Air Quality Benefits of Active Travel

Executive Summary

Sustrans is increasingly aware of the need to articulate the contribution, or the potential contribution, of their delivery activity in terms of reducing air pollution or improving air quality. Sustrans therefore commissioned Eunomia to construct a model that will enable the quantification of the potential contribution of walking and cycling in the context of air quality. The work to date focuses on infrastructure schemes, i.e. cycling and walking routes. The funding for this study came from Transport Scotland. Eunomia and Sustrans therefore would like to gratefully acknowledge the contribution of Transport Scotland.

E.1.1 Scheme-Based Model

E.1.1.1 Methodology

Eunomia has developed two models that considers the potential air pollution impacts of some of Sustrans activities. The first approach is the scheme-based model, which takes data on specific Sustrans schemes such as Connect2 and Community Links for specific areas, with the aim of estimating air pollution impacts for these schemes. The model developed here therefore uses a bottom-up approach to estimating the air pollution impacts of the changing travel behaviour, with the air pollution impacts modelled based on numbers of individuals changing their travel behaviour.

The model estimates two kinds of air pollution benefits from shifting to active travel. These are:

1) **Reducing Car Journeys:** This relates to the air quality benefits to the local population due to reduced emissions from car journeys replaced by active travel
2) **Route Users Personal Exposure:** This relates to the air quality benefit (or dis-benefit) to an individual due to change in pollution exposure from shifting to active travel. This key component of the model has not been considered the modelling published by government in this field to date, although it is considered in the academic literature on the subject

E.1.1.2 Results

Impacts from the schemes varied from £1,740 in Leeds (representing a dis-benefit) to £104,820 in Glasgow. The performance of the scheme is influenced significantly by the number of scheme participants. Other influential factors include

- The proportion of scheme that is traffic-free;
- The proportion of essential journeys undertaken by bus in the counterfactual scenario (bus journeys taking longer than car journeys, thereby exposing people to more pollution);
- The location of the scheme – in particular, the population density of the surrounding area.

Contents

1.0 Introduction

1.1 Background to the study

Sustrans aims to make smarter travel choices possible, desirable and inevitable. Sustrans is a leading UK charity enabling people to travel by foot, bike or public transport for more of the journeys they make every day. Sustrans works with families, communities, policy makers and partner organisations so that people are able to choose healthier, cleaner and cheaper journeys, with better places and spaces to move through and live in.

Sustrans' delivery work focuses on increasing active travel. In that sense it is reasonable to infer that most of Sustrans' delivery aims to impact on air quality. However, the extent of the contribution that Sustrans' delivery activity makes in terms of reducing air pollution or improving air quality is uncertain. Sustrans therefore commissioned Eunomia to construct a model that will enable the quantification of the potential contribution of walking and cycling in the context of air quality. A key component of this work is the consideration of the changes in scheme users' exposure to pollution occurring as a result of the switch to active travel, which is currently not considered in much of the modelling work published by government in this field to date.

For Sustrans, reporting on the impact of their work in terms of air quality is an aspiration in the context of advocacy and making the case for continued and expanded delivery in the sort of programmes that they deliver. However, it is also an exercise in understanding how to refine delivery to build greater effect, and in being able to acknowledge where there are gaps in evidence of scheme effectiveness in respect of air quality in some areas.

The work has a much wider application too. Sustrans is one among many organisations delivering interventions that support walking and cycling. We hope that this model will have application across the sector. This report is published against the backdrop of the UK Government's attempts to establish a national air quality strategy, and the development of, for example, Clean Air Zones and the CleanAir Fund in England.

The funding for this study came from Transport Scotland. Eunomia and Sustrans would like to gratefully acknowledge the contribution of Transport Scotland.

Key outputs from this study are the following:

- Analysis of the air pollution impacts of 19 Sustrans schemes operating across England and Scotland;
- An estimate of the potential air pollution benefits associated with undertaking a wide scale intervention across a city;
- An estimate of the potential air pollution benefits associated with England's Cycling and Walking Investment Strategy (CWIS) and the Cycling Action Plan for Scotland (CAPS).

1.2 Modelling the Air Pollution Impacts of Sustrans Activities

Eunomia has developed two models that considers the potential air pollution impacts of some of Sustrans activities. These have taken two different approaches to estimate the air quality benefits of its work.

