed by a blank legend until the next Bridge Lift was in operation

<u>Bridge lift complete</u>

4. Monitoring

In order to fully assess the impacts of the trial, a mix of quantitative and qualitative methods in monitoring of vehicle idling with respect to Tower Bridge. This included on street surveys to record attitudes and behaviours of drivers in advance of the measures being implemented and idling surveys carried out manually to assess the impacts of VMS messages on driver behaviour, specifically engine idling.

The following section provides details on the idling and driver awareness surveys.

4.1 Idling Surveys

The idling surveys were carried out manually by enumerators to assess the impacts of VMS messages on driver behaviour, specifically engine idling.

4.1.1 Survey Process

The following section describes the process by which the data was recorded:

1. Before each 'Bridge Lift', enumerators stood as close to their survey station position (1-8), but where they could see the lights on the approach to the centre of the bridge.
2. Record the exact time at which the lights on the approach to the centre of the bridge started to flash.
3. Walk as quickly as possible to their survey start position.
4. Record the exact time at which the first vehicle, in their survey area, stops as a direct result of Tower Bridge lifting.
5. Walk from the front of the queue of traffic to the back of the queue, counting the traffic into the specified classes as they progress, splitting this traffic into those that have their engine running and those that have their engine turned off.
6. Return to the front of the queue, recording the exact time at which they get there.
7. Walk from the front of the queue of traffic to the back of the queue, counting the traffic into the specified classes as they progress, splitting this traffic into those that have their engine running and those that have their engine turned off
8. Repeat process 6 and 7 until the Tower Bridge lights stopping flashing and the bridge is fully lowered and traffic starts to flow again.
9. Record the exact time at which the vehicle at the end of the queue starts to move again.

4.1.2 Survey Locations

The survey start positions at the 8 locations surveyed are indicated in Figure 4-1.

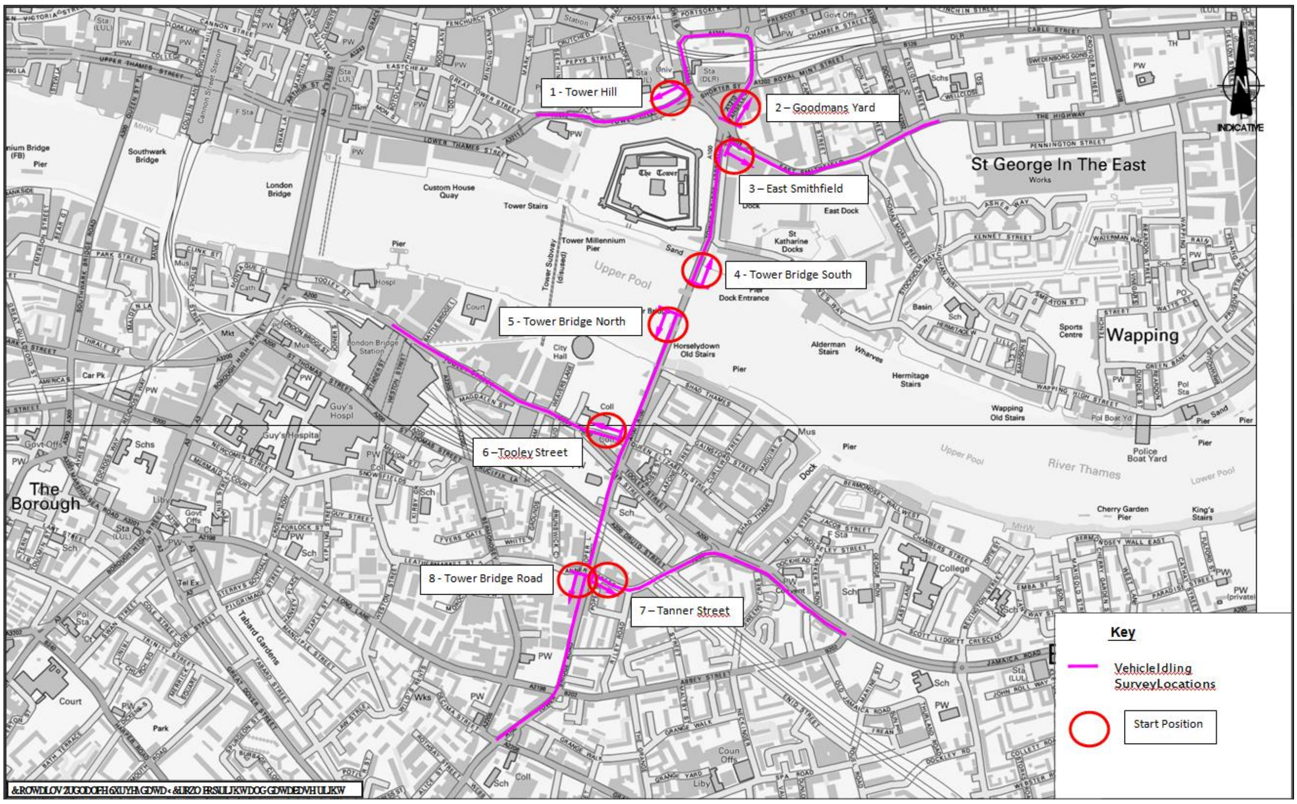


Figure 4-1 ***Idling survey start positions.***

A list of the survey sites are provided below:

1. Tower Hill
2. Goodmans Yard
3. East Smithfield
4. Tower Bridge Southbound Approach
5. Tower Bridge Northbound Approach
6. Tooley Street
7. Tanner Street
8. Tower Bridge Road

4.1.3 Pre-Trial Time Period

The data from the survey was collected over 5 days including 3 mid-week days (Tuesday, Thursday and Thursday) and a two weekend days (Saturday and Sunday). The table below provides details of the dates and times that the idling surveys were carried out.

Table 4-1 Pre-Trial scheduled Bridge Lift Time for Idling Surveys

Date	Scheduled Bridge Lift Time					
	1	2	3	4	5	6
Tuesday 10th July 2014	13:45	14:30	17:30	18:15	18:45	
Thursday 12th July 2014	13:00	13:45	17:00	17:45		
Saturday 14th July 2014	12:30*	13:30*	16:30*	17:30*	18:00	18:45
Thursday 19th July 2014	11:15	15:30	17:00	17:30*	18:15*	
Sunday 6th August 2014	09:00	09:30	12:45	13:45		

*Scheduled bridge lifts cancelled on the survey day

4.1.4 During-Trial Time Period

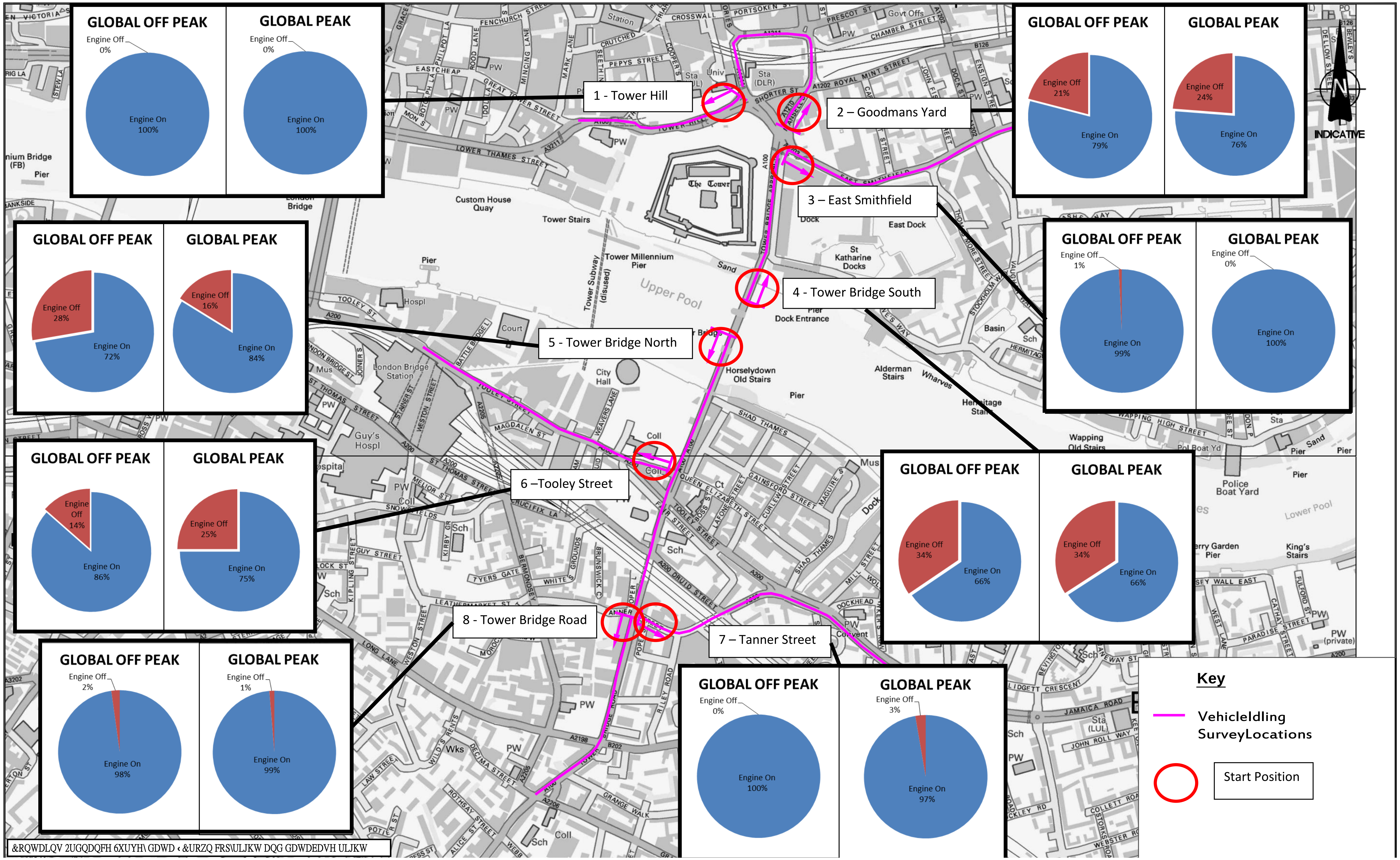
The data from the survey was collected over 4 days including 3 mid-week days (Tuesday, Thursday and Thursday) and a one weekend day (Saturday). The table below provides details of the dates and times that the idling surveys were carried out.

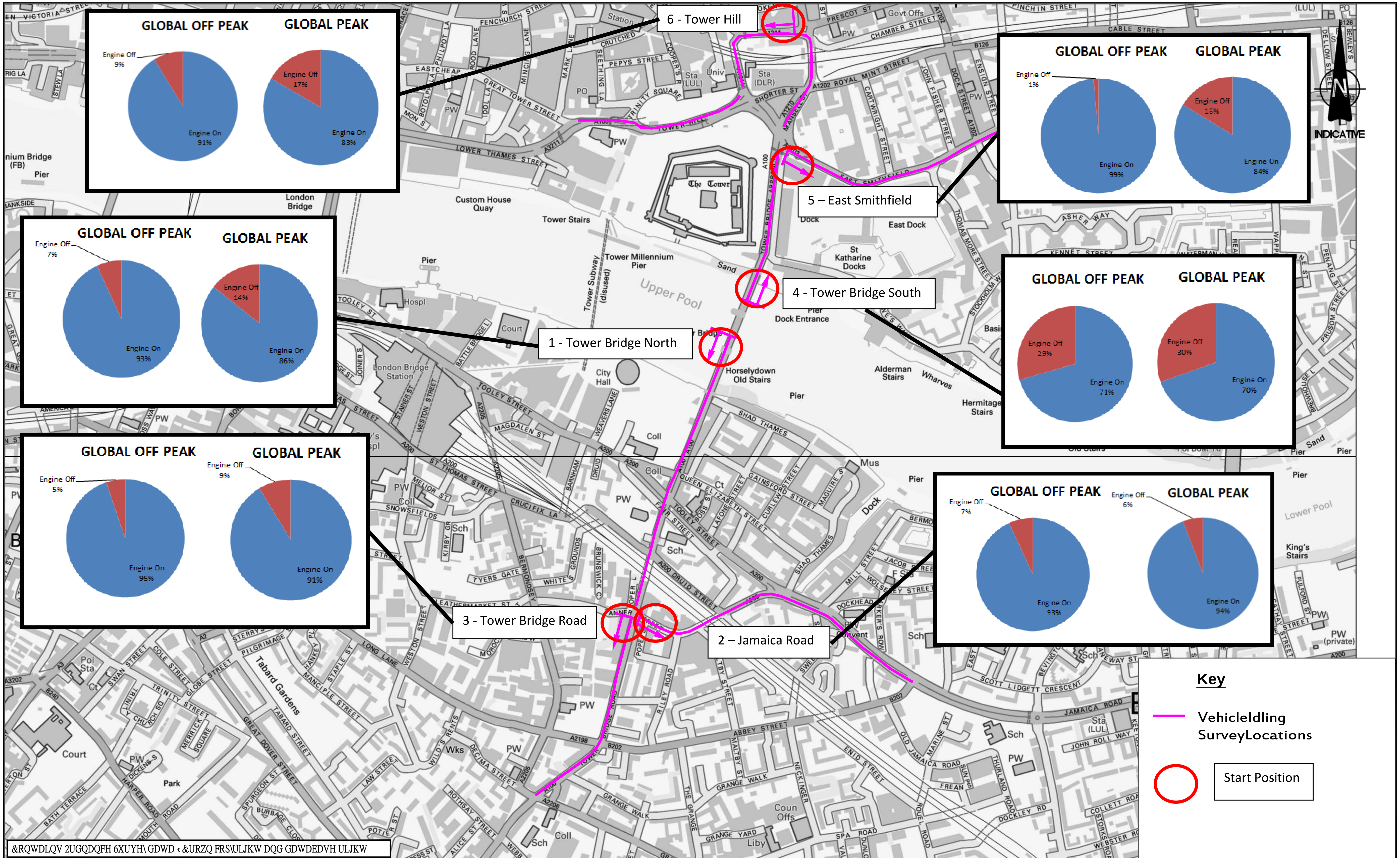
Table 4-2 During-Trial scheduled Bridge Lift Time for Idling Surveys

Date	Scheduled Bridge Lift Time					
	1	2	3	4	5	6
Wednesday 31st August 2016	09:30	14:50	18:45			
Friday 2nd Sept 2016	09:45	12:30	13:00	13:35	15:45	17:00
Saturday 3rd Sept 2016	15:45	16:30	17:00			
Wednesday 7th Sept 2016	09:45	12:45	17:00			

4.1.5 Results

The following figures provide a summary of the results from the idling surveys before and during the trial period.


1 - Tower Hill
GLOBAL OFF PEAK
Engine Off 0%
Engine On 100%
GLOBAL PEAK
Engine Off 0%
Engine On 100%
2 – Goodmans Yard
GLOBAL OFF PEAK
Engine Off 21%
Engine On 79%
GLOBAL PEAK
Engine Off 24%
Engine On 76%
3 – East Smithfield
GLOBAL OFF PEAK
Engine Off 1%
Engine On 99%
GLOBAL PEAK
Engine Off 0%
Engine On 100%
4 - Tower Bridge South
GLOBAL OFF PEAK
Engine Off 34%
Engine On 66%
GLOBAL PEAK
Engine Off 34%
Engine On 66%
5 - Tower Bridge North
GLOBAL OFF PEAK
Engine Off 28%
Engine On 72%
GLOBAL PEAK
Engine Off 16%
Engine On 84%
6 –Tooley Street
GLOBAL OFF PEAK
Engine Off 14%
Engine On 86%
GLOBAL PEAK
Engine Off 25%
Engine On 75%
7 – Tanner Street
GLOBAL OFF PEAK
Engine Off 0%
Engine On 100%
GLOBAL PEAK
Engine Off 3%
Engine On 97%
8 - Tower Bridge Road
GLOBAL OFF PEAK
Engine Off 2%
Engine On 98%
GLOBAL PEAK
Engine Off 1%
Engine On 99%
INDICATIVE
Key
VehicleIdling SurveyLocations
Start Position
&RQWDLQV 2UGQDQFH 6XUYH\ GDWD ‹ &URZQ FRS\ULJKW DQG GDWDEDVH ULJKW



GLOBAL OFF PEAK
Engine Off 9%
Engine On 91%
GLOBAL PEAK
Engine Off 17%
Engine On 83%
6 - Tower Hill
GLOBAL OFF PEAK
Engine Off 1%
Engine On 99%
GLOBAL PEAK
Engine Off 16%
Engine On 84%
INDICATIVE
5 – East Smithfield
GLOBAL OFF PEAK
Engine Off 7%
Engine On 93%
GLOBAL PEAK
Engine Off 14%
Engine On 86%
4 - Tower Bridge South
1 - Tower Bridge North
GLOBAL OFF PEAK
Engine Off 29%
Engine On 71%
GLOBAL PEAK
Engine Off 30%
Engine On 70%
GLOBAL OFF PEAK
Engine Off 5%
Engine On 95%
GLOBAL PEAK
Engine Off 9%
Engine On 91%
GLOBAL OFF PEAK
Engine Off 7%
Engine On 93%
GLOBAL PEAK
Engine Off 6%
Engine On 94%
3 - Tower Bridge Road
2 – Jamaica Road
Key
VehicleIdling SurveyLocations
Start Position
&RQWDLQV 2UGQDQFH 6XUYH\ GDWD ‹ &URZQ FRS\ULJKW DQG GDWDEDVH ULJKW

4.1.6 Conclusions

The results of the idling surveys carried out before and during the trial were compared and the following section provides an overview of the comparison:

- There is considerable improvement in the number of drivers switching off their engines in Tower Hill location (site 6): from all drivers idling pre-trial to 9% switching their engines in off-peak and 17% in peak period during-trial;
- Similarly, more drivers switch off their engines in East Smithfield (site 5) during peak period – a change from 0% to 16% has been observed. The percentage of drivers idling during off-peak period has not changed;
- 4-5% fewer drivers switch off their engines at Tower Bridge southbound location (site 4) compared to pre-trial both in peak and off-peak periods;
- The percentage of drivers with engines off at Tower Bridge northbound (site 1) has decreased significantly from 28% to 7% during off-peak period but remained approximately the same during peak period;
- Percentage of drivers with engines off at Tower Bridge Road (site 3) has increased by up to 8% in peak period;
- Divers started switching off their engines at Tanner Str/ Jamaica Road (site 2) pre-trial but still the percentage of drivers with engines switched off does not exceed 7%.
- Overall, similar to pre-trial results, the highest percentage of drivers switching off their engines is at Tower Bridge South (about 30% during-trial). There have been slight improvements in driver behaviour where almost all drivers were idling before - however, there have been a significant drop in percentage of vehicles with engines off at Tower Bridge North during off-peak period.
- On average, about 10% of various types of vehicles switch off their engines in peak hour. Car drivers and motorcyclists switch off their engines more often than the others– up to 17% on average in peak period.

