M1 SmogStop® Air Quality Barrier Trial

Final Report

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Executive summary

Overview

Roadside barriers have commonly been used to mitigate traffic noise on the strategic road network, but also have the potential to help mitigate roadside air pollution, either by passively containing or deflecting polluted air away from sensitive receptors, and / or by actively using catalysts to neutralise pollutants using chemical reactions.

The SmogStop® barrier is a combined noise and air pollution barrier for highways, designed and marketed by Envision SQ and Gramm Barrier Systems Ltd. The barrier is designed to function passively and actively using a photocatalytic coating to remediate nitrogen dioxide (NO_2) under the action of light. The SmogStop® barrier has previously been subjected to testing in a laboratory, wind tunnel and trialled at the roadside in Toronto. It has a double-walled design made from transparent acrylic panels, with an angled baffle at the top designed to create vortices on the leeward side of the barrier that push a portion of the polluted air from nearby traffic upwards, increasing the mixing of polluted air with clean air, decreasing pollution levels. It also has an inlet that funnels a portion of the polluted air between the two acrylic walls where the photocatalytic coating is located, and through the barrier to an outlet at the bottom of the outer wall. The transparent acrylic panels that form the walls of the barrier allow light to pass through to the photocatalyst, which has been shown to convert NO_2 pollution primarily into nitrogen (N_2) and oxygen (O_2). Further details on the SmogStop® barrier can be found in Annex 1.

Trial description

National Highways implemented a trial of the SmogStop® barrier technology on the M1 motorway between junctions 28 and 29, immediately north of Tibshelf services, adjacent to the southbound carriageway. A SmogStop® barrier ('trial barrier') 100 metres long was installed on the eastern side of the carriageway, a distance of 9 meters from the carriageway, with a barrier height of 3 metres, and angled baffle raising the total barrier height to 3.5 metres. A further 100 metres of wooden fencing ('control barrier') was installed immediately south of and adjoining the SmogStop® barrier, again at a distance of 9 meters from the carriageway, with a height of 3 metres. The SmogStop® barrier was previously trialled at a height of 6m in Toronto, however, for the field trial in Tibshelf, UK, a 3m high barrier was commissioned.

The National Highways trial was due to commence in January 2020, but was delayed by a serious crash involving a heavy goods vehicle at the site, damaging the trial barrier. In addition, the Covid related lockdown caused further delays. The National Highways trial eventually commenced in September 2020, and ran for twelve months until August 2021 inclusive.

A range of instrumentation was utilised to measure relevant variables at the trial site, including triplicate diffusion tubes to measure monthly average NO_2 concentrations, and 4 x chemiluminescent analysers to measure NO_2 concentrations at 5 minute intervals. NO_2 monitoring took place along six transects configured at 90 degrees (perpendicular) to the motorway. Transects N1 and S1 were located approximately 10 meters and 5 meters beyond the northern and southern ends of the barriers respectively, to monitor NO_2 concentrations with 'no barrier'. Transects T1 and T2 were located at 90 degrees to the trial barrier (approximately 45 meters apart), to monitor NO_2 concentrations in front of, behind, and at the barrier. Finally, transects C1 and C2 were located at 90 degrees to the control barrier (approximately 40 meters apart), to monitor NO_2 concentrations in front of, behind, and at the barrier.

Triplicate diffusion tubes were deployed at 123 spatial locations across the trial site along each of the six transects. Diffusion tubes were generally deployed at lateral distances of 1 meter and 4.5 meters in front of the barriers, and 1, 5, 10, 15 and 20 meters behind the barriers, as well as on the barriers themselves. The diffusion tubes were deployed at vertical heights of 0.75, 1.5, 2.25 and 3.0 meters, although at transects N1 and S1, diffusion tubes were only deployed at 1.5 meters height. At transects T1, T2, C1, and C2, the diffusion tubes deployed at 4.5 meters in front of the barriers (half way between the barriers and the carriageway) were only deployed at a height of 1.5 meters. The overall diffusion tube success rate was 96.4% (4,268 valid monthly measurements from a possible total of 4428), which is consistent with acceptable levels of data capture for the purpose of Local Air Quality Management reporting and evaluation of legal limit values for annual mean NO_2.

Each chemiluminescent NO_2 analyser (continuous automatic monitor) sampled air quality at four locations at five minute intervals. This provided sixteen air quality sampling locations, each sampling for a total of fifteen minutes (3 x 5 minutes) each hour. At transects T1, T2, and C1, chemiluminescent analyser monitoring took place at the barrier inlet (at 3 meters height), at the barrier outlet (at 0.5 meters height), and at 5 meters and 20 meters behind the barriers (at a height of 1.5 meters). In addition, at transect T2, chemiluminescent analyser monitoring took place at 1 meter in front of the barrier (at heights of 1.5 and 3.0 meters), at the barrier at a height of 3.5 meters (air flowing over the barrier), and at 1 meter behind the barrier at a height of 1 .5 meters.

Unfortunately, the chemiluminescent analyser at transect C1 failed during the trial, which meant that hourly NO_2 measurements were not available at the four monitoring locations along this transect. The remaining twelve chemiluminescent analyser monitoring locations were at transects T1 and T2, and therefore comparisons between the trial and control barrier could not be made from these measurements. Consequently, comparisons of the relative performance of the two barrier technologies could only be made using data from diffusion tubes. Given the relatively high associated uncertainty of diffusion tube measurements (typically quoted as ±25%, compared to ±15% for chemiluminescent analysers) and the limited sample size, this made it challenging to identify differences in the two barrier technologies with high statistical confidence.

The prevailing wind direction during the twelve month trial was from the SSW, (i.e. obliquely from the motorway towards the barriers), with a mean wind speed of 1.9 meters per second (6.8 kph).

Study findings

Diffusion tube NO_2 monitoring data

Analysis of the diffusion tube NO_2 data was carried out using both 'raw' data, and using 'de-seasonalised' data where monthly variation due to factors such as ambient temperature and other seasonal factors had been removed. The de-seasonalised values exhibit reduced variability, and smaller standard deviations associated with the annual mean values, but the 'de-seasonalised' annual mean NO_2 values remain essentially the same as the annual mean values derived from the raw data.

- When comparing the annual mean NO_2 concentrations in front of the barriers with those behind the barriers (both T1 & T2 SmogStop® and C1 & C2 wooden fence), there is a step change reduction of around 28% (circa 14 $\mu g/m^3$) between measurement locations 1 metre in front of the barriers, and 1 metre behind the barriers.
- Where no barriers are present (transects N1 & S1), the comparable reduction at a height of 1.5 metres is of the order of 16% (circa 8 $\mu g/m^3$) due to distance and dispersion effects, which suggests that the barriers are responsible for a reduction of around 12% (circa 6 $\mu g/m^3$) in NO_2 concentrations (1 metre in front of the barriers versus 1 metre behind the barriers).
- At 10 metres behind the barriers (T1 & T2 and C1 & C2) and no barriers (N1 and S1), the annual mean NO_2 concentrations tend to converge.

- When comparing the performance of the SmogStop® barrier and the wooden barrier, there are no statistically significant differences ($p > 0.05$) in the observed annual mean NO_2 concentrations behind the barriers in the raw (not de-seasonalised) diffusion tube data.
- There are no statistically significant differences ($p > 0.05$) in the annual mean NO_2 reduction performance of the SmogStop® barrier and the wooden fence barrier at a height of 1.5 metres, at 1m, 10m, or 20m behind the barriers, based on de-seasonalised data.
- However, at 5m behind the barrier at a height of 1.5m, the annual mean NO_2 concentrations behind the SmogStop® barrier are statistically significantly lower ($p < 0.05$) for three out of the four comparisons, based on de-seasonalised data. Transect T1 is statistically significantly lower than transect C1 (-2.8µg/m^3, -7.5%) and transect C2 (-2.3µg/m^3, -6.2%); transect T2 is statistically significantly lower than C1 (-1.7µg/m^3, -4.6%).
- At 15m behind the barriers at a height of 1.5m, the annual mean NO_2 concentration at transect T1 is statistically significantly lower ($p < 0.05$) than at transect C2 (-1.8µg/m^3, -5.3%), based on de-seasonalised data.
- Therefore, based on de-seasonalised diffusion tube data, the SmogStop® barrier appears to perform better than the wooden control barrier at 5 metres behind the barrier at a height of 1.5m, with reductions in annual mean NO_2 concentrations of between 1.7 µg/m^3 and 2.8 µg/m^3 ($p < 0.05$). In addition, the SmogStop® barrier appears to perform better than the wooden control barrier at 15 metres behind the barrier at a height of 1.5m, when comparing transect T1 with transect C2, with a reduction in annual mean NO_2 concentration of 1.8 µg/m^3 ($p <$ 0.05). However, there are no statistically significant differences ($p > 0.05$) between the two barrier technologies at 1m, 10m, or 20m behind the barriers.

Continuous automatic (chemiluminescent) NO_2 monitoring data

As mentioned above, a malfunction in the apparatus meant that the data from the 4 monitor locations along the control transect at C1 were invalid, and comparisons consequently could not be made between the control (transect C1) and trial barrier (transects T1 and T2). The data analysis is therefore limited to transects T1 and T2.

Of the analyser positions at T1 and T2, 4 were co-located, with 2 stationed at the barrier (the inlet and outlet) and 2 stationed downwind of the barrier (5m and 20m at head height). No analyser was co-located upwind at T1 and T2, and therefore, the inlet at the barrier was taken as a reference point by which to compare changes in NO_2 levels. For this analysis:

- Interpreting the observed changes in NO_2 was challenging, as the air flow within and around the barrier was complex.
- At T1, NO_2 levels increased on going from the inlet to the outlet, whereas at T2, NO_2 levels decreased. This resulted in more significant decreases in annual mean NO_2 (comparing the barrier inlet value with 20m behind the barrier) being observed at T2 (up to 8.2 µg/m^3; 23.0%) downwind of the barrier as compared with T1 (up to 3.0 µg/m^3; 10.3%).
- Greater reductions in NO_2 were seen during the daytime (up to 10.6 µg/m^3; 25.6%) than during the night time (up to 5.3 µg/m^3; 18.9%) at both T1 and T2, which was evidence of a photocatalytic effect. Approximately one quarter of the NO_2 removal function of the barrier was attributed to the photocatalytic coating, and the remaining three quarters of the NO_2 removal function to the aerodynamics of the barrier. However, as stated in the report, it was challenging to understand the observed differences in NO_2 levels found at the barrier given the complexity of the air flow at the barrier, and conflicting observed results at T1 and T2 inlet and outlet.
- When accounting for wind direction (comparing the barrier inlet value with 20m behind the barrier), net reductions in NO_2 were greatest (up to 9.2 µg/m^3, 20.3%) when wind blew from

the West (i.e. from the motorway) and smallest (up to 6.5 µg/m^3, 33.7%) when wind blew from the East (i.e. towards the motorway). An intermediate reduction was seen when wind blew from North or South (up to 8.0 µg/m^3, 23.0%).

At T2, 4 analysers were located at head height, with 1 stationed upwind 1m from the barrier, and 3 stationed downwind 1, 5 and 20m from the barrier. Information from these analysers was used to produce temporal contour maps of NO_2 levels approaching and behind the barrier at T2, and also, to compare differences seen upwind with those seen downwind. For this analysis:

- Reductions in annual mean NO_2 levels of up to 14.1 µg/m^3 (33.8%) were observed at 20m behind the barrier. These reductions were greater during the daytime (up to 18.5 µg/m^3; 37.5%) than during the night time (up to 8.7 µg/m^3; 27.6%). The annual mean NO_2 reduction at 1m behind the barrier was 10.6 µg/m^3 (25.5%), which is consistent with the diffusion tube observations.
- Greater reductions in NO_2 levels were seen when wind blew from the East (up to 17.3 µg/m^3; 57.5%) than when wind blew from the West (up to 11.9 µg/m^3; 24.7%). Intermediate reductions in NO_2 levels were seen when wind blew from North or South (up to 14.2 µg/m^3; 33.9%).
- At lower wind speeds (< 1m/s), greater reductions in NO_2 were observed (up to 16.1 µg/m^3; 40.1%) than at higher wind speeds.
- By comparing differences in daytime and night time performance 1m upwind and 1m downwind of the barrier, we estimate a 2.13 g photocatalytic remediation of NO_2 by the 100m long and 3m high barrier per day (or ~0.78 kg per annum). Using the Emissions Factor Toolkit, we estimate the photocatalytic remediation of the NO_2 emissions to be equivalent to the removal of ~230 vehicles per day, from 100,000 vehicles travelling along the barrier.

For any future deployment of the SmogStop® barrier technology, consideration should be given to the necessary scale of barrier (vertical height, length, and area of the photocatalytic coating) to achieve the desired NO_2 remediation. Also, positioning the barrier closer to the roadside (if feasible) should result in higher concentrations of NO_2 approaching the barrier, and therefore a greater likelihood for passive and active remediation to occur.

Contents

1. Introduction

1.1. The UK legal limits and strategies for reducing NO_x

The gases nitric oxide (NO) and nitrogen dioxide (NO_2) are formed when fossil fuels are burnt.[1] Collectively, NO and NO_2 are called NO_x, and cause a range of health and environmental problems. NO_x is responsible for ground level ozone and urban smog; created by their photochemical reactions with volatile organic compounds (VOCs). Short-term exposure to high levels of NO_x can exacerbate asthma, inhibit lung function and result in mortality.[2] Long-term exposure to high levels of NO_x has negative impacts on all organs, mental health and reduces life expectancy.[3, 4] In the UK, the largest source of NO_x is from road transport vehicles, contributing to 34% of total emissions in 2018.[5]

The National Institute for Occupational Safety and Health (NIOSH) have classified NO_2 to be 25 times more toxic than NO[6], and given the far greater toxicity of NO_2, the UK has focussed its targets on reducing this pollutant. The UK has set legal limits on NO_2 of: (i) an hourly average limit of 200 µg/m^3 (~0.1 ppm) that cannot be exceeded more than 18 times per calendar year and (ii) an annual average limit of 40 µg/m^3 (~0.02 ppm).[7] Although the implementation of stricter emission standards on new road vehicles has resulted in a decrease in UK annual average concentrations of NO_2 at the roadside from 57.3 µg/m^3 in 2000 to 23.0 µg/m^3 in 2020[7], a recent report by ClientEarth showed that 75% of all local reporting areas had annual average NO_2 levels of air pollution above the 40 µg/m^3 limit; with Greater London, Newport, Glasgow, Birmingham, Southampton and Edinburgh all exceeding the limit.[8] To further compound this challenge, the WHO has recently tightened its air pollution guidelines, and now recommends an annual average NO_2 concentration of 10 µg/m^3; a figure four times lower than the UK limit.[9]

To improve air quality and curb NO_2 emissions, the UK devised a Clean Air Strategy (2019).[10] This included the promise to end the sale of conventional fossil fuel powered vehicles by 2040 and achieve a net zero fleet by 2050. To reduce NO_2 levels in the interim, other strategies are being implemented, which include the introduction of low emission buses[11], low emission zones[12], increased cycle lanes on highways[13] and decreasing the speed limit for vehicles on certain highly polluting roads.[14] Also, new strategies are being explored, which include the use of air quality barriers at the roadside, and will form the focus of this report.[15]

1.2 Air quality barriers

1.2.1. A vertical wooden barrier

In 2015, Highways England trialled a wooden barrier, near junction 18 of the M62, near Simister, Greater Manchester.[16] The barrier was 100 m long, and was initially trialled at a height of 4 m for 12 months. The barrier was then extended in height to 6 m and trialled further. Air quality was monitored at locations around the barrier and, to serve as a control, at locations where no barrier was present. No conclusive differences in NO_2 levels were observed between the barrier and the control, with Highways England stating that this trial "did not support a definitive conclusion that the barrier would lead to a reduction in NO_2 concentrations behind either the 4 m or 6 m high barrier."[15]

1.2.2. A mineral polymer coated barrier

A mineral polymer, shown to be capable of removing NO_2 by absorption in laboratory conditions, was trialled by Highways England in 2017.[15] Highways England trialled a barrier coated with this mineral polymer, between junctions 28 and 29 of the M1, near Tibshelf, alongside the southbound carriageway. The mineral polymer coated barrier examined was 100 m long and 3 m high and was trialled alongside an uncoated wooden barrier that was also 100 m long and 3 m high to serve as a control. The barrier was trialled for 12 months between February 2017 and January 2018.[17] Air quality monitors installed around the barriers showed no discernible difference in NO_2 levels between the mineral coated and control barriers. To assess if the structure of the mineral polymer coated barrier controlled its NO_2 removal function, various designs were studied in a wind tunnel. However, these tests showed that the structure was not integral to its performance, with the mineral polymer showing it was ineffective at reducing ambient levels of NO_2 in this setting.

1.2.3. An overhanging acrylate barrier; the Dordrecht barrier

An overhanging barrier was developed by the Netherlands strategic roads authority for reducing noise and air pollution. The barrier is 9.3 m high and 1 km long, and is made from curved transparent acrylate built around concrete trusses, reinforced with steel girders.[18] This barrier was installed in the mid 1990's along the A16 near the city of Dordrecht, Netherlands.[19] In collaboration with the Dutch authorities, Highways England monitored air quality around this barrier, and at control sites along the same road, for 18 months.[15] Highways England saw reductions in annual mean NO_2 levels between 2 and 5 $\mu g/m^3$.[20] Further work was carried out by Highways England, where they used computational fluid dynamics (CFD) modelling to assess various barrier designs, including an overhanging barrier design analogous to the Dordrecht barrier.[18] The CFD model showed reductions in NO_2 levels of ~36% immediately behind the barrier for the Dordrecht design compared with no barrier.

1.2.4. The SmogStop® barrier

Envision SQ and Gramm Barriers have partnered to produce a noise and air pollution barrier for highways; the SmogStop® barrier[a]. This barrier differs from those discussed in the prior sections in that it uses a photocatalytic coating, which under the action of light, remediates NO_2.

It is a double-walled design, with an angled baffle at the top that: (i) creates vortices on the leeward side of the barrier that push a portion of the polluted air from nearby traffic upwards, increasing the mixing of polluted air with clean air, decreasing pollution levels, and (ii) possesses an inlet that funnels a portion of the polluted air from nearby traffic between the two walls, where the photo catalyst is located, and through the barrier to an outlet at the bottom of the outer wall (Figure 1).[b] The transparent acrylic panels, that form the walls of the barrier, allow light to transmit through to the photo catalyst, which uses ambient light to convert NO_2 pollution primarily into benign nitrogen (N_2) and oxygen (O_2). The SmogStop® barrier has therefore been designed with the motorist, pedestrian and environment in mind, as it aims to direct polluted air upwards at the barrier - preventing the rebound of NO_2 pollution back towards the motorist or over the barrier towards the pedestrian - and aims to remediate a portion of NO_2 which flows between the double-walls of the barrier, reducing the amount of NO_2 that is released into the environment[c]. After successful field trials in Toronto, the SmogStop® barrier received provisional approval as a 'Noise/Air Quality Barrier' by the Ministry of Transportation Ontario, Canada on April 8th 2022.[d] For full details on the development of this product, including laboratory testing, wind tunnel testing and the field trial in Toronto, see Annex 1.

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[a] This report will only evaluate the effectiveness of this product for abating NO_2 pollution from its field trial beside the M1 in Tibshelf, and will not assess its ability to reduce noise or any other pollutant.
[b] It should be noted that air can equally flow in through the outlet and out of the inlet depending on the weather conditions.
[c] Preventing its contribution to the formation of acid rain, which harms forests, crops and aquatic life.
[d] Subject to the provision that the precast concrete bottom panel must adhere to the requirements specified in the "DSM Noise Barrier - Concrete Requirements" version 1.3 dated April 2021. The product will be considered for full approval once all the requirements specified in the most recent version of "DSM Noise Barrier – Concrete Requirements" are met. The provisional approval will expire on October 28th, 2022.

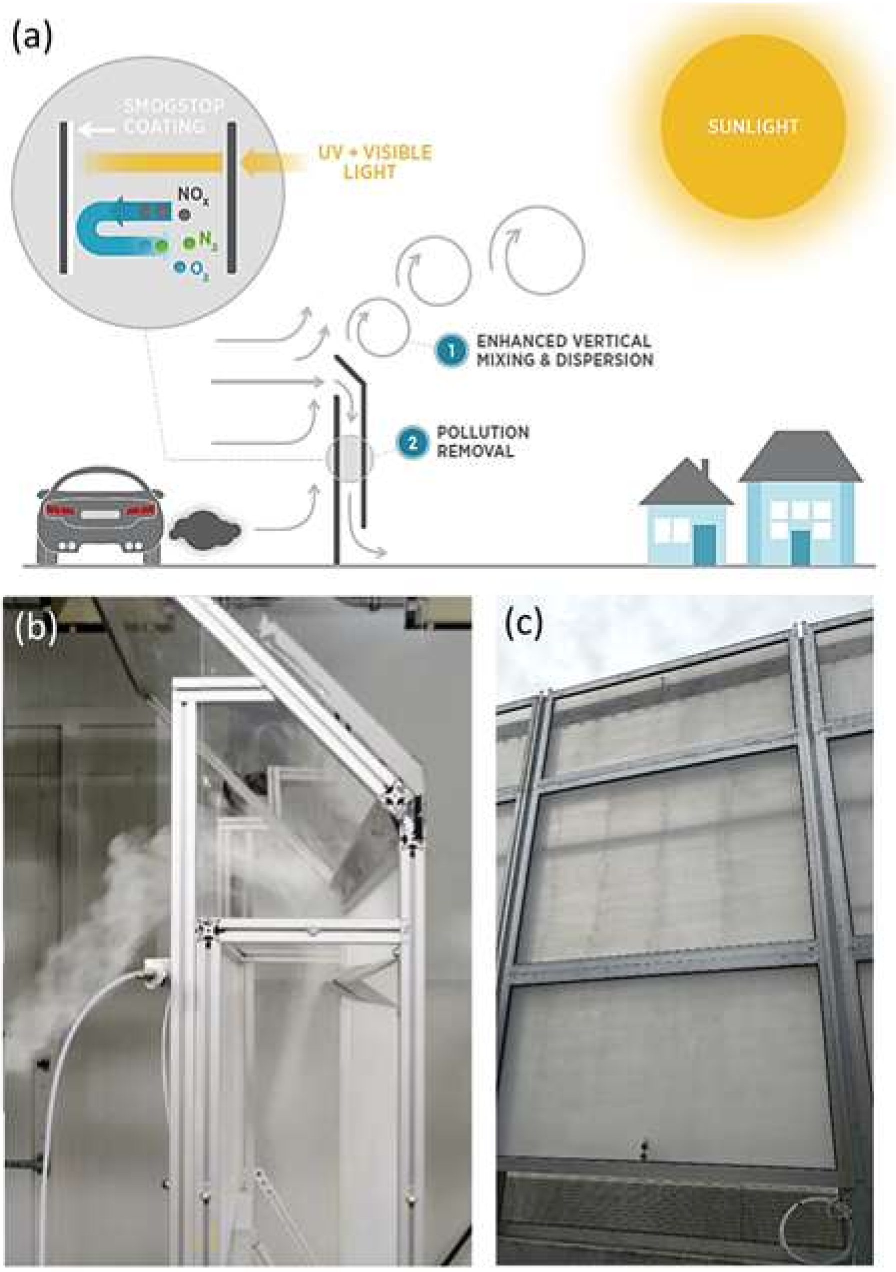

Figure 1: A schematic showing the function of the SmogStop® barrier, which disperses a portion of the polluted air upwards and funnels a portion of the polluted air between the two walls of the barrier, where it is treated by the photo catalyst, and through to an outlet at the bottom of the barrier. (b) Wind tunnel testing of a full scale model of the barrier, demonstrating its ability to funnel polluted air between its walls. (c) A section of a SmogStop® barrier installed in Toronto, Canada at the intersection of Highway 401 and Bayview Avenue as part of a field trial

1.3 Objectives

Based on the experimental design of the trial, specific objectives were identified by the authors of this report. The overarching objective is to determine the effectiveness of the 3 metre high SmogStop® barrier at reducing NO_2 pollution levels downwind of an active motorway. The specific objectives are:

- To determine and compare the effectiveness of the SmogStop® barrier against the control barrier and no barrier from annual average NO_2 levels measured using diffusion tubes on a monthly basis
- To determine and compare the effectiveness of the SmogStop® barrier against the control barrier from annual average NO_2 levels measured using chemiluminescent analyser measurements of hourly average NO_2 levels. This data could then be broken down into various sub-sets for time periods of day and night to assess the effectiveness of the photocatalytic coating on the SmogStop® barrier and time periods for specific wind directions or speeds to assess the effectiveness of the barrier as a whole for various wind conditions.

2. The M1 Tibshelf SmogStop barrier trial – Experimental design

2.1 Introduction

National Highways implemented a trial of the SmogStop® barrier technology on the M1 motorway between junctions 28 and 29, immediately north of Tibshelf services (latitude 53.142636°, -1.330425° longitude), as illustrated in Figure 2. A SmogStop® barrier 100 metres long was installed on the eastern side of the carriageway, with a barrier height of 3 metres. The SmogStop® barrier was also provided with an angled ‘crank’, raising the total barrier height to 3.5 metres. A further 100 metres of wooden fencing (‘control barrier’) was installed immediately south of and adjoining the SmogStop® barrier, again with a height of 3 metres. The purpose of the wooden fencing was to act as a control site for air quality monitoring. In-situ images of the SmogStop® barrier and the wooden control barrier are presented in Figure 3.

It should be noted that the design and previous testing of the SmogStop® barrier was all previously conducted assuming a barrier height of 4 metres or greater; with wind tunnel tests conducted on 4 metre and 5 metre scale models and field trials conducted on a 6 metre barrier (see Annex 1 for more details). However, for the field trial in Tibshelf, UK, a 3 metre high barrier was commissioned. CFD studies were carried out by the developers of the SmogStop® barrier to estimate the performance of a 3 metre high barrier. Their model estimated ~23.8%, ~24.7% and ~12.8% greater reductions in NO_2 levels compared with a vertical barrier (no crank or SmogStop® coating) of the same height and materials at 5, 20 and 40 metres downwind, respectively, assuming a wind speed of 4 m/s. The average wind speed during the Tibshelf trial, measured at a local National Highways monitoring station (Site 9), was 1.9 m/s.

The National Highways trial was due to commence in January 2020, but a serious crash involving a heavy goods vehicle at the site damaged the trial barrier, resulting in a delay to the commencement of the trial. In addition, Covid related lockdowns resulted in further delays. The National Highways trial eventually commenced in September 2020, and ran for twelve months until August 2021 inclusive.

A range of instrumentation was utilised to measure relevant variables at the trial site, including:

- Diffusion tubes to measure monthly average NO_2 concentrations;
- 4 x Teledyne API T200 chemiluminescent NO_2 analysers, compliant to ISO 7996 & CEN EN 14211:2005 (used to measure NO_2 concentrations at 5 minute intervals);
- 1 x Gill WindSonic anemometer located at an adjacent permanent National Highways monitoring site to measure ambient (horizontal) wind speed and direction;
- 2 x additional temporary sonic anemometers to measure ambient (horizontal) wind speed and direction;
- 2 x temporary sonic anemometers to measure (vertical) air flow speed and direction within the SmogStop® barrier;
- MIDAS (Motorway Incident Detection and Automatic Signalling) inductive loop traffic sensors, providing categorised traffic flow and speed data down to 1 minute time resolution.

2.2 Monthly NO_2 diffusion tube monitoring

Diffusion tubes are a type of passive sampler. They absorb the pollutant to be monitored directly from the surrounding air and need no power supply. Diffusion tubes are relatively easy to use and inexpensive, so they can be deployed in large numbers over a wide area, giving the potential for good spatial coverage. Diffusion tubes are often used to complement more expensive automatic monitoring techniques, or at locations where it would not be feasible to install an automatic monitor, for example where there is no power supply.

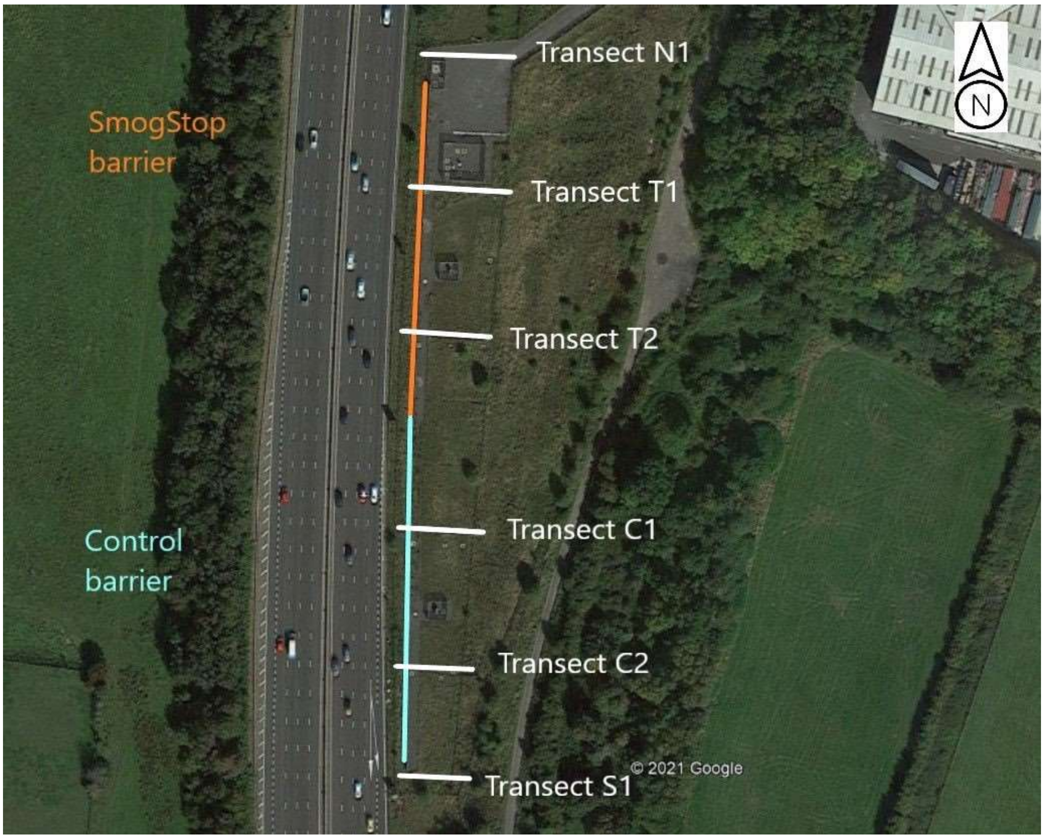

Figure 2: M1 Tibshelf barrier location and transects (map base ©Google Earth)

Figure 3: M1 Tibshelf barrier deployment (©Google Street View)

Diffusion tubes have two main limitations.[33] Firstly, they are an indicative monitoring technique. This refers to a technique with relatively high uncertainty, typically quoted as ± 25%. By contrast, the chemiluminescence method, used in most automatic ambient monitoring apparatus for NO_2, is defined as the reference method for this pollutant, and its uncertainty is typically quoted as ± 15%.[1] Secondly, as the exposure period is typically several weeks, diffusion tube results cannot be compared with air quality standards and objectives based on shorter averaging periods such as hourly means, daytime vs night time etc. They also cannot differentiate wind direction. However, they can be used to make comparisons against annual average air quality standards, such as the UK annual average limit value for NO_2 of 40 µg/m^3.

For the purpose of monitoring NO_2 concentrations in the National Highways trial, diffusion tubes were deployed at 123 spatial locations across the trial site. The spatial deployment is presented in Table 1 and illustrated in Figure 2 and Figure 4. Diffusion tubes were deployed along the two transects perpendicular to the SmogStop® barrier (T1 and T2), and along the two transects perpendicular to the wooden fence control barrier (C1 and C2). In addition to the barrier transects, two additional transects (N1 and S1) were installed, one at each end of the site (north and south). These transects (N1 and S1) were located beyond the ends of the barrier fences, and so were directly exposed to vehicle generated air pollution from the motorway.

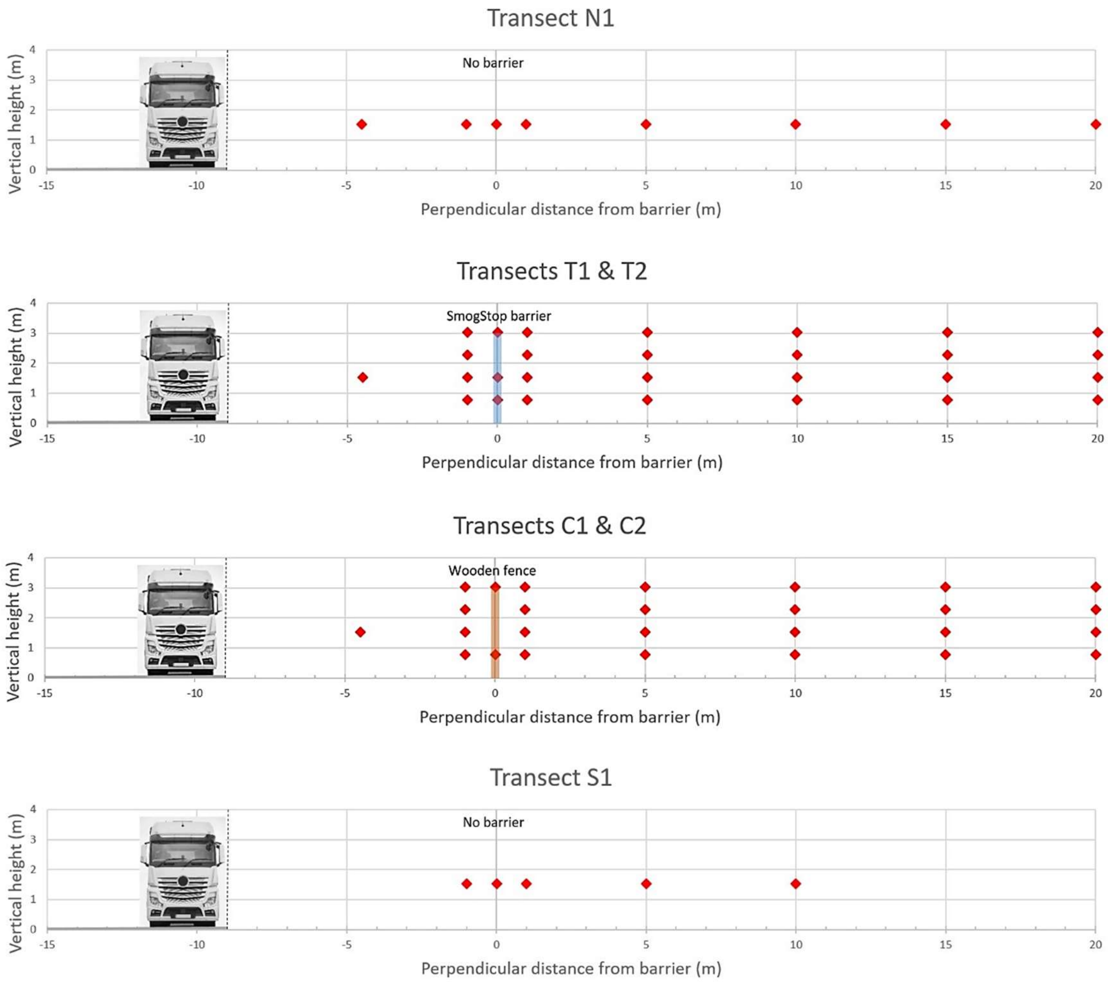

Figure 4: Diffusion tube NO_2 monitoring locations by transect

Table 1: Locations of triplicate NO_2 diffusion tubes

Distance from traffic	**4.5m**	**8m**	**9m**	**10m**	**14m**	**19m**	**24m**	**29m**
Distance from barrier	**-4.5m**	**-1m**	**0m**	**+1m**	**+5m**	**+10m**	**+15m**	**+20m**
Transect	**Vertical height**							
N1	1.5m	1.5m	1.5m	1.5m	1.5m	1.5m	1.5m	1.5m
T1	- - 1.5m -	3m 2.25m 1.5m 0.75m	3m - 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m
T2	- - 1.5m -	3m 2.25m 1.5m 0.75m	3m - 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m
C1	- - 1.5m -	3m 2.25m 1.5m 0.75m	3m - - 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m
C2	- - 1.5m -	3m 2.25m 1.5m 0.75m	3m - - 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m	3m 2.25m 1.5m 0.75m
S1	-	1.5m	1.5m	1.5m	1.5m	1.5m	-	-

It can be seen from Table 1 and Figure 4 that whilst the majority of diffusion tubes were located behind (to the east of) the barriers, some diffusion tubes were deployed in front of (to the west of) the barriers to measure NO_2 concentrations on the 'traffic' side. This would provide the opportunity to quantify the scale of reduction in NO_2 concentrations behind both the SmogStop® barrier and the wooden control barrier, relative to the 'traffic' side. The deployment would also facilitate comparisons with the 'no barrier' situations observed on transects N1 and S1.

NO_2 concentration results were obtained from these diffusion tubes on a monthly basis. All diffusion tubes were deployed in 'triplicates' i.e. three diffusion tubes at each monitoring location for each month. In principle, this would result in 4,428 diffusion tube measurements (123 locations x 3 x 12 months). In practice, the diffusion tube data occasionally had missing or faulty values, although the overall success rate was 96.4% (4,268 valid measurements from a possible total of 4428), which is consistent with acceptable levels of data capture for the purpose of Local Air Quality Management reporting and evaluation of legal limit values for annual mean NO_2. The success rate ranged from 100% in February and May 2021, to 81.3% in June 2021. Table 2 presents the diffusion tube success rate over the twelve month trial period, by location.

Table 2: Diffusion tube success rate over twelve months by location

Distance from traffic Distance from barrier		4.5m -4.5m	8m -1m	9m 0m	10m 1m	14m 5m	19m 10m	24m 15m	29m 20m
Transect	**Height**	**Diffusion tube capture rate (36 = 100%)**							
N1	1.5m	36	36	34	36	35	35	36	35
T1	3m	-	33	23	35	34	36	34	36
	2.25m	-	32	-	35	36	36	36	36
	1.5m	32	32	35	35	35	36	36	35
	0.75m	-	31	36	34	36	35	35	36
T2	3m	-	33	24	35	31	35	35	30
	2.25m	-	33	-	35	36	36	36	35
	1.5m	33	33	35	35	35	36	35	34
	0.75m	-	30	36	36	36	36	35	35
C1	3m	-	32	35	36	36	36	36	36
	2.25m	-	32	-	35	36	36	36	36
	1.5m	33	32	-	36	36	36	36	36
	0.75m	-	32	36	36	36	36	36	36
C2	3m	-	32	35	36	36	36	36	35
	2.25m	-	31	-	36	36	36	35	36
	1.5m	32	32	-	35	36	36	36	35
	0.75m	-	33	33	36	36	36	36	35
S1	1.5m	-	35	35	36	36	34	-	-

2.3 Continuous automatic NO_2 monitoring

Four Teledyne API T200 chemiluminescent NO_2 analysers were deployed on site, each monitor sampling air quality at four locations at five minute intervals. This provided sixteen air quality sampling locations, each sampling for a total of fifteen minutes (3 x 5 minutes) each hour. The locations of the sixteen NO_2 sampling points are illustrated in Figure 5 and listed in Table 3. It can be seen that four comparable sampling locations are located on each of three transects T1, T2, and C1 (Table 3a) to facilitate inter transect comparisons behind the SmogStop® and wooden control barriers. In addition, four sampling locations (Table 3b) are clustered in the immediate vicinity of the SmogStop® barrier on transect T2 to provide additional NO_2 measurements in close proximity to the barrier. NO_2 monitoring data (µg/m^3) were received from National Highways summarised as hourly averages (each monitoring location was in fact sampled for 15 minutes within each hour).

Unfortunately, the chemiluminescent NO_2 analyser at transect C1 failed during the trial. The implications of this failure are discussed further in Section 5.

Over the twelve month trial period, the average data capture success rate for the remaining 12 continuous automatic monitoring locations was 97.7%, varying between 96.3% and 98.4% depending on monitoring location.

No automatic air quality monitoring was installed along transects N1, C2, or S1 due to logistical constraints (for example, availability of suitable power supply).