The first approach is the

estimating the health benefits in both models, but Eunomia's model uses more recent data (the core datasets updated in 2015 and 2017, in comparison to the use of data from 2001 and 2011 in Webtag).

The estimation of health benefits in HEAT does not directly consider air pollution benefits. However, estimates of the overall benefits to health derived from the physical activity of cycling and walking will be influenced by the amount of pollution that active travellers were exposed to. This, in turn, is captured in the epidemiological evidence used to develop the health benefits estimates in HEAT. As such, there is an overlap between the two tools in this respect. This is discussed further in section 5.2.

2.0 Methodology for Scheme -based Model

2.1 Introduction

Eunomia has developed a model that considers the potential air pollution impacts of some of Sustrans' schemes. This section discusses the methodology behind the modelling work.

The model estimates two kinds of air pollution benefits from shifting to active travel. These are:

3) **Reducing Car Journeys:** This relates to the air quality benefits to the local population due to reduced emissions from car journeys replaced by active travel
4) **Route Users Personal Exposure:** This relates to the air quality benefit (or -dis benefit) to an individual due to change in pollution exposure from shifting to active travel.

Figure 1 illustrates the main steps involved in the calculation of the abovementioned benefits. The approach used can be summarised as follows:

- Data from Sustrans is used to consider switches in active travel occurring at a local level, supplemented by data from the UK's National Travel survey;
- Key technical assumptions in respect of calculating the route user's personal exposure are largely derived from the peer reviewed academic literature;
- The health benefits arising from changes in pollution (as a result of either a reduction in car journeys, or changes to route user's personal exposure) are estimated in line with the UK government's methodology for assessing these impacts.

Detailed assumptions, data sources, and various other technical aspects behind these calculation steps are discussed in the following sections.

Figure 1: Modelling of Health Impacts of Air Pollution

Source: Eunomia

2.2 Reducing Car Journeys

Air pollution benefits occurring from a reduction in car journeys as result of the shift to active travel are estimated using the following steps:

1) Estimate the total car kilometres avoided in a year, which is derived from the total individual shi

Table 3: Pollution Emission Factors

	PM_{10}		NOx	
	Petrol	**Diesel**	**Petrol**	**Diesel**
Exhaust Emissions factor (g/km)	0.001	0.016	0.118	0.635
Brake/Tyre/Road Emissions factor (g/km)	0.022	0.022		

Source: NAEI

The model assumes approximately half of the fleet is petrol and half diesel, based on the national average fleet distribution by fuel types. However, this is a scheme level assumption, and thus can be adjusted for each scheme separately if more information becomes available on the proportion of vehicles of each fuel type for a particular area.

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Location Type	Health impacts per tonne of pollutant per year

With reference to the first point, the starting point for understanding the exposure of travelling individuals to pollution in each microenvironment is the measured air pollution data, sourced from Defra's UK-Air website. This site provides measured pollution concentration data for each area in the UK. Different measurements are available in some cases, both the background pollution (away from kerbside sites) and kerbside measurements are available, whereas in other areas, one or the other may not be available.

In most cases, when calculating the personal exposure in the microenvironment for different travel modes we have used the average annual mean of measured kerbside concentration of pollutants. We have used Defra's modelled background pollution levels for estimating the exposure of travellers on the off-road schemes, as these route users will not be being exposed to the same level of pollution as those travelling on the road. This value is assumed to be representative of exposure within buildings (rather than being outdoors). The same source is used to estimate pollution levels when individuals are not travelling. In this case, however, we use the modelled background concentration with the uplift factor for resting.[7]

To account for variation in pollution in the microenvironment associated with each mode of travel – including the change in inhalation rates through exercise – we have used data from the peer reviewed literature to create uplift factors. These are applied to the data on the pollutant concentration for each area. The aim is that these factors take into account the 'deposition of pollution in the lungs' of the travellers, as set out in the points above.

