Personal Exposure to $PM_{2.5}$ and Sustainable Travel

Pilot Study Report

Project Aim:
To use measurements of the personal exposure to $PM_{2.5}$ to develop exposure reduction advice, raise public awareness and support behavioural change.

Project Objectives:
1. To equip volunteers with personal $PM_{2.5}$ monitors and GPS loggers for 24 hours while they conduct their normal activities.
2. To map the exposure of the volunteers by location, and to plot exposure against time and activity.
3. To provide personal travel planning advice to the volunteers and to use their monitoring data to suggest changes they could make which would reduce their exposure.
4. To repeat exposure measurements and review the effectiveness of the advice given and any changes made.
5. To produce outputs for public information based on the findings and use social marketing techniques to encourage behavioural change.

Introduction
The evidence for the health impacts of air pollution are growing, and are not linked solely to concentrations above the air quality objective levels. A reduction in exposure, particularly to fine particles will deliver health benefits, whatever the initial concentration. Previous studies in London and other cities have shown that daily patterns of exposure are very personal to individuals, and that reductions can be achieved by changing travel habits. For example changing the route used to walk or cycle, or changing from car to bike. In Devon, where concentrations are generally lower and hotspots of pollution are of smaller geographic extent, these changes may not be so great, but even small reductions are of benefit.

Personal exposure provides a new way of communicating air pollution issues, and encouraging behavioural change. For example it may reach those groups who do not engage with messages about climate change. The study will provide visual outputs for public information, as well as improved travel planning advice which will be used in social marketing messages.

Pilot Study
The proposed project methodology was piloted with three volunteers in June and July 2015 to test the methodology, gain an understanding of likely results and make recommendations for the development of the project.

For the pilot study, a personal $PM_{2.5}$ monitor was borrowed at no cost and a GPS watch was purchased for £200. No other costs have been incurred for the pilot study apart from officer time as follows:
1. Environmental Health officer time to identify and communicate with volunteers, arrange hand over of the equipment, training, download and analyse data, arrange travel planning advice etc. This takes less than a day of officer time per volunteer. The time is spread over several days or a couple of weeks.
2. Travel planning advice is provided by Devon County Council officers.

The pilot study volunteers were chosen because they travel from a variety of home locations, and to test different potential options for alternative sustainable travel choices. Their travel modes and home locations are shown in Table 1 below.

Table 1 Pilot Study Volunteers

Volunteer Number	Home Location	Work Location	Initial travel mode	Sustainable travel mode
1	Cranbrook	City centre	Car	Bus
2	A30 (south of the city)	Topsham Road	Car	Car (alternative route)
3	Lympstone	City centre	Car	Bike

The volunteers reported that the study methodology worked well, and did not recommend any changes. They were all interested in the travel planning advice they were given, and found this valuable.

The study results for each volunteer are described in Tables 2, 3 and 4. These show that for car journeys, the route is important in determining the exposure to ultra fine particles. For example, volunteer 1 travels between Cranbrook and Exeter normally by car, but on different roads in the morning and afternoon. Their exposure was higher when travelling via East Wonford Hill and Heavitree Road than via Pinhoe Road (Figure 1). This result may also have been affected by the time of day when the journeys were made, but this pattern is not unexpected since ambient nitrogen dioxide monitoring also shows higher concentrations on the Heavitree corridor.

For volunteer 2, measured concentrations also varied with route. For this person it was not possible to suggest a realistic alternative travel mode other than to change the route used for her car commute. This was because of the configuration of home and work locations, plus the fact that the volunteer was not confident to cycle without repairs to her bicycle. Her alternative route followed back roads rather than main roads, which allowed her to maintain a more constant speed and more efficient driving style. This reduced exposure, compared to driving along main roads, as shown in Table 3 and Figure 2.

Volunteer 3 was able to choose a sustainable travel mode (bike from Lympstone) for their second day of testing and this did result in lower exposure than the car commute (Table 4, Figures 3 and 4). However for volunteer 1, who changed to bus, the average exposure on the second day was higher than in a private car. Here again, the route used may be significant as the bus from Cranbrook travels along the Heavitree corridor and the maximum exposure for this journey was similar to maximum exposure along the same route at a similar time of day in a car (Table 2).

