



# Clean Air Walking Routes

## Monitoring Report for Cross River Partnership



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June 2017

**KING'S**  
*College*  
**LONDON**



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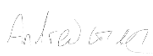
<b>Title</b>	Clean Air Walking Routes Monitoring Report
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## 1. Summary

In early 2017, Cross River Partnership (CRP) commissioned King's College London (King's) to assess cumulative black carbon concentrations along contrasting walking route pairs in central London.

Route pairs were selected by CRP and partners in the Clean Air Better Business (CABB) programme which is supported by the Mayor of London.

More well known, but often busier routes between stations and popular destinations were monitored in parallel with 'Clean Air Walking Routes' which are alternative, quieter routes between the same points.

These route pairs were assessed using portable black carbon monitors on several days between March and May 2017.

The routes assessed were:

- Euston Station to King's Cross Station
- King's Cross Station to Camden Town
- Euston Station to Regent's Park
- Warren Street Station to Regent's Park
- Embankment Station to Covent Garden via John Adams Street
- Embankment Station to Covent Garden via Embankment Gardens
- Earl's Court Station to Holland Park

For each route, high time-resolution black carbon measurements were taken by researchers walking the alternative routes in parallel.

Black carbon is a more sensitive measure of traffic emissions than PM<sub>2.5</sub> and for this reason is a better indicator of traffic exposure.

The summary table below shows the cumulative difference in black carbon concentrations between each of the routes expressed as a percentage difference between the 'standard' route and the 'Clean Air Route'.

These results show that Clean Air Routes had consistently lower cumulative and average black carbon concentrations over the course of the route than the standard routes in the range of 30-60%.

CRP will continue to work with public and private sector partners to realise the positive health impacts of Clean Air Walking Routes, including developing on-street signage and promoting an [online Clean Air Route finder](#) developed with King's.

Table 1 Summary of cumulative black carbon concentrations along route pairs.

Route		Cumulative total (BC) (ug/m3)	% difference	
Euston Station <> King's Cross Station	Standard Route	118	51	% lower
	Clean Air Route	57		
King's Cross Station <> Camden Lock	Standard Route	164	39	% lower
	Clean Air Route	99		
Euston Station <> Regent's Park	Standard Route	80	32	% lower
	Clean Air Route	54		
Warren St <> Regent's Park	Standard Route	83	41	% lower
	Clean Air Route	49		
Embankment Station <> Covent Garden via John Adams Street	Standard Route	46	47	% lower
	Clean Air Route	24		
Embankment Station <> Covent Garden via Embankment Gardens	Standard Route	85	53	% lower
	Clean Air Route	40		
Earl's Court Station <> Holland Park via Earl's Court Road	Standard Route	121	46	% lower
	Clean Air Route	65		
Earl's Court <> Holland Park via Warwick road	Standard Route	133	61	% lower
	Clean Air Route	52		

## 2. Background

Research by King's College London for the Mayor in 2015 found that in London, two pollutants of concern; nitrogen dioxide and PM2.5 particulates, are responsible for the early deaths of up to 5,879 Londoners and 3,537 Londoners respectively each year. This is equivalent to a total of 140,743 life years lost across the population.

In 2014 The World Health Organization (WHO) categorised air pollution as “The world’s largest single environmental health risk” contributing to the early deaths of seven million people worldwide (WHO, 2014). In 2016 WHO released updated figures showing that more than 80% of the world’s urban population now live in cities that exceed WHO standards for pollution (WHO, 2016).

WHO have also classified diesel engine exhaust as carcinogenic to humans (Group 1), “based on sufficient evidence that exposure is associated with an increased risk for lung cancer” (WHO, 2012).

In 2015, London’s first Clean Air Walking Route was launched by Urban Partners, the business partnership for Euston and King’s Cross & St Pancras (Urban Partners, 2015). The route runs between Euston and King’s Cross stations and encourages commuters to take a quieter backstreet route avoiding the busy Euston Road.

The route has proved to be popular with Urban Partners reporting a threefold increase in footfall and a positive response from businesses along the new route.

While government and industry work to reduce emissions, there are actions individuals can take to reduce their own exposure to pollution such as taking quieter routes like these with less traffic exposure.

The Euston to King’s Cross route is now being made permanent and its success has led to the development of several others across central London by partners in CRP’s Clean Air Better Business programme.

## 3. Aims

This study aimed to assess differences in air pollution exposure along several contrasting ‘Clean Air’ and standard route pairs in central London.

## 4. Method

### 1.1 Measuring black carbon

Black Carbon is defined by the technique used to measure it – namely light absorption. It’s main sources in urban areas are combustion engines (especially diesel) and residential burning of wood and coal.

A report into black carbon released by WHO (WHO, 2012) noted that a review of available evidence is sufficient to suggest an association between short-term variations in black carbon concentrations and health (cardiovascular mortality and cardiopulmonary hospital admissions). And that evidence also suggests an association between cardiopulmonary mortality and long-term averages of black carbon exposure. Significantly,

*“Studies of short-term health effects show that the associations with BC are more robust than those with PM<sub>2.5</sub> or PM<sub>10</sub>, suggesting that BC is a better indicator of harmful particulate substances from combustion sources (especially traffic) than undifferentiated PM mass.”*

The report goes on to say that whilst there is insufficient evidence to allow an evaluation of the differences in health effects of black carbon and undifferentiated particulate mass, black carbon can nevertheless act as a useful indicator in evaluating exposure to combustion-related particulate matter (particularly PM<sub>2.5</sub>) for which a substantial body of health effects evidence exists.

For this reason, black carbon was chosen as the metric by which to evaluate traffic exposure characteristics of walking routes in this study.

#### 4.1 Sampling strategy

The monitoring method involved carrying small sensors to measure concentrations of black carbon (a component of PM<sub>2.5</sub> particulate pollution associated with diesel exhaust emissions) along several route pairs.

In order to fairly assess the pollution concentrations of alternative routes, the routes were measured in parallel at the same time. The routes were walked by King’s researchers and members of the CABB programme wearing personal sampling equipment. Each researcher started and finished in the same location at the same time.

#### 4.2 Equipment

The monitors selected for this study were AethLabs microAeth AE51 (<https://aethlabs.com/microaeth>).

These instruments measure black carbon, a primary component of diesel exhaust particulate matter. They are small, reliable, portable and importantly can measure at high time frequencies. These characteristics made this instrument a good choice for this study where it was desirable to be able to detect contrasts in pollution characteristics of contrasting routes in central London.

The microAeth samples ambient air at a set flow rate onto a small filter stip. As particulate accumulates on the filter, the instrument measures the rate of change in the absorption of light passing through the filter at 880 nm. This rate of change in light absorption, combined with the flow rate is then expressed as a mass (ng) of black carbon (BC) per cubic metre of air (m<sup>3</sup>).

The instruments were set to a standard flow rate of 100 ml of air per minute and 1 minute averaging. At these settings, the instrument has a precision of +/- 0.1 BC ug/m<sup>3</sup> (AethLabs, 2016).

The instruments were carried by researchers from the start to the end of the routes.

### 4.3 Non-linear loading correction

microAeths calculate black carbon (BC) concentrations from the rate of change of light transmission through the filter. The faster the filters turns black, the higher the instrument infers the black carbon concentration to be. microAeths assume that there is a linear relationship between the rate of loading the concentration. However, research by (Virkkula, 2007) showed that this is not the case and in fact as the loading on the filter increases, the rate of change in the attenuation may slow despite the concentration of black carbon staying the same or increasing.

Aethalometer measurements were corrected to account for this non-linear performance.



## 5. Results

### 5.1 Euston Station to King's Cross Station

CABB Partner: Urban Partners

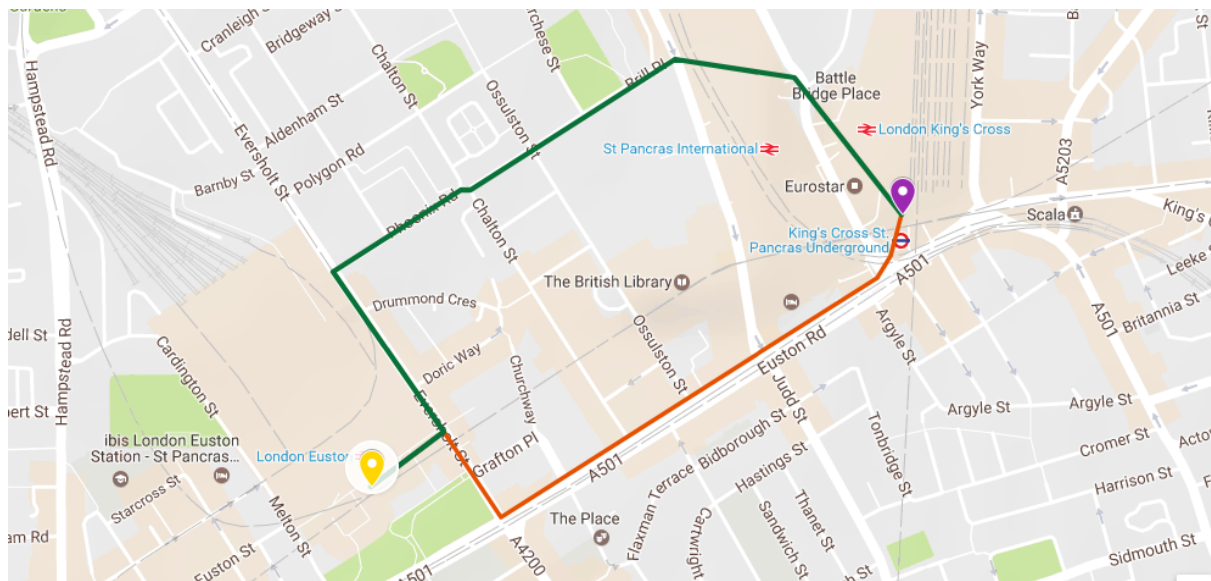
Monitoring date: 15/03/17

Start time: 12:09

End time: 12:28

Weather: Sunny, 15°C, 7mph south-westerly wind

*Figure 1 Route pair between Euston Station and King's Cross Station*



The standard route between Euston Station and King's Cross is along the Euston Road. The Euston Road is a heavily trafficked major east – west route through central London. Urban Partners estimate that 'tens of thousands' of people walk between these two stations each day.

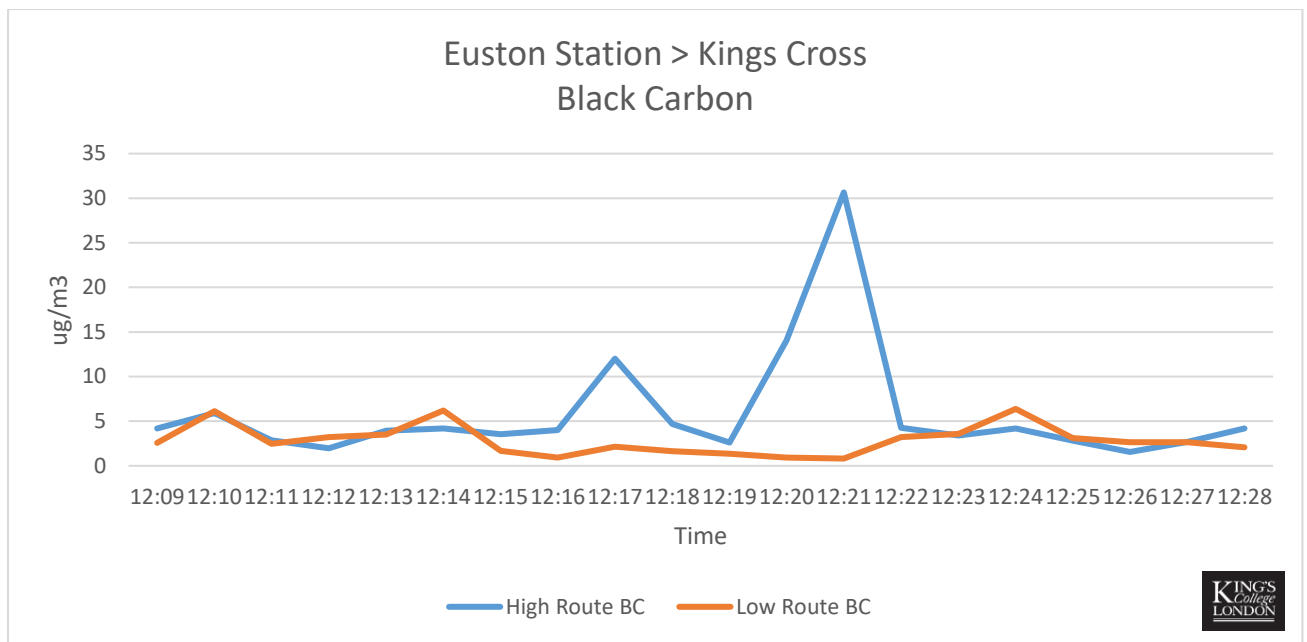
The Clean Air Route takes a route through the backstreets of King's Cross via Phoenix Road, Brill Place and through St Pancras and King's Cross Stations.

King's researchers and CABB partners set off from Euston Station at 12:09. One researcher walked along Euston Road while the other walked along the Clean Air Route.

The team then met at the front of King's Cross station at 12:28.

Figure 2 below shows the black carbon concentrations measured along each route.

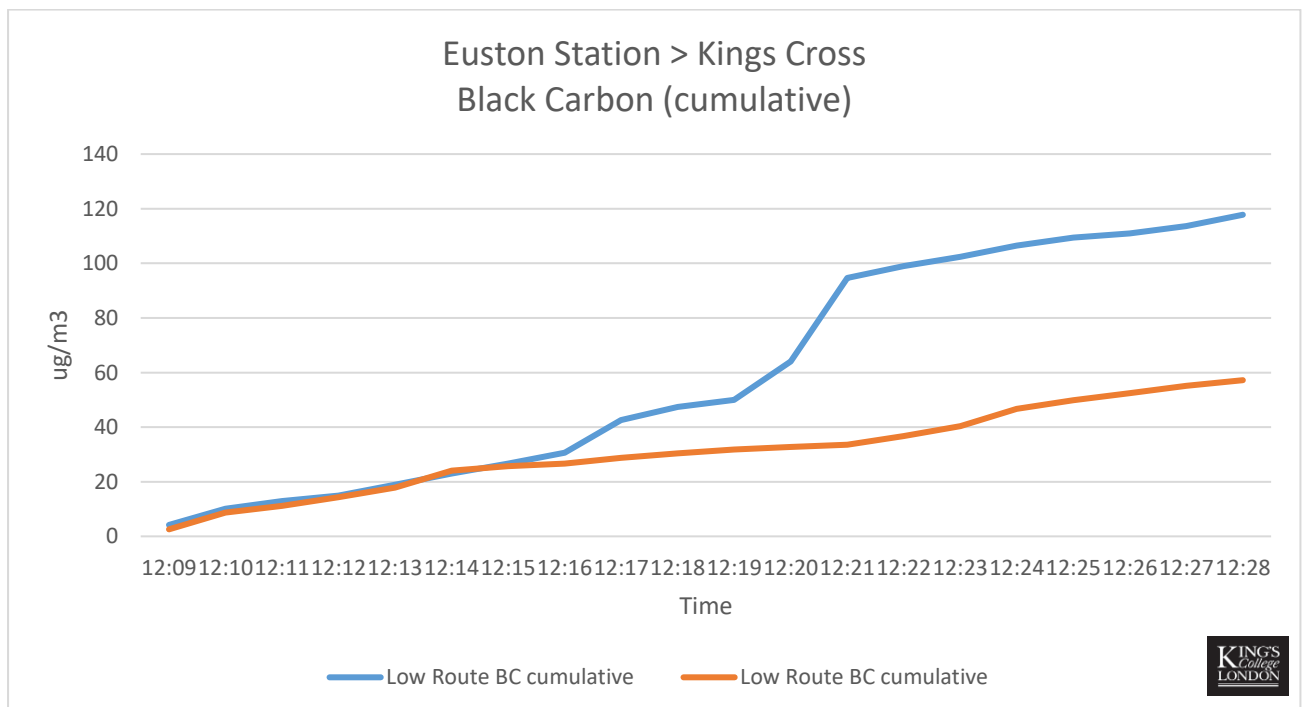
Figure 2 Time series showing black carbon concentrations on the Euston Station > King's Cross route pair.



