THE PLANNING ACT 2008

M4 (JUNCTIONS 3 TO 12) (SMART MOTORWAY) DEVELOPMENT CONSENT ORDER APPLICATION

TR010019

Issue Specific Hearing - Environment

Appendix F - Assessment of the Effect of a NOx Barrier on Air Quality

Deadline IV - 26 November 2015

NOxer© Barrier

Assessment of the Effect of a NOxer© Barrier on Air Quality

22/10/09

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Executive Summary

A new technique has been developed which claims to reduce nitrogen dioxide concentrations by using a photocatalyst of titanium dioxide to oxidise nitrogen oxides (NOx). NOx comprises of nitric oxide (NO) and nitrogen dioxide (NO_2) The Highways Agency was keen to test the effectiveness of this technique to determine if it was suitable for use on the strategic road network as a measure to improve air quality.

The technology used was an environmental barrier called the NOxer© barrier which contains titanium dioxide. The HA appointed Atkins to manage the research programme. Atkins commissioned TRL to carry out the continuous monitoring. The photocatalytic oxidation technology had been previously trialled in the Netherlands, France and elsewhere in the UK, though no results exist for a NOxer© barrier under typical British meteorological conditions.

A monitoring regime was implemented to establish baseline conditions (concentrations of ambient NOx dioxide at fixed positions at or near the fence) with the original barrier in place. Once the new barrier was installed, monitoring recommenced to allow comparison of pre- and post-installation results.

Data was collected simultaneously at the barrier face of both NOxer© and standard untreated sections and analysed to determine whether the NOxer© barrier removed ambient NO_2 as expected. Duplicate monitoring took place a few metres behind the barrier as a measure of the potential effects on air quality at actual exposure locations (e.g. residential properties)

The results at the NOxer© barrier face were generally lower than the control barrier. There was no distinct pattern of reductions but a set of “optimum” conditions generally gave the largest decreases in NO_2 concentration; influenced by wind speed, solar intensity, temperature and especially wind direction. The results collected behind the NOxer© and control barriers showed generally only showed a net decrease in NO_2 concentrations when the optimum conditions were met.

1. Introduction

1.1 The Highways Agency (HA) is committed to playing its part in delivering the Air Quality Strategy and will implement projects that can improve air quality in local authority Air Quality Management Areas (AQMAs). The majority of AQMAs have been declared for nitrogen dioxide. A new technique has been developed which claims to reduce nitrogen dioxide concentrations by using a photocatalyst of titanium dioxide to oxidise nitrogen oxides (NOx). NOx comprises of nitric oxide (NO) and nitrogen dioxide (NO_2) The HA was keen to test the effectiveness of this technique to determine if it was suitable for use on the strategic road network.

1.2 The measure selected for evaluation was an environmental barrier called the NOxer© barrier which contains titanium dioxide (TiO_2). The HA appointed Atkins to manage the research programme. Atkins commissioned TRL to carry out the continuous monitoring.

1.3 Laboratory trials had shown that the NOxer© material was capable of removing up to 80% of oxidized nitrogen pollutants from the air. The barrier is impregnated with finely divided titanium dioxide. Titanium dioxide acts as a catalyst to oxidise nitric oxide (NO) and nitrogen dioxide (NO_2) into nitrate (NO_3^-) in the presence of ambient oxygen and ultraviolet radiation. The titanium dioxide is incorporated into a cement coated woodchip that has a concrete back to the active facing.

1.4 As the barrier reduces noise as well as improving air quality, the HA was keen to locate it in an area where both needed to be improved. The site selected was on the eastern side of the M60 between Junctions 13 and 14 near Swinton, in Salford, Greater Manchester. This is in Salford MBC’s AQMA and is a Hansard site for noise. The closest properties are within 20 metres of the M60. The M60 is on a densely- wooded embankment at this point. The barrier is described in Section 2.

1.5 The photocatalytic oxidation technology had been previously trialled in the Netherlands, France and elsewhere in the UK, though no results exist for a NOxer© barrier under typical British meteorological conditions.

1.6 A monitoring regime was implemented to establish baseline conditions (concentrations of ambient nitrogen dioxide at fixed positions at or near the fence) with the original barrier in place. Once the new barrier was installed, monitoring recommenced to allow comparison of pre- and post-installation results. The monitoring regime is described in Section 3

1.7 The results from the monitoring are described in Section 4 and discussed in Section 5.

1.8 The location of the trial site is shown in Figure 2.1. Various photographs of measurement locations are included in Appendix A.

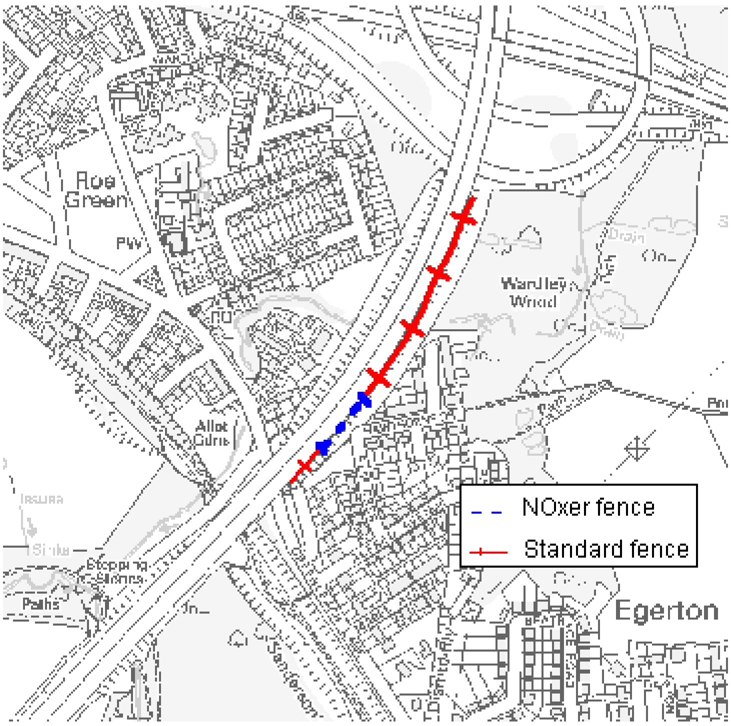
2. The Barrier

2.1 Six organisations were involved with the design, manufacture and installation of the NOxer© environmental barrier. It was designed and patented by Eurovia in France. PBM Groupe manufactured the bespoke panels for the environmental barrier in their French factory. The UK agent for NOxer© was Ringway. Ringway facilitated the design of the NOxer© panels and arranged their import and delivery to site. A-one+, the Managing Agent Contractor for the Area 10 Network, was responsible for the design and delivery of the NOxer© Environmental Barrier Scheme. Capita Symonds was commissioned as designers. Tarmac was commissioned to construct the Scheme and erected the NOxer© and standard panels.

2.2 The barrier was designed to provide the 25 db noise reduction required. The barrier was 3 m high. The NOxer© barrier section needed a minimum surface area of 200 m^2, according to the manufacturer, in order to have an effect on pollutant concentrations. The greater the surface area, the greater effect it could have. The NOxer© section was included in a mid section of the standard barrier to avoid edge effects.

2.3 The total length of the original acoustic barrier was approximately 250 metres and was of timber construction. The original barrier was replaced in its entirety with concrete panels, of which an 80 metre length as shown in blue on Figure 2.1 was the NOxer© barrier (the Figure shows the extent of the replacement barrier. The length of the replacement barrier was approximately 350 m so was 100m longer than the original barrier, This extra length was at the northern end. The barrier was installed to provide acoustic screening to residential properties in Elm Crescent, Sanderson Drive and Hawthorne Drive.

Figure 2.1 – Location of trial site



2.4 The NOxer© barrier section was corrugated to provide a greater surface area and hence reaction surface, and was a dark pink colour (see Figure 2.1). The remainder of the barrier was manufactured from standard concrete, lined in black woven plastic fastened by wooden upright posts at approximately 0.5 metre intervals (see Figure 2.2).

Figure 2.2 – NOxer© Barrier Section

2.5 The active surface of the NOxer© barrier faced the M60. The entire rear length of the barrier was clad in plastic with wooden uprights as described above (see Figure 2.2) and was not active.

Figure 2.3 – Standard Barrier Section

2.6 The original and replacement barriers were three metres high including gravel boards. The original barrier tapered off in height at the northern end in one metre increments to a height of approximately one metre at its northernmost extent (see Figure 2.4). The replacement barrier was of uniform height along its entire length.

Figure 2.4 – Lower Northern End of Original Barrier

3. Monitoring regime

3.1 This section describes the measurement techniques used in the trial and a chronology describing when the various apparatus was deployed.

Measurement techniques

Active measurement

Oxides of nitrogen (NOx)

3.2 Concentrations of oxides of nitrogen (total oxides of nitrogen and nitrogen dioxide, with nitric oxide (NO) calculated by difference) were measured in real time using direct reading chemiluminescence analysers, the specifications of which meet the criteria for the EU Reference Method for measuring NOx[1]. The models used were API 200A/E series analysers.

3.3 Initially, two analysers of the same make and model were installed at the barrier site. These were installed on concrete plinths next to nearest practicable electrical power spurs behind the barrier. One analyser site was adjacent to the future location of the NOxer© barrier whilst the other was the northern extreme. The northern analyser was situated behind a section of the fence which was due to be replaced by a standard panel. This location was hence viewed as a control site, since neither the original nor replacement fence at this location was designed to remove NOx.

3.4 Given the practicalities of locating analyser cabinets in the vicinity of a viable power supply, the northern control site was located behind the section of the original barrier of lower height than the majority of the remainder (see Figure 2.4). This was not the ideal situation but unavoidable due to the steep embankment behind the barrier. As Figure 2.4 shows, the analyser's intake was at a height of 1.5 m above ground

3.5 The southern analyser intake was fed through a hole drilled in the fence and fixed at 0.10 m from the original barrier front at a height of 1.5 m. It was expected that the most pronounced changes in NOx concentrations would be measured next to the active surface hence the choice of position.

3.6 Following the replacement of the barrier, both sampling positions were fixed at 0.10 m in front of the barrier at a height of 1.5 m.

3.7 "Before and after" sampling locations immediately next to the front of the barrier were hence comparable at the southern location but less so at the northern control site. These near-field sampling points are referred to as "Barrier face" positions.

3.8 Following the replacement of the barrier, a further two analysers were installed – one at each site. The purpose of these additional analysers was to measure NOx at a greater distance back from the barrier at positions more representative of personal exposure. A small gantry was installed at both locations to support a sample hose whose inlet was 5 m behind the barrier. These sampling points are referred to as "Behind barrier" positions.

Meteorological conditions

3.9 A small meteorological station measuring wind speed and direction was installed at the northern control site following the replacement barrier's installation at approximately 1 metre above the top of the barrier. Local turbulence effects at the front and rear of the barrier were suspected of interfering with actual measurement of wind speed and direction and these results were ultimately

[1] CEN EN 14211:2005

eschewed in favour of Met Office data from the nearby Manchester Woodford met station[2]. Data for solar radiation intensity were retained as there was no analogous measurement at the Met Office station and solar radiation is not affected by turbulence.

3.10 Data from Manchester Woodford included temperature, wind speed, wind direction and six-hourly aggregated precipitation (rainfall).

Passive techniques

3.11 Two types of passive sampling device were used in the monitoring regime, known as NO_2 diffusion tubes and NOx diffusion tubes. These are indicative monitoring techniques and so do not offer the same precision and accuracy as the automatic chemiluminescent analyser. As the name suggests, the gaseous pollutant diffuses through a reagent-coated substrate and forms a reaction product. The concentration of the reaction product, an azo-compound, is determined spectrophotometrically and the average concentration of the gaseous pollutant over the exposure period calculated. The analytical process is a “single shot” and produces a single result equivalent to the average concentration over the exposure period. Tubes were generally paired to minimise data loss from defective tubes or failed analyses. Three tubes were co-located with each of the chemiluminescent analysers measuring at the barrier face to determine the bias factors.

3.12 NO_2 diffusion tubes were provided and analysed by Harwell Scientifics. A 50:50 solution of triethanolamine in acetone was used as the reagent. Harwell Scientifics received a “good” score in the Workplace Analysis Scheme for Proficiency (WASP) between April 2007 and April 2008. A “good” score means that the diffusion tube results were within 13% of the correct value. Harwell Scientifics is accredited to the UKAS standard.

3.13 NO_2 diffusion tubes absorb NO_2 only and hence provide average NO_2 concentrations for the period over which they were exposed. Diffusion tubes are neither as accurate nor precise as chemiluminescence analysers so data from the latter is used to correct any inherent bias in the results of the former. This process is known as co-location and was undertaken at both continuous analyser sites.

3.14 A NOx tube consists of two tubes. One tube measures NO_2 as described above and the other contains an oxidising substrate to convert NO to NO_2 which is then measured as described above. Analysis of the latter will provide a total NOx concentration. ; NO is calculated as the difference in results between the two tubes.

3.15 NOx tubes were provided and analysed by Gradko. The reagent was 20% triethanolamine in water. Gradko also received a “good” score in the Workplace Analysis Scheme for Proficiency (WASP) between April 2007 and April 2008 for NO_2 tubes. There is no WASP scheme for NO_x tubes. Gradko is a UKAS accredited laboratory. NOx tubes are not widely used and it is considered that their precision and accuracy is poorer for NO than for NO_2.

3.16 NOx tubes were not corrected for bias and results are presented as measured.

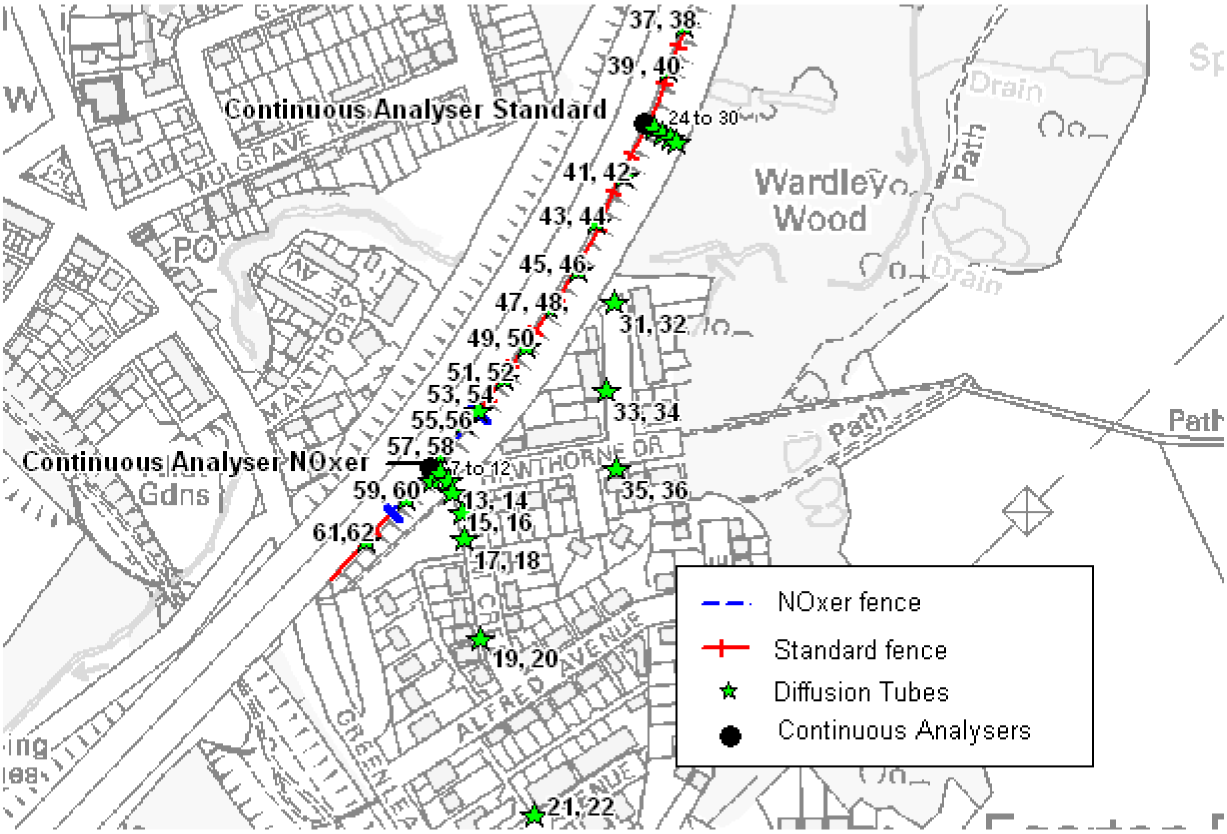
3.17 Whilst method performance is not to the standard of continuous analysers operated to the EU Reference Method, diffusion tubes are a comparatively cheap means of achieving a large spatial coverage. They are unobtrusive but nonetheless commonly stolen.