4.2 Driver Awareness Surveys

The aim of the surveys was to record attitudes and behaviours of drivers in advance of the measures being implemented. This was carried out through on street surveys. It is important to note that it was not possible to capture this information from a driver at the roadside as it would have required a safe area for the driver to stop along with police presence. However, drivers in the surrounding areas such as car parks, local businesses that are likely to use the bridge were surveyed using questionnaires.

4.2.1 Methodology

In total 407 interviews were conducted at numerous locations in the vicinity of Tower Bridge including London Bridge, Fenchurch Street, Guys Hospital and Tower Walk, between 5th – 17th June 2014.

Face to Face interviews were conducted by trained and experienced interviewers. The sample includes only drivers who have experienced queuing as a result of the bridge lifting, and not just general traffic congestion. A short screening question was used to identify drivers in scope followed immediately by the main questionnaire, as follows.

S1 Have you driven across Tower Bridge in the last 3 months? (show map)

No CLOSE

Yes CONTINUE

Note: Bus drivers and taxi drivers are likely to use the bridge frequently and were included in the survey sample.

Fieldwork covered a range of times of day (06:00 – 20:00) and days of the week to generate a mix of respondent types who travel for different journey purposes. There were no quotas for males/females/age groups etc. but interviewers were instructed to include a representative mix of drivers.

No incentives were offered to respondents.

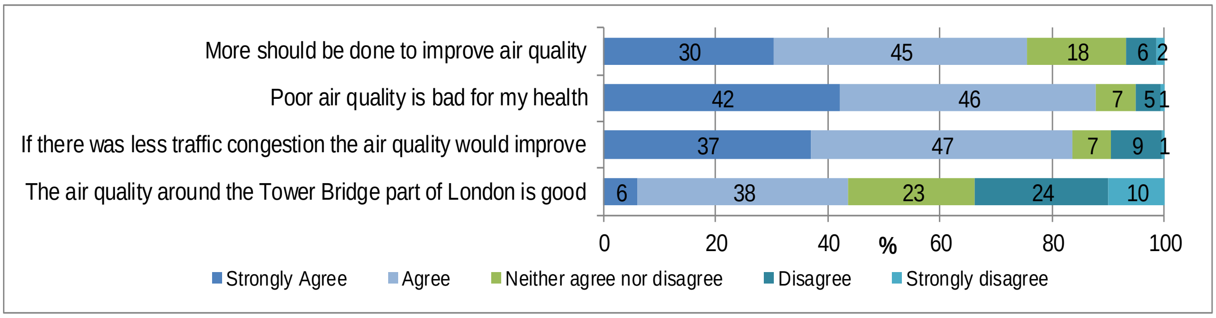
The questionnaire included sections on:

- Attitudes and perceptions of air quality;
- Behaviour regarding idling in stationary traffic;
- Use of Tower Bridge (frequency, purpose, vehicle type) and frequency of encountering bridge lifts; and
- Perceived effectiveness of measures aimed at improving air quality.

The questionnaire that was used during the surveys is provided in Appendix C followed by the results from the survey that are tabulated in Appendix D.

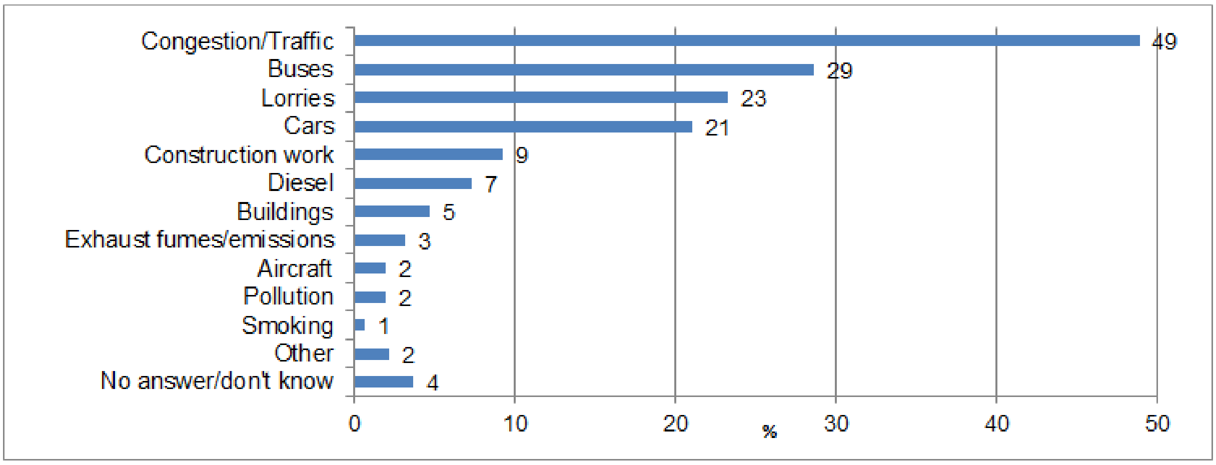
4.2.2 Attitudes and Perceptions of Air Quality

Just 44% of drivers agreed that air quality around Tower Bridge was good, and 34% disagreed. Most, 88% agreed that poor air quality would be bad for their health, and three quarters agreed that more should be done to improve air quality. Most, 84% agreed that less traffic congestion would contribute to improving air quality.



To what extent do you agree or disagree…

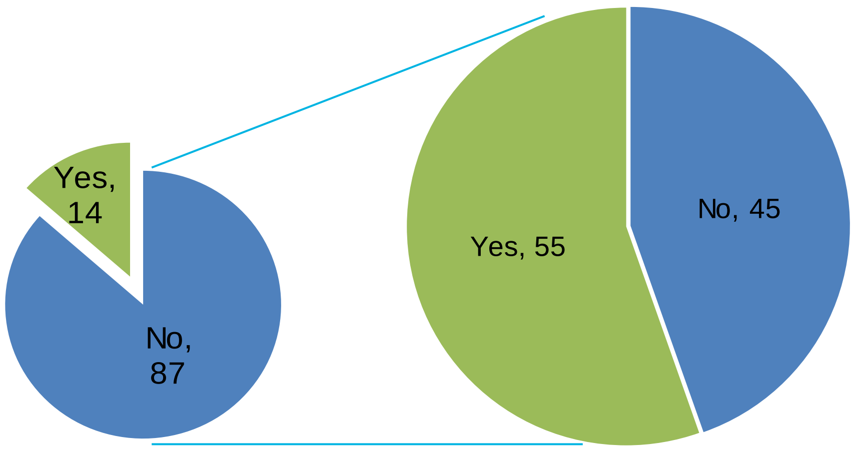
When asked what they though the causes of poor air quality were, almost half, 49%, stated traffic or congestion in general. Where specific vehicle types were mentioned buses (29%) and lorries (23%) were both mentioned more regularly than cars/taxis (21%).



What do you think is the main contributor to poor air quality in this area?

4.2.3 Behaviour regarding idling

Fourteen percent of respondents owned a vehicle with an engine that automatically shuts down when idle. Of those respondents that did not own such a vehicle, just over half (55%) stated that they switch off their engine when stationary



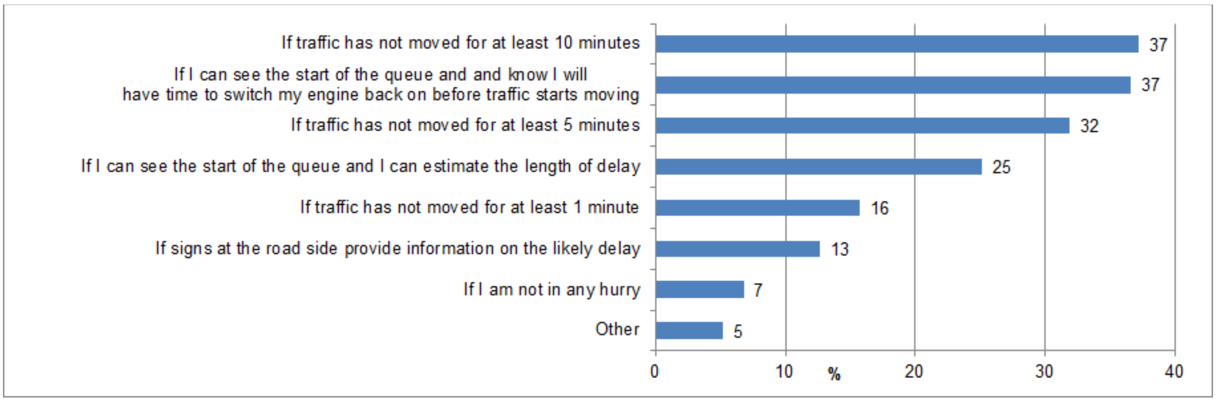
Do you drive a vehicle that automatically turns off the engine when in stationary traffic? n=406) *Do you ever turn off your engine when stuck in stationary traffic? (n=352)*

Of those who WOULD turn off their engines when stuck in stationary traffic, just 16% would do so if stationary for one minute, this increased to 32% if stationary for 5 minutes and 37% if stationary for 10 minutes.

Being able to estimate the length of delay would also encourage drivers to switch off their engines:

- Being able to see the end of the queue 25%;
- Knowing they will have to switch their engines back on in good time 37%.

A sign at the roadside providing information on the likely delay would encourage only 13% of drivers to switch off.



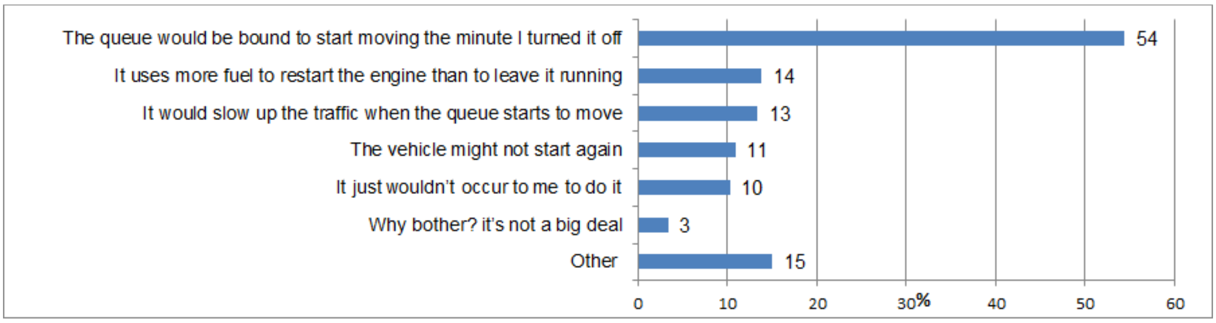
In what circumstances do you switch off your engine when sitting in traffic? (respondents could give more than one answer) (n=191)

Other reasons specified included four people saying ‘if the bridge goes up’ and one, ‘to save petrol’.

All drivers were asked in what circumstances they leave their engines running even though traffic is stationary. The most cited reason for not switching off (54%) was the belief that the queue would start moving again as soon as they did.

Just over one in ten (11%) had concerns that their vehicle might not start again if the engine was turned off, and it just wouldn't occur to a further 10% to do it.

One in seven (14%) thought it would increase fuel use to do so, and 13% thought it would add to traffic delays.



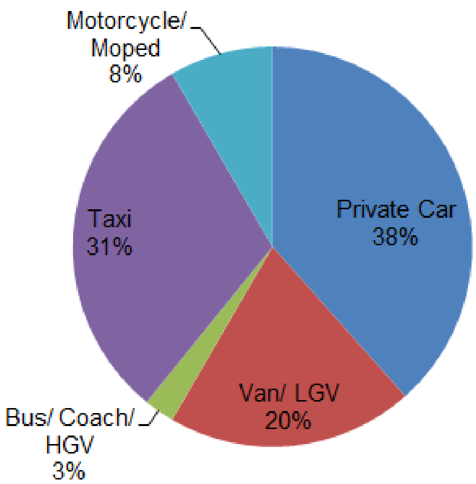
What are the reasons for keeping your engine running when sitting in stationary traffic? (respondents could give more than one answer) (n=320)

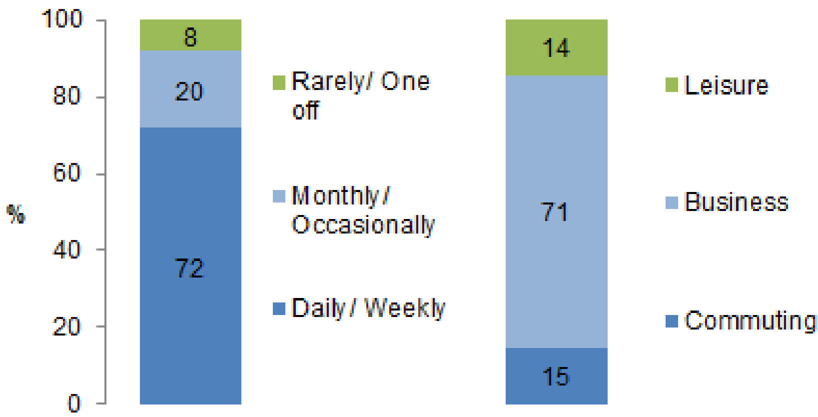
The main other reason for keeping the engine running was to maintain temperature inside the vehicle (n=11).

4.2.4 Usage of Tower Bridge

The sample included a range of vehicle types with car and taxi drivers forming the largest groups (38% and 31% respectively).

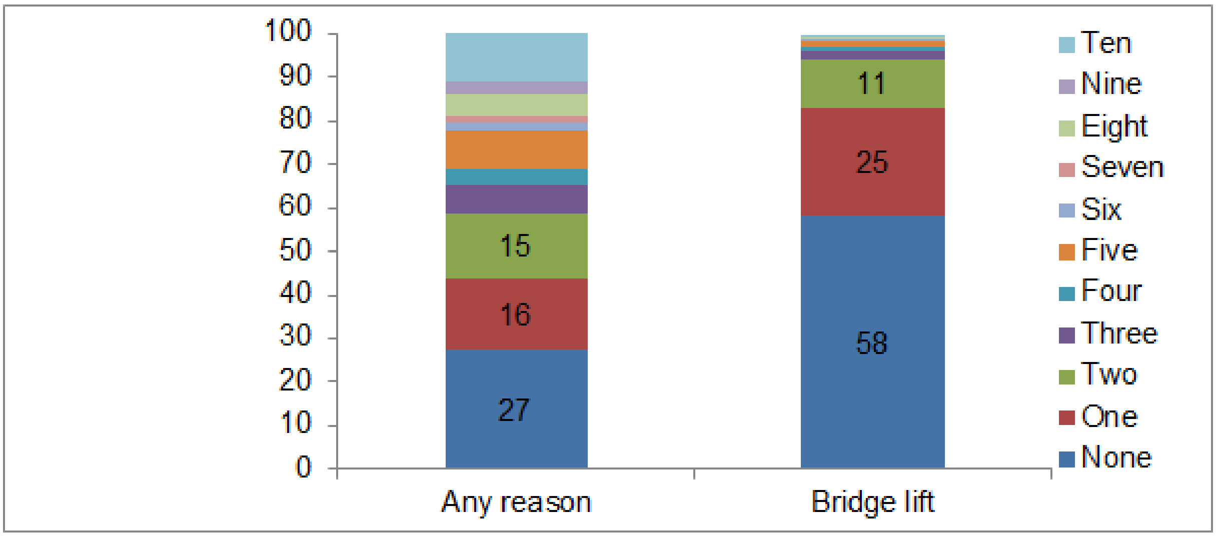
The majority were frequent users of the crossing at Tower Bridge with 71% of journeys being made for business purposes.





n=406

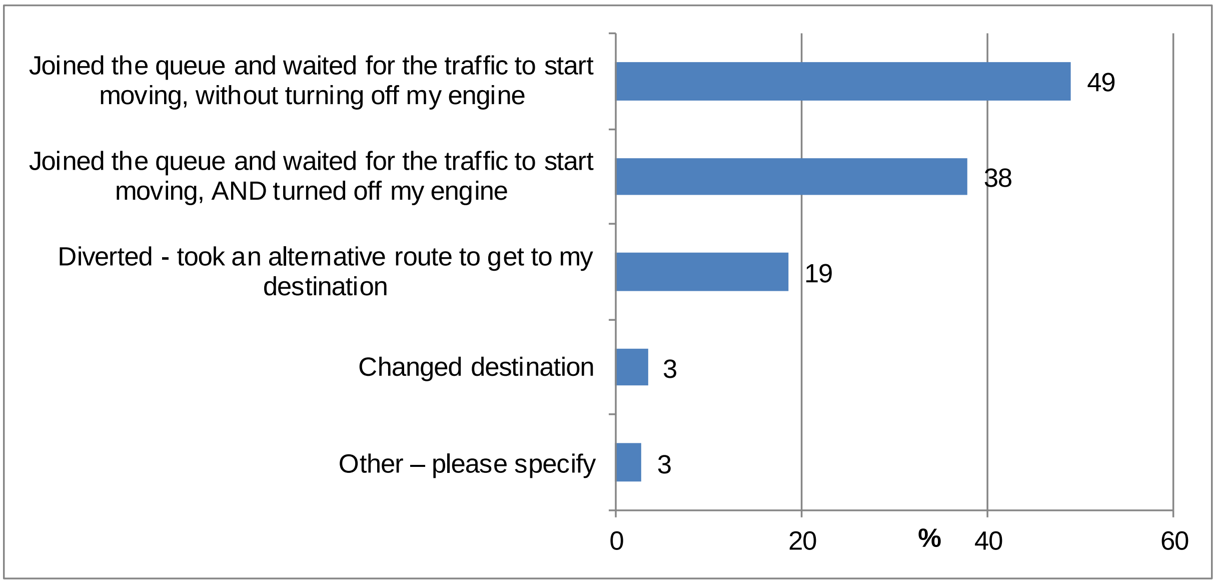
Those who use the bridge more than rarely were asked about their delay frequency and whether these delays were due to the bridge being raised. Delays due to bridge lifts were much less frequent than other reasons, 58% of drivers saying none in ten journeys were delayed by bridge lifts, compared with just 27% of drivers never being delayed.



On approximately how many in 10 journeys across Tower Bridge have you had to queue? N=359, 329

Of those who had experienced a delay the longest wait had been 37 minutes with an average delay of just over 12minutes. This average was similar regardless of vehicle type, frequency of travel or journey purpose.