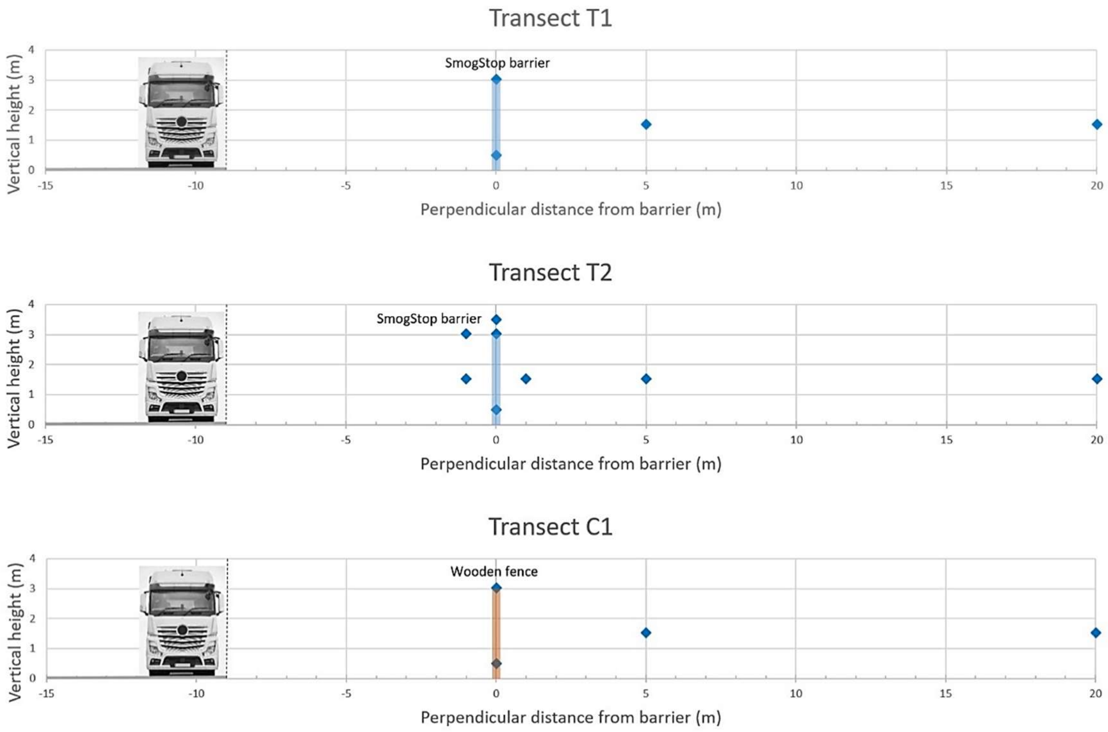

Figure 5: Continuous automatic NO_2 monitoring locations by transect

Table 3: Locations of continuous NO_2 sampling points

a) Inter transect comparisons			
Number	**Transect**	**Perpendicular distance behind barrier (m)**	**Height (m)**
1	T1	0	Barrier inlet @ 3m height
2	T1	0	Barrier outlet @ 0.5m height
3	T1	5m	1.5m
4	T1	20m	1.5m
5	T2	0	Barrier inlet @ 3m height
6	T2	0	Barrier outlet @ 0.5m
7	T2	5m	1.5m
8	T2	20m	1.5m
9	C1	0	Top of barrier @ 3m height
10	C1	0	Behind barrier at 0.5m
11	C1	5m	1.5m
12	C1	20m	1.5m
b) Additional NO_2 measurements around the barrier			
Number	**Transect**	**Perpendicular distance behind barrier (m)**	**Height (m)**
13	T2	-1m (1meter in front of barrier)	3m
14	T2	-1m (1meter in front of barrier)	1.5m
15	T2	0	3.5m (flowing over barrier)
16	T2	1m	1.5m

2.4 Monitoring of ambient wind direction and wind speed

Two temporary anemometers were deployed measuring wind speed and wind direction on the horizontal plane for the duration of the trial, reporting hourly average values:

- Anemometer labelled 'M1' – Located on top of the barrier at transect T2, at a height of 3.5 metres;
- Anemometer labelled 'M4' – Located on a pole approximately 10m to the north of the end of the SmogStop® barrier, at a height of 3.5m;

In addition, wind speed and direction data were available from a permanent National Highways monitoring site (Site 9) located approximately 270 metres to the north east of the SmogStop® barrier, 3.5 metres above ground level (at latitude 53.145223°, longitude -1.328343°). The primary purpose of the permanent Site 9 monitoring station is to provide National Highways with information relevant to highway network management (for example, to inform safety management, weather conditions, gritting operations etc.).

2.5 Monitoring of air flow direction and speed within the SmogStop® barrier

The previous SmogStop® barrier trial implemented in Toronto in 2017/2018 focused on differences in NO_x concentrations between the 'inlet' at the top of the barrier, and the 'outlet' at the bottom of the barrier, due to the action of the photocatalytic coating. However, the actual air flow direction within the barrier can vary depending on factors such as wind direction. For the National Highways trial at Tibshelf, two 2-D sonic anemometers labelled 'M2' and 'M3' were installed 'within' the barrier at transect T2, located between the two acrylic sheets, as illustrated in Figure 6. These were oriented to measure air flow (direction and speed) on a vertical plane (parallel to the barrier walls) within the barrier.

2.6 Motorway traffic flow data

Motorway traffic flow data were obtained from MIDAS (Motorway Incident Detection and Automatic Signalling) inductive loop traffic sensors, providing categorised traffic flow and speed data down to 1 minute time resolution. Site M1/4226A was utilised for northbound traffic, and site M1/4226B for southbound traffic[e]. Generally, traffic flows were aggregated as hourly averages, unless specifically required at higher time resolutions.

[e] See for example traffic data available at https://webtris.highwaysengland.co.uk/

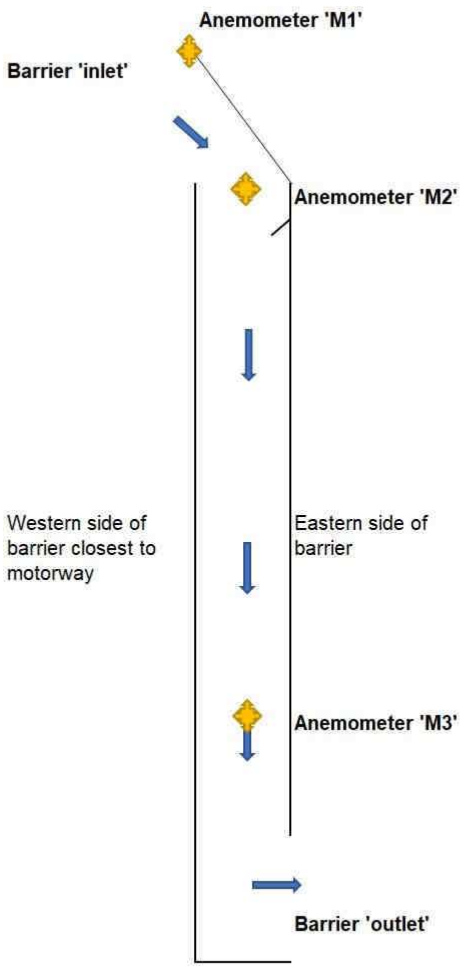

Figure 6: Location of anemometers 'M2' and 'M3' within the SmogStop® barrier at transect T2

3. Ambient trial conditions

3.1 Wind direction

Wind direction has initially been aggregated at two levels of resolution, (a) using 90 degree sectors, and (b) using 45 degree sectors. The annual results aggregating to 90 degrees sectors are presented in Table 4, whereas the results aggregating to 45 degree sectors are presented in Table 5.

From the data set, it was observed that site M4 recorded no data for wind from between 318 degrees and 39 degrees, i.e. from the north. It is possible that results at site M4 may have been influenced by the proximity of trees located immediately to the north. It is also observed that the results across the three monitoring sites are highly variable. It was therefore decided to use wind direction data from permanent site 9 to categorise the NO_2 data with respect to ambient wind direction. Site 9 indicates that there were 1256 hours (14.3%) when the wind was blowing from the west (between 226 and 315 degrees), i.e. from the motorway and across the SmogStop® and wooden control barriers. Overall, it should be noted that the prevailing wind direction over the twelve month period was from the SSW and SW, with an overall mean wind speed of 1.9m/s.

Figure 7 presents the average wind direction and wind speed data at Site 9 for the twelve month period September 2020 to August 2021 in the form of a wind rose, with the data being disaggregated into a higher number of directional segments. Again, it can be seen that the prevailing wind direction was from the SSW and SW.

Table 4: Wind direction data subdivided by 90 degree sectors (September 2020 to August 2021)

Direction (from)	**Direction degrees**	**Site M1 % (hours)**	**Site M4 % (hours)**	**Site 9 % (hours)**
North	316 to 45	31.9% (2791)	0.7% (62)	30.2% (2645)
East	46 to 135	35.7% (3129)	28.2% (2468)	8.8% (769)
South	136 to 225	27.5% (2412)	47.8% (4186)	46.0% (4028)
West	226 to 315	3.1% (268)	18.5% (1617)	14.3% (1256)
No data		1.8% (160)	4.8% (427)	0.7% (62)
Total		100% (8760)	100% (8760)	100% (8760)

Table 5: Wind direction data subdivided by 45 degree sectors (September 2020 to August 2021)

Direction (from)	**Direction degrees**	**Site M1 % (hours)**	**Site M4 % (hours)**	**Site 9 % (hours)**
North	338 to 22	10.9% (957)	No data	20.1% (1757)
North east	23 to 67	32.9% (2879)	10.3% (906)	11.8% (1029)
East	68 to 112	15.4% (1346)	12.9% (1128)	2.9% (256)
South east	113 to 157	14.7% (1289)	11.4% (995)	2.6% (229)
South	158 to 202	18.2% (1596)	19.8% (1736)	24.8% (2170)
South west	203 to 247	3.1% (271)	31.5% (2762)	28.5% (2499)
West	248 to 292	1.4% (126)	7.9% (692)	3.7% (324)
North west	293 to 337	1.6% (136)	1.3% (114)	4.9% (434)
No data		1.8% (160)	4.9% (427)	0.7% (62)
Total		100% (8760)	100% (8760)	100% (8760)

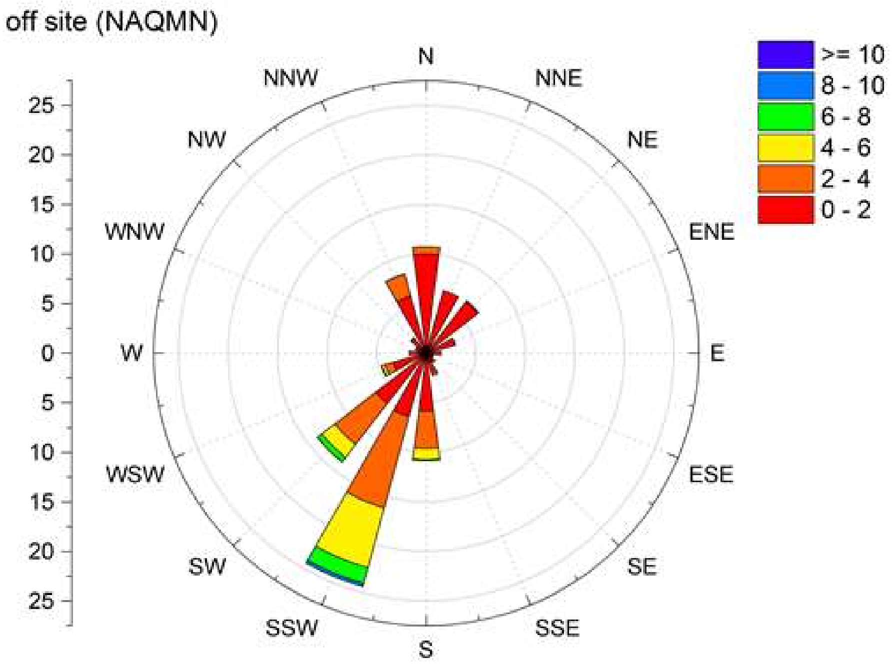

Figure 7: M1 Tibshelf National Highways Site 09 wind direction and speed (September 2020 to August 2021)

3.2 Solar radiation

The SmogStop® technology relies on radiation in the visible and ultra-violet spectrum to drive the photocatalytic reduction of NO_x passing through the SmogStop® barrier, to nitrogen gas (N_2) and oxygen gas (O_2). There is no street lighting on this section of the M1 motorway, so the photocatalytic reaction will depend primarily on solar radiation.

Solar radiation data were obtained from the NASA POWER project website. Solar insolation (Global Horizontal Irradiance; W/m^{-2}) was acquired and used to plot a bar chart of the power received per day and a bar chart of the daylight and night time hours, as illustrated in Figure 8.

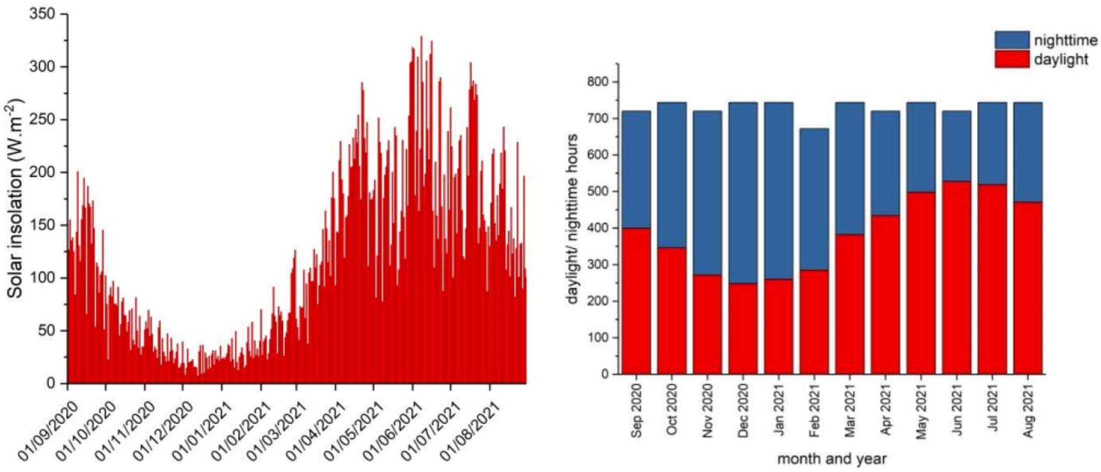

Figure 8: Solar insolation and daylight / night time hours

3.3 Motorway traffic flow

Traffic flow data were obtained from MIDAS site M1/4226A (northbound) and M1/4226B (southbound). MIDAS (Motorway Incident Detection and Automatic Signalling) generally uses inductive loop traffic sensor technology, providing categorised traffic flow and speed data by lane. Heavy duty vehicles (HDV's) which include heavy goods vehicles and buses/coaches are inferred based on vehicle length (>6.6 metres). Figure 9 presents the average daily two way traffic flow on the M1 at Tibshelf for the period August 2019 to October 2021. The impact of the various stages of Covid-19 'lockdown' can be seen in the data. Flows of heavy goods vehicles are relatively stable during this period, but flows of light vehicles are seen to be more sensitive to 'lockdown'. Two way traffic flows in the scheme assessment period (September 2020 to August 2021) are on average about 100,000 vehicles per day, which compares with approximately 123,000 vehicles per day in the pre-Covid period in the previous year (August 2019 to February 2020), i.e. approximately 19% lower. However, by June 2021, traffic flows had returned to near pre-Covid levels.

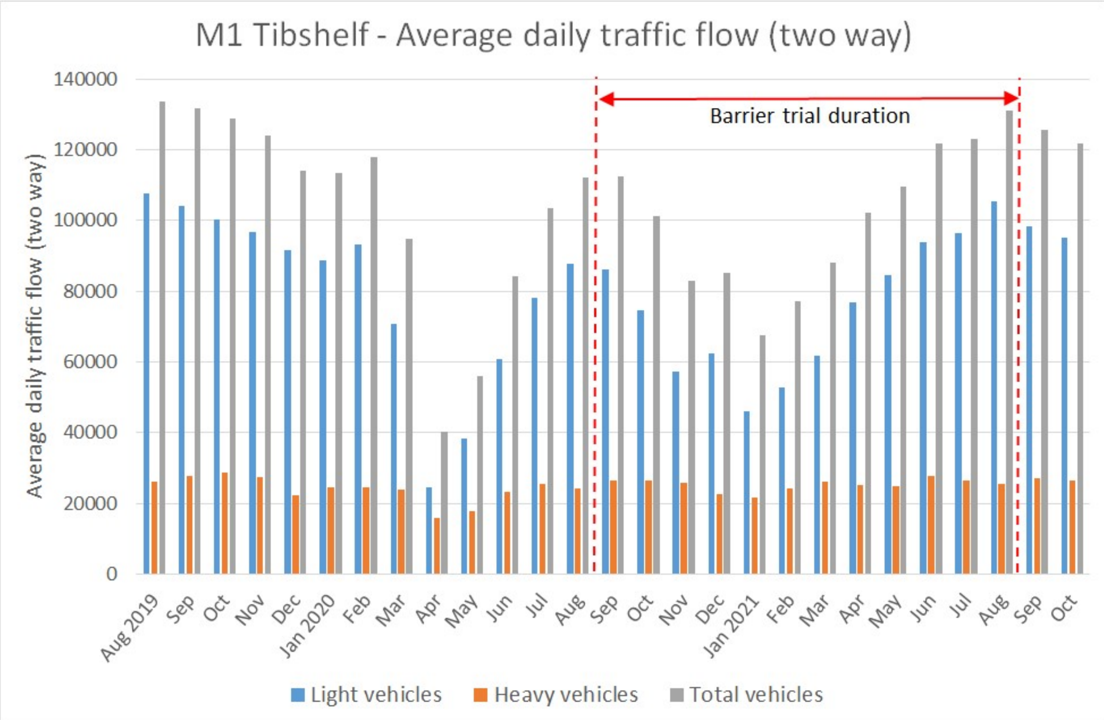

Figure 9: M1 Tibshelf – Average daily traffic flow (two way)

4. Diffusion tube results

4.1 Raw data

4.1.1 Overview

Diffusion tubes were installed at locations across the trial site during the assessment period, recording mean NO_2 concentrations on a monthly basis. Diffusion tubes were deployed in front of and behind the barriers on four transects T1, T2, C1, and C2, as presented in Table 1 and Figure 4. In addition, diffusion tubes were deployed along transects N1 and S1 (to the north and south of the barriers), which are located beyond the ends of the barrier fences, and so were directly exposed to vehicle generated air pollution from the motorway.

A subset of diffusion tubes were co-located with the continuous hourly automatic NO_2 monitoring on transects T1, T2, and C1 at 5 metres and 20 metres behind the barriers, which permitted comparison of the measured NO_2 values from the two measurement techniques.

The diffusion tubes were changed on a monthly basis in line with standard UK practice. With monthly diffusion tube data, it is not possible to disaggregate data by wind direction. The measured NO_2 concentrations data will therefore be influenced by the prevailing wind direction during the assessment period (from September 2020 to August 2021), as illustrated by the wind rose in Figure 7. It can be seen from Figure 7 that the wind during the assessment period, as measured at Site 09, is predominantly from the SSW.

The diffusion tube results have been presented as annual mean NO_2 $\mu g/m^3$ values (September 2020 to August 2021). The annual mean is the key metric for National Highways air quality appraisal, UK legislation requiring that the annual mean NO_2 value may not exceed 40 micrograms per cubic metre ($\mu g/m^3$). Where error bars are included in the results, these represent the calculated 95% confidence intervals about the mean values.

For sample sizes of 30 or more:

$$\text{Lower boundary of confidence interval} = \overline{\mathrm{X}} - (1.96 \times SE)$$
$$\text{Upper boundary of confidence interval} = \overline{\mathrm{X}} + (1.96 \times SE)$$

Where: $\bar{X}$ is the value of the mean
1.96 is the critical value of z-score from the normal distribution[f]
SE is the standard error

For sample sizes less than 30:

$$\text{Lower boundary of confidence interval} = \overline{\mathrm{X}} - (t_{n-1} \times SE)$$
$$\text{Upper boundary of confidence interval} = \overline{\mathrm{X}} + (t_{n-1} \times SE)$$

Where: $\bar{X}$ is the value of the mean
n-1 is the degrees of freedom (i.e. sample size – 1)
t is the value of the *t-distribution* for a two-tailed test with probability of 0.05
SE is the standard error

[f] From the *central limit theorem*, we know that in large samples (above about 30) the sampling distribution tends to be normally distributed (Reference: Discovering statistics using R. Andy Field, Jeremy Miles & Zoë Field. Sage Publications Ltd., 2012).

4.1.2 Barrier vs no-barrier comparison

The comparison of the 'barrier' vs 'no-barrier' performance in terms of reduction in NO_2 concentrations behind the barrier can only be carried out at a vertical height of 1.5m because diffusion tube data were only collected at the 'no-barrier' transects N1 and S1 at this height.

Figure 10 presents a contour plot in plan view of the measured annual mean NO_2 concentrations at 1.5m vertical height for the entire trial site, including transects N1, T1, T2, C1, C2, and S1. Figure 11 presents the same data as a line graph, with annual mean NO_2 concentrations at 1.5m vertical height plotted on the 'y' axis, and lateral distance from the barrier plotted on the 'x' axis (error bars indicate 95% confidence intervals about the mean values). Figure 12 and Figure 13 present the data as bar charts, grouped by transect and by perpendicular distance from the barrier respectively. The annual mean NO_2 µg/m^3 values and associated 95% confidence intervals are presented in tabular form in Annex 2.

It can be seen that measured NO_2 concentrations in front of the barriers 4.5 metres from the traffic stream at a height of 1.5 metres vary between 56.0 and 61.5 µg/m^3, whereas values behind the barriers (transects T1, T2, C1, and C2) are reduced significantly, with a slightly sharper reduction immediately behind the SmogStop® barrier. For example, at 5 metres behind the barrier, NO_2 concentrations vary between 34.2 and 37.1 µg/m^3, whereas at 10 metres behind the barrier, NO_2 concentrations vary between 33.3 and 34.7 µg/m^3. However, it can be seen from Figure 13 that such variation tends to fall within the bounds of the calculated 95% confidence intervals about the mean values (i.e. the calculated confidence intervals overlap).

It is clear when comparing the NO_2 concentrations in front of the barriers with those behind the barriers on both transects T1 and T2, and transects C1 and C2, that there is a step change reduction of around 29% between measurement locations 1 metre in front of the barriers, and 1 metre behind the barriers. This is visible in the data at all measurement heights (0.75, 1.5, 2.25 and 3 metres, although at a height of 3 metres the reduction is slightly less at around 26%).

On transects N1 and S1 (without the barriers), the comparable reduction at a height of 1.5 metres is of the order of 13% (circa 6.2 µg/m^3), which suggests that the barriers are responsible for a reduction of around 16% (circa 8.4 µg/m^3) in NO_2 concentrations (1 metre in front of the barriers versus 1 metre behind the barriers). These calculations are in the context of prevailing wind conditions at the Tibshelf site during the trial period (see Section 3.1).

The other notable feature in Figure 12 is the difference in the rate of change (gradient) in NO_2 concentration with respect to distance from the carriageway, comparing barrier transects (T1, T2, C1, and C2) versus no barrier transects (N1 and S1). The 'no barrier' transects exhibit a gradual reduction in NO_2 concentration with respect to distance from the carriageway, whilst the 'barrier' transects exhibit a clear step change reduction due to the presence of the barrier (both SmogStop® and wooden control barrier).

However, it can be seen from Figure 13 that the difference between 'barrier' and 'no barrier' is significantly diminished at a distance of 5 metres behind the barrier. Indeed, at 5 metres behind the barrier, all of the 95% confidence intervals about the mean NO_2 values overlap, suggesting that there is likely to be little statistically significant difference between 'barrier' and 'no barrier' in the raw data.

The effect of perpendicular distance beyond 5 metres behind the barriers is similar across all transects, both barrier (T1, T2, C1, and C2), and non-barrier (N1 and S1). Mean NO_2 concentrations 20 metres behind the barriers (both with and without a barrier) tend to be between 10 - 15% lower than at 5 metres behind the barriers.

It is concluded that the effect of either barrier (SmogStop® and wooden control fence) is visible in the data to a perpendicular distance of 5 – 10 metres behind the barriers, but there is likely to be no statistically significant difference between ‘barrier’ and ‘no barrier’ beyond 5 metres behind the barriers. See Annex 3 for independent *t-test* results.

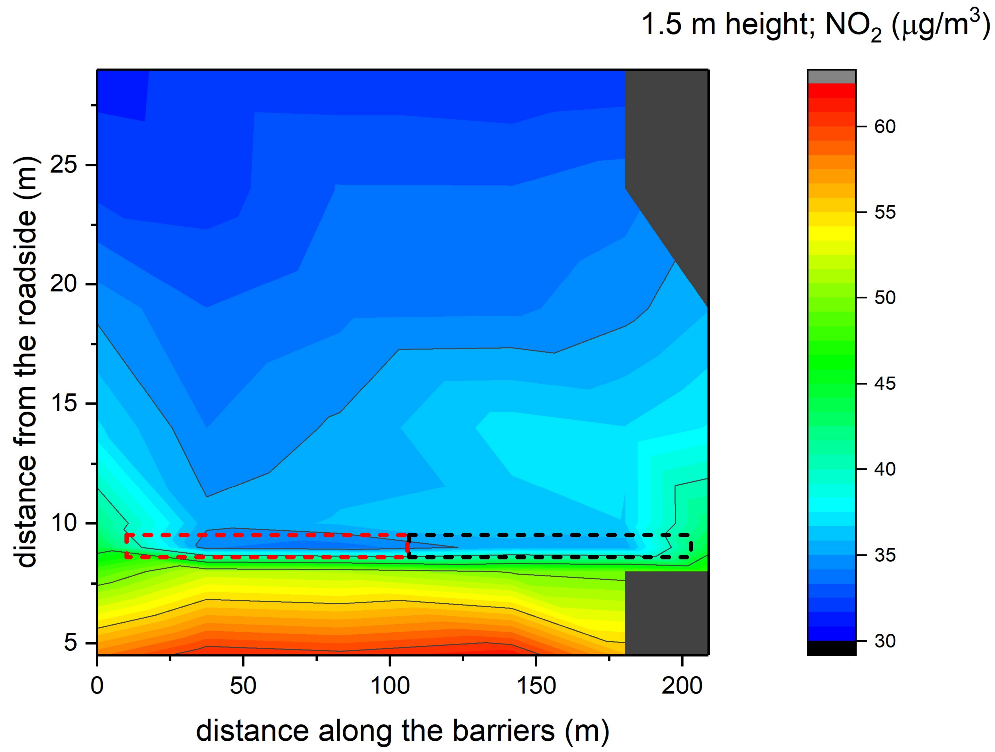

Figure 10: Diffusion tube contour plot (annual mean NO_2 µg/m^3) at 1.5m height (plan view). 'SmogStop®' barrier shown as red dotted line; wooden control barrier shown as black dotted line. Linear interpolation applied between measurement locations.

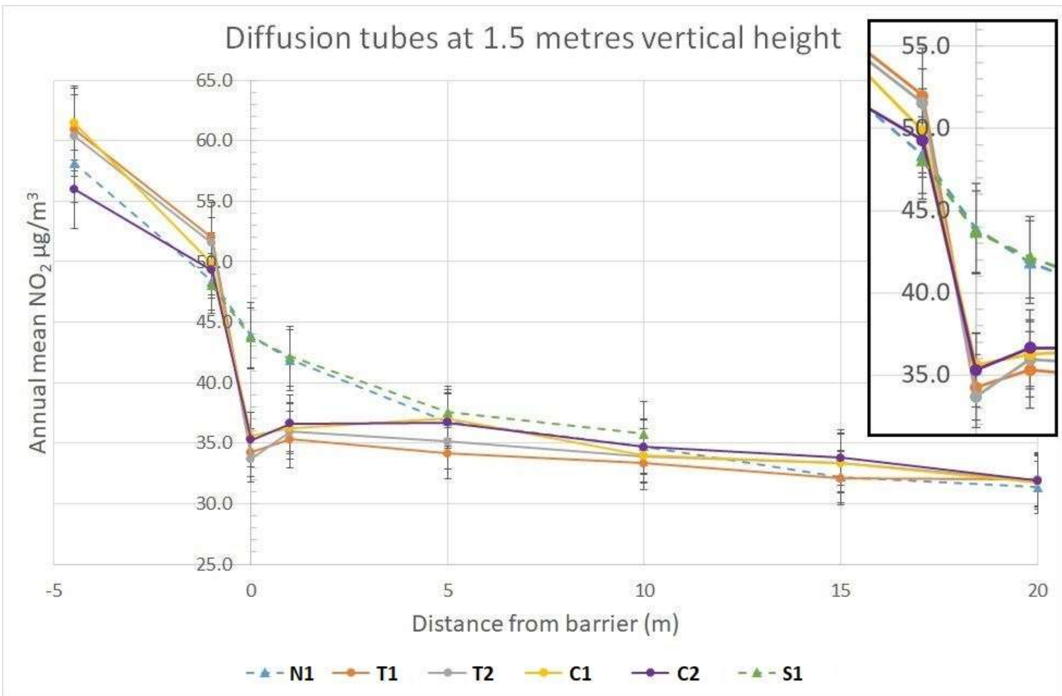

Figure 11: Annual mean diffusion tube NO_2 µg/m^3 at 1.5m height, by transect and distance from barrier. Transects N1 & S1 (no barrier); T1 & T2 (SmogStop® barrier); C1 & C2 (wooden fence barrier).

4.1.3 Difference in performance between SmogStop® barrier and wooden fence barrier

Figure 14, Figure 15, and Figure 16 present the observed annual mean NO_2 concentrations at vertical heights of 0.75m, 2.25m, and 3m respectively. The data are presented as bar charts, grouped by perpendicular distance from the barrier.

With reference to Annex 2 and Figure 13, Figure 14, Figure 15, and Figure 16, considering the distances 1 metre, 5 metres, and 10 metres behind the barriers, it can be seen that there is an overall tendency for the average NO_2 concentrations measured behind the wooden control barrier to be marginally higher than behind the SmogStop® barrier (differences in the range -0.2 to +2.2µg/m^3, with an overall mean difference of approximately +1.2µg/m^3). The direction of the effect is reasonably consistent across the majority of measurements. However, the observed differences in annual mean NO_2 concentrations all fall within the calculated 95% confidence intervals about the mean values. This suggests that there is a small difference in performance of the two barrier technologies. Such small differences may or may not be important for a particular scheme implementation, depending on local circumstances and objectives. See Annex 3 for independent *t-test* results.

An alternative approach is to consider the changes in NO_2 concentrations behind the barriers relative to the NO_2 concentrations 1 metre in front of the barriers, by transect.

Table 6 to Table 9 inclusive present the percentage differences at vertical heights of 3m, 2.25m, 1.5m, and 0.75m respectively. The main point to note in these tables is that the differences in percentage reduction are driven by the differences in NO_2 concentrations at 1 metre in front of the barrier. It should also be noted that the differences in NO_2 concentrations at 1 metre in front of the barrier at transects T1, T2, C1, and C2 all fall within the overlapping 95% confidence intervals, as can be seen for example in Figure 13.

Finally, Figure 17 presents contour plots on the vertical axis at each transect, T1, T2, C1, and C2 respectively. These figures help to illustrate the changes in annual mean NO_2 concentrations at each transect with respect to both distance from the roadside and vertical height. The significant reduction in NO_2 concentrations immediately behind both barriers is again clear. There is a suggestion in the graphs of slightly higher NO_2 concentrations between 2.25m and 3m vertical height at C1 and C2 relative to T1 and T2, up to around 5m behind the barriers. However, the differences in annual mean NO_2 concentrations between the two barrier technologies are not statistically significant using t-tests ($p > 0.05$), and all fall within the calculated 95% confidence intervals.

4.1.4 Longitudinal variation along the motorway

As noted above, there is observed variation in NO_2 concentrations in front of the barriers, by transect, along the trial site from N1 in the north to S1 in the south. This can be seen at both 4.5m in front of the barriers and at 1m in front of the barriers in Figure 12 to Figure 16 inclusive. The observed differences in annual mean NO_2 concentrations between transects in front of the barriers, at -4.5 metres and -1 metre, are up to 5.5µg/m^3 and 4.0µg/m^3 respectively i.e. the longitudinal differences in NO_2 concentrations along the motorway in front of the barriers are potentially as large as the lateral differences behind the barriers. However, in the raw data set these differences all fall within the calculated 95% confidence intervals. See section 4.2.5 for further discussion.

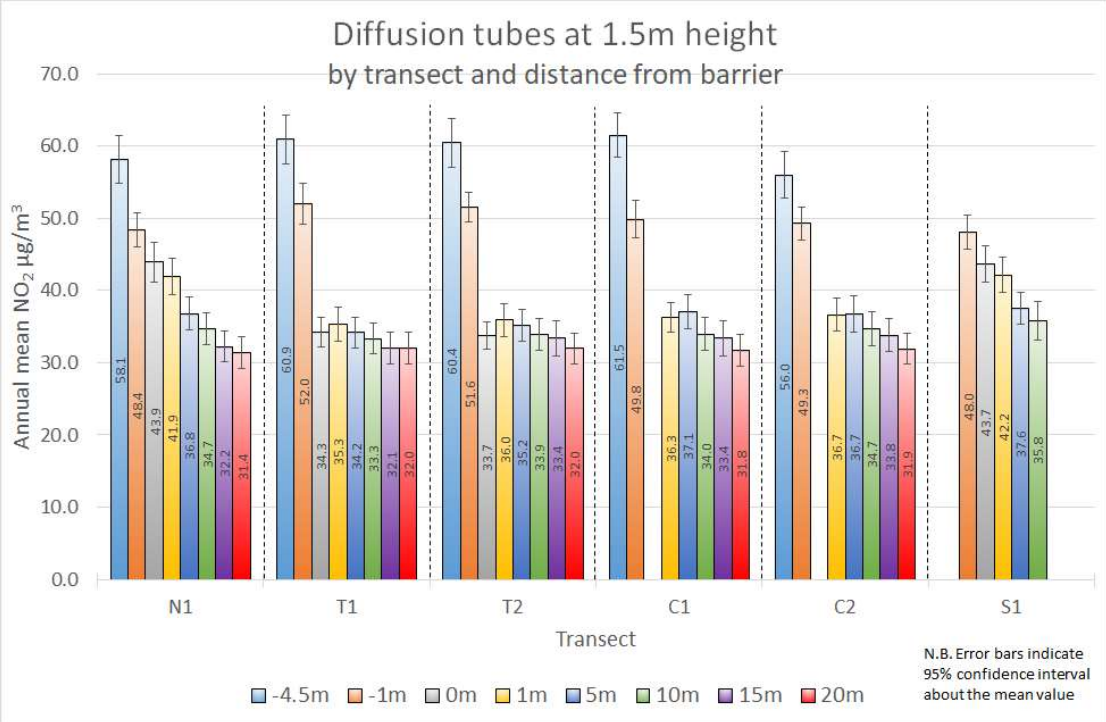

Figure 12: Annual mean diffusion tube NO_2 µg/m^3 at 1.5m height – September 2020 to August 2021. By transect and distance from barrier.

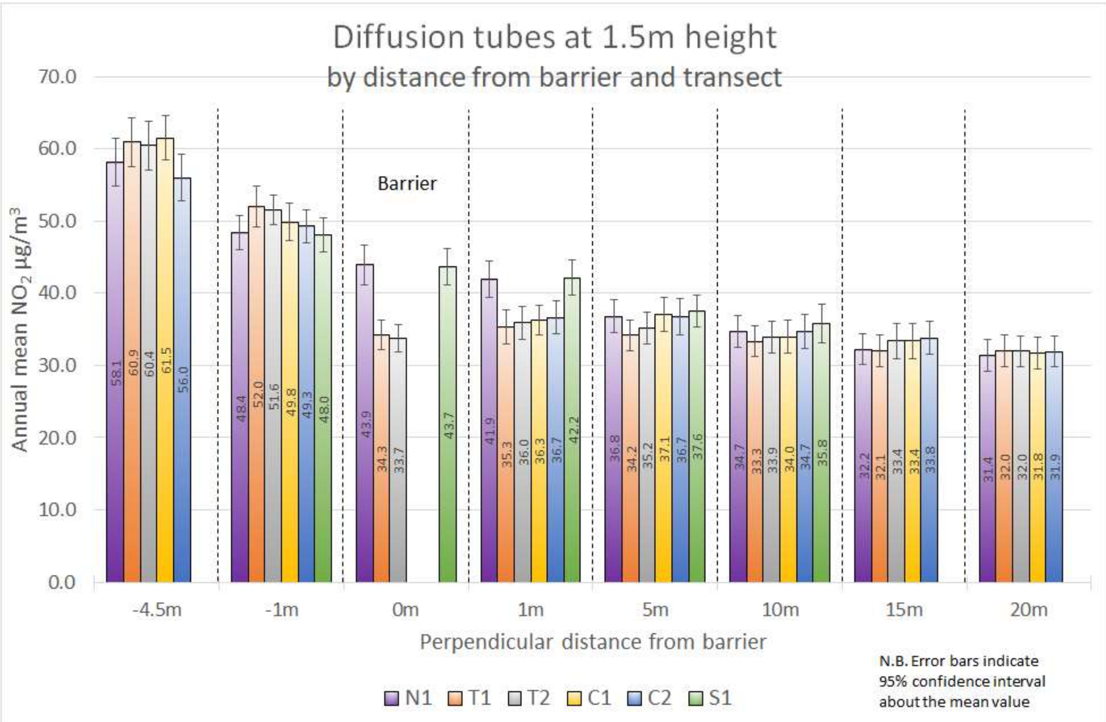

Figure 13: Annual mean diffusion tube NO_2 µg/m^3 at 1.5m height – September 2020 to August 2021. By distance from barrier and transect.

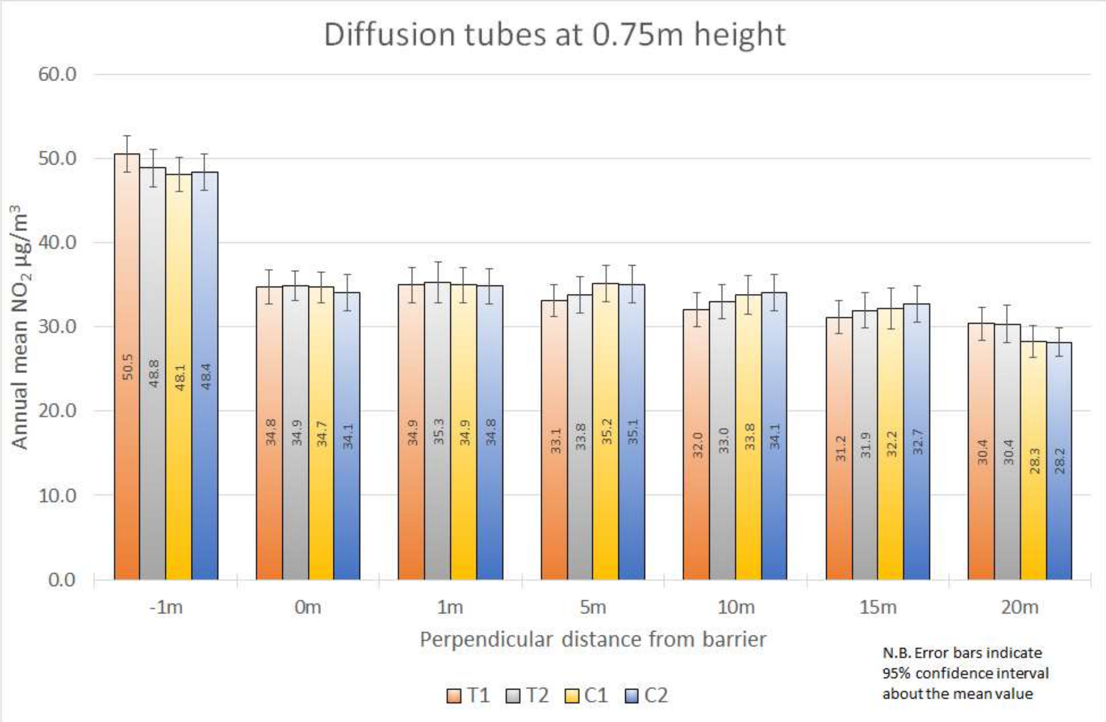

Figure 14: Annual mean diffusion tube NO_2 µg/m^3 at 0.75m height – September 2020 to August 2021. By distance from barrier and transect.

Figure 15: Annual mean diffusion tube NO_2 µg/m^3 at 2.25m height – September 2020 to August 2021. By distance from barrier and transect.