3.18 Tubes were installed as transects behind the standard and NOxer© sections of the barrier to investigate the difference in declines of pollutant concentrations with distance from both barrier types. Tubes were also installed along the front of the barrier and in four vertical transects at three different heights above ground for both the standard and NOxer© sections of barrier, front and rear, to investigate any changes in concentration with height.

3.19 Measurement positions are shown in Figure 3.1.

[2] Woodford Aerodrome, Greater Manchester SK7 1AG; grid reference 390110, 381800

Figure 3.1 – Monitoring locations



Runoff sampling

3.20 The NO_2 converted by the barrier does not disappear; it is converted to nitrate salts or nitric acid depending on the presence of other compounds on the barrier surface. It was decided to check the barrier runoff as a precaution, even though the mass quantities of NO_2 involved were unlikely to significantly affect either the pH or nitrate concentration of the runoff and hence the quality of receiving waters or other ecological parameters.

3.21 Two sampling systems were installed post-installation of the replacement barrier, at the same NOxer© southern and standard northern sites used for air sampling, to take advantage of the hard standing installed at these positions.

3.22 A 2 m length of guttering was installed on the gravel board of the NOxer© barrier and at a corresponding height (~0.5 metres above ground) at the standard control location. A rubber membrane was affixed to the fence which channelled rainwater and runoff into the guttering. The guttering drained via a pipe fed through the base of the barrier into a collection bucket on the hardstanding at the rear of each sampling point. Each bucket had a small hole such that the contents would gradually drain out over a 24 hour period.

3.23 An automatic wastewater sampler took duplicate samples from each collection bucket on a 12 hourly basis. One of the duplicate sample bottles was pre-treated with bleach to prevent interference from nitrogen fixing micro-organisms.

3.24 Each sampler collected two cumulative samples over a two week period. The samples were sent for analysis for nitrate content and pH[3]. The analysis was undertaken by I2 Limited using ion selective electrode measurement for nitrate and standard electrode testing for pH. The pH tests were covered under the scope of the laboratory's UKAS accreditation but the nitrate was not.

Project chronology

Pre-installation – monitoring at and around the original barrier

3.25 Site reconnaissance took place in September 2007. The location of the southern continuous monitoring location (to be used for the continuous analyser cabinet and later the wastewater sampling system) was an existing small hardstanding next to a flight of steps which run from a gate on Hawthorne Drive to a gate in the barrier itself (see Appendix A). The location of the northern site was dictated by a safe and level position to install the analyser cabinet. The only such position was at the northern extreme of the original barrier (see Figure 2.3). The very steep slope behind this end of the barrier precluded any other option. Electrical supply spurs were installed near each monitoring location.

3.26 Two NO_2 diffusion tube transects were also established around this time, with exposure beginning on 09/10/07. The transects were intended to be perpendicular to the barrier, beginning at the two analyser locations and hence extending back from the future sites of the control and treated barrier. The target spacing for tubes in metres from the barrier was 0.1 m from the barrier face (at the same position as the analyser intakes), 1, 5, 10, 20, 30, 50, 100 and 200 m from the barrier. In practice these exact distances were not achievable and details are included in Section 4. A plan of the diffusion tube transects is shown in Figure 3.1.

3.27 The two NOx chemiluminescent analysers sampling at the barrier face positions were installed on 18/10/07.

3.28 The first set of NO_2 diffusion tubes was exposed for four weeks, thereafter the exposure period was reduced to two weeks to coincide with the analyser site operator's calibration and maintenance visits so that the same operative could exchange tubes.

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[3] The samples pre-treated with bleach were not pH tested as bleach is strongly alkaline and would as such interfere with the pH of a sample of the size collected (up to one litre).

3.29 The diffusion tube sampling regime was enhanced on 08/01/08 with the addition of several new sampling positions along the barrier face. NO_2 tubes were installed on the barrier at a height of 1.5 m at positions 25 and 50 m north of the northern analyser site (i.e. up to 50 m beyond the end of the original barrier). Further sites were established 25, 50, 75, 100, 125, 150 and 171 m south of the northern analyser site along what would be the extent of the new standard section of the barrier, affixed to other structures such as gantries and fence posts. The NOxer© section would be 80 m long and tubes were installed at 20, 40 and 60 m from the northern edge of the NOxer© section. One further site was established 25 m south of the point where the NOxer© section would terminate. These locations are shown in Figure 3.1.

3.30 Again on 08/01/08, NOx tubes were co-located with all NO_2 tubes.

3.31 Monitoring by continuous analyser continued in this manner until 01/02/08, and the final set of pre-construction phase diffusion tubes was collected on 04/02/08.

Construction phase

3.32 The construction phase started on 01/02/08 and ended on 29/04/08. It caused some disruption to the monitoring regime. The analyser cabinets were an obstacle to construction and had to be removed. The installation of the new barrier, pouring of the new hardstandings for the analyser cabinets and cladding of the rear of the barrier took several weeks and meant that no real-time monitoring was possible from 01/02/08 until 29/04/08. For the same reasons, no diffusion tubes were installed at the barrier face during this period.

3.33 The rest of the NO_2 diffusion tube sampling regime continued during the construction phase. The majority of NO_2 tubes exposed from 04/02/08 to 15/02/08 were lost during the demolition of the original barrier. The NOx tubes exposed from 14/03/08 to 07/04/08 were also lost. The remainder of the construction phase caused minimal disruption to the diffusion tube regime.

Post-installation – monitoring at and around the replacement barrier

3.34 Continuous monitoring at the barrier face recommenced on 29/04/08. The northern control site was now situated in a comparable position to the southern NOxer© site in that both analyser cabinets were now located behind a 3 m high section of barrier, sampling at a distance of 0.10 m from the barrier face at a height of 1.5 m.

3.35 The “behind barrier” analysers were also installed on 29/04/08, measuring NO and NO_2 at a distance of 5 m behind the barrier at each analyser cabinet site. The analyser behind the NOxer© barrier had run briefly before construction (see Table 3.1).

3.36 All of the previous diffusion tube (NO_2 and NOx) sites on the barrier face were reinstalled on 29/04/08. Sampling along the transects continued as before.

3.37 Four vertical transects were installed on 29/04/09. Each vertical transect consisted of a pair of NO_2 tubes and NOx tubes fixed at heights of 1.0, 1,5 and 2.0 m above ground on both the front and rear of the barrier. One pair of transects was installed on the NOxer© section and one on the standard. Locations are shown in Figure 3.1.

3.38 Rainwater runoff sampling commenced on 24/06/08.

3.39 Continuous chemiluminescent analyser data was partially lost between 04/08/08 and 04/09/08 due to instrument problems caused by suspected inlet blockages.

3.40 Diffusion tube changeovers and runoff collections continued generally on a two weekly basis until 26/01/09. The four continuous analysers were decommissioned on 13/02/09.

Table 3.1 - NOx analyser installation and decommissioning dates

Analyser location	Monitoring duration pre-installation	Monitoring duration post-installation (see 3.39)
NOxer© Barrier Face	18/10/07 – 01/02/08	29/04/08 – 13/02/09
Standard Barrier Face	18/10/07 – 01/02/08	29/04/08 – 13/02/09
NOxer© - Behind Barrier	09/01/08 – 01/02/08	29/04/08 – 13/02/09
Standard – Behind Barrier	Not installed	29/04/08 – 13/02/09

4. Results

4.1 This section presents a summary of results as measured with emphasis on comparison between the standard and NOxer© barriers post-installation. Full results are presented in Appendix B (Barrier face NO and NO_2 results by continuous analyser, NOxer© barrier), Appendix C (Barrier face NO and NO_2 results by continuous analyser, standard barrier), Appendix D (Behind barrier NO and NO_2 results by continuous analyser, NOxer© barrier), Appendix E (Behind barrier NO and NO_2 results by continuous analyser, standard barrier), Appendix F (NO_2 diffusion tube results), Appendix G (NOx diffusion tube results) and Appendix H (runoff results).

4.2 NO_2 diffusion tubes have been corrected according to TG(09) principles of long-term co-location. Three NO_2 diffusion tubes were co-located at each of the barrier face chemiluminescence analysers. The two co-location factors derived from the two barrier face analysers from October 2007 to February 2009 were very similar at 0.72 and 0.75; so a mean of 0.735 has been applied to all NO_2 tube results included in the tables below. This factor compares well with that derived from UWE for a range of studies for 2008 which was 0.77. The diffusion tube results reported are the mean of two values where duplicate tubes survived.

4.3 Because the pre and post installation monitoring was carried out at different times, account has to be taken of the different meteorological conditions during the two separate monitoring periods. There will also be changes to emission sources and background pollutant concentrations. An indication of the change due to these factors can be obtained by comparing measurements during the two periods at other monitoring sites. Defra's Automatic Urban and Rural monitoring network (AURN) has five active monitoring sites in Greater Manchester, Eccles being the closest at 3.6 km to the NOxer© barrier. The results from these sites are shown in Table 4.1. The regional background concentration of NO_2 and NO were without exception slightly lower in the post-installation period. The diffusion tubes at the background site also measured a lower NO_2 concentration of 2 $\mu g/m^3$ in the post- installation period which was consistent with the Eccles AURN site that measured the same difference.

Table 4.1 - NOx concentrations measured at Nearby AURN Monitoring Stations

Salford Eccles (Urban Industrial)	Preinstallation and construction phase (19/10/07 – 29/04/09)	Post installation (29/04/08 – 13/02/09)*	Difference ($\mu g/m^3$)	Difference (% of preinstallation mean)
Mean NO_2 concentration ($\mu g/m^3$)	39.9	37.8	-2.1	94.7
Mean NO concentration ($\mu g/m^3$)	22.9	19.1	-3.8	83.4
Mean NOx as NO_2 concentration ($\mu g/m^3$)	74.7	66.7	-8.0	89.3
Manchester Piccadilly (Urban Background)				
Mean NO_2 concentration ($\mu g/m^3$)	44.6	42.0	-2.6	94.2
Mean NO concentration ($\mu g/m^3$)	34.3	26.5	-7.8	77.3
Mean NOx as NO_2 concentration ($\mu g/m^3$)	96.9	87.5	-9.4	90.3
Manchester South (Suburban)				
Mean NO_2 concentration ($\mu g/m^3$)	25.3	24.8	-0.5	98.0
Mean NO concentration ($\mu g/m^3$)	14.8	9.9	-4.9	66.9
Mean NOx as NO_2 concentration ($\mu g/m^3$)	47.6	39.7	-7.9	83.4
Bury Roadside (Roadside)				
Mean NO_2 concentration ($\mu g/m^3$)	72.9	69.4	-3.5	95.2
Mean NO concentration ($\mu g/m^3$)	88.7	73.4	-15.3	82.8
Mean NOx as NO_2 concentration ($\mu g/m^3$)	208.2	181.3	-26.9	87.1
Wigan Centre (Urban Background)				
Mean NO_2 concentration ($\mu g/m^3$)	28.9	24.5	-4.4	84.8
Mean NO concentration ($\mu g/m^3$)	18.3	11.8	-6.5	64.5
Mean NOx as NO_2 concentration ($\mu g/m^3$)	56.9	42.4	-14.5	74.5

Table 4.2 - Summary of results - continuous analysers

	Pre-installation (19/10/07 – 01/02/08)*			Post installation (29/04/08 – 13/02/09)		
	NO_2 (µg/m^3)	NO (µg/m^3)	NOx as NO_2 (µg/m^3)	NO_2 (µg/m^3)	NO (µg/m^3)	NOx as NO_2 (µg/m^3)
Standard – barrier face	77.1	110.5	246.0	84.4	127.7	276.9
NOxer© – barrier face	86.4	141.6	302.7	80.7	140.7	331.1
Standard – behind barrier	N/A	N/A	N/A	41.5	56.9	128.5
NOxer© – behind barrier ¥	58.4	54.1	140.9	44.5	57.7	137.0

¥ 09/01/08 - 01/02/08 for NOxer© – Behind Barrier
Concentrations are long- term averages

Table 4.3 - Summary of results - NO_2 diffusion tubes (transects perpendicular to fence)

Location / ID	Pre installation (including construction period) NO_2 concentration (µg/m^3)	Post installation NO_2 concentration (µg/m^3)	Difference (µg/m^3)
	09/10/07 – 29/04/08	29/04/08 – 01/02/09	
Manchester Eccles AURN	39.9	37.8	-2.1
Manchester Piccadilly AURN	44.6	42.0	-2.6
Manchester South AURN	25.3	24.8	-0.5
Bury Roadside AURN	72.9	69.4	-3.5
Wigan Centre AURN	28.9	24.5	-4.4
Standard Barrier			
Transect North- 1 m	57.1	41.0	-16.1
Transect North – 5 m	54.9	38.3	-16.6
Transect North – 9 m	50.1	38.3	-11.8
Transect North – 22 m	44.1	35.8	-8.3
Transect North – 30 m	41.1	34.4	-6.7
Transect North - 70 m	47.8	33.0	-14.8
Transect North - 118 m	40.8	32.9	-7.9
Background (212 m)	36.5	34.5	-2.0
NOxer© Barrier			
Transect South – 1 m	53.7	41.8	-11.9
Transect South – 5 m	50.8	40.2	-10.6
Transect South – 11 m	46.7	38.7	-8.0
Transect South – 17 m	46.3	36.3	-10.0
Transect South – 30 m	46.4	43.1	-3.3
Transect South – 50 m	43.7	36.3	-7.4
Transect South – 92 m	44.3	33.3	-11.0

Table 4.4 - Summary of results - NO_2 diffusion tubes along fence from north to south (post installation only)

Location / ID	NO_2 Concentration (µg/m^3)
	29/04/08 – 01/02/09
Standard Barrier 225 m north of NOxer© section	78.6
Standard Barrier 200 m north	79.9
Standard Barrier 175 m north	98.8
Standard Barrier 150 m north	95.6
Standard Barrier 125 m north	82.4
Standard Barrier 100 m north	93.1
Standard Barrier 75 m north	96.4
Standard Barrier 50 m north	90.4
Standard Barrier 25 m north	88.2
NOxer© Barrier 20 m s. from northern end	98.7
NOxer© Barrier 40 m s. from northern end	96.6
NOxer© Barrier 60 m s. from northern end	94.4
Standard Barrier 25 m south of NOxer© section	82.2

Table 4.5 - Summary of results - NO_2 diffusion tubes in vertical transects (post installation only)

Location	NOxer section NO_2 concentrations (µg/m^3)	Standard section NO_2 concentrations (µg/m^3)
	29/04/08 – 01/02/09	
Barrier Front – 1 m height	108.8	105.3
Barrier Front – 1.5 m height	90.4	96.6
Barrier Front – 2 m height	118.1	113.9
Barrier Rear – 1 m height	50.2	48.5
Barrier Rear – 1.5 m height	51.6	53.8
Barrier Rear – 2 m height	52.2	54.5

Table 4.6 - NO tube summary

Location / ID	Pre installation (including construction period) NO concentrations (µg/m³)	Post installation NO concentrations (µg/m³)	Difference
	08/01/08 – 29/04/08	29/04/08 – 13/02/09	
Manchester Eccles AURN	22.9	19.1	-3.8
Standard Barrier			
At Barrier face / CMS inlet	44.5	48.9	+4.4
Transect North – 1 m	N/A	29.8	
Transect North – 5 m	26.4	30.5	+4.1
Transect North – 9 m	26.2	27.6	+1.4
Transect North – 22 m	24.9	24.7	-0.2
Transect North – 30 m	25.9	30.7	+4.8
Transect North - 70 m	22.8	35.5	+12.7
Transect North - 118 m	24.0	22.7	-1.3
Background (212 m)	23.6	18.8	-4.8
NOxer© Barrier			
At Barrier face / CMS inlet	47.0	81.1	+34.1
Transect South – 1 m	25.0	31.1	+6.1
Transect South – 5 m	19.2	30.0	+10.8
Transect South – 11 m	38.5	25.7	-12.8
Transect South – 17 m	19.6	27.8	+8.2
Transect South – 30 m	21.7	20.6	-1.1
Transect South – 50 m	17.4	15.6	-1.8
Transect South – 92 m	17.8	18.0	+0.2

Table 4.7 - Summary of results - NO diffusion tubes along fence from north to south

Location / ID	Preinstallation (including construction period) NO concentrations (µg/m^3)	Post installation NO concentrations (µg/m^3)
	08/01/08 – 01/02/09	29/04/08 – 13/02/09
Manchester Eccles AURN	22.9	19.1
Standard Barrier 225 m north of NOxer© section	N/A	65.4
Standard Barrier 200 m north	24.0	85.3
Standard Barrier 175 m north	10.7	80.6
Standard Barrier 150 m north	43.6	71.0
Standard Barrier 125 m north	59.2	65.1
Standard Barrier 100 m north	19.2	65.8
Standard Barrier 75 m north	9.6	62.9
Standard Barrier 50 m north	5.1	76.4
Standard Barrier 25 m north	36.3	99.3
NOxer© Barrier 20 m s. of northern end	34.3	70.0
NOxer© Barrier 40 m s. of northern end	83.3	76.9
NOxer© Barrier 60 m from northern end	53.4	83.9
Standard Barrier 25 m south of NOxer© section	N/A	54.6

Table 4.8 - Summary of results - NO diffusion tubes in vertical transects (post installation only – 29/04/08 – 13/02/09)

Location	NOxer© Section NO concentrations (µg/m^3)	Standard section NO concentrations (µg/m^3)
Barrier Front – 1 m height	80.8	68.9
Barrier Front – 1.5 m	76.9	76.4
Barrier Front – 2 m	68.4	79.4
Barrier Rear – 1 m	41.2	38.3
Barrier Rear – 1.5 m	34.0	35.2
Barrier Rear – 2 m	36.5	28.3

4.4 Runoff results are included in Appendix H as discussed. The overall dataset is too small to draw any conclusions owing to sampling and analytical difficulties. Nonetheless, the mean nitrate concentration from NOxer© barrier runoff is slightly higher than that of the standard barrier as was expected.