For a more detailed discussion on microenvironment concentrations and respiration rates under different travel modes, see, for example: de Nazelle et al. (2012),[8] Zuurbier et al. (2009, 2010, 2011),[9,10,11] and Int Panis et al. (2010).[12]

Table 8 presents the different relative inhalation rates and associated relative pollution concentrations for different microenvironments, together with our estimated pollution uplift factors which are used in the model.[13,14] The data on inhalation rates and pollution concentration were sourced from various academic literature and then scaled appropriately using expert judgement. Then the concentration uplift factor for each microenvironment is

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[7] The use of time-weighting is discussed further in Section **Error! Reference source not found.**

[8] de Nazelle, A., Fruin, S., Westerdahl, D., Martinez, D., Ripoll, A., Kubesch, N., and Nieuwenhuijsen, M. (2012) A travel mode comparison of commuters' exposures to air pollutants in Barcelona, Atmospheric Environment, Vol.59, pp.151-159

[9] Zuurbier, M., Hoek, G., Hazel, P. van den, and Brunekreef, B. (2009) Minute ventilation of cyclists, car and bus passengers: an experimental study, Environmental Health, Vol.8, No.1, p.48

[10] Zuurbier, M., Hoek, G., Oldenwening, M., Lenters, V., Meliefste, K., van den Hazel, P., and Brunekreef, B. (2010) Commuters' Exposure to Particulate Matter Air Pollution Is Affected by Mode of Transport, Fuel Type, and Route, Environmental Health Perspectives, Vol.118, No.6, pp.783-789

[11] Zuurbier, M., Hoek, G., Oldenwening, M., Meliefste, K., van den Hazel, P., and Brunekreef, B. (2011) Respiratory Effects of Commuters' Exposure to Air Pollution in Traffic:, Epidemiology, Vol.22, No.2, pp.219-227

[12] Int Panis, L., de Geus, B., Vandenbulcke, G., et al. (2010) Exposure to particulate matter in traffic: A comparison of cyclists and car passengers, Atmospheric Environment, Vol.44, No.19, pp.2263-2270

[13] We have ignored the effects on lung deposition factor because of lack of data for different microenvironments.

[14] See, for example, de Nazelle, A., Fruin, S., Westerdahl, D., Martinez, D., Ripoll, A., Kubesch, N., and Nieuwenhuijsen, M. (2012) A travel mode comparison of commuters' exposures to air pollutants in Barcelona, Atmospheric Environment, Vol.59, pp.151-159, Zuurbier, M., Hoek, G., Hazel, P. van den, and Brunekreef, B. (2009) Minute ventilation of cyclists, car and bus passengers: an experimental study, Environmental Health, Vol.8, No.1, p.48, Zuurbier, M., Hoek, G., Oldenwening, M., Lenters, V., Meliefste, K., van den Hazel, P., and Brunekreef, B. (2010) Commuters' Exposure to Particulate Matter Air Pollution Is Affected by Mode of

derived by multiplying the relative inhalation rates with the associated pollution concentrations. It can be seen that where active travellers are concerned, different concentration uplift factors are provided for the busy traffic

Microenvironment	Inhalation Rate (relative to rest level)	Concentration (relative to background level)	Concentration uplift factor
Walk (Busy)	2.04	2.03	4.13
Walk (Traffic-free)	2.04	1.00	2.04

Note:

1.

Other (non-regular) trips	**Car**	0.0561	3
	Taxi	0.0561	3
	Bus	0.0873	5
	Rail	0.0234	1

Source: Eunomia

Similarly, for walking and cycling trips, we calculate the travel duration on an average day for each group (commuters, education and other). However, the travel duration on an average day for walking and cycling trips is split into the time spent travelling on busy (on-road) and quiet (off-road) parts of the route, based on the route characteristics for each scheme.

Finally, we calculate for an individual traveller the time weighted exposure to pollution associated with each journey purpose and relating to each transport mode, accounting for the differences in travel duration. To do this, we calculate the exposure to an individual over 24 hours. At points in the day when individuals are not travelling, we assume they are exposed to the background concentration of pollution. During the journey period, travellers receive the personal exposure for each transport mode calculated in Section 2.3.1.

Time weighted exposure levels calculated for bus and rail travellers also incorporate the fraction of buses that are electric-powered, and the fraction of rail travel that takes place underground within the area where the scheme is located, respectively to reflect the differential in exposure within these different microenvironments seen in the data.

2.3.3 Health Risks Attributable to Change in Travel Modes

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this analysis are presented in Table 13.[15,16,17,18] To interpret the values in the table, the values mean, for example, that for every 10 µg/m^3 increase in $PM_{2.5}$, the data indicates that the risk of premature mortality increases by 6%.