Tables 2, 3 and 4 show average concentrations to which the volunteers were exposed whilst they were at work (lunchtime activities and work visits etc have been excluded from this). These concentrations were generally similar to or lower than averages during commuting journeys, but not always. Volunteer 2 measured lower concentrations during her commute along back roads than during her working day. Figures 3 and 5 shows peaks in exposure during the working day that occur during lunchtimes and work visits, or whilst the volunteers were in the office. These can be of greater magnitude than peaks in exposure during the commute. The exact source of these is not clear.

Because only one particulate monitor was used, and the volunteers had it on two separate days, the results summarised above might be affected by variations in background $PM_{2.5}$ concentrations between each day. It is difficult to control for this without having a second monitor measuring background concentrations in the city on each test day. Background $PM_{2.5}$ measurements are made in Plymouth, but an analysis of this data shows that concentrations at this monitoring stations are higher than those measured by the pilot study participants most of the time. It has not therefore been possible to adjust for background concentrations during the pilot study.

Table 2 Particulate ($PM_{2.5}$) Exposure for Volunteer 1 (ug/m3)

	car journey (Pinhoe Road) am	car journey (East Wonford Hill) pm	bus journey (East Wonford Hill) am	bus journey (East Wonford Hill) pm
maximum	8.1	11.3	18.7	11.3
average	5.2	4.9	12.1	7.7
average in office	3.3		4.3	

Table 3 Particulate ($PM_{2.5}$) Exposure for Volunteer 2 (ug/m3)

	car journeys on main roads	car journeys on back roads
maximum	13.4	7.3
average	5.4	2.9
average in office	5.4	4.4

Table 4 Particulate ($PM_{2.5}$) Exposure for Volunteer 3 (ug/m3)

	car journeys	bike journeys
maximum	15.4	9.5
average	5	3.5
average in office	3.9	3.9

Figure 1 Particulate Concentrations measured by Volunteer 1 during Car Journeys on Different Routes