- The greatest black carbon concentration measured on the Euston Road route was 31  $\mu\text{g}/\text{m}^3$  at 21:21
- The greatest black carbon concentration measured on the Clean Air Route was 6  $\mu\text{g}/\text{m}^3$  at 12:24

Figure 3 shows the cumulative black carbon concentrations measured along each route.

Figure 3 Time series showing cumulative black carbon concentrations along the Euston > King's Cross route pair.



- The cumulative black carbon concentration measured along the Euston Road route was 118  $\mu\text{g}/\text{m}^3$

- The cumulative black carbon concentration measured along the Clean Air Route was 57  $\mu\text{g}/\text{m}^3$

The cumulative black carbon concentration along the Euston Station to King's Cross Clean Air Route was 51% lower than the standard Euston Road route.

## 5.2 King's Cross Station to Camden Lock

CABB Partner: Camden Town Unlimited

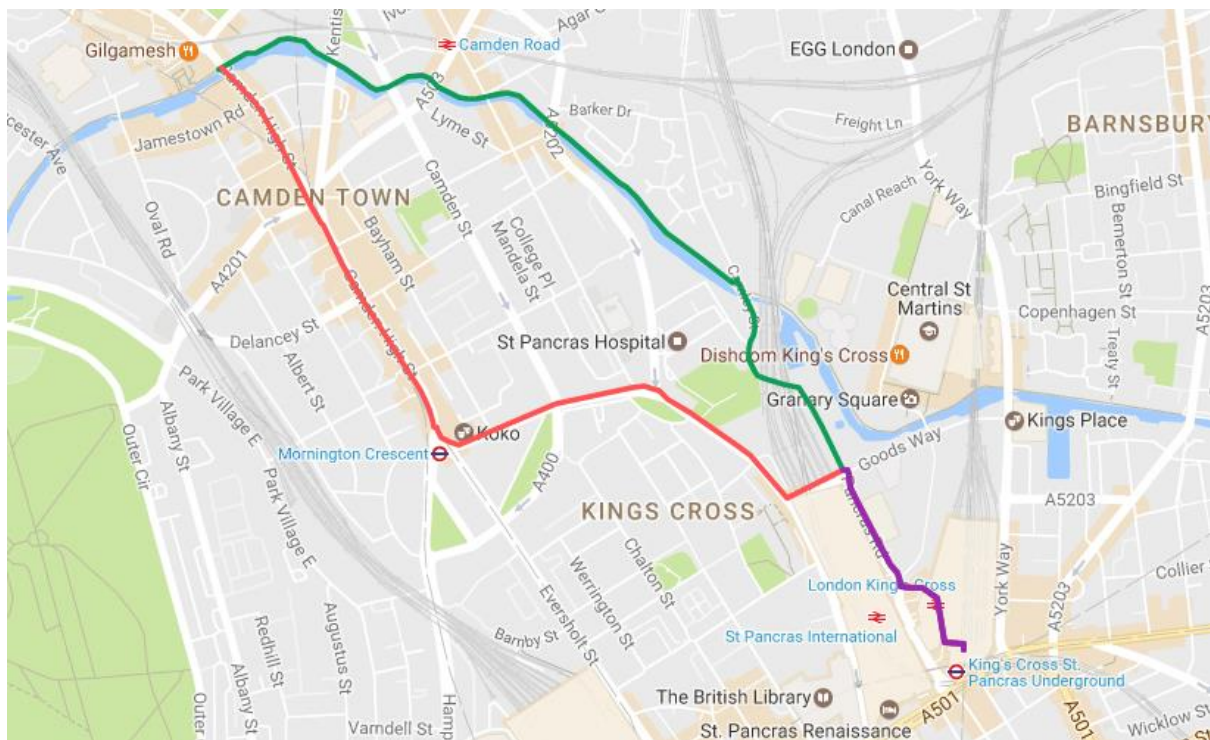
Monitoring date: 22/05/17

Start time: 09:20

End time: 09:52

Weather: Sunny, 17°C, 7mph southerly wind

Figure 4 Route pair between Camden Lock and King's Cross Station (shared section from Goods Way to King's Cross in purple)



Walking between Camden and King's Cross takes around half an hour. The majority of the Clean Air Route is along the Regent's Canal - a very pleasant route in the heart of the city.

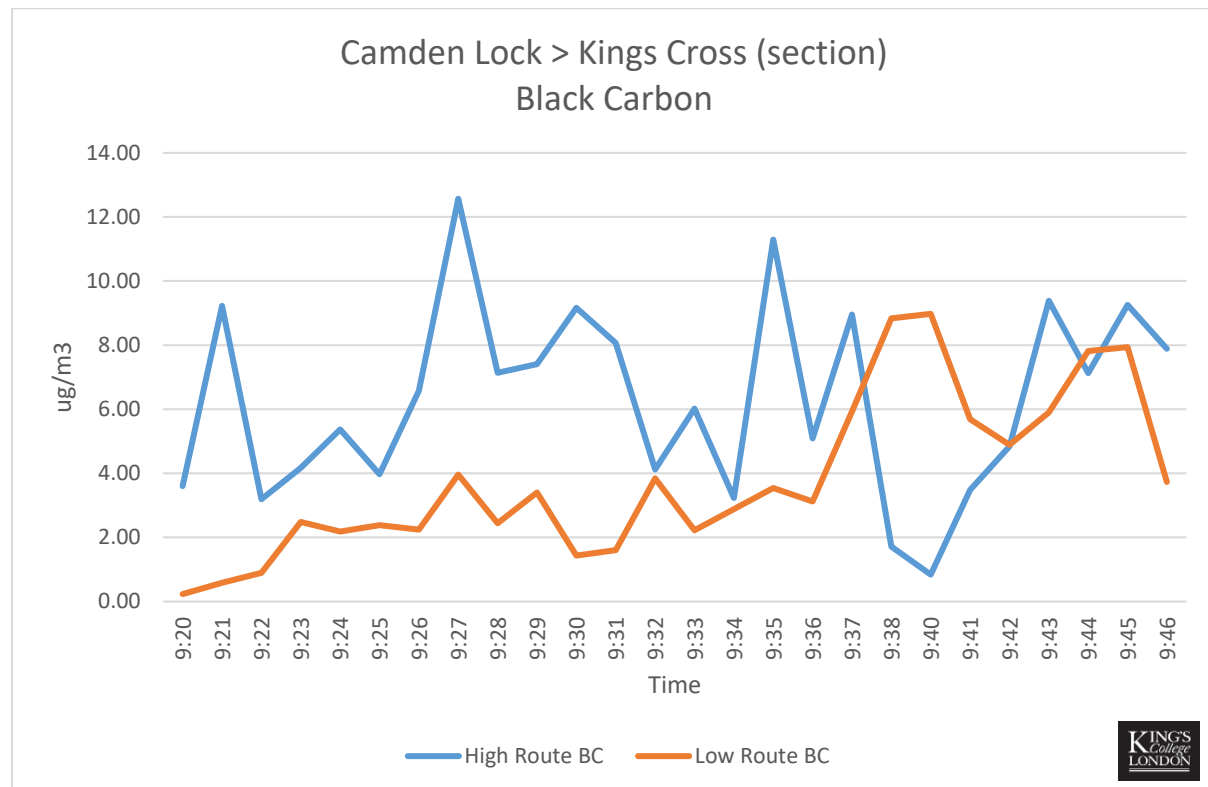
This route pair shares a significant section from Goods Way to King's Cross (indicated on the map in figure 4 in purple)

King's researchers set off from Camden Lock at 09:20 and met at Goods Way at 09:46. They then continued together down Pancras Road and through King's Cross Station to the front.

The concentration difference between the full routes (including the shared section) was 33%. The difference between the routes looking only at the divergent section between Camden Lock and Goods Way was 39%. This was the figure used in the summary table in the introduction.

The figures below show the data from the divergent sections of the route. The annex contains the full data set for these routes.

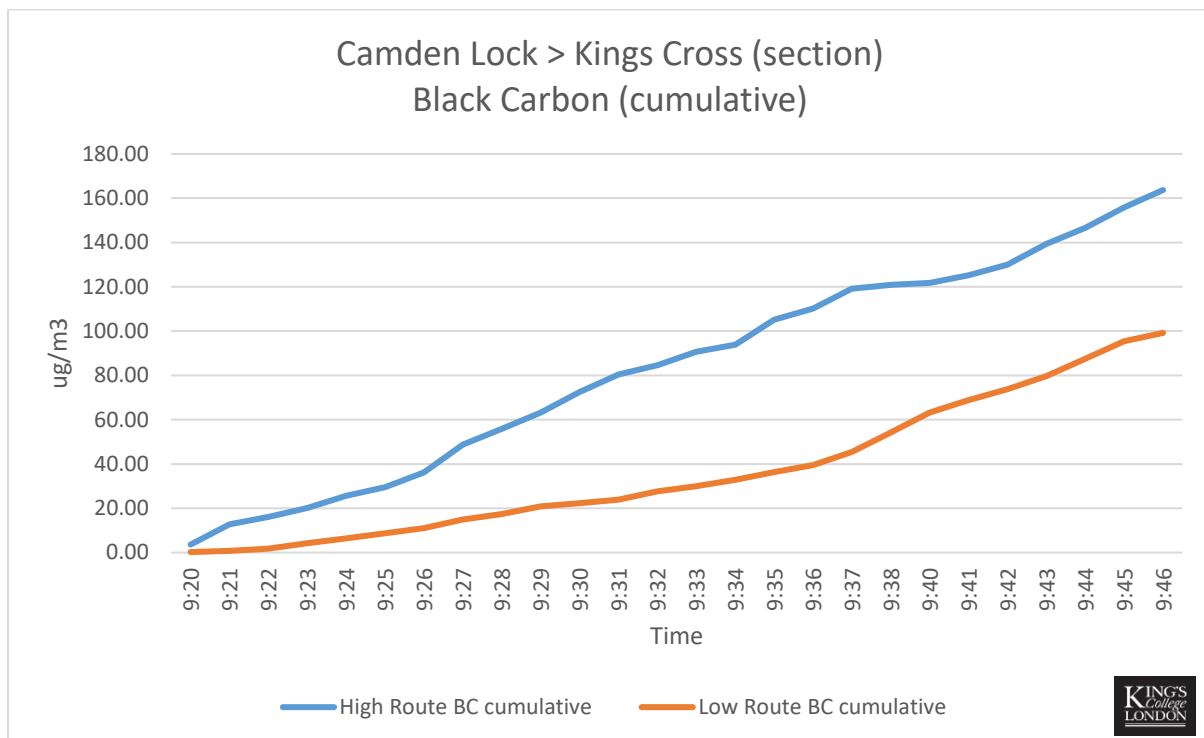
*Figure 5 Time series showing black carbon concentrations along the divergent section of the Camden > King's Cross route pair*



- The greatest black carbon concentration along the Camden High St route was 12.5  $\mu\text{g}/\text{m}^3$  at 09:27.
- The greatest black carbon concentration along the Clean Air Route was 9  $\mu\text{g}/\text{m}^3$  at 09:40.

Figure 6 shows the cumulative black carbon concentrations measured along each route.

Figure 6 Time series showing cumulative black carbon concentrations along the divergent section of the Camden Lock > King's Cross route pair.



- The cumulative black carbon concentration measured along the Camden High St route was 164  $\mu\text{g}/\text{m}^3$
- The cumulative black carbon concentration measured along the Clean Air Route was 99  $\mu\text{g}/\text{m}^3$

The cumulative black carbon concentration along the Camden Lock to King's Cross Clean Air Route was 39% lower than the standard Camden High Street / Crowndale Road route.

### 5.3 Euston Station to Regent's Park

CABB Partner: Euston BID

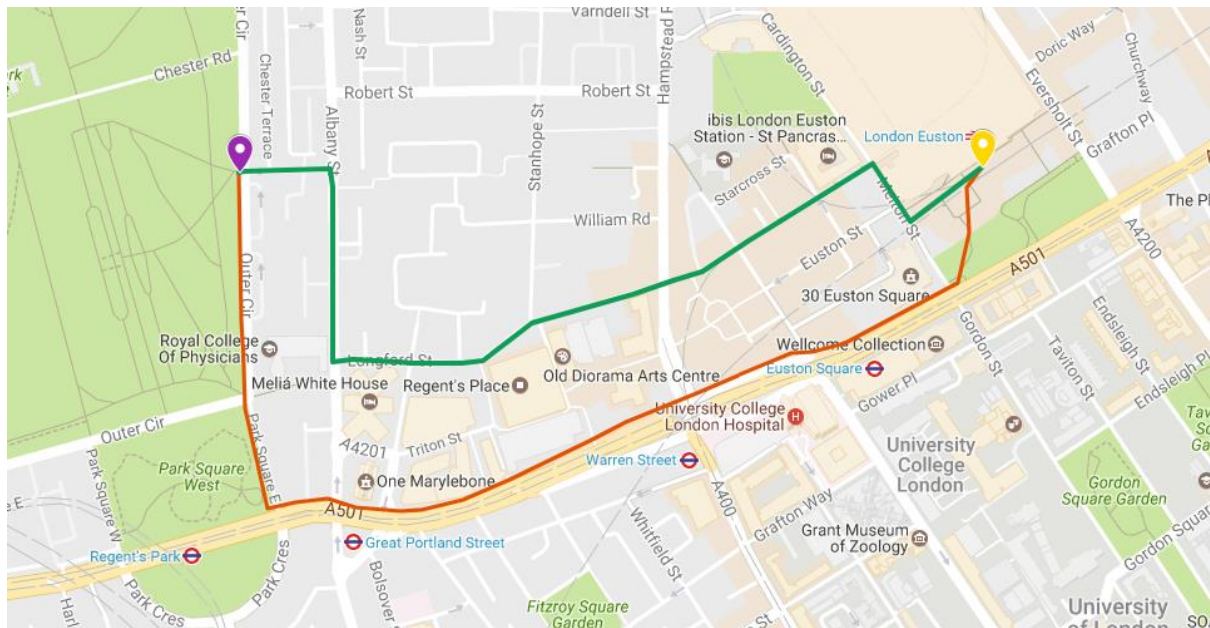
Monitoring date: 26/05/17

Start time: 08:52

End time: 09:10

Weather: Sunny, 21°C, 14mph south-easterly wind

Figure 7 Route pair between Euston Station and Regent's Park



The standard route between these two points is along Euston Road. As described earlier Euston Road is a major east-west corridor in London comprising four lanes of traffic.