5. Interpretation

Approach

5.1 The continuous analyser results summary in Section 4 suggest that concentrations were lower at the NOxer© barrier site after installation of the NOxer© barrier than before. However, there will have been differences in concentrations between the two monitoring periods due to different meteorological conditions, emissions and background concentrations. An examination of monitoring data from other local sites gives an indication of these effects. Pollutant concentrations in the post-installation period were slightly lower than those in the pre-installation period.

5.2 A more meaningful approach is to compare simultaneous readings taken from the standard barrier sites with those from the NOxer© barrier sites. The hourly average results are suitably granular for this purpose. By comparing simultaneous readings, many of the variables will have been standardised (particularly meteorological conditions, background concentrations, traffic flows and emission rates). Scatter plots were prepared showing how measured concentrations compared at the NOxer© and standard barrier sites. Figures 5.1 and 5.2 compare NO_2 and NO for pre-installation at the barrier face. Figures 5.3 and 5.4 compareNO_2 and NO post-installation at the barrier face. Figures 5.5 and 5.6 compares NO and NO_2 post-installation at the behind-barrier sites.

Figure 5.1 – Pre-installation NO_2 at both monitoring sites

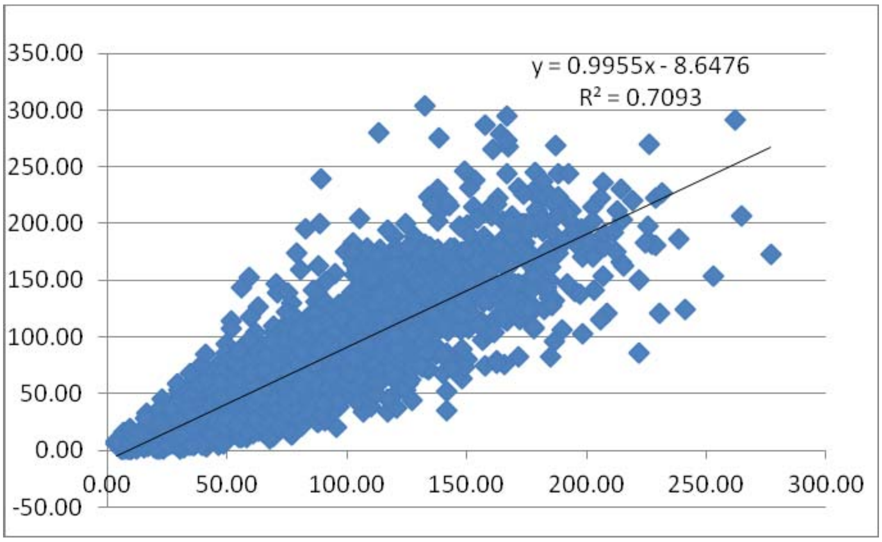


Figure 5.2 – Pre-installation NO at both monitoring sites

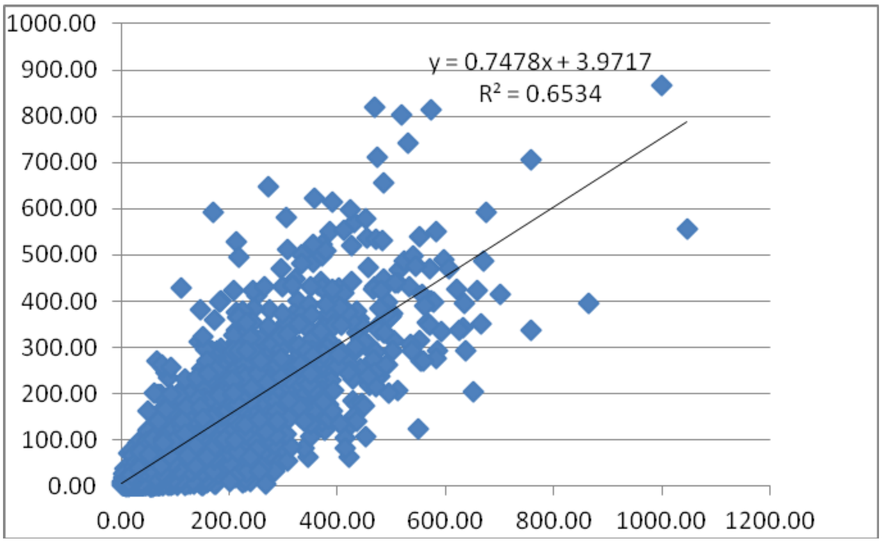


Figure 5.3 – Post-installation NO_2 at both monitoring sites

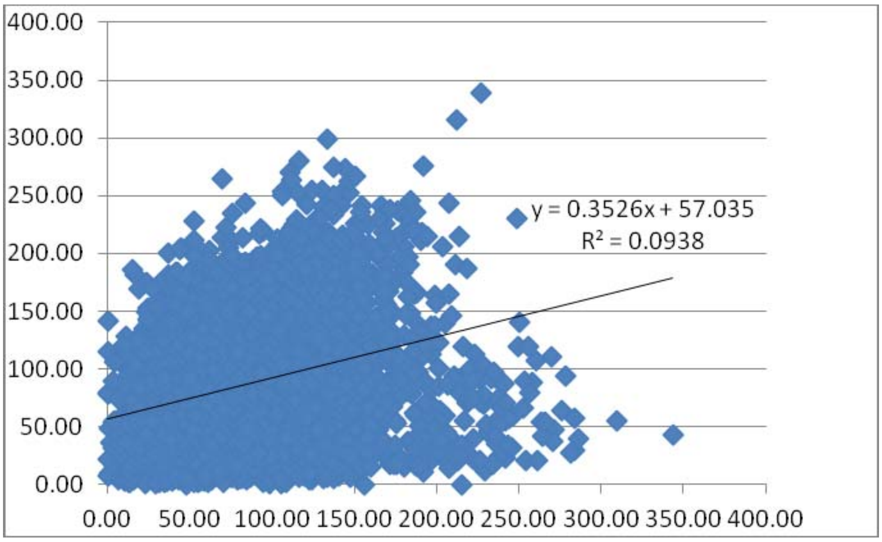


Figure 5.4 – Post-installation NO at both monitoring sites

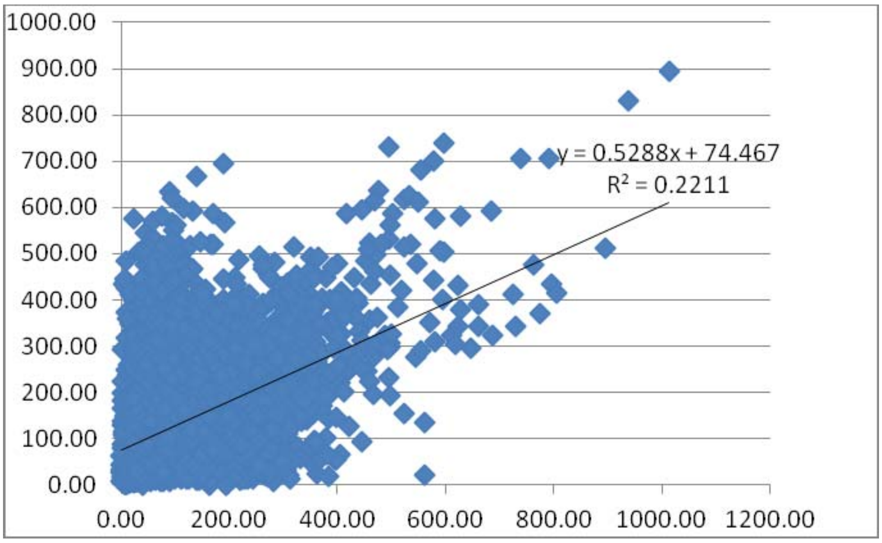


Figure 5.5 – Post-installation NO_2 at both monitoring sites behind barrier

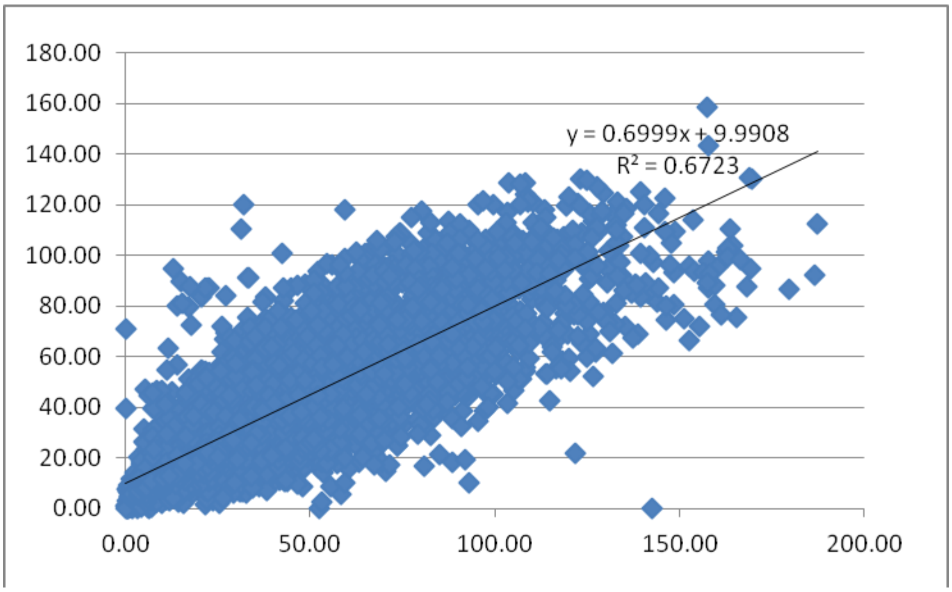
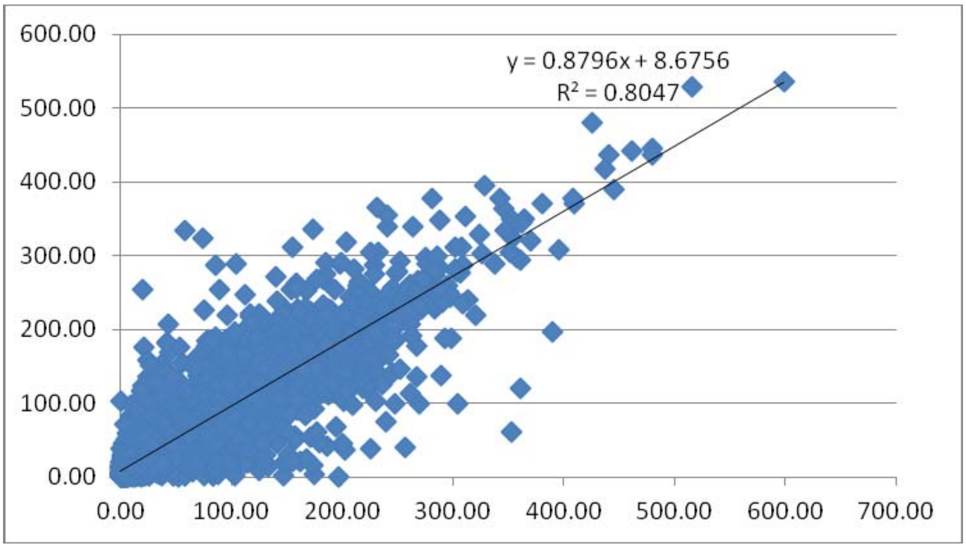


Figure 5.6 – Post-installation NO at both monitoring sites behind barrier



5.3 The relationship characterised by the relatively high R^2 values pre-installation suggests a good correlation between the two sets of simultaneous results. This is to be expected since other than a slight geographical separation and different dispersion effects from the dissimilar barrier heights at points of sampling, conditions at each point are identical.

5.4 The relationship is far less clear post-installation for both NO and NO_2. This suggests a significant change in conditions between the two sampling points. This is possibly the effect of the NOxer© barrier acting at highly variable efficiencies under different prevailing conditions. The strong correlation between the two monitoring sites behind the barrier suggests that using the same argument, this distance is beyond the area of influence of the barrier.

5.5 There is considerable difference between the NO and NO_2 concentrations measure in the pre-installation case at the barrier face sites. Concentrations at the NOxer© site are much higher, this is probably due to much better dispersion at the standard barrier site as the monitoring inlet was above the top of the barrier whereas at the NOxer© site, the inlet was against the barrier face. It is therefore not appropriate to further compare the two barrier face sites before installation.

5.6 The concentrations at the NOxer© sites and the standard sites were compared hour by hour. The difference between the two was negative meaning that concentrations at the NOxer© site were lower.

5.7 An indicator of the effect of the NOxer© barrier is the difference in concentrations between the NOxer© barrier site and the standard barrier site for simultaneous measurements. If the result is negative, it means there are lower concentrations at the NOxer© site. If positive then there are lower concentrations at the standard site.

5.8 By re-examining the summary data in Table 4.1, it is clear that long-term average barrier face NO_2 concentrations were lower at the NOxer© site than the standard site during the post-installation monitoring period. However, without knowing how concentrations compared at the two sites in the pre-installation period, it is not possible to comment on whether the difference observed in the post-installation case is due to the NOxer© effect or some other effect such as regional background concentrations.

5.9 The obvious other effect is that of wind direction. Any barrier will restrict dispersion when the wind is blowing onto the front or back of the barrier. The dominant wind directions in Manchester are south-easterly and south-westerly so the wind will tend to blow pollution from the southern end of the barrier towards the northern end. Higher concentrations at the northern end, where the standard barrier site is located, would be expected. This is what occurs for NO_2 but not for NO. Therefore, only hours when the wind is perpendicular to the front of the barrier should be considered in the analysis to determine the effect of the photocatalyst as under other wind directions, the physical presence of the barrier will have a significant effect. However, analysis has also been carried out for other wind directions to show the effect of the physical barrier.

5.10 The Dutch IPL air quality research programme has carried out trials into TiO_2 products designed to remove NOx. The research found that the products will only function under certain conditions. Other studies have found that the photocatalyst functions best with high temperatures, low relative humidity (<30%) and light intensities greater than 300 nm. The long-term average relative humidity in Manchester is 86% in the morning and 68% in the afternoon, much higher than the 30% for best performance. Discussions were also held with the barrier manufacturer who concurred with the preference for low wind speeds and UV radiation but though that it should work in high relative humidities as long as the barrier was dry. Optimal conditions for the barrier were taken to be:

- Solar radiation intensity of greater than 5 Watts per square metre (which precludes night-time functioning, the oxidation of NOx being activated by ultraviolet radiation)
- Low wind speeds to give maximum contact time at the barrier face and allow the reaction to proceed (less than 3 metres per second was suggested)
- Warm temperatures (greater than 10 °C was suggested)
- Dry conditions as a damp surface prevents the NOx from reaching the active surface.

5.11 No measurements were available of barrier surface moisture so an indicator was used to identify possible damp conditions. If it had rained on the day of the monitoring, then the barrier was assumed to be damp. This was not ideal as the barrier could be damp due to night time condensation and could take more than a few hours to dry after rain.

Periods of consistent performance

5.12 Conditions which gave rise to consistent, long-term negative delta values were examined to see if they agreed with the conditions identified above. However, these conditions and those which promoted adverse or inconsistent performance were not very different. This comparison is presented in Appendix I for information.