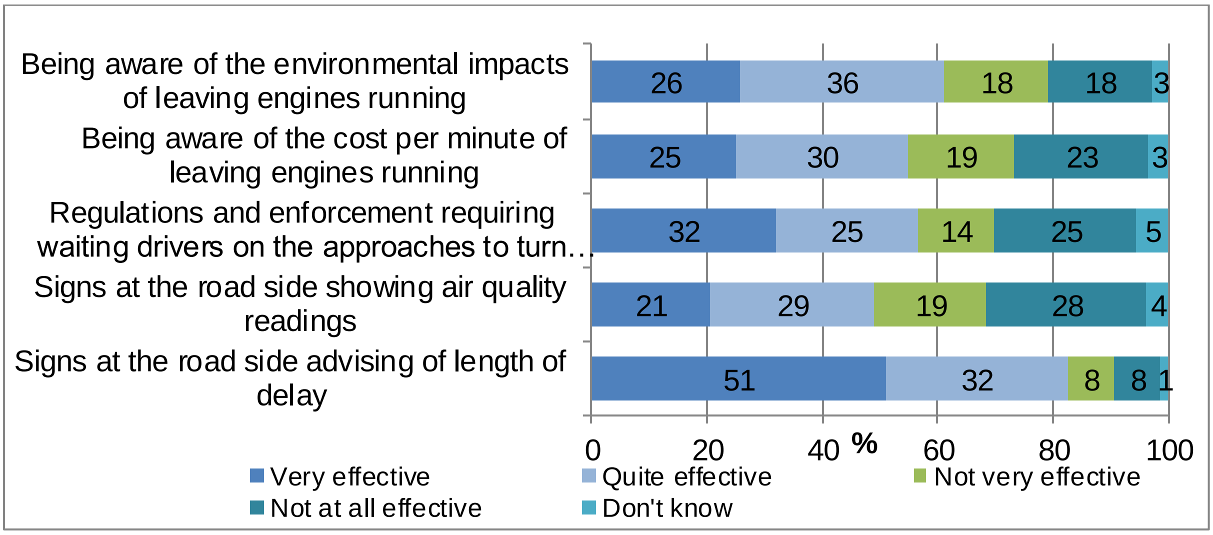
Drivers who had been delayed at the crossing at some point were asked what they did the last time they were delayed. Almost half (49%) said they waited with their engine running whilst they were waiting whilst 38% said they waited AND turned their engine off.



Thinking about the last journey you made which was affected in some way by the lifting of Tower Bridge, which of the following did you do? (respondents could give more than one answer) (n=145)

4.2.5 Effectiveness of Planned Measures

Respondents were asked their opinion of the effectiveness of a variety of measures in getting motorists to shut off their engines. More than two fifths (83%) felt that signage informing of the length of delay would be effective, followed by making drivers more aware of the environmental impact (62%).

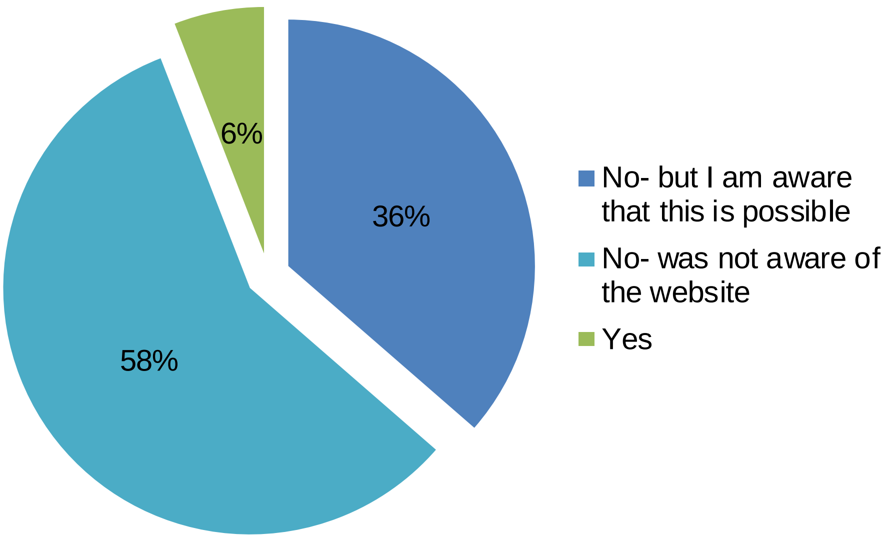


How effective do you think each of these measures will be? (n=406)

Drivers aged 17-34 were significantly more likely to state that regulations and enforcement requiring drivers to turn off their engines would be effective than those aged 35+ (68% compared to 51%). Leisure users were also significantly more likely to feel this would be an effective measure (78%) than business users (53%) or commuters (51%)

Older drivers (60+) were more likely to feel that signs showing air quality readings would not be effective (64%) than drivers aged under 60 (44%). Business users (47%) were more likely to feel that making drivers aware of the cost per minute of running an engine would not be effective then leisure users (28%) or commuters (31%).

Finally drivers were asked whether they check bridge opening times on the website. Just 6% of respondents stated that they did with over half (58%) not knowing about the website at all.



Have you ever checked for when the bridge is going to lift on the website? (n=404)

4.2.6 Summary

There is little tendency for drivers to check for bridge openings on the website. This may be because it would appear that delays in the area due to bridge lifts are relatively insignificant compared with delay due to other causes.

Almost two fifths would turn off their engines if queueing at the bridge. Less than a fifth of drivers would look for alternative routes if delayed at the crossing, with almost half sitting in the queue with engines running. Over half of those who tend not to switch off their engines when queuing say this is because they expect the queue to start moving quickly.

Many drivers are reluctant to switch off their engines when queuing, unless traffic has not moved for some considerable time. This could increase in very cold or very hot weather to maintain air conditions in the vehicle.

Road signs providing information on the likely delay would encourage only 13% of drivers to switch off, although this was thought to be one of the most effective measures that could be taken.

Air quality readings were not recognised as very effective, even though most drivers know it is bad for their health.

4.3 Air Quality Monitoring

This study had been designed to investigate the potential air quality benefits of the Tower Bridge anti-idling trial. This section presents analyses of the data collected. It provides a statistical summary of the data collected over the monitoring period, compares the measured concentrations against the relevant air quality objectives, and examines whether the anti-idling trial resulted in any demonstrable changes in NO_X and NO_2 concentrations at Tower Bridge Road.

4.3.1 Background

Tower Bridge is raised on average 900 times per year, for approximately 10-15 minutes each time, to allow tall vessels to pass along the River Thames. During these periods Tower Bridge Road is temporarily closed and large traffic queues form on the approaches to Tower Bridge and surrounding roads.

The primary requirement for the trial was to monitor oxides of nitrogen (NO and NO_2). Due to the short periods of time for which vehicles are stationary and idling any impacts on ambient air quality are likely to be small and may not be detectable over monthly or annual timescales. To capture any air quality impacts required measurement techniques that have time resolutions of 15 minutes or less.

The chemiluminescence measurement method for NO_X is the EU Approved Reference Method for determining NO_X, NO and NO_2 concentrations allowing results to be compared against the relevant EU Limit Values / UK Air Quality Objectives. This method is widely used across the UK and is used by Defra for reporting to the EU. It also a high time resolution and accuracy for monitoring that is suitable for the purposes of this trial. Therefore a continuous monitoring station housing a chemiluminescence analyser was the most suitable instrument for real-time ambient air quality monitoring of oxides of nitrogen (NO and NO_2). However, the following limitations apply to this type of monitoring station:

- A large space is required for the installation of the enclosure in which to house the continuous monitoring equipment. The enclosure also requires a concrete plinth to be laid to which the enclosure can be secured.
- Requirement for a power supply for the continuous monitoring equipment.
- The cost of purchase and operation of the continuous monitoring station is high.
- A minimum of one site visit per month will be required to carry out routine calibrations and maintenance.

To quantify the impact of the anti-idling trial on local air quality, the ideal scenario to maximise the quality and accuracy of the results would have been to carry out monitoring in the vicinity of Tower Bridge alongside all the roads that are likely to be affected during periods of road closure. However, due to the limitations above regarding the space required and cost of the monitoring station, there was only one suitable location identified to deploy a continuous monitoring station.

An air quality monitoring station was installed on the southern approach to Tower Bridge, on the west side of Tower Bridge Road at the junction with Druid Street. Continuous monitoring of oxides of nitrogen (NO_X), nitric oxide (NO) and nitrogen dioxide (NO_2) commenced on 1st February 2016.

In addition to the continuous monitoring, the annual mean NO_2 concentration is of interest as the objective is being exceeded. Therefore, diffusion tubes were set up to measure monthly mean NO_2 concentrations. Southwark Council carried out NO_2 diffusion tube monitoring at 15 locations alongside Tower Bridge Road and adjacent roads. The diffusion tube survey commenced in March 2014.

4.3.2 Monitoring Results

The results of the air quality monitoring are presented in the following sections. Section 4.3.3 discusses the results of the continuous monitoring. Section 4.3.3.2 examines the data in more detail, looking at diurnal patterns and temporal variations, whilst Section 4.3.3.3 assesses the effects of bridge lifts and the VMS on levels of NO_2.

Section 4.3.4 presents the results of the Southwark Council NO_2 diffusion tube survey, comparing the monitored concentrations with the air quality objectives and examining the data for evidence of any changes in NO_2 concentrations that might have been attributable to the VMS trial.

4.3.3 Continuous Monitoring

4.3.3.1 Summary Statistics

The period mean concentrations for the whole monitoring period from 1st February to 21st November 2016 are presented in Table 4-3, along with numbers of exceedances of 1-hour mean NO_2 standard of 200 $\mu g/m^3$ and data capture rates. Table 4-4 presents the monthly mean concentrations and data capture rates at Tower Bridge Road for February 2016 to November 2016, inclusive.

Graphs of 1-minute, 1-hour and 24-hour mean NO_2 concentrations are included in **Error! Reference source not found.**(Figure 4 to Figure 13).

The key observations from the monitoring results are:

- Data capture was 92.6%, which is well above the 85% recommended by Defra for quality purposes and to allow representative comparisons to be made with the UK Air Quality Objectives.
- The only significant data loss occurred during February 2016 as a result of a fault with the analyser pump. This pump failure invalidated all data between 1st February and 21st February 2016, the date when the fault was fixed by a service engineer. No other significant data losses were incurred.
- The annual mean NO_2 standard of 40 $\mu g/m^3$ was exceeded for all months and for the period as a whole. The mean NO_2 concentration over the whole monitoring period was 56.4 $\mu g/m^3$.
- The highest monthly mean NO_2 concentration was 75.1 $\mu g/m^3$ in February 2016. However, data capture at Tower Bridge Road was compromised during February 2016 due to a fault with the analyser pump. The issue was rectified on 21st February 2016. The highest monthly mean NO_2 concentration for a month with good data capture (i.e. greater than 85%) was 67.3 $\mu g/m^3$ in May 2016.

- There was one exceedance of the 1-hour mean NO_2 standard of 200 µg/m^3, on 13th September 2016 at 17:00. The maximum 1-hour mean NO_2 concentration was 231.3 µg/m^3.

Table 4-3. Summary of Air Quality Monitoring at Tower Bridge Road, 1st February to 21st November 2016

Statistic	NO_2	NO_X	NO
Period Mean Concentration (µg/m^3)	56.4	150.9	61.6
Number of exceedances of 1-hour NO_2 Standard (200 µg/m^3)	1	N/A	N/A
Maximum 1-hour NO_2 Concentration (µg/m^3)	231.3	N/A	N/A
Data Capture (%)	92.6	92.6	92.6

N/A = Not applicable

Table 4-4. Monthly Mean NO_2, NO_X and NO Concentrations (µg/m^3) at Tower Bridge Road

Month	NO_2	NO_X	NO	Data Capture (%)
February 2016	75.1	253.7	116.4	27.4
March 2016	60.7	172.9	73.2	99.7
April 2016	60.5	155.0	61.6	99.7
May 2016	67.3	175.4	70.5	100
June 2016	57.0	154.4	63.5	100
July 2016	41.3	99.4	37.9	100
August 2016	50.1	126.8	50.0	100
September 2016	57.4	157.3	65.1	100
October 2016	53.3	145.7	60.2	99.5
November 2016	54.3	141.3	56.7	97.2

4.3.3.2 Variable Message Sign (VMS) Operation

The Variable Message Signs (VMS) on Tower Bridge Road were in operation from 10th February 2016 to 15th April 2016, and from 5th July 2016 to 9th September 2016 (VMS On). Between 15th April 2016 and 5th July 2016, and from 9th September 2016 to 21st November 2016, the VMS was not in operation (VMS Off). Table 4-5 presents a comparison of the summary statistics for the VMS On and VMS Off periods. The data capture rates for the two VMS periods were very good (greater than 97%) and the number of hours of valid observations for both periods were comparable.

The mean NO_2 concentration for the VMS On period was 54.2 µg/m^3. The mean NO_2 concentration for the VMS Off period was slightly higher (58.0 µg/m^3). The maximum 1-hour NO_2 concentration for the VMS On period was 175.8 µg/m^3, whilst for the VMS Off period the maximum 1-hour NO_2 concentration was 231.3 µg/m^3. The lower concentrations for the VMS On period may indicate that the operation of the VMS had a slightly beneficial impact on local air quality.

Table 4-5. Comparison of NO_2 Concentrations with VMS in Operation and VMS not in Operation

Statistic	VMS in Operation	VMS not in Operation
Period Mean NO_2 Concentration ($\mu g/m^3$)	54.2	58.0
Number of exceedances of 1-hour NO_2 Standard (200 $\mu g/m^3$)	0	1
Maximum 1-hour NO_2 Concentration ($\mu g/m^3$)	175.8	231.3
Data Capture (%)	97.3	97.2
Number of valid 1-hour observations	2854	3700

To investigate the impact of the VMS trial on air quality at Tower Bridge Road in greater detail, analyses were carried out of the temporal variations in NO_2 concentrations for the VMS On and VMS Off periods (Figure 4-2).

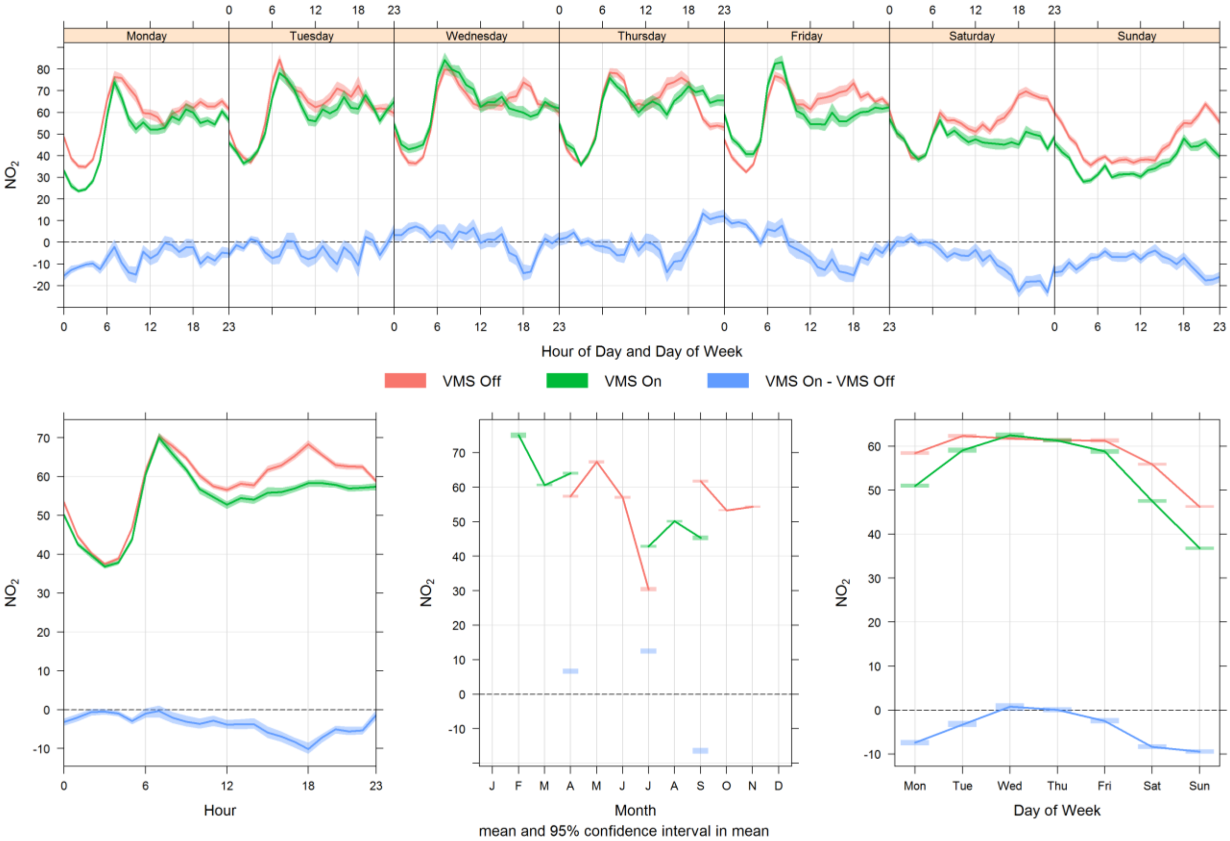
The top panel of Figure 4-2 displays the variation in mean NO_2 concentration by hour of the day and day of the week. It illustrates that NO_2 concentrations were generally lower with the VMS in operation (VMS On). The difference in NO_2 concentrations between VMS On and VMS Off is particularly apparent over the weekend, between noon on Friday and 6 am on Monday.

The lower left panel of Figure 4-2 shows the variation in mean NO_2 concentrations by hour of the day, whilst the lower right panel shows the variation in mean NO_2 concentrations by day of the week. These plots show more clearly that monitored NO_2 concentrations were lower during the period when the VMS was operational than for the VMS Off period.

With regard to hour of the day, the mean NO_2 concentrations for the VMS On data were lower than the VMS Off data for all hours between 06:00 and midnight. The differences were greatest during the afternoon and evening hours, in particular around the PM peak period at 18:00 when mean NO_2 concentrations with VMS On were around 10 $\mu g/m^3$ lower than with VMS Off.

With regard to day of the week, the mean NO_2 concentrations were lower for all days except Wednesdays and Thursdays when the VMS were on than when the VMS were off. The largest differences were observed on Saturdays and Sundays, when mean NO_2 concentrations were around 9 $\mu g/m^3$ lower for the VMS On period than the VMS Off period, and to a lesser extent, Mondays. There was little difference in mean NO_2 concentrations between VMS On and VMS Off on Wednesdays and Thursdays.