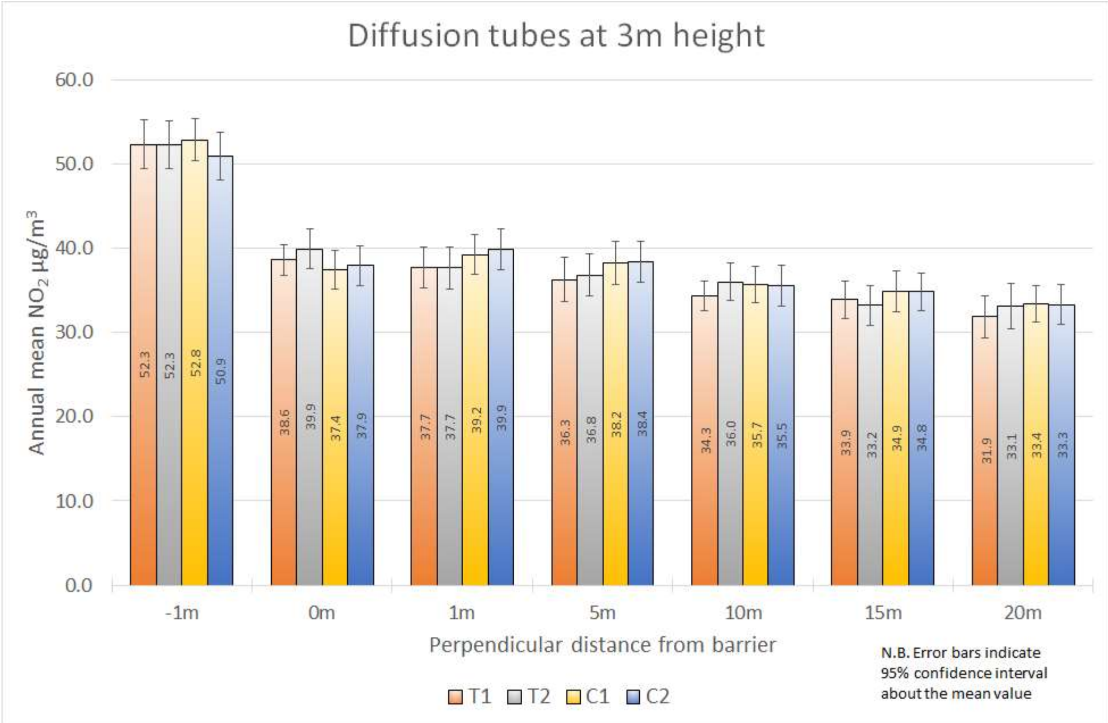

Figure 16: Annual mean diffusion tube NO_2 µg/m³ at 3m height – September 2020 to August 2021. By distance from barrier and transect.

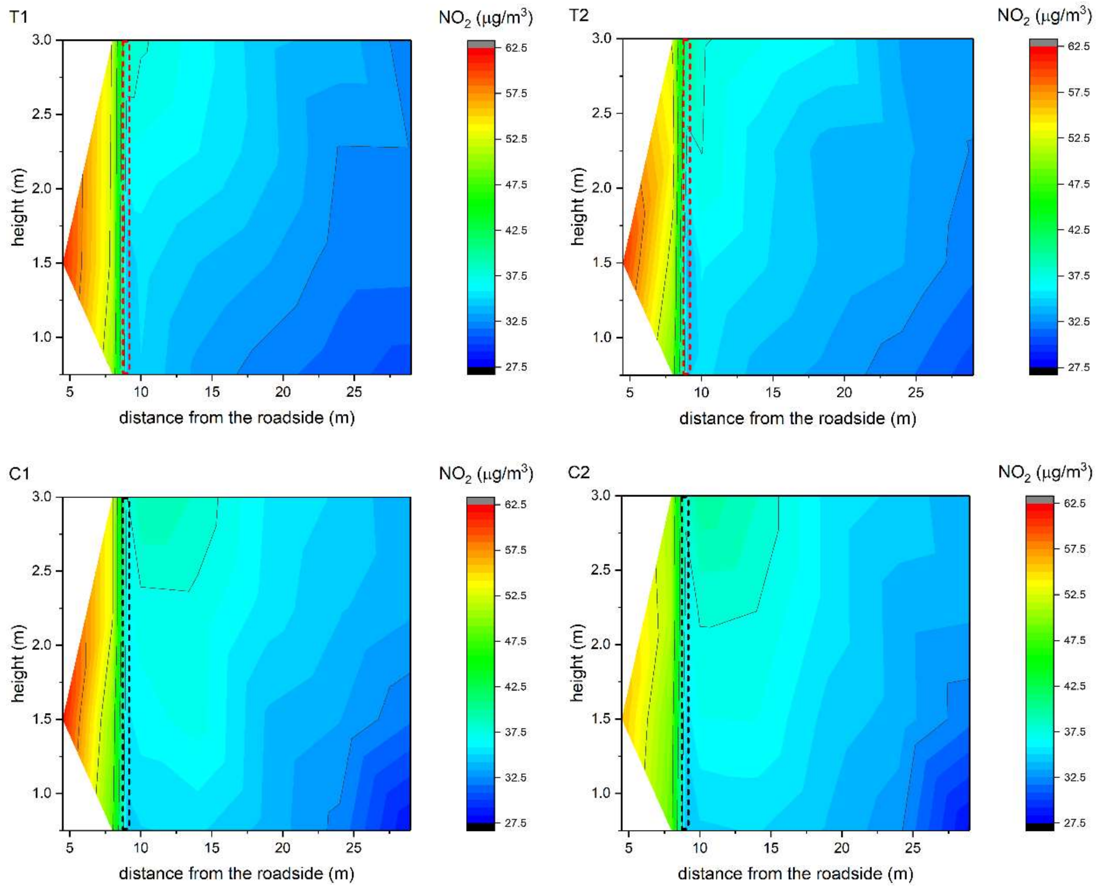

Figure 17: Diffusion tube vertical contour plots (annual mean NO_2 µg/m^3) at transects T1, T2, C1 & C2. Linear interpolation applied between measurement locations.

Table 6: Percentage reduction in NO_2 concentration by transect, relative to 1m in front of barrier. Height = 3m.

Dist. from traffic		8m	9m	10m		14m		19m		24m		29m	
Dist. from barrier		-1m	0m	1m		5m		10m		15m		20m	
		Annual mean		Annual mean	%	Annual mean	%	Annual mean	%	Annual mean	%	Annual mean	%
Transect	Height	NO_2 µg/m^3		NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction
N1	3m	-		-		-		-		-		-	
T1	3m	**52.3**		37.7	*-28%*	36.3	*-31%*	34.3	*-34%*	33.9	*-35%*	31.9	*-39%*
T2	3m	**52.3**		37.7	*-28%*	36.8	*-30%*	36.0	*-31%*	33.2	*-36%*	33.1	*-37%*
C1	3m	**52.8**		39.2	*-26%*	38.2	*-28%*	35.7	*-32%*	34.9	*-34%*	33.4	*-37%*
C2	3m	**50.9**		39.9	*-22%*	38.4	*-25%*	35.5	*-30%*	34.8	*-32%*	33.3	*-35%*
S1	3m	-		-		-		-		-		-	

Table 7: Percentage reduction in NO_2 concentration by transect, relative to 1m in front of barrier. Height = 2.25m.

Dist. from traffic		8m	9m	10m		14m		19m		24m		29m	
Dist. from barrier		-1m	0m	1m		5m		10m		15m		20m	
		Annual mean		Annual mean	%	Annual mean	%	Annual mean	%	Annual mean	%	Annual mean	%
Transect	Height	NO_2 µg/m^3		NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction
N1	2.25m	-		-		-		-		-		-	
T1	2.25m	**52.1**		36.5	*-30%*	35.9	*-31%*	34.4	*-34%*	32.4	*-38%*	32.5	*-38%*
T2	2.25m	**53.8**		37.5	*-30%*	35.4	*-34%*	33.7	*-37%*	33.5	*-38%*	32.4	*-40%*
C1	2.25m	**52.9**		37.1	*-30%*	37.2	*-30%*	35.4	*-33%*	34.3	*-35%*	33.5	*-37%*
C2	2.25m	**51.3**		37.7	*-27%*	37.5	*-27%*	35.5	*-31%*	33.7	*-34%*	33.6	*-35%*
S1	2.25m	-		-		-		-		-		-	

Table 8: Percentage reduction in NO_2 concentration by transect, relative to 1m in front of barrier. Height = 1.5m.

Dist. from traffic		8m	9m	10m		14m		19m		24m		29m	
Dist. from barrier		-1m	0m	1m		5m		10m		15m		20m	
		Annual mean		Annual mean	%	Annual mean	%	Annual mean	%	Annual mean	%	Annual mean	%
Transect	Height	NO_2 µg/m^3		NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction
N1	1.5m	**48.4**		41.9	*-13%*	36.8	*-24%*	34.7	*-28%*	32.2	*-33%*	31.4	*-35%*
T1	1.5m	**52.0**		35.3	*-32%*	34.2	*-34%*	33.3	*-36%*	32.1	*-38%*	32.0	*-38%*
T2	1.5m	**51.6**		36.0	*-30%*	35.2	*-32%*	33.9	*-34%*	33.4	*-35%*	32.0	*-38%*
C1	1.5m	**49.8**		36.3	*-27%*	37.1	*-26%*	34.0	*-32%*	33.4	*-33%*	31.8	*-36%*
C2	1.5m	**49.3**		36.7	*-26%*	36.7	*-26%*	34.7	*-30%*	33.8	*-31%*	31.9	*-35%*
S1	1.5m	**48.0**		42.2	*-12%*	37.6	*-22%*	35.8	*-25%*				

Table 9: Percentage reduction in NO_2 concentration by transect, relative to 1m in front of barrier. Height = 0.75m.

Dist. from traffic		8m	9m	10m		14m		19m		24m		29m	
Dist. from barrier		-1m	0m	1m		5m		10m		15m		20m	
		Annual mean		Annual mean	%	Annual mean	%	Annual mean	%	Annual mean	%	Annual mean	%
Transect	Height	NO_2 µg/m^3		NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction	NO_2 µg/m^3	reduction
N1	0.75m	-		-	-	-	-	-	-	-	-	-	-
T1	0.75m	**50.5**		34.9	*-31%*	33.1	*-35%*	32.0	*-37%*	31.2	*-38%*	30.4	*-40%*
T2	0.75m	**48.8**		35.3	*-28%*	33.8	*-31%*	33.0	*-32%*	31.9	*-35%*	30.4	*-38%*
C1	0.75m	**48.1**		34.9	*-27%*	35.2	*-27%*	33.8	*-30%*	32.2	*-33%*	28.3	*-41%*
C2	0.75m	**48.4**		34.8	*-28%*	35.1	*-28%*	34.1	*-30%*	32.7	*-32%*	28.2	*-42%*
S1	0.75m	-		-		-		-		-		-	

4.2 De-seasonalised data

4.2.1 Overview

The raw NO_2 data presented in section 4.1 includes seasonal variation which will have an influence on the calculation of measures of variability such as the standard deviation, which will in turn influence the calculation of confidence intervals around the calculated mean values. Seasonal variation in NO_2 concentrations will be influenced by factors such as ambient temperature and weather conditions in different seasons, consequent impacts on vehicle emissions and atmospheric chemistry, and other factors such as variation in traffic flow. It is possible to remove these 'seasonal' effects by applying a simple de-seasonalisation adjustment, to obtain 'de-seasonalised' values. The de-seasonalised values will exhibit reduced variability, and smaller standard deviations associated with the annual mean values. The following simple approach is adopted:

(a) Calculate a mean NO_2 value over all available diffusion tube data (from 123 x 3 = 369 data values) for each month (Sep 2020 to Aug 2021 inclusive);

Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
42.3	41.3	47.0	36.9	40.5	36.6	42.3	21.0	38.4	31.2	36.2	41.1

(b) Calculate a mean NO_2 value over all available diffusion tube data (from 123 x 3 x 12 = 4428 data values). This gives a value **of 38.0 µg/m^3**;

(c) Divide the result of (b) by the result of (a) for each month, to obtain a set of de-seasonalisation factors;

Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
0.90	0.92	0.81	1.03	0.94	1.04	0.90	1.81	0.99	1.22	1.05	0.92

(d) Apply these de-seasonalisation factors to the raw NO_2 diffusion tube concentration data, to obtain de-seasonalised values.

The above approach works well when the monthly diffusion tube data sets are reasonably complete. It works less well when there are significant gaps in the monthly data sets at particular locations, which can then result in distortions. With reference to Table 2, the diffusion tube data at measurement locations behind the barriers are generally complete, with most measurement locations having 35 or 36 observations (out of a possible maximum of 36). In front of the barrier, most measurement locations have 32 or more observations (out of a possible maximum of 36). The two measurement locations which have significant data gaps are at:

- Transect T1, at the barrier, at a height of 3 metres (23 observations), and;
- Transect T2, at the barrier, at a height of 3 metres (24 observations).

Consequently, care should be taken when interpreting calculated annual mean NO_2 diffusion tube results from these two locations (both raw data and de-seasonalised data).

4.2.2 De-seasonalised results

Figure 18 to Figure 22 inclusive present the de-seasonalised annual mean NO_2 diffusion tube data, comparable with the raw unadjusted results previously presented in Figure 12 to Figure 16. The de-seasonalised data is presented in tabular form in Annex 4. It can be seen that the annual mean NO_2 values are essentially the same. The only significant difference is that the error bars representing the 95% confidence intervals have been reduced in size. The consequence of this change is that some differences in annual mean NO_2 concentrations (e.g. SmogStop® barrier vs wooden fence barrier) which were not likely to be statistically significant in the raw data, may become statistically significant in the de-seasonalised data.

This issue has been explored in more detail by calculating the absolute and percentage differences between the annual mean NO_2 concentrations behind the SmogStop® barrier (at transects T1 and T2), and the annual mean NO_2 concentrations behind the wooden fence barrier (at transects C1 and C2).

In addition to the calculated confidence intervals, a Welch independent t- test has also been implemented for each comparison. The t- test is used to determine if the means of the two sets of data are statistically significantly different from each other. The Welch formulation of the t-test was used because (a) there is variation in sample size by monitoring location, and (b) with triplicate diffusion tube data at each monitoring location, it is not possible to define corresponding 'pairs' of data (multiple permutations are possible).

For each reported t-test, the following information is presented:

- Mean – The calculated annual mean NO_2 concentration (μg/m^3);
- SE – The standard error (SE) provides an indication of the variability between sample means;
- *t*-statistic – If the experiment results in an effect, we would expect that the *t*-statistic would be at least 1. For example, where the *t*-statistic is positive, the mean control NO_2 value (C1 or C2) is larger than the test value (T1 or T2). Where the *t*-statistic is negative, the mean control NO_2 value (C1) is smaller than the test value (T1 or T2);
- df – Degrees of freedom;
- *p* value – The significance (probability value). In this case a two tailed (non-directional) significance value of 0.05 is adopted. If $p < 0.05$ we reject the null hypothesis of no difference (i.e. there is a statistically significant difference). If $p > 0.05$, we accept the null hypothesis of no difference (i.e. there is no statistically significant difference);
- *r* – It is possible for a difference to be statistically significant, but in practice very small (or for a difference to be in practice large, but statistically insignificant). For this reason, we also calculate an 'effect size', in this case using: $r = \sqrt{(\frac{t^2}{t^2+df})}$ [g]. Calculating an effect size allows us to move beyond the binary assessment of statistically significant / insignificant, and quantify a standardised size of the effect. This is important because the *p* value is a function of both the size of the effect **and** the sample size, so a small effect with a large sample size will tend to be statistically significant ($p < 0.05$). Cohen (1988)[h] suggests an r value of 0.10 is a 'small' effect, 0.30 a 'medium' effect, and 0.50 a 'large' effect. Note that 'r' is not measured on a linear scale.

For comparison, the results of Welch *t-tests* based on the raw annual mean diffusion tube results (i.e. pre de-seasonalisation) are presented in Annex 3.

[g] Field A.; Miles J.; and Field Z. (2012). Discovering statistics using R. SAGE Publications Ltd.
[h] Cohen, J. (1988). Statistical power analysis for the behavioural sciences (2nd edition). New York: Academic Press.

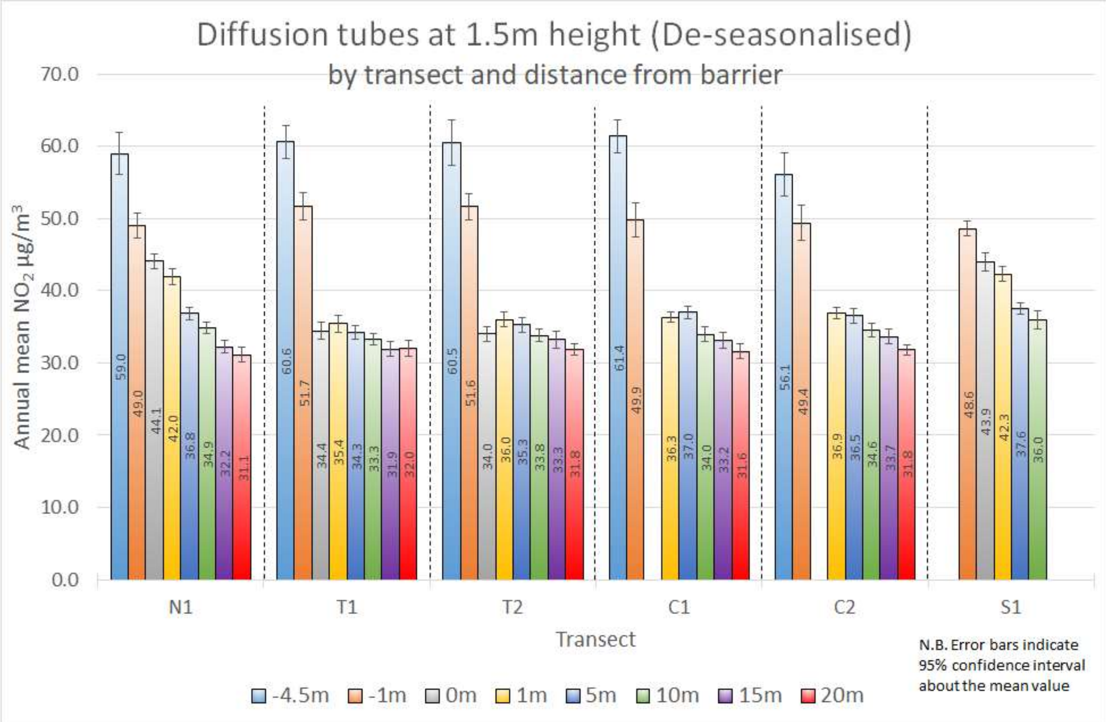

Figure 18: Annual mean diffusion tube NO_2 µg/m^3 at 1.5m height. By transect and distance from barrier. De-seasonalised data.

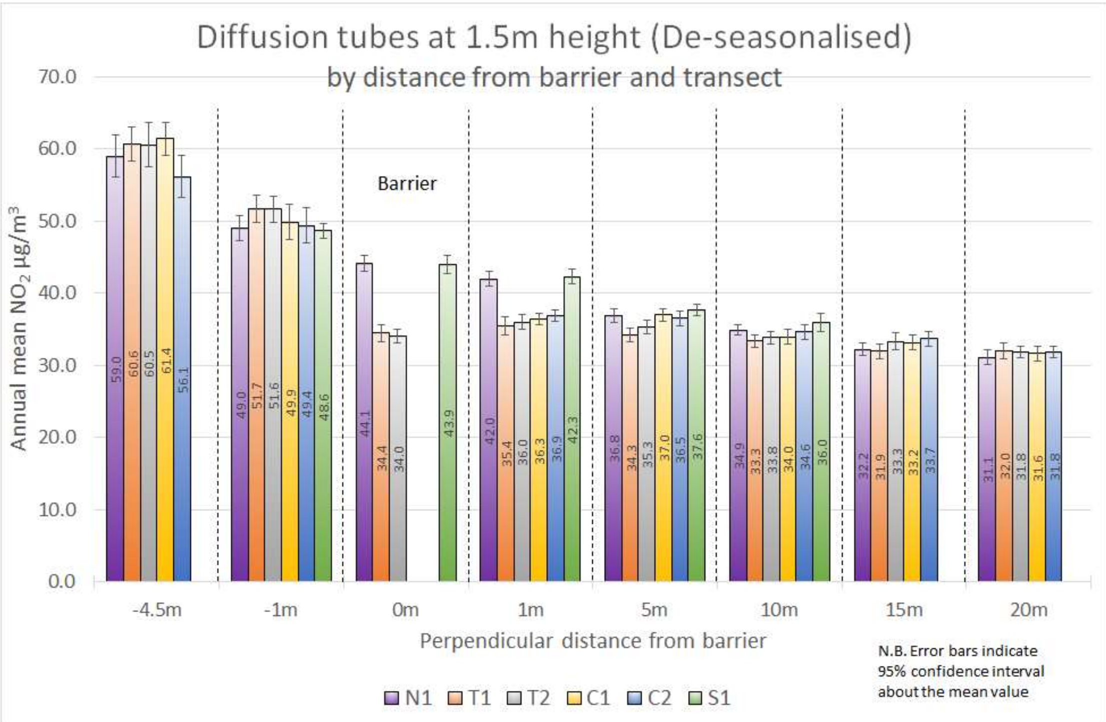

Figure 19: Annual mean diffusion tube NO_2 µg/m^3 at 1.5m height. By distance from barrier and transect. De-seasonalised data.

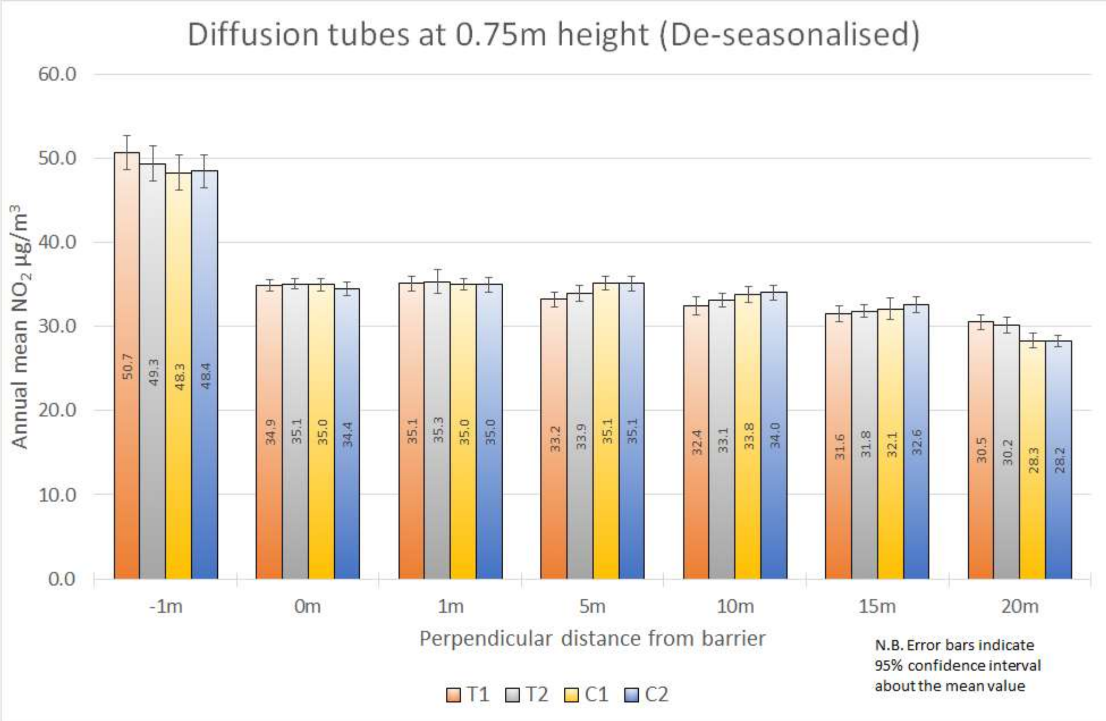

Figure 20: Annual mean diffusion tube NO_2 µg/m^3 at 0.75m height. By distance from barrier and transect. De-seasonalised data.

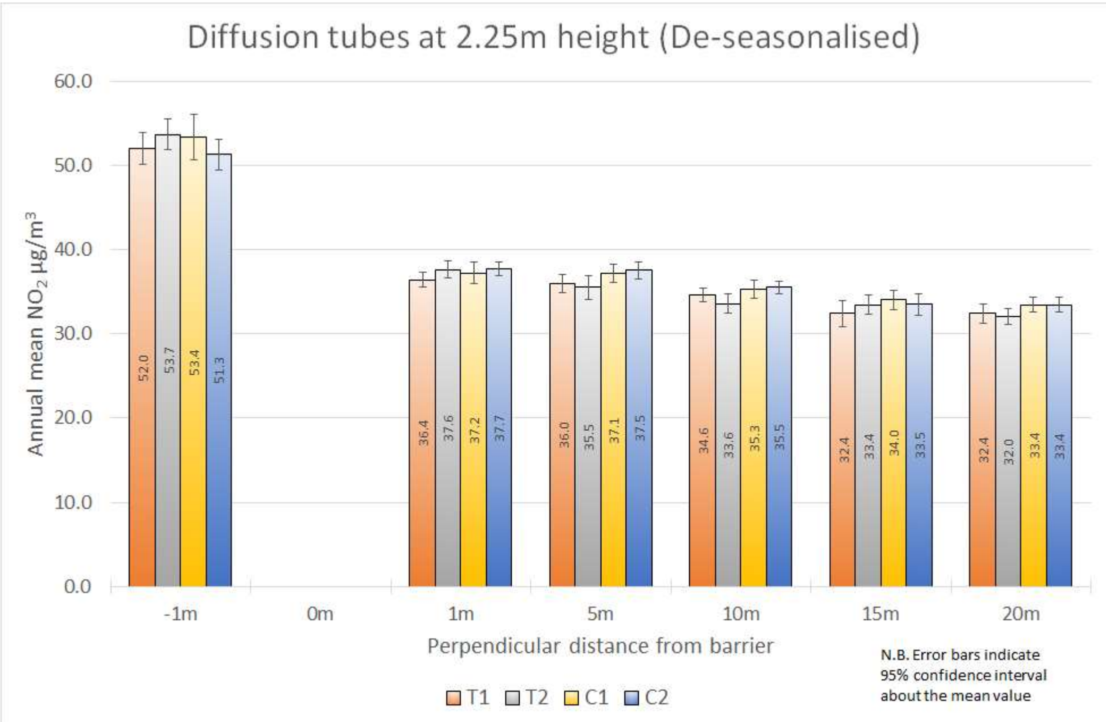

Figure 21: Annual mean diffusion tube NO_2 µg/m^3 at 2.25m height. By distance from barrier and transect. De-seasonalised data.

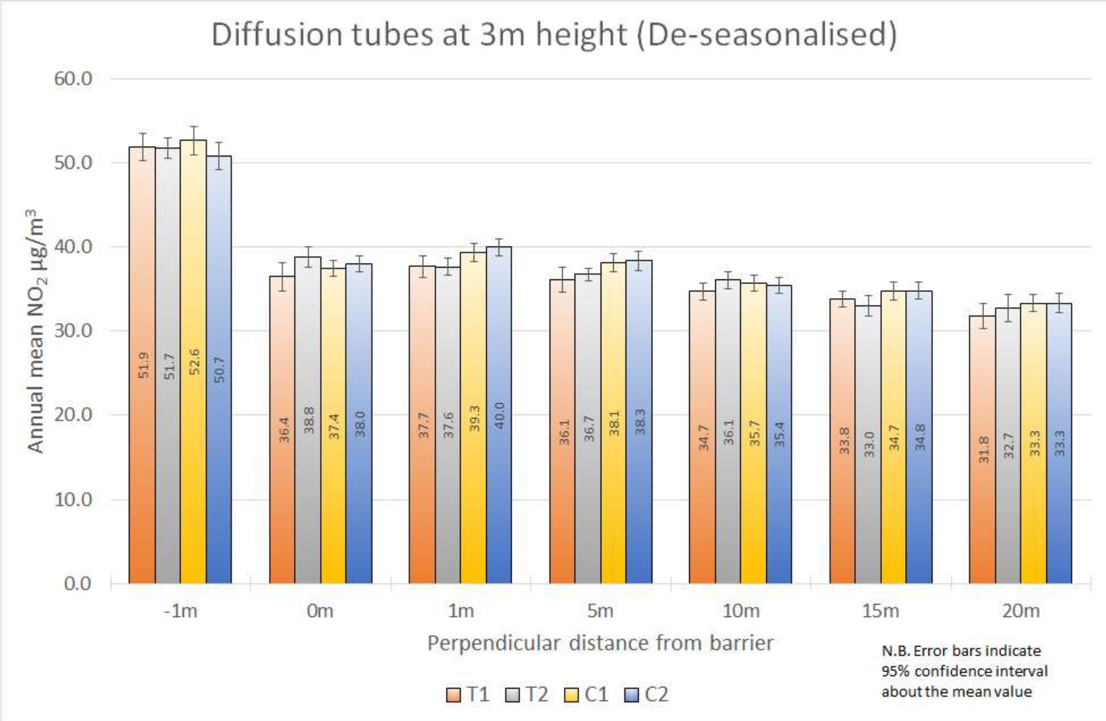

Figure 22: Annual mean diffusion tube NO_2 µg/m³ at 3m height. By distance from barrier and transect. De-seasonalised data.

4.2.3 Difference in performance between SmogStop® barrier and wooden fence barrier

Table 10 to Table 19 inclusive present the difference results for the diffusion tube measurements obtained at a height of 1.5 metres, at distances of 1m, 5m, 10m, 15m and 20m behind the barriers respectively. The tables present the absolute and percentage differences between the SmogStop® barrier and wooden fence barrier values, and also the absolute and percentage ranges of the confidence intervals at 95%, 90%, and 85% confidence. The comparisons shaded in green for the confidence intervals indicate the locations where the confidence intervals about the differences do not include zero at the indicated confidence level, i.e. the confidence intervals do not overlap.

Each comparison also includes a t-test (for example Table 10 and Table 11), to determine if the means of the two sets of data are statistically significantly different from each other.

Again, it can be seen that there is an overall tendency for the average NO_2 concentrations measured behind the wooden control barrier to be slightly higher than behind the SmogStop® barrier (differences in the range -0.4µg/m^3 to +2.8µg/m^3, with an overall mean difference of approximately +0.8µg/m^3). The direction of the effect is reasonably consistent across the majority of measurements up to around 15 metres behind the barriers. However, the observed differences in annual mean NO_2 concentrations are not always statistically significant.

It can be seen from Table 11, Table 15, and Table 19 that there are no statistically significant differences in the performance of the SmogStop® barrier and the wooden fence barrier at a height of 1.5 metres, at 1m, 10m, or 20m behind the barriers.

However, Table 13 indicates that at 5m behind the barrier, the NO_2 concentrations behind the SmogStop® barrier are statistically significantly lower for three out of the four comparisons. The annual mean NO_2 concentrations at T1 are statistically significantly lower than at C1 (-2.8µg/m^3, -7.5%) and C2 (-2.3µg/m^3, -6.2%), with a medium effect size[i]. The annual mean NO_2 concentrations at T2 are statistically significantly lower than at C1 (-1.7µg/m^3, -4.6%), also with a medium effect size.

Table 17 indicates that at 15m behind the barriers, the annual mean NO_2 concentrations at T1 is statistically significantly lower than at C2 (-1.7µg/m^3, -5.1%), with a medium effect size.

Comparable NO_2 difference results for the diffusion tube measurements obtained at a height of 3 metres, 2.25 metres, and 0.75 metres are presented in Annex 5. It should be noted that there are instances where the annual mean NO_2 concentrations measured behind the wooden fence barrier are statistically significantly lower than the annual mean NO_2 concentrations measured behind the SmogStop® barrier. This is the case at 20m behind the barriers at a height of 0.75 metres (see Annex 5).

[i] Using Cohen statistical power test (see section 4.2.2, page 31)

Table 10: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 1 metre behind the barriers at 1.5m height.

1m behind barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%
				CI lower	*-2.9*	*-8.1%*	*-2.6*	*-7.2%*	*-2.4*	*-6.6%*
C1	**36.3**	**T1**	**35.4**		**-0.9**	**-2.6%**	**-0.9**	**-2.6%**	**-0.9**	**-2.6%**
				CI upper	*1.1*	*3.0%*	*0.8*	*2.1%*	*0.6*	*1.5%*
				CI lower	*-2.1*	*-5.9%*	*-1.8*	*-5.1%*	*-1.7*	*-4.6%*
C1	**36.3**	**T2**	**36.0**		**-0.3**	**-1.0%**	**-0.3**	**-1.0%**	**-0.3**	**-1.0%**
				CI upper	*1.4*	*3.9%*	*1.1*	*3.2%*	*1.0*	*2.6%*
				CI lower	*-3.5*	*-9.5%*	*-3.2*	*-8.7%*	*-3.0*	*-8.1%*
C2	**36.9**	**T1**	**35.4**		**-1.5**	**-4.1%**	**-1.5**	**-4.1%**	**-1.5**	**-4.1%**
				CI upper	*0.5*	*1.4%*	*0.2*	*0.5%*	*0.0*	*-0.1%*
				CI lower	*-2.7*	*-7.3%*	*-2.4*	*-6.6%*	*-2.2*	*-6.1%*
C2	**36.9**	**T2**	**36.0**		**-0.9**	**-2.5%**	**-0.9**	**-2.5%**	**-0.9**	**-2.5%**
				CI upper	*0.9*	*2.3%*	*0.6*	*1.5%*	*0.4*	*1.0%*

Table 11: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 1 metre behind the barriers at 1.5m height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	36.3	0.40	**T1**	35.4	0.64	1.23	57	$p > 0.05$	0.16
C1	36.3	0.40	**T2**	36.0	0.52	0.53	64	$p > 0.05$	0.07
C2	36.9	0.40	**T1**	35.4	0.64	2.00	57	$p > 0.05$	0.26
C2	36.9	0.40	**T2**	36.0	0.52	1.41	64	$p > 0.05$	0.17

Table 12: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 5 metres behind the barriers at 1.5m height.

5m behind barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%
				CI lower	*-4.6*	*-12.3%*	*-4.3*	*-11.6%*	*-4.1*	*-11.1%*
C1	**37.0**	**T1**	**34.3**		**-2.8**	**-7.5%**	**-2.8**	**-7.5%**	**-2.8**	**-7.5%**
				CI upper	*-1.0*	*-2.6%*	*-1.3*	*-3.4%*	*-1.4*	*-3.9%*
				CI lower	*-3.6*	*-9.7%*	*-3.3*	*-8.9%*	*-3.1*	*-8.3%*
C1	**37.0**	**T2**	**35.3**		**-1.7**	**-4.6%**	**-1.7**	**-4.6%**	**-1.7**	**-4.6%**
				CI upper	*0.2*	*0.5%*	*-0.1*	*-0.4%*	*-0.3*	*-0.9%*
				CI lower	*-4.3*	*-11.6%*	*-3.9*	*-10.8%*	*-3.7*	*-10.2%*
C2	**36.5**	**T1**	**34.3**		**-2.3**	**-6.2%**	**-2.3**	**-6.2%**	**-2.3**	**-6.2%**
				CI upper	*-0.3*	*-0.9%*	*-0.6*	*-1.7%*	*-0.8*	*-2.3%*
				CI lower	*-3.3*	*-8.9%*	*-2.9*	*-8.0%*	*-2.7*	*-7.5%*
C2	**36.5**	**T2**	**35.3**		**-1.2**	**-3.4%**	**-1.2**	**-3.4%**	**-1.2**	**-3.4%**
				CI upper	*0.8*	*2.2%*	*0.5*	*1.3%*	*0.3*	*0.8%*

Table 13: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 5 metres behind the barriers at 1.5m height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	37.0	0.45	**T1**	34.3	0.48	4.20	69	$p < 0.05$	0.45
C1	37.0	0.45	**T2**	35.3	0.52	2.48	67	$p < 0.05$	0.29
C2	36.5	0.54	**T1**	34.3	0.48	3.17	68	$p < 0.05$	0.36
C2	36.5	0.54	**T2**	35.3	0.52	1.64	69	$p > 0.05$	0.19

Table 14: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 10 metres behind the barriers at 1.5m height.

10m behind barrier					Confidence level					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-2.5*	*-7.3%*	*-2.2*	*-6.4%*	*-2.0*	*-5.8%*
C1	**34.0**	**T1**	**33.3**		**-0.6**	**-1.8%**	**-0.6**	**-1.8%**	**-0.6**	**-1.8%**
				CI upper	*1.2*	*3.6%*	*0.9*	*2.7%*	*0.7*	*2.2%*
				CI lower	*-2.1*	*-6.2%*	*-1.8*	*-5.3%*	*-1.6*	*-4.7%*
C1	**34.0**	**T2**	**33.8**		**-0.1**	**-0.4%**	**-0.1**	**-0.4%**	**-0.1**	**-0.4%**
				CI upper	*1.8*	*5.4%*	*1.5*	*4.5%*	*1.3*	*3.9%*
				CI lower	*-3.0*	*-8.7%*	*-2.7*	*-7.9%*	*-2.5*	*-7.3%*
C2	**34.6**	**T1**	**33.3**		**-1.3**	**-3.6%**	**-1.3**	**-3.6%**	**-1.3**	**-3.6%**
				CI upper	*0.5*	*1.4%*	*0.2*	*0.6%*	*0.0*	*0.1%*
				CI lower	*-2.6*	*-7.6%*	*-2.3*	*-6.8%*	*-2.1*	*-6.2%*
C2	**34.6**	**T2**	**33.8**		**-0.8**	**-2.2%**	**-0.8**	**-2.2%**	**-0.8**	**-2.2%**
				CI upper	*1.1*	*3.2%*	*0.8*	*2.3%*	*0.6*	*1.7%*

Table 15: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 10 metres behind the barriers at 1.5m height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	34.0	0.55	**T1**	33.3	0.41	0.91	65	$p > 0.05$	0.11
C1	34.0	0.55	**T2**	33.8	0.47	0.19	69	$p > 0.05$	0.02
C2	34.6	0.49	**T1**	33.3	0.41	1.97	68	$p > 0.05$	0.23
C2	34.6	0.49	**T2**	33.8	0.47	1.13	70	$p > 0.05$	0.13

Table 16: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 15 metres behind the barriers at 1.5m height.

15m behind barrier					Confidence level					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-3.3*	*-10.0%*	*-3.0*	*-9.0%*	*-2.8*	*-8.3%*
C1	**33.2**	**T1**	**31.9**		**-1.2**	**-3.7%**	**-1.2**	**-3.7%**	**-1.2**	**-3.7%**
				CI upper	*0.9*	*2.6%*	*0.5*	*1.6%*	*0.3*	*1.0%*
				CI lower	*-2.2*	*-6.6%*	*-1.8*	*-5.5%*	*-1.6*	*-4.8%*
C1	**33.2**	**T2**	**33.3**		**0.1**	**0.3%**	**0.1**	**0.3%**	**0.1**	**0.3%**
				CI upper	*2.4*	*7.2%*	*2.0*	*6.1%*	*1.8*	*5.4%*
				CI lower	*-3.8*	*-11.2%*	*-3.4*	*-10.2%*	*-3.2*	*-9.6%*
C2	**33.7**	**T1**	**31.9**		**-1.7**	**-5.1%**	**-1.7**	**-5.1%**	**-1.7**	**-5.1%**
				CI upper	*0.3*	*1.0%*	*0.0*	*0.0%*	*-0.2*	*-0.6%*
				CI lower	*-2.6*	*-7.8%*	*-2.3*	*-6.8%*	*-2.0*	*-6.1%*
C2	**33.7**	**T2**	**33.3**		**-0.4**	**-1.2%**	**-0.4**	**-1.2%**	**-0.4**	**-1.2%**
				CI upper	*1.8*	*5.5%*	*1.5*	*4.4%*	*1.2*	*3.7%*

Table 17: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 15 metres behind the barriers at 1.5m height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	33.2	0.57	**T1**	31.9	0.52	1.59	69	$p > 0.05$	0.19
C1	33.2	0.57	**T2**	33.3	0.62	-0.11	68	$p > 0.05$	0.01
C2	33.7	0.54	**T1**	31.9	0.52	2.29	70	$p < 0.05$	0.26
C2	33.7	0.54	**T2**	33.3	0.62	0.49	68	$p > 0.05$	0.06

Table 18: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 20 metres behind the barriers at 1.5m height.[j]

20m behind barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean	Transect	Mean		NO_2 µg/m³		NO_2 µg/m³		NO_2 µg/m³	
	NO_2 µg/m³		NO_2 µg/m³		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-1.8*	*-5.7%*	*-1.5*	*-4.6%*	*-1.2*	*-3.9%*
C1	**31.6**	**T1**	**32.0**		**0.4**	**1.2%**	**0.4**	**1.2%**	**0.4**	**1.2%**
				CI upper	*2.6*	*8.1%*	*2.2*	*7.0%*	*2.0*	*6.3%*
				CI lower	*-1.7*	*-5.3%*	*-1.4*	*-4.4%*	*-1.2*	*-3.7%*
C1	**31.6**	**T2**	**31.8**		**0.2**	**0.6%**	**0.2**	**0.6%**	**0.2**	**0.6%**
				CI upper	*2.1*	*6.5%*	*1.8*	*5.5%*	*1.6*	*4.9%*
				CI lower	*-1.7*	*-5.3%*	*-1.4*	*-4.3%*	*-1.2*	*-3.7%*
C2	**31.8**	**T1**	**32.0**		**0.2**	**0.6%**	**0.2**	**0.6%**	**0.2**	**0.6%**
				CI upper	*2.1*	*6.5%*	*1.8*	*5.5%*	*1.6*	*4.9%*
				CI lower	*-1.5*	*-4.9%*	*-1.3*	*-4.1%*	*-1.1*	*-3.6%*
C2	**31.8**	**T2**	**31.8**		**0.0**	**0.0%**	**0.0**	**0.0%**	**0.0**	**0.0%**
				CI upper	*1.5*	*4.8%*	*1.3*	*4.1%*	*1.1*	*3.5%*

Table 19: Differences in annual mean NO_2 µg/m³ diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 20 metres behind the barriers at 1.5m height. t-test results.[k]

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	31.6	0.55	**T1**	32.0	0.59	-0.48	68	p > 0.05	0.06
C1	31.6	0.55	**T2**	31.8	0.42	-0.27	65	p > 0.05	0.03
C2	31.8	0.38	**T1**	32.0	0.59	-0.27	58	p > 0.05	0.04
C2	31.8	0.38	**T2**	31.8	0.42	0.01	66	p > 0.05	0.00

[j] The comparisons shaded in green indicate the locations where the confidence intervals about the differences do not include zero at the indicated confidence level, i.e. the confidence intervals do not overlap.