Analysis by meteorology

5.13 Preliminary analysis suggested that wind direction was one of the principal influences on the effect of the barrier for the reason suggested above – winds blowing a polluted air mass along the barrier and away from the NOxer© section would obscure the effect of the photocatalyst as the physical movement of the air would reduce concentrations at the NOxer© section whilst increasing it at the standard section. Winds blowing onto the rear of the barrier would in effect move the polluted air mass away from the front of the barrier. Wind directions blowing the polluted air directly onto the barrier face would give the best opportunity to show the effect of the NOxer© surface.

5.14 The barrier lies approximately 45° to north with the active surface facing north-west. Wind directions were categorised into eight sectors as shown in Table 5.2. The sectors were split as such so that their mid-points were parallel and perpendicular to the barrier. Sector 7 represented perpendicular winds to the barrier face and those of most interest.

Table 5.1 - Key to Wind Sectors

Sector ID	Angle range (°)	Description
1	22.5 – 67.5	Northeasterly, parallel to barrier
2	67.5 - 112.5	Easterly, onto rear of barrier
3	112.5 – 157.5	Southeasterly, onto rear of barrier
4	157.5 – 202.5	Southerly, onto rear of barrier
5	202.5 – 247.5	Southwesterly, parallel to barrier
6	247.5 – 292.5	Westerly, onto front of barrier
7	292.5 – 337.5	Northwesterly, onto front of barrier
8	337.5 – 22.5	Northerly, onto front of barrier

5.15 The following tables present the difference in hourly concentrations between the NOxer© barrier and the standard barrier with lower concentrations at the NOxer© barrier having a negative value (([$NO_{2 \text{ or } NO}$] (NOxer© -[$NO_{2 \text{ or } NO}$](standard)) in micrograms per cubic metre filtered for various meteorological conditions to investigate periods of optimal conditions.

5.16 The first group of eight tables are for barrier face NO_2 concentrations, examining the performance of the barrier under all eight wind direction sectors. The total number of hours from 29/04/08 to 13/02/09 during which the wind direction was within the particular sector range, and the average difference value, are shown at the top of each table. The table then goes on to show how many hours the difference was negative (NOxer© barrier with lower concentrations) and positive (NOxer© barrier with higher concentrations) for a particular wind direction sector.

5.17 The total hours in each sector are then sorted according to the suggested optimal criteria in 5.5 above and the relative prevalence of each condition type expressed as a percentage of the total hours for that wind sector. Finally, hours in which the optimal conditions coincide are examined in the final row.

5.18 Tables for the perpendicular wind sector (292.5 – 337.5°), are expected to be the most relevant when determining the effectiveness of the NOxer© barrier as these remove wind directions from the analysis where other factors are likely to be more important in determining the difference in concentrations. The perpendicular wind direction sector was also sorted by two additional higher temperature ranges to examine whether increased temperature has a beneficial effect under these conditions.

5.19 A windrose from Manchester Woodford met station for May 2008 to February 2009 is shown in Figure 5.7.

Figure 5.7 – Manchester Woodford Aerodrome Windrose April 08 – Feb 09

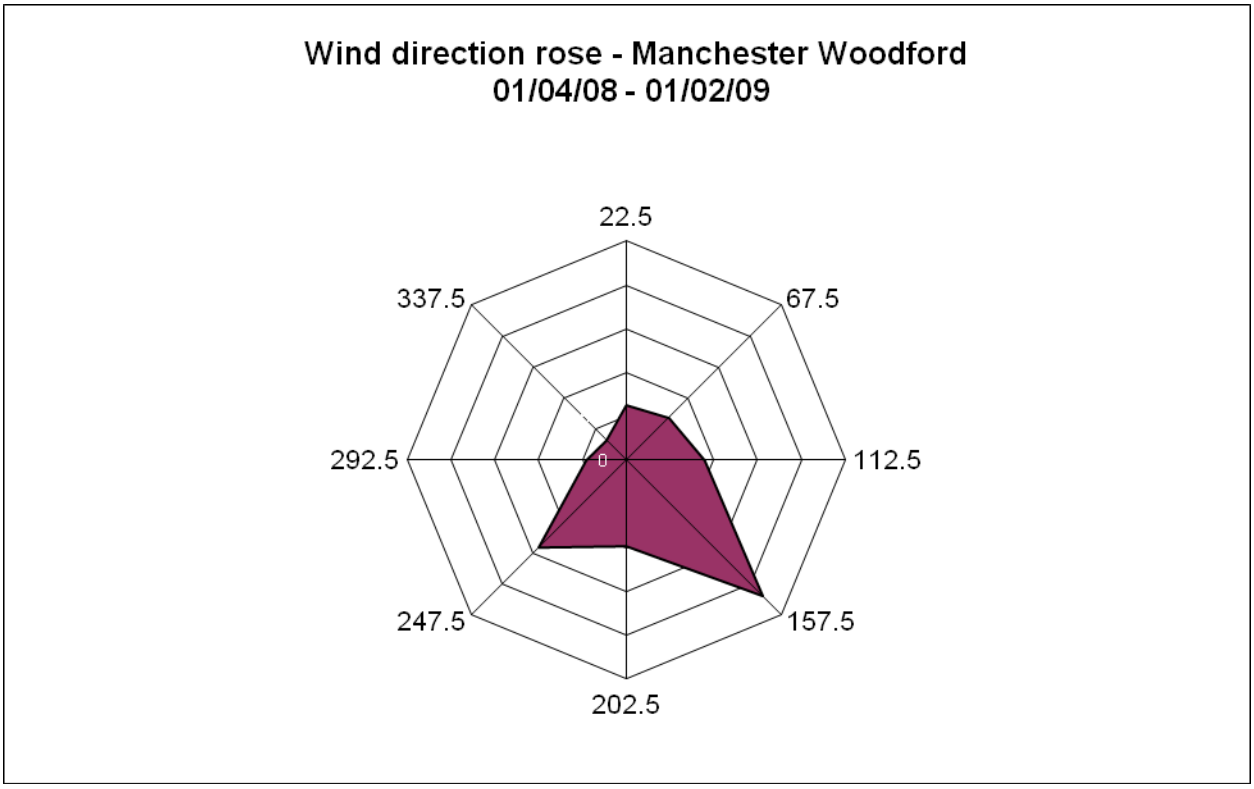


Table 5.2 - Wind Sector 1 - Barrier face NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **NE Parallel** to the barrier (22.5 - 67.5°) – Sector 1	519			15.4		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m³)	no. hours	%	Average difference (μg/m³)
Total hours	121	23	-13.5	394	77	24.2
No Rain	95	21	-13.5	355	79	25.0
WS <3 m/s	58	45	-17.2	70	55	17.5
SR >5 W/m²	27	12	-15.5	207	88	28.3
T>10° C	34	15	-9.6	199	85	21.3
T>10, WS<3, SR>5, No Rain	1	9	-5.2	10	91	24.8

Table 5.3 - Wind Sector 2 - Barrier face NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **E behind** the barrier (67.5 - 112.5) – Sector 2	593			0.6		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m³)	no. hours	%	Average difference (μg/m³)
Total hours	274	47	-17.3	313	53	16.3
No Rain	229	45	-18.0	283	55	15.9
WS <3 m/s	126	57	-19.2	95	43	17.7
SR >5 W/m²	95	37	-23.0	160	63	19.3
T>10° C	119	38	-19.6	195	62	17.5
T>10, WS<3, SR>5, No Rain	12	46	-23.6	14	54	18.8

Table 5.4 - Wind Sector 3 - Barrier face NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **perpendicularly behind** the barrier (112.5 - 157.5) – Sector 3	736			-12.2		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (µg/m^3)	no. hours	%	Average difference (µg/m^3)
Total hours	494	69	-28.5	224	31	23.8
No Rain	389	70	-29.8	169	30	22.7
WS <3 m/s	203	71	-28.6	84	29	27.3
SR >5 W/m^2	183	67	-35.9	90	33	22.4
T>10° C	206	63	-24.4	122	37	16.0
T>10, WS<3, SR>5, No Rain	30	77	-18.0	9	23	28.6
T>15, WS<3, SR>5, No Rain	8	57	-15.7	6	43	38.9
T>20, WS<3, SR>5, No Rain	0	0	0.0	1	100	20.9

Table 5.5 - Wind Sector 4 - Barrier face NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **S behind** the barrier (157.5 - 202.5) – Sector 4	1673			-21.8		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (µg/m^3)	no. hours	%	Average difference (µg/m^3)
Total hours	1301	79	-33.9	336	21	24.9
No Rain	960	80	-33.7	242	20	22.4
WS <3 m/s	404	83	-32.2	85	17	21.0
SR >5 W/m^2	520	80	-41.2	132	20	27.1
T>10° C	628	86	-28.9	101	14	12.0
T>10, WS<3, SR>5, No Rain	70	80	-29.1	18	20	7.8

Table 5.6 - Wind Sector 5 - Barrier face NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **SW parallel** to the barrier (202.5 - 247.5) – Sector 5	704			-20.1		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference ($\mu g/m^3$)	no. hours	%	Average difference ($\mu g/m^3$)
Total hours	576	84	-28.0	113	16	20.2
No Rain	344	82	-29.8	78	18	19.0
WS <3 m/s	185	84	-31.6	34	16	28.3
SR >5 W/m^2	300	90	-33.3	33	10	13.7
T>10° C	367	87	-26.3	54	13	14.8
T>10, WS<3, SR>5, No Rain	44	88	-34.2	6	12	13.5

Table 5.7 - Wind Sector 6 - Barrier face NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **W onto** the barrier (247.5 - 292.5) – Sector 6	962			-14.8		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference ($\mu g/m^3$)	no. hours	%	Average difference ($\mu g/m^3$)
Total hours	732	77	-26.4	223	23	23.4
No Rain	541	78	-28.3	149	22	26.4
WS <3 m/s	204	78	-27.8	57	22	36.2
SR >5 W/m^2	490	82	-29.5	106	18	21.7
T>10° C	566	91	-26.5	58	9	13.6
T>10, WS<3, SR>5, No Rain	65	88	-25.7	9	12	15.1

Table 5.8 - Wind Sector 7 - Barrier face NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **perpendicularly onto** front of barrier (292.5 - 337.5) – Sector 7	365			-5.4		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
Total hours	232	64	-28.6	128	36	36.8
No Rain	185	62	-30.5	113	38	38.6
WS <3 m/s	94	63	-25.1	55	37	38.9
SR >5 W/m^2	140	76	-32.4	44	24	38.5
T>10° C	147	97	-30.4	4	3	4.1
T>10, WS<3, SR>5, No Rain	25	96	-21.3	1	4	8.6
T>15, WS<3, SR>5, No Rain	19	100	-19.7	0	0	0.0
T>20, WS<3, SR>5, No Rain	4	100	-26.2	0	0	0.0

Table 5.9 - Wind Sector 8 - Barrier face NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **N Onto** the barrier (337.5 - 22.5) – Sector 8	666			4.4		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
Total hours	312	48	-24.7	338	52	31.3
No Rain	264	47	-25.7	295	53	32.0
WS <3 m/s	263	59	-25.0	184	41	32.3
SR >5 W/m^2	96	45	-32.1	118	55	26.6
T>10° C	109	60	-23.2	74	40	15.3
T>10, WS<3, SR>5, No Rain	33	60	-29.2	22	40	15.9

Comments on barrier face NO_2 differences

5.20 There are lower NO_2 concentrations at the NOxer© barrier than at the standard barrier for five out of eight wind sectors (3 to 7 inclusive i.e. 112.5° -337.5°). There are higher NO_2 concentrations at the NOxer© barrier when the wind has a northerly component (sectors, 8, 1 and 2 i.e. 337.5° – 112.5°) . Under these conditions, the polluted air will be funnelled along the barrier from the northern end to the southern end with increasing concentrations as it moves along the barrier due to restricted dispersion. The same effect would be expected for sectors 4 to 6, i.e. 157.5° – 292.5° where there is a southerly component resulting in lower concentrations at the NOxer© barrier than at the standard barrier. Wind sector 7 (blowing perpendicular onto the barrier) is therefore the most significant when determining the effect of the NOxer© barrier

5.21 The magnitude of differences between concentrations at the NOxer© barrier face and the standard barrier face for each wind sector is shown in Figure 5.8. This figure illustrates the mean difference under all conditions, whilst the next Figure 5.9 shows the magnitude of the differences by sector under otherwise optimal conditions (i.e. wind speed less than 3 metres per second, solar intensity greater than 10 Watts per square metre, zero rainfall and an ambient temperature of more than 10°C). The mid-point of each sector is represented by a coloured line, with the magnitude of change in proportion to the length of the line. A green line shows a lower mean concentration at the NOxer© barrier and a red line a lower mean concentration at the standard barrier.

Figure 5.8 – Magnitude of differences in barrier face NO_2 concentrations by wind sector, all conditions

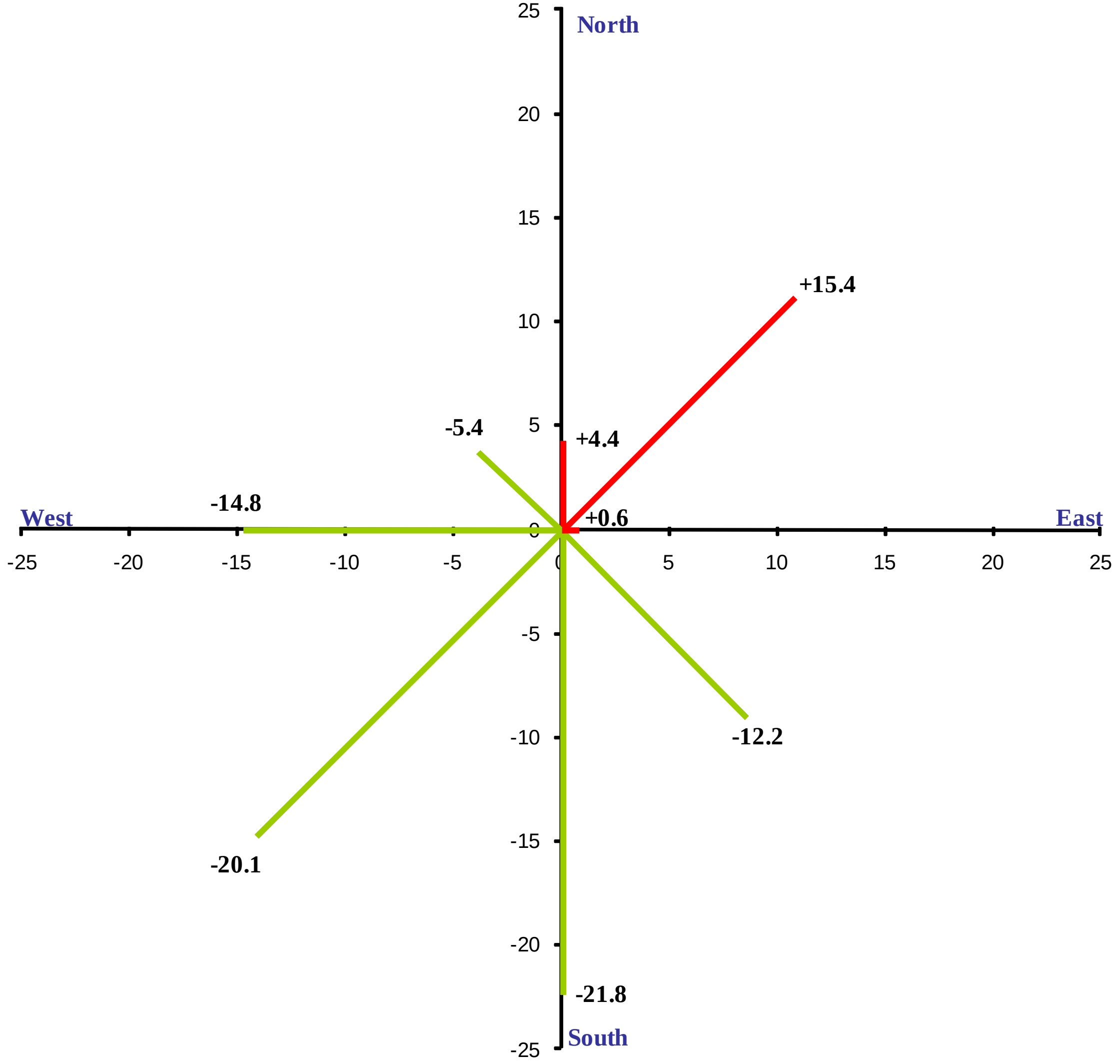


Figure 5.9 – Magnitude of differences in barrier face NO_2 concentrations by wind sector, optimal conditions