Figure 4-2. Diurnal Variations in NO_2 Concentrations (µg/m³) at Tower Bridge Road by VMS Operational Status



4.3.3.3 Bridge Lifts

Tower Bridge was lifted on 439 occasions between 13th February 2016 and 9th October 2016 for durations ranging from less than 1 minute to more than 41 minutes. The average bridge lift time was 8 minutes 30 seconds. The total duration of the bridge lifts was 62 hours 42 minutes. As the bridge lift periods were always less than 1 hour it is not appropriate to calculate hourly average values for these periods, and consequent discussions focus on the monitored 1-minute time resolution data.

Table 4-6 shows the mean NO_2 concentrations for the “Bridge Up” and “Bridge Down” periods. “Bridge Up” when the bridge is raised and Tower Bridge Road is closed to crossing traffic, and “Bridge Down” when the bridge is lowered and Tower Bridge Road is open. Good data capture was achieved for the “Bridge Up” and “Bridge Down” periods (both greater than 97%); however, it should be noted that there are more than 100 times more valid 1-minute measurements for the “Bridge Down” period than for the “Bridge Up” period.

The mean NO_2 concentration for the “Bridge Up” periods was 60.4 µg/m³, whilst for the “Bridge Down” periods the mean NO_2 concentration was slightly lower (56.3 µg/m³). This observation is consistent with increased emissions generated by the stationary traffic during bridge lifts, resulting in higher monitored concentrations than during the “Bridge Down” periods when traffic would be expected to be flowing and emissions to be slightly lower. However, it should be kept in mind the much smaller sample size upon which the “Bridge Up” mean NO_2 concentration is calculated.

Table 4-6. Comparison of NO_2 Concentrations by Bridge Position

Statistic	Bridge Up	Bridge Down
Period Mean NO_2 Concentration (µg/m^3)	60.4	56.3
Data Capture (%)	98.8	97.2
Number of valid 1-minute observations	3708	379035

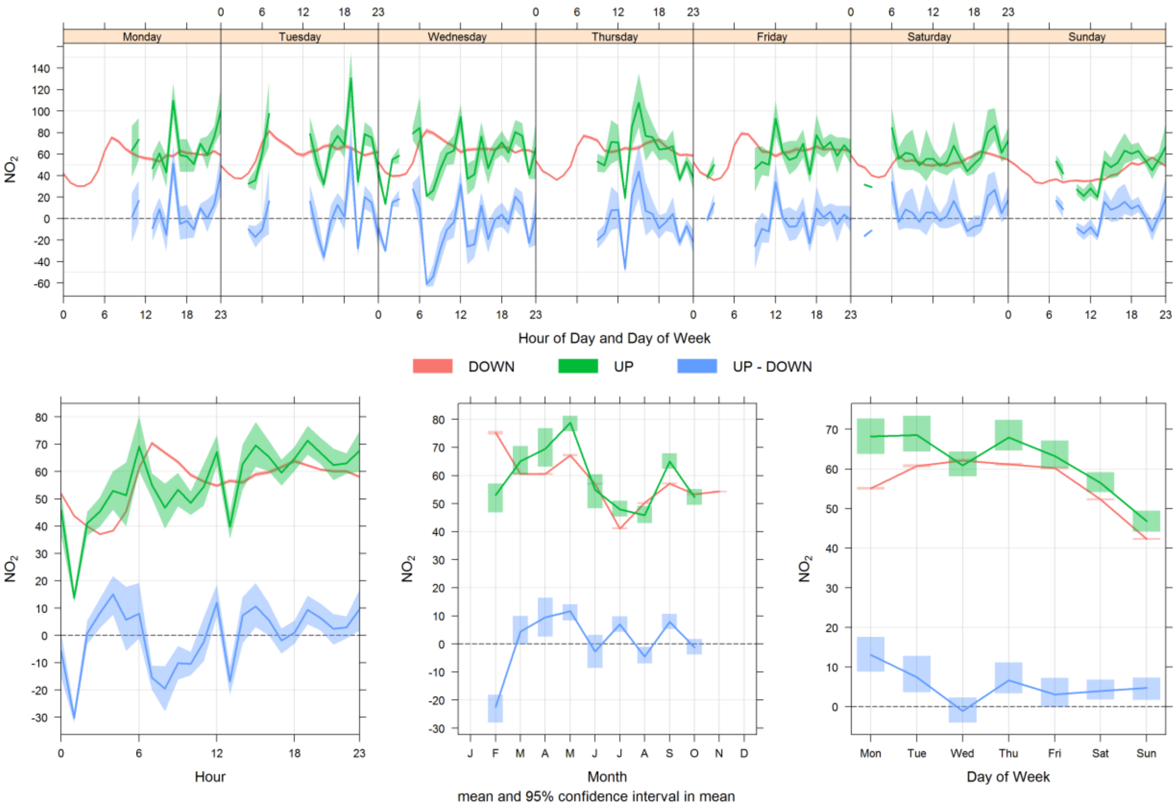
Figure 4-3 shows the diurnal variations in mean NO_2 concentrations according to bridge position. As would be expected due to the small sample size the diurnal profiles for the "Bridge Up" position show considerable scatter and the uncertainties associated with these periods are greater.

Examination of the top panel of Figure 4-3 shows no conclusive evidence that bridge position has any effect on NO_2 concentrations at Tower Bridge Road. The "Bridge Up" data displays a lot of variability due to the relatively small sample size. It can be seen from the top panel of Figure 4-3 that the majority of the bridge lifts occur during daytime hours – this may in part explain the higher mean NO_2 concentration for the "Bridge Up" dataset as traffic flow would be expected to be higher during these hours.

The lower left panel of Figure 4-3 shows the variation in NO_2 concentration by hour of the day. There is some evidence that NO_2 concentrations are slightly higher for the "Bridge Up" data during the afternoon and evening hours, and during the early morning hours (before 06:00). Between 06:00 and 11:00, the NO_2 concentrations appear to be slightly lower for the "Bridge Up" position than the "Bridge Down" position.

The lower right panel of Figure 4-3 displays the variation in NO_2 concentration by day of the week. The data suggest that NO_2 concentrations are higher for the "Bridge Up" position for all days of the week, except Wednesday. The largest differences in NO_2 concentrations appear to be on Mondays when "Bridge Up" concentrations are around 12 µg/m^3 higher than "Bridge Down"; for Thursday to Sunday mean NO_2 concentrations appear to be between 3 – 6 µg/m^3 higher for the "Bridge Up" position compared to "Bridge Down". As noted above, some of the observed difference may be accounted for by the majority of bridge lifts occurring during the daytime when traffic levels and ambient NO_2 concentrations would be expected to be higher.

Figure 4-3. Diurnal Variations in NO_2 Concentrations (µg/m^3) at Tower Bridge Road by Bridge Position



4.3.4 NO_2 Diffusion Tube Monitoring

Southwark Council installed NO_2 diffusion tubes at 15 locations alongside Tower Bridge Road and adjacent roads in March 2014. The annual mean NO_2 concentrations for 2014, 2015 and 2016 from the diffusion tube survey are presented in Table 4-7 along with details of the monitoring locations. The full raw monthly diffusion tube data is provided in Appendix B.

The annual mean NO_2 concentrations in Table 4-7 have been bias-adjusted using factors obtained from Defra's national spreadsheet of bias adjustment factors. The bias adjustment factors for 2014, 2015 and 2016 (for Gradko International, 20% TEA / water) are 0.92, 0.87 and 0.94, respectively (see Appendix B). All sites achieved at least 75% data in all years and so no seasonal adjustments are required to "annualise" the monitored concentrations.

4.3.4.1 Comparisons with Air Quality Objectives

Annual mean NO_2 concentrations exceeded the annual mean NO_2 air quality objective of 40 $\mu g/m^3$ at all diffusion tube monitoring locations in 2014 and 2016. In 2015 all sites, except SDT 23 and SDT 28, exceeded the annual mean NO_2 objective.

Annual mean NO_2 concentrations of greater than 60 $\mu g/m^3$ were monitored at 12 of the 15 monitoring locations in 2014 and 2016; at these locations there is a likelihood that the short-term NO_2 objective (1-hour mean not to exceed 200 $\mu g/m^3$ more than 18 hours per year) may have been exceeded. The highest annual mean NO_2 concentrations in 2014, 2015 and 2016 were recorded across three sites – SDT 18, SDT 24 and SDT 29:

- 2014:
  - SDT 18 (85.9 $\mu g/m^3$)
  - SDT 24 (89.2 $\mu g/m^3$)
  - SDT 29 (85.0 $\mu g/m^3$)
- 2015
  - SDT 18 (75.3 $\mu g/m^3$)
  - SDT 24 (82.0 $\mu g/m^3$)
  - SDT 29 (79.5 $\mu g/m^3$)
- 2016
  - SDT 18 (79.1 $\mu g/m^3$)
  - SDT 24 (90.0 $\mu g/m^3$)
  - SDT 29 (93.3 $\mu g/m^3$)

4.3.4.2 Temporal Trends

The diffusion tube survey only covers a 3-year period and so drawing any firm conclusions about temporal trends is not possible; however, at all sites except SDT 17 annual mean NO_2 concentrations were lower in 2015 than 2014 or 2016.

At sites SDT 17, SDT 18, SDT 20, SDT 21, SDT 22, SDT 23, SDT 26, SDT 27, SDT 30 and SDT 31 the highest NO_2 concentrations of the 3-year period were measured in 2014. At sites SDT 19, SDT 24, SDT 25, SDT 28 and SDT 29 the highest NO_2 concentrations were recorded in 2016.

Due to the long-term nature of diffusion tube measurements it is not possible to distinguish any impacts on monitored NO_2 concentrations as a result of the VMS trial. Also, despite the closure of Tower Bridge for a period of approximately 12 weeks from October 2016 to December 2016 there is no conclusive evidence that this closure impacted annual mean NO_2 concentrations at any of the diffusion tube monitoring locations. It would appear that the year-to-year variations observed in the diffusion tube monitoring results are primarily influenced by variations in meteorological conditions and inter-annual variations in the bias adjustment factors.

Table 4-7. Southwark Council NO_2 Diffusion Tube Survey Results, Tower Bridge Road, 2014 – 2016

Site ID	Description	X, Y Coordinates	Site Type	Annual Mean NO_2 Concentration ($\mu g/m^3$)		
				2014	2015	2016
SDT 17	MAQF Tower Bridge Project 1 - Tooley Street Memorial Bus Stop North side	533503, 179949	Kerbside	**<u>80.6</u>**	**58.8**	**58.3**
SDT 18	MAQF Tower Bridge Project 2 - Tower Bridge Lamppost No 1 East side	533599, 180062	Kerbside	**<u>85.9</u>**	**<u>75.3</u>**	**<u>79.1</u>**
SDT 19	MAQF Tower Bridge Project 3 - Tooley Street / Boss Street Lamppost 159/04 North side	533586, 179867	Kerbside	**<u>67.4</u>**	**56.7**	**<u>68.7</u>**
SDT 20	MAQF Tower Bridge Project 4 - Tower Bridge school fence Tower Bridge Road East side	533518, 179844	Kerbside	**<u>73.0</u>**	**<u>62.6</u>**	**<u>70.8</u>**
SDT 21	MAQF Tower Bridge Project 5 - Druid Street adjacent to playground North Side	533572, 179732	Kerbside	**<u>62.8</u>**	**57.7**	**<u>62.3</u>**
SDT 22	MAQF Tower Bridge Project 6 - Tower Bridge Road South of Rail Bridge West side	533469, 179721	Kerbside	**<u>79.0</u>**	**<u>69.8</u>**	**<u>74.5</u>**
SDT 23	MAQF Tower Bridge Project 7 - Tanner Street West Camera Pole by park South side	533409, 179657	Kerbside	**45.8**	37.5	**45.8**
SDT 24	MAQF Tower Bridge Project 8 - Opposite Papa John’s West side	533439, 179599	Kerbside	**<u>89.2</u>**	**<u>82.0</u>**	**<u>90.0</u>**
SDT 25	MAQF Tower Bridge Project 9 - Abbey Street By phone Box South side	533460, 179369	Kerbside	**59.5**	**55.4**	**<u>62.0</u>**
SDT 26	MAQF Tower Bridge Project 10 - Long Lane by St Mary's Churchyard North side	533324, 179404	Kerbside	**<u>64.9</u>**	**54.3**	**<u>60.3</u>**
SDT 27	MAQF Tower Bridge Project 11 - Grange Road Triangle by Barclays Bank North side	533297, 179289	Kerbside	**<u>79.4</u>**	**<u>61.0</u>**	**<u>69.8</u>**
SDT 28	MAQF Tower Bridge Project 12 - Webb Street By school on lamppost 48/03	533217, 179153	Kerbside	**42.5**	36.4	**45.5**
SDT 29	MAQF Tower Bridge Project 13 - Opposite Haddon Hall, West side	533111, 179121	Kerbside	**<u>85.0</u>**	**<u>79.5</u>**	**<u>93.3</u>**
SDT 30	MAQF Tower Bridge Project 14 - Bricklayers Arms North side	533003, 179069	Kerbside	**<u>76.8</u>**	**<u>63.5</u>**	**<u>70.5</u>**
SDT 31	MAQF Tower Bridge Project 15 - Bricklayers Arms Roundabout - by St Olave's School, West side	532934, 179033	Kerbside	**<u>68.2</u>**	**58.5**	**<u>64.3</u>**

Notes: Exceedances of the annual mean NO_2 air quality objective (40 $\mu g/m^3$) are shown in **bold**. Annual mean NO_2 concentrations greater than 60 $\mu g/m^3$ indicating potential exceedance of the short-term NO_2 air quality objective are **<u>underlined bold</u>**.

4.3.5 Analysis of Air Quality Monitoring

Continuous monitoring of oxides of nitrogen (NO_X), nitric oxide (NO) and nitrogen dioxide (NO_2) was carried out at Tower Bridge Road to investigate the potential air quality benefits of the Tower Bridge anti-idling trial. An automatic monitoring station was installed on the southern approach to Tower Bridge, on the west side of Tower Bridge Road at the junction with Druid Street and monitoring commenced on 1st February 2016. In addition to the continuous monitoring, Southwark Council carried out NO_2 diffusion tube monitoring at 15 locations alongside Tower Bridge Road and adjacent roads. The diffusion tube survey commenced in March 2014.

This section presents the results of the continuous monitoring and the diffusion tube survey. The key findings are as follows:

- Continuous Monitoring:
  - Good data capture was achieved for the period (92.6%). This is above the 85% value recommended by Defra for data quality purposes.
  - No valid data was collected between 1st February 2016 and 21st February, inclusive, due to a fault with the analyser pump. The fault was fixed by a service engineer on 21st February 2016. No other significant data losses were incurred.
  - The mean NO_2 concentration for the monitoring period was 56.4 µg/m^3. This is greater than the annual mean NO_2 UK Air Quality Objective value of 40 µg/m^3.
  - The 1-hour mean NO_2 UK Air Quality Standard of 200 µg/m^3 was exceeded on one occasion during the monitoring period (231.3 µg/m^3 on 13th September 2016 at 17:00).
  - The maximum monthly mean NO_2 concentration was 67.3 µg/m^3 in May 2016.
  - The mean NO_2 concentration for the periods when the VMS were operational was 54.2 µg/m^3. The mean NO_2 concentration for the periods when the VMS were inoperative was 58.0 µg/m^3.
  - The maximum 1-hour NO_2 concentration for the periods when the VMS were operational was 175.8 µg/m^3. The maximum 1-hour NO_2 concentration for the periods when the VMS were inoperative was 231.3 µg/m^3.
  - The diurnal profiles of mean NO_2 concentrations by VMS status indicate that the operation of the VMS may have had a small beneficial effect on local air quality. For all hours of the day between 07:00 and 00:00, mean NO_2 concentrations were lower when the VMS were operational compared to when the VMS were inoperative. For hours of the day from midnight to 07:00 there was no observable differences in mean NO_2 concentrations with VMS in operation and not operational.
  - The mean NO_2 concentration for periods when Tower Bridge was raised ("Bridge Up") was 60.4 µg/m^3. The mean NO_2 concentration for periods when Tower Bridge was in the lowered position ("Bridge Down") was 56.3 µg/m^3. These results indicate that NO_2 concentrations may be higher at times when the bridge is raised and stationary traffic results in

excess emissions and elevated ambient concentrations. However, it should be noted that the “Bridge Up” period comprises a relatively small sample (62 hours). It should also be noted that the majority of bridge lifts occur during daytime hours, in particular in the afternoon, at times when traffic flows are higher and pollutant concentrations would be expected to be higher.

– The diurnal profiles of mean NO_2 concentrations by bridge position did not provide any conclusive evidence of differences in concentration when Tower Bridge was raised compared to when the bridge was in the lowered position. There was some evidence of an increase in NO_2 concentrations during afternoon and evening hours when the bridge was raised. However, the scatter in the data due to the limited number of data points makes interpretation of any significant change in levels of NO_2 difficult.

- Diffusion Tube Monitoring
  – Good data capture (>75%) was achieved at all sites in all years.
  – Annual mean NO_2 concentrations exceeded the annual mean NO_2 air quality objective (40 µg/m^3) at all sites in 2014 and 2016, and at all sites except SDT 23 and SDT 28 in 2015.
  – Annual mean NO_2 concentrations of greater than 60 µg/m^3 were monitored at 12 of the 15 sites in 2014 and 2016. At these locations there is a likelihood that the short-term NO_2 objective (1-hour mean not to exceed 200 µg/m^3 more than 18 hours per year) may have been exceeded.
  – The sites recording the highest annual mean NO_2 concentrations in all years were:
    - SDT 18 (75.3 µg/m^3 – 85.9 µg/m^3)
    - SDT 24 (82.0 µg/m^3 – 90.0 µg/m^3)
    - SDT 29 (79.5 µg/m^3 – 93.3 µg/m^3)
  – There is no conclusive evidence that the VMS trial or the closure of Tower Bridge for a period of approximately 12 weeks in 2016 had any measurable impact upon annual mean NO_2 concentrations at any of the diffusion tube monitoring locations.

5. Conclusions

The results of the idling surveys indicate that there is little tendency for drivers to check for bridge openings on the website. This may be because it would appear that delays in the area due to bridge lifts are relatively insignificant compared with delay due to other causes. Almost two fifths would turn off their engines if queueing at the bridge. Less than a fifth of drivers would look for alternative routes if delayed at the crossing, with almost half sitting in the queue with engines running. Over half of those who tend not to switch off their engines when queuing say this is because they expect the queue to start moving quickly.