Table 13: Relative Risk Parameters

Health Endpoint		Relative Risk Parameters	
		$PM_{2.5}$	NO_2
Long term effects	Chronic or Premature Mortality	1.06	1.0175
Short term effects	Respiratory Hospital Admissions (RHA)	1.019	1.0052
	Cardiovascular Hospital Admissions (CHA)	1.0091	1.0042

Source: COMEAP, meta-analysis studies

The relative risk parameters are applied to the calculated change in pollution exposure values for travellers switching modes, using a Log (multiplicative) scaling technique. This technique is used because the relationship between the variables is non-linear.

Health benefits are calculated in the model by considering the number of cases of each health endpoint that are avoided through changes in the level of exposure to air pollution. This is calculated by multiplying the changed relative risk for travellers (calculated in the previous step) by the background incidence rate. The background incidence rate is expressed in terms of the number of cases per person for a given year; values used in the model are detailed in Table 14, and are provided for each health endpoint, as follows:

> The background incidence rate for premature mortality has been calculated using the population and mortality data from the 2011 population census for the UK. A backge aret1oET qm3ms

Chronic (or premature) Mortality	0.01382
Respiratory Hospital Admissions (RHA)	0.01379
Cardiovascular Hospital Admissions (CHA)	0.00955

Source: Eunomia (calculated based on data from ONS and Public Health England)

A more detailed discussion on estimating health risk attributable to change in pollution concentration/exposure can be found in the Public Health England report on estimating mortality burdens on particulate air pollution.[19]

2.3.4 Monetised and Non -

Almondvale Park, West Lothian
Dunoon, Argyll and Bute
Great Glen Way, Scottish Canals

3.0 Results of Scheme-based Model

3.1 Results from Case Study Schemes

Headline results for the Connect2 schemes are shown in Table 16. Results show separately the value of impacts relating to the reduction in car journeys, and the value of impacts relating to changes in the individual's exposure to pollution through changing transport modes. In the case of the latter, a breakdown is provided in respect of the purpose of the journey – allowing for a separate consideration of the contribution of regular journeys (commuting and education) from leisure travel, as was discussed in Section 2.2.

Table 17 shows the initial results for 7 Scottish Community Links schemes. The data for these schemes shows smaller impacts for most of these schemes than is the case for the Connect2 schemes, occurring as a result of the reduced numbers of users in some cases according to the survey data. In a few cases – such as for the Leeds scheme – the number of scheme users appeared to reduce post intervention, leading to negative benefits with respect to the avoided emissions from a reduction in the level of car journeys.

The results in both tables are positive where a benefit is seen, but may be negative in some cases where the net impact is an increase in the health impacts associated with increased exposure to air pollution in the form of

The data shows that of different schemes, the impacts in respect of the exposure of active travellers to air pollution arising from their change in travel behaviour are sometimes positive, and sometimes negative. A benefit is always seen from the avoided emissions from the reduction in car journeys, but the size of this benefit also varies between the different case studies. The factors associated with the variation in these different elements are discussed separately in the sub-sections that follow, which discuss separately:

- the benefits arising from a reduction in the number of car journeys (occurring from avoided car emissions), discussed in Section 3.1.1;
- the impacts arising as a result of changes in route users' personal exposure to pollution, discussed in Section 3.1.2.

The results from the central scenario are also alternatively expressed in terms of the years of life gained, QALYs gained, premature deaths avoided, and avoided respiratory and cardiovascular hospital admissions – this is discussed further in Section 3.1.3.

3.1.1 Benefits from reduced numbers of car journeys

Section 2.2 confirms that a key element of the model considers the benefits arising from a reduction in car journeys and the avoided emissions arising from this. The benefits in this case are considered for the population of the area where the scheme operates, rather than just being focused on those affecting scheme users.

Benefits arising from a reduction in the number of car journeys are directly correlated to the number of scheme users who would have journeyed by car prior to changing to active travel modes; impacts also vary depending on the number of individuals using the scheme. This is shown for each of the Connect2 schemes in Table 18, and for the Community Links schemes in Table 19. The table also presents the other key characteristics that affect a significant proportion of the variability between the case studies, as will be discussed subsequently. Section 2.2.3 further confirms that there is some variation in the damage cost applied to the different locales, with pollution impacts in central London, for example, being given a higher damage cost than is the case for other conurbations. This variability arises from the size of population assumed affected by the pollution.