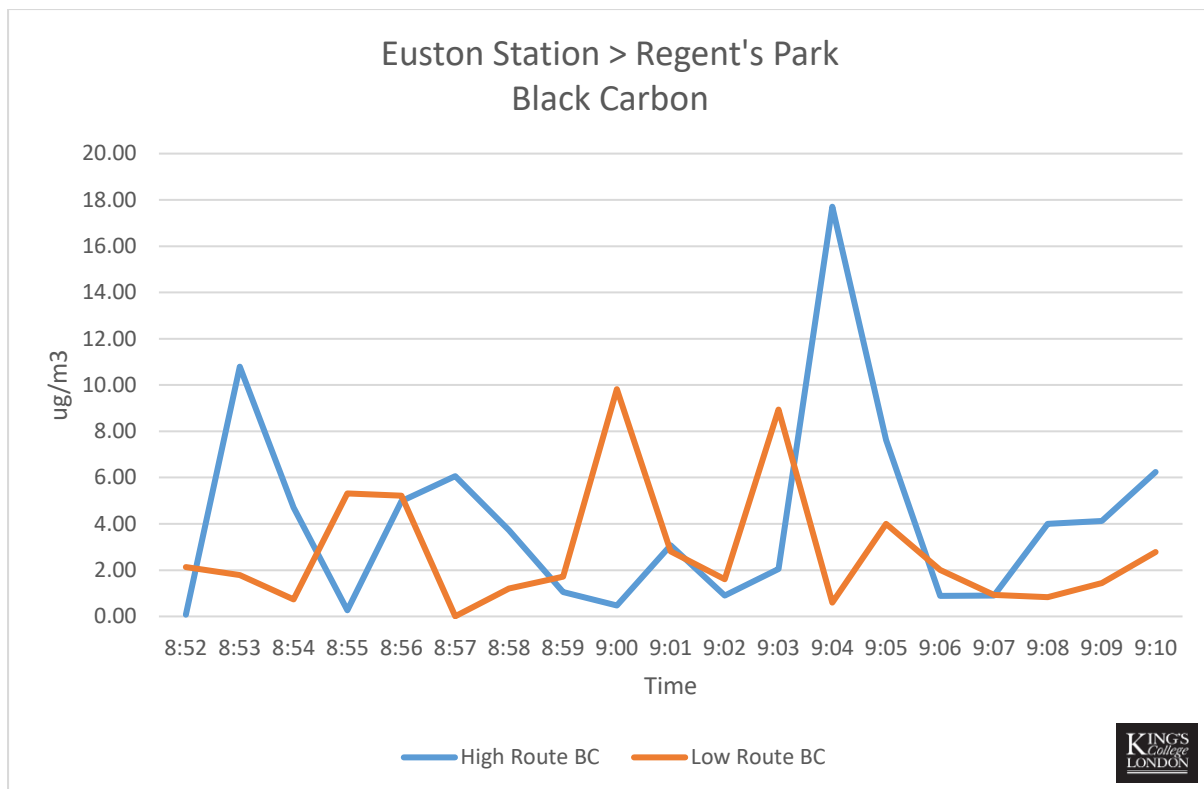
The Clean Air Route goes through the backstreets of Euston via Drummond Street, Longford Street, Albany Street and Chester Gate.

King's researchers and CABB partners set off from Euston Station at 08:52. One researcher walked along Euston Road while the other walked along the Clean Air Route.

The team then met at the western edge of Regent's Park adjacent to Chester Gate at 09:10.

Figure 8 shows the black carbon concentrations measured along each route.

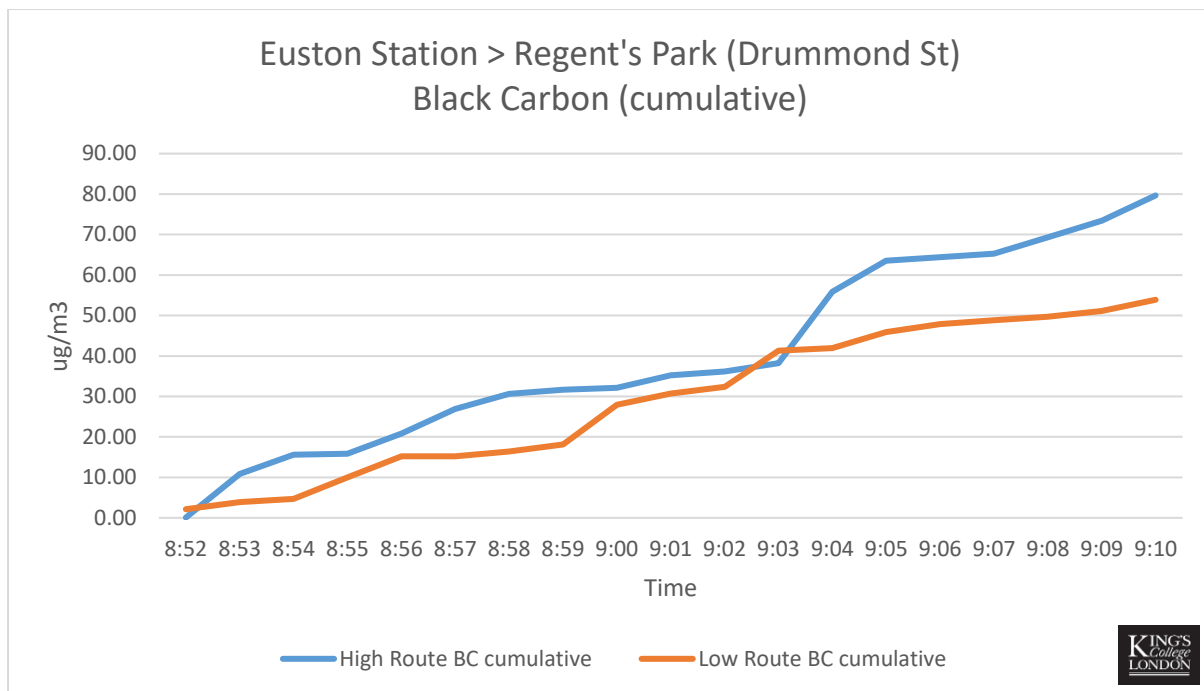
Figure 8 Time series showing black carbon concentrations on the Euston Station > Regent's Park route pair.



- The greatest black carbon concentration measured along the Euston Road route was 18  $\mu\text{g}/\text{m}^3$  at 09:04.
- The greatest black carbon concentration measured along the Clean Air Route was 10  $\mu\text{g}/\text{m}^3$  at 09:00.

Figure 9 shows the cumulative black carbon concentrations measured along each route.

Figure 9 Time series showing cumulative black carbon concentrations on the Euston Station > Regent's Park route pair



- The cumulative black carbon concentration measured along the Euston Road route was 80  $\mu\text{g}/\text{m}^3$ .
- The cumulative black carbon concentration measured along the Clean Air Route was 54  $\mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentration along the Euston Station to Regent's Park Clean Air Route was 32% lower than the standard Euston Road route.

#### 5.4 Warren Street to Regent's Park

CABB Partner: Fitzrovia BID

Monitoring date: 15/03/17

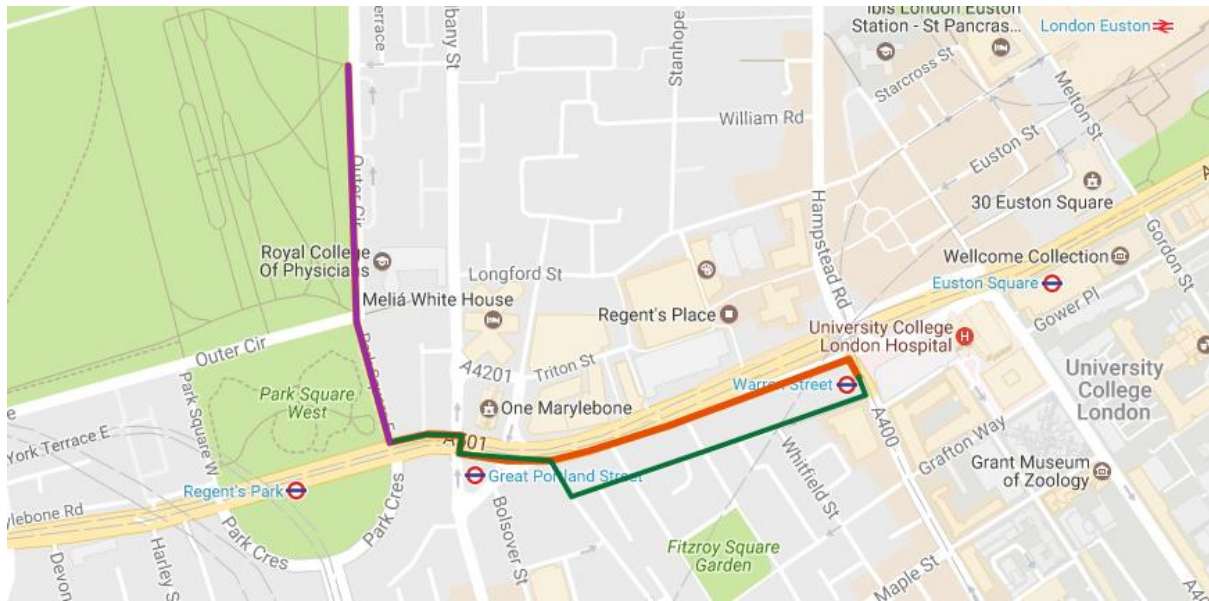
Start time: 13:18

End time: 13:31

Weather: Sunny, 18°C, 6mph westerly wind



Figure 10 Route pair between Warren Street station and Regent's Park (shared section from Euston Road to Regent's Park in purple)



The standard route between these two points is along the Euston Road and the Outer Circle of Regent's Park.

The Clean Air Route avoids most of Euston Road by taking a route along Warren Street and Cleveland Place.

King's researchers and BID members set off from Warren Street station at 13:18. One researcher walked along Euston Road and up the outer circle of Regent's Park while the other walked along Warren Street and Cleveland Place before crossing Euston Road and up the outer circle of Regent's Park.

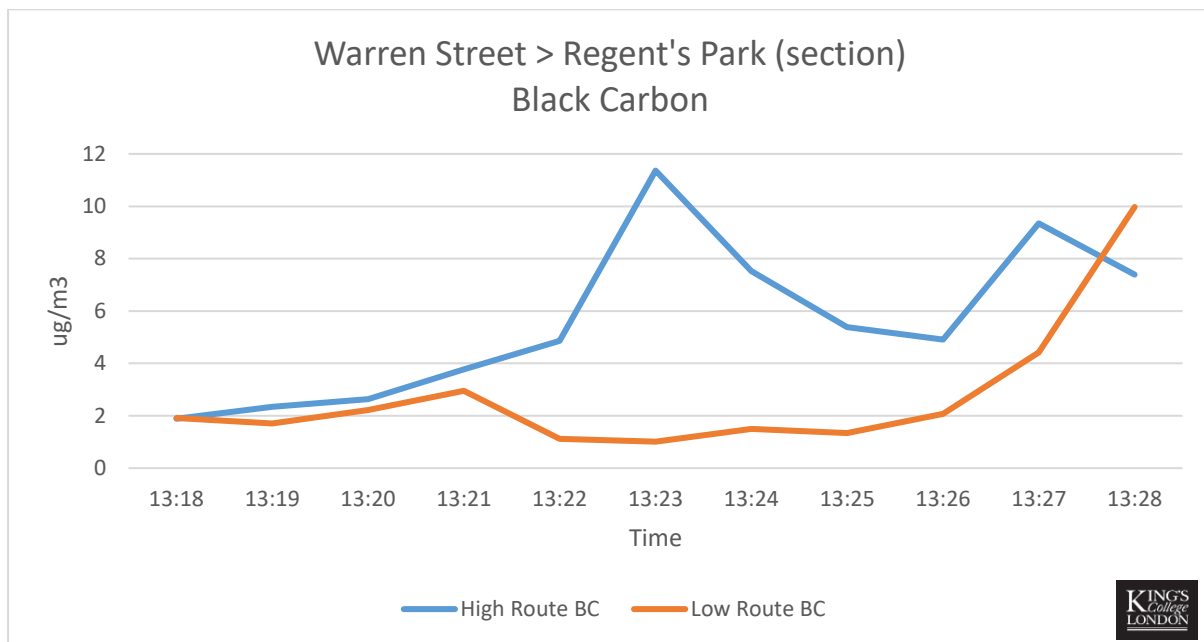
The team then met at the western edge of Regent's Park adjacent to Chester Gate at 13:31.

Like the Camden Lock to King's Cross route, the route pair shares some route from the junction of Cleveland Street/Euston Road and then up the western edge of Regent's Park.

The difference between cumulative black carbon concentrations measured along the whole route showed that the Clean Air Route along Warren Street was 41% lower than the standard route along Euston Road.

The data presented below is from the divergent section of the route pair from Warren Street Station to the junction of Euston Road and Park Square East. Researchers reached this point at 13:28. The shared section of the route pair is indicated by a purple line on the map in figure 10.

Figure 11 Time series showing black carbon concentrations along the divergent section of the Warren Street station > Regent's Park route pair.