Many drivers are reluctant to switch off their engines when queuing, unless traffic has not moved for some considerable time. This could increase in very cold or very hot weather to maintain air conditions in the vehicle.

VMS providing information on the likely delay would encourage only 13% of drivers to switch off, although this was thought to be one of the most effective measures that could be taken.

The continuous monitoring of oxides of nitrogen (NO_X), nitric oxide (NO) and nitrogen dioxide (NO_2) was carried out at Tower Bridge Road to investigate the potential air quality benefits of the Tower Bridge Variable Message Sign trial. The results of this monitoring indicate that:

- Good data capture was achieved for the period (92.6%). This is above the 85% value recommended by Defra for data quality purposes.
- The mean NO_2 concentration for the monitoring period was 56.4 μg/m^3. This is greater than the annual mean NO_2 UK Air Quality Objective value of 40 μg/m^3.
- The 1-hour mean NO_2 UK Air Quality Standard of 200 μg/m^3 was exceeded on one occasion during the monitoring period (231.3 μg/m^3 on 13th September 2016 at 17:00).
- The maximum monthly mean NO_2 concentration was 67.3 μg/m^3 in May 2016.
- The diurnal profiles of mean NO_2 concentrations by VMS status indicate that the operation of the VMS may have had a small beneficial effect on local air quality. For all hours of the day between 07:00 and 00:00, mean NO_2 concentrations were lower when the VMS were operational compared to when the VMS were inoperative. For hours of the day from midnight to 07:00 there was no observable differences in mean NO_2 concentrations with VMS in operation and not operational.
- The mean NO_2 concentration for periods when Tower Bridge was raised (“Bridge Up”) was 60.4 μg/m^3. The mean NO_2 concentration for periods when Tower Bridge was in the lowered position (“Bridge Down”) was 56.3 μg/m^3. These results indicate that NO_2 concentrations may be higher at times when the bridge is raised and stationary traffic results in excess emissions and elevated ambient concentrations. However, it should be noted that the “Bridge Up” period comprises a relatively small sample (62 hours). It should also be noted that the majority of bridge lifts occur during daytime hours, in particular in the afternoon, at times when

traffic flows are higher and pollutant concentrations would be expected to be higher.

– The diurnal profiles of mean NO_2 concentrations by bridge position did not provide any conclusive evidence of differences in concentration when Tower Bridge was raised compared to when the bridge was in the lowered position. There was some evidence of an increase in NO_2 concentrations during afternoon and evening hours when the bridge was raised. However, the scatter in the data due to the limited number of data points makes interpretation of any significant change in levels of NO_2 difficult.

The results of the Diffusion Tube Monitoring indicate that:

– Good data capture (>75%) was achieved at all sites in all years.

– Annual mean NO_2 concentrations exceeded the annual mean NO_2 air quality objective (40 µg/m^3) at all sites in 2014 and 2016, and at all sites except SDT 23 and SDT 28 in 2015.

– Annual mean NO_2 concentrations of greater than 60 µg/m^3 were monitored at 12 of the 15 sites in 2014 and 2016. At these locations there is a likelihood that the short-term NO_2 objective (1-hour mean not to exceed 200 µg/m^3 more than 18 hours per year) may have been exceeded.

– The sites recording the highest annual mean NO_2 concentrations in all years were:

  - SDT 18 (75.3 µg/m^3 – 85.9 µg/m^3)
  - SDT 24 (82.0 µg/m^3 – 90.0 µg/m^3)
  - SDT 29 (79.5 µg/m^3 – 93.3 µg/m^3)

– There is no conclusive evidence that the VMS trial or the closure of Tower Bridge for a period of approximately 12 weeks in 2016 had any measurable impact upon annual mean NO_2 concentrations at any of the diffusion tube monitoring locations.

The bridge will be open for less than 1% of the year. Even if all vehicles turned their engines off and there were zero emissions for 1% of the year, this small effect would be difficult to detect in monthly or annual mean concentrations. The queuing traffic may last longer than 1% of the year if it takes, say, 15 minutes for the queues to clear but the change would still occur over a very small proportion of the year.

A further complicating factor for air quality monitoring is that concentrations are continually changing due to changes in emissions (traffic), wind speed which affects dispersion of the pollutants and wind direction which transports the pollution to the monitor. Changes to any of these will change the concentrations being measured. Year to year variation in annual mean concentrations can be 10% due to changes in meteorology alone. Having said that it will be difficult to measure such small changes in concentrations does not mean that the anti-idling is not worthwhile as the emission reductions would still be beneficial but it does mean that another approach such as air dispersion modelling may be more helpful in determining the change in air quality.

Dispersion modelling is a cost-effective and convenient way to assess the change in concentrations due to a change in one particular parameter such as queuing traffic without altering the other parameters such as meteorology. Data from the trial showing the proportion of vehicles with engines running during queuing would be used to assess the change in NO_2 and PM_{10} that should result from the anti-idling campaign. Scenarios would also be run for 0% and 100% compliance with anti-idling to enable the comparison to be made.

Appendix A Time Series Plots

Figure 4 to Figure 13 display time series NO_2 and NO_X concentrations at Tower Bridge Road for each month from February 2016 to November 2016, inclusive. The two panels in each monthly plot show, respectively:

- 1-minute average NO_2 and NO_X concentrations; and
- 1-hour mean NO_2 and NO_X concentrations, along with the 1-hour mean NO_2 standard of 200 µg/m^3.

Figure 4. Tower Bridge Road Air Quality Monitoring Results, 22nd February 2016 to 29th February 2016

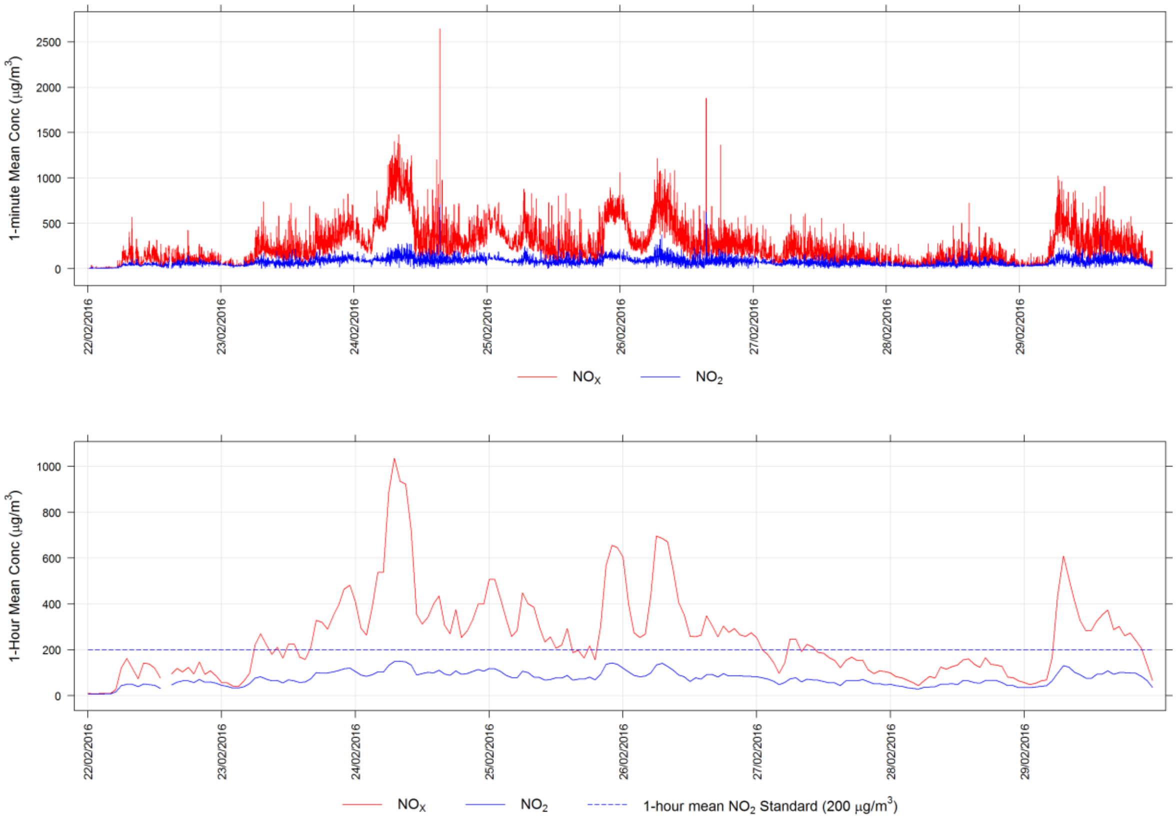


Figure 5. Tower Bridge Road Air Quality Monitoring Results, 1st March 2016 to 31st March 2016

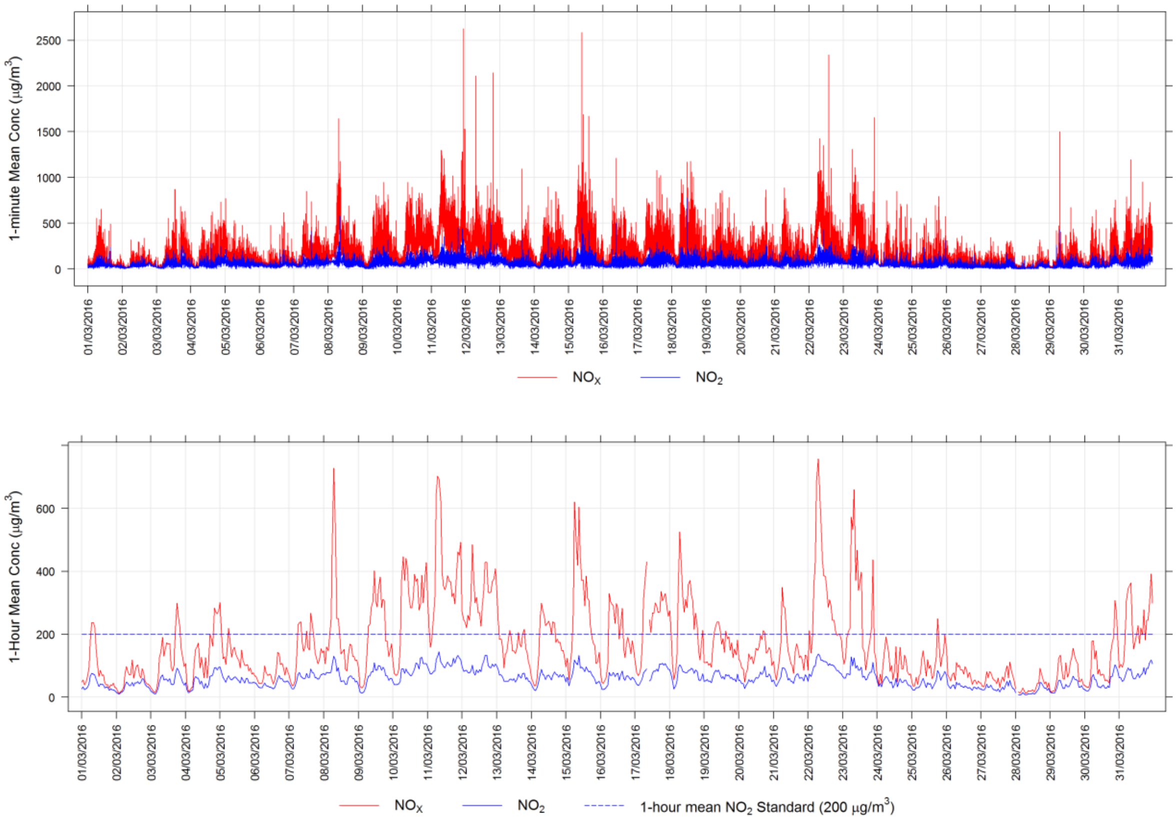


Figure 6. Tower Bridge Road Air Quality Monitoring Results, 1st April 2016 to 30th April 2016

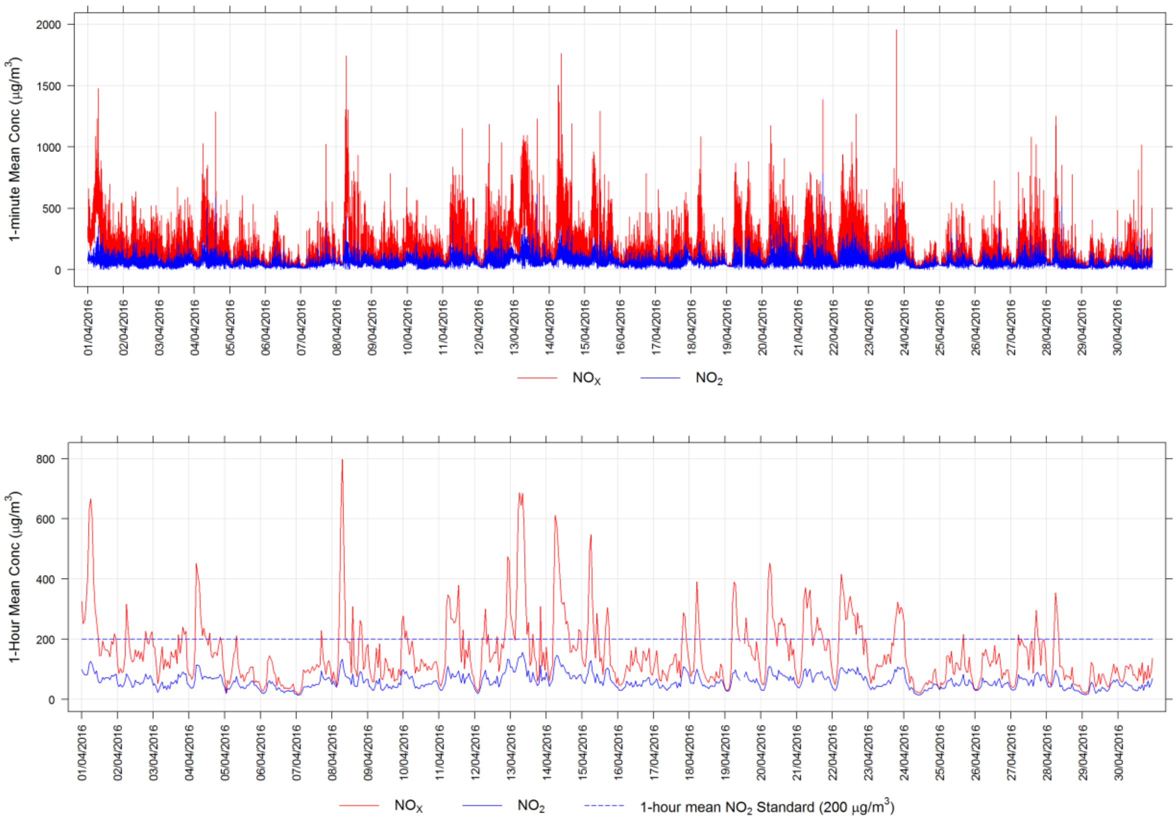


Figure 7. Tower Bridge Road Air Quality Monitoring Results, 1st May 2016 to 31st May 2016

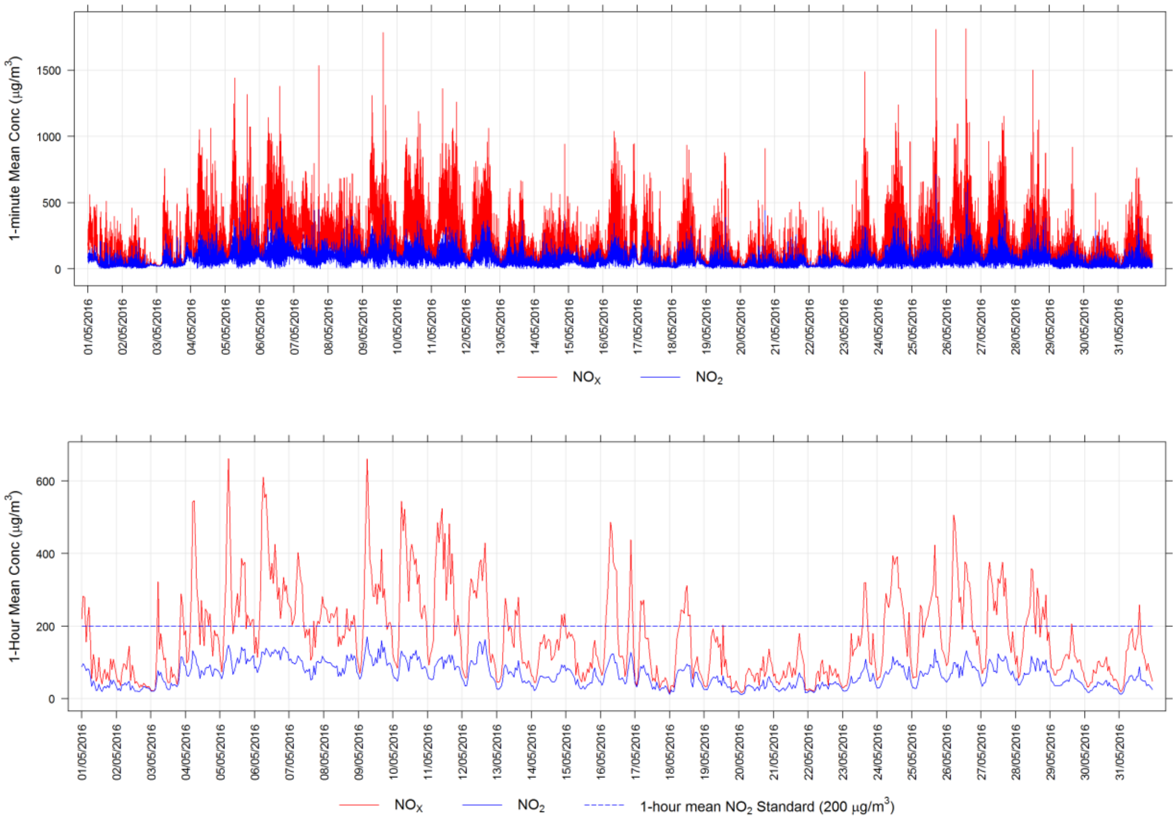


Figure 8. Tower Bridge Road Air Quality Monitoring Results, 1st June 2016 to 30th June 2016