[k] *t*-test '$p > 0.05$' shaded red indicates that the means are not significantly different; '$p < 0.05$' shaded green indicates that the means are significantly different.

4.2.4 Barrier vs no-barrier comparison

Table 20 to Table 33 present the differences in annual mean NO_2 concentrations between transect N1 (no barrier), and the barrier transects at T1 & T2 (SmogStop® barrier) and C1 & C2 (wooden fence barrier), for each perpendicular distance from the barrier (-4.5m, -1m, 1m, 5m, 10m, 15m, and 20m respectively), at a vertical height of 1.5 metres.

It can be seen from Table 21 that at 4.5 metres in front of the barrier (4.5 metres from the motorway), there are no statistically significant differences between N1 (no barrier) and T1, T2, C1 or C2 (barrier).

At 1 metre in front of the barrier (Table 23) there is a statistically significant difference between N1 and T1 (+2.7 $\mu g/m^3$, +5.5%) with a small to medium effect size, and between N1 and T2 (+2.6 $\mu g/m^3$, +5.3%) with a small to medium effect size. There are no statistically significant differences between N1 and C1 & C2.

Unsurprisingly, at 1 metre behind the barriers at 1.5 metre height (Table 25), the differences between N1 and T1, T2, C1 & C2 are all statistically significant with large effect sizes, consistent with the results presented in Figure 18 and Figure 19, a reduction behind the barriers of between 5.1 $\mu g/m^3$ (-12.0%) and 6.6 $\mu g/m^3$ (-15.6%) compared to the ‘no barrier’ situation.

At 5 metres behind the barrier (Table 27), there is a statistically significant difference between N1 and T1 (-2.6 $\mu g/m^3$, -7.0%) with a medium effect size, and between N1 and T2 (-1.5 $\mu g/m^3$, -4.2%) with a small to medium effect size.

At 10 metres behind the barrier (Table 29), there is a statistically significant difference between N1 and T1 (-1.5 $\mu g/m^3$, -4.4%) with a medium effect size. There are no other statistically significant differences at T2, C1, or C2.

At 15 metres behind the barrier (Table 31), there is a statistically significant difference between N1 and C2 (+1.5 $\mu g/m^3$, +4.6%) with a small to medium effect size. There are no other statistically significant differences at T1, T2, or C1.

Finally, at 20 metres behind the barrier (Table 33), there are no statistically significant differences in the observed annual mean NO_2 concentrations (transect N1 vs transects T1, T2, C1 & C2).

Table 34 to Table 41 present the differences in annual mean NO_2 concentrations between transect S1 (no barrier), and the barrier transects at T1 & T2 (SmogStop® barrier) and C1 & C2 (wooden fence barrier), for each perpendicular distance from the barrier (-1m, 1m, 5m, and 10m respectively), again at a vertical height of 1.5 metres. Diffusion tube measurement locations were not available on transect S1 at 4.5 metres in front of the barrier alignment, or at 15 or 20 metres behind the barrier alignment.

At 1 metre in front of the barrier (Table 35) there is a statistically significant difference between S1 and T1 (+3.1 $\mu g/m^3$, +6.4%) with a medium effect size, and between S1 and T2 (+3.0 $\mu g/m^3$, +6.2%), also with a medium effect size. There are no statistically significant differences between S1 and C1 & C2.

Again unsurprisingly, at 1 metre behind the barriers at 1.5 metre height (Table 37), the differences between S1 and T1, T2, C1 & C2 are all statistically significant, consistent with the results presented in Figure 18 and Figure 19, a reduction behind the barriers of between 5.4 $\mu g/m^3$ (-12.7%) and 6.9 $\mu g/m^3$ (-16.3%) compared to the ‘no barrier’ situation.

At 5 metres behind the barrier (Table 39), the annual mean NO_2 concentrations are statistically significantly lower at T1 (-3.3 $\mu g/m^3$, -8.9%) with a large effect size, and at T2 (-2.3 $\mu g/m^3$, -6.1%) with a medium effect size, compared to transect S1. There are no statistically significant differences between S1 and C1 or C2 at this location.

At 10 metres behind the barrier (Table 41), the annual mean NO_2 concentration is statistically significantly lower at T1 (-2.6 μg/m^3, -7.3%) compared to S1, with a medium effect size. Transects T2 (-2.2 μg/m^3, -6.0%) and C1 (-2.0 μg/m^3, -5.6%) are also statistically significantly lower than transect S1 at 10 metres behind the barrier. There is no statistically significant difference between S1 and C2 at this location at 10 metres behind the barrier.

Table 20: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 4.5 metres in front of the barriers at 1.5 metres height.

4.5m in front of barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%
				CI lower	*-3.7*	*-6.2%*	*-2.8*	*-4.8%*	*-2.3*	*-3.8%*
N1	**59.0**	**T1**	**60.6**		**1.6**	**2.7%**	**1.6**	**2.7%**	**1.6**	**2.7%**
				CI upper	*6.9*	*11.7%*	*6.0*	*10.2%*	*5.5*	*9.3%*
				CI lower	*-4.5*	*-7.6%*	*-3.5*	*-5.9%*	*-2.9*	*-4.9%*
N1	**59.0**	**T2**	**60.5**		**1.6**	**2.6%**	**1.6**	**2.6%**	**1.6**	**2.6%**
				CI upper	*7.6*	*12.8%*	*6.6*	*11.2%*	*6.0*	*10.1%*
				CI lower	*-2.9*	*-4.8%*	*-2.0*	*-3.4%*	*-1.5*	*-2.5%*
N1	**59.0**	**C1**	**61.4**		**2.4**	**4.1%**	**2.4**	**4.1%**	**2.4**	**4.1%**
				CI upper	*7.7*	*13.0%*	*6.8*	*11.6%*	*6.3*	*10.6%*
				CI lower	*-8.7*	*-14.8%*	*-7.8*	*-13.2%*	*-7.2*	*-12.1%*
N1	**59.0**	**C2**	**56.1**		**-2.9**	**-4.9%**	**-2.9**	**-4.9%**	**-2.9**	**-4.9%**
				CI upper	*3.0*	*5.0%*	*2.0*	*3.4%*	*1.4*	*2.4%*

Table 21: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 4.5 metres in front of the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	59.0	1.51	**T1**	60.6	1.22	-0.83	65	$p > 0.05$	0.10
N1	59.0	1.51	**T2**	60.5	1.60	-0.71	66	$p > 0.05$	0.09
N1	59.0	1.51	**C1**	61.4	1.21	-1.24	65	$p > 0.05$	0.15
N1	59.0	1.51	**C2**	56.1	1.51	1.34	66	$p > 0.05$	0.16

Table 22: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre in front of the barriers at 1.5 metres height.

1m in front of barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%
				CI lower	*-0.9*	*-1.8%*	*-0.3*	*-0.6%*	*0.1*	*0.1%*
N1	**49.0**	**T1**	**51.7**		**2.7**	**5.5%**	**2.7**	**5.5%**	**2.7**	**5.5%**
				CI upper	*6.3*	*12.9%*	*5.7*	*11.7%*	*5.3*	*10.9%*
				CI lower	*-0.9*	*-1.8%*	*-0.3*	*-0.7%*	*0.0*	*0.1%*
N1	**49.0**	**T2**	**51.6**		**2.6**	**5.3%**	**2.6**	**5.3%**	**2.6**	**5.3%**
				CI upper	*6.1*	*12.4%*	*5.5*	*11.3%*	*5.2*	*10.5%*
				CI lower	*-3.2*	*-6.6%*	*-2.6*	*-5.3%*	*-2.2*	*-4.4%*
N1	**49.0**	**C1**	**49.9**		**0.8**	**1.7%**	**0.8**	**1.7%**	**0.8**	**1.7%**
				CI upper	*4.9*	*10.0%*	*4.3*	*8.7%*	*3.8*	*7.8%*
				CI lower	*-3.7*	*-7.6%*	*-3.1*	*-6.3%*	*-2.7*	*-5.4%*
N1	**49.0**	**C2**	**49.4**		**0.4**	**0.8%**	**0.4**	**0.8%**	**0.4**	**0.8%**
				CI upper	*4.5*	*9.2%*	*3.8*	*7.8%*	*3.4*	*6.9%*

Table 23: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre in front of the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	49.0	0.88	**T1**	51.7	0.98	-2.05	64	$p < 0.05$	0.25
N1	49.0	0.88	**T2**	51.6	0.93	-2.03	66	$p < 0.05$	0.24
N1	49.0	0.88	**C1**	49.9	1.23	-0.55	58	$p > 0.05$	0.07
N1	49.0	0.88	**C2**	49.4	1.25	-0.24	57	$p > 0.05$	0.03

Table 24: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre behind the barriers at 1.5 metres height.

1m behind barrier Height = 1.5m					Confidence level					
					95%		90%		85%	
A		B			B - A		B - A		B - A	
					NO_2 µg/m³		NO_2 µg/m³		NO_2 µg/m³	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-8.9*	*-21.2%*	*-8.5*	*-20.3%*	*-8.3*	*-19.7%*
N1	**42.0**	**T1**	**35.4**		**-6.6**	**-15.6%**	**-6.6**	**-15.6%**	**-6.6**	**-15.6%**
				CI upper	*-4.2*	*-10.1%*	*-4.6*	*-11.0%*	*-4.9*	*-11.6%*
				CI lower	*-8.1*	*-19.2%*	*-7.7*	*-18.4%*	*-7.5*	*-17.9%*
N1	**42.0**	**T2**	**36.0**		**-6.0**	**-14.2%**	**-6.0**	**-14.2%**	**-6.0**	**-14.2%**
				CI upper	*-3.9*	*-9.3%*	*-4.2*	*-10.1%*	*-4.4*	*-10.6%*
				CI lower	*-7.5*	*-17.8%*	*-7.2*	*-17.1%*	*-7.0*	*-16.7%*
N1	**42.0**	**C1**	**36.3**		**-5.6**	**-13.4%**	**-5.6**	**-13.4%**	**-5.6**	**-13.4%**
				CI upper	*-3.8*	*-9.0%*	*-4.1*	*-9.7%*	*-4.3*	*-10.2%*
				CI lower	*-6.9*	*-16.4%*	*-6.6*	*-15.7%*	*-6.4*	*-15.3%*
N1	**42.0**	**C2**	**36.9**		**-5.1**	**-12.0%**	**-5.1**	**-12.0%**	**-5.1**	**-12.0%**
				CI upper	*-3.2*	*-7.6%*	*-3.5*	*-8.3%*	*-3.7*	*-8.8%*

Table 25: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	42.0	0.56	**T1**	35.4	0.64	7.70	67	p < 0.05	0.68
N1	42.0	0.56	**T2**	36.0	0.52	7.81	69	p < 0.05	0.69
N1	42.0	0.56	**C1**	36.3	0.40	8.18	63	p < 0.05	0.72
N1	42.0	0.56	**C2**	36.9	0.40	7.35	63	p < 0.05	0.68

Table 26: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 5 metres behind the barriers at 1.5 metres height.

5m behind barrier Height = 1.5m					Confidence level					
					95%		90%		85%	
A		B			B - A		B - A		B - A	
					NO_2 µg/m³		NO_2 µg/m³		NO_2 µg/m³	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-4.4*	*-12.0%*	*-4.1*	*-11.2%*	*-3.9*	*-10.7%*
N1	**36.8**	**T1**	**34.3**		**-2.6**	**-7.0%**	**-2.6**	**-7.0%**	**-2.6**	**-7.0%**
				CI upper	*-0.8*	*-2.1%*	*-1.1*	*-2.9%*	*-1.3*	*-3.4%*
				CI lower	*-3.4*	*-9.3%*	*-3.1*	*-8.5%*	*-2.9*	*-8.0%*
N1	**36.8**	**T2**	**35.3**		**-1.5**	**-4.2%**	**-1.5**	**-4.2%**	**-1.5**	**-4.2%**
				CI upper	*0.4*	*1.0%*	*0.1*	*0.2%*	*-0.1*	*-0.4%*
				CI lower	*-1.6*	*-4.3%*	*-1.3*	*-3.6%*	*-1.1*	*-3.1%*
N1	**36.8**	**C1**	**37.0**		**0.2**	**0.5%**	**0.2**	**0.5%**	**0.2**	**0.5%**
				CI upper	*1.9*	*5.3%*	*1.7*	*4.5%*	*1.5*	*4.0%*
				CI lower	*-2.2*	*-6.1%*	*-1.9*	*-5.3%*	*-1.7*	*-4.7%*
N1	**36.8**	**C2**	**36.5**		**-0.3**	**-0.8%**	**-0.3**	**-0.8%**	**-0.3**	**-0.8%**
				CI upper	*1.6*	*4.4%*	*1.3*	*3.6%*	*1.1*	*3.0%*

Table 27: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 5 metres behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	36.8	0.46	**T1**	34.3	0.48	3.88	68	p < 0.05	0.43
N1	36.8	0.46	**T2**	35.3	0.52	2.20	67	p < 0.05	0.26
N1	36.8	0.46	**C1**	37.0	0.45	-0.27	69	p > 0.05	0.03
N1	36.8	0.46	**C2**	36.5	0.54	0.44	68	p > 0.05	0.05

Table 28: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 10 metres behind the barriers at 1.5 metres height.

10m behind barrier Height = 1.5m					Confidence level					
					95%		90%		85%	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%
				CI lower	*-3.1*	*-8.8%*	*-2.8*	*-8.1%*	*-2.7*	*-7.6%*
N1	**34.9**	**T1**	**33.3**		**-1.5**	**-4.4%**	**-1.5**	**-4.4%**	**-1.5**	**-4.4%**
				CI upper	*0.0*	*0.0%*	*-0.3*	*-0.7%*	*-0.4*	*-1.2%*
				CI lower	*-2.7*	*-7.8%*	*-2.4*	*-7.0%*	*-2.3*	*-6.5%*
N1	**34.9**	**T2**	**33.8**		**-1.1**	**-3.0%**	**-1.1**	**-3.0%**	**-1.1**	**-3.0%**
				CI upper	*0.6*	*1.7%*	*0.3*	*1.0%*	*0.2*	*0.5%*
				CI lower	*-2.7*	*-7.8%*	*-2.4*	*-6.9%*	*-2.2*	*-6.4%*
N1	**34.9**	**C1**	**34.0**		**-0.9**	**-2.6%**	**-0.9**	**-2.6%**	**-0.9**	**-2.6%**
				CI upper	*0.9*	*2.5%*	*0.6*	*1.7%*	*0.4*	*1.2%*
				CI lower	*-2.0*	*-5.6%*	*-1.7*	*-4.9%*	*-1.5*	*-4.4%*
N1	**34.9**	**C2**	**34.6**		**-0.3**	**-0.8%**	**-0.3**	**-0.8%**	**-0.3**	**-0.8%**
				CI upper	*1.4*	*4.0%*	*1.1*	*3.2%*	*1.0*	*2.7%*

Table 29: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 10 metres behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	34.9	0.38	**T1**	33.3	0.41	2.75	69	$p < 0.05$	0.31
N1	34.9	0.38	**T2**	33.8	0.47	1.73	66	$p > 0.05$	0.21
N1	34.9	0.38	**C1**	34.0	0.55	1.37	62	$p > 0.05$	0.17
N1	34.9	0.38	**C2**	34.6	0.49	0.45	65	$p > 0.05$	0.06

Table 30: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 15 metres behind the barriers at 1.5 metres height.

15m behind barrier Height = 1.5m					Confidence level					
					95%		90%		85%	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%
				CI lower	*-2.1*	*-6.5%*	*-1.8*	*-5.6%*	*-1.6*	*-5.0%*
N1	**32.2**	**T1**	**31.9**		**-0.2**	**-0.8%**	**-0.2**	**-0.8%**	**-0.2**	**-0.8%**
				CI upper	*1.6*	*5.0%*	*1.3*	*4.1%*	*1.1*	*3.5%*
				CI lower	*-1.0*	*-3.0%*	*-0.6*	*-2.0%*	*-0.4*	*-1.3%*
N1	**32.2**	**T2**	**33.3**		**1.1**	**3.3%**	**1.1**	**3.3%**	**1.1**	**3.3%**
				CI upper	*3.1*	*9.7%*	*2.8*	*8.7%*	*2.6*	*8.0%*
				CI lower	*-1.0*	*-3.0%*	*-0.7*	*-2.1%*	*-0.5*	*-1.4%*
N1	**32.2**	**C1**	**33.2**		**1.0**	**3.1%**	**1.0**	**3.1%**	**1.0**	**3.1%**
				CI upper	*2.9*	*9.1%*	*2.6*	*8.2%*	*2.4*	*7.5%*
				CI lower	*-0.4*	*-1.3%*	*-0.1*	*-0.4%*	*0.1*	*0.2%*
N1	**32.2**	**C2**	**33.7**		**1.5**	**4.6%**	**1.5**	**4.6%**	**1.5**	**4.6%**
				CI upper	*3.4*	*10.5%*	*3.1*	*9.6%*	*2.9*	*8.9%*

Table 31: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 15 metres behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	32.2	0.45	**T1**	31.9	0.52	0.36	69	$p > 0.05$	0.04
N1	32.2	0.45	**T2**	33.3	0.62	-1.41	62	$p > 0.05$	0.18
N1	32.2	0.45	**C1**	33.2	0.57	-1.36	66	$p > 0.05$	0.16
N1	32.2	0.45	**C2**	33.7	0.54	-2.10	67	$p < 0.05$	0.25

Table 32: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 20 metres behind the barriers at 1.5 metres height.

20m behind barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean	Transect	Mean		NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3	
	NO_2 µg/m^3		NO_2 µg/m^3		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-1.2*	*-4.0%*	*-0.9*	*-2.9%*	*-0.7*	*-2.1%*
N1	**31.1**	**T1**	**32.0**		**0.9**	**2.9%**	**0.9**	**2.9%**	**0.9**	**2.9%**
				CI upper	*3.0*	*9.7%*	*2.7*	*8.6%*	*2.5*	*7.9%*
				CI lower	*-1.1*	*-3.5%*	*-0.8*	*-2.6%*	*-0.6*	*-2.0%*
N1	**31.1**	**T2**	**31.8**		**0.7**	**2.3%**	**0.7**	**2.3%**	**0.7**	**2.3%**
				CI upper	*2.5*	*8.0%*	*2.2*	*7.1%*	*2.0*	*6.5%*
				CI lower	*-1.5*	*-4.9%*	*-1.2*	*-3.9%*	*-1.0*	*-3.2%*
N1	**31.1**	**C1**	**31.6**		**0.5**	**1.7%**	**0.5**	**1.7%**	**0.5**	**1.7%**
				CI upper	*2.6*	*8.2%*	*2.2*	*7.2%*	*2.0*	*6.5%*
				CI lower	*-1.0*	*-3.3%*	*-0.7*	*-2.4%*	*-0.6*	*-1.8%*
N1	**31.1**	**C2**	**31.8**		**0.7**	**2.3%**	**0.7**	**2.3%**	**0.7**	**2.3%**
				CI upper	*2.4*	*7.8%*	*2.2*	*6.9%*	*2.0*	*6.4%*

Table 33: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 20 metres behind the barriers at 1.5 metres height. t-test results.

Transect	**Mean**	**SE**	**Transect**	**Mean**	**SE**	**t**	**df**	**p**	**r**
N1	31.1	0.51	**T1**	32.0	0.59	-1.15	67	p > 0.05	0.14
N1	31.1	0.51	**T2**	31.8	0.42	-1.06	65	p > 0.05	0.13
N1	31.1	0.51	**C1**	31.6	0.55	-0.69	69	p > 0.05	0.08
N1	31.1	0.51	**C2**	31.8	0.38	-1.11	63	p > 0.05	0.14

Table 34: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre in front of the barriers at 1.5 metres height.

1m in front of barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3	
					Absolute	%	Absolute	%	Absolute	%
				CI lower	*0.2*	*0.3%*	*0.6*	*1.3%*	*0.9*	*1.9%*
S1	**48.6**	**T1**	**51.7**		**3.1**	**6.4%**	**3.1**	**6.4%**	**3.1**	**6.4%**
				CI upper	*6.0*	*12.4%*	*5.6*	*11.4%*	*5.3*	*10.8%*
				CI lower	*0.2*	*0.3%*	*0.6*	*1.3%*	*0.9*	*1.9%*
S1	**48.6**	**T2**	**51.6**		**3.0**	**6.2%**	**3.0**	**6.2%**	**3.0**	**6.2%**
				CI upper	*5.8*	*12.0%*	*5.4*	*11.0%*	*5.1*	*10.4%*
				CI lower	*-2.2*	*-4.5%*	*-1.6*	*-3.4%*	*-1.3*	*-2.6%*
S1	**48.6**	**C1**	**49.9**		**1.2**	**2.5%**	**1.2**	**2.5%**	**1.2**	**2.5%**
				CI upper	*4.7*	*9.6%*	*4.1*	*8.4%*	*3.7*	*7.7%*
				CI lower	*-2.7*	*-5.5%*	*-2.1*	*-4.4%*	*-1.8*	*-3.6%*
S1	**48.6**	**C2**	**49.4**		**0.8**	**1.6%**	**0.8**	**1.6%**	**0.8**	**1.6%**
				CI upper	*4.2*	*8.7%*	*3.7*	*7.5%*	*3.3*	*6.8%*

Table 35: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre in front of the barriers at 1.5 metres height. t-test results.

Transect	**Mean**	**SE**	**Transect**	**Mean**	**SE**	**t**	**df**	**p**	**r**
S1	48.6	0.54	**T1**	51.7	0.98	-2.77	48	$p < 0.05$	0.37
S1	48.6	0.54	**T2**	51.6	0.93	-2.80	52	$p < 0.05$	0.36
S1	48.6	0.54	**C1**	49.9	1.23	-0.92	43	$p > 0.05$	0.14
S1	48.6	0.54	**C2**	49.4	1.25	-0.56	42	$p > 0.05$	0.09

Table 36: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre behind the barriers at 1.5 metres height.

1m behind barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3	
					Absolute	%	Absolute	%	Absolute	%
				CI lower	*-9.2*	*-21.7%*	*-8.8*	*-20.8%*	*-8.6*	*-20.2%*
S1	**42.3**	**T1**	**35.4**		**-6.9**	**-16.3%**	**-6.9**	**-16.3%**	**-6.9**	**-16.3%**
				CI upper	*-4.6*	*-10.8%*	*-4.9*	*-11.7%*	*-5.2*	*-12.3%*
				CI lower	*-8.4*	*-19.8%*	*-8.0*	*-19.0%*	*-7.8*	*-18.5%*
S1	**42.3**	**T2**	**36.0**		**-6.3**	**-14.9%**	**-6.3**	**-14.9%**	**-6.3**	**-14.9%**
				CI upper	*-4.2*	*-10.0%*	*-4.6*	*-10.8%*	*-4.8*	*-11.3%*
				CI lower	*-7.8*	*-18.4%*	*-7.5*	*-17.7%*	*-7.3*	*-17.2%*
S1	**42.3**	**C1**	**36.3**		**-5.9**	**-14.1%**	**-5.9**	**-14.1%**	**-5.9**	**-14.1%**
				CI upper	*-4.1*	*-9.7%*	*-4.4*	*-10.4%*	*-4.6*	*-10.9%*
				CI lower	*-7.2*	*-17.0%*	*-6.9*	*-16.3%*	*-6.7*	*-15.9%*
S1	**42.3**	**C2**	**36.9**		**-5.4**	**-12.7%**	**-5.4**	**-12.7%**	**-5.4**	**-12.7%**
				CI upper	*-3.5*	*-8.4%*	*-3.8*	*-9.1%*	*-4.0*	*-9.5%*

Table 37: Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre behind the barriers at 1.5 metres height. t-test results.

Transect	**Mean**	**SE**	**Transect**	**Mean**	**SE**	**t**	**df**	**p**	**r**
S1	42.3	0.55	**T1**	35.4	0.64	8.16	67	$p < 0.05$	0.71
S1	42.3	0.55	**T2**	36.0	0.52	8.34	69	$p < 0.05$	0.71
S1	42.3	0.55	**C1**	36.3	0.40	8.79	64	$p < 0.05$	0.74
S1	42.3	0.55	**C2**	36.9	0.40	7.95	64	$p < 0.05$	0.71

Table 38: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 5 metres behind the barriers at 1.5 metres height.

5m behind barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%
				CI lower	*-5.1*	*-13.5%*	*-4.8*	*-12.7%*	*-4.6*	*-12.3%*
S1	**37.6**	**T1**	**34.3**		**-3.3**	**-8.9%**	**-3.3**	**-8.9%**	**-3.3**	**-8.9%**
				CI upper	*-1.6*	*-4.3%*	*-1.9*	*-5.0%*	*-2.1*	*-5.5%*
				CI lower	*-4.1*	*-10.9%*	*-3.8*	*-10.1%*	*-3.6*	*-9.6%*
S1	**37.6**	**T2**	**35.3**		**-2.3**	**-6.1%**	**-2.3**	**-6.1%**	**-2.3**	**-6.1%**
				CI upper	*-0.5*	*-1.3%*	*-0.8*	*-2.1%*	*-1.0*	*-2.6%*
				CI lower	*-2.2*	*-6.0%*	*-2.0*	*-5.2%*	*-1.8*	*-4.8%*
S1	**37.6**	**C1**	**37.0**		**-0.6**	**-1.5%**	**-0.6**	**-1.5%**	**-0.6**	**-1.5%**
				CI upper	*1.1*	*2.9%*	*0.8*	*2.2%*	*0.7*	*1.7%*
				CI lower	*-2.9*	*-7.7%*	*-2.6*	*-6.9%*	*-2.4*	*-6.4%*
S1	**37.6**	**C2**	**36.5**		**-1.1**	**-2.8%**	**-1.1**	**-2.8%**	**-1.1**	**-2.8%**
				CI upper	*0.8*	*2.1%*	*0.5*	*1.3%*	*0.3*	*0.8%*

Table 39: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 5 metres behind the barriers at 1.5 metres height. t-test results.

Transect	**Mean**	**SE**	**Transect**	**Mean**	**SE**	**t**	**df**	**p**	**r**
S1	37.6	0.41	**T1**	34.3	0.48	5.29	67	$p < 0.05$	0.54
S1	37.6	0.41	**T2**	35.3	0.52	3.45	65	$p < 0.05$	0.39
S1	37.6	0.41	**C1**	37.0	0.45	0.94	69	$p > 0.05$	0.11
S1	37.6	0.41	**C2**	36.5	0.54	1.57	65	$p > 0.05$	0.19

Table 40: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 10 metres behind the barriers at 1.5 metres height.

10m behind barrier					**Confidence level**					
Height = 1.5m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%
				CI lower	*-4.7*	*-13.0%*	*-4.3*	*-12.1%*	*-4.1*	*-11.5%*
S1	**36.0**	**T1**	**33.3**		**-2.6**	**-7.3%**	**-2.6**	**-7.3%**	**-2.6**	**-7.3%**
				CI upper	*-0.6*	*-1.7%*	*-0.9*	*-2.6%*	*-1.2*	*-3.2%*
				CI lower	*-4.3*	*-12.0%*	*-4.0*	*-11.0%*	*-3.7*	*-10.4%*
S1	**36.0**	**T2**	**33.8**		**-2.2**	**-6.0%**	**-2.2**	**-6.0%**	**-2.2**	**-6.0%**
				CI upper	*0.0*	*0.0%*	*-0.4*	*-1.0%*	*-0.6*	*-1.6%*
				CI lower	*-4.3*	*-12.0%*	*-3.9*	*-10.9%*	*-3.7*	*-10.3%*
S1	**36.0**	**C1**	**34.0**		**-2.0**	**-5.6%**	**-2.0**	**-5.6%**	**-2.0**	**-5.6%**
				CI upper	*0.3*	*0.8%*	*-0.1*	*-0.3%*	*-0.3*	*-0.9%*
				CI lower	*-3.6*	*-9.9%*	*-3.2*	*-8.9%*	*-3.0*	*-8.3%*
S1	**36.0**	**C2**	**34.6**		**-1.4**	**-3.8%**	**-1.4**	**-3.8%**	**-1.4**	**-3.8%**
				CI upper	*0.8*	*2.2%*	*0.4*	*1.2%*	*0.2*	*0.6%*

Table 41: Differences in annual mean NO_2 µg/m³ diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 10 metres behind the barriers at 1.5 metres height. t-test results.

Transect	**Mean**	**SE**	**Transect**	**Mean**	**SE**	**t**	**df**	**p**	**r**
S1	36.0	0.64	**T1**	33.3	0.41	3.48	57	$p < 0.05$	0.42
S1	36.0	0.64	**T2**	33.8	0.47	2.71	62	$p < 0.05$	0.33
S1	36.0	0.64	**C1**	34.0	0.55	2.40	66	$p < 0.05$	0.28
S1	36.0	0.64	**C2**	34.6	0.49	1.72	63	$p > 0.05$	0.21

4.2.5 Comparison of 'in front' and 'behind' the barrier at each transect

Table 42 to Table 44 present the differences in annual mean NO_2 concentrations between 1 metre in front of the barriers, and 1m, 5m, and 10m behind the barriers respectively, at a vertical height of 1.5 metres. These are consistent with the results presented in Figure 18 and Figure 19.

As expected, the annual mean NO_2 concentrations observed behind the barriers (transects T1, T2, C1, & C2) decrease relative to the values observed at 1 metre in front of the barriers, due to both the effect of distance and dispersion, and due to the effect of the barriers themselves. At transects N1 and S1 (no barriers), the reduction is lower because there is no barrier effect, particularly at 1 metre and 5 metres behind the alignment of the barrier. However, the NO_2 concentrations measured behind the barriers tend to converge at 10 metres behind the barrier alignment (annual mean NO_2 concentrations at N1, T1, T2, C1, C2, & C2 in the range 33.3 μg/m^3, to 36.0 6 μg/m^3).

However, when interpreting Table 42 to Table 44, it should be noted that there were no statistically significant differences in the observed annual mean NO_2 concentrations at 1 metre in front of the barriers across transects T1, T2, C1, & C2 (i.e. the variability in annual mean NO_2 concentrations at 1 metre in front of the barriers at these transects is not statistically significant). This is demonstrated using the t-test results presented in Table 45. This indicates that the annual mean NO_2 concentrations at 1 metre in front of both the SmogStop® barrier and the wooden control barrier are not statistically different.

Interestingly, when the 'no-barrier' transects (N1 and S1) are compared with the SmogStop® barrier transects (T1 and T2) at 1 metre in front of the barrier, it is shown in Table 45 that the NO_2 concentrations in front of the SmogStop® barrier are statistically significantly higher ($p < 0$) than the 'no-barrier' situation (by between 2.6 and 3.0 μg/m^3). Annual mean NO_2 concentrations in front of the wooden control barrier (C1 and C2) are also elevated compared to transects N1 and S1 (by between 0.4 and 1.3 μg/m^3), but the differences are not statistically significant ($p > 0$). It can be hypothesised that NO_2 pollution is being reflected / deflected back towards the motorway by both barrier technologies, but the effect is statistically significant only in the case of the SmogStop® barrier.

To explore this issue further, the de-seasonalised annual mean NO_2 data, 1 meter in front of the barrier (8 meters from the carriageway), and 1 meter behind the barrier (10 meters from the carriageway), at 1.5 meters height, is analysed.

Firstly, the change in NO_2 concentration in the 'Do nothing' situation (no barrier) is quantified, as presented in Figure 23. There is an average reduction of 6.6 μg/m^3 over the distance of 2 meters (from 8 meters to 10 meters from the carriageway), as observed at transects N1 and S1. The 'Do nothing' NO_2 value at 10 meters from the carriageway (42.2 μg/m^3) becomes the benchmark against which the barrier performance is assessed.

The NO_2 concentrations are then assessed in the 'Do something' situations, i.e. with the wooden barrier (transects C1 & C2), and with the SmogStop barrier (transects T1 & T2). The results are presented in Figure 24, Figure 25, Figure 26, and Figure 27.

As seen in the graphs, with each of the 'Do something' barrier scenarios, an increase in the NO_2 concentration is observed at 8 meters from the carriageway (1 meter in front of the barriers). In any scheme assessment, the analyst would need to decide whether the increase in NO_2 concentration should be included in the air quality assessment, for example to assess the potential negative impact on the travelling public / receptors in front of the barrier. However, in this assessment, the increases in NO_2 concentrations observed in front of the barriers have been ignored for the moment.

The decrease in NO_2 concentrations observed at each barrier transect is quantified relative to the 'Do nothing' value, at 10 meters from the carriageway (1 meter behind the barriers). These are shown to range between 5.3 and 5.9 µg/m^3 behind the wooden barrier, and between 6.2 and 6.8 µg/m^3 behind the SmogStop barrier. The statistical significance (or otherwise) of these differences in annual mean values have already been discussed earlier in the report.

Table 46 and Figure 28 present the comparison of the 'Do something' (barrier) versus 'Do nothing' (no barrier) at 1.5m height for each distance from the carriageway. The distance effect tends to be dominant at all measurement locations behind the barrier, particularly from 5 meters behind the barrier and beyond. It should also be noted that the differences in performance between the SmogStop® and wooden barriers are generally not statistically significant beyond 5 meters behind the barrier (see Table 15, Table 17, and Table 19). Further, there were no statistically significant differences in the observed annual mean NO_2 concentrations at 1 metre in front of the barriers across transects T1, T2, C1, & C2, i.e. the variability in annual mean NO_2 concentrations at 1 metre in front of the barriers at these transects is not statistically significant ($p > 0.05$).

Table 42: Differences in annual mean NO_2 µg/m^3 diffusion tube values – 1 metre behind the barriers vs 1 metre in front of the barriers at 1.5 metres height.

1m in front versus 1m behind barrier										
Height = 1.5m					**Confidence level**					
1m in front of barrier A		1m behind barrier B			**95%** B - A NO_2 µg/m^3		**90%** B - A NO_2 µg/m^3		**85%** B - A NO_2 µg/m^3	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-9.8*	*-20.0%*	*-9.4*	*-19.1%*	*-9.1*	*-18.5%*
N1	**49.0**	**N1**	**42.0**		**-7.0**	**-14.4%**	**-7.0**	**-14.4%**	**-7.0**	**-14.4%**
				CI upper	*-4.3*	*-8.7%*	*-4.7*	*-9.6%*	*-5.0*	*-10.2%*
				CI lower	*-19.4*	*-37.6%*	*-18.9*	*-36.6%*	*-18.6*	*-36.0%*
T1	**51.7**	**T1**	**35.4**		**-16.3**	**-31.5%**	**-16.3**	**-31.5%**	**-16.3**	**-31.5%**
				CI upper	*-13.2*	*-25.5%*	*-13.7*	*-26.4%*	*-14.0*	*-27.1%*
				CI lower	*-18.4*	*-35.7%*	*-18.0*	*-34.8%*	*-17.7*	*-34.2%*
T2	**51.6**	**T2**	**36.0**		**-15.6**	**-30.3%**	**-15.6**	**-30.3%**	**-15.6**	**-30.3%**
				CI upper	*-12.8*	*-24.8%*	*-13.3*	*-25.7%*	*-13.6*	*-26.3%*
				CI lower	*-16.7*	*-33.4%*	*-16.2*	*-32.4%*	*-15.8*	*-31.7%*
C1	**49.9**	**C1**	**36.3**		**-13.5**	**-27.1%**	**-13.5**	**-27.1%**	**-13.5**	**-27.1%**
				CI upper	*-10.4*	*-20.8%*	*-10.9*	*-21.8%*	*-11.2*	*-22.5%*
				CI lower	*-15.6*	*-31.7%*	*-15.1*	*-30.6%*	*-14.8*	*-30.0%*
C2	**49.4**	**C2**	**36.9**		**-12.5**	**-25.2%**	**-12.5**	**-25.2%**	**-12.5**	**-25.2%**
				CI upper	*-9.3*	*-18.8%*	*-9.8*	*-19.8%*	*-10.1*	*-20.5%*
				CI lower	*-8.4*	*-17.3%*	*-8.1*	*-16.6%*	*-7.9*	*-16.2%*
S1	**48.6**	**S1**	**42.3**		**-6.3**	**-13.0%**	**-6.3**	**-13.0%**	**-6.3**	**-13.0%**
				CI upper	*-4.2*	*-8.7%*	*-4.6*	*-9.4%*	*-4.8*	*-9.9%*

Table 43: Differences in annual mean NO_2 µg/m^3 diffusion tube values – 5 metres behind the barriers vs 1 metre in front of the barriers at 1.5 metres height.

1m in front versus 5m behind barrier										
Height = 1.5m					**Confidence level**					
1m in front of barrier A		5m behind barrier B			**95%** B - A NO_2 µg/m^3		**90%** B - A NO_2 µg/m^3		**85%** B - A NO_2 µg/m^3	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-14.8*	*-30.1%*	*-14.4*	*-29.3%*	*-14.1*	*-28.7%*
N1	**49.0**	**N1**	**36.8**		**-12.2**	**-24.8%**	**-12.2**	**-24.8%**	**-12.2**	**-24.8%**
				CI upper	*-9.6*	*-19.5%*	*-10.0*	*-20.4%*	*-10.3*	*-20.9%*
				CI lower	*-20.3*	*-39.2%*	*-19.8*	*-38.3%*	*-19.5*	*-37.8%*
T1	**51.7**	**T1**	**34.3**		**-17.5**	**-33.8%**	**-17.5**	**-33.8%**	**-17.5**	**-33.8%**
				CI upper	*-14.6*	*-28.3%*	*-15.1*	*-29.2%*	*-15.4*	*-29.8%*
				CI lower	*-19.1*	*-37.0%*	*-18.6*	*-36.1%*	*-18.4*	*-35.6%*
T2	**51.6**	**T2**	**35.3**		**-16.3**	**-31.6%**	**-16.3**	**-31.6%**	**-16.3**	**-31.6%**
				CI upper	*-13.5*	*-26.2%*	*-14.0*	*-27.0%*	*-14.3*	*-27.6%*
				CI lower	*-16.1*	*-32.3%*	*-15.6*	*-31.2%*	*-15.2*	*-30.5%*
C1	**49.9**	**C1**	**37.0**		**-12.8**	**-25.7%**	**-12.8**	**-25.7%**	**-12.8**	**-25.7%**
				CI upper	*-9.6*	*-19.2%*	*-10.1*	*-20.3%*	*-10.4*	*-20.9%*
				CI lower	*-16.3*	*-33.0%*	*-15.7*	*-31.9%*	*-15.4*	*-31.2%*
C2	**49.4**	**C2**	**36.5**		**-12.8**	**-26.0%**	**-12.8**	**-26.0%**	**-12.8**	**-26.0%**
				CI upper	*-9.4*	*-19.0%*	*-9.9*	*-20.1%*	*-10.3*	*-20.9%*
				CI lower	*-12.9*	*-26.4%*	*-12.6*	*-25.8%*	*-12.4*	*-25.4%*
S1	**48.6**	**S1**	**37.6**		**-11.0**	**-22.7%**	**-11.0**	**-22.7%**	**-11.0**	**-22.7%**
				CI upper	*-9.2*	*-18.9%*	*-9.5*	*-19.5%*	*-9.7*	*-19.9%*

Table 44: Differences in annual mean NO_2 µg/m³ diffusion tube values – 10 metres behind the barriers vs 1 metre in front of the barriers at 1.5 metres height.