The combined impact can be seen by comparing several case studies and the associated characteristics:

- Glasgow and Plymouth show the highest benefits in terms of the avoided car emissions. Each has a relatively high number of scheme users who would have been using cars to undertake the journeys prior to switching to active travel;
- Northampton has the third highest benefit from a reduction in car journeys despite having far fewer scheme users than Glasgow and Plymouth, but has a higher proportion of the scheme users in Northampton used cars prior to switching to active travel;
- For some areas such as Norwich and Dumfries, the overall proportion of scheme users that were formerly using cars for the different journey purposes is relatively low, and

Table 18: Key Characteristics of the Connect2 Case Studies

	Additional active travel scheme users

3.1.2 ersonal exposure

The second key element in the model concerns changes to the route user's personal exposure to pollution. In contrast to the impacts set out in Section 3.1.1, the impacts in this section consider just those relating to scheme users, rather than the population of the area within which the scheme is based.

The results show both positive and negative values. The negative values mean a dis-benefit – i.e., the scheme users are exposed to a greater amount of pollution than was the case before switching to active travel. As was the case with the avoided car emissions, these impacts are also correlated to a certain extent with the number of additional scheme users, with impacts being generally more substantial (either in positive or negative terms) for those schemes that attracted greater numbers of users. These values are typically smaller for the Community Links schemes, because many of them are in smaller settlements and consequently they have a smaller number of users.

Cyclists are assumed to receive a higher exposure of pollution than walkers, as the journey lengths are assumed to be longer (than is the case with the walkers) and the inhalation rate of cyclists is also assumed to be higher. The latter is reflected in the higher concentration uplift factors for cyclists presented in Table 8 derived from the literature previously presented in Section 2.3.1; the same section also confirms assumptions in respect of journey duration.

Dis-benefits arising from increased exposure to pollution following a shift to active travel are therefore more likely to be seen for cyclists than walkers. Thus those schemes with the highest numbers of walkers tend to show higher overall benefits than those with a large number of cyclists. Results in this regard are sensitive to assumptions regarding the length of journey – if cyclists' journey times are in fact shorter than is modelled here, or car trips are longer, this would make it more likely that a benefit will arise from the personal exposure element for cyclists.

In this respect, as was discussed in Section 2.3.1, a key scheme characteristic is the proportion of the active travel route that is off-road, as this directly affects all active traveller's exposure to pollution. It will be seen from the data presented in Table 18 and Table 19 that this varies considerably between different routes – in Glasgow, where the benefit in respect of route user's personal exposure is the greatest, a significant proportion of the route is off-road, whereas the proportion is much lower in areas like Plymouth and Cardiff where results suggest there is a dis-benefit in terms of individuals' personal exposure to pollution.

As discussed in Section 5.2, it is important to note that to consider this properly, the model needs several data points for the local area in question, relating to the urban background pollution levels as well as the kerbside pollution data. The former is considered a better indication of exposure levels for off-road users than the latter. This information was not available for all areas – in many cases only the kerbside data was available – but the requisite data is available for Glasgow.

Our model suggests benefits arising from the personal exposure element of the model are also more likely to be seen where route users have switched from public transport to active travel, in comparison to schemes where more passengers switch from car to active travel. In particular, benefits are more consistently seen for bus passengers switching to

active travel, as bus journeys are relatively long in duration in comparison to other forms of motorised transport and the data suggests that ambient pollution levels are slightly higher than is typically seen in a car.

Conversely, personal exposure levels tend to be lower where a larger number of route users switch from car to active travel, as journey times are shorter and ambient pollution levels are somewhat lower for car passengers than is the case for bus passengers (again, this is reflected in the lower pollution concentration uplift factor for car passengers).