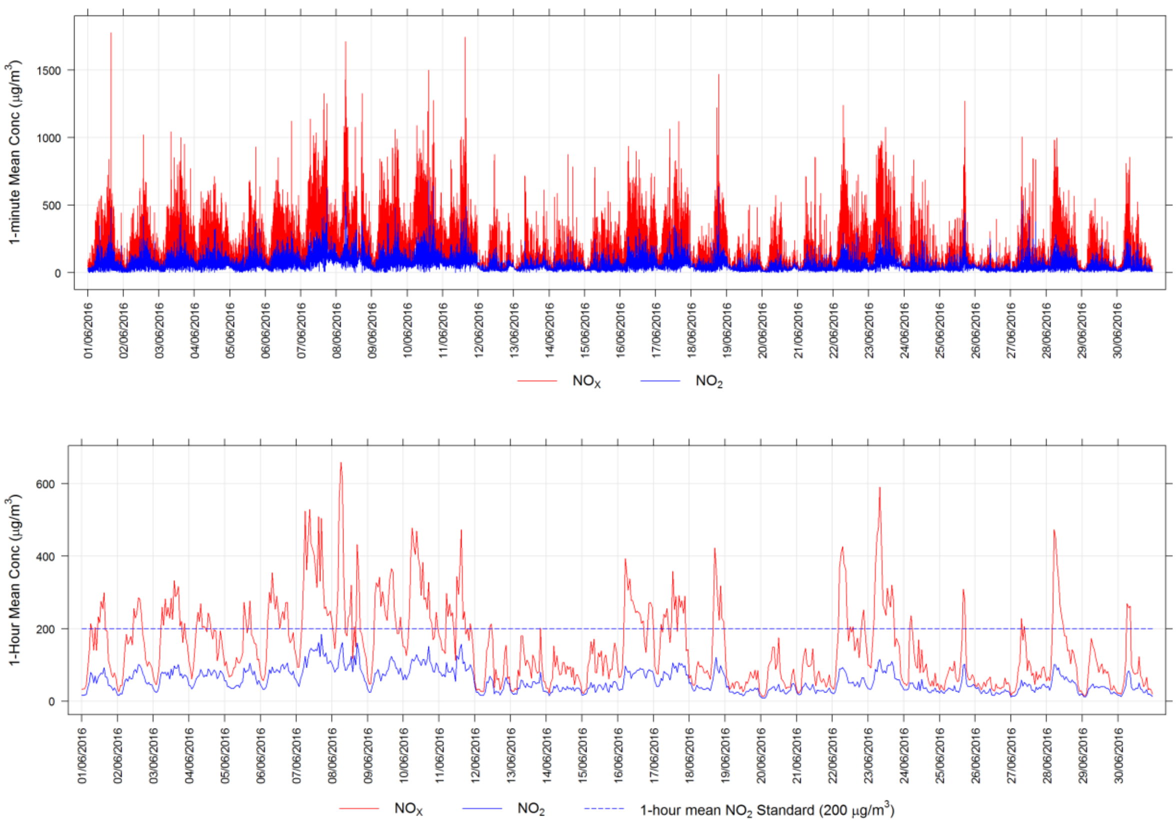
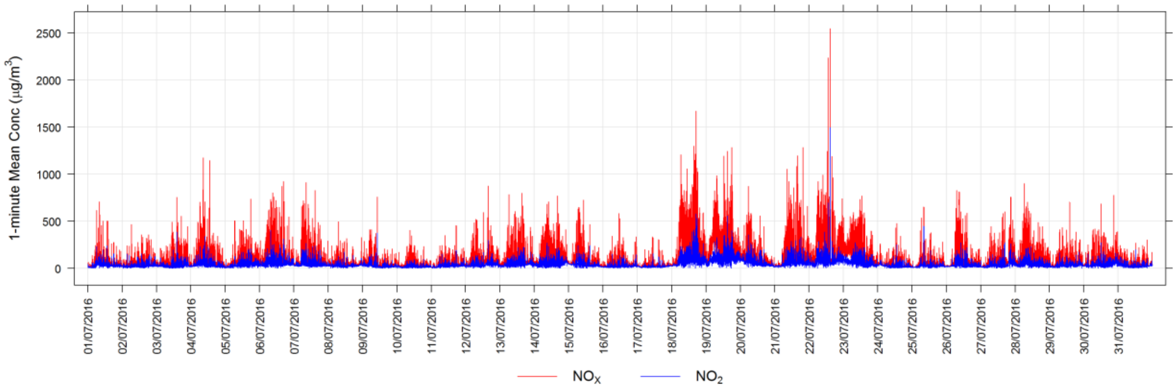


Figure 9. Tower Bridge Road Air Quality Monitoring Results, 1st July 2016 to 31st July 2016



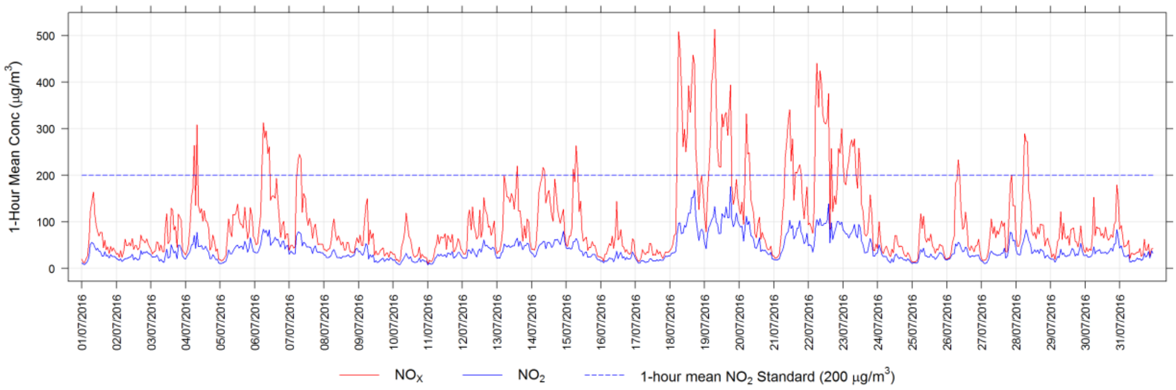


Figure 10. Tower Bridge Road Air Quality Monitoring Results, 1st August 2016 to 31st August 2016

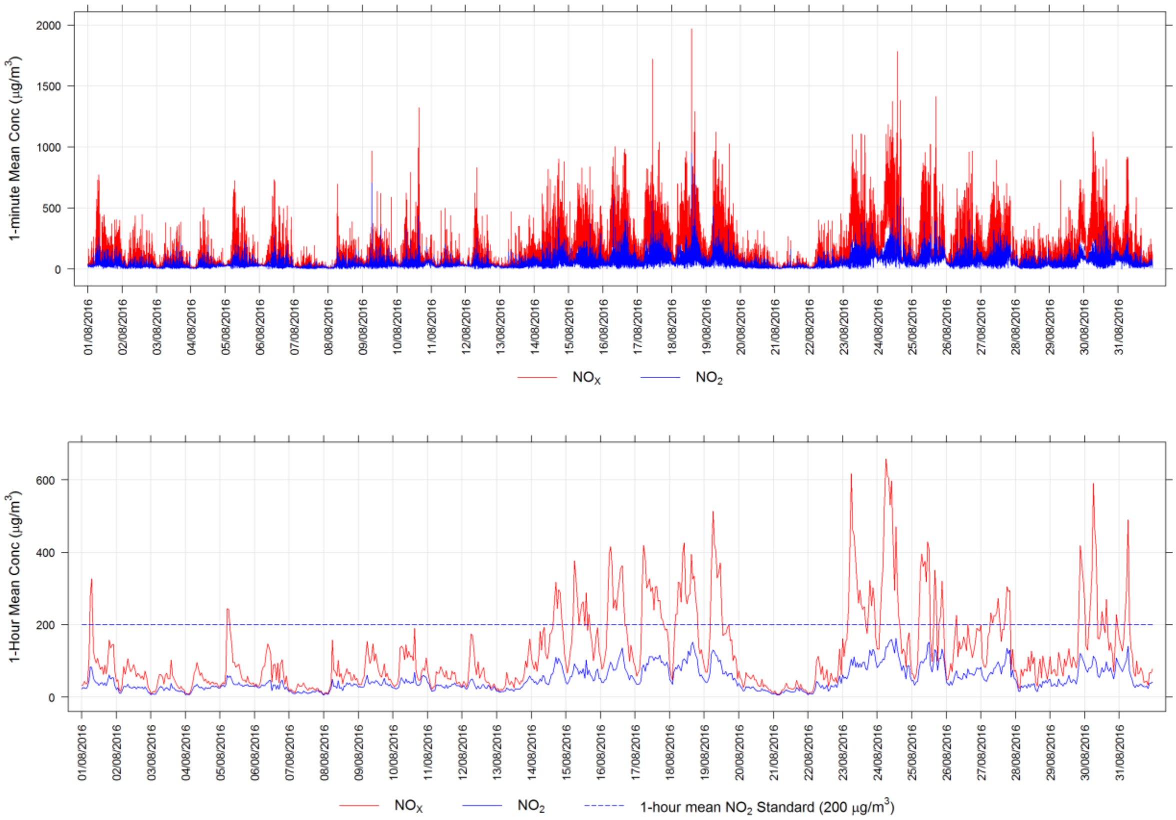


Figure 11. Tower Bridge Road Air Quality Monitoring Results, 1st September 2016 to 30th September 2016

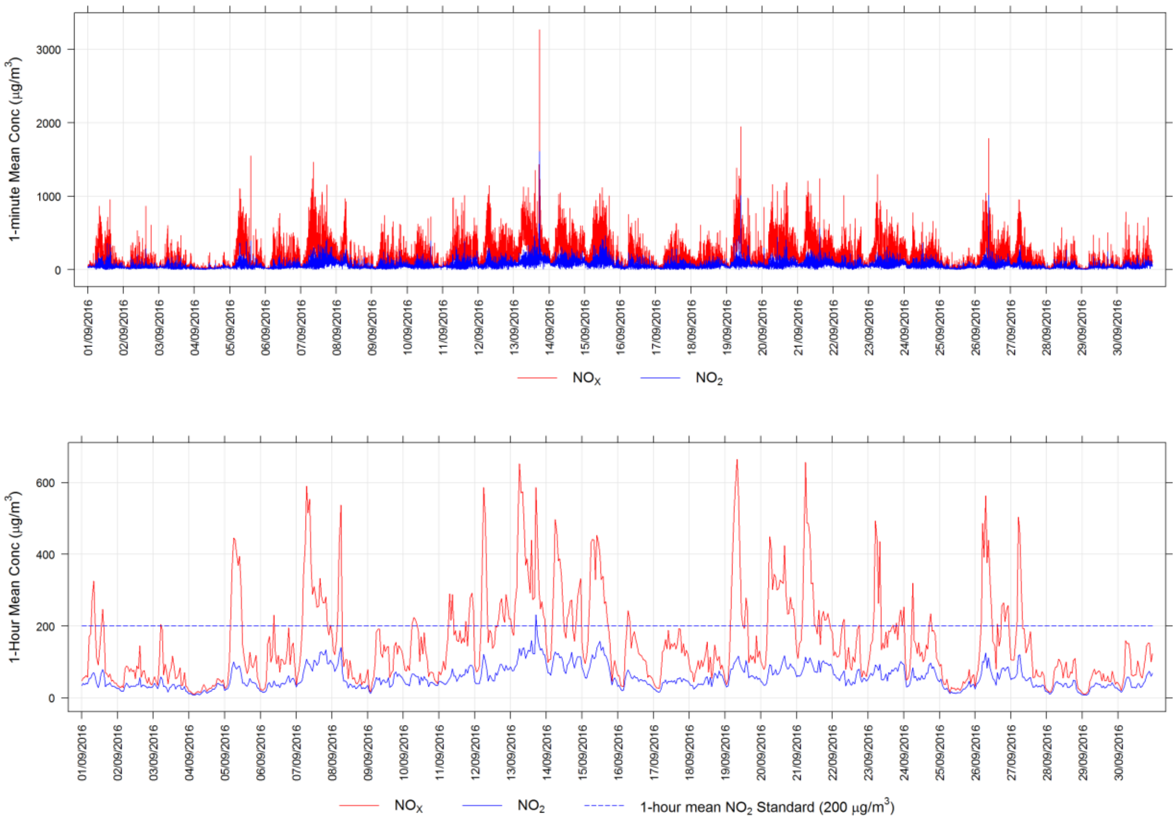


Figure 12. Tower Bridge Road Air Quality Monitoring Results, 1st October 2016 to 31st October 2016

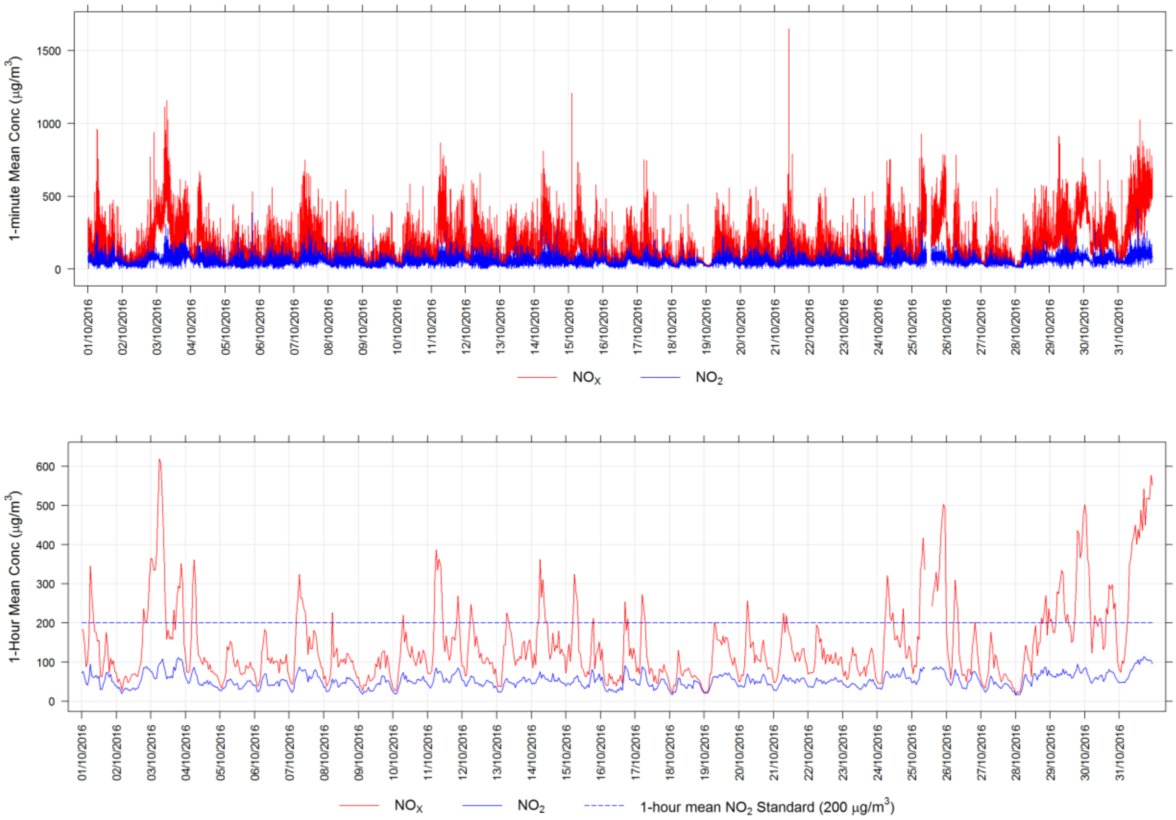
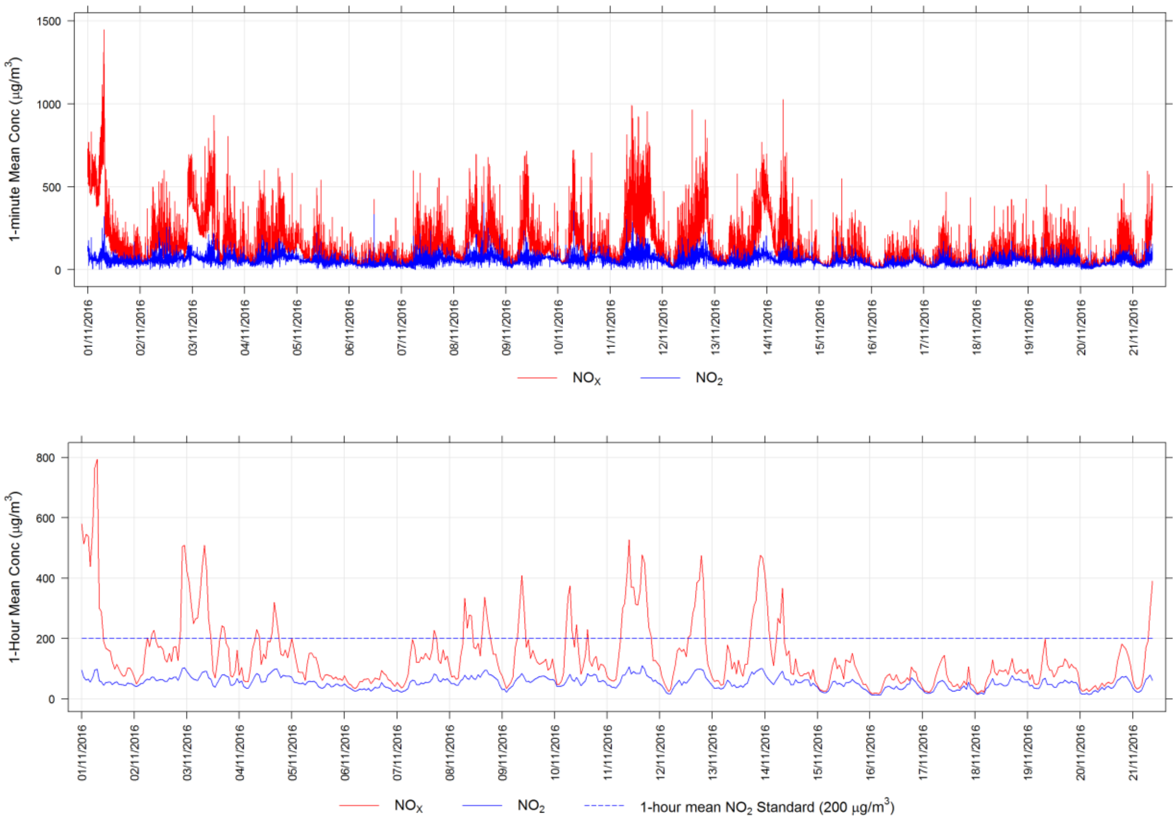


Figure 13. Tower Bridge Road Air Quality Monitoring Results, 1st November 2016 to 21st November 2016