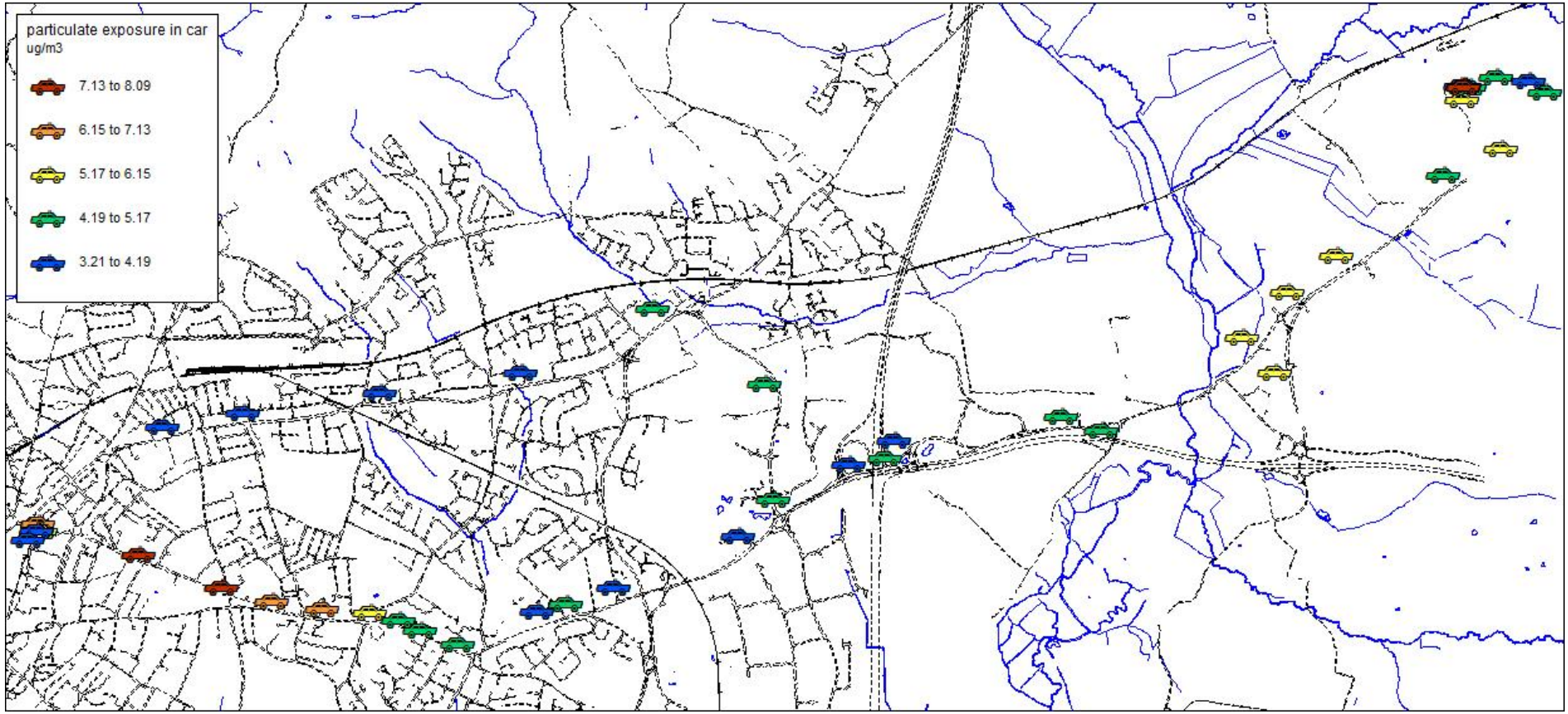


Figure 2 Particulate Concentrations measured by Volunteer 2 during Car Journeys along Different Routes