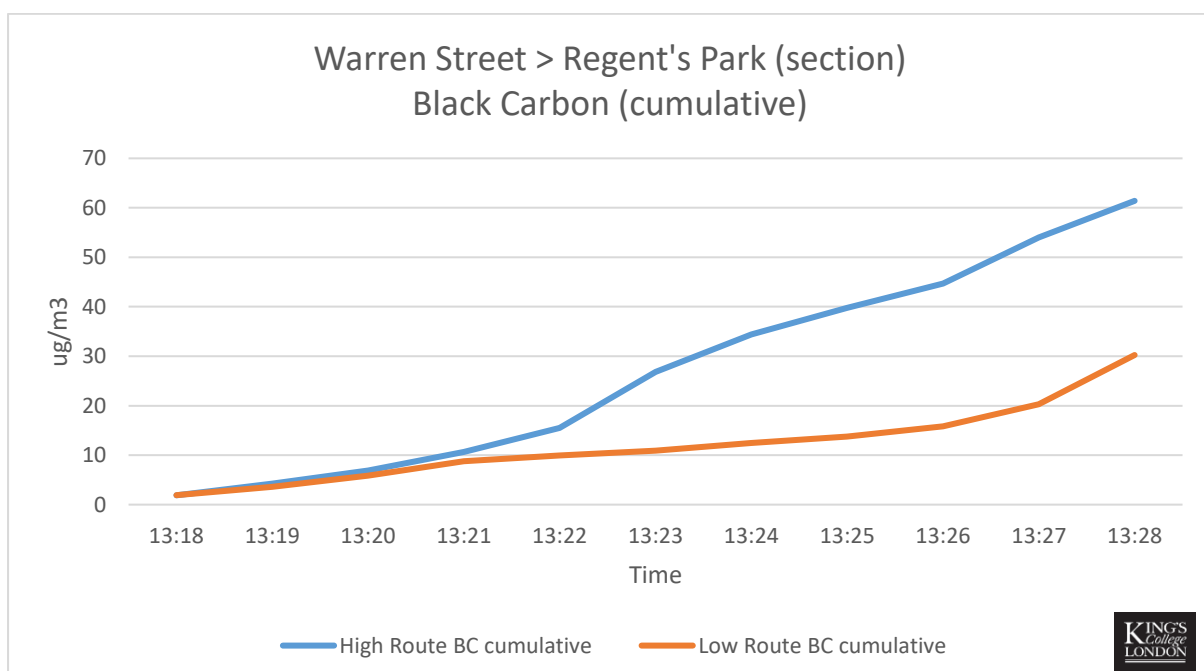


On the section where the Clean Air Route runs along Warren Street and the standard route runs along Euston Road (i.e not the section at the end where the Clean Air Route rejoins Euston Road):

- The reatest black carbon concentration measured on the Euston Road route was 11  $\mu\text{g}/\text{m}^3$  at 13:23.
- The greatest black carbon concentration measured on the Clean Air Route was 3  $\mu\text{g}/\text{m}^3$  at 13:21

Figure 12 shows the cumulative black carbon concentration measured along each route.

Figure 12 Time series showing cumulative black carbon concentrations along the divergent section of the Warren Street station > Regent's Park route pair.



- The cumulative black carbon concentration measured along the Euston Road route was 83  $\mu\text{g}/\text{m}^3$ .
- The cumulative total black carbon concentration measured along the Clean Air Route was 49  $\mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentration along the Warren Street station to Regent's Park Clean Air Route was 51% lower than the standard Euston Road route.

## 5.5 Embankment Station to Covent Garden (via Embankment Gardens)

CABB Partner: Northbank BID

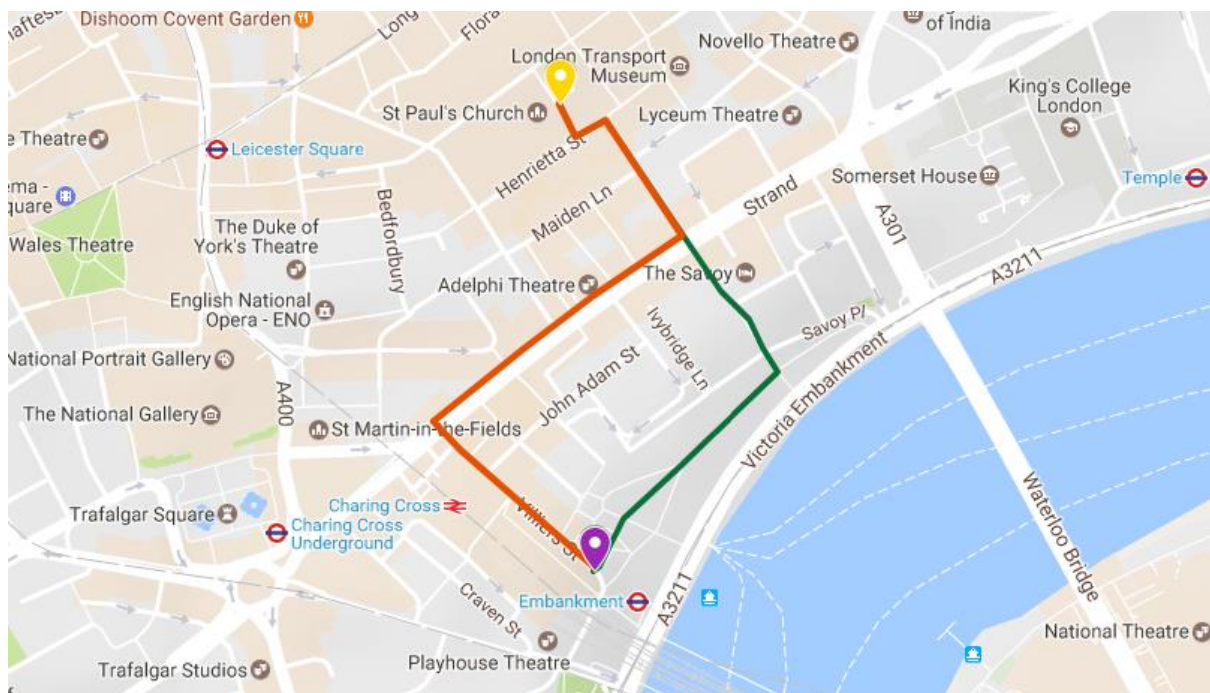
Monitoring date: 16/03/17

Start time: 09:56

End time: 10:10

Weather: Cloudy, 10oC, 8mph south-westerly wind

Figure 13 Route pair between Covent Garden and Embankment.

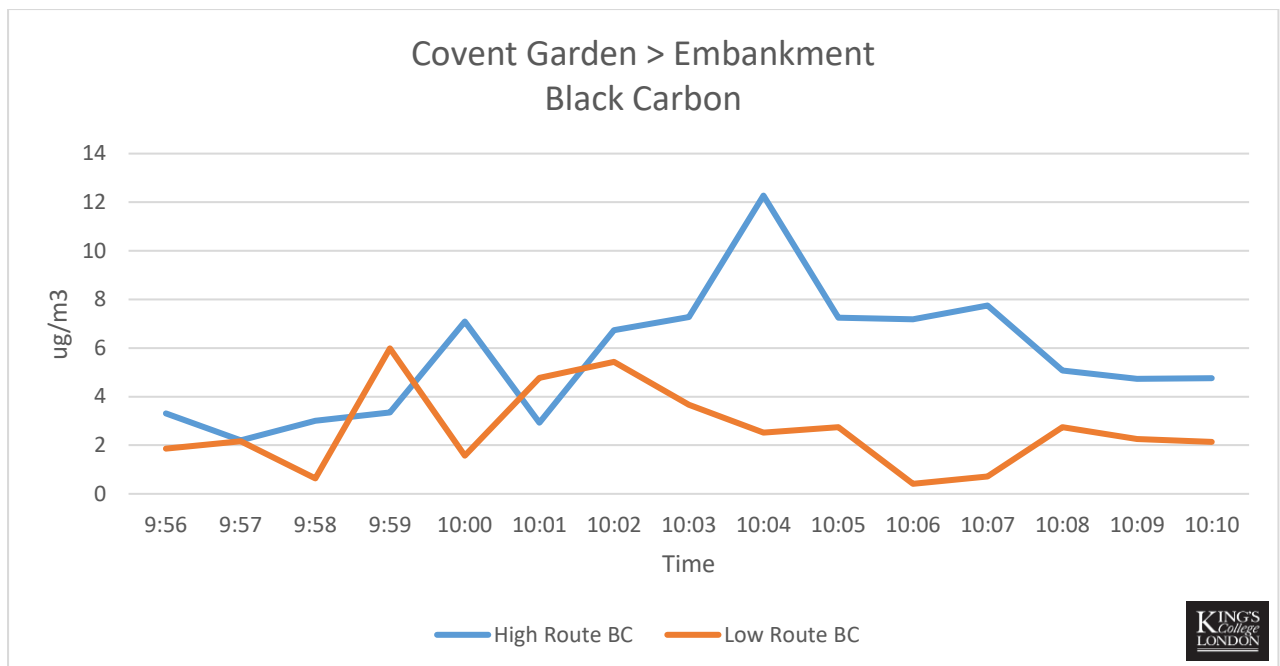


On this route pair, the standard route follows a course along the Strand. The Clean Air Route runs over the Strand, down Carting Lane and through Victoria Embankment Gardens to Embankment Station.

King's researchers and CABB Partners set off from Covent Garden at 09:56 and met outside Embankment Station at 10:10.

Figure 14 shows the black carbon concentrations measured along each route.

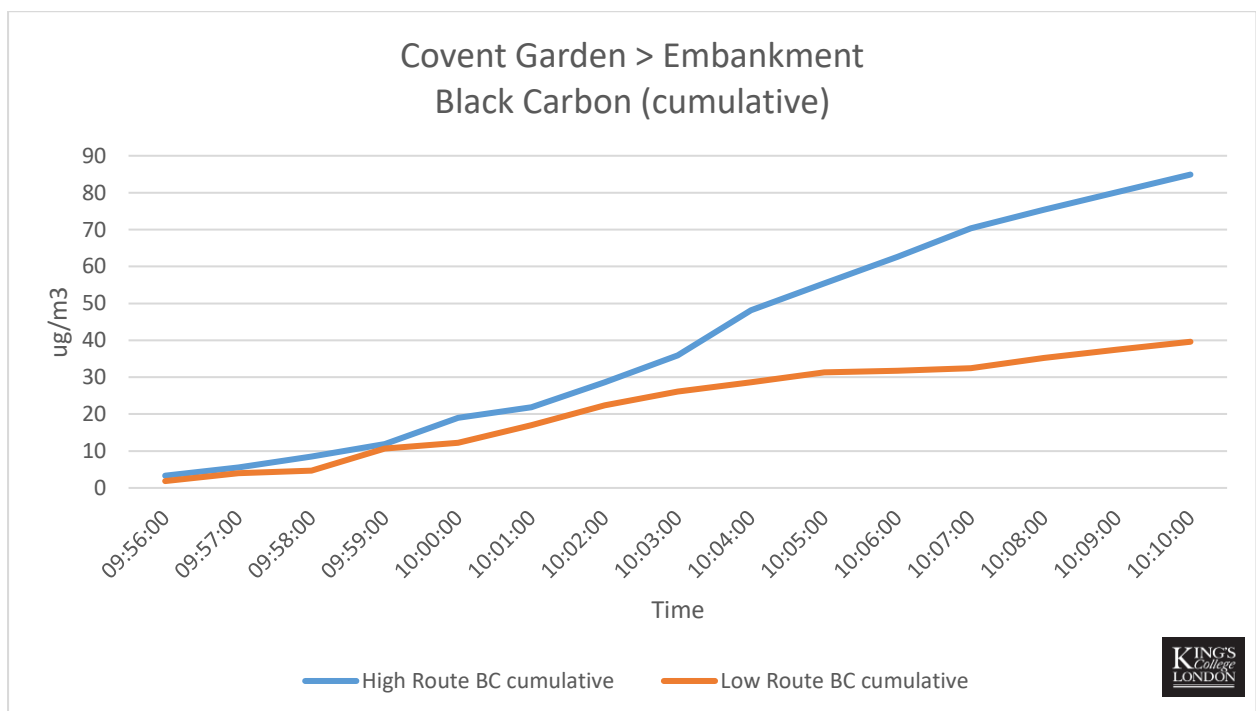
Figure 14 Time series showing black carbon concentrations along the Covent Garden > Embankment route pair.



- The greatest black carbon concentration measured on the Strand route was 12  $\mu\text{g}/\text{m}^3$  at 10:04.
- The greatest black carbon concentration measured on the Clean Air Route was 6  $\mu\text{g}/\text{m}^3$  at 9:59.

Figure 15 shows the cumulative black carbon concentration measured along each route between Embankment Station and the Strand.

Figure 15 Timeseries showing cumulative black carbon concentrations along the Covent Garden > Embankment route pair.



- The cumulative black carbon concentration measured along the Strand route was 85  $\mu\text{g}/\text{m}^3$ .

- The cumulative black carbon concentration measured along the Clean Air Route was 40  $\mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentration along the Clean Air Route from Covent Garden to Embankment Station was 53% lower than the standard Strand route.

## 5.6 Embankment Station to Covent Garden (via John Adams Street)

CABB Partner: Northbank BID

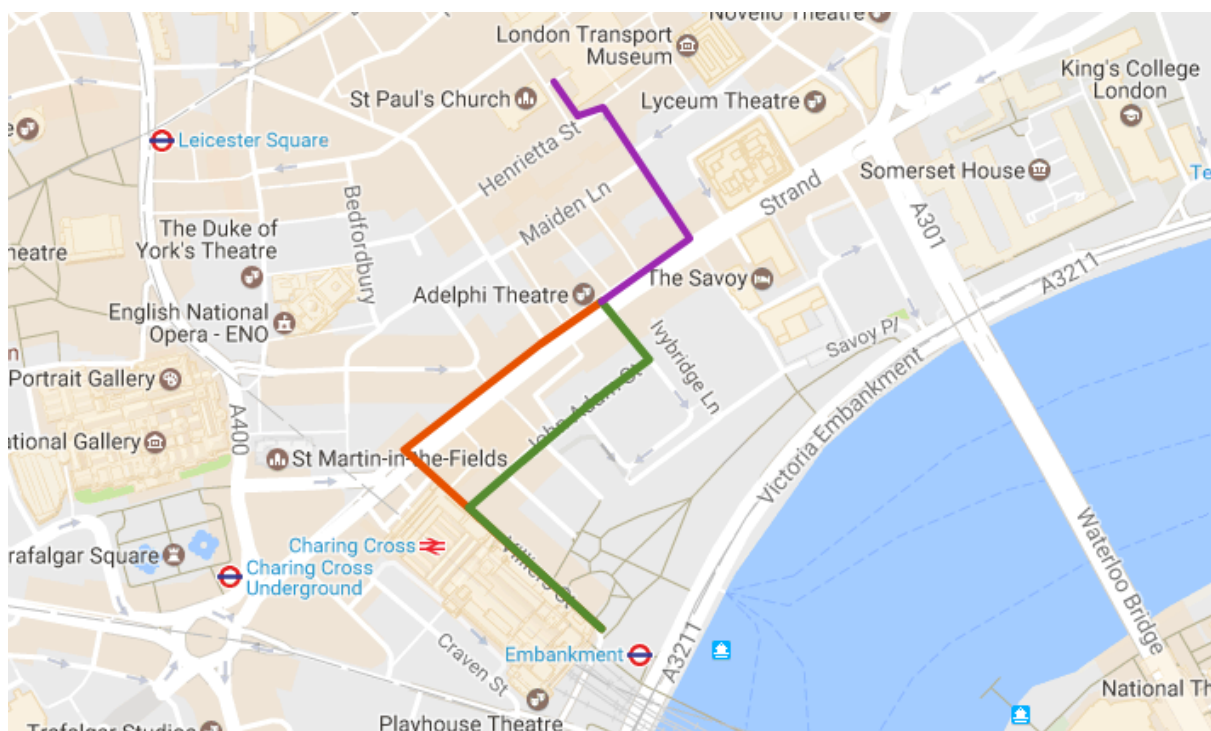
Monitoring date: 16/03/17

Start time: 09:21

End time: 09:38

Weather: Cloudy, 10°C, 8mph south-westerly wind

*Figure 16 Route pair between Embankment Station and Covent Garden (shared section from Strand to Covent Garden in purple)*