1m in front versus 10m behind barrier											
Height = 1.5m					**Confidence level**						
1m in front of barrier		10m behind barrier			**95%**		**90%**		**85%**		
A		B			B - A		B - A		B - A		
Transect	Mean NO_2 µg/m³	Transect	Mean NO_2 µg/m³		NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%	NO_2 µg/m³ Absolute	%	
				CI lower	*-16.6*	*-33.8%*	*-16.2*	*-33.0%*	*-15.9*	*-32.5%*	
N1	**49.0**	**N1**	**34.9**		**-14.1**	**-28.8%**	**-14.1**	**-28.8%**	**-14.1**	**-28.8%**	
				CI upper	*-11.7*	*-23.9%*	*-12.1*	*-24.7%*	*-12.3*	*-25.2%*	
				CI lower	*-21.1*	*-40.7%*	*-20.6*	*-39.9%*	*-20.4*	*-39.4%*	
T1	**51.7**	**T1**	**33.3**		**-18.4**	**-35.5%**	**-18.4**	**-35.5%**	**-18.4**	**-35.5%**	
				CI upper	*-15.7*	*-30.4%*	*-16.1*	*-31.2%*	*-16.4*	*-31.7%*	
				CI lower	*-20.5*	*-39.7%*	*-20.1*	*-38.9%*	*-19.8*	*-38.3%*	
T2	**51.6**	**T2**	**33.8**		**-17.8**	**-34.5%**	**-17.8**	**-34.5%**	**-17.8**	**-34.5%**	
				CI upper	*-15.1*	*-29.2%*	*-15.5*	*-30.1%*	*-15.8*	*-30.6%*	
				CI lower	*-19.3*	*-38.8%*	*-18.8*	*-37.7%*	*-18.4*	*-36.9%*	
C1	**49.9**	**C1**	**34.0**		**-15.9**	**-31.9%**	**-15.9**	**-31.9%**	**-15.9**	**-31.9%**	
				CI upper	*-12.5*	*-25.0%*	*-13.0*	*-26.1%*	*-13.4*	*-26.8%*	
				CI lower	*-18.2*	*-36.8%*	*-17.6*	*-35.7%*	*-17.3*	*-35.0%*	
C2	**49.4**	**C2**	**34.6**		**-14.8**	**-30.0%**	**-14.8**	**-30.0%**	**-14.8**	**-30.0%**	
				CI upper	*-11.4*	*-23.1%*	*-12.0*	*-24.2%*	*-12.3*	*-25.0%*	
				CI lower	*-14.9*	*-30.7%*	*-14.5*	*-29.9%*	*-14.3*	*-29.4%*	
S1	**48.6**	**S1**	**36.0**		**-12.6**	**-26.0%**	**-12.6**	**-26.0%**	**-12.6**	**-26.0%**	
				CI upper	*-10.4*	*-21.3%*	*-10.7*	*-22.1%*	*-11.0*	*-22.6%*	

Table 45: Differences in annual mean NO_2 µg/m³ diffusion tube values – All transects. 1 metre in front of the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
T1	51.7	0.98	**T2**	51.6	0.93	0.08	63	p > 0.05	0.01
T1	51.7	0.98	**C1**	49.9	1.23	1.18	59	p > 0.05	0.15
T1	51.7	0.98	**C2**	49.4	1.25	1.47	59	p > 0.05	0.19
T2	51.6	0.93	**C1**	49.9	1.23	1.14	58	p > 0.05	0.15
T2	51.6	0.93	**C2**	49.4	1.25	1.43	58	p > 0.05	0.19
C1	49.9	1.23	**C2**	49.4	1.25	0.27	62	p > 0.05	0.03
N1	49.0	0.88	**T1**	51.7	0.98	-2.05	64	p < 0.05	0.25
N1	49.0	0.88	**T2**	51.6	0.93	-2.03	66	p < 0.05	0.24
N1	49.0	0.88	**C1**	49.9	1.23	-0.55	58	p > 0.05	0.07
N1	49.0	0.88	**C2**	49.4	1.25	-0.24	57	p > 0.05	0.03
S1	48.6	0.54	**T1**	51.7	0.98	-2.77	48	p < 0.05	0.37
S1	48.6	0.54	**T2**	51.6	0.93	-2.80	52	p < 0.05	0.36
S1	48.6	0.54	**C1**	49.9	1.23	-0.92	43	p > 0.05	0.14
S1	48.6	0.54	**C2**	49.4	1.25	-0.56	42	p > 0.05	0.09

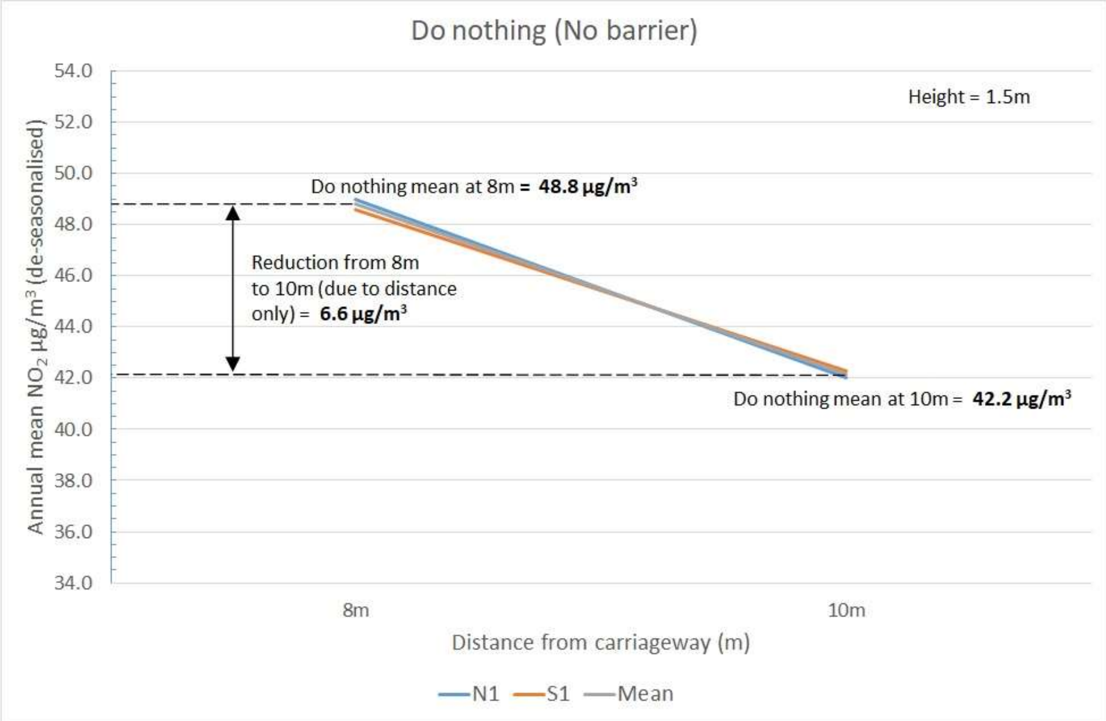

Figure 23: 'Do nothing' (no barrier) annual mean NO_2 concentrations at 8m and 10m from the carriageway at 1.5m height

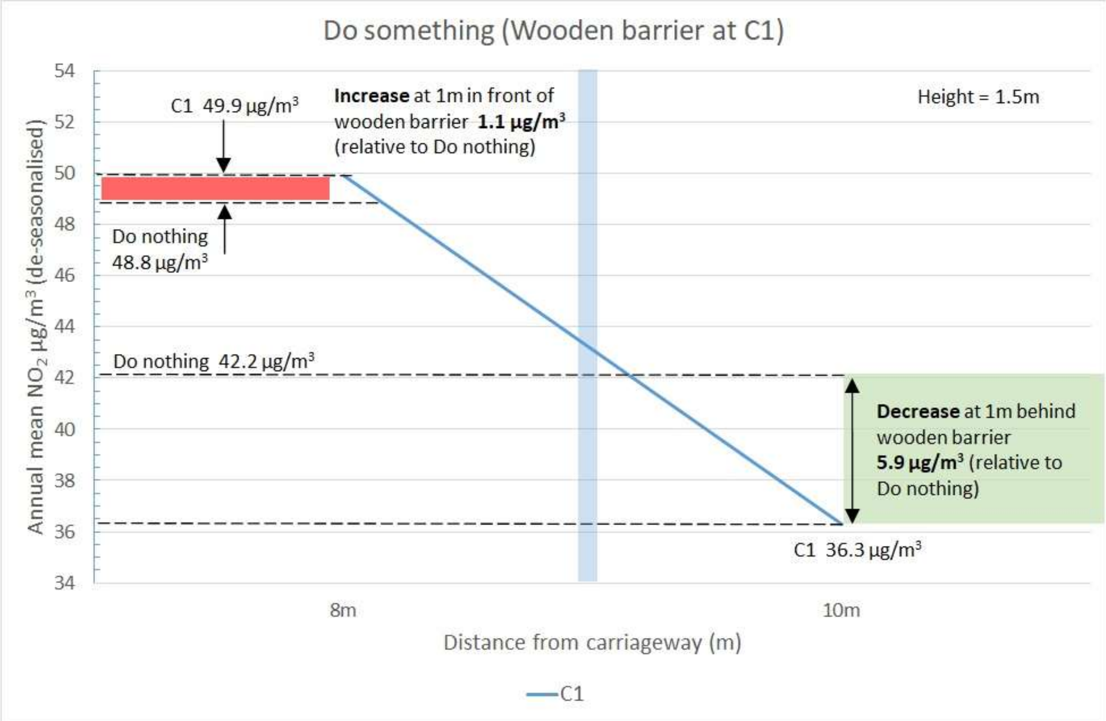

Figure 24: Comparison of 'Do something' (wooden barrier at C1) versus 'Do nothing' (no barrier) at 8m and 10m from the carriageway at 1.5m height

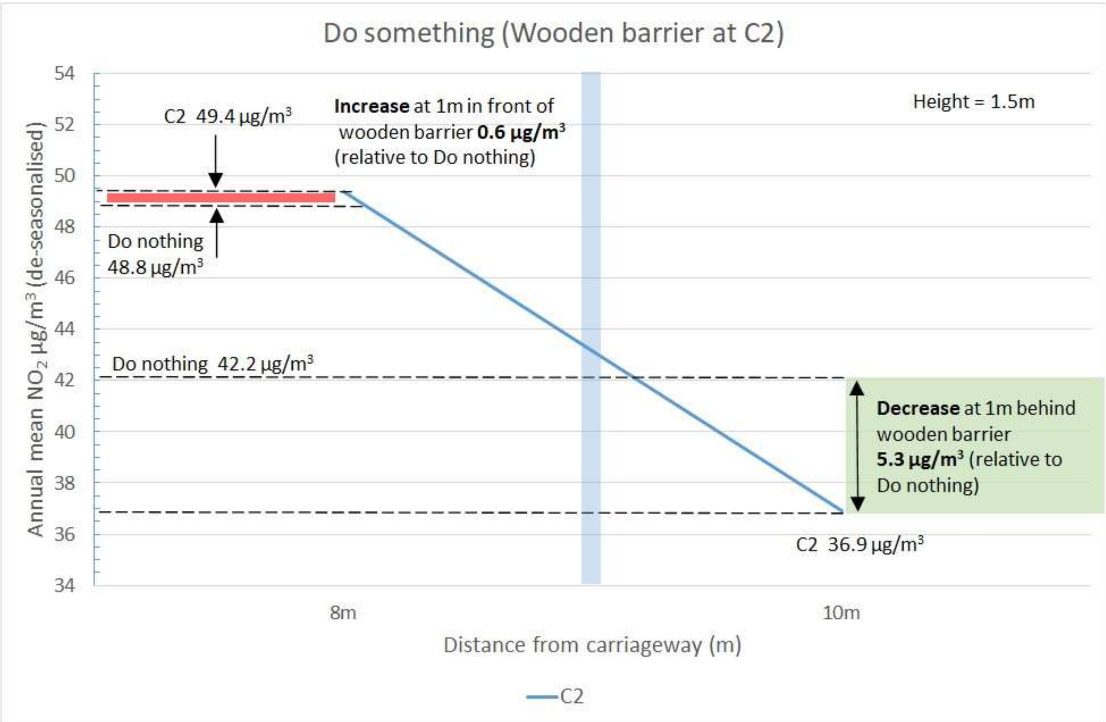

Figure 25: Comparison of 'Do something' (wooden barrier at C2) versus 'Do nothing' (no barrier) at 8m and 10m from the carriageway at 1.5m height

Figure 26: Comparison of 'Do something' (SmogStop® barrier at T1) versus 'Do nothing' (no barrier) at 8m and 10m from the carriageway at 1.5m height

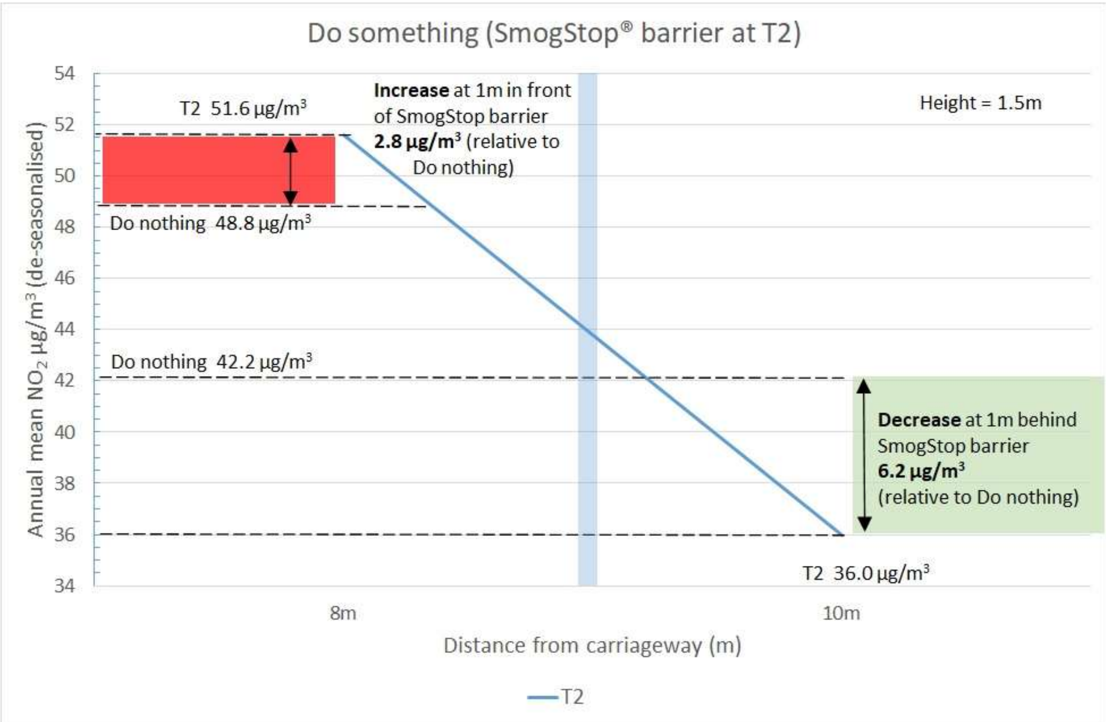

Figure 27: Comparison of 'Do something' (SmogStop® barrier at T2) versus 'Do nothing' (no barrier) at 8m and 10m from the carriageway at 1.5m height

Table 46: Comparison of 'Do something' (barrier) versus 'Do nothing' (no barrier) at 1.5m height. Change in annual mean NO_2 µg/m³ (% change)

Distance from barrier	**-1m**	**1m**	**5m**	**10m**	**15m**	**20m**
Distance from traffic	**8m**	**10m**	**14m**	**19m**	**24m**	**29m**
Transect	**Change in annual mean NO_2 µg/m³ relative to 'Do nothing' (no barrier)**					
T1	2.9 (+6%)	-6.8 (-16%)	-2.9 (-8%)	-2.2 (-6%)	-0.3 (-1%)	0.9 (+3%)
T2	2.8 (+6%)	-6.2 (-15%)	-1.9 (-5%)	-1.7 (-5%)	1.1 (+3%)	0.7 (+2%)
C1	1.1 (+2%)	-5.9 (-14%)	-0.2 (-1%)	-1.5 (-4%)	1.0 (+3%)	0.5 (+2%)
C2	0.6 (+1%)	-5.3 (-13%)	-0.7 (-2%)	-0.9 (-2%)	1.5 (+5%)	0.7 (+2%)

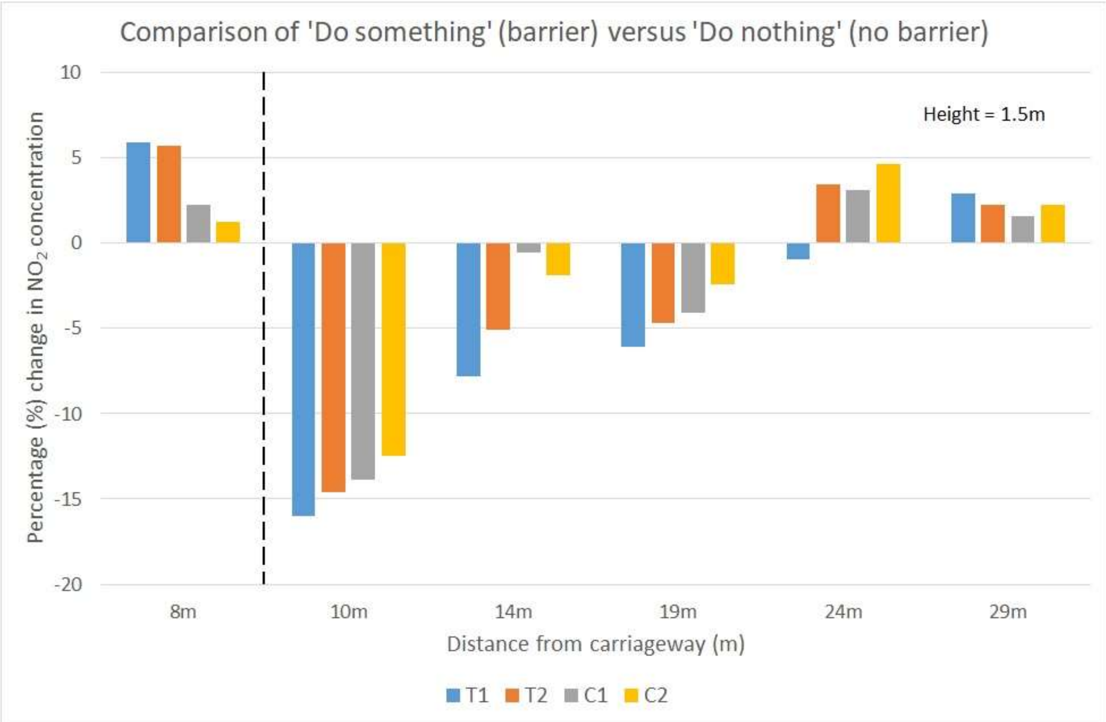

Figure 28: Comparison of 'Do something' (barrier) versus 'Do nothing' (no barrier) at 1.5m height. Percentage (%) change in annual mean NO_2 µg/m³

5. Continuous automatic monitoring results

Chemiluminescence analysers were used to measure hourly NO_2 levels at 16 locations within the trial site (Table 3). These hourly NO_2 levels are plot as bar charts in Figure 29 and tabulated in Table 47.

As previously stated, a malfunction in the continuous automatic monitoring equipment at C1 caused the measurements to be near equivalent from the 4 sampling points along this transect, making measurements from this transect void. Although this meant that no comparisons could be made against the control barrier for results from continuous automatic monitoring of NO_2 levels, no such malfunction occurred at the remaining 12 locations, which encompassed the SmogStop® barrier at T1 and T2, and are thus compared in this section.

Firstly, it should be noted that the 95% confidence intervals about the annual means from the continuous automatic monitors were significantly lower than those measured using diffusion tubes, due mainly to the larger sample size. Over the trial period, the average 95% confidence interval about the annual mean from the continuous automatic monitors[l] was 0.40 μg/m^3, which represented an average error about the mean of 1.3%, whereas, the average 95% confidence interval about the annual mean from the diffusion tubes was 1.23 μg/m^3, which represented an average error about the mean of 3.2%.

At T2, 8 monitors were stationed at various distances from the barrier and heights. Annual mean NO_2 levels decreased with increasing distance from the roadside, with the sharpest fall being seen from the inlet (top) to the outlet (bottom) of the barrier. At T1, 4 monitors were stationed at various distances from the barrier and heights. Annual mean NO_2 levels initially increased on going from the inlet (top) to the outlet (bottom) of the barrier, and then subsequently decreased with increasing distance from the roadside. At T2, annual mean NO_2 levels decreased from 35.8 to 30.5 μg/m^3 on going from the inlet to the outlet of the barrier, respectively. However, at T1, annual mean NO_2 levels increased from 28.7 to 32.1 μg/m^3 on going from the inlet to the outlet of the barrier, respectively. At T2, downwind from the outlet of the barrier, NO_2 levels decreased only marginally, reducing from 30.5 μg/m^3 at the outlet of the barrier to 27.6 μg/m^3 20m downwind of the barrier (3.0 μg/m^3 net reduction; 9.7% reduction). However, at T1, downwind from the outlet of the barrier, NO_2 levels decreased more greatly, reducing from 32.1 μg/m^3 at the outlet of the barrier to 25.7 μg/m^3 20m downwind of the barrier (6.4 μg/m^3 net reduction; 19.9% reduction).

[l] For the 12 valid continuous monitors at T1 and T2

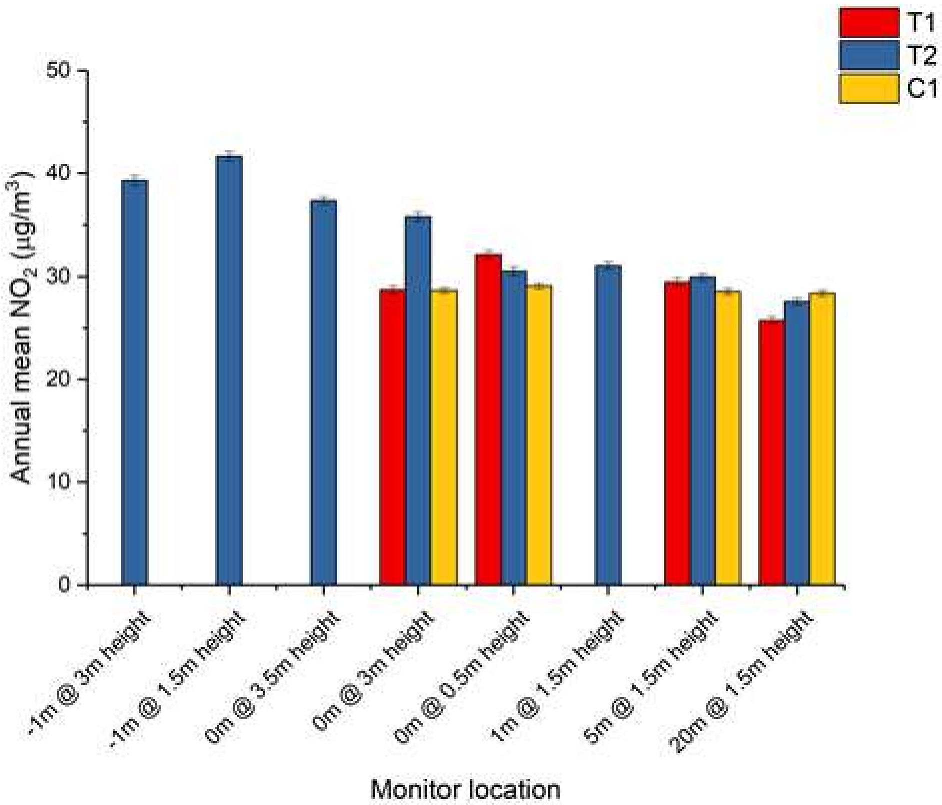

Figure 29: Annual mean NO_2 levels and 95% confidence intervals about the mean ($\mu g/m^3$) measured using continuous automatic monitors at the 16 locations across the trial site that encompassed the SmogStop® barrier at T1 and T2 and the Control barrier at C1.

Table 47: Summary of the annual mean NO_2 levels (µg/m^3), and statistical parameters used to determine the 95% confidence interval about the mean, measured using continuous automatic monitors at the 16 locations across the trial site that spanned the SmogStop® barrier at T1 and T2 and the Control barrier at C1.

Inter transect comparisons								
Barrier location				Annual mean NO_2 (µg/ m^3)				
Number	Transect	Distance from barrier (m)	Height (m)	Count	Annual mean	Standard Deviation	Standard Error	95% confidence interval (±)
1	T1	0 (inlet)	3	8455	28.7	18.2	0.2	0.4
2	T1	0 (outlet)	0.5	8455	32.1	19.5	0.2	0.4
3	T1	5	1.5	8454	29.5	18.1	0.2	0.4
4	T1	20	1.5	8438	25.7	16.1	0.2	0.3
5	T2	0 (inlet)	3	8598	35.8	20.2	0.2	0.4
6	T2	0 (outlet)	0.5	8616	30.5	19.9	0.2	0.4
7	T2	5	1.5	8613	29.9	16.7	0.2	0.4
8	T2	20	1.5	8596	27.6	16.3	0.2	0.3
9	C1	0 (inlet)	3	8682	28.7	13.9	0.1	0.3
10	C1	0 (outlet)	0.5	8683	29.1	14.0	0.2	0.3
11	C1	5	1.5	8683	28.5	14.0	0.1	0.3
12	C1	20	1.5	8671	28.4	13.9	0.1	0.3
Additional NO_2 measurements around the barrier at T2								
Barrier location				Annual mean NO_2 (µg/ m^3)				
Number	Transect	Distance from barrier (m)	Height (m)	Count	Annual mean	Standard Deviation	Standard Error	95% confidence interval (±)
13	T2	-1	3	8615	39.3	21.8	0.2	0.5
14	T2	-1	1.5	8613	41.7	21.2	0.2	0.4
15	T2	0	3.5	8609	37.4	18.4	0.2	0.4
16	T2	1	1.5	8615	31.1	18.1	0.2	0.4

Hourly data was segregated by time of measurement (daytime or night time), or wind direction (Northern-Southern, Eastern or Western), and annual means were determined for a given meteorological condition. These are summarised for the data from the 12 valid continuous monitors located along T1 and T2 in Figure 30 and Figure 31, and Table 48.

At both T1 and T2, daytime levels of NO_2 were significantly higher than night time levels (up to ~60% higher during the day compared with the night, and on average ~45% higher). This can be attributed to the far higher traffic flows and therefore NO_2 emissions during the daytime as compared with the night time. These higher levels of NO_2 during the day may also be attributed to the photochemical oxidation of NO emissions to NO_2 by ozone (O_3), which is produced in the presence of VOCs, NO_x and UV light. Generally speaking, how these NO_2 levels changed with position from the roadside were broadly similar for daytime and night time; however, net and percentage reduction in NO_2 were generally greater during the day. For example, at T2, if we take the analyser closest to the roadside as a reference point, we see average daytime and night time reductions of ~17% and ~11%, respectively. These differences in daytime and night time reductions will be assessed in more detail in Sections 5.1 and 5.2.

Also, with wind direction, we also see significantly different NO_2 levels. NO_2 levels were highest when the wind blew from the West (i.e. from the motorway), averaging 41.2 µg/m^3 across the 12 analysers. And NO_2 levels were lowest when the wind blew from the East (i.e. towards the motorway), averaging

17.7 μg/m^3 across the 12 analysers. And intermediate NO_2 levels were seen when the wind blew from North-South (i.e. parallel to the motorway and barrier), averaging 31.5 μg/m^3 across the 12 analysers. Again, broadly speaking, how these NO_2 levels changed with the position in which they were measured from the roadside were similar for the 3 different wind categories. Nevertheless, akin to daytime and night time measurements, greater differences were observed with specific wind directions. For example, at T2, if we take the analyser closest to the roadside[m] as a reference point, we see average reductions of ~11%, ~15% and ~22% with Western, Northern-Southern and Eastern wind directions, respectively. Again, these differences with wind direction will be assessed in more detail in Sections 5.1 and 5.2.

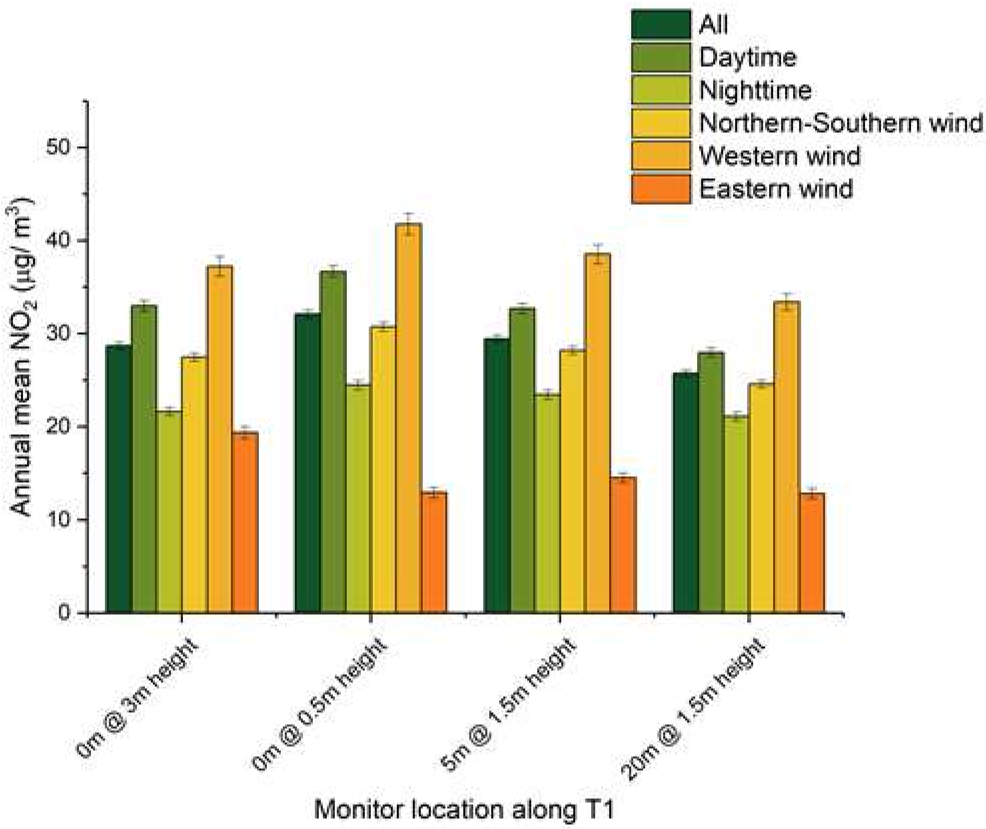

Figure 30: Annual mean NO_2 levels and 95% confidence intervals about the mean (μg/m^3) measured using continuous automatic monitors at the 4 locations along T1 at the SmogStop® barrier, segregated by weather condition; daytime, night time, Northern-Southern wind (315 to 45^o and 135 to 225^o), Western wind (225 to 315^o) and Eastern wind (45 to 135^o).

[m] and of greatest height

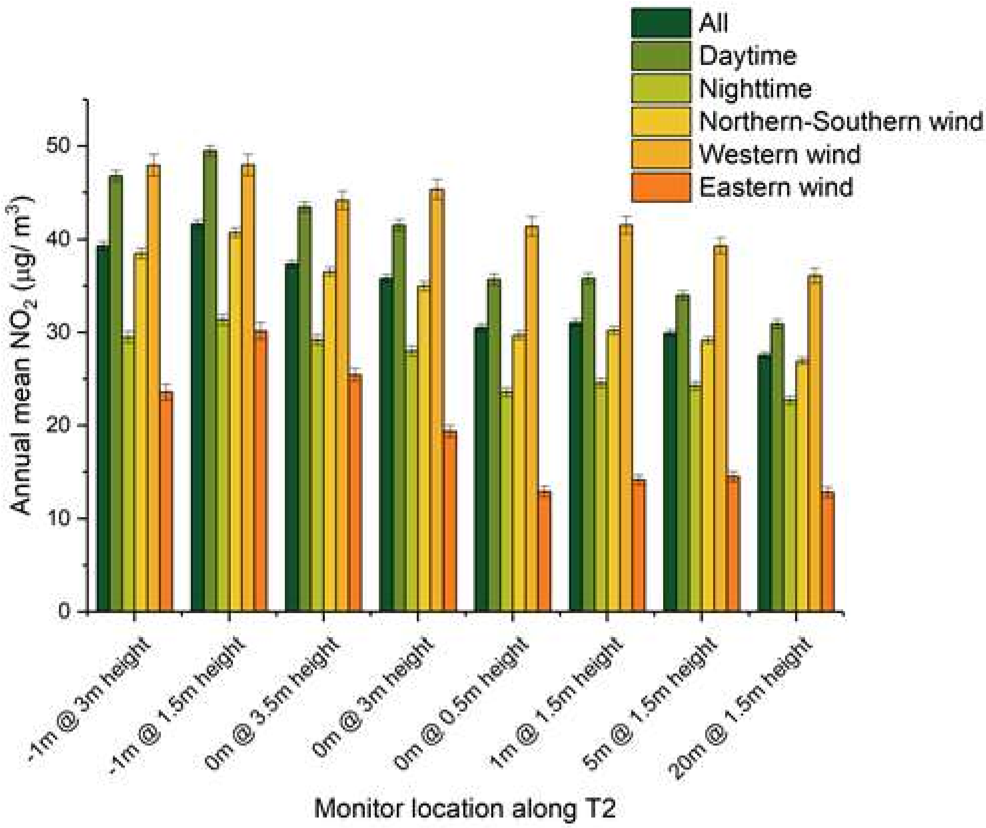

Figure 31: Annual mean NO_2 levels and 95% confidence intervals about the mean (µg/m^3) measured using continuous automatic monitors at the 8 locations along T2 at the SmogStop® barrier, segregated by weather condition; daytime, night time, Northern-Southern wind (315 to 45^o and 135 to 225^o), Western wind (225 to 315^o) and Eastern wind (45 to 135^o).

Table 48: Summary of the annual mean NO_2 levels (µg/m^3) measured using continuous automatic monitors at the 12 locations across the trial site that encompassed the SmogStop® barrier at T1 and T2, segregated by weather condition; daytime, night time, Northern-Southern wind (315 to 45^o and 135 to 225^o), Western wind (225 to 315^o) and Eastern wind (45 to 135^o).

Inter transect comparisons									
Barrier location				Annual mean NO_2 (µg/ m^3)					
Number	Transect	Distance from barrier (m)	Height (m)	All	Day	Night	N-S wind	W wind	E wind
1	T1	0 (inlet)	3	28.7	33.0	21.7	27.5	37.2	12.8
2	T1	0 (outlet)	0.5	32.1	36.7	24.5	30.8	41.8	14.2
3	T1	5	1.5	29.5	32.7	23.5	28.2	38.5	12.8
4	T1	20	1.5	25.7	28.0	21.1	24.6	33.4	11.8
5	T2	0 (inlet)	3	35.8	41.6	28.0	35.0	45.3	19.4
6	T2	0 (outlet)	0.5	30.5	35.7	23.6	29.7	41.4	12.9
7	T2	5	1.5	29.9	34.0	24.3	29.2	39.3	14.5
8	T2	20	1.5	27.6	30.9	22.7	26.9	36.1	12.8
Additional NO_2 measurements around the barrier at T2									
Barrier location				Annual mean NO_2 (µg/ m^3)					
Number	Transect	Distance from barrier (m)	Height (m)	All	Day	Night	N-S wind	W wind	E wind
13	T2	-1	3	39.3	46.8	29.5	38.5	47.9	23.6
14	T2	-1	1.5	41.7	49.5	31.4	40.7	48.0	30.2
15	T2	0	3.5	37.4	43.4	29.2	36.5	44.2	25.5
16	T2	1	1.5	31.1	35.8	24.6	30.2	41.5	14.2

5.1. An in-depth comparison of the analogous analyser locations at T1 and T2

Hourly NO_2 levels were measured at 4 analogous locations along transects T1 and T2 (Numbers 1 - 8; Table 48). These analysers were located within the barrier inlet @ 3m height, within the barrier outlet @ 0.5m height, 5m downwind of the barrier @ 1.5m height and 20 m downwind of the barrier @ 1.5 m height.[n] The annual mean NO_2 levels, with respect to their distance from the barrier are plot in Figure 32 for the 4 continuous monitors at analogous locations along transects T1 and T2.

[n] It should be noted that no chemiluminescent analyser was placed upwind of the barriers at T1 and C1, so comparisons could only be made between the pollution level observed at the barrier and downwind

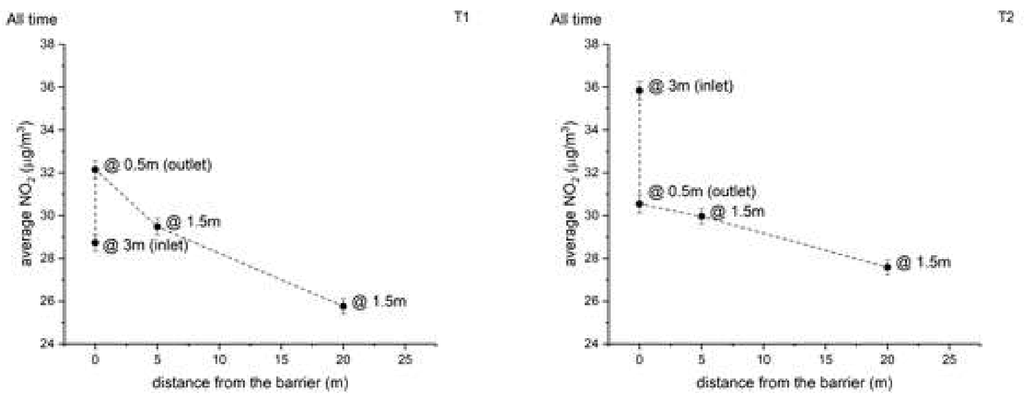

Figure 32: Annual mean NO_2 levels and 95% confidence intervals about the mean ($\mu g/m^3$) vs distance from the barrier (m) measured using continuous automatic monitors at the 4 analogous locations along T1 and T2 that encompass the SmogStop® barrier [numbers in brackets represent the height the monitor was positioned].

As described earlier, at T1, NO_2 levels rose on going from the inlet to the outlet (by 3.4 $\mu g/m^3$; 11.9%), whereas at T2, NO_2 levels fell on going from the inlet to the outlet (by 5.3 $\mu g/m^3$; 14.8%). This observation indicated airflow varied along the SmogStop® barrier.[o] This can be better understood by comparing wind direction data (anemometers M1 and M4) and air flow data within the barrier (anemometers M2 and M3) measured on the trial site, and wind direction data from the National Highways local monitoring station (Site 9) (Figure 33). At the local monitoring station (located 270m North East of the trial @ 3.5m height), the average wind direction was 193.7° (i.e. South-South Western), with wind blowing primarily from the South (46.0% of all measured instances). Similarly, at M4 (located 10m North of the Northern end of the SmogStop® barrier @ 3.5m height), the average wind direction was 171.8° (i.e. Southern), with wind again blowing primarily from the South (47.8% of all measured instances).[p] However, at M1 (located at the top of the crank at T2 @3.5 m height), the average wind direction was 134.2° (i.e. South-Eastern), and wind blew primarily from the East (35.7% of all measured instances). Although this differed from Site 9 and M4, it correlated with anemometer measurements taken inside the barrier at M2 and M3, which on average showed that air flowed up the barrier (i.e. from the outlet to the inlet; indicative of a predominant Eastern airflow at this location).

Overall, the anemometer measurements showed that airflow in and around the barrier at T2 differed from the prevailing wind measured elsewhere. This turbulent airflow may have been caused by the aerodynamics of the barrier or pressure and airflow changes caused by nearby traffic.

[o] Although it should be noted that air flow inside the barrier was only measured at transect T2 using anemometers M2 and M3, and not at transect T1.

[p] It should be noted that this anemometer did not measure winds from the North, which was likely caused by nearby trees blocking the flow of air from the North.