It is important to note that where a reduction in

Table 21: Non-monetised Health Benefits for 7 Community Links Case Studies

	Health Benefits per Annum				Health Benefits over 30 years			
	Years of Life Gained	QALYs Gained	Avoided Premature Deaths	Avoided Hospital Admissions	Years of Life Gained	QALYs Gained	Avoided Premature Deaths	Avoided Hospital Admissions
[redacted]								

3.2 What-If Analysis based on Norwich Connect2

3.2.1 Introduction

The air quality model has been applied to case studies of existing Sustrans Connect2 schemes and the appropriate impact data, but it can also be used to conduct 'What-If' analysis – testing future options to change existing schemes, attract more people to active travel or target specific types of user, or even test the potential impact of new schemes. This section of the report demonstrates some ways of conducting What-If analysis based on the Norwich Connect2 scheme.

The model results in Table 22 shows the existing Connect2 scheme in Norwich to have a positive overall benefit in terms of air quality health impacts. This is mostly due to the reduction in car journeys which results in avoided car emissions in this case, as is seen in the second column in the table. Commuters experience a personal benefit in moving to active travel as do those travelling for education whereas those travelling for other purposes experience a dis-benefit interms of air quality health impacts. Car users in Norwich see a dis-benefit- in terms of their personal exposure to pollution when switching to active travel in the central case, for the reasons set out in Section 3.1.2 There are more car users than public transport users in the "Others" category than is the case in the Commuting and Education categories. As a result, the overall personal exposure impact for this category is negative.

Table 22: Headline Results for Norwich Case Study

	Reduction in car journeys	, P S D F W V I U R P U R X W H X V H to pollution				Overall impact
		Commuting	Education	Others	Total	
Connect 2 Norwich	£3,186	£739	£115	-£234	£619	

Table 25 shows the results for this scenario. The reduction in car journeys is unaffected as this primarily relates to the number of additional route users rather than route length and

progress since 2010, and develop a set of actions that to help achieve the shared vision of "10% of everyday journeys to be made by bike, by 2020". This aspiration is recognised as a challenge for all stakeholders. Cycling Scotland's progress report against CAPS outlined six pre

of the CWIS cycling target. It is important to note that the relationship between the total monetised benefits from the schemes and the number of avoided premature deaths is not a linear one, as different methodologies are used to calculate avoided premature deaths arising as a result of changes in personal exposure, compared to those that are associated with a reduction in vehicle mileage.

Overall, output from the above calculation and those of Section 3.3.1 confirm that a concerted focus in England and Scotland on cycling and walking has the potential to bring about significant benefits in respect of air pollution alongside other benefits to public health and other beneficial outcomes.

In addition, as indicated in Section 5.2, the scheme-based model is not able to properly consider potential benefits that may occur in terms of the reduced pollution exposure of scheme users occurring as a result of the reduction in the number of car journeys. For interventions that bring about a substantive change in active travel – such as that considered in this section – the approach used in the scheme-based model is expected to und

a result of the intervention. This is then used to calculate the potential health benefit arising as a result of the intervention for the population of the city as a whole.

4.2 Summary of Approach

The starting point for undertaking this assessment is the model originally developed by Eunomia for NICE. The model considers health benefits to the population arising from interventions to tackle air pollution. The benefits are modelled based on wide-area changes to the dispersed atmospheric pollution occurring as a result of the intervention. The advantage of this approach is that it allows a relatively high-level consideration of the potential results of a more substantial intervention affecting larger numbers of people.[25] Figure 2 illustrates the main steps involved in modelling the air pollution impacts of area-wide interventions using the NICE model.

Figure 2: Modelling Air Pollution Impacts of Area-Wide Interventions

Source: Eunomia

The scheme-based model and the NICE model take the same approach when calculating the health impacts arising from changing pollution levels (for the most part using standard government datasets, as is set out in Section 2.3.3 and Section 2.3.4. However, unlike the scheme-based model, the area-wide model does not consider in detail the changes in travel patterns such as changes in the numbers of cars on the road, and in the number of active travellers – that bring about the change in atmospheric pollution levels. It only considers the changes in pollution arising from a high level consideration of transportation changes. As such, it is not possible to use the top-down model to estimate the potential benefits that would arise from the cycling and walking investment strategy, which requires a calculation of impacts relating to the number of walking and cycling stages.

Key assumptions used in the area-wide model are:

- Sustained changes in atmospheric pollution levels for key pollutants occurring as a result of the intervention. Both NO_2 and $PM_{2.5}$ were considered in the original model, although the analysis set out here focuses on NO_2 only due to time constraints on the project;

[25] Further information on the technical details behind the modelling work is set out in Eunomia / UWE (2017) Air Pollution: Economic Analysis, Final Report for NICE, April 2017

The number of people affected by the change in atmospheric pollution levels.