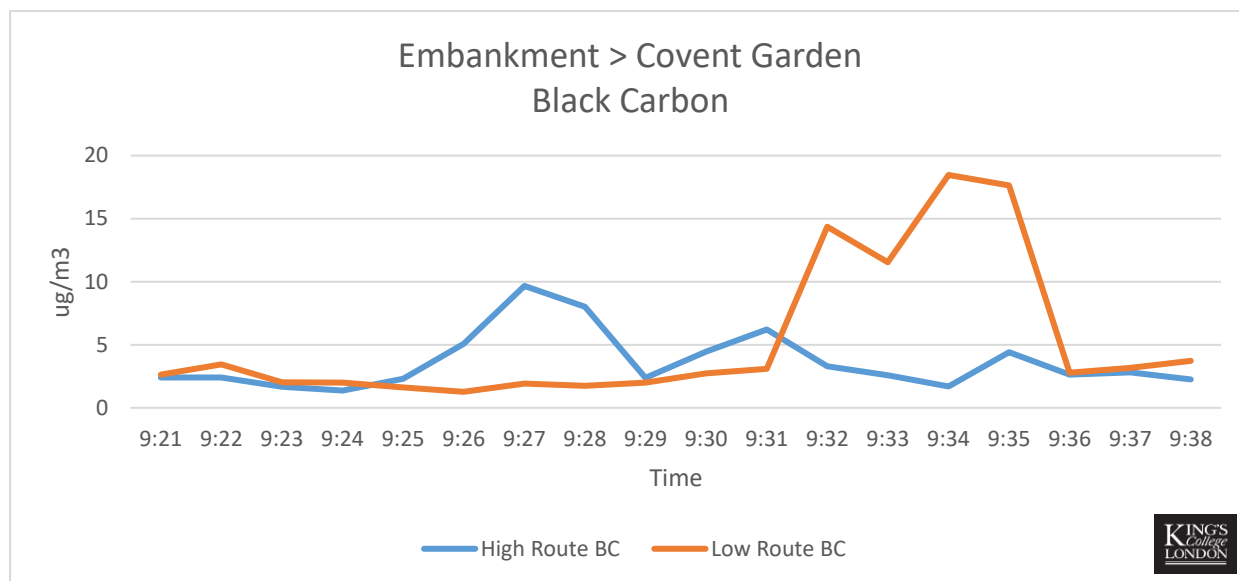
The standard route between these two points is along the Strand. The Strand is a major East/West thoroughfare in central London, it hosts several bus routes and often has standing traffic.

The Clean Air Route takes a route along John Adam Street and Adam Street before joining the Strand.

King's researchers and CABB partners set off from Embankment station at 09:21. One researcher walked along The Strand and Southampton Street to Covent Garden Piazza. The others walked along John Adam Street and Adam Street, along a small section of the Strand before walking up Southampton Street to Covent Garden.

Figure 17 shows the black carbon concentrations measured along each route.

Figure 17 Time series showing black carbon concentrations on the Embankment station > Covent Garden route pair



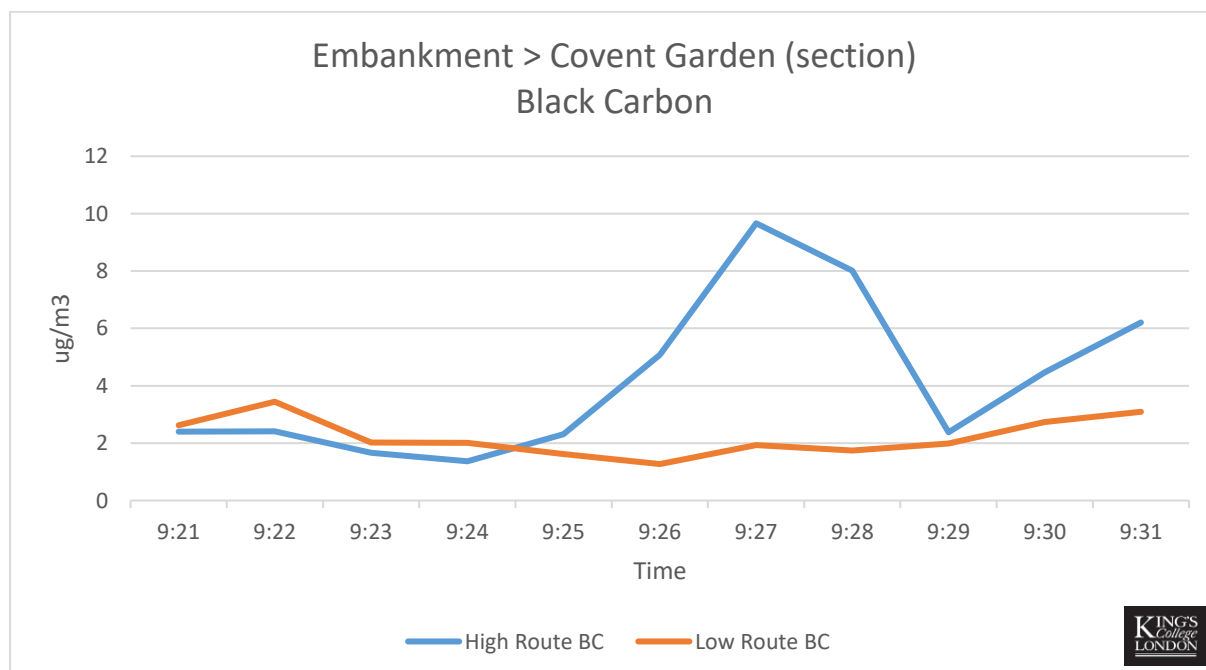
The Clean Air Route concentrations were generally lower than those on the Strand until the point around 9:32 when the researchers joined the Strand. At this point concentrations rose sharply.

The relatively high concentrations of the Clean Air Route section on the Strand meant that the cumulative total of the Clean Air Route ended up greater than the standard route.

In order to compare the parallel sections of the Strand and John Adam Street more fairly, the route pairs were compared stopping where the Clean Air Route reached the Strand at Adam Street.

The shared section of the route pair is indicated on the map (figure 13) by the purple line.

Figure 18 Time series showing black carbon concentrations along the divergent section of the Embankment station > Strand route pair



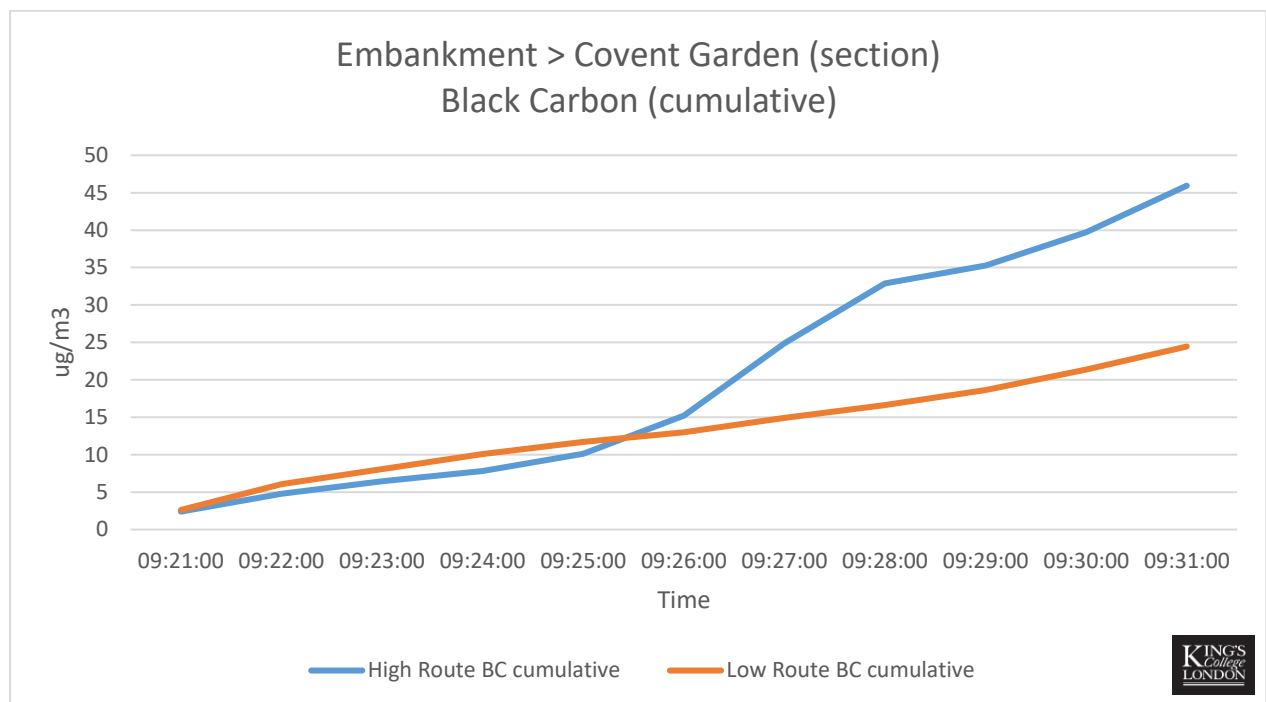


On the section where the Clean Air Route runs along John Adam Street and the standard route runs along the Strand:

- The greatest black carbon concentration measured on the Strand route was  $10 \mu\text{g}/\text{m}^3$  at 9:27.
- The greatest black carbon concentration measured on the Clean Air Route was  $3 \mu\text{g}/\text{m}^3$  at 9:22.

Figure 19 shows the cumulative black carbon concentrations measured along each route between Embankment Station and the Strand.

*Figure 19 Time series showing cumulative black carbon concentrations along the divergent section of the Embankment station > Covent Garden route pair*



- The cumulative black carbon concentration measured along the Strand route was  $46 \mu\text{g}/\text{m}^3$ .
- The cumulative black carbon concentration measured along the Clean Air Route was  $24 \mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentrations along the Embankment station to Strand Clean Air Route (section) was 47% lower than the standard Strand route.

## 5.7 Earls' Court Station to Holland Park

For these route pairs, the Royal Borough of Kensington & Chelsea wanted to assess the Clean Air Route against two alternative standard routes; one along Earl's Court Road and the other along Warwick Road. Both are major north/south roads and heavily congested throughout the day.

Researchers measured these by walking in parallel from Earl's Court Station to Holland Park via the Clean Air Route and Earl's Court Road. And then from Holland Park back to Earl's Court Station via the Clean Air Route and Warwick Avenue arriving at the rear of Earl's Court station.

These walks were performed three times through the day to determine if there was any difference noted between the Clean Air Routes and the standard routes depending on time of day.

Researchers noted more traffic variability on Earl's Court Road over the course of the route than on Warwick Avenue. This may explain the larger variation in differences found between the Earl's Court Road Route and the Clean Air Route.

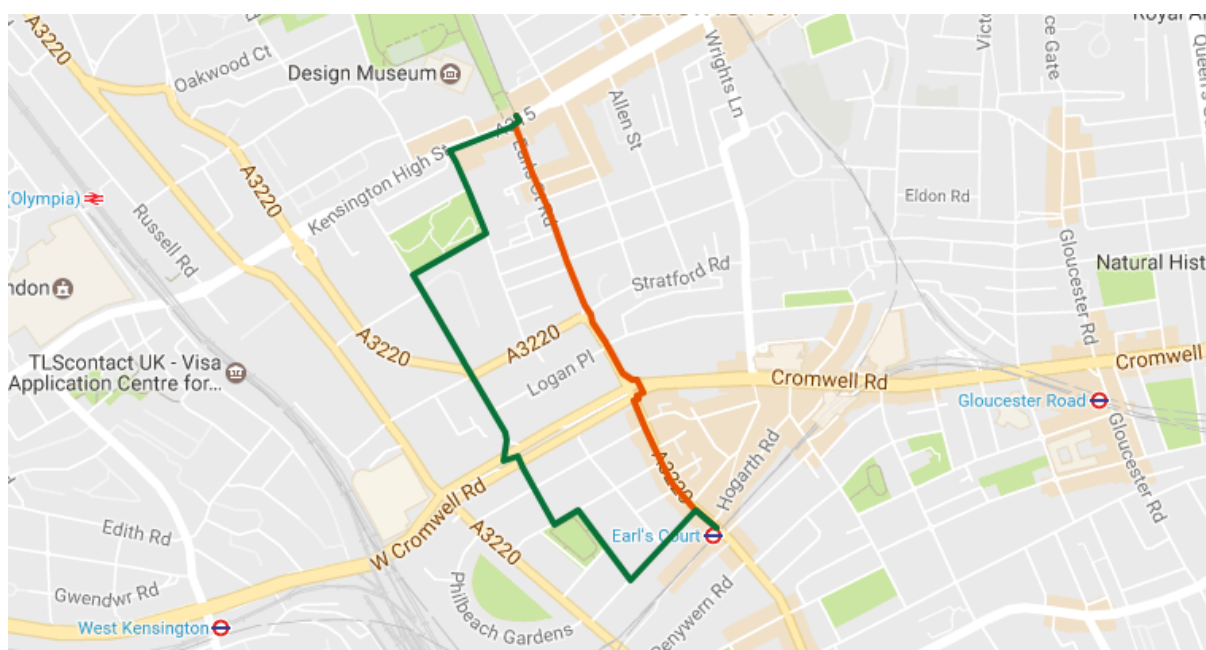
The morning, lunchtime and afternoon results are presented here. It should be noted that it was raining heavily during the afternoon walk which may have affected the results. For this reason, the lunchtime results were selected for the summary table in the introduction.

### 5.7.1 Earl's Court Road

For this assessment, researchers set off from the front entrance of Earl's Court Station and walked in parallel down Earl's Court Road and the Clean Air Route to the entrance to Holland Park. The Clean Air Route goes through the backstreets of Earl's Court along Trebovir Road, Nevern Square, Pembroke Gardens and Edwardes Square.

This was performed three times during the day in the morning, lunchtime and afternoon.