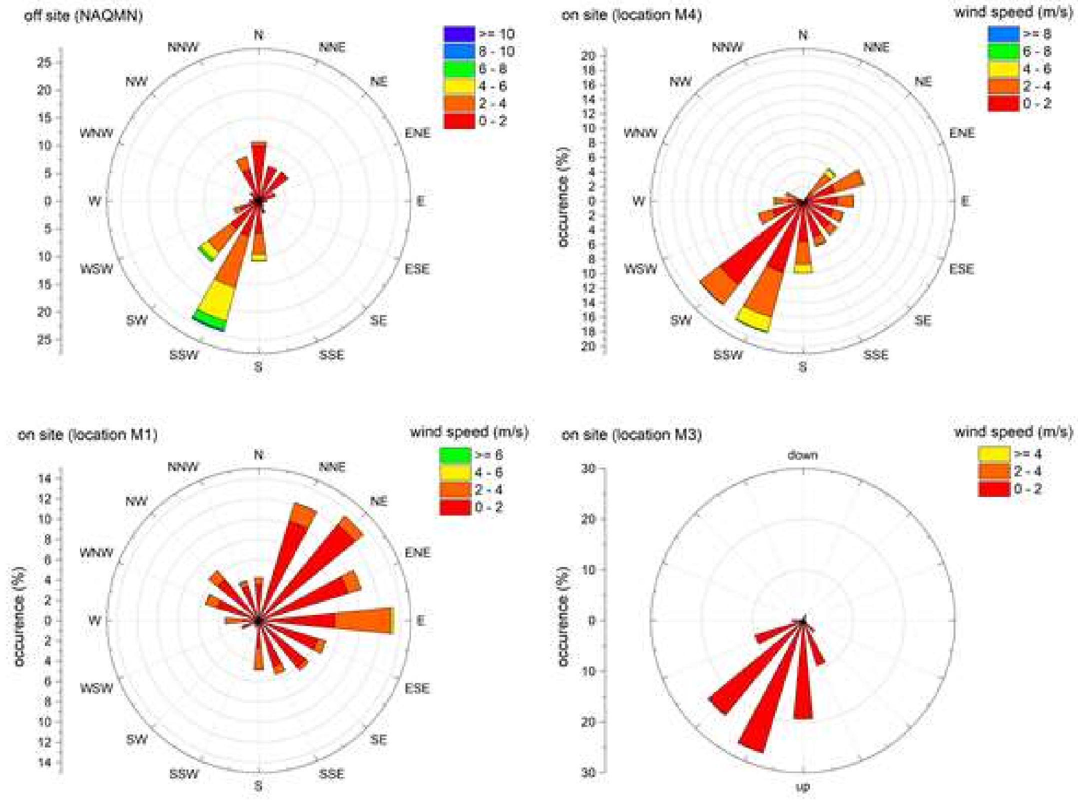

Figure 33: Wind speed and direction over the trial period measured at a local National Air Quality Monitoring Network (NAQMN) station (Site 9) located ~270m to the North East of the test site @ 3.5m height, the on-site monitor M4 located ~10m to the North of the Northern end of the SmogStop® barrier @ 3.5m height, the on-site monitor M1 located on top of the crank of the SmogStop® barrier at T2 @ 3.5m height, and the on-site monitor M3 located inside the SmogStop® barrier at T2.

Despite the predominant upward flow of air within the barrier at T2, NO_2 levels increased from the outlet to the inlet. Given the photocatalyst functions primarily by reducing NO_2 to N_2 and O_2, any increase in NO_2 level could not be attributed to the photocatalyst.[q] To explain this increase, we conclude that air flowing through the barrier mixed with surrounding air at both the inlet and outlet before it was measured by the continuous analyser. Because of this mixing of air, it was not possible to carry out an analogous analysis of the photocatalytic performance to the Toronto trial.[21] Instead, we decided to take the inlet (top) of the barrier as a fixed reference point by which to compare changes in NO_2 levels at the outlet (bottom) and downwind of the barrier. Student t-tests (paired, 2-tailed) were used to determine the probability of a significant difference, and Cohen's d-values were used to determine the 'effect size' of this difference (where ~0.2 is a small difference, ~0.5 is a moderate difference and ~0.8 is a large difference). For the 4 analogous continuous monitor locations at T1 and T2, annual means are shown in Table 49, and the net and percentage changes with respect to the monitor at the inlet are shown in Table 50.

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[q] This is corroborated by the fact that NO_2 levels increase from the outlet to the inlet in the night time as well, which will be discussed later in this section

Table 49: Summary of the annual mean NO_2 and 95% confidence intervals (µg/m^3) measured using continuous monitors positioned at 4 analogous locations along T1 and T2, which encompassed the SmogStop® barrier. Data is sub-categorised into 'All' of the trial period, 'Daytime' and 'Night time' hours, and hours of Western (225 - 315°; 'W'), Eastern (45 - 125°; 'E') and Northern-Southern (315 - 45° and 135 - 215°; 'N-S') winds.

	Annual mean NO_2 (µg/m^3)							
	T1				T2			
	inlet (0m @ 3m height)	outlet (0m @ 0.5m height)	5m downwind (@ 1.5m height)	20m downwind (@ 1.5m height)	inlet (0m @ 3m height)	outlet (0m @ 0.5m height)	5m downwind (@ 1.5m height)	20m downwind (@ 1.5m height)
All	28.7	32.1	29.5	25.8	35.8	30.5	30.0	27.6
Daytime	33.0	36.7	32.7	28.0	41.6	35.7	34.0	30.9
Night time	21.7	24.5	23.5	21.1	28.0	23.6	24.3	22.7
E wind	12.8	14.2	12.8	11.8	19.4	12.9	14.5	12.8
W wind	37.2	41.8	38.5	33.4	45.4	41.4	39.3	36.1
N-S wind	27.5	30.8	28.2	24.6	35.0	29.7	29.2	26.9

	95% confidence intervals of the annual mean NO_2 (µg/m^3)							
	T1				T2			
	inlet (0m @ 3m height)	outlet (0m @ 0.5m height)	5m downwind (@ 1.5m height)	20m downwind (@ 1.5m height)	inlet (0m @ 3m height)	outlet (0m @ 0.5m height)	5m downwind (@ 1.5m height)	20m downwind (@ 1.5m height)
All	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3
Daytime	0.6	0.6	0.6	0.5	0.6	0.6	0.5	0.5
Night time	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5
E wind	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.6
W wind	1.1	1.1	1.0	0.9	1.1	1.0	0.9	0.8
N-S wind	0.4	0.5	0.4	0.4	0.5	0.5	0.4	0.4

Table 50: Summary of the average net (µg/m^3) and percentage (%) reductions in NO_2 levels measured using continuous monitors positioned at 4 analogous locations along T1 and T2, which encompassed the SmogStop® barrier. Reductions in NO_2 seen at the outlet of the barrier (0m from the barrier @0.5 height) and downwind of the barrier (5m downwind of the barrier @1.5 height and 20m downwind of the barrier @1.5 height) were versus those measured at the inlet of the barrier (0m from the barrier @3.5 height). Reductions are sub-categorised into 'All' of the trial period, 'Daytime' and 'Night time' hours, and hours of Western (225 - 315°; 'W'), Eastern (45 - 125°; 'E') and Northern-Southern (315 - 45° and 135 - 215°; 'N-S') winds.

	Net reductions in NO_2 (µg/m^3)						Percentage reductions in NO_2 (%)					
	T1			T2			T1			T2		
	inlet - outlet	inlet - 5 m downwind	inlet - 20 m downwind	inlet - outlet	inlet - 5 m downwind	inlet - 20 m downwind	inlet - outlet	inlet - 5 m downwind	inlet - 20 m downwind	inlet - outlet	inlet - 5 m downwind	inlet - 20 m downwind
All	-3.4	-0.8	3.0	5.3	5.9	8.2	-11.9	-2.6	10.3	14.8	16.4	23.0
Daytime	-3.7	0.3	5.0	5.9	7.6	10.6	-11.2	0.8	15.2	14.1	18.2	25.6
Nighttime	-2.8	-1.8	0.5	4.4	3.8	5.3	-13.1	-8.3	2.4	15.8	13.4	18.9
E wind	-1.4	0.0	1.0	6.4	4.8	6.5	-11.2	0.1	7.9	33.3	25.0	33.7
W wind	-4.5	-1.3	3.8	3.9	6.0	9.2	-12.2	-3.5	10.3	8.7	13.3	20.3
N-S wind	-3.3	-0.7	2.9	5.3	5.8	8.0	-11.9	-2.6	10.5	15.1	16.5	23.0

Boxes with red font represent reductions where the probability of being significantly different is < 0.95.
Boxes shaded white, red and green represent Cohen's d values where the effect size of these differences are none to small (0 to 0.2), small to moderate (0.2 to 0.5) and moderate to large (0.5 to 0.8), respectively.

At T1, annual average NO_2 levels increased from the inlet to the outlet of the barrier (3.4 µg/m^3; 11.9%), and the inlet to 5m downwind of the barrier (0.8 µg/m^3; 2.6%). However, from the inlet to 20m downwind of the barrier, the annual average NO_2 levels decreased (3.0 µg/m^3; 10.3%). When sub-categorised for meteorological condition, be it daytime or night time, or wind direction, NO_2 levels always increased on going from the inlet to the outlet; even when the prevailing wind direction was from the East and flowing in the direction of the outlet to the inlet. However, notable differences in behaviour were observed. For example, reductions in NO_2 from the inlet to 5 and 20m downwind of the barrier were greater during the daytime (up to 5.0 µg/m^3; 15.2%) than during the night time (up to 0.5 µg/m^3; 2.4%), which was evidence of an enhanced photocatalytic effect.[r] The average percentage increase in NO_2 reduction during the daytime at T1 and T2 were 7.9% and 3.3%, respectively. With wind direction, reductions in NO_2 were greatest (up to 3.8 µg/m^3; 10.3 %) when wind blew from the West (i.e. from the motorway) and smallest (up to 1.0 µg/m^3; 7.9%) when wind blew from the East (i.e. towards the motorway). However, overall it should be noted that differences in NO_2 levels at T1 were relatively small. Several differences were not outside the 95% confidence interval, and most effect sizes were between none and small. Nevertheless, notable exceptions were seen during the daytime and Western winds, with effect sizes reaching small to moderate.

At T2, annual average NO_2 levels consistently decreased from the inlet to the outlet of the barrier (5.3 µg/m^3; 14.8%), the inlet to 5m downwind of the barrier (5.9 µg/m^3; 16.4%), and the inlet to 20m downwind of the barrier (8.2 µg/m^3; 23.0%). Similar to T1, when sub-categorised for meteorological condition, notable differences in behaviour were observed. During the daytime (up to 10.6 µg/m^3), net reductions in NO_2 were consistently higher than during the night time (up to 5.3 µg/m^3), which was

[r] It should be noted that average daytime and night time wind directions and wind speeds, as measured at the local National Highways monitoring station (Site 9) were near equivalent; with daytime average wind directions and speeds of 198° and 1.9 m/s, respectively, and night time average wind directions and speeds of 189° and 1.8 m/s, respectively.

again indicative of an enhanced photocatalytic effect. With wind direction, net reductions in NO_2 were greatest (up to 9.2 μg/m^3) when wind blew from the West and smallest (up to 6.5 μg/m^3) when wind blew from the East; however, percentage reductions were greatest when wind blew from the East (up to 33.7%). Overall, differences in net NO_2 levels were significantly higher at T2 than at T1. All differences were within 95% confidence, and all effect sizes were at least between small to moderate. Notably, there were occasions where the effect sizes reached moderate to large during the daytime, and with Eastern and Western winds.

The analysis carried out in this section is greatly influenced by the monitor taken as the reference point. Contrasting differences in behaviour at T1 and T2 are observed because NO_2 levels increase from the inlet (the reference point) to the outlet at T1, and decrease from the inlet to the outlet at T2. As discussed earlier, airflow at the barrier was contrary to the prevailing wind; indicative of turbulent airflow. Given this complex flow of air at the barrier, it is challenging to understand these observed differences in NO_2 levels found at the barrier, and therefore, it is difficult to ascertain the effectiveness of the barrier without a suitable reference point located upwind of the barrier. The only location where continuous monitors were placed upwind was T2 (-1m @ 1.5m height and -1m @ 3m height). Interestingly, 4 monitors along T2 were stationed at a height of 1.5m, positioned at -1, 1, 5 and 20m from the barrier. Comparisons of the NO_2 levels from these 4 monitors along T2 are evaluated in Section 5.2.

5.2. Comparing differences in NO_2 levels at head height (1.5 m) upwind and downwind of the SmogStop® barrier

Hourly NO_2 levels were measured using continuous monitors at 8 locations at T2, which encompassed the SmogStop® barrier. Of these 8 locations, 4 were positioned at a height of 1.5m at distances of -1, 1, 5 and 20m from the barrier (Analysers 14, 16, 7 and 8; Table 48), which form the basis of the analysis in this section.

From these 4 monitors along T2, a time-resolved (24 hr period) contour map of the annual mean hourly NO_2 levels, at a fixed height of 1.5m, is shown in Figure 34. Upwind of the barrier, peak NO_2 levels (up to ~55 μg/m^3) are seen at ~8:00 hours and ~17:00 hours, which correspond to times of peak traffic. During the night, significantly lower NO_2 levels are seen upwind of the barrier (~20 to 25 μg/m3).

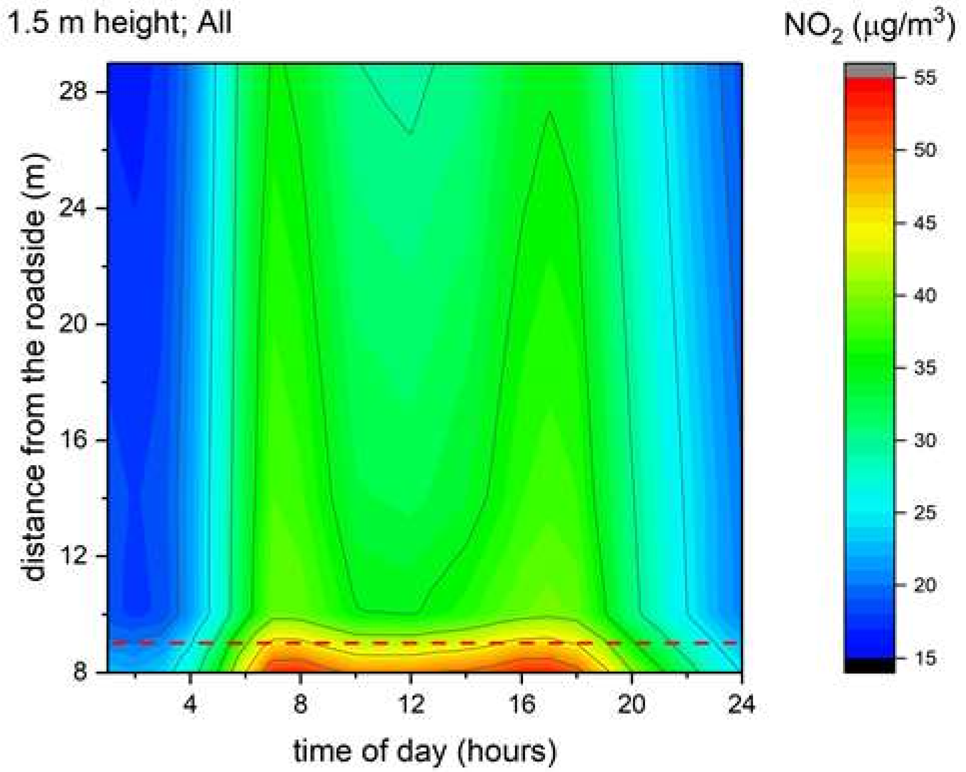

Figure 34: Time-resolved (24 hr period) contour plot of the annual mean hourly NO_2 level at T2, which encompasses the SmogStop® barrier, using data from continuous monitors positioned at a height of 1.5m and located 8, 10, 14 and 29 m from the roadside (-1, 1, 5 and 20m from the barrier, respectively). The red dashed line represents the location of the SmogStop® barrier (9 m from the roadside).

Annual mean NO_2 levels and their 95% confidence intervals are shown in Table 51 for the 4 analysers along T2 at head height (1.5m).

Table 51: Summary of the annual mean NO_2 and 95% confidence intervals (µg/m^3) measured using continuous monitors positioned at 4 locations (-1, 1, 5 and 20m of the barrier) of analogous height (1.5m) along T2, which encompassed the SmogStop® barrier. Reductions are sub-categorised into 'All' of the trial period, 'Daytime' and 'Night time' hours, hours of Western (225 - 315°; 'W'), Eastern (45 - 125°; 'E') and Northern-Southern (315 - 45° and 135 - 215°; 'N-S') winds, and hours of wind speed (ws, m/s) for ws < 1, 1 ≤ ws < 2, 2 ≤ ws < 3 and ws ≥ 3.

	Annual mean NO_2 (µg/ m^3)				95% confidence interval (µg/ m^3)			
	1 m upwind	1m downwind	5m downwind	20 m downwind	1 m upwind	1m downwind	5m downwind	20 m downwind
All	41.7	31.1	29.9	27.6	0.4	0.4	0.4	0.3
Day	49.5	35.8	34.0	30.9	0.6	0.5	0.5	0.5
Night	31.4	24.6	24.3	22.7	0.6	0.5	0.5	0.5
E	30.2	14.2	14.5	12.8	0.9	0.5	0.5	0.6
W	48.0	41.5	39.3	36.1	1.1	0.9	0.9	0.8
N-S	41.9	31.1	30.0	27.7	0.5	0.4	0.4	0.4
ws < 1	40.0	26.5	26.1	24.0	0.7	0.6	0.6	0.6
1 ≤ ws < 2	44.2	32.7	31.5	29.2	0.9	0.7	0.7	0.7
2 ≤ ws < 3	45.5	36.6	34.8	32.3	1.3	1.0	1.0	0.9
ws ≥ 3	38.4	32.9	31.2	28.4	0.9	0.7	0.7	0.7
ws < 1; Day	46.9	29.3	28.3	25.1	1.0	1.0	0.9	0.9
ws <1; Night	33.6	24.0	24.1	23.0	0.9	0.7	0.7	0.7
1 ≤ ws < 2; Day	51.1	35.9	34.2	31.3	1.1	1.0	1.0	1.0
1 ≤ ws < 2; Night	35.4	28.5	28.0	26.5	1.2	1.0	0.9	0.9
2 ≤ ws < 3; Day	53.9	42.6	40.0	37.0	1.5	1.3	1.2	1.1
2 ≤ ws < 3; Night	34.5	28.6	27.9	26.0	1.8	1.4	1.3	1.3
ws ≥ 3; Day	48.3	41.0	38.3	35.2	1.0	0.8	0.7	0.7
ws ≥ 3; Night	26.1	22.9	22.3	19.8	1.2	0.9	0.9	0.9

Student t-tests were carried out, comparing the average difference in NO_2 from -1m upwind of the barrier to 1, 5 and 20m downwind of the barrier (Table 52). Data was sub-categorised by meteorological condition (daytime/ night time, wind direction and wind speed). All differences were significant ($p > 0.99$), with a range of effect sizes observed from small to large (denoted by colour) depending on the meteorological condition.

Table 52: Summary of the average net (µg/m^3) and percentage (%) reductions in NO_2 levels measured using continuous monitors positioned at 4 locations (-1, 1, 5 and 20m of the barrier) of analogous height (1.5m) along T2, which encompassed the SmogStop® barrier. Reductions in NO_2 were versus those measured at -1m from the barrier (1m upwind). Reductions are sub-categorised into 'All' of the trial period, 'Daytime' and 'Night time' hours, hours of Western (225 - 315^o; 'W'), Eastern (45 - 125^o; 'E') and Northern-Southern (315 - 45^o and 135 - 215^o; 'N-S') winds, and hours of wind speed (ws, m/s) for ws < 1, 1 ≤ ws < 2, 2 ≤ ws < 3 and ws ≥ 3. All differences were significant (p > 0.99).

	NO_2 reduction (µg/ m^3)			NO_2 reduction (%)		
	1 m upwind - 1 m downwind	1 m upwind - 5 m downwind	1 m upwind - 20 m downwind	1 m upwind - 1 m downwind	1 m upwind - 5 m downwind	1 m upwind - 20 m downwind
All	10.6	11.7	14.1	25.5	28.1	33.8
Day	13.7	15.5	18.5	27.6	31.3	37.5
Night	6.8	7.1	8.7	21.8	22.7	27.6
Eastern	16.0	15.7	17.3	53.0	51.9	57.5
Western	6.4	8.7	11.9	13.4	18.1	24.7
Northern-Southern	10.8	11.9	14.2	25.8	28.3	33.9
ws < 1	13.5	13.9	16.1	33.7	34.7	40.1
1 ≤ ws < 2	11.5	12.7	15.0	26.0	28.8	33.9
2 ≤ ws < 3	9.0	10.8	13.3	19.7	23.7	29.2
ws ≥ 3	5.5	7.3	10.1	14.4	18.9	26.2
ws < 1; Day	17.6	18.5	21.8	37.6	39.6	46.5
ws <1; Night	9.6	9.5	10.7	28.6	28.4	31.8
1 ≤ ws < 2; Day	15.2	16.9	19.8	29.7	33.2	38.7
1 ≤ ws < 2; Night	6.9	7.4	8.9	19.4	20.8	25.1
2 ≤ ws < 3; Day	11.3	13.9	16.9	20.9	25.9	31.4
2 ≤ ws < 3; Night	5.9	6.6	8.5	17.1	19.2	24.5
ws ≥ 3; Day	7.3	10.0	13.1	15.2	20.7	27.0
ws ≥ 3; Night	3.3	3.8	6.3	12.4	14.5	24.2

Boxes shaded red, green and blue represent Cohen's d values where the effect size of these differences are small to moderate (0.2 to 0.5), moderate to large (0.5 to 0.8) and large (> 0.8), respectively.

Comparing all the data, average differences of ~10.6, ~11.7 and ~14.1 µg/m^3 were observed 1, 5 and 20 m downwind of the barrier, respectively. These corresponded to reductions in NO_2 of ~25.5, ~28.1 and ~33.8%, with all differences being significant (p > 0.99) and with effect sizes between moderate to large. Importantly, average NO_2 levels at 1.5m, which is ~ head height, decrease from levels that are above the prescribed annual mean limit value 1m upwind of the barrier (~41.7 µg/m^3) to levels below this limit value 1, 5 and 20m downwind of the barrier (~31.1, ~29.9 and ~27.6 µg/m^3, respectively).

Significantly larger reductions in NO_2 were observed during the daytime than during the night time. For example, if we compare differences seen 1 m downwind of the barrier, during the daytime, an average reduction of ~13.7 µg/m3 (~27.6%) was observed, and during the night time, an average reduction of ~6.8 µg/m3 (~21.8%) was observed. Importantly, during the daytime, all effect sizes were large, whereas during the night time all effect sizes were between moderate to large, which was evidence of a photocatalytic effect improving the function of the barrier. If we compare the average reductions found downwind of the barrier during the daytime (~32.1%) with those found during the night time (~24.0%) we see an enhanced reduction of ~8.1%. We can therefore attribute ~1/4 of the NO_2 removal function of the barrier to the photocatalytic coating, and the remaining ~3/4 of the NO_2 removal function to the aerodynamics of the barrier.

NO_2 measurements were also sub-categorised for wind direction, and are shown as contour plots in Figure 35 and as differences against the upwind reference point in Table 52.[s] As wind was dominated by Northern-Southern winds (~76% of all winds)[t], the contour plot of Northern-Southern winds largely follows what was seen for the case of all wind directions. However, contrastingly different behaviours are found for Western and Eastern winds. The lowest reductions in NO_2 levels were found when wind blew from the West (i.e. from the motorway), with NO_2 levels 1 m upwind of the barrier (~48.0 µg/m^3) decreasing by ~13.4% 1 m downwind of the barrier (~41.5 µg/m^3). With Western winds, NO_2 levels below the prescribed annual mean limit value were reached 5 m downwind of the barrier (~39.3 µg/m^3). On the other hand, the highest reductions in NO_2 levels were found when wind blew from the East (i.e. towards the motorway), with NO_2 levels 1 m upwind of the barrier (~30.2 µg/m^3) decreasing by ~53.0% 1 m downwind of the barrier (~14.2 µg/m^3).

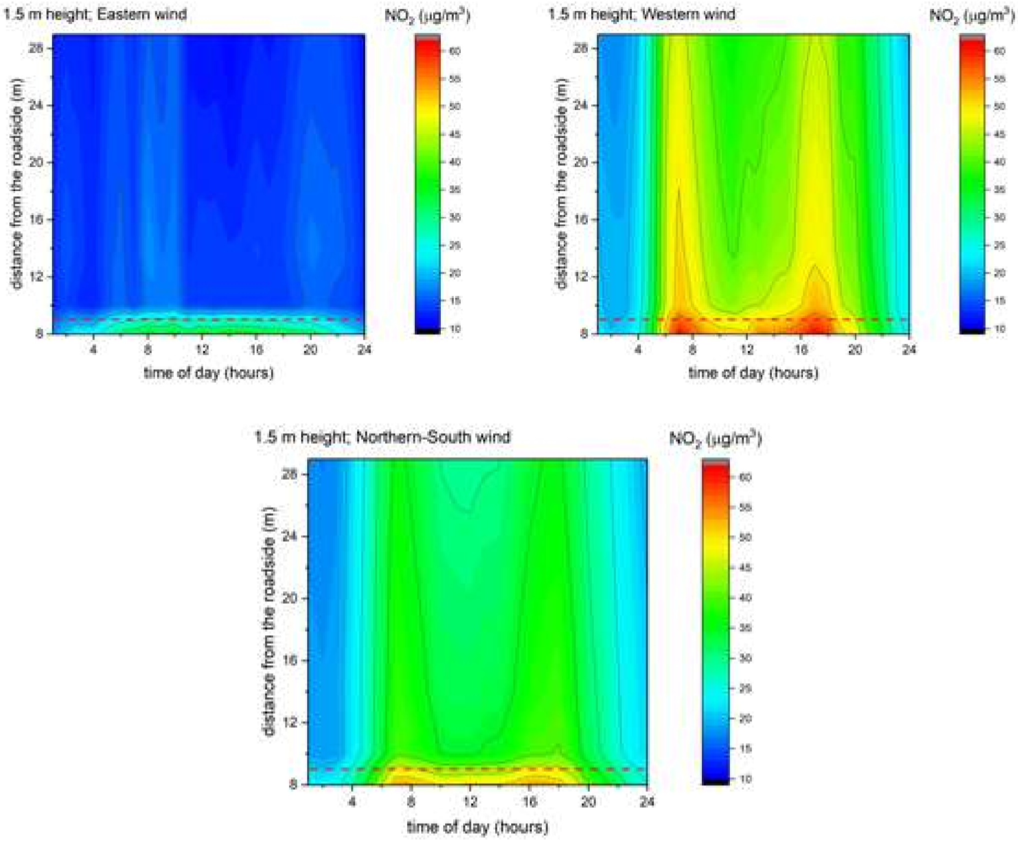

Figure 35: Time-resolved (24 hr period) contour plots of the annual mean hourly NO_2 level at T2, which encompasses the SmogStop® barrier, using data from continuous monitors positioned at a height of 1.5m and located 8, 10, 14 and 29 m from the roadside (-1, 1, 5 and 20m from the barrier, respectively). Contour maps were sub-categorised into Eastern (45 - 135^o,), Western (225 - 315^o) and

[s] It should be noted that average daytime and night time wind directions and wind speeds, when sub-categorised by wind direction, as measured at the local National Highways monitoring station (Site 9) were near equivalent

[t] Whilst winds from the north and from the south have been combined in the figure, the prevailing wind direction over the trial period was from the SSW.

Northern-Southern (315 - 45^o and 135 - 225^o) winds only. The red dashed line represents the location of the SmogStop® barrier (9 m from the roadside).

NO_2 measurements were also sub-categorised for wind speed (Table 53). Approximately 1/3 of all wind was less than 1 m/s, approximately 1/3 of all wind was between 1 and 2 m/s, approximately 1/6 of all wind was between 2 and 3 m/s, and approximately 1/6 of all wind was > 3 m/s.

Table 53: A summary of the fraction of wind by wind speed, the average direction at the wind speed interval, and the percentage of Eastern (45 - 135^o,), Western (225 - 315^o) and Northern-Southern (315 - 45^o and 135 - 225^o) winds at the wind speed interval. The wind speed (ws, m/s) intervals chosen were ws < 1, 1 ≤ ws < 2, 2 ≤ ws < 3 and ws ≥ 3.

	Total (%)	average wind direction (^{o})	E (%)	W (%)	N-S (%)
all	100	193.7	8.8	14.2	75.6
ws < 1	35.6	148.9	18.1	15.1	65.5
1 ≤ ws < 2	29.3	220.1	7.6	16.3	74.9
2 ≤ ws < 3	13.4	230.6	1.0	13.6	84.4
ws ≥ 3	21.7	208.4	0.0	10.5	88.6

Contour plots of these 4 selected wind speed intervals are shown in Figure 36 and as differences against the reference monitor upwind in Table 52. The greatest reductions in NO_2 were seen when the wind speed was lowest, with a 33.7% reduction seen 1m downwind at < 1 m/s (a reduction from 40.0 to 26.5 μg/m^3). The smallest reductions in NO_2 were seen when the wind speed was fastest, with a 14.3% reduction seen 1m downwind at >3 m/s (a reduction from 38.1 to 32.7 μg/m^3). Effect sizes were between moderate to large at wind speeds < 1 m/s. This decreased to between small to moderate at wind speeds ≥ 3 m/s. The greater reduction in NO_2 at lower wind speeds may be attributed to the increased residence time of the pollutant on the photocatalytic barrier, therefore increasing its remediation efficacy. This is evidenced by the higher percentage reductions in NO_2 seen during the daytime than during the night time at lower wind speeds (up to 14.2% greater reductions at wind speeds < 1 m/s) as compared with higher wind speeds (up to 6.3% greater at wind speeds ≥ 3 m/s). However, it should be noted that the average wind direction did differ at low wind speeds, as measured at the local National Highways monitoring station (Site 9), with average wind directions of 148.9, 220.1, 230.6 and 208.4^o seen at wind speeds of < 1 m/s, 1 to 2 m/s, 2 to 3 m/s and ≥ 3 m/s, respectively. Wind therefore blew more prominently from an Eastern direction at wind speeds of < 1 m/s, with reductions in NO_2 seen at this wind speed correlating well with what was observed with Eastern winds only. However, at wind speeds greater than 1 m/s, average wind directions were broadly similar. The reduction in performance at higher wind speeds can therefore be attributed to a mass transport effect, where the NO_2 pollution from nearby traffic is carried at a faster speed towards the barrier.

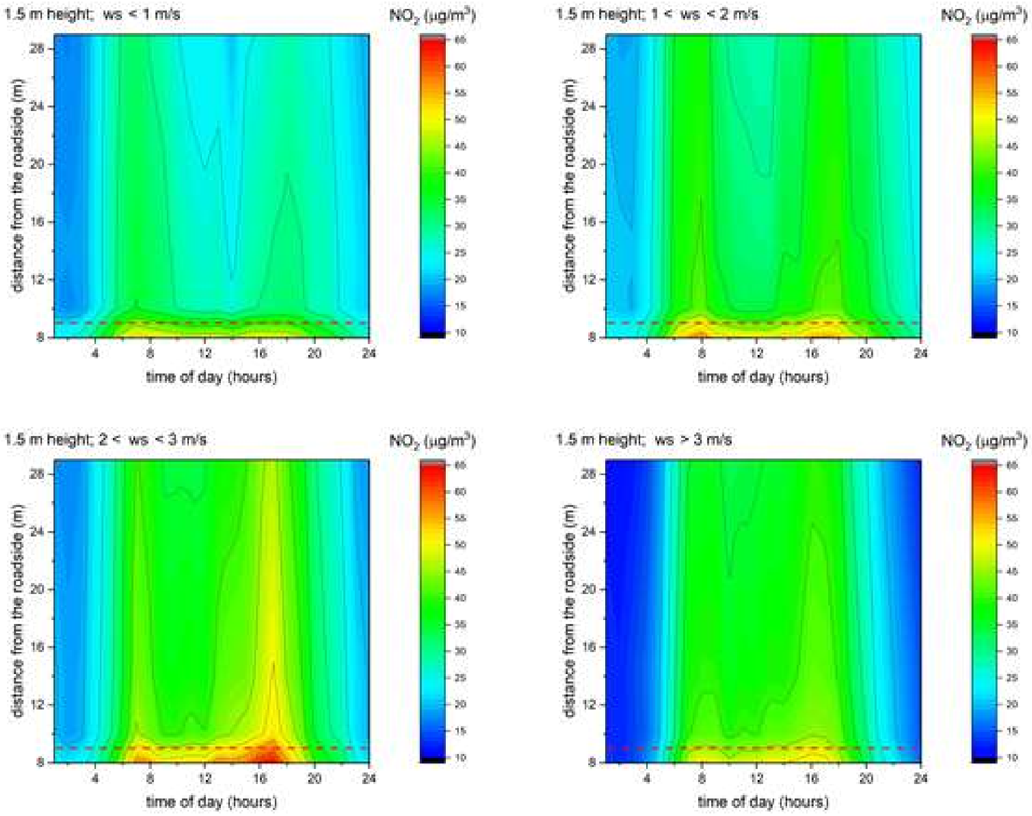

Figure 36: Time-resolved (24 hr period) contour plots of the annual mean hourly NO_2 level at T2, which encompasses the SmogStop® barrier, using data from continuous monitors positioned at a height of 1.5m and located 8, 10, 14 and 29 m from the roadside (-1, 1, 5 and 20m from the barrier, respectively). Contour maps were sub-categorised by wind speed (ws, m/s) for ws < 1, 1 ≤ ws < 2, 2 ≤ ws < 3 and ws ≥ 3. The red dashed line represents the location of the SmogStop® barrier (9 m from the roadside).

5.2.1. An estimate of the total NO_2 remediated by the SmogStop® barrier

The analysis in this section showed that the SmogStop® barrier, at T2, reduced NO_2 levels from 41.6 μg/m^3 1m upwind of the barrier at head height to 31.1 μg/m^3 1m downwind of the barrier at head height over the trial period, which represented a 25.5% reduction.[u] Between these two locations, when sub-categorised for daytime and night time periods, reductions of 27.6% and 21.8% are seen, respectively. We can therefore estimate, between these two locations, that ~21% of all daytime NO_2 reductions was due to a photocatalytic remediation effect, and that ~79% of all daytime NO_2 reductions was due to dispersion by the barrier. This represents an average daytime photocatalytic remediation of 2.87 μg/m^3.

The average flow of air through the barrier at T2 can be determined from air flow speed and direction data collected at anemometer M3. The average air flow direction and speed seen at M3 was 199^o and

[u] This percentage reduction is consistent with the findings from the analysis of the diffusion tube data. See section 4.1.2.

0.73 m/s, respectively, and therefore, on average travelled through the barrier at a speed of 0.69 m/s.[v] As the gap between the two panes of the SmogStop® barrier is 25cm, the flow rate of air travelling through this 100m long and 3m high barrier is 17.2 m^3/s. Therefore, over the period of a day, the mass reduction of NO_2 due to photocatalytic remediation for this 100m long and 3m high barrier would be ~2.13 g,[w] and over a period of a year, ~0.78 kg.

The Emissions Factor Toolkit indicates an average NO_x g/km motorway emission rate in 2021 of 0.336g/vehicle km, assuming (15% HDV) at 100kph. Assuming 100,000 vehicles per day, this equates to 3.64 kg of NO_x per 100m per day. Of this, 27.9% is primary NO_2, which equates to 0.94 kg of primary NO_2/100m/day. Therefore, we estimate the photocatalytic remediation of ~0.23% of these emissions, which equates to the removal of ~230 vehicles per day. It is likely that this remediation effect will increase as the barrier is scaled, and therefore, the area of the photocatalytic coating is increased. Moreover, positioning the barrier closer to the roadside should result in higher concentrations of NO_2 approaching the barrier, and therefore a greater likelihood for photocatalytic remediation to occur.

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[v] Assuming the average wind direction and speed seen at M3 is a vector, the cosine of the angle towards the upward vector (19.9^{o}) multiplied by the average wind speed (0.73 m/s) gives 0.69 m/s.

[w] Assuming a 12 hour day.

6. Comparison of NO_2 monitoring results at co-located sampling points

The co-location of both diffusion tubes and continuous automatic monitoring instruments for the measurement of NO_2 concentrations during the trial provides the opportunity to compare results from the two measurement methods. As highlighted in Section 2, diffusion tubes are an indicative monitoring technique. By contrast, the chemiluminescence method, used in most automatic ambient monitoring apparatus for NO_2, is defined as the reference method for this pollutant.[33] Whilst ideal for identifying locations where NO_2 concentrations are highest, diffusion tubes do not provide the same level of accuracy as automatic chemiluminescent monitoring techniques.

Figure 37 and Figure 38 present a comparison of the measured annual mean NO_2 concentrations from the two measurement methods at 5 metres and 20 metres behind the barriers respectively. All are at a vertical height of 1.5 metres.

At 5 metres behind the barriers, the diffusion tube annual mean NO_2 measurements are seen to be between 16% and 17% higher than the comparable continuous automatic monitor measurements. At 20 metres behind the barriers, the diffusion tube annual mean NO_2 measurements are seen to be between 16% and 24% higher than the comparable continuous automatic monitor measurements.

The primary objective of the trial is to compare the *relative* performance of the SmogStop® barrier technology with the wooden fence barrier acting as a control. Therefore, differences in the *absolute* levels measured by the two techniques will not undermine this objective. The differences in measurement performance of the two techniques should nevertheless be noted.

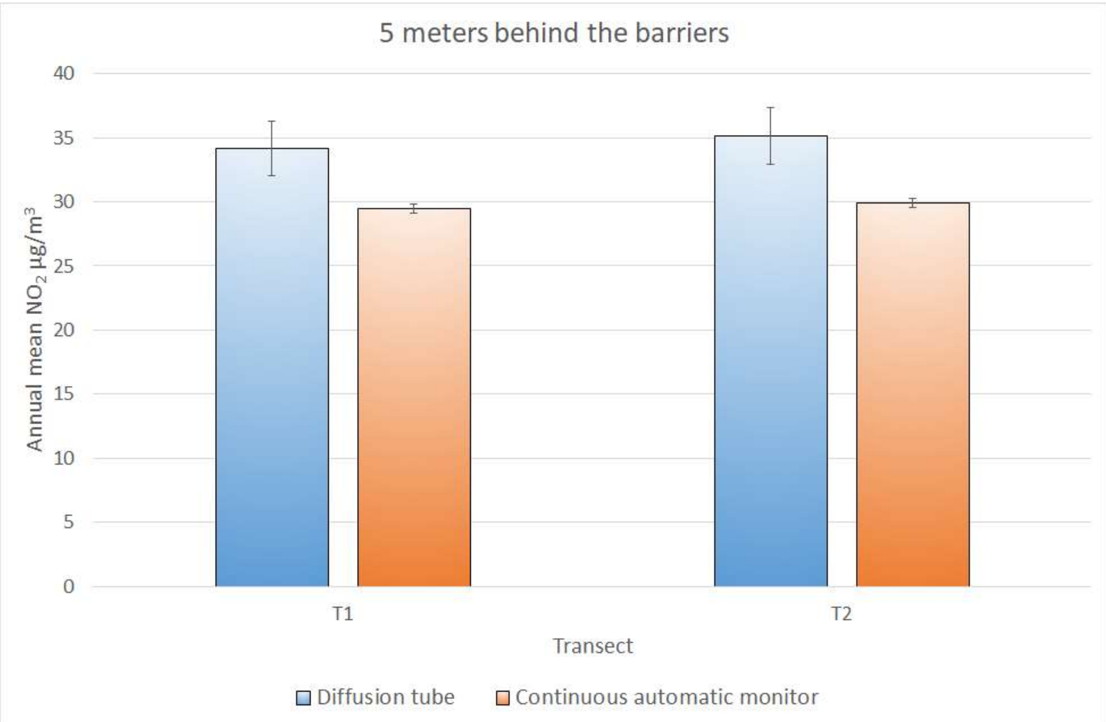

Figure 37: Comparison of annual mean NO_2 µg/m^3 at co-located sampling points 5 metres behind the barriers.

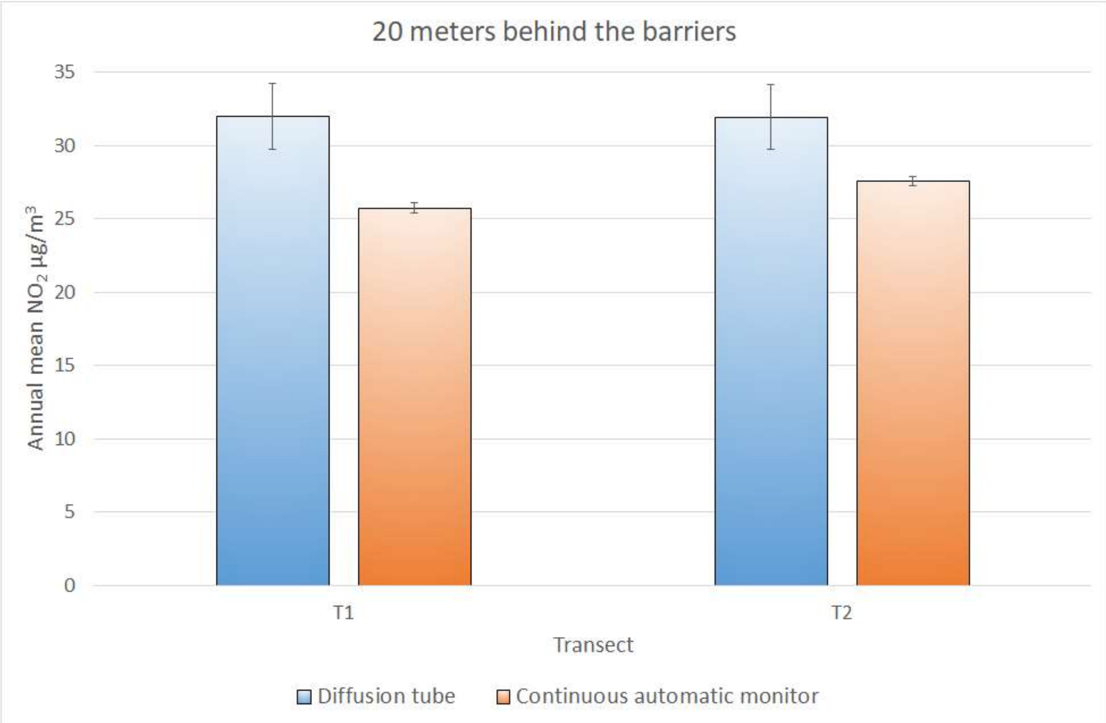

Figure 38: Comparison of annual mean NO_2 µg/m^3 at co-located sampling points 20 metres behind the barriers.