Appendix B Diffusion Tube Monitoring

Table 8. Raw Monthly NO_2 Diffusion Tube Monitoring Results, 2014

Month	Start of Period	End of Period	Monthly Mean NO_2 Concentration (Raw; µg/m^3)														
			SDT 17	SDT 18	SDT 19	SDT 20	SDT 21	SDT 22	SDT 23	SDT 24	SDT 25	SDT 26	SDT 27	SDT 28	SDT 29	SDT 30	SDT 31
Jan-14	08/01/2014	06/02/2014															
Feb-14	06/02/2014	06/03/2014															
Mar-14	06/03/2014	02/04/2014	94.7	95.8	72.0	84.4	83.9	99.3	62.2	96.3	73.5	77.4	92.6	58.4	86.9	97.1	83.4
Apr-14	02/04/2014	30/04/2014	80.5	92.3	69.0	78.6	70.3	88.8	46.5	87.3	60.9	67.0	88.1	44.6	89.6	81.0	74.5
May-14	30/04/2014	28/05/2014	93.3	95.3	75.3	81.3	ND	69.2	42.8	103.8	62.9	70.9	92.3	41.8	94.7	85.2	79.8
Jun-14	28/05/2014	02/07/2014	85.6	97.4	68.8	83.4	66.6	94.7	45.7	71.6	57.8	71.9	83.7	33.4	79.4	74.9	66.5
Jul-14	02/07/2014	30/07/2014	94.6	92.6	73.9	89.6	67.9	93.4	43.3	107.4	65.5	67.1	85.3	40.5	102.7	75.7	64.8
Aug-14	30/07/2014	27/08/2014	73.9	89.7	69.8	70.3	54.5	72.2	37.0	105.6	48.7	62.8	73.7	38.9	95.6	66.0	64.0
Sep-14	27/08/2014	01/10/2014	107.0	98.6	87.0	80.4	74.9	105.0	61.1	89.2	65.5	80.9	94.0	43.2	101.7	90.2	79.4
Oct-14	01/10/2014	29/10/2014	84.6	87.0	77.0	75.7	67.7	76.6	46.0	106.8	60.2	74.1	89.6	47.1	95.7	93.0	77.0
Nov-14	29/10/2014	03/12/2014	101.1	101.0	73.5	78.4	69.4	ND	59.6	87.5	73.8	70.6	90.0	54.5	ND	85.8	83.7
Dec-14	03/12/2014	07/01/2015	61.2	83.9	66.7	71.4	59.1	74.0	54.0	114.5	78.2	63.1	74.2	60.0	85.5	85.5	68.1
Annual Mean (Raw)			**87.6**	**93.4**	**73.3**	**79.4**	**68.2**	**85.9**	**49.8**	**97.0**	**64.7**	**70.6**	**86.3**	**46.2**	**92.4**	**83.4**	**74.1**
Data Capture (%)			**83**	**83**	**83**	**83**	**75**	**75**	**83**	**83**	**83**	**83**	**83**	**83**	**75**	**83**	**83**

Note: ND = "No data"; monitoring commenced in March 2014

Table 9. Raw Monthly NO_2 Diffusion Tube Monitoring Results, 2015

Month	Start of Period	End of Period	Monthly Mean NO_2 Concentration (Raw; $\mu g/m^3$)														
			SDT 17	SDT 18	SDT 19	SDT 20	SDT 21	SDT 22	SDT 23	SDT 24	SDT 25	SDT 26	SDT 27	SDT 28	SDT 29	SDT 30	SDT 31
Jan-15	07/01/2015	04/02/2015	ND	106.8	65.4	65.9	84.3	71.2	47.4	94.1	67.3	62.4	67.8	51.1	95.4	81.6	62.8
Feb-15	04/02/2015	04/03/2015	79.5	99.9	72.8	70.9	77.5	83.8	50.7	105.2	73.8	68.5	66.1	56.3	100.0	80.8	70.6
Mar-15	04/03/2015	01/04/2015	66.1	81.7	65.7	81.7	67.8	86.8	49.4	91.4	63.1	73.4	79.8	48.7	96.4	70.2	65.0
Apr-15	01/04/2015	29/04/2015	65.8	88.7	61.9	74.4	60.6	96.5	46.3	85.3	ND	60.6	82.5	38.1	95.0	65.0	64.8
May-15	29/04/2015	27/05/2015	65.0	75.9	63.1	71.3	64.0	71.9	35.8	94.6	59.6	59.6	71.2	38.5	88.5	72.0	64.1
Jun-15	27/05/2015	01/07/2015	70.5	89.8	69.9	71.3	68.2	81.7	38.0	112.2	62.7	63.2	73.2	37.1	104.3	74.4	65.5
Jul-15	01/07/2015	29/07/2015	70.1	82.9	66.7	71.5	58.3	75.4	35.5	100.2	60.3	61.8	63.5	35.9	87.6	67.9	61.2
Aug-15	29/07/2015	26/08/2015	75.0	98.9	69.3	79.0	62.0	85.8	42.8	89.9	56.6	64.7	ND	37.9	92.5	83.9	76.9
Sep-15	26/08/2015	30/09/2015	55.1	58.6	56.7	60.6	51.3	60.4	41.4	71.9	ND	56.4	54.1	ND	67.7	65.6	59.6
Oct-15	30/09/2015	28/10/2015	71.8	80.5	67.5	87.6	74.7	98.5	52.9	100.7	68.4	75.2	82.1	40.6	86.7	81.5	77.8
Nov-15	28/10/2015	02/12/2015	63.9	92.4	63.5	64.6	70.5	69.0	39.1	96.8	65.9	55.1	65.1	34.4	90.9	63.5	70.8
Dec-15	02/12/2015	06/01/2016	61.2	82.0	60.0	64.7	56.7	82.2	38.2	88.4	59.0	47.6	65.6	ND	ND	69.2	67.7
Annual Mean (Raw)			**67.6**	**86.5**	**65.2**	**71.9**	**66.3**	**80.3**	**43.1**	**94.2**	**63.7**	**62.4**	**70.1**	**41.9**	**91.4**	**73.0**	**67.2**
Data Capture (%)			**92**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**83**	**100**	**92**	**83**	**92**	**100**	**100**

Note: ND = “No data”

Table 10. Raw Monthly NO_2 Diffusion Tube Monitoring Results, 2016

Month	Start of Period	End of Period	Monthly Mean NO_2 Concentration (Raw; µg/m^3)														
			SDT 17	SDT 18	SDT 19	SDT 20	SDT 21	SDT 22	SDT 23	SDT 24	SDT 25	SDT 26	SDT 27	SDT 28	SDT 29	SDT 30	SDT 31
Jan-16	06/01/2016	03/02/2016	80.2	99.2	68.9	74.2	69.8	81.9	50.1	103.2	71.5	64.6	ND	58.4	96.7	92.5	84.3
Feb-16	03/02/2016	02/03/2016	74.2	92.7	67.3	87.2	68.9	82.9	54.0	ND	65.0	67.9	73.3	53.5	99.6	92.2	68.9
Mar-16	02/03/2016	30/03/2016	59.3	85.6	ND	75.3	77.3	63.2	46.3	75.5	ND	62.6	67.9	45.9	78.7	74.5	65.2
Apr-16	30/03/2016	27/04/2016	69.7	95.2	65.8	84.1	65.3	91.6	48.1	95.0	60.1	60.4	72.7	46.6	100.7	79.6	71.0
May-16	27/04/2016	25/05/2016	55.9	89.5	61.1	80.7	69.0	96.0	52.1	101.3	62.3	63.6	84.4	41.7	103.3	75.4	70.9
Jun-16	25/05/2016	29/06/2016	55.7	81.4	58.7	83.1	ND	93.7	46.4	99.8	61.9	67.2	80.8	39.6	115.7	74.2	70.3
Jul-16	29/06/2016	27/07/2016	52.6	86.9	60.8	73.4	56.5	78.0	34.7	121.7	ND	59.9	71.2	41.1	121.2	67.1	62.8
Aug-16	27/07/2016	24/08/2016	44.8	98.5	51.0	68.2	53.3	70.8	34.5	96.7	50.1	51.2	66.3	ND	70.4	59.6	60.1
Sep-16	24/08/2016	29/09/2016	61.9	ND	95.5	84.2	64.2	94.9	45.3	121.9	71.4	70.8	85.8	ND	62.2	44.4	38.8
Oct-16	29/09/2016	27/10/2016	51.4	51.9	137.5	59.9	ND	58.4	47.7	66.8	67.1	55.4	65.2	44.5	133.1	61.9	73.7
Nov-16	27/10/2016	01/12/2016	66.8	68.3	65.9	66.3	68.2	68.5	61.1	77.7	69.4	71.6	70.3	58.2	95.4	83.3	76.6
Dec-16	01/12/2016	05/01/2017	71.7	75.9	71.5	67.4	69.9	70.9	64.2	93.8	80.6	75.2	78.7	54.4	113.9	95.6	78.8
Annual Mean (Raw)			**62.0**	**84.1**	**73.1**	**75.3**	**66.2**	**79.2**	**48.7**	**95.8**	**65.9**	**64.2**	**74.2**	**48.4**	**99.2**	**75.0**	**68.4**
Data Capture (%)			**100**	**92**	**92**	**100**	**83**	**100**	**100**	**92**	**83**	**100**	**92**	**83**	**100**	**100**	**100**

Note: ND = “No data”

Table 11. National Diffusion Tube Bias Adjustment Factors, 2014

Analysed By	Method	Year	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (mg/m^3)	Automatic Monitor Mean Conc. (Cm) (mg/m^3)	Bias (B)	Tube Precision	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	20% TEA in water	2014	UC	Belfast City Council	11	33	32	5.6%	G	**0.95**
Gradko	20% TEA in water	2014	R	Borough Council of King's Lynn & West Norfolk	12	29	21	37.7%	G	**0.73**
Gradko	20% TEA in water	2014	R	Brighton & Hove City Council	12	55	48	15.2%	G	**0.87**
Gradko	20% TEA in water	2014	R	Brighton & Hove City Council	11	60	57	6.2%	G	**0.94**
Gradko	20% TEA in water	2014	R	Cheshire West and Chester	11	40	40	-1.0%	G	**1.01**
Gradko	20% TEA in water	2014	R	Dudley MBC	12	36	31	18.1%	G	**0.85**
Gradko	20% TEA in water	2014	UB	Dudley MBC	12	26	23	11.2%	G	**0.90**
Gradko	20% TEA in water	2014	R	Dudley MBC	12	41	35	15.2%	G	**0.87**
Gradko	20% TEA in water	2014	R	Dudley MBC	12	52	60	-12.6%	G	**1.14**
Gradko	20% TEA in water	2014	R	Gateshead Council	10	35	32	10.8%	G	**0.90**
Gradko	20% TEA in water	2014	R	Gateshead Council	12	36	36	-0.1%	G	**1.00**
Gradko	20% TEA in water	2014	R	Gateshead Council	12	34	32	6.4%	G	**0.94**
Gradko	20% TEA in water	2014	UB	Luton Borough Council	9	36	37	-4.0%	G	**1.04**
Gradko	20% TEA in water	2014	KS	Marylebone Road Intercomparison	12	115	80	42.8%	G	**0.70**
Gradko	20% TEA in water	2014	R	Monmouthshire County Council	10	42	38	10.1%	G	**0.91**
Gradko	20% TEA in water	2014	R	NOTTINGHAM CITY COUNCIL	12	44	39	14.9%	G	**0.87**
Gradko	20% TEA in water	2014	R	Bedford Borough Council	12	38	39	-2.7%	G	**1.03**
Gradko	20% TEA in water	2014	R	City of Lincoln Council	12	45	38	16.8%	G	**0.86**
Gradko	20% TEA in water	2014	R	East Herts Council	11	37	33	14.5%	G	**0.87**
Gradko	20% TEA in water	2014	R	Lancaster City Council	11	36	38	-4.0%	G	**1.04**
Gradko	20% TEA in water	2014	R	Wokingham Borough Council	12	40	37	9.3%	G	**0.91**
Gradko	20% TEA in water	2014	UC	Southampton City Council	11	32	31	3.5%	G	**0.97**
Gradko	20% TEA in water	2014		**Overall Factor (22 studies)**				**Use**		**0.92**

Source: Diffusion Tube Bias Adjustment Factors Spreadsheet for March 2017 (v2). https://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

Table 12. National Diffusion Tube Bias Adjustment Factors, 2015

Analysed By	Method	Year	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (mg/m^3)	Automatic Monitor Mean Conc. (Cm) (mg/m^3)	Bias (B)	Tube Precision	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	20% TEA in water	2015	R	Ards and North Down Borough Council	12	38	26	48.6%	G	**0.67**
Gradko	20% TEA in water	2015	UC	Breckland Council	12	30	29	1.5%	G	**0.99**
Gradko	20% TEA in water	2015	R	Cheltenham Borough Council	12	35	35	2.7%	G	**0.97**
Gradko	20% TEA in water	2015	R	Lisburn & Castlereagh City Council	10	36	29	24.8%	G	**0.80**
Gradko	20% TEA in water	2015	R	Luton Borough Council	12	46	44	6.0%	G	**0.94**
Gradko	20% TEA in water	2015	R	Monmouthshire County Council	12	41	37	11.0%	G	**0.90**
Gradko	20% TEA in water	2015	B	Pembrokeshire Council	10	4	3	36.7%	G	**0.73**
Gradko	20% TEA in water	2015	R	City of Lincoln Council	12	39	33	17.9%	G	**0.85**
Gradko	20% TEA in water	2015	R	Borough Council of King's Lynn and West Norfolk	12	29	22	32.5%	G	**0.75**
Gradko	20% TEA in water	2015	R	Cheshire West and Chester	10	38	40	-5.2%	G	**1.06**
Gradko	20% TEA in water	2015	R	Dudley MBC	12	47	50	-5.9%	G	**1.06**
Gradko	20% TEA in water	2015	R	Dudley MBC	12	40	35	14.0%	G	**0.88**
Gradko	20% TEA in water	2015	R	Dudley MBC	12	34	31	10.0%	G	**0.91**
Gradko	20% TEA in water	2015	UB	Dudley MBC	11	23	19	20.9%	G	**0.83**
Gradko	20% TEA in water	2015	KS	Marylebone Road Intercomparison	12	102	81	26.2%	G	**0.79**
Gradko	20% TEA in water	2015	UB	Liverpool	12	20	22	-9.0%	G	**1.10**
Gradko	20% TEA in water	2015	R	Preston City Council	12	29	27	8.9%	G	**0.92**
Gradko	20% TEA in water	2015	R	Thurrock Borough Council	12	28	23	22.5%	G	**0.82**
Gradko	20% TEA in water	2015	R	Gateshead Council	11	33	34	-1.2%	G	**1.01**
Gradko	20% TEA in water	2015	R	Gateshead Council	12	28	27	3.9%	G	**0.96**
Gradko	20% TEA in water	2015	R	Gateshead Council	10	36	32	11.5%	G	**0.90**
Gradko	20% TEA in water	2015	KS	New Forest DC	11	47	36	31.1%	P	**0.76**
Gradko	20% TEA in water	2015	R	New Forest DC	11	33	25	31.7%	G	**0.76**
Gradko	20% TEA in water	2015	UC	Southampton City Council	12	28	29	-3.5%	G	**1.04**
Gradko	20% TEA in water	2015	R	Wokingham Borough Council	11	36	33	7.9%	G	**0.93**
Gradko	20% TEA in water	2015	R	Brighton & Hove City Council	9	47	38	24.1%	G	**0.81**
Gradko	20% TEA in water	2015	R	NOTTINGHAM CITY COUNCIL	12	40	39	4.3%	G	**0.96**
Gradko	20% TEA in water	2015	R	Lancaster City Council	11	34	35	-3.0%	G	**1.03**
Gradko	20% TEA in water	2015	R	Hounslow Council	12	71	54	31.4%	G	**0.76**
Gradko	20% TEA in water	2015	R	Hounslow Council	12	66	45	47.1%	G	**0.68**
Gradko	20% TEA in water	2015		**Overall Factor (30 studies)**				**Use**		**0.87**

Source: Diffusion Tube Bias Adjustment Factors Spreadsheet for March 2017 (v2). https://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

Table 13. National Diffusion Tube Bias Adjustment Factors, 2016

Analysed By	Method	Year	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (mg/m^3)	Automatic Monitor Mean Conc. (Cm) (mg/m^3)	Bias (B)	Tube Precision	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	20% TEA in water	2016	R	Gateshead Council	12	29	26	10.5%	G	**0.90**
Gradko	20% TEA in water	2016	R	Gateshead Council	11	35	37	-6.0%	G	**1.06**
Gradko	20% TEA in water	2016	R	Gateshead Council	12	37	31	19.0%	G	**0.84**
Gradko	20% TEA in water	2016	R	Wokingham Borough Council	11	45	41	9.0%	G	**0.92**
Gradko	20% TEA in water	2016	R	Wokingham Borough Council	11	37	34	9.5%	G	**0.91**
Gradko	20% TEA in water	2016	R	Cheshire West and Chester	12	37	39	-5.3%	G	**1.06**
Gradko	20% TEA in water	2016	R	Thurrock Borough Council	12	29	26	11.0%	G	**0.90**
Gradko	20% TEA in water	2016	R	Borough Council of King's Lynn & West Norfolk	11	30	25	18.2%	G	**0.85**
Gradko	20% TEA in water	2016	UB	Eastleigh Borough Council	11	29	30	-4.7%	G	**1.05**
Gradko	20% TEA in water	2016	R	Eastleigh Borough Council	12	44	42	2.9%	G	**0.97**
Gradko	20% TEA in water	2016	R	Brighton & Hove City Council	12	52	48	8.8%	G	**0.92**
Gradko	20% TEA in water	2016	R	Eastleigh Borough Council	11	29	37	-22.0%	G	**1.28**
Gradko	20% TEA in water	2016	KS	Marylebone Road Intercomparison	12	99	79	25.2%	G	**0.80**
Gradko	20% TEA in water	2016	R	Monmouthshire County Council	11	39	34	16.6%	G	**0.86**
Gradko	20% TEA in Water	2016	R	Preston City Council	10	30	27	10.0%	G	**0.91**
Gradko	20% TEA in water	2016	R	Dudley MBC	12	37	34	11.0%	G	**0.90**
Gradko	20% TEA in water	2016	UB	Dudley MBC	12	26	22	18.6%	G	**0.84**
Gradko	20% TEA in water	2016	R	Dudley MBC	11	43	38	12.4%	G	**0.89**
Gradko	20% TEA in water	2016	R	Dudley MBC	12	51	54	-5.6%	G	**1.06**
Gradko	20% TEA in water	2016	B	LB Waltham Forest	12	31	30	2.3%	G	**0.98**
Gradko	20% TEA in water	2016	R	NOTTINGHAM CITY COUNCIL	12	37	39	-5.4%	G	**1.06**
Gradko	20% TEA in water	2016		**Overall Factor (21 studies)**				**Use**		**0.94**

Source: Diffusion Tube Bias Adjustment Factors Spreadsheet for March 2017 (v2). https://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

Appendix C Driver Awareness Survey June 2014 Questionnaire

Tower Bridge Survey Questionnaire

Interviewer:	
Date:	
Time:	
Survey Location:	
Reference Number (OFFICE USE ONLY)	

Screening

Good morning/afternoon/evening

We are conducting some research on behalf of Southwark and Tower Hamlets Council with drivers. Could you spare a few minutes to answer some questions?