Figure 20 Route pair between Earl's Court Station and Holland Park



#### 5.7.1.1 Morning

CABB Partner: Royal Borough of Kensington & Chelsea

Monitoring date: 18/05/17

Start time: 09:10

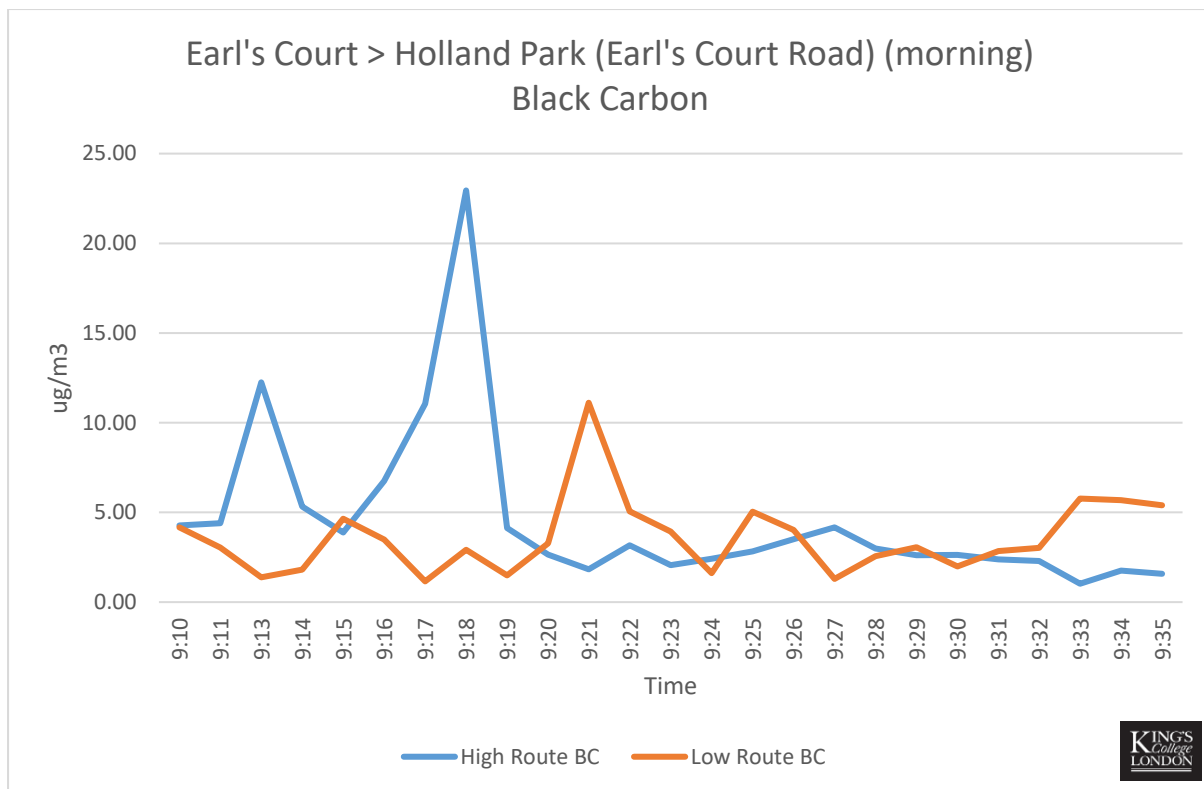
End time: 09:35

Weather: Cloudy, 21°C, 11mph south-westerly wind

Figure 20 shows the black carbon concentrations measured along each route.



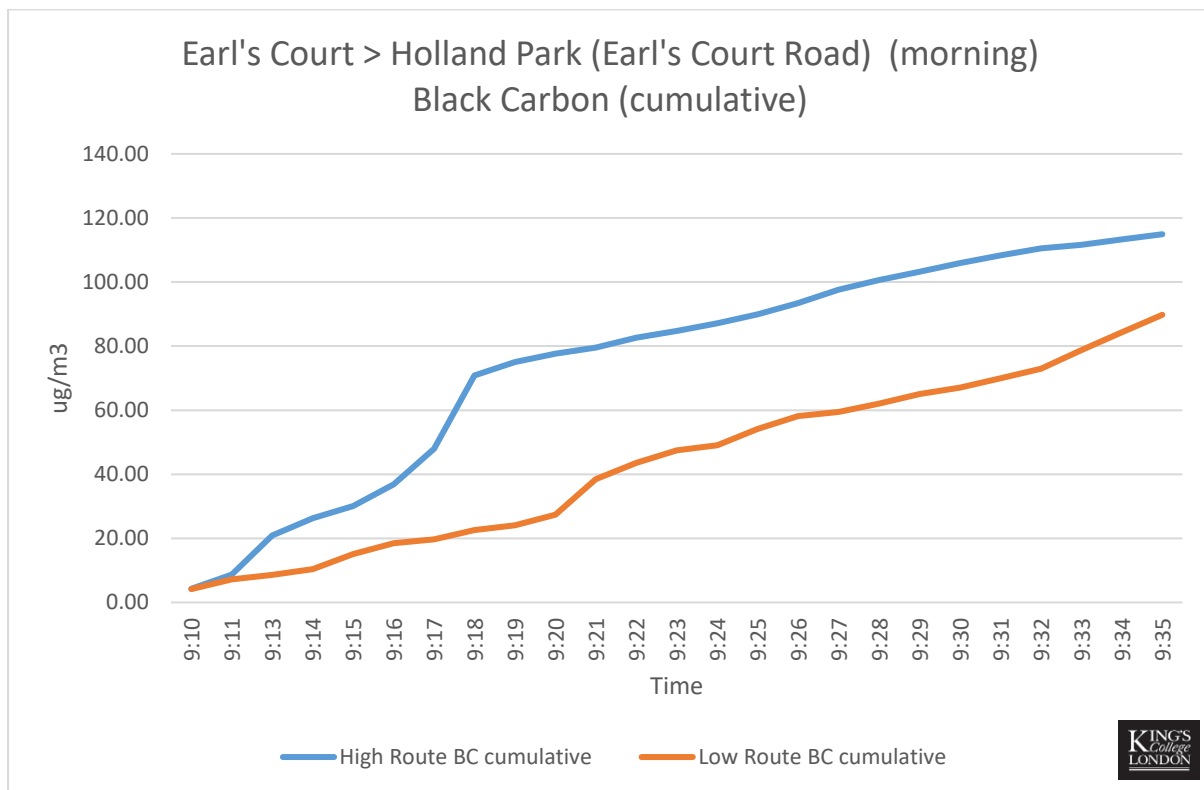
Figure 21 Time series showing black carbon concentrations along the Earl's Court Station Holland Park route pair.



- The greatest black carbon concentration measured on the Earl's Court Road route was 23  $\mu\text{g}/\text{m}^3$  at 09:18.
- The greatest black carbon concentration measured on the Clean Air Route was 11  $\mu\text{g}/\text{m}^3$  at 09:21.

Figure 22 shows the cumulative black carbon concentration measured along each route.

Figure 22 Time series showing cumulative black carbon concentrations along the Earl's Court Station Holland Park route pair.



- The cumulative total of black carbon measured along the Earl's Court Road route was 115  $\mu\text{g}/\text{m}^3$ .
- The cumulative total black carbon measured along the Clean Air Route was 90  $\mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentration along the Earl's Court Station to Holland Park Clean Air Route was 22% lower than the standard Earl's Court Road route.

#### 5.7.1.2 Lunchtime

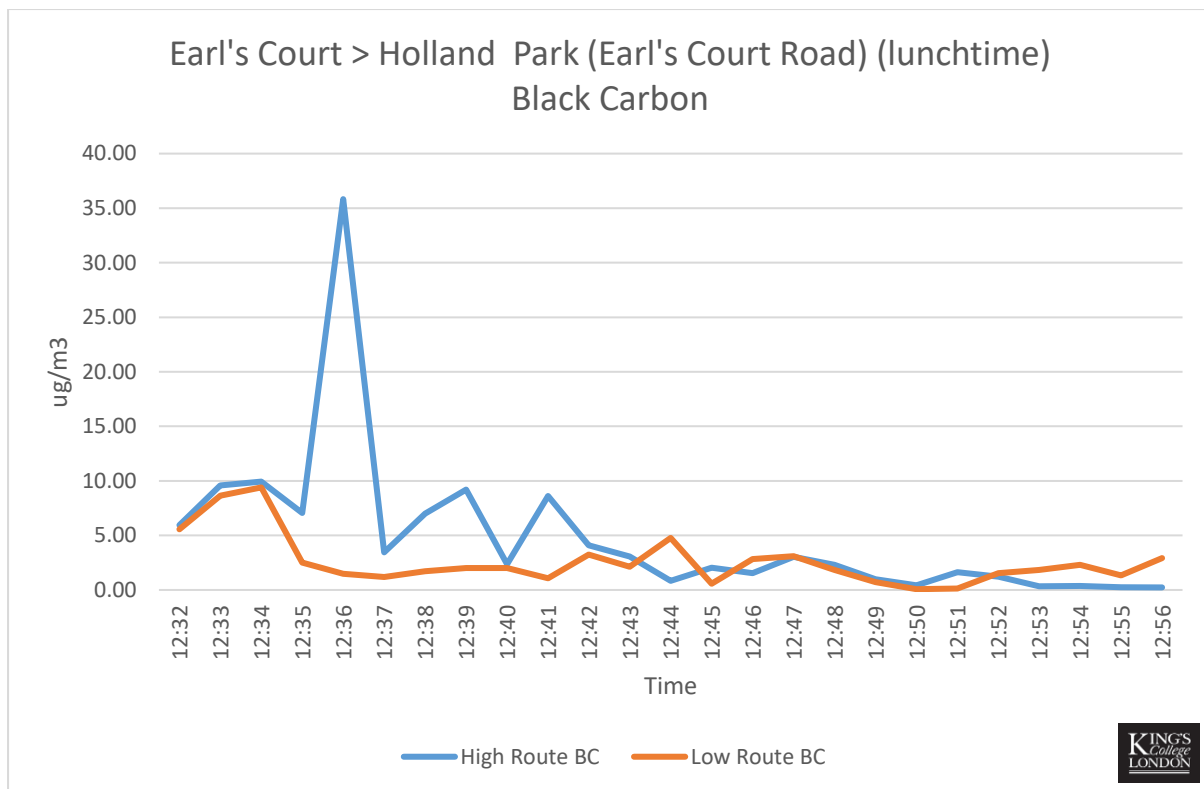
Start time: 12:32

End time: 12:56

Weather: Cloudy, 23°C, 16mph westerly wind

Figure 23 shows the black carbon concentrations measured along each route.

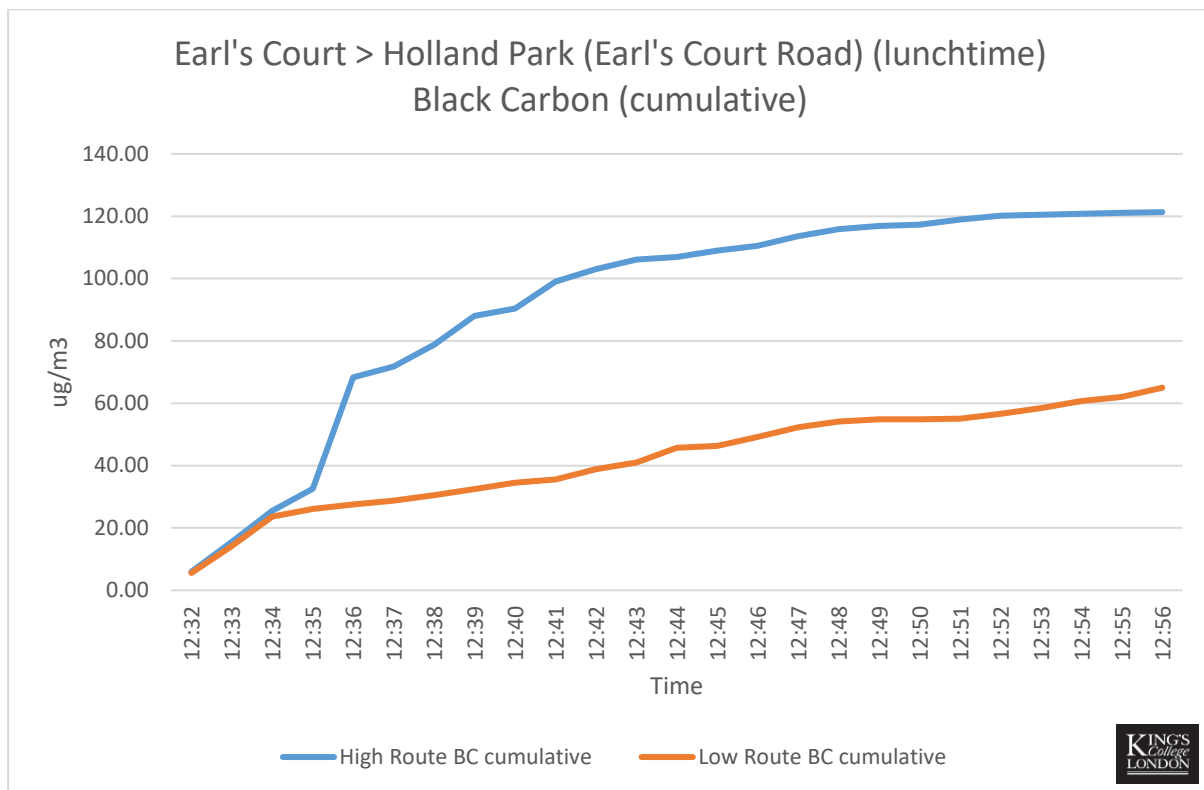
Figure 23 Time series showing black carbon concentration along the Earl's Court Station Holland Park route pair.



- The greatest black carbon concentration measured on the Earl's Court Road route was 36  $\mu\text{g}/\text{m}^3$  at 12:36.
- The greatest black carbon concentration measured on the Clean Air Route was 9  $\mu\text{g}/\text{m}^3$  at 12:34.

Figure 24 shows the cumulative black carbon concentration measured along each route.

Figure 24 Time series showing cumulative black carbon concentrations along the Earl's Court Station Holland Park route pair.



- The cumulative black carbon concentration measured along the Earl's Court Road route was 121  $\mu\text{g}/\text{m}^3$ .
- The cumulative black carbon concentration measured along the Clean Air Route was 65  $\mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentrations along the Clean Air Route to Holland Park was 46% lower than the Earl's Court Road route.