We initially considered the potential changes in recorded atmospheric NO_2 levels that might occur as a result of the walk to school week, which were set out in a paper written by Grace Gardner, a student at Southampton University[26]. This paper is one of relatively few studies in the literature to try to link changes in travel behaviour to atmospheric pollution levels. It suggested that relatively large potential reductions in the levels of local pollution might occur in the short term as a result of the intervention in several schools. A short term reduction in NO_2 levels of up to 25% was seen in the research, and there was also some indication that the reduction may have been sustained beyond the initial study period. However, only a relatively small number of data points were presented in this study as evidence of the potential impacts on dispersed pollution. Given this, there was felt to be a relatively high risk of the data being influenced by climatic factors, which could reduce the accuracy of the estimated impacts considerably.

To improve the accuracy of estimates on the potential pollution reduction that might occur through this type of intervention, we have therefore considered other data that exists in respect of the variation in pollution levels between school holiday time and term time. As this is a longer term dataset, this should allow the potential impact for climatic factors to be reduced.

Extensive monitoring data exists for Newcastle, some of which is held and developed by Newcastle University. Initial discussion with the University has suggested that NO_2 pollution levels outside of term time in Newcastle are reduced by 7% in comparison to pollutant levels seen during term time, based on the long-term time series data the University has obtained in recent years.

No data is available at present directly linking changes in atmospheric pollution levels to changes in transport use occurring as a result of active travel interventions, so assumptions must be developed to consider the impacts. In modelling the potential effect, we have assumed a city-wide intervention is successful in making a long-term reduction in 10% of the vehicles that are assumed to cause the normal drop in school-related travel in Southampton. This is assumed to be roughly equivalent to a sustained reduction in 10% of school-related traffic across the whole city. The Newcastle monitoring data indicates the pollution levels outside term time are reduced by 7%. To develop our initial estimate of the impact of a city-wide intervention in Southampton, we have taken the lower figure of 5% as the starting estimate.

5.2 Limitations and Further Work

Currently, a number of the key variables used within the model to establish the exposure of cyclists and walkers to pollution are based on modelling assumptions. Key variables of this nature include:

- The length of journey for each of the different journey purposes;
- The speed at which active travellers cycle or walk their journeys;
- The regularity of the journeys undertaken by users of the schemes.

levels will start to use the scheme. In this respect, the estimation of air pollution benefits should improve in its accuracy as scheme participation widens within the community.

In this respect, it is also important to note that the data on the physical health benefits of cycling overlaps somewhat with the estimation of the air pollution benefits accounted for within the scheme.

benefit value of such schemes. In this respect, it is important to note that the above results reflect the benefits that would be obtained from one year only. Furthermore, benefits from the CWIS and CAPS are likely to continue for longer than those of other interventions aimed primarily at tackling tailpipe emissions – such as the Clean Air Zones (CAZ) proposed by Government – as the reduction in the number of cars on the road from the CWIS and the CAPS will bring about continued benefits in terms of the reduction in PM emissions occurring due to a reduction in car tyre wear and related impacts.

The modelling work has demonstrated which factors drive higher benefit values in respect of individual schemes. These include increasing scheme user numbers, targeting regular travellers, focussing in on more densely populated urban areas, reducing rates of exposure to air pollution of scheme users through the use of off-road routes. These factors are explored in the modelling work both through "what-if" analysis. Alongside this, outputs from the area-wide model latter in particular suggests that the potential benefits from a more substantial intervention are very considerable. Wider benefits could be brought about with more complete networks, denser networks, behaviour change accompaniment, measures to reduce exposures, better targeting of specific user groups. Such measures could bring about a reduction in the impacts of air pollution in the local area, as well as representing more effective delivery of measures to support walking and cycling.

To bring about this level of change, delivery of the above measures needs to happen as part of a large scale, integrated package of intervention/delivery, potentially in tandem with effective traffic-restraint measures. In this way, the two types of intervention could be mutually supportive, as cycling and walking is an important part of the local mobility solution when motorised mobility is necessarily constrained.