7. Conclusions

7.1 Conclusions

7.1.1 Overview

It has been noted in Section 2.1 that the design and previous testing of the SmogStop® barrier was all previously conducted assuming a barrier height of 4 meters or greater, with wind tunnel tests conducted on 4 meter and 5 meter scale models, and field trials conducted on a 6 meter barrier (see Annex 1 for more details). However, for the field trial in Tibshelf, UK, a 3 meter high SmogStop® barrier (plus 0.5 meter crank) was commissioned.

It should also be noted that the barrier deployment for the Tibshelf trial was at a distance of 9 meters from the carriageway, whereas the previous Toronto barrier trial was at an approximate distance of 4 meters from the carriageway. Differing trial results may be expected with different combinations of both barrier height and barrier distance from the pollution source.

As previously noted in Section 2.2, the NO_2 data collected need to be interpreted with knowledge of the limitations of the measurement techniques used in the trial. Diffusion tubes are an indicative monitoring technique with relatively high uncertainty, typically quoted as ± 25%.[33] As such they are useful for assessing the Air Quality Standards Regulations 2010 annual objective of 40 µg/m^3, but cannot be used to assess the number of hours greater than 200 µg/m^3, since the exposure period for diffusion tubes is typically several weeks. In addition, they obviously cannot differentiate wind direction. In contrast, the chemiluminescence method (continuous automatic monitoring) is defined as the reference method for this pollutant, with data typically collected at an hourly time resolution, and its uncertainty is usually quoted as ± 15%.[1]

7.1.2 Diffusion tube data

- When comparing the annual mean NO_2 concentrations in front of the barriers with those behind the barriers (both T1 & T2 SmogStop® and C1 & C2 wooden fence), there is a step change reduction of around 28% (circa 14 µg/m^3) between measurement locations 1 metre in front of the barriers, and 1 metre behind the barriers, as illustrated in Figure 11.
- Where no barriers are present (transects N1 & S1), the comparable reduction at a height of 1.5 metres is of the order of 16% (circa 8 µg/m^3) due to distance and dispersion effects, which suggests that the barriers are responsible for a reduction of around 12% (circa 6 µg/m^3) in NO_2 concentrations (1 metre in front of the barriers versus 1 metre behind the barriers).
- At 10 metres behind the barriers, the annual mean NO_2 concentrations (barrier and no-barrier) tend to converge.
- When comparing the performance of the SmogStop® barrier and the wooden barrier, whilst it is observed that there is an overall tendency for the average NO_2 concentrations measured behind the wooden control barrier to be marginally higher than behind the SmogStop® barrier, there are no statistically significant differences ($p > 0.05$) in the observed annual mean NO_2 concentrations behind the barriers in the raw (not de-seasonalised) diffusion tube data (see Annex 3).
- There are no statistically significant differences ($p > 0.05$) in the annual mean NO_2 reduction performance of the SmogStop® barrier and the wooden fence barrier at a height of 1.5 metres, at 1m, 10m, or 20m behind the barriers, based on de-seasonalised data.
- However, at 5m behind the barrier at a height of 1.5m, the annual mean NO_2 concentrations behind the SmogStop® barrier are statistically significantly lower ($p < 0.05$) for three out of the four comparisons, based on de-seasonalised data. Transect T1 is statistically significantly lower

than transect C1 (-2.8μg/m^3, -7.5%) and transect C2 (-2.3μg/m^3, -6.2%); transect T2 is statistically significantly lower than C1 (-1.7μg/m^3, -4.6%). See Table 12 and Table 13.

- At 15m behind the barriers at a height of 1.5m, the annual mean NO_2 concentration at transect T1 is statistically significantly lower ($p < 0.05$) than at transect C2 (-1.8μg/m^3, -5.3%), based on de-seasonalised data. See Table 17.
- Therefore, based on de-seasonalised diffusion tube data, the SmogStop® barrier appears to perform better than the wooden control barrier at 5 metres behind the barrier at a height of 1.5m, with reductions in annual mean NO_2 concentrations of between 1.7 μg/m^3 and 2.8 μg/m^3 ($p < 0.05$). In addition, the SmogStop® barrier appears to perform better than the wooden control barrier at 15 metres behind the barrier at a height of 1.5m, when comparing transect T1 with transect C2, with a reduction in annual mean NO_2 concentration of 1.8 μg/m^3 ($p < 0.05$). However, there are no statistically significant differences ($p > 0.05$) between the two barrier technologies at 1m, 10m, or 20m behind the barriers.

7.1.3 Continuous automatic monitor data

Chemiluminescence analysers were used to monitor hourly NO_2 levels at 16 locations on the trial site (4 at T1; 8 at T2; 4 at C1). A malfunction in the apparatus meant that the data from the 4 monitors stationed along the control at C1 were invalid, and comparisons therefore could not be made between the wooden fence barrier (transect C1) and the SmogStop® barrier (transects T1 and T2). The data analysis is therefore limited to transects T1 and T2.

Of the analyser positions at T1 and T2, 4 were co-located, with 2 stationed at the barrier (the inlet and outlet) and 2 stationed downwind of the barrier (5m and 20m at head height). No analyser was co-located upwind at T1 and T2, and therefore, the inlet at the barrier was taken as a reference point by which to compare changes in NO_2 levels. For this analysis:

- Interpreting the observed changes in NO_2 was challenging, as the air flow within and around the barrier was complex.
- At T1, NO_2 levels increased on going from the inlet to the outlet, whereas at T2, NO_2 levels decreased. This resulted in more significant decreases in annual mean NO_2 (comparing the barrier inlet value with 20m behind the barrier) being observed at T2 (up to 8.2 μg/m^3; 23.0%) downwind of the barrier as compared with T1 (up to 3.0 μg/m^3; 10.3%).
- Greater reductions in NO_2 were seen during the daytime (up to 10.6 μg/m^3; 25.6%) than during the night time (up to 5.3 μg/m^3; 18.9%) at both T1 and T2, which was evidence of a photocatalytic effect. Approximately one quarter of the NO_2 removal function of the barrier was attributed to the photocatalytic coating, and the remaining three quarters of the NO_2 removal function to the aerodynamics of the barrier. However, as stated in Section 5.1, it was challenging to understand the observed differences in NO_2 levels found at the barrier given the complexity of the air flow at the barrier, and conflicting observed results at T1 and T2 inlet and outlet.
- With wind direction (comparing the barrier inlet value with 20m behind the barrier), net reductions in NO_2 were greatest (up to 9.2 μg/m^3, 20.3%) when wind blew from the West (i.e. from the motorway) and smallest (up to 6.5 μg/m^3, 33.7%) when wind blew from the East (i.e. towards the motorway). An intermediate reduction was seen when wind blew from North or South (up to 8.0 μg/m^3, 23.0%).

At T2, 4 analysers were located at head height, with 1 stationed upwind 1m from the barrier, and 3 stationed downwind 1, 5 and 20m from the barrier. Information from these analysers were used to produce temporal contour maps of NO_2 levels approaching and behind the barrier at T2, and also, to compare differences seen upwind with those seen downwind. For this analysis:

- Reductions in annual mean NO_2 levels of up to 14.1 µg/m^3 (33.8%) were observed at 20m behind the barrier. These reductions were greater during the daytime (up to 18.5 µg/m^3; 37.5%) than during the night time (up to 8.7 µg/m^3; 27.6%). The annual mean NO_2 reduction at 1m behind the barrier was to 10.6 µg/m^3 (25.5%), which is consistent with the diffusion tube observations, taking into account the differences in measurement technology.
- Greater reductions in NO_2 levels were seen when wind blew from the East (up to 17.3 µg/m^3; 57.5%) than when wind blew from the West (up to 11.9 µg/m^3; 24.7%). Intermediate reductions in NO_2 levels were seen when wind blew from North or South (up to 14.2 µg/m^3; 33.9%).
- At lower wind speeds (< 1m/s), greater reductions in NO_2 were observed (up to 16.1 µg/m^3; 40.1% than at higher wind speeds. This was attributed to both a greater residence time of the pollutant on the photocatalytic coating and a slight change in wind direction at lower wind speeds (predominantly South Eastern at < 1 m/s; predominantly South Western at > 1 m/s).
- By comparing differences in daytime and night time performance 1m upwind and 1m downwind of the barrier, we estimate a 2.13 g photocatalytic remediation of NO_2 by the 100m long and 3m high barrier per day (or ~0.78 kg per annum). Using the Emissions Factor Toolkit, we estimate the photocatalytic remediation of the NO_2 emissions to be equivalent to the removal of ~230 vehicles per day, from 100,000 vehicles travelling along the barrier.

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Annexes

Annex 1 – SmogStop® barrier technical overview

In this technical annex, we provide details on the various laboratory tests, wind tunnel tests and field trial in Toronto of the SmogStop® barrier developed by Envision SQ and Gram Barriers[x].

The SmogStop® barrier

As stated in the main report, the SmogStop® barrier is a double-walled barrier, with an angled baffle at the top. The angled baffle enhances the vertical mixing of polluted air that encounters the barrier; however, a portion of the air is also funnelled between the two walls of the barrier. A photocatalytic coating is located within the two walls (on the back panel), which under the action of light, can remediate NO_2 to benign N_2 and O_2. The barrier therefore reduces NO_2 in two ways: (i) by enhanced vertical dispersion of air that approaches the barrier and (ii) by remediating a portion of the air that flows through the barrier under the action of photo catalysis.

The SmogStop® photo catalyst

Photocatalysts use ambient light to drive useful chemical reactions, and are increasingly being applied in paints, concretes and tiles to remedy air pollution.[22] Most products on the market use the photo catalyst titanium dioxide (TiO_2), which remedies NO_x through an oxidation pathway. The process begins with the absorption of light by the photocatalyst, which excites electrons in the material from the ground state to an excited state; leaving behind positive holes. These electrons can react with oxygen (O_2) in the air to form superoxide radicals (O_2^-), and these positive holes can react with ambient water (H_2O) to form hydroxyl radicals ($OH^\bullet$). These radicals oxidise NO_x, with O_2^- reacting with NO to form nitrate (NO_3^-) and $OH^\bullet$ reacting with NO_x in a sequential manner, taking NO to nitrous acid (HONO) to NO_2 to NO_3^-.[23] The oxidation pathway results in the formation of NO_3^- at the surface of the photocatalyst, which not only inhibits its ability to remediate NO_x, but also suppresses the oxidation of NO_x beyond NO_2.[24] The function of the TiO_2-based photocatalyst can be restored by rainfall/ washing the photocatalyst to remove NO_3^- build-up, but may result in the acidification of surrounding soils. An additional problem caused by some TiO_2-based photocatalysts is a tendency to produce HONO[25, 26]; a toxic gas that can promote the formation of ground level ozone. This happens when NO is singly oxidised and not fully oxidised to NO_3^-, and was recently highlighted by the UK Air Quality Expert Group in their evaluation of traditional TiO_2 photocatalysts.[27]

Envision SQ have developed a unique composite photocatalyst, SmogStop®, which functions differently to traditional TiO_2 photocatalysts by remedying NO_x through a reduction pathway.

Distinctive reduction pathway

SmogStop® primarily remedies NO_x by reducing it back to nitrogen (N_2) and O_2. Experiments carried out by researchers at the University of Guelph, Canada, provide evidence for this mechanism in Figure A1, which shows the photocatalytic behaviours of TiO_2 and SmogStop® against a gas stream of NO (~120 ppb) in air. For the TiO_2-based photocatalyst, there are consistent drops (~50%) in the NO concentration when the light is turned on for each cycle (Figure A1 (a)). However, alongside this drop in NO concentration is a rise in the steady-state formation of NO_2, where NO is oxidised to NO_2 (up to ~30%). This is characteristic of TiO_2-based photocatalysts which produce NO_3^- through an oxidation pathway, as the NO_3^- reacts with positive charges on TiO_2 and NO to form NO_2 (and H_2O).[28] For the SmogStop® photocatalyst, there are consistent drops in the NO concentration when the light is turned on with each cycle, similar to the TiO_2-based photocatalyst (Figure A1(b)). However, alongside the drop in NO concentration, there is only a small steady-state formation of NO_2 (< 10%), which is indicative of the strong preference for the reduction pathway in the SmogStop® photocatalyst.

[x] As this information is not publically available, but may be made available upon request.

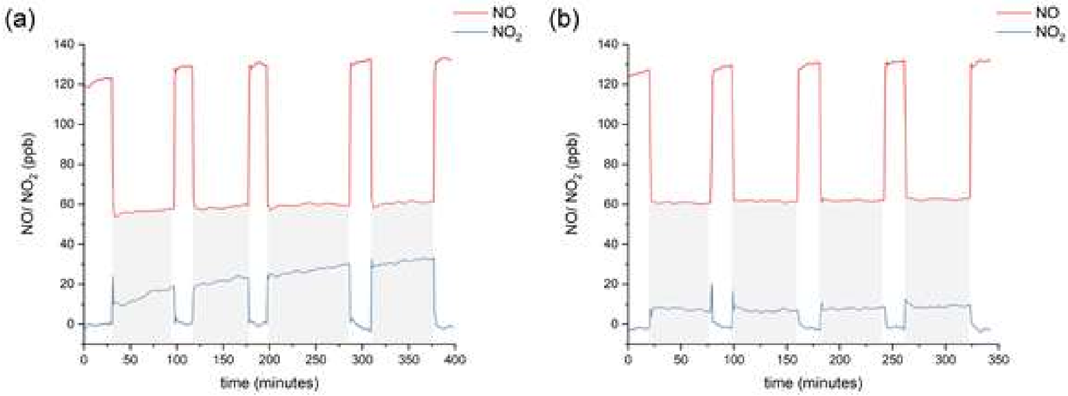

Figure A1: Photocatalytic test, carried out in accordance with ISO 22197-1: 2016[y] with some alterations to better emulate outdoor conditions (NO concentration lowered to ~120 ppb [~160 μg/m^3] as opposed to 1 ppm [~1.35 mg/m^3]; light source used was a solar simulator at 35 mW.cm^{-2} as opposed to a UVA lamp at 1 mW.cm^{-2}). (a) A traditional TiO_2 photocatalyst (Evonik Aeroxide P25) and (b) SmogStop® were measured for comparison. Shaded regions represent periods of illumination, and non-shaded regions represent periods of dark. NO and NO_2 concentrations were measured using a chemiluminescence analyser.

Suppressed nitrate formation

Researchers at the University of Guelph, Canada provided further evidence for the predominant reduction pathway and suppressed NO_3^- formation in the SmogStop® photocatalyst in Figure A2, which shows the increase in the amount of NO_3^- on the surface of the material after photocatalytic testing. For the TiO_2-based photocatalyst, there is a larger increase in the amount of NO_3^- (~0.28 mg/L) compared with the SmogStop® photocatalyst (~0.028 mg/L), despite the activity of these materials being comparable. Overall, the TiO_2-based photocatalyst produced 10 times more nitrate than the SmogStop® photocatalyst during the photocatalytic test.

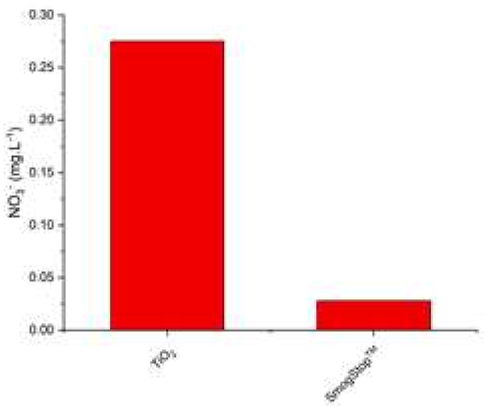

Figure A2: The increase in surface NO_3^-, measured by ion chromatography from washings of the surface with distilled water (100 ml) after photocatalytic testing. The photocatalytic test was carried out in accordance with ISO 22197-1: 2016 with some alterations to better emulate outdoor conditions (NO concentration lowered to ~100 ppb [~135 μg/m^3] as opposed to 1 ppm [~1.35 mg/m^3]; light source used

[y] International Organization for Standardization; Test method for air-purification performance of semiconducting photocatalytic materials, Part 1: Removal of nitric oxide

was a solar simulator at 35 mW.cm^{-2} as opposed to a UVA lamp at 1 mW.cm^{-2}; test carried out for a period of 5 hr). The TiO_2 photocatalyst used was Evonik Aeroxide P25.

No detectable nitrous acid (HONO)

As mentioned above, some TiO_2-based photocatalysts have been shown to produce the hazardous by-product nitrous acid (HONO) during the photocatalytic oxidation of NO_x. However, laboratory trials carried out by researchers at the University of Guelph, Canada show that SmogStop® does not produce HONO. This is evidenced in Figure A3, where the concentrations of NO, HONO, NO_2 and NO_3^- were simultaneously measured during a photocatalytic test. In this test, SmogStop® was exposed to a pure gas stream of NO (~60 ppb) in air. When the light was turned on, the NO concentration dropped sharply (to ~5 ppb). Alongside this drop in NO, no concomitant formation of NO_2 was observed, which further supports the predominance of the reduction pathway exhibited by this photocatalyst. Importantly, no formation of HONO was observed as well (within the resolution of the measurement, < 0.1 ppb).

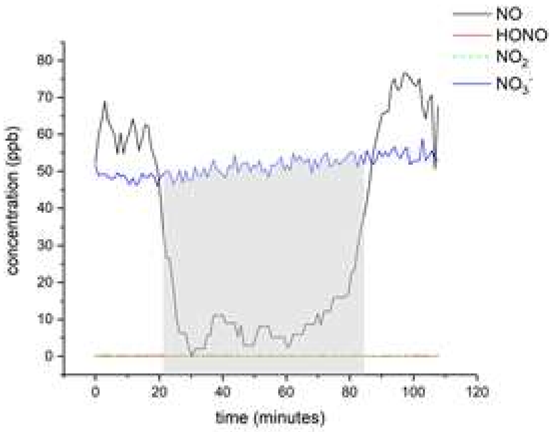

Figure A3: Photocatalytic test of SmogStop® where the concentrations of NO, HONO, NO_2 and NO_3^- were measured using Fourier-transform infrared spectroscopy (FTIR). The test was carried out in accordance with ISO 22197-1: 2016 with some alterations to better emulate outdoor conditions (NO concentration lowered to ~60 ppb [~80 µg/m^3] as opposed to 1 ppm [~1.35 mg/m^3]; light source used was a solar simulator at 35 mW.cm^{-2} as opposed to a UVA lamp at 1 mW.cm^{-2}). The shaded area represents the period of time when the light was turned on.

Photocatalytic activity

Researchers at the University of Guelph, Canada measured the photocatalytic activity of SmogStop® against a traditional TiO_2 photocatalyst for a range of conditions. The efficacy of NO_x removal was examined at two concentrations of NO (either ~100 ppb or ~1 ppm) one concentration of NO_2 (~100 ppb) using one of two light sources; a solar simulated spectrum (that possessed both UV and visible light) and a UV filtered solar simulated spectrum (that possessed visible light alone). The results are summarised in Table A1.

Gas	Level	Light	Light power (mW/cm²)	Experiment time (hrs)	SmogStop® NO/NO₂ removed (%)			TiO₂ NO/NO₂ removed (%)			Improvement factor
					Initial	Final	Average	Initial	Final	Average	
NO	100 ppb	Visible	35	5	~25	~15	15	~30	~0	0.5	30
NO	100 ppb	Solar	35	5	~65	~63	64	~60	~10	18	3.6
NO	1 ppm	Solar	35	5	~40	~25	29	~40	~0	6	4.8
NO	100 ppb	Solar	100	~2	~60	~57	57	~60	~0	18	3.2
NO_2	100 ppb	Solar	35	5	~30	~20	26	~50	~10	21	1.2
NO_2	100 ppb	Solar	100	~2	~40	~30	33	~30	~18	21	1.6

Table A1: A summary of the photocatalytic activity of SmogStop® in remediating NO_x versus a traditional TiO_2 photocatalyst (Evonik Aeroxide P25). The tests were carried out in accordance with ISO 22197-1: 2016 with some alterations (for some experiments NO_x gas was changed from NO to NO_2 for some experiments; NO_x concentration was lowered to ~100 ppb; the light source was changed from a UVA lamp at 1 mW.cm^{-2} to either a solar simulator that contained UV and visible light [Solar] or UV-filtered solar simulator [Visible] at either 35 or 100 mW.cm^{-2}; the length of the experiment was decreased from the standard of 5 hr to ~2 hr. Initial and final NO_x removed (%) were assessed from the first and last 10 min of data respectively.

For the range of photocatalytic experiments carried out, SmogStop® showed consistently higher activity than TiO_2. When only visible light was used, SmogStop® showed ~30 times higher activity than TiO_2. This can be attributed to the formulation of SmogStop®, which contains visible-light active components that can absorb wavelengths up to ~470 nm (the blue region of the spectrum). TiO_2 can only absorb wavelengths up to ~410 nm. The effect of light power was studied at 35 and 100 mW/cm^2 to emulate winter and summer conditions. For NO at ~1 ppm and lower light power, SmogStop® removed 29% of NO_x and TiO_2 removed only 6%. And for NO at ~100 ppb and higher light power, SmogStop® removed 57% of NO_x and TiO_2 removed 18%. For NO_2 at ~100 ppb and lower light power, SmogStop® removed 26% of NO_x and TiO_2 removed 21%. And for NO_2 at ~100 ppb and lower light power, SmogStop® removed 33% of NO_x and TiO_2 removed 21%.

Of note, the activity of TiO_2 decreased far more markedly than SmogStop® throughout each test, which is attributed to the accumulation of NO_3^- on its surface that inhibits its ability to remove NO_x. The SmogStop® photocatalyst suppresses NO_3^- formation by preferentially reducing NO_x to N_2.

Comparing the photocatalytic activity of the SmogStop® photocatalyst with other literature reports is not trivial, as the light source used in these experiments was solar simulated light, whereas the bulk of literature reports use UV light alone. However, there have been some reports where solar simulated light was used. For example, Pérez-Nicolás and co-workers studied TiO_2-containing cements and saw NO_x reductions of up to 18% under solar simulated light (NO ~500 ppb)[29], and Poon and co-workers studied TiO_2-coated concrete and NO_x and saw NO_x reductions of ~60% under solar simulated light (NO ~1 ppm).[30] As the SmogStop® photocatalyst showed NO reductions of 29% at 1 ppm and 57% at 100 ppb under solar simulated light, it compares favourably with previous studies.

Durability

Researchers at the University of Guelph, Canada also examined the durability of the SmogStop® photocatalyst coating by accelerated weathering tests, equivalent to a total period of ~10 years of outdoor conditions (Figure A4). The photocatalytic activity of SmogStop® towards a pure gas stream of

NO (~100 ppb) in air was measured at 10 time intervals over this period. The activity was relatively consistent over the period of accelerated weathering, showing an average NO_x removal of 49.3 ± 4.1 %.

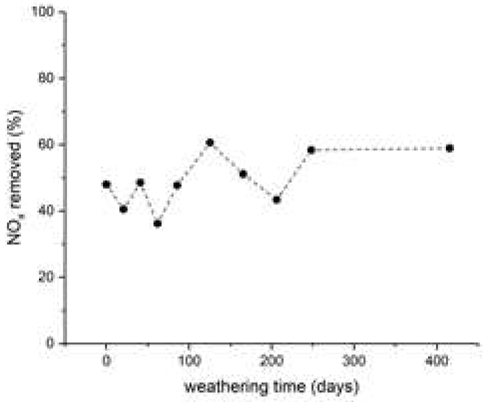

Figure A4: Accelerated weathering of SmogStop® equivalent to a total period of ~10 years of outdoor conditions, where the photocatalytic activity was measured at 10 points over the time period. The photocatalytic test was carried out in accordance with ISO 22197-1: 2016 with some alterations to better emulate outdoor conditions (NO concentration lowered to ~100 ppb [~135 µg/m^3] as opposed to 1 ppm [~1.35 mg/m^3]; light source used was a solar simulator at 35 mW.cm^{-2} as opposed to a UVA lamp at 1 mW.cm^{-2}). An average NO_x removal of 49.3 ± 4.1 % (1σ) was observed over the time period.

The SmogStop® barrier

Wind tunnel testing and CFD

Researchers from Envision SQ, the University of Guelph, Canada and Western University, Canada, carried out wind tunnel tests (~2.6 m/s) of a small-scale prototype and showed that the barrier was 50% more effective in lowering the concentration of a test pollutant (ethane) than a standard sound barrier. Computational fluid dynamics (CFD) modelling showed that the angled baffle enhances vertical mixing of the polluted air with clean air and reduces ground-level pollution levels downwind.

Photocatalytic activity of the SmogStop® barrier

Researchers from Envision SQ, the University of Guelph, Canada and Ontario Tech, Canada, measured the photocatalytic activity of full scale models of the barrier in a wind tunnel. The effectiveness of 4 and 5 m high barriers were tested at wind speeds of ~1.4 and ~2.2 m/s[z]. To simulate an environment next to a highway, a NO_x pollution level, consistent with the Ontario Ambient Air Quality Criteria (AAQC) of a 24 hr standard of 100 ppb of NO_x, was chosen for the study. The ratio of NO: NO_2 used was 8:1 NO: NO_2 (~89 ppb of NO and ~11 ppb of NO_2), as this is the typical ratio observed at the roadside in Ontario, Canada. The NO_x gas was passed through the inlet of the barrier using a perforated pipe, which released the gas equally across the length of the barrier. Chemiluminescence analysers were placed at the outlet of the barrier to continuously monitored changes in NO and NO_2 levels (and 3 m upwind to measure background levels). The SmogStop® photocatalyst was activated using solar simulated light[aa]. The

[z] For context, the average wind speed during the Tibshelf trial was ~1.9 m/s, as measured at a local NH monitoring site[31].

[aa] The average irradiance across the surface of the 4 and 5 m high barriers were 39.5 and 27.4 mW/m^2, respectively. For context, the average irradiances in Toronto and Tibshelf in 2020, where field trials of the SmogStop® barrier have been conducted, were 15.9 and 12.0 mW/m^2, respectively[32].

relative humidity was maintained at 60%[bb]. At a barrier height of 4 m and wind speed of ~1.4 m/s, the observed reductions in NO, NO_2 and overall NO_x were 24, 33 and 24%, respectively. At a barrier height of 5 m and wind speed of ~2.2 m/s, the observed reductions in NO, NO_2 and overall NO_x were 28, 35 and 28%, respectively.

The Toronto field trial of the SmogStop® barrier

The Ministry of Transportation, Ontario commissioned a field trial of the SmogStop® barrier. A report was produced by Envision SQ and the University of Guelph, Canada.[21]

In March 2017, the installation of a 15 m long and 6.5 m high SmogStop® barrier was completed in Toronto, Canada at the intersection of Highway 401 and Bayview Avenue, residing ~2 m from the closest active lane on the north side of the highway (Figure A5). Highway 401 is North America's busiest highway, where each day in the region of 340,000 vehicles travel this 14-lane road.

Chemiluminescence analysers were used to continuously measure (every minute) changes in NO and NO_2 levels. One was placed at the inlet of the barrier (at the top) and another was placed at the outlet of the barrier (at the bottom). The level of NO_x reduction was determined for flow moving up or down the channel of the two walls. When air was moving up through the channel, the bottom analyser provided the baseline level; when air was moving down through the channel, the top analyser provided the baseline level. The relative difference between the two analysers was used to calculate the reduction in NO_x.

Figure A5: The SmogStop® barrier (15 m long and 6.5 m high; 5 panels installed) in Toronto, Canada at the intersection of Highway 401 and Bayview Avenue as part of a field trial. Image taken from Google maps.

Data collection began on Aug 18th 2017 and continued until Feb 28th 2018. The average daytime NO_x reduction for the full study was 34%, where during peak daylight hours, maximum daily and hourly reductions of 92% and 95% were observed, respectively. Throughout the field trial, significant

[bb] For context, the average relative humidities in Toronto and Tibshelf in 2020, where field trials of the SmogStop® barrier have been conducted, were ~70 and ~80%[31].

reductions in NO_x were also observed during the night (average ~30%). This was attributed to the high-mast lighting, used to illuminate the highway at night time.

NO_x mass removal rates for daytime and night time periods were determined.[cc] For the daytime and night time 0.88 and 0.38 kg NOx/ VKT/ day were removed, respectively. To put this into context, 0.88 kg of NO_x corresponds to the complete remediation of ~6,200 m^3 of polluted air.[dd] The average night time NO_x mass removal rate was ~57% lower than that of daytime, which was attributed to the significantly lower traffic volumes and light levels experienced during the night.

During the trial, samples of the SmogStop® coating were removed from the inner wall of the barrier for analysis. Laboratory measurements showed that there was no significant loss in the performance of the coating. Figure A6 presents photographs of the SmogStop® barrier ~6 and ~12 months after its installation in the Toronto field trial. Minimal soiling of the SmogStop® coating is observed.

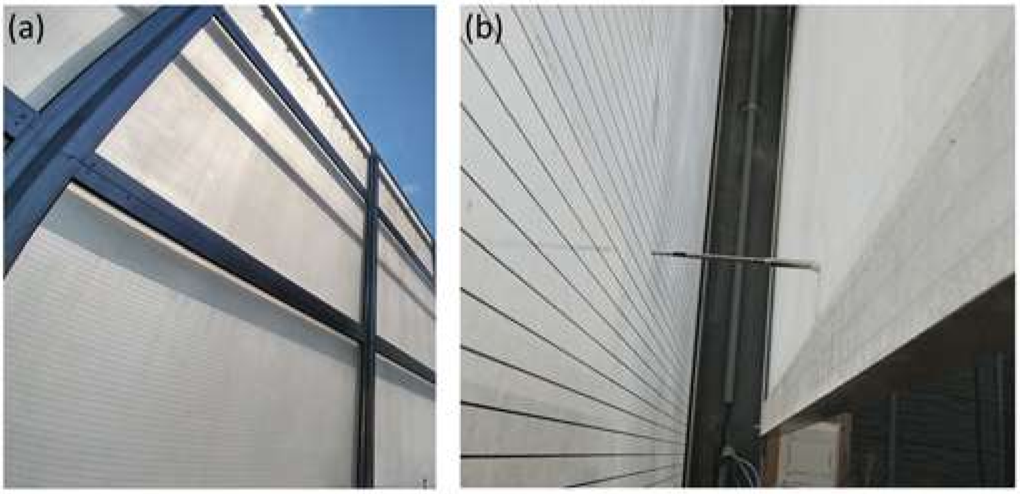

Figure A6: Example photographs of the SmogStop® barrier installed in Toronto, Canada at the intersection of Highway 401 and Bayview Avenue as part of a field trial; (a) an exterior view of the barrier ~6 months after installation and (b) an interior view of the barrier ~12 months after installation (where the SmogStop® coating is located on the right wall). Images provided courtesy of Envision SQ.

[cc] Removal rates were calculated on a mass basis; kilograms of NO_x removed/ vehicle kilometre travelled/ day (kg NO_x/ VKT/ day). This was derived using a fleet-wide emission rate collected from the Motor Vehicle Emission Simulator (MOVES) for the 2016 vehicle fleet, assuming a 1 km long SmogStop® barrier is installed; a 30 year age distribution; an average speed of 90 km/hr, and a 60/40 split between passenger cars and light duty trucks.
[dd] Assuming an 8:1 ratio of NO: NO_2 at a concentration of 100 ppb.

Annex 2 – Annual mean NO_2 µg/m³ diffusion tube results - Raw data

Annual mean NO_2 µg/m³ diffusion tube results - Raw data - Height = 3m

Distance from traffic		4.5m	8m	9m	10m	14m	19m	24m	29m
Distance from barrier		-4.5m	-1m	0m	1m	5m	10m	15m	20m
Transect		Annual mean NO_2 µg/m³							
T1	*CI95% lower*		*49.4*	*36.7*	*35.2*	*33.6*	*32.6*	*31.7*	*29.4*
	Mean		**52.3**	**38.6**	**37.7**	**36.3**	**34.3**	**33.9**	**31.9**
	CI95% upper		*55.2*	*40.4*	*40.2*	*38.9*	*36.0*	*36.1*	*34.4*
T2	*CI95% lower*		*49.4*	*37.5*	*35.2*	*34.3*	*33.8*	*30.8*	*30.4*
	Mean		**52.3**	**39.9**	**37.7**	**36.8**	**36.0**	**33.2**	**33.1**
	CI95% upper		*55.1*	*42.3*	*40.1*	*39.3*	*38.2*	*35.6*	*35.8*
C1	*CI95% lower*		*50.3*	*35.1*	*36.8*	*35.7*	*33.5*	*32.4*	*31.2*
	Mean		**52.8**	**37.4**	**39.2**	**38.2**	**35.7**	**34.9**	**33.4**
	CI95% upper		*55.4*	*39.7*	*41.6*	*40.7*	*37.8*	*37.3*	*35.6*
C2	*CI95% lower*		*48.1*	*35.6*	*37.4*	*35.9*	*33.2*	*32.5*	*30.9*
	Mean		**50.9**	**37.9**	**39.9**	**38.4**	**35.5**	**34.8**	**33.3**
	CI95% upper		*53.7*	*40.2*	*42.3*	*40.8*	*37.9*	*37.1*	*35.7*

Annual mean NO_2 µg/m³ diffusion tube results - Raw data - Height = 2.25m

Distance from traffic		4.5m	8m	9m	10m	14m	19m	24m	29m
Distance from barrier		-4.5m	-1m	0m	1m	5m	10m	15m	20m
Transect		Annual mean NO_2 µg/m³							
T1	*CI95% lower*		*49.5*		*34.1*	*33.8*	*32.5*	*29.9*	*30.2*
	Mean		**52.1**		**36.5**	**35.9**	**34.4**	**32.4**	**32.5**
	CI95% upper		*54.8*		*38.8*	*37.9*	*36.4*	*34.9*	*34.7*
T2	*CI95% lower*		*51.3*		*35.1*	*33.0*	*31.4*	*31.2*	*30.4*
	Mean		**53.8**		**37.5**	**35.4**	**33.7**	**33.5**	**32.4**
	CI95% upper		*56.3*		*40.0*	*37.7*	*36.1*	*35.8*	*34.4*
C1	*CI95% lower*		*50.9*		*34.6*	*34.7*	*33.0*	*31.8*	*31.3*
	Mean		**52.9**		**37.1**	**37.2**	**35.4**	**34.3**	**33.5**
	CI95% upper		*54.9*		*39.6*	*39.6*	*37.8*	*36.7*	*35.7*
C2	*CI95% lower*		*48.7*		*35.4*	*35.1*	*33.3*	*31.2*	*31.3*
	Mean		**51.3**		**37.7**	**37.5**	**35.5**	**33.7**	**33.6**
	CI95% upper		*53.9*		*40.0*	*39.9*	*37.7*	*36.3*	*35.8*

Annual mean NO_2 µg/m³ diffusion tube results - Raw data - Height = 1.5m

Distance from traffic		4.5m	8m	9m	10m	14m	19m	24m	29m
Distance from barrier		-4.5m	-1m	0m	1m	5m	10m	15m	20m
Transect		Annual mean NO_2 µg/m³							
N1	*CI95% lower*	*54.9*	*46.0*	*41.2*	*39.4*	*34.6*	*32.5*	*30.1*	*29.2*
	Mean	**58.1**	**48.4**	**43.9**	**41.9**	**36.8**	**34.7**	**32.2**	**31.4**
	CI95% upper	*61.4*	*50.7*	*46.7*	*44.4*	*39.1*	*36.9*	*34.4*	*33.5*
T1	*CI95% lower*	57.5	49.1	32.3	33.0	32.1	31.2	29.9	29.8
	Mean	**60.9**	**52.0**	**34.3**	**35.3**	**34.2**	**33.3**	**32.1**	**32.0**
	CI95% upper	*64.4*	*54.9*	*36.2*	*37.7*	*36.3*	*35.5*	*34.3*	*34.2*
T2	*CI95% lower*	*57.1*	*49.5*	*31.8*	*33.7*	*32.9*	*31.7*	*30.9*	*29.8*
	Mean	**60.4**	**51.6**	**33.7**	**36.0**	**35.2**	**33.9**	**33.4**	**32.0**
	CI95% upper	*63.8*	*53.6*	*35.6*	*38.2*	*37.4*	*36.2*	*35.8*	*34.1*
C1	*CI95% lower*	*58.4*	*47.3*		*34.2*	*34.7*	*31.8*	*31.0*	*29.6*
	Mean	**61.5**	**49.8**		**36.3**	**37.1**	**34.0**	**33.4**	**31.8**
	CI95% upper	*64.5*	*52.4*		*38.4*	*39.4*	*36.2*	*35.8*	*34.0*
C2	*CI95% lower*	*52.8*	*47.0*		*34.3*	*34.2*	*32.4*	*31.5*	*29.8*
	Mean	**56.0**	**49.3**		**36.7**	**36.7**	**34.7**	**33.8**	**31.9**
	CI95% upper	*59.2*	*51.5*		*39.0*	*39.2*	*37.0*	*36.1*	*34.0*
S1	*CI95% lower*		*45.7*	*41.2*	*39.7*	*35.4*	*33.1*		
	Mean		**48.0**	**43.7**	**42.2**	**37.6**	**35.8**		
	CI95% upper		*50.4*	*46.2*	*44.6*	*39.7*	*38.4*		

Annual mean NO_2 µg/m³ diffusion tube results - Raw data - Height = 0.75m

Distance from traffic		4.5m	8m	9m	10m	14m	19m	24m	29m
Distance from barrier		-4.5m	-1m	0m	1m	5m	10m	15m	20m
Transect		Annual mean NO_2 µg/m³							
T1	*CI95% lower*		*48.3*	*32.8*	*32.9*	*31.2*	*30.0*	*29.3*	*28.4*
	Mean		**50.5**	**34.8**	**34.9**	**33.1**	**32.0**	**31.2**	**30.4**
	CI95% upper		*52.7*	*36.8*	*37.0*	*35.0*	*34.0*	*33.1*	*32.3*
T2	*CI95% lower*		*46.7*	*33.1*	*32.8*	*31.7*	*31.0*	*29.9*	*28.2*
	Mean		**48.8**	**34.9**	**35.3**	**33.8**	**33.0**	**31.9**	**30.4**
	CI95% upper		*51.0*	*36.7*	*37.8*	*36.0*	*35.1*	*34.0*	*32.5*
C1	*CI95% lower*		*46.1*	*32.9*	*32.9*	*33.0*	*31.5*	*29.8*	*26.4*
	Mean		**48.1**	**34.7**	**34.9**	**35.2**	**33.8**	**32.2**	**28.3**
	CI95% upper		*50.1*	*36.5*	*37.0*	*37.4*	*36.1*	*34.6*	*30.2*
C2	*CI95% lower*		*46.2*	*31.9*	*32.8*	*32.9*	*31.9*	*30.5*	*26.5*
	Mean		**48.4**	**34.1**	**34.8**	**35.1**	**34.1**	**32.7**	**28.2**
	CI95% upper		*50.5*	*36.2*	*36.9*	*37.2*	*36.2*	*34.9*	*29.9*

Annex 3 – Annual mean NO_2 µg/m^3 diffusion tube results - Raw data. Comparison of means using Welch t-test.