### 5.7.1.3 Afternoon

Start time: 16:19

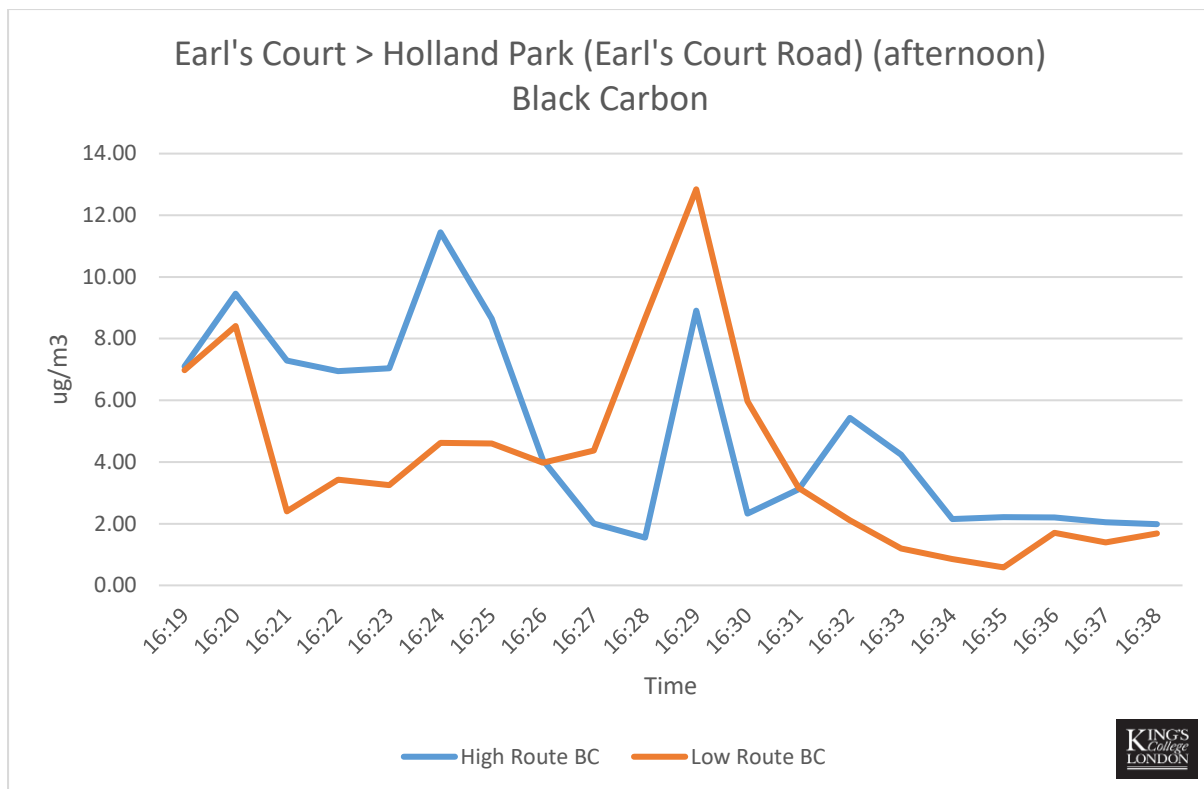
End time: 16:38

Weather: Raining, 19°C, 8mph south-westerly wind

It should be noted that it was raining heavily during this assessment.

Figure 25 shows the black carbon concentrations measured along each route.

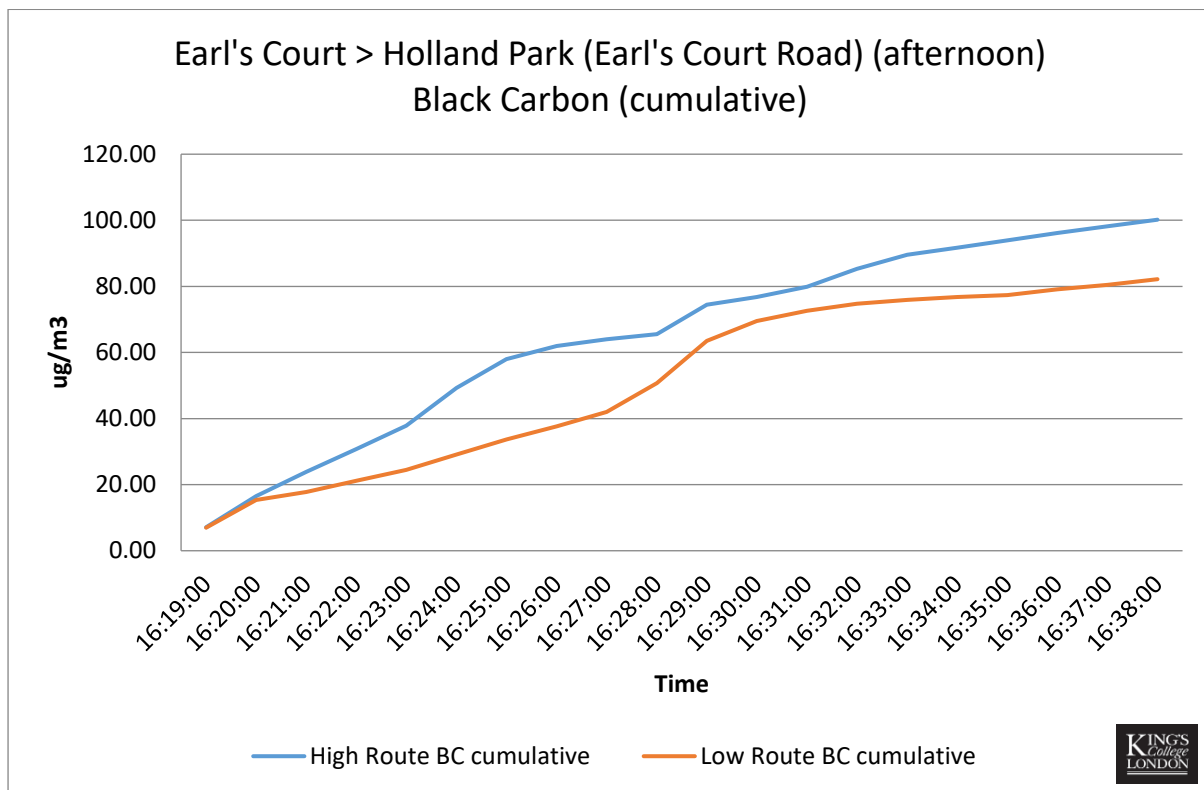
Figure 25 Time series showing black carbon concentrations along the Earl's Court Station Holland Park route pair.



- The greatest black carbon concentration on the Earl's Court Road route was 11.5  $\mu\text{g}/\text{m}^3$  at 16:24
- The greatest black carbon concentration on the Clean Air Route was 13  $\mu\text{g}/\text{m}^3$  at 16:29

Figure 26 shows the cumulative black carbon concentration measured along each route.

Figure 26 Time series showing cumulative black carbon concentrations along the Earl's Court Station Holland Park route pair.



- The cumulative black carbon concentration measured along the Earl's Court Road route was 100  $\mu\text{g}/\text{m}^3$ .
- The cumulative black carbon concentration measured along the Clean Air Route was 82  $\mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentrations along the Clean Air Route to Holland Park was 18% lower than the standard Earl's Court Road route.

It should be noted though that it was raining heavily during this assessment

### 5.7.2 Warwick Avenue

For the Warwick Avenue assessment, King's researchers set off from the entrance to Holland Park and walked in parallel along the Clean Air Route and down Warwick Avenue. The researcher who walked down Warwick avenue noted it was consistently busier than the Earl's Court Road route. This is reflected in less variability between the measured than the Earl's Court Road measurements.

Figure 27 Route pair between Holland Park and Earl's Court Station



#### 5.7.2.1 Morning

Monitoring date: 18/05/17

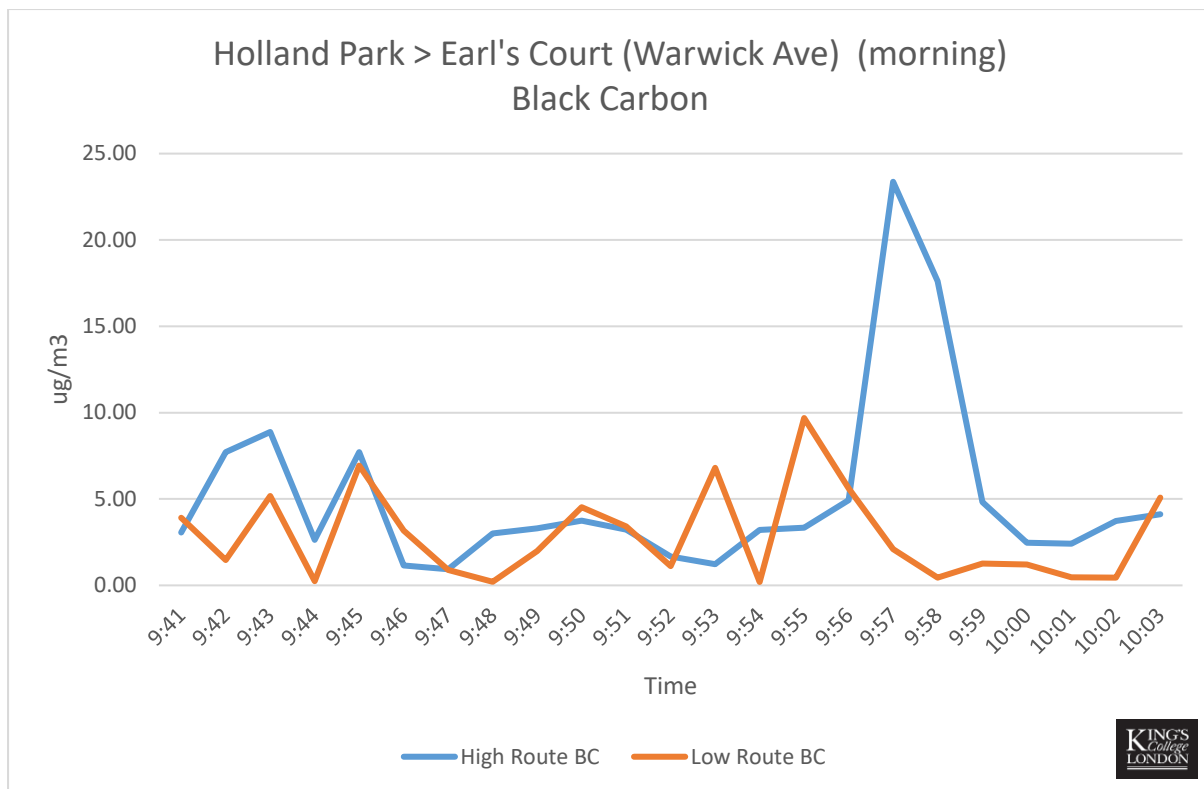
Start time: 09:10

End time: 09:35

Weather: Cloudy, 21°C, 11mph south-westerly wind

Figure 28 shows the black carbon concentrations measured along each route.

Figure 28 Time series of black carbon concentrations along the Holland Park to Earl's Court Station route pair

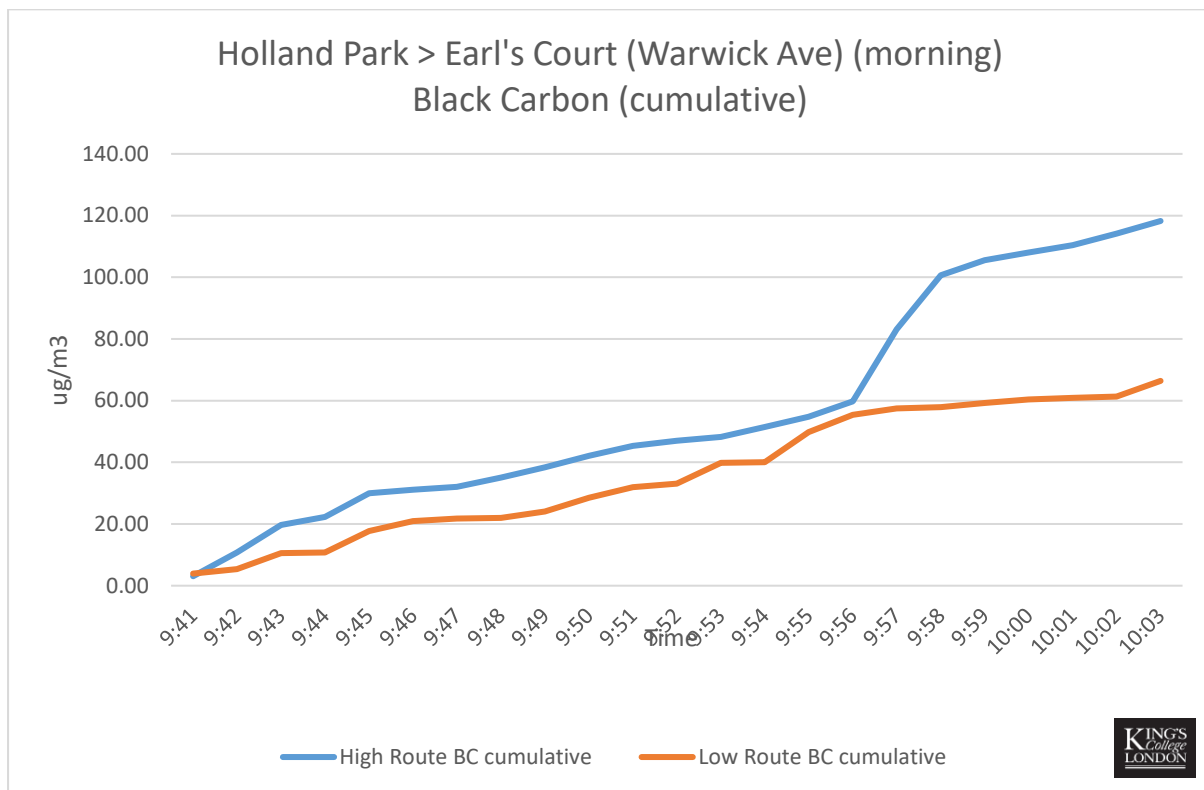


- The greatest black carbon concentration on the Warwick Avenue route was 23  $\mu\text{g}/\text{m}^3$  at 09:57.
- The greatest black carbon concentration on the Clean Air Route was 10  $\mu\text{g}/\text{m}^3$  at 09:55.

Figure 29 shows the cumulative black carbon concentration measured along each route.



Figure 29 Time series showing cumulative black carbon concentrations along the Holland Park to Earl's Court Station route pair.



- The cumulative black carbon concentration measured along the Warwick Avenue route was 118  $\mu\text{g}/\text{m}^3$ .
- The cumulative black carbon concentration measured along the Clean Air Route was 66  $\mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentrations along the Clean Air Route to Earl's Court Station was 44% lower than the standard Warwick Avenue route.