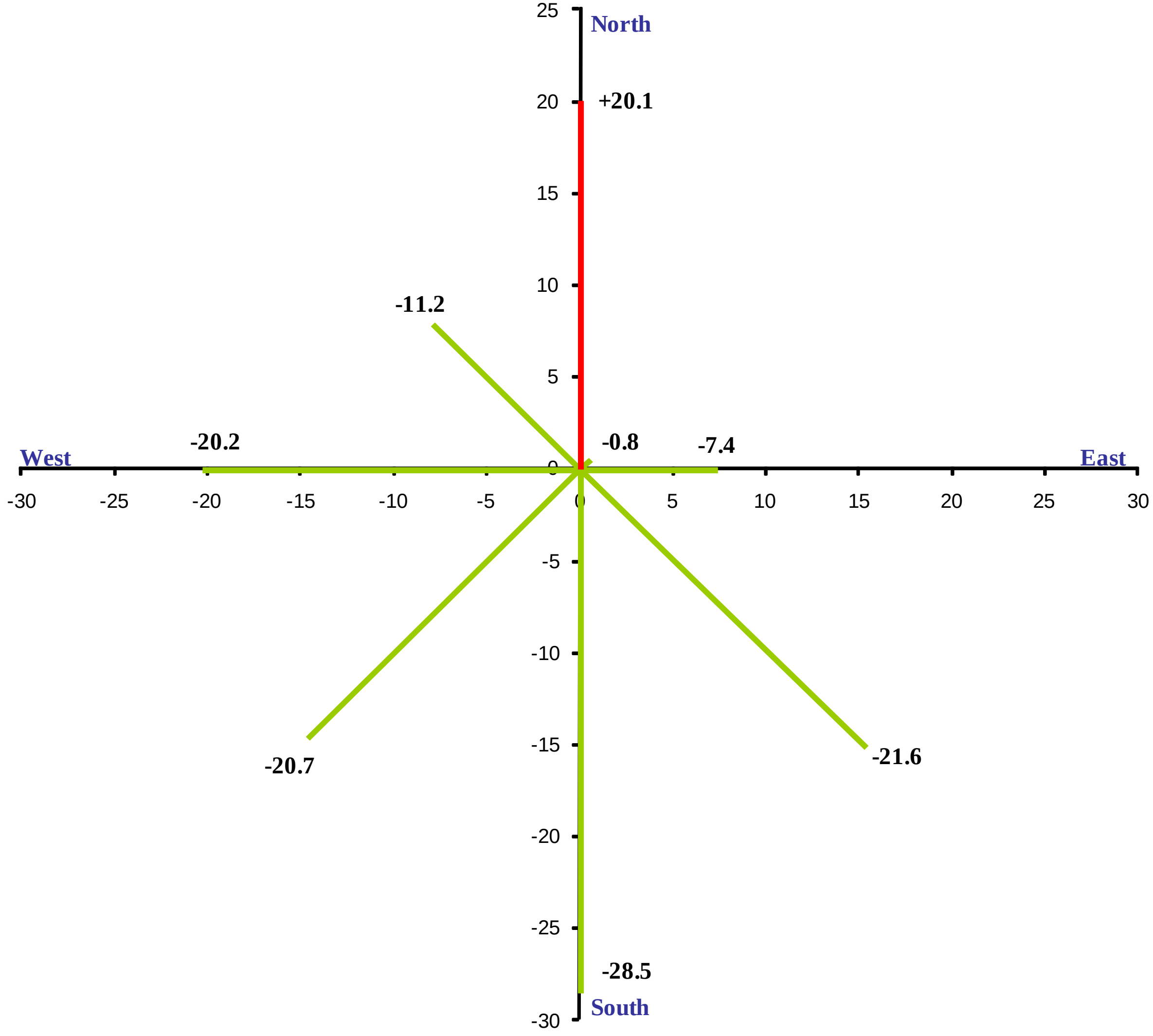


Table 5.10 - Wind Sector 1 - Behind barrier NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **NE Parallel** to the barrier (22.5 - 67.5°) – Sector 1	519			9.0		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
WD	105	21	-3.7	406	79	12.3
No Rain	77	17	-3.6	374	83	12.3
WS <3 m/s	18	14	-7.8	111	86	13.8
SR >5 W/m2	58	25	-3.7	177	75	12.3
T>10 C	72	32	-3.7	156	68	10.2
T>10, WS<3, SR>5, No Rain	3	27	-12.7	8	73	6.3

Table 5.11 - Wind Sector 2 - Behind barrier NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **E behind** the barrier (67.5 - 112.5) – Sector 2	593			5.4		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
WD	212	38	-5.5	351	62	11.9
No Rain	192	38	-5.6	318	62	12.1
WS <3 m/s	45	21	-7.8	170	79	16.6
SR >5 W/m2	122	50	-5.6	121	50	8.9
T>10 C	160	54	-5.7	134	46	9.7
T>10, WS<3, SR>5, No Rain	12	46	-8.6	14	54	10.9

Table 5.12 - Wind Sector 3 - Behind barrier NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **perpendicularly behind** the barrier (112.5 - 157.5) – Sector 3	736			4.1		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
WD	274	39	-5.7	421	61	10.5
No Rain	204	38	-6.7	336	62	10.7
WS <3 m/s	83	30	-5.7	191	70	13.0
SR >5 W/m2	138	52	-6.8	129	48	9.3
T>10 C	211	68	-6.0	99	32	6.8
T>10, WS<3, SR>5, No Rain	14	37	-6.4	24	63	11.0
T>15, WS<3, SR>5, No Rain	8	57	-4.1	6	43	6.4
T>20, WS<3, SR>5, No Rain	1	100	-1.9	0	0	0.0

Table 5.13 - Wind Sector 4 - Behind barrier NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **SW behind** the barrier (157.5 - 202.5) – Sector 4	1673			1.5		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
WD	754	48	-7.7	808	52	10.1
No Rain	556	49	-7.6	589	51	10.2
WS <3 m/s	170	36	-10.2	297	64	12.9
SR >5 W/m2	300	49	-8.9	317	51	10.2
T>10 C	487	73	-8.6	176	27	6.4
T>10, WS<3, SR>5, No Rain	34	41	-10.4	49	59	7.4

Table 5.14 - Wind Sector 5 - Behind barrier NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **SW parallel** to the barrier (202.5 - 247.5) – Sector 5	704			-4.7		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference ($\mu g/m^3$)	no. hours	%	Average difference ($\mu g/m^3$)
WD	428	63	-14.4	247	37	12.2
No Rain	250	61	-14.8	161	39	12.9
WS <3 m/s	111	53	-12.6	98	47	17.2
SR >5 W/m2	231	71	-17.6	94	29	14.3
T>10 C	311	76	-16.3	96	24	8.7
T>10, WS<3, SR>5, No Rain	25	54	-18.2	21	46	15.8

Table 5.15 - Wind Sector 6 - Behind barrier NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **W onto** the barrier (247.5 - 292.5) – Sector 6	962			-3.8		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference ($\mu g/m^3$)	no. hours	%	Average difference ($\mu g/m^3$)
WD	585	62	-15.4	353	38	15.4
No Rain	449	65	-16.2	238	35	16.7
WS <3 m/s	139	55	-12.9	115	45	24.4
SR >5 W/m2	382	65	-17.3	202	35	14.4
T>10 C	473	78	-17.0	135	22	10.6
T>10, WS<3, SR>5, No Rain	43	59	-13.4	30	41	16.2

Table 5.16 - Wind Sector 7 - Behind barrier NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **perpendicularly onto** front of barrier (292.5 - 337.5) – Sector 7	365			6.6		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference ($\mu g/m^3$)	no. hours	%	Average difference ($\mu g/m^3$)
WD	129	38	-15.1	209	62	20.0
No Rain	113	39	-15.4	174	61	20.8
WS <3 m/s	50	34	-15.0	97	66	22.4
SR >5 W/m2	79	45	-19.7	98	55	23.3
T>10 C	89	65	-19.2	47	35	16.6
T>10, WS<3, SR>5, No Rain	18	69	-25.8	8	31	20.4
T>15, WS<3, SR>5, No Rain	14	74	-30.5	5	26	17.6
T>20, WS<3, SR>5, No Rain	3	75	-14.9	1	25	6.6

Table 5.17 - Wind Sector 8 - Behind barrier NO_2 data

	Total Number of Hours			Average Difference		
Wind blowing **N Onto** the barrier (337.5 - 22.5) – Sector 8	666			17.7		
	Lower NO_2 conc. at NOxer© barrier (-ve)			Higher NO_2 conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference ($\mu g/m^3$)	no. hours	%	Average difference ($\mu g/m^3$)
WD	90	14	-7.0	550	86	21.8
No Rain	81	15	-7.3	473	85	21.7
WS <3 m/s	78	18	-7.0	363	82	20.5
SR >5 W/m2	19	9	-6.8	191	91	21.8
T>10 C	42	24	-6.5	131	76	14.7
T>10, WS<3, SR>5, No Rain	12	24	-4.6	39	76	15.4

Comments on behind barrier NO_2 differences

5.22 The magnitude of differences between concentrations behind the NOxer© barrier and behind the standard barrier for each wind sector is shown in Figure 5.10. This figure illustrates the mean difference under all conditions, whilst the next Figure 5.11 shows the magnitude of the differences by sector under otherwise optimal conditions (i.e. wind speed less than 3 metres per second, solar intensity greater than 10 Watts per square metre, zero rainfall and an ambient temperature of more than 10°C). A perpendicular wind to the barrier face resulted in lower NO_2 concentrations behind the barrier at the NOxer© site only under optimal conditions. The locations of the behind barrier monitors were not ideal as they will have been influenced by the steep wooded terrain behind the barrier.

Figure 5.10 – Magnitude of differences in behind-barrier NO_2 concentrations by wind sector, all conditions

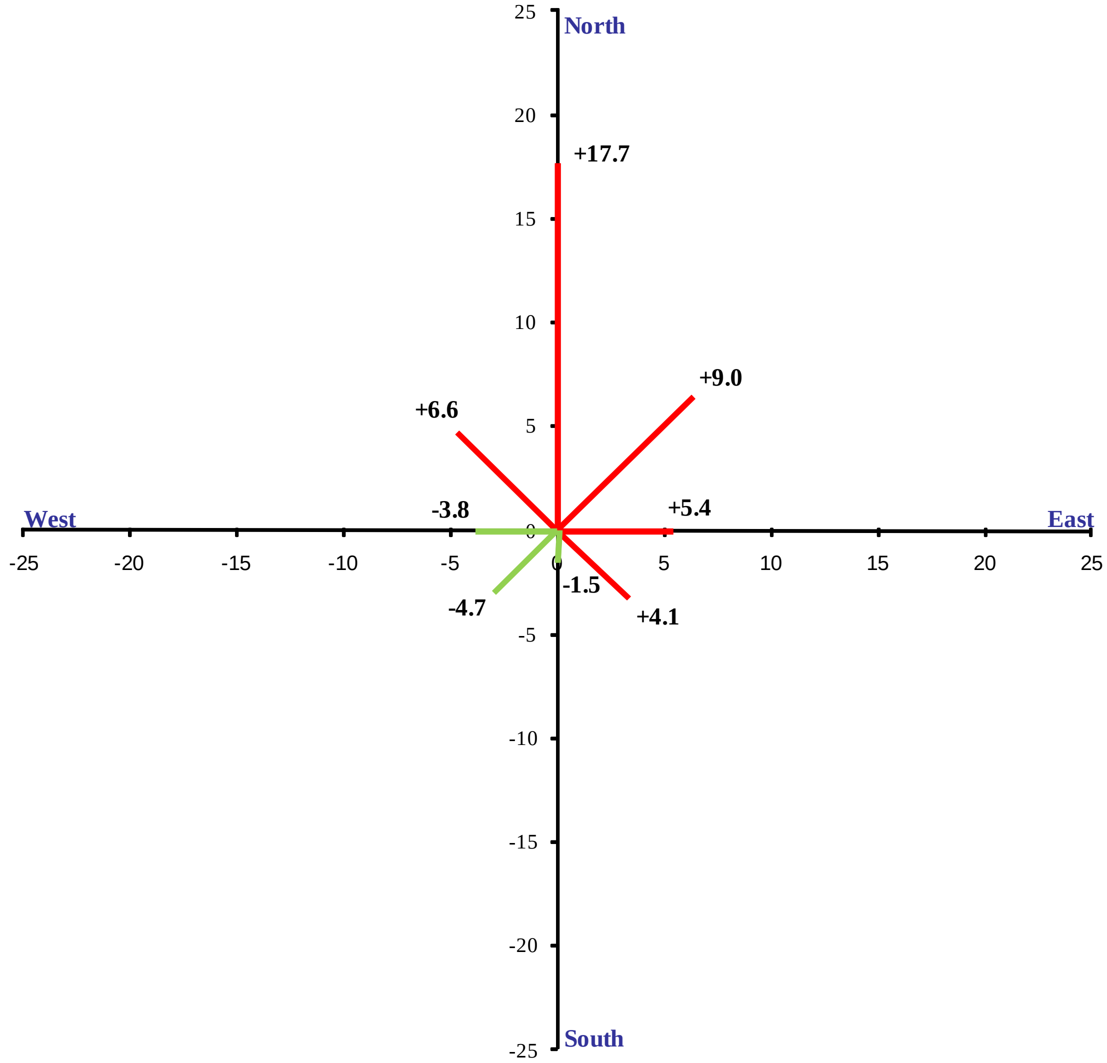


Figure 5.11 – Magnitude of differences in behind-barrier NO_2 concentrations by wind sector, optimal conditions

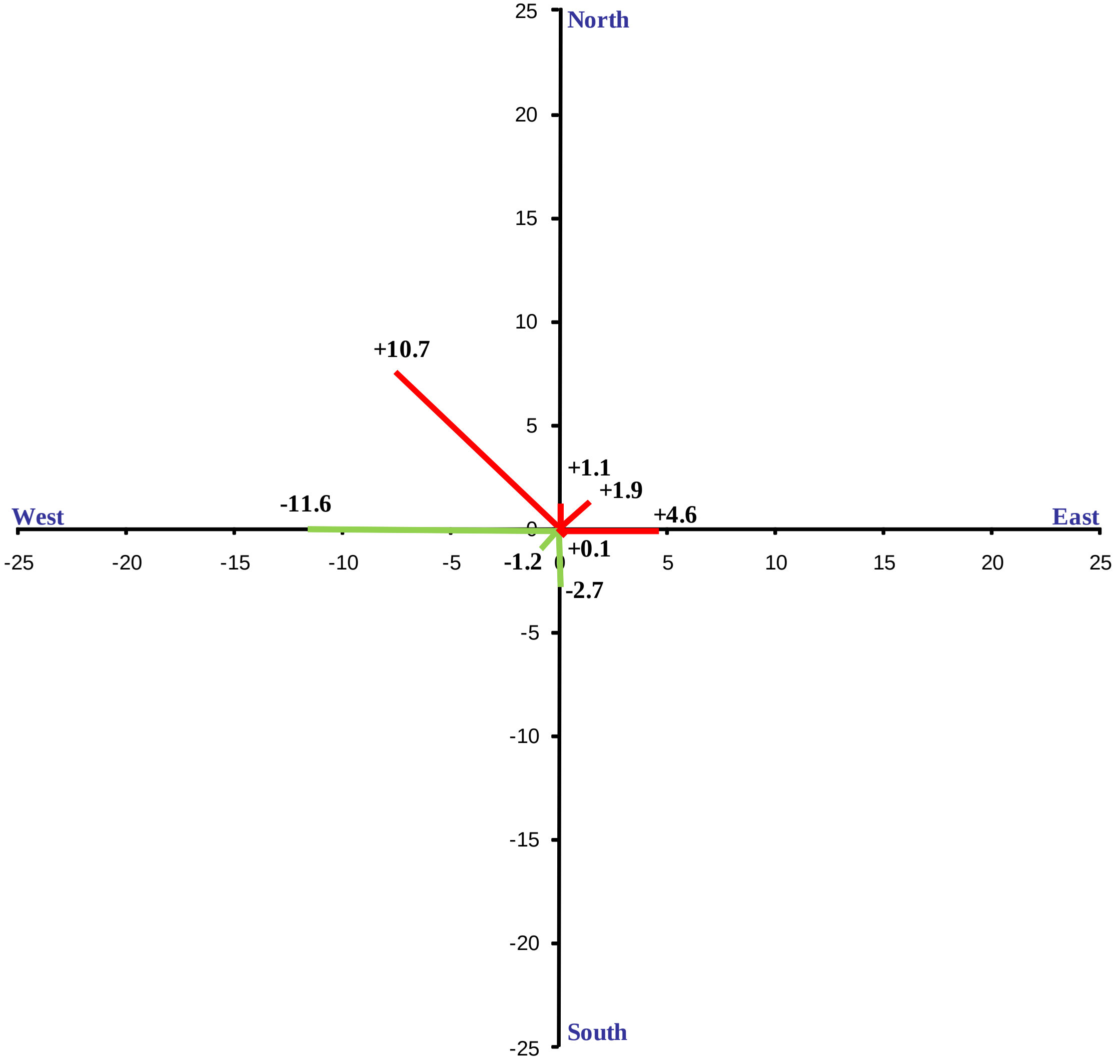


Table 5.18 - Wind Sector 1 - Barrier face NO data

	Total Number of Hours			Average Difference		
Wind blowing **NE Parallel** to the barrier (22.5 - 67.5°) – Sector 1	519			49.4		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
WD	20	4	-15.3	495	96	52.1
No Rain	12	3	-14.9	438	97	53.2
WS <3 m/s	7	5	-16.1	121	95	52.9
SR >5 W/m2	3	1	-25.0	231	99	66.6
T>10 C	4	2	-8.9	229	98	51.8
T>10, WS<3, SR>5, No Rain	0	0		11	100	112.1