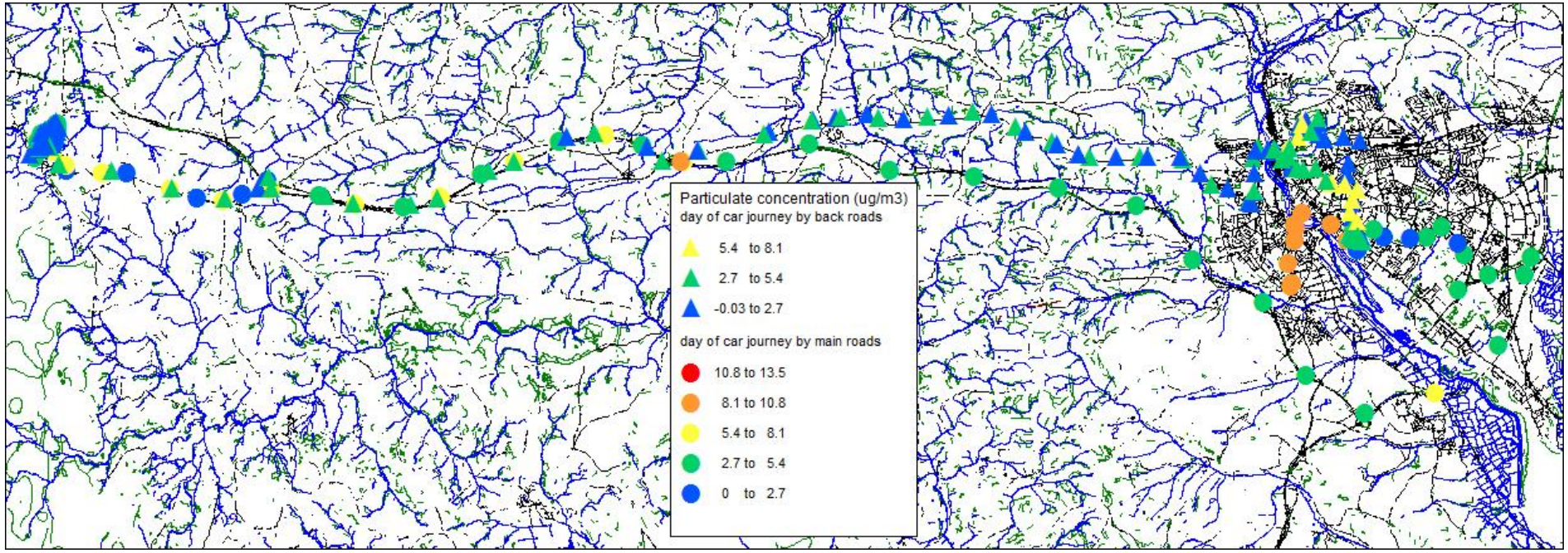


Figure 3 Particulate Concentrations measured by Volunteer 3 on both Test Days

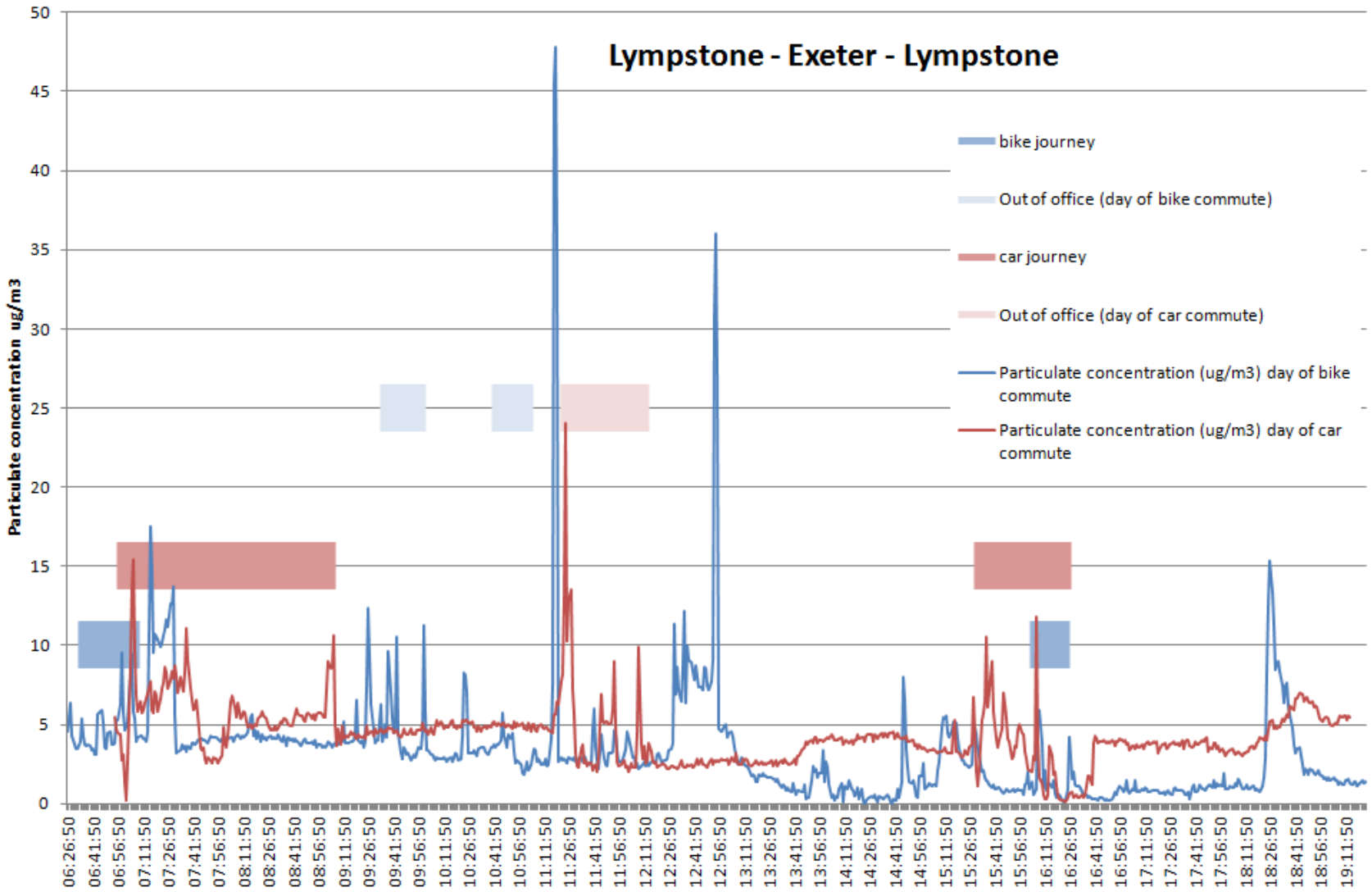


Figure 4 Particulate Concentrations measured by Volunteer 3 and comparing Car and Bike Journeys