#### 5.7.2.2 Lunchtime

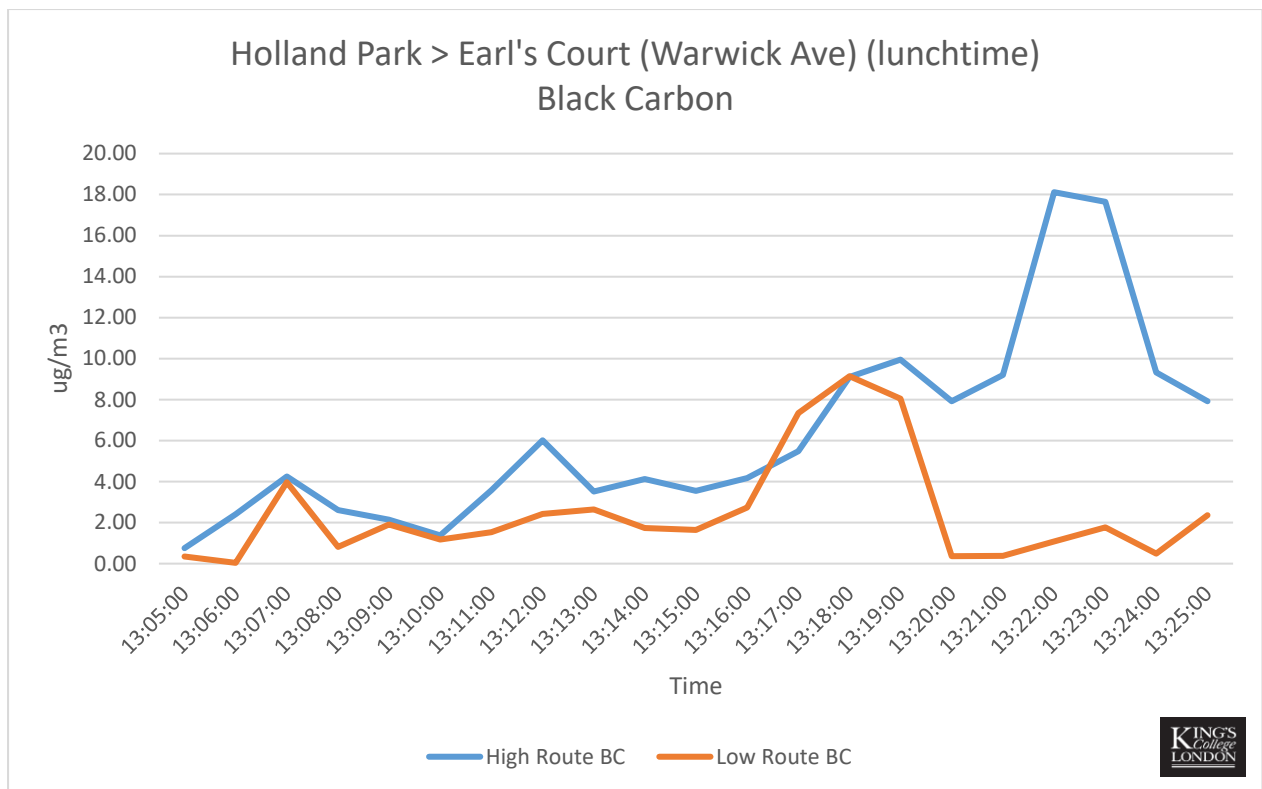
Start time: 13:05

End time: 13:25

Weather: Cloudy, 23°C, 16mph westerly wind

Figure 30 shows the black carbon concentrations measured along each route.

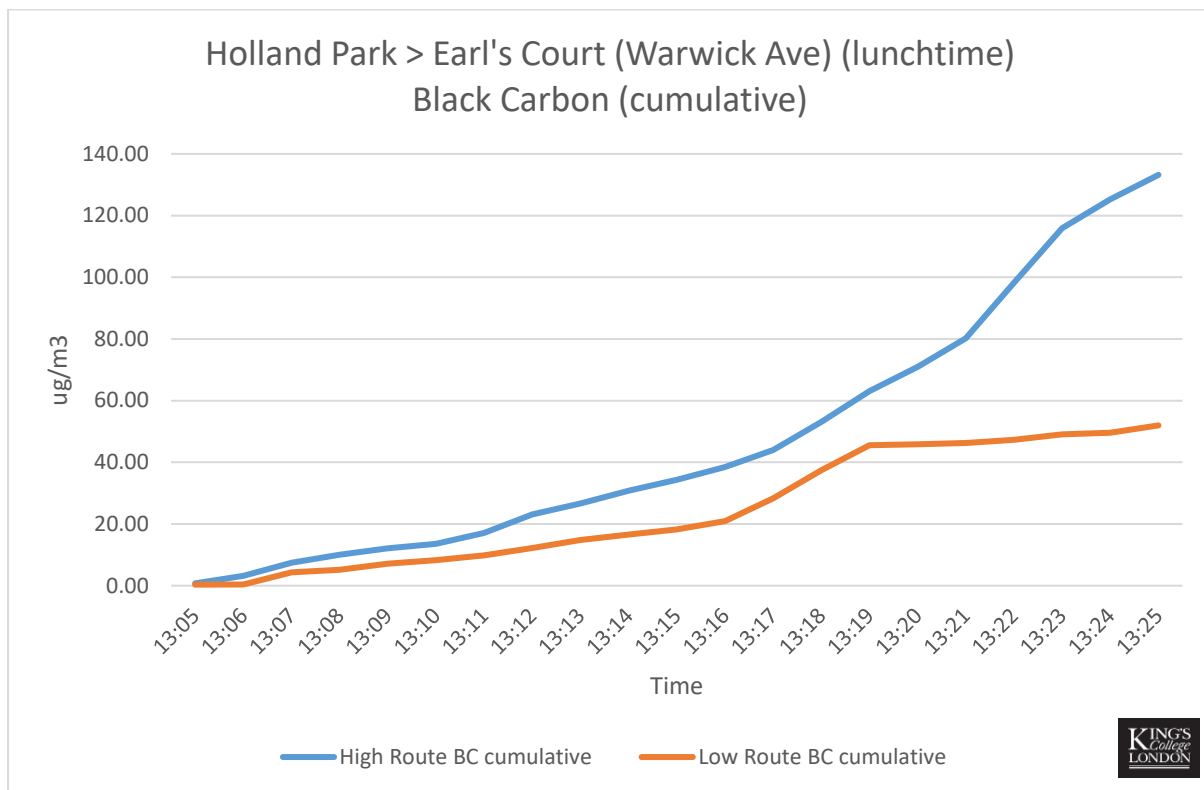
Figure 30 Time series showing black carbon concentrations along the Holland Park to Earl's Court Station route pair.



- The greatest black carbon concentration measured along the Warwick Avenue route was 18  $\mu\text{g}/\text{m}^3$  at 13:22.
- The greatest black carbon concentration measured along on the Clean Air Route was 9  $\mu\text{g}/\text{m}^3$  at 13:18.

Figure 31 shows the cumulative black carbon concentration measured along each route.

Figure 31 Time series showing cumulative black carbon concentrations along the Holland Park to Earl's Court Station route pair.



- The cumulative total of black carbon measured along the Warwick Avenue route was 133  $\mu\text{g}/\text{m}^3$ .
- The cumulative total black carbon measured along the Clean Air Route was 52  $\mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentrations along the Clean Air Route to Holland Park was 61% lower than the Warwick Avenue route.

### 5.7.2.3 Afternoon

Start time: 16:19

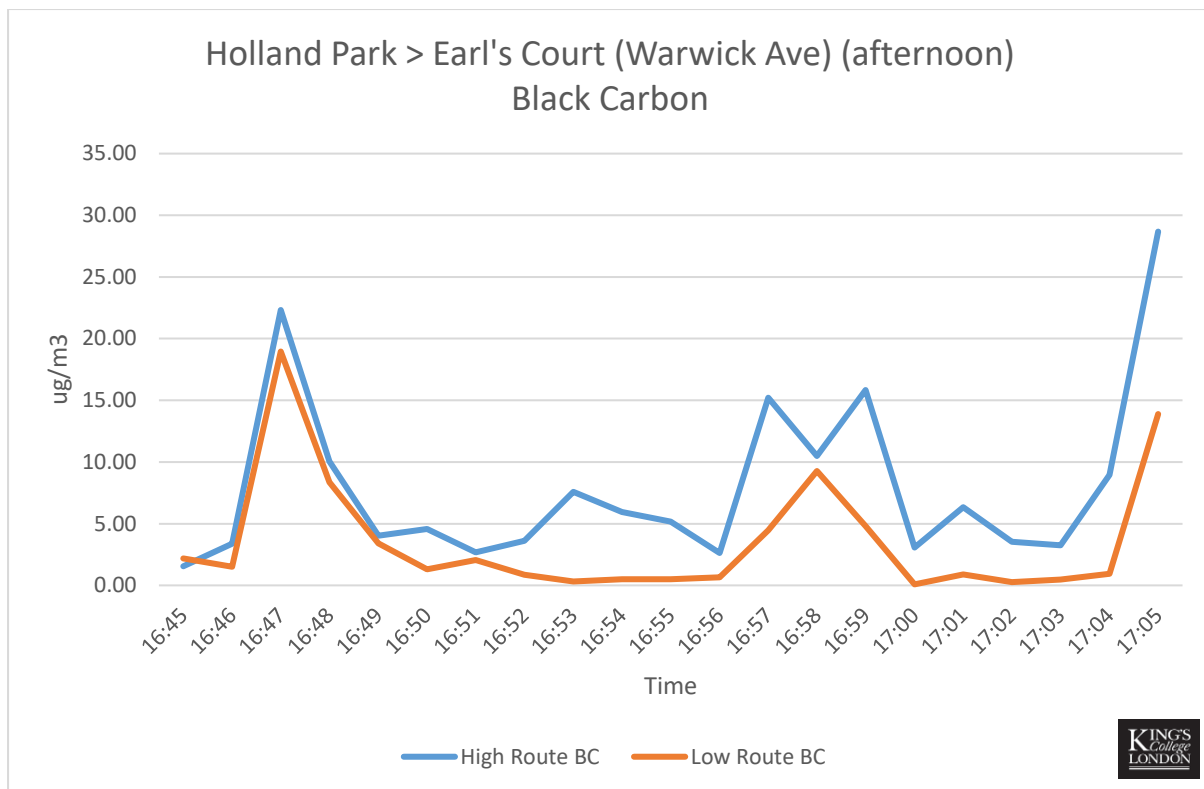
End time: 16:38

Weather: Raining, 19°C, 8mph south-westerly wind

It should be noted that it was raining heavily during this assessment.

Figure 32 shows the black carbon concentrations measured along each route.

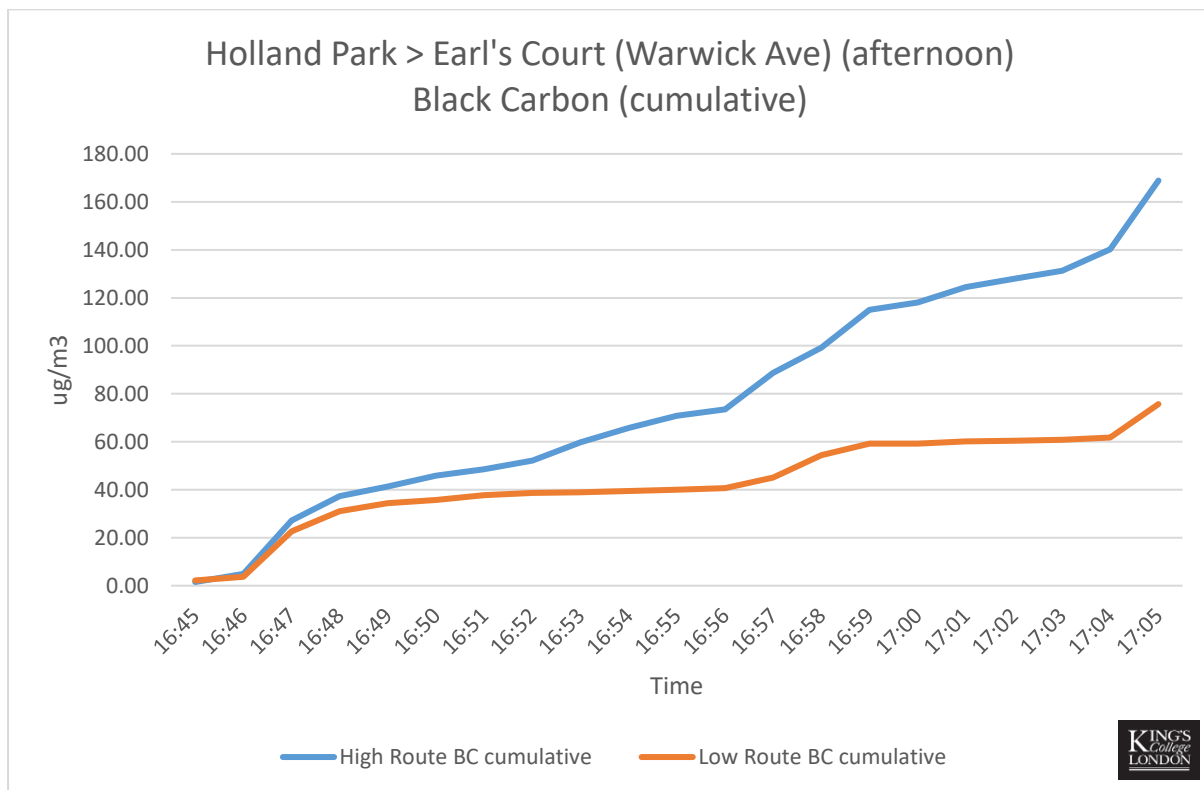
Figure 32 Time series showing black carbon concentrations along Holland Park to Earl's Court Station route pair.



- The greatest black carbon concentration measured on the Warwick Avenue route was 27  $\mu\text{g}/\text{m}^3$  at 17:05.
- The greatest black carbon concentration measured on the Clean Air Route was 19  $\mu\text{g}/\text{m}^3$  at 16:47.

Figure 33 shows the cumulative black carbon measured along each route.

Figure 33 Time series showing cumulative black carbon concentrations along Holland Park to the Earl's Court Station route pair



- The cumulative black carbon concentration measured along the Warwick Avenue route was 169  $\mu\text{g}/\text{m}^3$ .
- The cumulative black carbon concentration measured along the Clean Air Route was 76  $\mu\text{g}/\text{m}^3$ .

The cumulative black carbon concentrations along the Clean Air Route to Earl's Court Station was 55% lower than the Warwick Avenue route.

## 6 Conclusions

The concentration of black carbon as an indicator of traffic related air pollution was assessed along eight Clean Air Routes and compared to standard routes between popular locations in central London.

The results showed that black carbon concentrations measured along the Clean Air Routes were between 30% and 60% lower than the standard routes indicating an important exposure reduction potential for the public choosing these routes.

Whilst it is difficult to say what effect a reduction in exposure to black carbon and PM<sub>2.5</sub> (of which it is a component) can have on an individual, at a population level, evidence shows that health outcomes improve as concentrations decrease. A World Health Organisation review of studies from around suggests at 6% decrease in mortality in the population for every 10 µg/m<sup>3</sup> decrease in the ambient concentration of PM<sub>2.5</sub> (WHO, 2013).

The Mayor of London's 'Healthy Streets' initiative aims to encourage more Londoners to walk and cycle in the capital both to improve health and air quality. Clean Air Routes complement this initiative by providing cleaner, quieter walking routes between popular destinations and encouraging regeneration of local areas.

Clean Air Routes are simple yet effective ways to achieve exposure reduction for the public and the results of this study provide evidence to support their continued development.

A study of this type could be improved and expanded by measuring footfall and calculating exposure along each of the routes. Such an approach would allow a pre and post analysis to be undertaken to assess the impact of any intervention undertaken on the route. It would also provide more robust metrics on modelled exposure reduction of these types of routes.

## 7 Thanks & Acknowledgements

We would like to thank Cross River Partnership for commissioning King's to undertake this research and the Mayor's Air Quality Fund.

Thanks also to the CABB partners who researched and created their Clean Air Routes and those who joined us on the monitoring walks.

Andrew Grieve & Dr Gary Fuller.

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