Table 5.19 - Wind Sector 2 - Barrier face NO data

	Total Number of Hours			Average Difference		
Wind blowing **E behind** the barrier (67.5 - 112.5) – Sector 2	593			38.9		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
WD	48	8	-25.8	540	92	44.7
No Rain	43	8	-27.4	470	92	44.2
WS <3 m/s	22	10	-40.6	200	90	55.6
SR >5 W/m2	10	4	-52.8	245	96	57.3
T>10 C	15	5	-21.2	299	95	50.8
T>10, WS<3, SR>5, No Rain	3	12	-33.3	23	88	73.9

Table 5.20 - Wind Sector 3 - Barrier face NO data

	Total Number of Hours			Average Difference		
Wind blowing **perpendicularly behind** the barrier (112.5 - 157.5) – Sector 3	736			9.3		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (µg/m³)	no. hours	%	Average difference (µg/m³)
WD	249	35	-52.7	470	65	42.2
No Rain	170	30	-59.6	389	70	44.2
WS <3 m/s	98	34	-66.7	189	66	53.6
SR >5 W/m2	71	26	-77.4	202	74	44.8
T>10 C	73	22	-16.3	255	78	38.1
T>10, WS<3, SR>5, No Rain	7	18	-47.5	32	82	51.6
T>15, WS<3, SR>5, No Rain	2	14	-37.3	12	86	46.8
T>20, WS<3, SR>5, No Rain	0	0	0.0	1	100	106.7

Table 5.21 - Wind Sector 4 - Barrier face NO data

	Total Number of Hours			Average Difference		
Wind blowing **SW behind** the barrier (157.5 - 202.5) – Sector 4	1673			-20.0		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (µg/m³)	no. hours	%	Average difference (µg/m³)
WD	1036	63	-53.0	601	37	36.7
No Rain	743	62	-55.2	459	38	36.4
WS <3 m/s	241	49	-55.0	248	51	43.9
SR >5 W/m2	397	61	-68.9	255	39	41.7
T>10 C	472	65	-37.9	257	35	31.3
T>10, WS<3, SR>5, No Rain	32	36	-26.4	56	64	32.5

Table 5.22 - Wind Sector 5 - Barrier face NO data

	Total Number of Hours			Average Difference		
Wind blowing **SW parallel** to the barrier (202.5 - 247.5) – Sector 5	704			-13.5		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m³)	no. hours	%	Average difference (μg/m³)
WD	452	66	-33.6	237	34	24.9
No Rain	266	63	-36.3	156	37	26.4
WS <3 m/s	115	53	-37.4	104	47	32.2
SR >5 W/m2	233	70	-41.4	100	30	32.9
T>10 C	272	65	-28.5	149	35	21.9
T>10, WS<3, SR>5, No Rain	19	38	-48.1	31	62	29.7

Table 5.23 - Wind Sector 6 - Barrier face NO data

	Total Number of Hours			Average Difference		
Wind blowing **W onto** the barrier (247.5 - 292.5) – Sector 6	962			-3.3		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m³)	no. hours	%	Average difference (μg/m³)
WD	606	63	-20.3	350	37	26.1
No Rain	444	64	-20.6	246	36	29.8
WS <3 m/s	133	51	-20.6	128	49	41.0
SR >5 W/m2	414	69	-23.6	182	31	27.2
T>10 C	469	75	-19.0	155	25	18.2
T>10, WS<3, SR>5, No Rain	37	50	-21.7	37	50	24.7

Table 5.24 - Wind Sector 7 - Barrier face NO data

	Total Number of Hours			Average Difference		
Wind blowing **perpendicularly onto** front of barrier (292.5 - 337.5) – Sector 7	365			7.0		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (µg/m³)	no. hours	%	Average difference (µg/m³)
WD	179	50	-24.0	181	50	37.7
No Rain	145	49	-24.4	153	51	41.2
WS <3 m/s	54	36	-20.4	95	64	44.9
SR >5 W/m2	110	60	-28.2	74	40	41.5
T>10 C	110	73	-23.6	41	27	20.0
T>10, WS<3, SR>5, No Rain	11	42	-14.7	15	58	18.9
T>15, WS<3, SR>5, No Rain	9	47	-3.6	10	53	21.1
T>20, WS<3, SR>5, No Rain	1	25	-1.1	3	75	8.5

Table 5.25 - Wind Sector 8 - Barrier face NO data

	Total Number of Hours			Average Difference		
Wind blowing **N Onto** the barrier (337.5 - 22.5) – Sector 8	666			47.6		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (µg/m³)	no. hours	%	Average difference (µg/m³)
WD	124	19	-24.4	526	81	64.5
No Rain	106	19	-25.7	453	81	63.3
WS <3 m/s	93	21	-26.7	354	79	60.9
SR >5 W/m2	39	18	-30.1	175	82	73.4
T>10 C	37	20	-20.9	146	80	52.1
T>10, WS<3, SR>5, No Rain	8	15	-38.9	47	85	51.5

Table 5.26 - Wind Sector 1 - Behind Barrier NO data

	Total Number of Hours			Average Difference		
Wind blowing **NE Parallel** to the barrier (22.5 - 67.5°) – Sector 1	519			6.9		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
WD	190	37	-3.8	321	63	13.3
No Rain	169	37	-3.9	282	63	13.5
WS <3 m/s	36	28	-8.5	93	72	22.5
SR >5 W/m2	100	43	-2.5	135	57	10.7
T>10 C	93	41	-1.6	135	59	10.3
T>10, WS<3, SR>5, No Rain	5	45	-3.2	6	55	7.5

Table 5.27 - Wind Sector 2 - Behind barrier NO data

	Total Number of Hours			Average Difference		
Wind blowing **E behind** the barrier (67.5 - 112.5) – Sector 2	593			5.2		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m^3)	no. hours	%	Average difference (μg/m^3)
WD	297	53	-5.8	266	47	17.6
No Rain	268	53	-6.3	242	47	18.5
WS <3 m/s	95	44	-13.6	120	56	29.9
SR >5 W/m2	146	60	-5.6	97	40	6.8
T>10 C	145	49	-2.6	149	51	8.0
T>10, WS<3, SR>5, No Rain	16	62	-4.7	10	38	5.1

Table 5.28 - Wind Sector 3 - Behind barrier NO data

	Total Number of Hours			Average Difference		
Wind blowing **perpendicularly behind** the barrier (112.5 - 157.5) – Sector 3	736			-1.5		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (µg/m³)	no. hours	%	Average difference (µg/m³)
WD	510	73	-9.1	185	27	19.3
No Rain	384	71	-9.6	156	29	21.4
WS <3 m/s	169	62	-12.1	105	38	27.6
SR >5 W/m2	212	79	-7.3	55	21	6.7
T>10 C	228	74	-4.0	82	26	12.1
T>10, WS<3, SR>5, No Rain	31	82	-6.4	7	18	10.2
T>15, WS<3, SR>5, No Rain	10	71	-4.1	4	29	16.8
T>20, WS<3, SR>5, No Rain	1	100	-2.9	0	0	0.0

Table 5.29 - Wind Sector 4 - Behind barrier NO data

	Total Number of Hours			Average Difference		
Wind blowing **SW behind** the barrier (157.5 - 202.5) – Sector 4	1673			-7.3		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (µg/m³)	no. hours	%	Average difference (µg/m³)
WD	1217	78	-13.7	345	22	15.1
No Rain	873	76	-13.4	272	24	14.9
WS <3 m/s	288	62	-18.5	179	38	20.0
SR >5 W/m2	499	81	-15.4	118	19	12.6
T>10 C	536	81	-11.0	127	19	6.2
T>10, WS<3, SR>5, No Rain	62	75	-8.7	21	25	4.9

Table 5.30 - Wind Sector 5 - Behind barrier NO data

	Total Number of Hours			Average Difference		
Wind blowing **SW parallel** to the barrier (202.5 - 247.5) – Sector 5	704			-16.2		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m³)	no. hours	%	Average difference (μg/m³)
WD	554	82	-23.6	121	18	17.9
No Rain	322	78	-21.8	89	22	17.5
WS <3 m/s	138	66	-23.3	71	34	21.1
SR >5 W/m2	273	84	-31.0	52	16	12.9
T>10 C	353	87	-23.2	54	13	8.3
T>10, WS<3, SR>5, No Rain	25	54	-32.7	21	46	12.6

Table 5.31 - Wind Sector 6 - Behind barrier NO data

	Total Number of Hours			Average Difference		
Wind blowing **W onto** the barrier (247.5 - 292.5) – Sector 6	962			-10.4		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%	Average difference (μg/m³)	no. hours	%	Average difference (μg/m³)
WD	720	77	-19.5	218	23	19.5
No Rain	528	77	-20.2	159	23	20.3
WS <3 m/s	148	58	-21.2	106	42	24.5
SR >5 W/m2	475	81	-22.2	109	19	16.3
T>10 C	506	83	-19.7	102	17	13.3
T>10, WS<3, SR>5, No Rain	42	58	-18.6	31	42	19.0

Table 5.32 - Wind Sector 7 - Behind barrier NO data

	Total Number of Hours			Average Difference		
Wind blowing **perpendicularly onto** front of barrier (292.5 - 337.5) – Sector 7	365			-3.8		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%				
WD	192	57	-23.8	146	43	22.5
No Rain	161	56	-24.0	126	44	22.8
WS <3 m/s	73	50	-22.5	74	50	23.6
SR >5 W/m2	110	62	-30.3	67	38	22.9
T>10 C	95	70	-29.6	41	30	18.8
T>10, WS<3, SR>5, No Rain	16	62	-38.3	10	38	19.0
T>15, WS<3, SR>5, No Rain	14	74	-35.0	5	26	7.5
T>20, WS<3, SR>5, No Rain	2	50	-6.5	2	50	4.1

Table 5.33 - Wind Sector 8 - Behind barrier NO data

	Total Number of Hours			Average Difference		
Wind blowing **N Onto** the barrier (337.5 - 22.5) – Sector 8	666			16.9		
	Lower NO conc. at NOxer© barrier (-ve)			Higher NO conc. at NOxer© barrier (+ve)		
	no. hours	%				
WD	203	32	-17.5	437	68	32.9
No Rain	184	33	-18.1	370	67	31.9
WS <3 m/s	151	34	-19.3	290	66	34.3
SR >5 W/m2	84	40	-20.8	126	60	27.1
T>10 C	59	34	-10.9	114	66	18.6
T>10, WS<3, SR>5, No Rain	27	53	-10.2	24	47	14.5

Table 5.34 - Summary table for Barrier face NO_2 difference

	Total Number of Hours	Average Difference (µg/m^3)
All wind directions	6218	-10.3
All wind directions under optimal conditions	369	-16.4
All wind directions under non optimal conditions	5742	-10.0
Wind perpendicular onto barrier, all conditions	**358**	**-5.1**
Wind perpendicular onto barrier, optimal conditions	**26**	**-20.1**
As above, non optimal	334	-4.2

Table 5.35 - Summary table for Behind Barrier NO_2 difference

	Total Number of Hours	Average Difference (µg/m^3)
All wind directions	6218	3.3
All wind directions under “Optimal” conditions	354	0.8
All wind directions under non optimal conditions	5568	3.5
Wind perpendicular onto barrier, all conditions	**340**	**6.9**
Wind perpendicular onto barrier, optimal conditions	**26**	**-11.6**
As above, non optimal	312	8.1

Table 5.36 - Summary table for Barrier Face NO difference

	Total Number of Hours	Average Difference (µg/m^3)
All wind directions	6218	7.1
All wind directions under “Optimal” conditions	369	20.3
All wind directions under non optimal conditions	5745	6.2
Wind perpendicular onto barrier, all conditions	**365**	**7.9**
Wind perpendicular onto barrier, optimal conditions	**26**	**4.6**
As above, non optimal	334	7.2

Table 5.37 - Summary table for Behind Barrier NO difference

	Total Number of Hours	Average Difference (µg/m^3)
All wind directions	6218	-2.9
All wind directions under "Optimal" conditions	354	-4.7
All wind directions under non optimal conditions	5568	-2.8
Wind perpendicular onto barrier, all conditions	**365**	**-7.2**
Wind perpendicular onto barrier, optimal conditions	**26**	**-16.3**
As above, non optimal	312	-2.8

Discussion

Differences in Concentrations at the Barrier Face

5.23 Any effect due to the photocatalyst should be observed at the barrier face.

5.24 Following installation of the replacement barrier, long term average NO_2 concentrations were lower at the NOxer© barrier face than at the standard barrier face, however, NO concentrations were higher. However, it is likely that wind direction played a significant part in determining concentrations with southerly winds blowing pollution towards the standard barrier and away from the NOxer© barrier.

5.25 Winds perpendicular to the barrier face resulted in lower concentrations of NO_2 by 5.1 $\mu g/m^3$ at the NOxer© barrier but higher NO concentrations by 7.9 $\mu g/m^3$ than at the standard barrier. However, the barrier could not have been functioning during many of these hours due to darkness, low temperatures or a damp surface. When only optimal conditions were analysed, concentrations of NO_2 were much lower, (by 20.1 $\mu g/m^3$) and NO concentrations were only slightly higher, by 4.6 $\mu g/m^3$, at the NOxer© barrier. Due to the orientation of the barrier, optimal conditions with a perpendicular wind direction occurred for only 0.4% of the monitoring period.

Differences in Concentrations Behind the Barrier

5.26 Any effect due to the photocatalyst is expected to be less behind the barrier than at the barrier face due to dilution of the air that has been in contact with the active barrier face with polluted air.

5.27 At the behind barrier sites, long term average NO and NO_2 concentrations were higher behind the NOxer barrier than the standard barrier. However, it is likely that wind direction had a significant effect in determining these concentrations. The steep wooded terrain behind the barrier is also likely to have influenced results.

5.28 Winds perpendicular to the barrier face resulted in higher NO_2 (by 6.9 $\mu g/m^3$) concentrations at the behind NOxer© barrier site and lower NO concentrations (by 7.2 $\mu g/m^3$) than at the site behind the standard barrier. However, the barrier could not have been functioning during many of these hours due to darkness, low temperatures or a damp surface. When only optimal conditions were analysed, concentrations of NO_2 (by 11.6 $\mu g/m^3$) and NO (by 16.3 $\mu g/m^3$) were lower behind the NOxer© barrier site than the site behind the standard barrier. These differences are larger than at the barrier face so some other factor(s) must also be having an effect

5.29 There have been studies of the reduction of NO to nitrous acid (HNO_2) by a photocatalysed reaction with water[4]; however, nitrous acid is thought to rapidly decomposed into a mixture of nitric acid, NO and NO_2 so this mechanism for removal is probably not significant; moreover it would occur under “optimal” conditions when the barrier is dry as HNO_2 is not known to exist in any other phase than in solution. A more likely route is the oxidation of NO to NO_2 (or even NO_3 ions).

NO_2 diffusion tube results – long term averages

5.30 Concentrations of NO_2 were generally lower after installation of the NOxer© barrier, due to some extent to the lower ambient background concentration (see Table 5.1) in the pre-installation phase. Concentrations along the transect generally decreased with increasing distance from the main M60 road source.

5.31 There appears to be no significant difference in concentrations between the two transects. Any difference would be expected to be larger nearer the barrier than further afield as the affected air would become more diluted with air that had not been in contact with the NOxer© barrier.