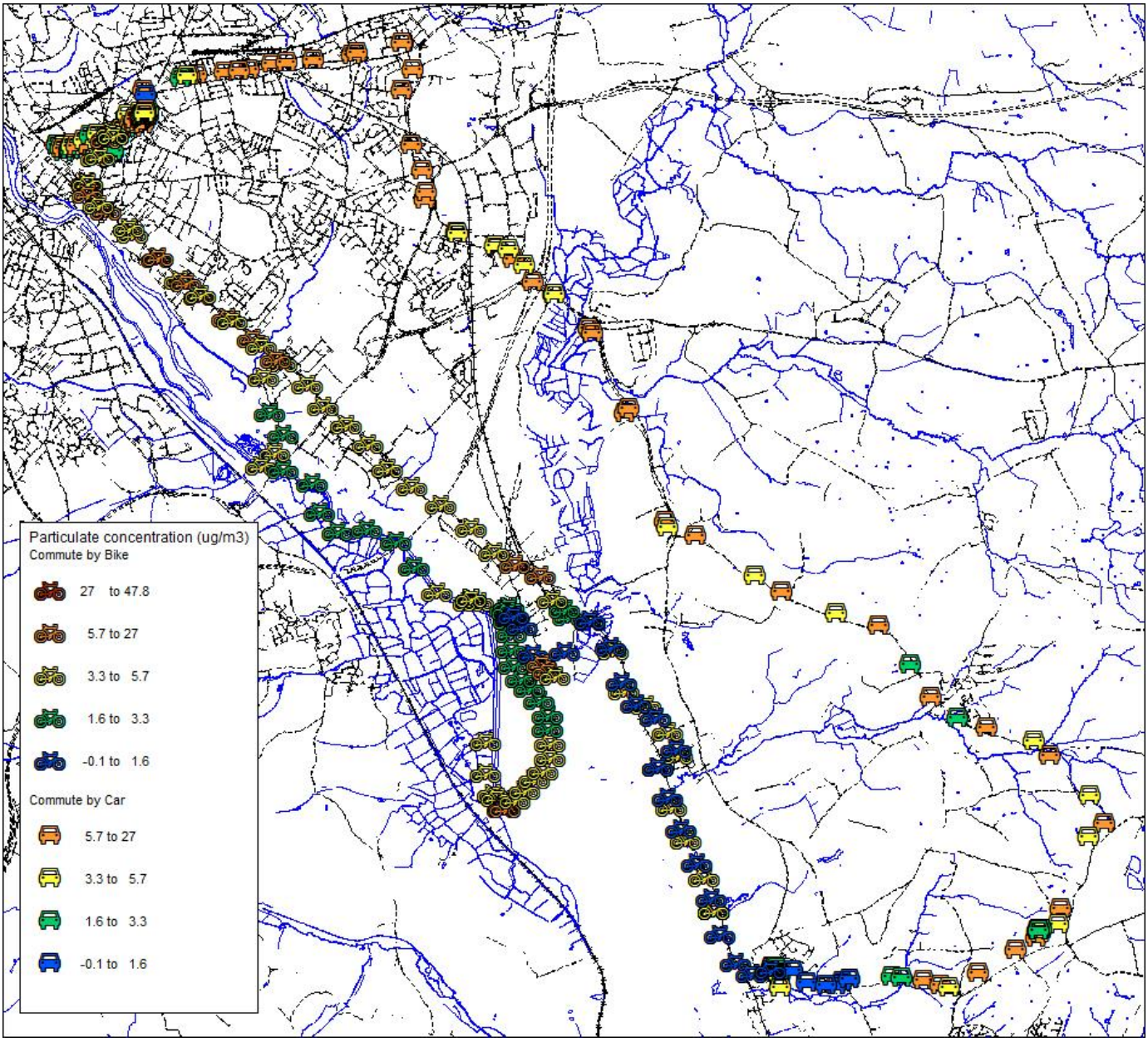
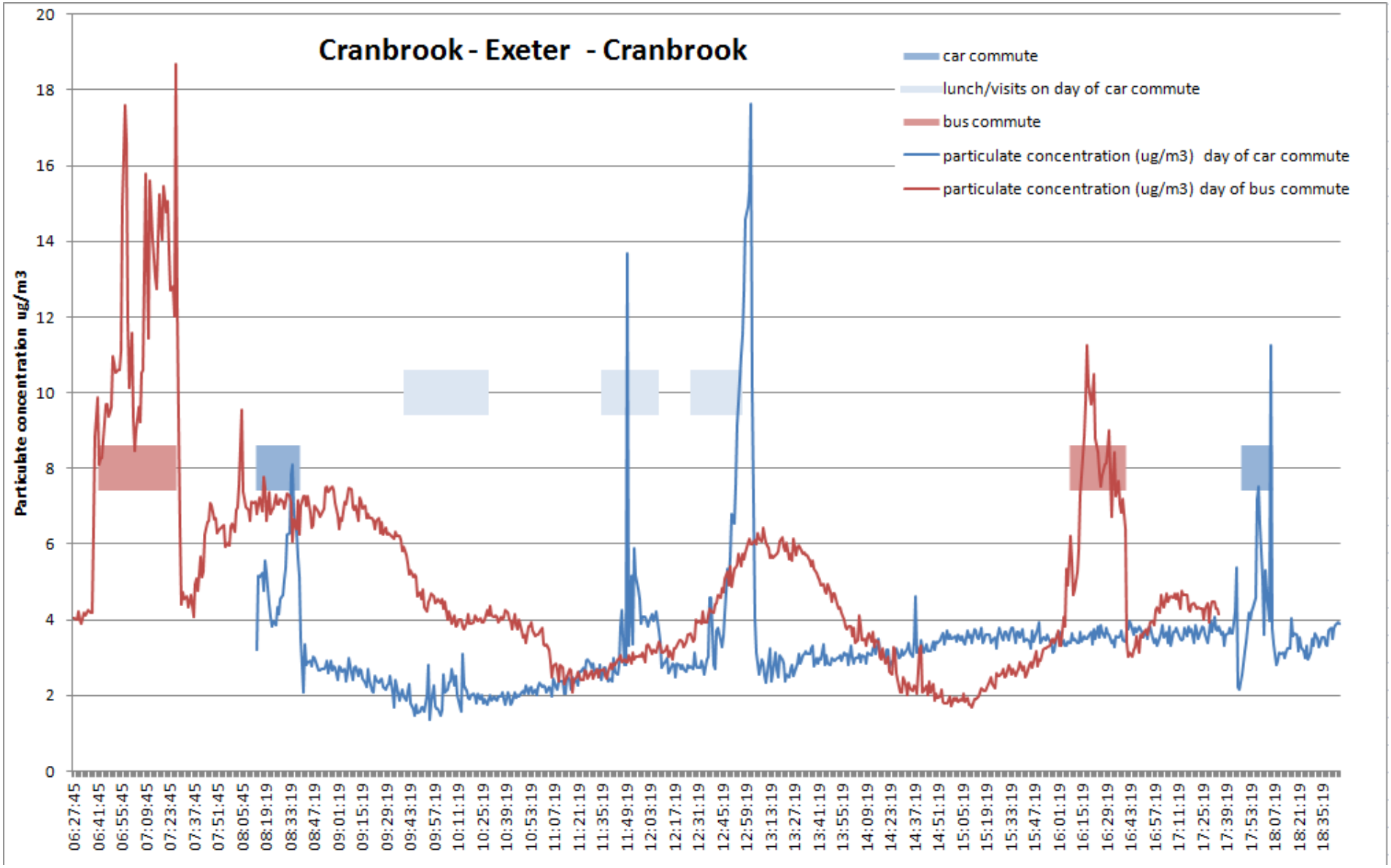