Yes 1 **CONTINUE**

No 2 **THANK AND CLOSE**

S1 Have you driven across Tower Bridge in the last 3 months? (show map)

Yes 1 **CONTINUE**

No 2 **THANK AND CLOSE**

Remember to record LENGTH of Interview

Section 1 – Air Quality

Q1 To what extent do you agree or disagree with the following statements about air quality in London? SHOWCARD A *(Tick one for each row)*

	Strongly Agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly Disagree*
The air quality in this part of London is good	1	2	3	4	5
If there was less traffic congestion the air quality would improve	1	2	3	4	5
Poor air quality is bad for my health	1	2	3	4	5
More should be done to improve air quality	1	2	3	4	5

Q2 What do you think is the main contributor to poor air quality in this area?

Record Verbatim PROBE FULLY

Section 2 – Anti-Idling

Q3 Do you drive a vehicle that automatically turns off the engine when in stationary traffic? Code one only

- ☐1 Yes **GO TO Q7**
- ☐2 No **Continue**

Q4 Do you ever turn off your engine when stuck in stationary traffic? Code one only

- ☐1 Yes **Continue**
- ☐2 No **GO TO Q6**

ASK ONLY IF DO TURN OFF ENGINE

Q5 In what circumstances do you switch off your engine when sitting in traffic?

Tick all that apply SHOWCARD B

- ☐1 If I can see the start of the queue and and know I will have time to switch my engine back on before traffic starts moving
- ☐2 If traffic has not moved for at least 10 minutes
- ☐3 If I am not in any hurry
- ☐4 If traffic has not moved for at least 5 minutes
- ☐5 If signs at the road side provide information on the likely delay
- ☐6 If traffic has not moved for at least 1 minute
- ☐7 If I can see the start of the queue and I can estimate the length of delay
- ☐8 Other – please specify

ASK ALL

Q6 What are the reasons for keeping your engine running when sitting in stationary traffic?

Tick all that apply SHOWCARD C

- ☐1 The queue would be bound to start moving the minute I turned it off
- ☐2 The vehicle might not start again

☐3 It would slow up the traffic when the queue starts to move

☐4 It uses more fuel to restart the engine than to leave it running

☐5 It just wouldn't occur to me to do it

☐6 Why bother? it's not a big deal

☐7 Other – please specify

Section 3 – Use of Tower Bridge

Q7 How often do you make journeys, as a driver, across Tower Bridge? *(Tick one only)*

☐1 Daily / Weekly **Continue**

☐2 Monthly / Occasionally **Continue**

☐3 Rarely /One off **GO TO Q11**

Q8 On approximately how many in 10 journeys across Tower Bridge have you had to queue?

write in number – best estimate

a) For any reason	in 10	
b) Due a bridge lift (or suspected bridge lift)	in 10	**If ZERO, GO TO Q11**

Q9 What would you say was the average time you were queuing and stationary as a result of the

bridge lifting? *(write in number)*

minutes

Q10 Thinking about the last journey you made which was affected in some way by the lifting of Tower Bridge, which of the following did you do?

(Tick all that apply) SHOWCARD G

☐1 Joined the queue and waited for the traffic to start moving, without turning off my engine

☐2 Diverted - took an alternative route to get to my destination

☐3 Changed destination

☐4 Joined the queue and waited for the traffic to start moving, AND turned off my engine

☐5 Checked the website to find out about bridge lift times and avoided the area altogether

☐6 Other – please specify

Q11 When using Tower Bridge, which of the following types of journey do you make? IF MORE THAN ONE TICK THE JOURNEY MADE MOST OFTEN

☐1 Commuting

☐2 Business

☐3 Leisure

Q12 And is this by... *(Tick one only)*

☐1 Private Car

☐2 Van/Light goods vehicle

☐3 Bus/coach/HGV

☐4 Taxi

☐5 Motorcycle/moped

Q13 I will now show you some measures designed to encourage drivers to switch off their engines while queuing on the approach to Tower Bridge. How effective do you think each would be?

Showcard H *(Tick one for each row)*

	effective	effective	effective	at all	Don't know
Signs at the road side advising of length of delay	1	2	3	4	5
Signs at the roadside showing air quality readings	1	2	3	4	5
Regulations and enforcement requiring waiting drivers on the approaches to turn off their engines when Tower Bridge was open	1	2	3	4	5
Being aware of the cost per minute of leaving engines running	1	2	3	4	5
Being aware of the environmental impacts of leaving engines running	1	2	3	4	5

Q14 Is there anything else that you think would be effective? Please specify

Q15 Have you ever checked for when the bridge is going to lift on the website?

- □1 Yes
- □2 No – was not aware of the website
- □3 No – but am aware that this is possible

And finally, just to ensure that we have spoken to a representative sample of drivers

D1 Which age group do you fall into?

□1	17-19	□5	45-54
□2	20-24	□6	55-59
□3	25-34	□7	60-64
□4	35-44	□8	65+

D2 Gender (DO NOT ASK)

- □1 Male
- □2 Female

D3 Which of the following best described your working status? *Tick one only*

- □1 Full-time (30 hours/wk+)
- □2 Part time (8-29 hours/wk)
- □3 Not working (under 8 hours)
- □4 Retired
- □5 Unemployed
- □6 Student
- □7 Other (please specify) ____________________________

D4 Interviewer please probe for SEG code

- □1 AB
- □2 C1
- □3 C2
- □4 DE

D5 Please could you provide the first part of your home postcode e.g. NW12?

____

Could I please take a contact number? This is just for quality control procedures; a supervisor may call to verify that the survey has been properly conducted.

Name ______________________

Telephone number_________________________

How long did the Interview take

____
Mins

THANK AND CLOSE

Appendix D Driver Awareness Survey Results

Section 1 – Air Quality

Q1 To what extent do you agree or disagree with the following statements about air quality in London? SHOWCARD A *(Tick one for each row)*

		Count	Column N %
The air quality around the Tower Bridge part of London is good	Strongly Agree	25	6.1
	Agree	153	37.6
	Neither agree nor disagree	92	22.6
	Disagree	96	23.6
	Strongly disagree	41	10.1
	Total	**407**	**100.0**
If there was less traffic congestion the air quality would improve	Strongly Agree	150	36.9
	Agree	189	46.6
	Neither agree nor disagree	28	6.9
	Disagree	37	9.1
	Strongly disagree	2	0.5
	Total	**406**	**100.0**
Poor air quality is bad for my health	Strongly Agree	170	42.1
	Agree	185	45.8
	Neither agree nor disagree	28	6.9
	Disagree	18	4.5
	Strongly disagree	3	0.7
	Total	**404**	**100.0**
More should be done to improve air quality	Strongly Agree	122	30.3
	Agree	182	45.2
	Neither agree nor disagree	71	17.6
	Disagree	22	5.5
	Strongly disagree	6	1.5
	Total	**403**	**100.0**

NB 1 respondent did not answer Q1b, 2 respondents did not answer Q1c, 4 respondents did not answer Q1d

Q2 What do you think is the main contributor to poor air quality in this area?

Record Verbatim PROBE FULLY

	Count	Column N %
Congestion/Traffic	199	48.9
Buses	117	28.7
Lorries	95	23.3
Cars/Taxis	86	21.1
Diesel	30	7.4
Buildings	19	4.7
Construction work	38	9.3
No answer/don't know	15	3.7
Pollution	8	2.0
Exhaust fumes/emissions	13	3.2
Aircraft	8	2.0
Smoking	3	0.7
Other	9	2.2
Total	**407**	

Big trucks, No trees, Trees soak up pollution don't they?
Too many cars, old cars especially, are illegal. MOT's just pass them, shouldn't be on the road.
Syncing of traffic lights
Too many road works that are not organized.
Shut up of side streets so we all have to sit on main rd and we all have to sit on it.
Traffic congestion, lack of greenery, not enough promotion/incentives around walking and cycling, bad road surface on cycle paths, not enough cycle networks.
China and India putting crap in the air it's all in the atmosphere
Farming pollution from France
20mph on bridge

Section 2 – Anti-Idling

Q3 Do you drive a vehicle that automatically turns off the engine when in stationary traffic? Code one only

	Count	Column N %
No	351	86.5
Yes	55	13.5
Total	**406**	**100.0**

NB 1 respondent did not answer

Q4 Do you ever turn off your engine when stuck in stationary traffic? Code one only

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	157	38.6	44.6	44.6
	Yes	195	47.9	55.4	100.0
	Total	**352**	**86.5**	**100.0**	
Missing	Car turns off automatically	55	13.5		
Total		**407**	**100.0**		

ASK ONLY IF DO TURN OFF ENGINE

Q5 In what circumstances do you switch off your engine when sitting in traffic?

Tick all that apply SHOWCARD B

	Count	Column N %
If I can see to know when to restart engine	70	36.6
If traffic has not moved for at least 10 minutes	71	37.2
If I am not in any hurry	13	6.8
If traffic has not moved for at least 5 minutes	61	31.9
If signs at the road side provide information on the likely delay	24	12.6
If traffic has not moved for at least 1 minute	30	15.7
If I can see the start of the queue and I can estimate the length of delay	48	25.1
Other	10	5.2
Total	**191**	

NB 4 respondents did not answer

Heavy traffic
If bridge goes up (n=4)
If there are school kids waiting
If there is an accident
On motorway i.e. tailback
Only on tower bridge when going up
To save petrol

ASK ALL

Q6 What are the reasons for keeping your engine running when sitting in stationary traffic?

Tick all that apply SHOWCARD C

	Count	Column N %
The queue would be bound to start moving the minute I turned it off	174	54.4
The vehicle might not start again	35	10.9
It would slow up the traffic when the queue starts to move	43	13.4
It uses more fuel to restart the engine than to leave it running	44	13.8
It just wouldn't occur to me to do it	33	10.3
Why bother? it's not a big deal	11	3.4
Other – please specify	48	15.0
Total	**320**	

NB 32 respondents did not answer

It's company vehicle
Habit
Doors unlock and lock when
Keep air con or heating on (n=7)
I use diesel, pretty cheap anyway.
I wouldn't if there was any delay at all
If you can see queue will be moving shortly
In winter when its cold (n=4)
Would depend on how long the traffic was going to be stationary for
Depends how long the queue
If I am at front of traffic llights
If on a main road at lights
Abnormal red light
Would always turn off (n=8)
Car economical anyway
Harms the engine and vehicle in the long term.
More pollution by turning off in stationary traffic
It takes too long too start
Not good for starter
It's a clean running vehicle - no need
Not built for it
Tiring
Don't need to
Motorcycle/Moped (n=8)

Section 3 – Use of Tower Bridge

Q7 How often do you make journeys, as a driver, across Tower Bridge? *(Tick one only)*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Daily/Weekly	291	71.5	71.9	71.9
	Monthly/Occasionally	81	19.9	20.0	91.9
	Rarely/One off	33	8.1	8.1	100.0
	Total	**405**	**99.5**	**100.0**	
Missing	Did Not Answer	2	.5		
Total		**407**	**100.0**		

Q8 On approximately how many in 10 journeys across Tower Bridge have you had to queue?

write in number – best estimate

a) For any reason

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	98	24.1	27.3	27.3
	1	59	14.5	16.4	43.7
	2	53	13.0	14.8	58.5
	3	24	5.9	6.7	65.2
	4	14	3.4	3.9	69.1
	5	31	7.6	8.6	77.7
	6	7	1.7	1.9	79.7
	7	5	1.2	1.4	81.1
	8	19	4.7	5.3	86.4
	9	10	2.5	2.8	89.1
	10	39	9.5	10.9	100.0
	Total	**359**	**88.2**	**100.0**	
Missing	Rarely use bridge	33	8.1		
	Did not answer	15	3.7		
Total		**407**	**100.0**		

b) Due a bridge lift (or suspected bridge lift)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	191	46.9	58.1	58.1
	1	82	20.1	24.9	83.0
	2	37	9.1	11.2	94.2
	3	6	1.5	1.8	96.0
	4	3	.7	.9	97.0
	5	5	1.2	1.5	98.5
	6	2	.5	.6	99.1
	8	1	.2	.3	99.4
	10	2	.5	.6	100.0
	Total	**329**	**80.8**	**100.0**	
Missing	Rarely use bridge	33	8.1		
	Did not answer	45	11.1		
Total		**407**	**100.0**		

Q9 What would you say was the average time you were queuing and stationary as a result of the bridge lifting? *(write in number)*

	N	Minimum	Maximum	Mean	Std. Deviation
Delay in minutes	154	0.0	37.0	12.377	6.6471

Q10 Thinking about the last journey you made which was affected in some way by the lifting of Tower Bridge, which of the following did you do? *(Tick all that apply)* SHOWCARD G

	Count	Column N %
Joined the queue and waited for the traffic to start moving, without turning off my engine	71	49.0
Diverted - took an alternative route to get to my destination	27	18.6
Changed destination	5	3.4
Joined the queue and waited for the traffic to start moving, AND turned off my engine	55	37.9
Other – please specify	4	2.8
Total	**145**	

Heard on radio that bridge was lifting so found another route to work
Queue time determines whether I turn the engine off or not.
Can’t remember
Can't remember. So long ago.

Q11 When using Tower Bridge, which of the following types of journey do you make? IF MORE THAN ONE TICK THE JOURNEY MADE MOST OFTEN

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Commuting	59	14.5	14.5	14.5
	Business	289	71.0	71.2	85.7
	Leisure	58	14.3	14.3	100.0
	Total	**406**	**99.8**	**100.0**	
Missing	Did not answer	1	.2		
Total		**407**	**100.0**		

Q12 And is this by... *(Tick one only)*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Private Car	156	38.3	38.4	38.4
	Van/LGV	81	19.9	20.0	58.4
	Bus/Coach/HGV	10	2.5	2.5	60.8
	Taxi	125	30.7	30.8	91.6
	Motorcycle/Moped	34	8.4	8.4	100.0
	Total	**406**	**99.8**	**100.0**	
Missing	Did not answer	1	.2		
Total		**407**	**100.0**		

Q13 I will now show you some measures designed to encourage drivers to switch off their engines while queuing on the approach to Tower Bridge. How effective do you think each would be?

Showcard H *(Tick one for each row)*

		Count	Column N %
Signs at the road side advising of length of delay	Very effective	206	50.9
	Quite effective	128	31.6
	Not very effective	33	8.1
	Not at all effective	33	8.1
	Don't know	5	1.2
	Total	**405**	**100.0**
Signs at the road side showing air quality readings	Very effective	83	20.5
	Quite effective	116	28.6
	Not very effective	78	19.3
	Not at all effective	113	27.9
	Don't know	15	3.7
	Total	**405**	**100.0**
Regulations and enforcement requiring waiting drivers on the approaches to turn off their engines when Tower Bridge was open	Very effective	129	31.8
	Quite effective	100	24.6
	Not very effective	55	13.5
	Not at all effective	100	24.6
	Don't know	22	5.4
	Total	**406**	**100.0**
Being aware of the cost per minute of leaving engines running	Very effective	102	25.1
	Quite effective	120	29.6
	Not very effective	75	18.5
	Not at all effective	95	23.4
	Don't know	14	3.4
	Total	**406**	**100.0**
Being aware of the environmental impacts of leaving engines running	Very effective	104	25.6
	Quite effective	144	35.5
	Not very effective	73	18.0
	Not at all effective	73	18.0
	Don't know	12	3.0
	Total	**406**	**100.0**

NB 2 respondents did not answer Q13a and Q13b, 1 respondent did not answer Q13c, Q13d, Q13e

Q14 Is there anything else that you think would be effective? Please specify

	Count	Column N %
Fines	8	2.0

Adverts	13	3.2
Signs/reminders	28	6.9
Traffic/vehicle regulations	40	9.8
Improve traffic flow	18	4.4
Build another crossing	3	.7
Incentives	16	3.9
Improve technology	14	3.4
No/Nothing/Don't know	299	73.5
Other	6	1.5
Total	**407**	

Own responsibility
Small boats going through not necessary when they skip at London Bridge.
Better public transport
Stop sill boat going west as often
Plant more trees and plants
Less construction dust and dirt adds to pollution

Q15 Have you ever checked for when the bridge is going to lift on the website?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No- but I am aware that this is possible	147	36.1	36.4	36.4
	No- was not aware of the website	233	57.2	57.7	94.1
	Yes	24	5.9	5.9	100.0
	Total	**404**	**99.3**	**100.0**	
Missing	Did not answer	3	.7		
Total		**407**	**100.0**		

D1 Which age group do you fall into?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	17-19	4	1.0	1.0	1.0
	20-24	16	3.9	3.9	4.9
	25-34	61	15.0	15.0	19.9
	35-44	105	25.8	25.8	45.7
	45-54	111	27.3	27.3	73.0
	55-59	49	12.0	12.0	85.0
	60-64	40	9.8	9.8	94.8
	65+	21	5.2	5.2	100.0
	Total	**407**	**100.0**	**100.0**	

D2 Gender (DO NOT ASK)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	46	11.3	11.6	11.6
	Male	351	86.2	88.4	100.0
	Total	**397**	**97.5**	**100.0**	
Missing	No response given	10	2.5		
Total		**407**	**100.0**		

D3 Which of the following best described your working status? *Tick one only*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Full time (30hours/wk +)	353	86.7	87.6	87.6

	Not working (under 8 hours)	5	1.2	1.2	88.8
	Other- please specify	2	.5	.5	89.3
	Part time (8-29 hours/wk)	37	9.1	9.2	98.5
	Retired	3	.7	.7	99.3
	Student	1	.2	.2	99.5
	Unemployed	2	.5	.5	100.0
	Total	**403**	**99.0**	**100.0**	
Missing	Did not answer	4	1.0		
Total		**407**	**100.0**		

D4 Interviewer please probe for SEG code

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	AB	66	16.2	16.8	16.8
	C1	132	32.4	33.5	50.3
	C2	143	35.1	36.3	86.5
	DE	53	13.0	13.5	100.0
	Total	**394**	**96.8**	**100.0**	
Missing	No response given	13	3.2		
Total		**407**	**100.0**		

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