[4] Gustafsson et al, Chemical Communication, 2006 (3936 – 3938)

5.32 NO_2 and NO concentrations were generally highest along the front of the treated barrier compared with the untreated. This was contrary to expectations. The vertical transects show no obvious stratification but illustrate a pronounced difference between concentrations at the front and rear of the barrier. It was expected that NO_2 would move rapidly from an area of high concentration to one of low concentration unless wind shear predominantly affected the dispersion pattern of the polluted air mass; however, the presence of a physical barrier appears to have quite a profound effect on the concentration gradient. More polluted air appears to be either shunted along the barrier away from the transects or pushed over the barrier where it is diluted by turbulent effects.

5.33 The intention of the diffusion tube survey was to provide a greater spatial distribution of measurement points. There does not appear to be any clear pattern to spatial distribution of delta values.

Summary of interpretation

5.34 The barrier appears to function best under the presupposed optimal conditions which are precluded by the barrier's current orientation. Winds are predominantly southwesterly as illustrated by the windrose in Figure 5.1. Winds blew onto the barrier from a perpendicular bearing (sector 7) for only 365 hours of the post-installation monitoring regime. It appears important for further field reductions in NO_2 (and indeed NO) concentration that winds blow from this sector (see Tables 5.36 and 5.38); however these datasets are very small.

5.35 The fundamental issue of barrier orientation appears to have precluded a wholly successful trial. Predominating winds in the British Isles are southwesterly, and a barrier would have to be situated at -45° to north for maximum efficacy, rather than +45° as is the current case.

Appendix A: Sampling position photographs

Appendix A - Sampling locations.pp

Appendix B: NOx Concentrations at NOxer© Barrier Face

Appendix B - NO and NO2 concentrations a

Appendix C: NOx Concentrations at Standard Barrier Face

Appendix C - NO and NO2 concentrations a

Appendix D: NOx Concentrations Behind NOxer© Barrier

Appendix D - NO and NO2 concentrations b

Appendix E: NOx Concentrations Behind Standard Barrier

Appendix E - NO and NO2 concentrations b

Appendix F: NO_2 Diffusion Tube Results

Table F1: Diffusion Tube Data for October 2007- Pre NOxer Installation

Exposure Periods	**09th October – 05th November**
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	86.5
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	Not in operation
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	129.9
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	91.7
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	Not in operation
Average Diffusion Tube Collocated Concentration Standard ($\mu g/m^3$)	117.0
Location	**Period Concentration**
7,8	74.4
9,10	66.9
11,12	51.3
13,14	Tube Missing
15,16	58.2
17,18	48.2
19,20	57.5
21,22	49.1
23,24	77.0
25,26	63.3
27,28	59.4
29,30	54.3
31,32	50.8
33,34	59.8
35,36	49.2
Notes The first set of tubes were exposed for a month. This changed to a two weekly exposure in November.	

Table F2: Diffusion Tube Data for November 2007- Pre NOxer Installation

Exposure Periods	**05th November**	**20th November**
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	83.7	97.0
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	Not in Operation	Not in Operation
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	129.6	136.5
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	76.5	91.7
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	Not in Operation	Not in Operation
Average Diffusion Tube Collocated Concentration Standard ($\mu g/m^3$)	115.2	121.1
Location	**Period Concentration**	**Period Concentration**
7,8	82.9	73.5
9,10	78.2	73.2
11,12	68.5	69.2
13,14	71.0	65.0
15,16	63.7	67.8
17,18	63.4	64.4
19,20	64.7	62.7
21,22	51.3	54.3
23,24	84.7	90.9
25,26	150.5	85.6
27,28	73.2	76.7
29,30	67.7	63.7
31,32	53.9	64.6
33,34	71.8	66.9
35,36	56.2	Tube Missing

Table F3: Diffusion Tube Data for December 2007- Pre NOxer Installation

Exposure Periods	3rd December	17th December
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	84.0	73.8
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	Not in Operation	Not in Operation
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	111.8	70.8
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	91.7	76.0
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	Not in Operation	Not in Operation
Average Diffusion Tube Collocated Concentration Standard ($\mu g/m^3$)	114.1	95.5
Location	**Period Concentration**	**Period Concentration**
7,8	Tube Missing	61.9
9,10	Tube Missing	56.0
11,12	68.6	51.0
13,14	60.8	51.5
15,16	66.0	53.1
17,18	58.8	50.8
19,20	63.5	53.5
21,22	54.3	46.0
23,24	77.3	53.0
25,26	76.4	59.5
27,28	69.8	53.2
29,30	61.0	46.4
31,32	54.8	43.1
33,34	69.7	51.4
35,36	55.9	43.4

Table F4: Diffusion Tube Data for January 2008 - Pre NOxer Installation

Exposure Periods	8th January	21st January
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	107.4	80.2
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	64.23	52.10
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	122.2	90.4
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	77.3	82.0
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	Not in Operation	Not in Operation
Average Diffusion Tube Collocated Concentration Standard ($\mu g/m^3$)	117.7	89.6
Location	**Period Concentration**	**Period Concentration**
7,8	72.5	72.7
9,10	72.1	55.6
11,12	62.9	61.1
13,14	39.3	64.9
15,16	62.5	62.3
17,18	62.0	54.1
19,20	65.1	55.7
21,22	51.8	45.1
23,24	83.9	Tube Missing
25,26	77.7	24.1
27,28	70.8	62.9
29,30	63.3	60.2
31,32	56.4	50.1
33,34	71.6	64.9
35,36	57.9	54.2

Table F5: Diffusion Tube Data for February 2008- Pre NOxer Installation

Exposure Periods	**15th February**
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	Continuous Monitor removed during construction
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	Construction Period
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	-
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	Continuous Monitor removed during construction
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	Not in Operation
Average Diffusion Tube Collocated Concentration Standard ($\mu g/m^3$)	-
Location	**Period Concentration**
7,8	97.4
9,10	80.3
11,12	72.2
13,14	75.1
15,16	68.0
17,18	69.5
19,20	66.2
21,22	56.5
23,24	Tube Missing
25,26	78.0
27,28	78.1
29,30	63.1
31,32	75.8
33,34	94.0
35,36	85.6
Notes	The first set of data is not available since tubes were lost during construction enabling works

Table F6: Diffusion Tube Data for March 2008- Pre NOxer Installation

Exposure Periods	**29th February**	**14th March**
CMS Barrier Face NO_2 NOxer (µg/m^3)	Continuous Monitor removed during construction	Continuous Monitor removed during construction
CMS Behind Fence NO_2 NOxer (µg/m^3)	Construction Period	Construction Period
Average Diffusion Tube Collocated Concentration NOxer (µg/m^3)	-	-
CMS Barrier Face NO_2 Standard (µg/m^3)	Continuous Monitor removed during construction	Continuous Monitor removed during construction
CMS Behind Barrier NO_2 Standard (µg/m^3)	Not in Operation	Not in Operation
Average Diffusion Tube Collocated Concentration Standard (µg/m^3)	-	-
Location	**Period Concentration**	**Period Concentration**
7,8	Tube Missing	Tube Missing
9,10	92.5	60.4
11,12	82.3	Tube Missing
13,14	78.6	61.9
15,16	87.9	58.1
17,18	79.6	56.1
19,20	67.3	47.9
21,22	59.2	32.5
23,24	Tube Missing	Tube Missing
25,26	103.3	57.9
27,28	89.4	61.7
29,30	80.1	55.4
31,32	70.5	48.8
33,34	72.6	50.4
35,36	62.2	44.4

Table F7: Diffusion Tube Data for April 2008- Pre NOxer Installation

Exposure Periods	**07th April**	**11th April**
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	Continuous Monitor removed during construction	Continuous Monitor removed during construction
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	Construction Period	Construction Period
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	-	-
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	Continuous Monitor removed during construction	Continuous Monitor removed during construction
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	Not in Operation	Not in Operation
Average Diffusion Tube Collocated Concentration Standard ($\mu g/m^3$)	-	-
Location	**Period Concentration**	**Period Concentration**
7,8	75.7	47.5
9,10	75.2	46.9
11,12	76.1	46.7
13,14	81.2	44.2
15,16	68.9	42.4
17,18	66.3	42.4
19,20	66.5	54.4
21,22	61.0	35.9
23,24	Tube Missing	Tube Missing
25,26	73.6	47.6
27,28	76.4	47.8
29,30	63.8	43.0
31,32	63.6	40.1
33,34	67.2	42.1
35,36	58.9	37.6

Table F8: Diffusion Tube Data for May 2008- Post NOxer Installation

Exposure Periods	29th April	12th May
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	86.0	78.2
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	45.23	17.43
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	143.4	122.3
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	101.0	65.4
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	43.21	14.73
Average Diffusion Tube CollocatedConcentration Standard ($\mu g/m^3$)	140.6	107.6
Location	**Period Concentration**	**Period Concentration**
7,8	61.2	29.7
9,10	59.8	29.5
11,12	55.4	28.3
13,14	32.1	27.6
15,16	56.9	133.3
17,18	48.1	28.4
19,20	48.4	120.4
21,22	43.2	28.1
23,24	54.9	29.5
25,26	54.6	27.7
27,28	50.1	24.4
29,30	50.1	24.1
31,32	45.5	26.2
33,34	48.6	27.9
35,36	45.6	19.8
37,38	123.2	83.0
39,40	135.6	90.6
41,42	150.2	119.5
43,44	152.8	133.5
45,46	136.8	115.4
47,48	141.4	129.0
49,50	156.0	141.1
51,52	162.6	26.0
53,54	156.5	131.5
55,56	168.1	141.4
57,58	167.2	148.8
59,60	162.2	147.3
61,62	151.6	27.7
63,64	151.2	122.8
65,66	157.9	132.4
67,68	170.8	140.9
69,70	174.2	145.2
71,72	56.0	42.3
73,74	61.0	44.2
75,76	66.5	43.8
77,78	61.9	33.2
79,80	63.6	33.8
81,82	66.8	37.0

Table F9: Diffusion Tube Data for June 2008- Post NOxer Installation

Exposure Periods	**27th May**	**9th June**
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	90.80	59.50
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	54.85	42.37
Average Diffusion Tube CollocatedConcentration NOxer ($\mu g/m^3$)	136.1	112.9
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	112.4	104.9
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	55.06	57.80
Average Diffusion Tube Collocated Concentration Standard ($\mu g/m^3$)	145.8	114.2
Location	**Period Concentration**	**Period Concentration**
7,8	71.4	76.8
9,10	67.2	65.3
11,12	63.9	62.1
13,14	65.2	63.5
15,16	61.6	59.0
17,18	59.6	56.2
19,20	35.7	33.5
21,22	51.0	45.5
23,24	62.1	67.8
25,26	56.6	63.1
27,28	63.4	66.5
29,30	61.9	64.0
31,32	53.1	57.1
33,34	53.2	54.2
35,36	45.8	46.0
37,38	121.0	111.5
39,40	129.3	110.3
41,42	155.2	130.9
43,44	155.8	126.3
45,46	133.8	115.9
47,48	154.8	125.1
49,50	160.8	110.6
51,52	157.4	112.7
53,54	147.0	113.7
55,56	166.1	120.0
57,58	159.7	111.0
59,60	147.5	112.9
61,62	135.1	102.0
63,64	142.3	102.3
65,66	151.1	118.3
67,68	140.7	102.3
69,70	150.5	101.3
71,72	68.9	66.6
73,74	76.1	67.6
75,76	83.3	60.4
77,78	76.9	61.1
79,80	81.0	64.3
81,82	43.4	67.2

Table F10: Diffusion Tube Data for July 2008- Post NOxer Installation

CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	24th June	7th July	21st July
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	76.5	80.7	81.3
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	25.18	26.43	21.43
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	110.9	92.0	111.8
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	100.9	99.8	86.5
Average Diffusion Tube Collocated Concentration Standard ($\mu g/m^3$)	32.84	45.17	29.89
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	104.3	93.8	103.3
Location	**Period Concentration**	**Period Concentration**	**Period Concentration**
7,8	40.3	58.0	47.0
9,10	41.4	57.6	45.2
11,12	38.7	52.6	43.1
13,14	40.4	53.8	43.0
15,16	37.4	46.5	45.1
17,18	35.5	63.5	43.7
19,20	24.3	26.8	31.1
21,22	35.6	41.1	38.7
23,24	45.6	55.9	47.6
25,26	38.3	54.9	45.7
27,28	37.6	56.1	39.8
29,30	33.5	53.9	40.4
31,32	35.6	48.8	39.8
33,34	34.9	50.9	39.3
35,36	29.8	37.2	33.3
37,38	104.8	89.4	97.2
39,40	107.9	93.3	89.0
41,42	124.0	109.0	129.6
43,44	130.5	105.8	130.9
45,46	101.8	90.3	110.1
47,48	116.4	102.0	119.7
49,50	124.4	93.1	128.8
51,52	118.8	107.6	136.5
53,54	103.2	99.8	126.9
55,56	118.1	127.6	139.4
57,58	128.0	111.9	134.3
59,60	112.9	98.6	137.2
61,62	103.3	86.7	119.6
63,64	113.4	95.3	113.2
65,66	128.3	108.5	118.7
67,68	115.4	98.2	119.4
69,70	121.2	105.8	143.9
71,72	46.3	50.2	55.0

73,74	46.5	65.7	57.0
75,76	44.8	65.4	59.5
77,78	43.6	63.5	49.6
79,80	46.1	61.1	52.0
81,82	45.2	65.0	53.2

Table F11: Diffusion Tube Data for August 2008- Post NOxer Installation

Exposure Periods	4th August	15th August
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	139.6	97.5
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	Tubes Lost	Tubes Lost
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	113.5	109.8
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	61.8	85.3
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	60.26	39.11
Average Diffusion Tube CollocatedConcentration Standard ($\mu g/m^3$)	110.7	74.9
Location	**Period Concentration**	**Period Concentration**
7,8	54.1	48.4
9,10	52.7	47.5
11,12	48.8	41.8
13,14	48.9	39.6
15,16	47.2	41.8
17,18	43.0	41.9
19,20	30.8	42.2
21,22	41.9	32.4
23,24	55.6	38.8
25,26	45.9	42.9
27,28	47.8	Tube Missing
29,30	40.9	38.0
31,32	43.4	41.5
33,34	42.7	33.6
35,36	34.6	36.1
37,38	101.2	102.8
39,40	104.6	98.8
41,42	131.6	126.2
43,44	115.3	122.8
45,46	104.1	100.0
47,48	124.2	109.4
49,50	126.7	117.5
51,52	128.6	120.8
53,54	112.3	113.1
55,56	122.1	130.7
57,58	127.0	116.4
59,60	119.2	112.9
61,62	111.1	108.9
63,64	117.3	112.7
65,66	122.9	122.0
67,68	117.7	116.8
69,70	125.9	127.0
71,72	52.1	51.5
73,74	55.5	52.5
75,76	56.5	54.5
77,78	54.3	49.5
79,80	55.7	52.3
81,82	60.8	Tube Missing

Table F12: Diffusion Tube Data for September 2008- Post NOxer Installation

Exposure Periods	**29th September**
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	70.2
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	39.20
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	138.6
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	80.5
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	37.30
Average Diffusion Tube Collocated Concentration Control ($\mu g/m^3$)	140.4
Location	**Period Concentration**
7,8	75.0
9,10	69.0
11,12	61.1
13,14	58.7
15,16	67.8
17,18	51.4
19,20	43.6
21,22	63.0
23,24	77.4
25,26	61.3
27,28	67.0
29,30	59.0
31,32	62.9
33,34	67.0
35,36	52.1
37,38	121.7
39,40	130.3
41,42	164.5
43,44	162.7
45,46	112.1
47,48	140.2
49,50	159.2
51,52	160.0
53,54	135.1
55,56	160.1
57,58	156.4
59,60	151.0
61,62	149.6
63,64	148.5
65,66	156.0
67,68	144.2
69,70	162.0
71,72	78.0
73,74	80.0
75,76	79.7
77,78	74.6
79,80	77.4
81,82	82.3

Notes	The first set of data is not available since the tubes were lost for that period