Figure 5 Particulate Concentrations measured by Volunteer 1 on both Test Days



Conclusions from Pilot Study and Recommendations

The pilot study shows that differences in particulate concentration between travel modes can be shown for some individuals, but are not always clear-cut. The sustainable travel message that can be derived from the data is more subtle and nuanced than it appears from data obtained in similar studies in London. However in public health terms, all three volunteers could achieve a reduction in their daily exposure by behavioural change.

The pilot study has demonstrated the amount of officer time required to conduct the study. Including writing up the study, presenting the data etc this is a maximum of one full day per volunteer (assuming that Devon County could continue to provide a Travel Planner free of charge). This can be accommodated, but it does mean that the study will take some time to undertake, fitted in around other duties.

For the final project, a social marketing budget would need to be allocated, so that the outputs from the project could be used to maximum benefit. Public Health Devon have agreed to assist with this aspect and the techniques to be used will need to be developed further. This is the next priority for this project as it is important to understand what outputs will be most useful before further time is spent on testing.

A separate project is also being conducted using Public Health Devon grant (see below). There will be common areas between the projects where information and expertise can be shared.

Public Health Devon, District Grant - Air Quality Project

Part of Public Health Devon's grant to the District Councils will focus this financial year on air pollution. The money will support two projects, one of which is a personal exposure monitoring study with groups of three school children from Braunton, Newton Abbott and Exeter. The study will follow essentially the same methodology as described above but will focus on travel to schools in areas that have been identified as having higher air pollution levels.