Differences in annual mean NO_2 µg/m^3 diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 1 metre behind the barriers at 1.5m height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	36.3	1.09	**T1**	35.3	1.21	0.60	68	p > 0.05	0.07
C1	36.3	1.09	**T2**	35.9	1.18	0.20	68	p > 0.05	0.02
C2	36.7	1.20	**T1**	35.3	1.21	0.81	68	p > 0.05	0.10
C2	36.7	1.20	**T2**	35.9	1.18	0.44	68	p > 0.05	0.05

Differences in annual mean NO_2 µg/m^3 diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 5 metres behind the barriers at 1.5m height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	37.1	1.22	**T1**	34.1	1.09	1.79	68	p > 0.05	0.21
C1	37.1	1.22	**T2**	35.2	1.16	1.14	69	p > 0.05	0.14
C2	36.7	1.29	**T1**	34.1	1.09	1.51	67	p > 0.05	0.18
C2	36.7	1.29	**T2**	35.2	1.16	0.89	68	p > 0.05	0.11

Differences in annual mean NO_2 µg/m^3 diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 10 metres behind the barriers at 1.5m height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	34.0	1.15	**T1**	33.3	1.10	0.40	70	p > 0.05	0.05
C1	34.0	1.15	**T2**	33.9	1.16	0.04	70	p > 0.05	0.00
C2	34.7	1.19	**T1**	33.3	1.10	0.84	70	p > 0.05	0.10
C2	34.7	1.19	**T2**	33.9	1.16	0.47	70	p > 0.05	0.06

Differences in annual mean NO_2 µg/m^3 diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 15 metres behind the barriers at 1.5m height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	33.4	1.25	**T1**	32.1	1.14	0.77	69	p > 0.05	0.09
C1	33.4	1.25	**T2**	33.4	1.27	-0.01	69	p > 0.05	0.00
C2	33.8	1.19	**T1**	32.1	1.14	1.06	70	p > 0.05	0.13
C2	33.8	1.19	**T2**	33.4	1.27	0.25	69	p > 0.05	0.03

Differences in annual mean NO_2 µg/m^3 diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. 20 metres behind the barriers at 1.5m height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
C1	31.8	1.14	**T1**	32.0	1.16	-0.14	69	p > 0.05	0.02
C1	31.8	1.14	**T2**	31.9	1.13	-0.11	68	p > 0.05	0.01
C2	31.9	1.10	**T1**	32.0	1.16	-0.05	68	p > 0.05	0.01
C2	31.9	1.10	**T2**	31.9	1.13	-0.01	67	p > 0.05	0.00

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 4.5 metres in front of the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	58.1	1.68	**T1**	60.9	1.77	-1.14	65	p > 0.05	0.14
N1	58.1	1.68	**T2**	60.4	1.74	-0.94	67	p > 0.05	0.11
N1	58.1	1.68	**C1**	61.5	1.58	-1.45	67	p > 0.05	0.17
N1	58.1	1.68	**C2**	56.0	1.68	0.92	66	p > 0.05	0.11

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre in front of the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	48.4	1.21	**T1**	52.0	1.49	-1.91	61	p > 0.05	0.24
N1	48.4	1.21	**T2**	51.6	1.08	-1.97	67	p > 0.05	0.23
N1	48.4	1.21	**C1**	49.8	1.33	-0.82	64	p > 0.05	0.10
N1	48.4	1.21	**C2**	49.2	1.17	-0.52	66	p > 0.05	0.06

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	41.9	1.30	**T1**	35.3	1.21	3.71	69	p < 0.05	0.41
N1	41.9	1.30	**T2**	35.9	1.18	3.38	69	p < 0.05	0.38
N1	41.9	1.30	**C1**	36.3	1.09	3.31	68	p < 0.05	0.37
N1	41.9	1.30	**C2**	36.7	1.20	2.93	69	p < 0.05	0.33

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 5 metres behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	36.8	1.17	**T1**	34.1	1.09	1.66	68	p > 0.05	0.20
N1	36.8	1.17	**T2**	35.2	1.16	1.00	68	p > 0.05	0.12
N1	36.8	1.17	**C1**	37.1	1.22	-0.16	69	p > 0.05	0.02
N1	36.8	1.17	**C2**	36.7	1.29	0.06	68	p > 0.05	0.01

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 10 metres behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	34.8	1.14	**T1**	33.3	1.10	0.89	69	p > 0.05	0.11
N1	34.8	1.14	**T2**	33.9	1.16	0.51	69	p > 0.05	0.06
N1	34.8	1.14	**C1**	34.0	1.15	0.48	69	p > 0.05	0.06
N1	34.8	1.14	**C2**	34.7	1.19	0.03	69	p > 0.05	0.00

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 15 metres behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	32.2	1.12	**T1**	32.1	1.14	0.10	70	p > 0.05	0.01
N1	32.2	1.12	**T2**	33.4	1.27	-0.69	68	p > 0.05	0.08
N1	32.2	1.12	**C1**	33.4	1.25	-0.69	69	p > 0.05	0.08
N1	32.2	1.12	**C2**	33.8	1.19	-0.97	70	p > 0.05	0.12

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect N1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 20 metres behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
N1	31.3	1.13	**T1**	32.0	1.16	-0.40	68	p > 0.05	0.05
N1	31.3	1.13	**T2**	31.9	1.13	-0.37	67	p > 0.05	0.05
N1	31.3	1.13	**C1**	31.8	1.14	-0.27	69	p > 0.05	0.03
N1	31.3	1.13	**C2**	31.9	1.10	-0.37	68	p > 0.05	0.04

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre in front of the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
S1	48.0	1.21	**T1**	52.0	1.49	-2.09	61	$p < 0.05$	0.26
S1	48.0	1.21	**T2**	51.6	1.08	-2.18	65	$p < 0.05$	0.26
S1	48.0	1.21	**C1**	49.8	1.33	-1.01	64	$p > 0.05$	0.13
S1	48.0	1.21	**C2**	49.2	1.17	-0.73	65	$p > 0.05$	0.09

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 1 metre behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
S1	42.2	1.28	**T1**	35.3	1.21	3.90	69	$p < 0.05$	0.43
S1	42.2	1.28	**T2**	35.9	1.18	3.57	69	$p < 0.05$	0.40
S1	42.2	1.28	**C1**	36.3	1.09	3.51	68	$p < 0.05$	0.39
S1	42.2	1.28	**C2**	36.7	1.20	3.12	69	$p < 0.05$	0.35

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 5 metres behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
S1	37.6	1.13	**T1**	34.1	1.09	2.17	69	$p < 0.05$	0.25
S1	37.6	1.13	**T2**	35.2	1.16	1.48	69	$p > 0.05$	0.18
S1	37.6	1.13	**C1**	37.1	1.22	0.29	70	$p > 0.05$	0.04
S1	37.6	1.13	**C2**	36.7	1.29	0.50	69	$p > 0.05$	0.06

Differences in annual mean NO_2 µg/m^3 diffusion tube values – Transect S1 (no barrier) vs transects T1, T2, C1 & C2 (barrier). 10 metres behind the barriers at 1.5 metres height. t-test results.

Transect	Mean	SE	Transect	Mean	SE	t	df	p	r
S1	35.8	1.37	**T1**	33.3	1.10	1.38	64	$p > 0.05$	0.17
S1	35.8	1.37	**T2**	33.9	1.16	1.03	66	$p > 0.05$	0.13
S1	35.8	1.37	**C1**	34.0	1.15	1.00	65	$p > 0.05$	0.12
S1	35.8	1.37	**C2**	34.7	1.19	0.59	66	$p > 0.05$	0.07

Annex 4 – Annual mean NO_2 µg/m^3 diffusion tube results – De-seasonalised data

Annual mean NO_2 µg/m^3 diffusion tube results – De-seasonalised data - Height = 3m

Distance from traffic		4.5m	8m	9m	10m	14m	19m	24m	29m
Distance from barrier		**-4.5m**	**-1m**	**0m**	**1m**	**5m**	**10m**	**15m**	**20m**
Transect		**Annual mean NO_2 µg/m^3**							
	CI95% lower		*50.2*	*34.7*	*36.4*	*34.6*	*33.7*	*32.9*	*30.3*
T1	**Mean**		**51.9**	**36.4**	**37.7**	**36.1**	**34.7**	**33.8**	**31.8**
	CI95% upper		*53.5*	*38.1*	*39.0*	*37.5*	*35.7*	*34.7*	*33.2*
	CI95% lower		*50.5*	*37.6*	*36.6*	*35.9*	*35.0*	*31.8*	*31.0*
T2	**Mean**		**51.7**	**38.8**	**37.6**	**36.7**	**36.1**	**33.0**	**32.7**
	CI95% upper		*53.0*	*40.1*	*38.7*	*37.5*	*37.1*	*34.2*	*34.4*
	CI95% lower		*50.9*	*36.5*	*38.2*	*37.0*	*34.7*	*33.7*	*32.3*
C1	**Mean**		**52.6**	**37.4**	**39.3**	**38.1**	**35.7**	**34.7**	**33.3**
	CI95% upper		*54.3*	*38.4*	*40.4*	*39.2*	*36.6*	*35.8*	*34.3*
	CI95% lower		*49.2*	*37.0*	*39.0*	*37.2*	*34.5*	*33.8*	*32.1*
C2	**Mean**		**50.7**	**38.0**	**40.0**	**38.3**	**35.4**	**34.8**	**33.3**
	CI95% upper		*52.3*	*38.9*	*41.0*	*39.4*	*36.4*	*35.8*	*34.4*

Annual mean NO_2 µg/m^3 diffusion tube results – De-seasonalised data - Height = 2.25m

Distance from traffic		4.5m	8m	9m	10m	14m	19m	24m	29m
Distance from barrier		**-4.5m**	**-1m**	**0m**	**1m**	**5m**	**10m**	**15m**	**20m**
Transect		**Annual mean NO_2 µg/m^3**							
	CI95% lower		*50.1*		*35.5*	*34.9*	*33.8*	*30.8*	*31.2*
T1	**Mean**		**52.0**		**36.4**	**36.0**	**34.6**	**32.4**	**32.4**
	CI95% upper		*53.9*		*37.3*	*37.1*	*35.4*	*33.9*	*33.5*
	CI95% lower		*51.8*		*36.6*	*34.1*	*32.4*	*32.3*	*31.1*
T2	**Mean**		**53.7**		**37.6**	**35.5**	**33.6**	**33.4**	**32.0**
	CI95% upper		*55.5*		*38.7*	*36.9*	*34.8*	*34.5*	*33.0*
	CI95% lower		*50.7*		*35.9*	*36.0*	*34.3*	*32.9*	*32.6*
C1	**Mean**		**53.4**		**37.2**	**37.1**	**35.3**	**34.0**	**33.4**
	CI95% upper		*56.1*		*38.5*	*38.2*	*36.3*	*35.2*	*34.3*
	CI95% lower		*49.4*		*36.9*	*36.5*	*34.7*	*32.1*	*32.5*
C2	**Mean**		**51.3**		**37.7**	**37.5**	**35.5**	**33.5**	**33.4**
	CI95% upper		*53.1*		*38.6*	*38.6*	*36.3*	*34.8*	*34.3*

Annual mean NO_2 µg/m^3 diffusion tube results – De-seasonalised data - Height = 1.5m

Distance from traffic		4.5m	8m	9m	10m	14m	19m	24m	29m
Distance from barrier		-4.5m	-1m	0m	1m	5m	10m	15m	20m
Transect		Annual mean NO_2 µg/m^3							
N1	*CI95% lower*	*56.0*	*47.3*	*43.0*	*40.9*	*36.0*	*34.1*	*31.3*	*30.1*
	Mean	**59.0**	**49.0**	**44.1**	**42.0**	**36.8**	**34.9**	**32.2**	**31.1**
	CI95% upper	*61.9*	*50.7*	*45.1*	*43.1*	*37.7*	*35.6*	*33.1*	*32.1*
T1	*CI95% lower*	58.2	49.8	33.3	34.2	33.3	32.5	31.0	30.9
	Mean	**60.6**	**51.7**	**34.4**	**35.4**	**34.3**	**33.3**	**31.9**	**32.0**
	CI95% upper	*62.9*	*53.6*	*35.6*	*36.7*	*35.2*	*34.1*	*32.9*	*33.2*
T2	*CI95% lower*	*57.4*	*49.8*	*33.0*	*35.0*	*34.3*	*32.9*	*32.1*	*31.0*
	Mean	**60.5**	**51.6**	**34.0**	**36.0**	**35.3**	**33.8**	**33.3**	**31.8**
	CI95% upper	*63.6*	*53.4*	*35.0*	*37.0*	*36.3*	*34.7*	*34.5*	*32.6*
C1	*CI95% lower*	*59.0*	*47.5*		*35.6*	*36.2*	*32.9*	*32.1*	*30.6*
	Mean	**61.4**	**49.9**		**36.3**	**37.0**	**34.0**	**33.2**	**31.6**
	CI95% upper	*63.7*	*52.2*		*37.1*	*37.9*	*35.0*	*34.3*	*32.7*
C2	*CI95% lower*	*53.2*	*47.0*		*36.2*	*35.5*	*33.6*	*32.6*	*31.1*
	Mean	**56.1**	**49.4**		**36.9**	**36.5**	**34.6**	**33.7**	**31.8**
	CI95% upper	*59.0*	*51.8*		*37.7*	*37.6*	*35.5*	*34.7*	*32.6*
S1	*CI95% lower*		*47.6*	*42.7*	*41.2*	*36.8*	*34.7*		
	Mean		**48.6**	**43.9**	**42.3**	**37.6**	**36.0**		
	CI95% upper		*49.7*	*45.2*	*43.3*	*38.4*	*37.2*		

Annual mean NO_2 µg/m^3 diffusion tube results – De-seasonalised data - Height = 0.75m

Distance from traffic		4.5m	8m	9m	10m	14m	19m	24m	29m
Distance from barrier		-4.5m	-1m	0m	1m	5m	10m	15m	20m
Transect		Annual mean NO_2 µg/m^3							
T1	*CI95% lower*		*48.7*	*34.2*	*34.2*	*32.4*	*31.4*	*30.6*	*29.6*
	Mean		**50.7**	**34.9**	**35.1**	**33.2**	**32.4**	**31.6**	**30.5**
	CI95% upper		*52.6*	*35.6*	*36.0*	*34.1*	*33.5*	*32.5*	*31.4*
T2	*CI95% lower*		*47.3*	*34.4*	*34.0*	*32.9*	*32.3*	*31.1*	*29.3*
	Mean		**49.3**	**35.1**	**35.3**	**33.9**	**33.1**	**31.8**	**30.2**
	CI95% upper		*51.4*	*35.7*	*36.7*	*34.8*	*34.0*	*32.6*	*31.1*
C1	*CI95% lower*		*46.1*	*34.2*	*34.3*	*34.3*	*32.8*	*30.8*	*27.4*
	Mean		**48.3**	**35.0**	**35.0**	**35.1**	**33.8**	**32.1**	**28.3**
	CI95% upper		*50.4*	*35.7*	*35.7*	*35.9*	*34.7*	*33.3*	*29.1*
C2	*CI95% lower*		*46.5*	*33.6*	*34.1*	*34.2*	*33.1*	*31.7*	*27.5*
	Mean		**48.4**	**34.4**	**35.0**	**35.1**	**34.0**	**32.6**	**28.2**
	CI95% upper		*50.4*	*35.3*	*35.9*	*35.9*	*34.9*	*33.6*	*28.9*

Annex 5 – Differences in annual mean NO_2 µg/m^3 diffusion tube values – SmogStop® barrier vs wooden fence (control) barrier. De-seasonalised data.

Comparisons shaded green indicate the locations where the confidence intervals about the differences do not include zero at the indicated confidence level, i.e. the confidence intervals do not overlap.

1m behind barrier					**Confidence level**					
Height = 3m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%
				CI lower	*-4.0*	*-10.2%*	*-3.6*	*-9.2%*	*-3.4*	*-8.6%*
C1	**39.3**	**T1**	**37.7**		**-1.6**	**-4.2%**	**-1.6**	**-4.2%**	**-1.6**	**-4.2%**
				CI upper	*0.7*	*1.8%*	*0.3*	*0.9%*	*0.1*	*0.2%*
				CI lower	*-3.8*	*-9.7%*	*-3.5*	*-8.8%*	*-3.3*	*-8.3%*
C1	**39.3**	**T2**	**37.6**		**-1.7**	**-4.3%**	**-1.7**	**-4.3%**	**-1.7**	**-4.3%**
				CI upper	*0.4*	*1.1%*	*0.1*	*0.2%*	*-0.1*	*-0.3%*
				CI lower	*-4.5*	*-11.4%*	*-4.2*	*-10.5%*	*-3.9*	*-9.9%*
C2	**40.0**	**T1**	**37.7**		**-2.3**	**-5.7%**	**-2.3**	**-5.7%**	**-2.3**	**-5.7%**
				CI upper	*0.0*	*0.0%*	*-0.4*	*-0.9%*	*-0.6*	*-1.5%*
				CI lower	*-4.4*	*-10.9%*	*-4.0*	*-10.1%*	*-3.8*	*-9.6%*
C2	**40.0**	**T2**	**37.6**		**-2.3**	**-5.8%**	**-2.3**	**-5.8%**	**-2.3**	**-5.8%**
				CI upper	*-0.3*	*-0.7%*	*-0.6*	*-1.6%*	*-0.8*	*-2.1%*

1m behind barrier					**Confidence level**					
Height = 2.25m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%
				CI lower	*-3.0*	*-8.1%*	*-2.7*	*-7.1%*	*-2.4*	*-6.5%*
C1	**37.2**	**T1**	**36.4**		**-0.8**	**-2.1%**	**-0.8**	**-2.1%**	**-0.8**	**-2.1%**
				CI upper	*1.4*	*3.8%*	*1.1*	*2.9%*	*0.8*	*2.3%*
				CI lower	*-1.9*	*-5.1%*	*-1.5*	*-4.1%*	*-1.3*	*-3.5%*
C1	**37.2**	**T2**	**37.6**		**0.4**	**1.2%**	**0.4**	**1.2%**	**0.4**	**1.2%**
				CI upper	*2.8*	*7.4%*	*2.4*	*6.4%*	*2.1*	*5.8%*
				CI lower	*-3.1*	*-8.1%*	*-2.8*	*-7.3%*	*-2.6*	*-6.9%*
C2	**37.7**	**T1**	**36.4**		**-1.3**	**-3.5%**	**-1.3**	**-3.5%**	**-1.3**	**-3.5%**
				CI upper	*0.4*	*1.1%*	*0.2*	*0.4%*	*0.0*	*-0.1%*
				CI lower	*-1.9*	*-5.2%*	*-1.6*	*-4.4%*	*-1.5*	*-3.9%*
C2	**37.7**	**T2**	**37.6**		**-0.1**	**-0.2%**	**-0.1**	**-0.2%**	**-0.1**	**-0.2%**
				CI upper	*1.8*	*4.7%*	*1.5*	*3.9%*	*1.3*	*3.4%*

1m behind barrier					**Confidence level**					
Height = 0.75m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%
				CI lower	*-1.4*	*-4.1%*	*-1.2*	*-3.4%*	*-1.0*	*-3.0%*
C1	**35.0**	**T1**	**35.1**		**0.1**	**0.3%**	**0.1**	**0.3%**	**0.1**	**0.3%**
				CI upper	*1.7*	*4.8%*	*1.4*	*4.1%*	*1.3*	*3.6%*
				CI lower	*-1.7*	*-4.9%*	*-1.4*	*-3.9%*	*-1.2*	*-3.3%*
C1	**35.0**	**T2**	**35.3**		**0.4**	**1.0%**	**0.4**	**1.0%**	**0.4**	**1.0%**
				CI upper	*2.4*	*6.9%*	*2.1*	*5.9%*	*1.9*	*5.3%*
				CI lower	*-1.7*	*-4.7%*	*-1.4*	*-3.9%*	*-1.2*	*-3.4%*
C2	**35.0**	**T1**	**35.1**		**0.1**	**0.3%**	**0.1**	**0.3%**	**0.1**	**0.3%**
				CI upper	*1.9*	*5.4%*	*1.6*	*4.6%*	*1.4*	*4.0%*
				CI lower	*-1.9*	*-5.4%*	*-1.5*	*-4.4%*	*-1.3*	*-3.7%*
C2	**35.0**	**T2**	**35.3**		**0.4**	**1.0%**	**0.4**	**1.0%**	**0.4**	**1.0%**
				CI upper	*2.6*	*7.4%*	*2.2*	*6.4%*	*2.0*	*5.7%*

5 metres behind barriers

5m behind barrier							**Confidence level**			
Height = 3m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3	
					Absolute	%	Absolute	%	Absolute	%
				CI lower	*-4.6*	*-12.0%*	*-4.2*	*-10.9%*	*-3.9*	*-10.2%*
C1	**38.1**	**T1**	**36.1**		**-2.0**	**-5.3%**	**-2.0**	**-5.3%**	**-2.0**	**-5.3%**
				CI upper	*0.5*	*1.3%*	*0.1*	*0.2%*	*-0.2*	*-0.5%*
				CI lower	*-3.3*	*-8.7%*	*-3.0*	*-7.9%*	*-2.8*	*-7.4%*
C1	**38.1**	**T2**	**36.7**		**-1.4**	**-3.7%**	**-1.4**	**-3.7%**	**-1.4**	**-3.7%**
				CI upper	*0.5*	*1.3%*	*0.2*	*0.5%*	*0.0*	*0.0%*
				CI lower	*-4.8*	*-12.5%*	*-4.4*	*-11.4%*	*-4.1*	*-10.7%*
C2	**38.3**	**T1**	**36.1**		**-2.2**	**-5.8%**	**-2.2**	**-5.8%**	**-2.2**	**-5.8%**
				CI upper	*0.3*	*0.8%*	*-0.1*	*-0.3%*	*-0.4*	*-1.0%*
				CI lower	*-3.5*	*-9.2%*	*-3.2*	*-8.4%*	*-3.0*	*-7.9%*
C2	**38.3**	**T2**	**36.7**		**-1.6**	**-4.2%**	**-1.6**	**-4.2%**	**-1.6**	**-4.2%**
				CI upper	*0.3*	*0.7%*	*0.0*	*0.0%*	*-0.2*	*-0.6%*

5m behind barrier							**Confidence level**			
Height = 2.25m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3	
					Absolute	%	Absolute	%	Absolute	%
				CI lower	*-3.3*	*-8.8%*	*-2.9*	*-7.9%*	*-2.7*	*-7.3%*
C1	**37.1**	**T1**	**36.0**		**-1.1**	**-3.0%**	**-1.1**	**-3.0%**	**-1.1**	**-3.0%**
				CI upper	*1.0*	*2.8%*	*0.7*	*1.9%*	*0.5*	*1.3%*
				CI lower	*-4.1*	*-11.1%*	*-3.7*	*-10.0%*	*-3.5*	*-9.3%*
C1	**37.1**	**T2**	**35.5**		**-1.6**	**-4.4%**	**-1.6**	**-4.4%**	**-1.6**	**-4.4%**
				CI upper	*0.9*	*2.3%*	*0.5*	*1.2%*	*0.2*	*0.5%*
				CI lower	*-3.6*	*-9.7%*	*-3.3*	*-8.8%*	*-3.1*	*-8.2%*
C2	**37.5**	**T1**	**36.0**		**-1.5**	**-4.0%**	**-1.5**	**-4.0%**	**-1.5**	**-4.0%**
				CI upper	*0.6*	*1.7%*	*0.3*	*0.8%*	*0.1*	*0.2%*
				CI lower	*-4.5*	*-11.9%*	*-4.1*	*-10.9%*	*-3.8*	*-10.2%*
C2	**37.5**	**T2**	**35.5**		**-2.0**	**-5.4%**	**-2.0**	**-5.4%**	**-2.0**	**-5.4%**
				CI upper	*0.4*	*1.2%*	*0.0*	*0.1%*	*-0.2*	*-0.6%*

5m behind barrier							**Confidence level**			
Height = 0.75m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3		NO_2 µg/m^3	
					Absolute	%	Absolute	%	Absolute	%
				CI lower	*-3.5*	*-10.1%*	*-3.3*	*-9.3%*	*-3.1*	*-8.8%*
C1	**35.1**	**T1**	**33.2**		**-1.9**	**-5.3%**	**-1.9**	**-5.3%**	**-1.9**	**-5.3%**
				CI upper	*-0.2*	*-0.5%*	*-0.5*	*-1.3%*	*-0.6*	*-1.8%*
				CI lower	*-3.0*	*-8.5%*	*-2.7*	*-7.7%*	*-2.5*	*-7.2%*
C1	**35.1**	**T2**	**33.9**		**-1.2**	**-3.5%**	**-1.2**	**-3.5%**	**-1.2**	**-3.5%**
				CI upper	*0.5*	*1.5%*	*0.3*	*0.7%*	*0.1*	*0.2%*
				CI lower	*-3.6*	*-10.2%*	*-3.3*	*-9.4%*	*-3.1*	*-8.9%*
C2	**35.1**	**T1**	**33.2**		**-1.9**	**-5.3%**	**-1.9**	**-5.3%**	**-1.9**	**-5.3%**
				CI upper	*-0.1*	*-0.4%*	*-0.4*	*-1.2%*	*-0.6*	*-1.7%*
				CI lower	*-3.0*	*-8.6%*	*-2.7*	*-7.8%*	*-2.5*	*-7.2%*
C2	**35.1**	**T2**	**33.9**		**-1.2**	**-3.5%**	**-1.2**	**-3.5%**	**-1.2**	**-3.5%**
				CI upper	*0.6*	*1.6%*	*0.3*	*0.8%*	*0.1*	*0.3%*

10 metres behind barriers

10m behind barrier					Confidence level					
Height = 3m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%
				CI lower	*-3.0*	*-8.3%*	*-2.7*	*-7.4%*	*-2.4*	*-6.9%*
C1	**35.7**	**T1**	**34.7**		**-1.0**	**-2.8%**	**-1.0**	**-2.8%**	**-1.0**	**-2.8%**
				CI upper	*1.0*	*2.7%*	*0.6*	*1.8%*	*0.4*	*1.2%*
				CI lower	*-1.6*	*-4.5%*	*-1.3*	*-3.6%*	*-1.1*	*-3.1%*
C1	**35.7**	**T2**	**36.1**		**0.4**	**1.0%**	**0.4**	**1.0%**	**0.4**	**1.0%**
				CI upper	*2.3*	*6.6%*	*2.0*	*5.7%*	*1.8*	*5.1%*
				CI lower	*-2.7*	*-7.7%*	*-2.4*	*-6.8%*	*-2.2*	*-6.2%*
C2	**35.4**	**T1**	**34.7**		**-0.7**	**-2.1%**	**-0.7**	**-2.1%**	**-0.7**	**-2.1%**
				CI upper	*1.2*	*3.5%*	*0.9*	*2.6%*	*0.7*	*2.0%*
				CI lower	*-1.4*	*-3.9%*	*-1.1*	*-3.0%*	*-0.9*	*-2.4%*
C2	**35.4**	**T2**	**36.1**		**0.6**	**1.7%**	**0.6**	**1.7%**	**0.6**	**1.7%**
				CI upper	*2.6*	*7.4%*	*2.3*	*6.5%*	*2.1*	*5.9%*

10m behind barrier					Confidence level					
Height = 2.25m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%
				CI lower	*-2.5*	*-7.1%*	*-2.2*	*-6.2%*	*-2.0*	*-5.7%*
C1	**35.3**	**T1**	**34.6**		**-0.7**	**-1.9%**	**-0.7**	**-1.9%**	**-0.7**	**-1.9%**
				CI upper	*1.1*	*3.3%*	*0.9*	*2.4%*	*0.7*	*1.9%*
				CI lower	*-3.9*	*-11.1%*	*-3.5*	*-10.1%*	*-3.3*	*-9.4%*
C1	**35.3**	**T2**	**33.6**		**-1.7**	**-4.8%**	**-1.7**	**-4.8%**	**-1.7**	**-4.8%**
				CI upper	*0.5*	*1.5%*	*0.2*	*0.5%*	*-0.1*	*-0.1%*
				CI lower	*-2.5*	*-7.0%*	*-2.2*	*-6.2%*	*-2.0*	*-5.8%*
C2	**35.5**	**T1**	**34.6**		**-0.9**	**-2.5%**	**-0.9**	**-2.5%**	**-0.9**	**-2.5%**
				CI upper	*0.7*	*1.9%*	*0.4*	*1.2%*	*0.3*	*0.8%*
				CI lower	*-3.9*	*-10.9%*	*-3.6*	*-10.0%*	*-3.4*	*-9.4%*
C2	**35.5**	**T2**	**33.6**		**-1.9**	**-5.4%**	**-1.9**	**-5.4%**	**-1.9**	**-5.4%**
				CI upper	*0.1*	*0.2%*	*-0.2*	*-0.7%*	*-0.4*	*-1.3%*

10m behind barrier					Confidence level					
Height = 0.75m					**95%**		**90%**		**85%**	
A		B			B - A		B - A		B - A	
Transect	Mean NO_2 µg/m^3	Transect	Mean NO_2 µg/m^3		NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%	NO_2 µg/m^3 Absolute	%
				CI lower	*-3.4*	*-10.0%*	*-3.0*	*-9.0%*	*-2.8*	*-8.4%*
C1	**33.8**	**T1**	**32.4**		**-1.3**	**-3.9%**	**-1.3**	**-3.9%**	**-1.3**	**-3.9%**
				CI upper	*0.7*	*2.1%*	*0.4*	*1.1%*	*0.2*	*0.5%*
				CI lower	*-2.5*	*-7.3%*	*-2.2*	*-6.4%*	*-2.0*	*-5.8%*
C1	**33.8**	**T2**	**33.1**		**-0.6**	**-1.9%**	**-0.6**	**-1.9%**	**-0.6**	**-1.9%**
				CI upper	*1.2*	*3.5%*	*0.9*	*2.6%*	*0.7*	*2.0%*
				CI lower	*-3.5*	*-10.3%*	*-3.2*	*-9.4%*	*-3.0*	*-8.8%*
C2	**34.0**	**T1**	**32.4**		**-1.6**	**-4.6%**	**-1.6**	**-4.6%**	**-1.6**	**-4.6%**
				CI upper	*0.4*	*1.1%*	*0.1*	*0.2%*	*-0.2*	*-0.4%*
				CI lower	*-2.6*	*-7.7%*	*-2.3*	*-6.9%*	*-2.2*	*-6.3%*
C2	**34.0**	**T2**	**33.1**		**-0.9**	**-2.6%**	**-0.9**	**-2.6%**	**-0.9**	**-2.6%**
				CI upper	*0.8*	*2.4%*	*0.6*	*1.6%*	*0.4*	*1.1%*

15 metres behind barriers

15m behind barrier					Confidence level					
Height = 3m					95%		90%		85%	
A		B			B - A		B - A		B - A	
Transect	Mean NO$_2$ µg/m^3	Transect	Mean NO$_2$ µg/m^3		NO$_2$ µg/m^3		NO$_2$ µg/m^3		NO$_2$ µg/m^3	
					Absolute	%	Absolute	%	Absolute	%
				CI lower	*-2.9*	*-8.4%*	*-2.6*	*-7.5%*	*-2.4*	*-6.9%*
C1	**34.7**	**T1**	**33.8**		**-0.9**	**-2.7%**	**-0.9**	**-2.7%**	**-0.9**	**-2.7%**
				CI upper	*1.0*	*3.0%*	*0.7*	*2.1%*	*0.5*	*1.5%*
				CI lower	*-4.0*	*-11.4%*	*-3.6*	*-10.4%*	*-3.4*	*-9.7%*
C1	**34.7**	**T2**	**33.0**		**-1.7**	**-5.0%**	**-1.7**	**-5.0%**	**-1.7**	**-5.0%**
				CI upper	*0.5*	*1.4%*	*0.1*	*0.4%*	*-0.1*	*-0.3%*
				CI lower	*-2.9*	*-8.3%*	*-2.6*	*-7.4%*	*-2.4*	*-6.8%*
C2	**34.8**	**T1**	**33.8**		**-1.0**	**-2.8%**	**-1.0**	**-2.8%**	**-1.0**	**-2.8%**
				CI upper	*0.9*	*2.7%*	*0.6*	*1.8%*	*0.4*	*1.3%*
				CI lower	*-3.9*	*-11.3%*	*-3.6*	*-10.3%*	*-3.4*	*-9.7%*
C2	**34.8**	**T2**	**33.0**		**-1.8**	**-5.1%**	**-1.8**	**-5.1%**	**-1.8**	**-5.1%**
				CI upper	*0.4*	*1.2%*	*0.1*	*0.2%*	*-0.2*	*-0.5%*

15m behind barrier					Confidence level					
Height = 2.25m					95%		90%		85%	
A		B			B - A		B - A		B - A	
Transect	Mean NO$_2$ µg/m^3	Transect	Mean NO$_2$ µg/m^3		NO$_2$ µg/m^3		NO$_2$ µg/m^3		NO$_2$ µg/m^3	
					Absolute	%	Absolute	%	Absolute	%
				CI lower	*-4.3*	*-12.8%*	*-3.9*	*-11.5%*	*-3.6*	*-10.7%*
C1	**34.0**	**T1**	**32.4**		**-1.6**	**-4.8%**	**-1.6**	**-4.8%**	**-1.6**	**-4.8%**
				CI upper	*1.0*	*3.1%*	*0.6*	*1.8%*	*0.3*	*1.0%*
				CI lower	*-2.9*	*-8.4%*	*-2.5*	*-7.4%*	*-2.3*	*-6.7%*
C1	**34.0**	**T2**	**33.4**		**-0.6**	**-1.8%**	**-0.6**	**-1.8%**	**-0.6**	**-1.8%**
				CI upper	*1.7*	*4.9%*	*1.3*	*3.9%*	*1.1*	*3.2%*
				CI lower	*-3.9*	*-11.8%*	*-3.5*	*-10.4%*	*-3.2*	*-9.5%*
C2	**33.5**	**T1**	**32.4**		**-1.1**	**-3.2%**	**-1.1**	**-3.2%**	**-1.1**	**-3.2%**
				CI upper	*1.8*	*5.3%*	*1.3*	*3.9%*	*1.0*	*3.1%*
				CI lower	*-2.5*	*-7.4%*	*-2.1*	*-6.2%*	*-1.8*	*-5.4%*
C2	**33.5**	**T2**	**33.4**		**0.0**	**-0.1%**	**0.0**	**-0.1%**	**0.0**	**-0.1%**
				CI upper	*2.4*	*7.2%*	*2.0*	*6.0%*	*1.8*	*5.3%*

15m behind barrier					Confidence level					
Height = 0.75m					95%		90%		85%	
A		B			B - A		B - A		B - A	
Transect	Mean NO$_2$ µg/m^3	Transect	Mean NO$_2$ µg/m^3		NO$_2$ µg/m^3		NO$_2$ µg/m^3		NO$_2$ µg/m^3	
					Absolute	%	Absolute	%	Absolute	%
				CI lower	*-2.7*	*-8.5%*	*-2.4*	*-7.4%*	*-2.1*	*-6.7%*
C1	**32.1**	**T1**	**31.6**		**-0.5**	**-1.6%**	**-0.5**	**-1.6%**	**-0.5**	**-1.6%**
				CI upper	*1.7*	*5.2%*	*1.3*	*4.1%*	*1.1*	*3.4%*
				CI lower	*-2.3*	*-7.1%*	*-1.9*	*-6.0%*	*-1.7*	*-5.4%*
C1	**32.1**	**T2**	**31.8**		**-0.2**	**-0.7%**	**-0.2**	**-0.7%**	**-0.2**	**-0.7%**
				CI upper	*1.8*	*5.6%*	*1.5*	*4.6%*	*1.3*	*3.9%*
				CI lower	*-3.0*	*-9.0%*	*-2.6*	*-8.1%*	*-2.5*	*-7.5%*
C2	**32.6**	**T1**	**31.6**		**-1.1**	**-3.3%**	**-1.1**	**-3.3%**	**-1.1**	**-3.3%**
				CI upper	*0.8*	*2.4%*	*0.5*	*1.5%*	*0.3*	*0.9%*
				CI lower	*-2.5*	*-7.6%*	*-2.2*	*-6.8%*	*-2.0*	*-6.3%*
C2	**32.6**	**T2**	**31.8**		**-0.8**	**-2.4%**	**-0.8**	**-2.4%**	**-0.8**	**-2.4%**
				CI upper	*0.9*	*2.8%*	*0.6*	*2.0%*	*0.5*	*1.4%*

20 metres behind barriers

20m behind barrier Height = 3m					Confidence level					
					95%		90%		85%	
A		B			B - A		B - A		B - A	
Transcect	Mean	Transect	Mean		NO$_2$ µg/m^3		NO$_2$ µg/m^3		NO$_2$ µg/m^3	
	NO$_2$ µg/m^3		NO$_2$ µg/m^3		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-4.0*	*-11.9%*	*-3.6*	*-10.7%*	*-3.3*	*-9.9%*
C1	**33.3**	**T1**	**31.8**		**-1.5**	**-4.6%**	**-1.5**	**-4.6%**	**-1.5**	**-4.6%**
				CI upper	*0.9*	*2.7%*	*0.5*	*1.5%*	*0.2*	*0.7%*
				CI lower	*-3.2*	*-9.7%*	*-2.8*	*-8.4%*	*-2.5*	*-7.6%*
C1	**33.3**	**T2**	**32.7**		**-0.6**	**-1.8%**	**-0.6**	**-1.8%**	**-0.6**	**-1.8%**
				CI upper	*2.1*	*6.2%*	*1.6*	*4.9%*	*1.4*	*4.1%*
				CI lower	*-4.1*	*-12.4%*	*-3.7*	*-11.1%*	*-3.4*	*-10.3%*
C2	**33.3**	**T1**	**31.8**		**-1.5**	**-4.6%**	**-1.5**	**-4.6%**	**-1.5**	**-4.6%**
				CI upper	*1.1*	*3.3%*	*0.7*	*2.0%*	*0.4*	*1.2%*
				CI lower	*-3.4*	*-10.2%*	*-2.9*	*-8.9%*	*-2.7*	*-8.0%*
C2	**33.3**	**T2**	**32.7**		**-0.6**	**-1.7%**	**-0.6**	**-1.7%**	**-0.6**	**-1.7%**
				CI upper	*2.3*	*6.8%*	*1.8*	*5.4%*	*1.5*	*4.5%*

20m behind barrier Height = 2.25m					Confidence level					
					95%		90%		85%	
A		B			B - A		B - A		B - A	
Transect	Mean	Transect	Mean		NO$_2$ µg/m^3		NO$_2$ µg/m^3		NO$_2$ µg/m^3	
	NO$_2$ µg/m^3		NO$_2$ µg/m^3		Absolute	%	Absolute	%	Absolute	%
				CI lower	*-3.1*	*-9.2%*	*-2.8*	*-8.2%*	*-2.5*	*-7.6%*
C1	**33.4**	**T1**	**32.4**		**-1.1**	**-3.2%**	**-1.1**	**-3.2%**	**-1.1**	**-3.2%**
				CI upper	*0.9*	*2.8%*	*0.6*	*1.9%*	*0.4*	*1.2%*
				CI lower	*-3.2*	*-9.7%*	*-2.9*	*-8.8%*	*-2.8*	*-8.2%*
C1	**33.4**	**T2**	**32.0**		**-1.4**	**-4.2%**	**-1.4**	**-4.2%**	**-1.4**	**-4.2%**
				CI upper	*0.4*	*1.3%*	*0.1*	*0.4%*	*-0.1*	*-0.2%*
				CI lower	*-3.1*	*-9.2%*	*-2.7*	*-8.2%*	*-2.5*	*-7.6%*
C2	**33.4**	**T1**	**32.4**		**-1.0**	**-3.1%**	**-1.0**	**-3.1%**	**-1.0**	**-3.1%**
				CI upper	*1.0*	*2.9%*	*0.6*	*1.9%*	*0.4*	*1.3%*
				CI lower	*-3.2*	*-9.7%*	*-2.9*	*-8.8%*	*-2.7*	*-8.2%*
C2	**33.4**	**T2**	**32.0**		**-1.4**	**-4.2%**	**-1.4**	**-4.2%**	**-1.4**	**-4.2%**
				CI upper	*0.4*	*1.3%*	*0.1*	*0.4%*	*0.0*	*-0.1%*

20m behind barrier Height = 0.75m					Confidence level					
					95%		90%		85%	
A		B			B - A		B - A		B - A	
Transect	Mean	Transect	Mean		NO$_2$ µg/m^3		NO$_2$ µg/m^3		NO$_2$ µg/m^3	
	NO$_2$ µg/m^3		NO$_2$ µg/m^3		Absolute	%	Absolute	%	Absolute	%
				CI lower	*0.4*	*1.5%*	*0.7*	*2.5%*	*0.9*	*3.2%*
C1	**28.3**	**T1**	**30.5**		**2.2**	**7.8%**	**2.2**	**7.8%**	**2.2**	**7.8%**
				CI upper	*4.0*	*14.2%*	*3.7*	*13.2%*	*3.5*	*12.5%*
				CI lower	*0.1*	*0.4%*	*0.4*	*1.4%*	*0.6*	*2.1%*
C1	**28.3**	**T2**	**30.2**		**1.9**	**6.7%**	**1.9**	**6.7%**	**1.9**	**6.7%**
				CI upper	*3.7*	*12.9%*	*3.4*	*11.9%*	*3.2*	*11.3%*
				CI lower	*0.6*	*2.2%*	*0.9*	*3.2%*	*1.1*	*3.8%*
C2	**28.2**	**T1**	**30.5**		**2.3**	**8.0%**	**2.3**	**8.0%**	**2.3**	**8.0%**
				CI upper	*3.9*	*13.8%*	*3.6*	*12.8%*	*3.5*	*12.2%*
				CI lower	*0.3*	*1.1%*	*0.6*	*2.0%*	*0.7*	*2.6%*
C2	**28.2**	**T2**	**30.2**		**1.9**	**6.8%**	**1.9**	**6.8%**	**1.9**	**6.8%**
				CI upper	*3.5*	*12.5%*	*3.3*	*11.6%*	*3.1*	*11.0%*

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