Table F13: Diffusion Tube Data for October 2008- Post NOxer Installation

Exposure Periods	13th October	27th October
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	71.1	65.9
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	38.75	50.41
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	99.5	103.9
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	87.7	33.7
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	43.49	35.52
Average Diffusion Tube CollocatedConcentration Control ($\mu g/m^3$)	90.8	111.1
Location	**Period Concentration**	**Period Concentration**
7,8	51.6	31.6
9,10	47.1	57.7
11,12	46.5	82.6
13,14	41.1	52.2
15,16	43.3	54.9
17,18	43.4	54.4
19,20	35.8	48.5
21,22	46.8	55.8
23,24	50.2	62.3
25,26	44.1	61.4
27,28	40.9	51.0
29,30	39.9	54.7
31,32	45.1	40.1
33,34	38.9	38.8
35,36	49.8	59.8
37,38	108.4	110.1
39,40	101.9	100.6
41,42	108.8	142.5
43,44	113.8	120.4
45,46	104.1	114.5
47,48	115.5	143.2
49,50	112.7	148.9
51,52	104.2	115.0
53,54	109.5	107.9
55,56	122.2	131.6
57,58	115.1	140.3
59,60	112.7	120.5
61,62	95.4	123.0
63,64	108.0	116.7
65,66	120.2	126.3
67,68	106.1	138.4
69,70	119.3	156.2
71,72	56.1	30.9
73,74	57.5	69.1
75,76	57.8	68.7
77,78	52.8	62.0
79,80	54.5	61.6
81,82	57.5	69.8

Table F14: Diffusion Tube Data for November 2008- Post NOxer Installation

Exposure Periods	17th November	1st December
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	85.3	106.4
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	62.91	86.33
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	113.4	-
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	73.1	64.8
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	56.85	50.96
Average Diffusion Tube CollocatedConcentration Standard ($\mu g/m^3$)	115.2	-
Location	**Period Concentration**	**Period Concentration**
7,8	78.5	Non exposure
9,10	77.3	Non exposure
11,12	68.5	Non exposure
13,14	68.9	Non exposure
15,16	74.2	Non exposure
17,18	69.4	Non exposure
19,20	56.4	Non exposure
21,22	68.3	Non exposure
23,24	78.6	Non exposure
25,26	76.7	Non exposure
27,28	75.7	Non exposure
29,30	68.9	Non exposure
31,32	66.2	Non exposure
33,34	60.4	Non exposure
35,36	75.7	Non exposure
37,38	127.2	Non exposure
39,40	129.8	Non exposure
41,42	151.4	Non exposure
43,44	138.6	Non exposure
45,46	119.4	Non exposure
47,48	136.1	Non exposure
49,50	150.2	Non exposure
51,52	137.0	Non exposure
53,54	113.5	Non exposure
55,56	141.2	Non exposure
57,58	131.6	Non exposure
59,60	136.4	Non exposure
61,62	137.4	Non exposure
63,64	131.6	Non exposure
65,66	151.9	Non exposure
67,68	132.2	Non exposure
69,70	144.5	Non exposure
71,72	73.5	Non exposure
73,74	81.6	Non exposure
75,76	87.5	Non exposure
77,78	76.7	Non exposure
79,80	77.4	Non exposure
81,82	81.0	Non exposure

Table F15: Diffusion Tube Data for December 2008- Post Noxer Installation

Exposure Periods	16^{th} December	6^{th} January
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	74.2	44.0
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	52.07	47.10
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	93.0	-
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	96.1	103.1
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	39.39	37.18
Average Diffusion Tube CollocatedConcentration Standard ($\mu g/m^3$)	101.5	-
Location	**Period Concentration**	**Period Concentration**
7,8	57.1	Data invalid
9,10	53.2	Data invalid
11,12	51.7	Data invalid
13,14	54.6	Data invalid
15,16	54.8	Data invalid
17,18	54.7	Data invalid
19,20	53.1	Data invalid
21,22	57.9	Data invalid
23,24	55.7	Data invalid
25,26	55.1	Data invalid
27,28	52.6	Data invalid
29,30	51.3	Data invalid
31,32	47.1	Data invalid
33,34	42.1	Data invalid
35,36	50.8	Data invalid
37,38	87.6	Data invalid
39,40	87.8	Data invalid
41,42	123.0	Data invalid
43,44	99.8	Data invalid
45,46	103.8	Data invalid
47,48	113.6	Data invalid
49,50	106.5	Data invalid
51,52	120.5	Data invalid
53,54	99.3	Data invalid
55,56	87.4	Data invalid
57,58	100.4	Data invalid
59,60	118.6	Data invalid
61,62	102.9	Data invalid
63,64	117.4	Data invalid
65,66	125.0	Data invalid
67,68	108.4	Data invalid
69,70	126.6	Data invalid
71,72	55.5	Data invalid
73,74	56.8	Data invalid
75,76	50.8	Data invalid
77,78	58.2	Data invalid
79,80	61.7	Data invalid
81,82	57.7	Data invalid

Table F16: Diffusion Tube Data for January 2009- Post NOxer Installation

Exposure Periods	**12th January**
CMS Barrier Face NO_2 NOxer ($\mu g/m^3$)	61.1
CMS Behind Fence NO_2 NOxer ($\mu g/m^3$)	44.20
Average Diffusion Tube Collocated Concentration NOxer ($\mu g/m^3$)	122.3
CMS Barrier Face NO_2 Standard ($\mu g/m^3$)	101.6
CMS Behind Barrier NO_2 Standard ($\mu g/m^3$)	37.88
Average Diffusion Tube Collocated Concentration Standard ($\mu g/m^3$)	123.1
Location	**Period Concentration**
7,8	82.6
9,10	51.4
11,12	54.3
13,14	53.0
15,16	57.5
17,18	49.6
19,20	50.9
21,22	56.1
23,24	56.4
25,26	54.5
27,28	57.1
29,30	50.3
31,32	50.7
33,34	42.2
35,36	56.2
37,38	118.3
39,40	123.5
41,42	153.1
43,44	145.5
45,46	121.2
47,48	132.9
49,50	134.8
51,52	140.3
53,54	134.2
55,56	138.1
57,58	125.7
59,60	139.0
61,62	125.0
63,64	129.8
65,66	130.8
67,68	131.4
69,70	140.7
71,72	56.6
73,74	59.8
75,76	64.3
77,78	55.6
79,80	51.2
81,82	55.6

Appendix G: NOx diffusion tube data

Table G1: Diffusion Tube Data for January 2008 - Pre NOxer Installation

Exposure Periods	08/01/08 – 21/01/08			21/01/08 – 04/02/08		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1	**65.4**	**117.3**	**51.9**	**97.4**	**111.2**	**13.8**
5	**113.7**	**143.8**	**30.1**	**<L.O.D**	**<L.O.D**	**<L.O.D**
7	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
9	**61.2**	**79.0**	**17.8**	**59.8**	**64.2**	**4.4**
11	**<L.O.D**	**<L.O.D**	**<L.O.D**	**57.2**	**64.2**	**7.0**
13	**<L.O.D**	**<L.O.D**	**<L.O.D**	**43.7**	**57.2**	**13.6**
15	**54.3**	**61.6**	**7.3**	**51.5**	**71.4**	**19.9**
17	**48.1**	**52.0**	**3.9**	**48.6**	**54.8**	**6.3**
19	**54.6**	**67.1**	**12.5**	**45.5**	**52.8**	**7.3**
21	**<L.O.D**	**<L.O.D**	**<L.O.D**	**40.0**	**53.1**	**13.1**
23	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
25	**60.7**	**72.2**	**11.6**	**<L.O.D**	**<L.O.D**	**<L.O.D**
27	**<L.O.D**	**<L.O.D**	**<L.O.D**	**104.5**	**126.4**	**21.9**
29	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
31	**41.1**	**64.2**	**23.1**	**45.6**	**61.8**	**16.2**
33	**<L.O.D**	**<L.O.D**	**<L.O.D**	**44.9**	**61.1**	**16.2**
35	**11.4**	**84.5**	**40.1**	**44.4**	**53.6**	**9.1**
37	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
39	**83.8**	**125.5**	**41.8**	**2.2**	**8.4**	**6.2**
41	**103.1**	**113.7**	**10.7**	**<L.O.D**	**<L.O.D**	**<L.O.D**
43	**108.5**	**139.1**	**30.6**	**94.1**	**102.1**	**8.0**
45	**99.9**	**129.3**	**29.4**	**97.2**	**137.7**	**40.5**
47	**<L.O.D**	**<L.O.D**	**<L.O.D**	**105.7**	**121.9**	**16.3**
49	**111.9**	**116.0**	**4.1**	**102.0**	**117.2**	**15.1**
51	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
53	**<L.O.D**	**<L.O.D**	**<L.O.D**	**97.3**	**138.1**	**40.8**
55	**115.1**	**120.4**	**5.3**	**106.6**	**114.7**	**8.1**
57	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
59	**104.2**	**107.4**	**3.2**	**90.2**	**148.8**	**58.6**

Table G2: Diffusion Tube Data for February 2008 - Pre NOxer Installation

Exposure Periods	04/02/08 – 15/02/08			15/02/08 – 29/02/08		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1	**106.7**	**174.6**	**67.9**	**<L.O.D**	**<L.O.D**	**<L.O.D**
5	**64.0**	**127.9**	**64.0**	**<L.O.D**	**<L.O.D**	**<L.O.D**
7	**<L.O.D**	**<L.O.D**	**<L.O.D**	**18.7**	**48.9**	**30.2**
9	**54.1**	**72.2**	**18.2**	**<L.O.D**	**<L.O.D**	**<L.O.D**
11	**51.4**	**85.4**	**34.0**	**59.7**	**112.3**	**52.6**
13	**54.9**	**76.0**	**21.1**	**<L.O.D**	**<L.O.D**	**<L.O.D**
15	**56.0**	**92.1**	**36.1**	**54.9**	**73.5**	**18.6**
17	**61.5**	**115.3**	**53.8**	**57.9**	**61.9**	**4.0**
19	**56.3**	**84.5**	**28.2**	**57.9**	**69.3**	**11.4**
21	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
23	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
25	**<L.O.D**	**<L.O.D**	**<L.O.D**	**56.6**	**71.5**	**14.9**
27	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
29	**<L.O.D**	**<L.O.D**	**<L.O.D**	**44.4**	**61.5**	**17.0**
31	**52.4**	**64.1**	**11.7**	**53.1**	**99.8**	**46.7**
33	**57.1**	**87.2**	**30.1**	**59.6**	**74.1**	**14.6**
35	**49.4**	**89.3**	**39.9**	**41.7**	**59.6**	**17.9**
37	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
39	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
41	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
43	**109.8**	**202.0**	**92.2**	**<L.O.D**	**<L.O.D**	**<L.O.D**
45	**106.4**	**213.9**	**107.6**	**<L.O.D**	**<L.O.D**	**<L.O.D**
47	**121.1**	**143.2**	**22.1**	**<L.O.D**	**<L.O.D**	**<L.O.D**
49	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
51	**128.8**	**113.9**	**5.1**	**<L.O.D**	**<L.O.D**	**<L.O.D**
53	**116.2**	**147.9**	**31.8**	**<L.O.D**	**<L.O.D**	**<L.O.D**
55	**130.2**	**219.6**	**89.4**	**<L.O.D**	**<L.O.D**	**<L.O.D**
57	**126.8**	**210.1**	**83.3**	**<L.O.D**	**<L.O.D**	**<L.O.D**
59	**110.4**	**208.9**	**98.5**	**<L.O.D**	**<L.O.D**	**<L.O.D**

Table G3: Diffusion Tube Data for March 2008 - Pre NOxer Installation

Exposure Periods	29/02/08 – 14/03/08			14/03/08 - 07/04/08		
	NO_2	NOx	NO	NO_2	NOx	NO
Location				Data missing from records		
1	**<L.O.D**	**<L.O.D**	**<L.O.D**			
5	**<L.O.D**	**<L.O.D**	**<L.O.D**			
7	**<L.O.D**	**<L.O.D**	**<L.O.D**			
9	**82.1**	**96.5**	**14.4**			
11	**76.7**	**106.9**	**30.2**			
13	**<L.O.D**	**<L.O.D**	**<L.O.D**			
15	**55.1**	**75.3**	**20.3**			
17	**<L.O.D**	**<L.O.D**	**<L.O.D**			
19	**<L.O.D**	**<L.O.D**	**<L.O.D**			
21	**43.7**	**59.2**	**15.6**			
23	**<L.O.D**	**<L.O.D**	**<L.O.D**			
25	**91.5**	**95.4**	**3.8**			
27	**<L.O.D**	**<L.O.D**	**<L.O.D**			
29	**72.7**	**101.7**	**29.0**			
31	**53.0**	**83.7**	**30.7**			
33	**65.0**	**79.2**	**14.2**			
35	**<L.O.D**	**<L.O.D**	**<L.O.D**			
37	**<L.O.D**	**<L.O.D**	**<L.O.D**			
39	**<L.O.D**	**<L.O.D**	**<L.O.D**			
41	**<L.O.D**	**<L.O.D**	**<L.O.D**			
43	**<L.O.D**	**<L.O.D**	**<L.O.D**			
45	**<L.O.D**	**<L.O.D**	**<L.O.D**			
47	**<L.O.D**	**<L.O.D**	**<L.O.D**			
49	**<L.O.D**	**<L.O.D**	**<L.O.D**			
51	**<L.O.D**	**<L.O.D**	**<L.O.D**			
53	**<L.O.D**	**<L.O.D**	**<L.O.D**			
55	**<L.O.D**	**<L.O.D**	**<L.O.D**			
57	**<L.O.D**	**<L.O.D**	**<L.O.D**			
59	**<L.O.D**	**<L.O.D**	**<L.O.D**			

Table G4: Diffusion Tube Data for April 2008 - Pre NOxer Installation

Exposure Periods	07/04/08 – 11/04/08			11/04/08 – 29/04/08		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
5	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
7	**60.0**	**95.4**	**35.4**	**38.1**	**47.5**	**9.4**
9	**65.0**	**110.2**	**45.2**	**34.7**	**50.1**	**15.4**
11	**57.2**	**125.8**	**68.7**	**<L.O.D**	**<L.O.D**	**<L.O.D**
13	**69.5**	**99.1**	**29.6**	**39.3**	**53.5**	**14.3**
15	**56.8**	**94.6**	**37.8**	**37.9**	**49.6**	**11.8**
17	**60.9**	**81.0**	**20.2**	**33.3**	**49.3**	**16.0**
19	**52.6**	**93.4**	**40.7**	**35.2**	**41.8**	**6.6**
21	**48.1**	**106.1**	**58.0**	**30.7**	**38.4**	**7.7**
23	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
25	**64.2**	**144.3**	**80.2**	**40.7**	**62.4**	**21.7**
27	**59.6**	**98.3**	**38.7**	**39.3**	**57.3**	**18.0**
29	**56.3**	**94.2**	**37.8**	**33.7**	**49.6**	**15.9**
31	**49.4**	**84.7**	**35.4**	**34.2**	**52.0**	**17.7**
33	**60.0**	**116.0**	**55.9**	**36.8**	**42.5**	**5.7**
35	**44.8**	**71.6**	**26.7**	**31.6**	**42.1**	**10.5**
37	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
39	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
41	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
43	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
45	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
47	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
49	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
51	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
53	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
55	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
57	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**
59	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**	**<L.O.D**

Table G5: Diffusion Tube Data for May 2008 - Post NOxer Installation

Exposure Periods	29/04/08 – 12/05/08			12/05/08 – 27/05/08		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1	**127.9**	**190.0**	**62.1**	**<L.O.D**	**<L.O.D**	**<L.O.D**
5	**129.1**	**224.7**	**95.7**	**<L.O.D**	**<L.O.D**	**<L.O.D**
7	**54.4**	**63.3**	**8.9**	**<L.O.D**	**<L.O.D**	**<L.O.D**
9	**46.8**	**66.5**	**19.7**	**20.4**	**28.1**	**7.7**
11	**47.7**	**66.5**	**17.9**	**22.4**	**25.2**	**3.9**
13	**<L.O.D**	**46.4**	**46.4**	**<L.O.D**	**<L.O.D**	**<L.O.D**
15	**148.7**	**184.0**	**35.3**	**18.5**	**22.5**	**4.0**
17	**44.9**	**47.4**	**2.5**	**19.9**	**24.2**	**4.3**
19	**119.0**	**175.6**	**56.6**	**16.7**	**20.2**	**3.6**
21	**47.1**	**47.3**	**0.2**	**20.1**	**24.4**	**4.3**
23	**54.2**	**74.0**	**19.8**	**21.7**	**35.2**	**13.5**
25	**48.5**	**68.2**	**19.7**	**28.1**	**36.2**	**8.1**
27	**45.2**	**64.0**	**18.7**	**21.8**	**30.1**	**8.3**
29	**42.0**	**53.7**	**11.8**	**20.6**	**27.9**	**7.3**
31	**39.4**	**53.7**	**14.3**	**0.4**	**23.8**	**23.4**
33	**44.8**	**48.3**	**3.5**	**25.9**	**27.2**	**1.3**
35	**37.7**	**45.9**	**8.2**	**21.2**	**26.8**	**5.6**
37	**105.8**	**175.2**	**69.4**	**75.7**	**87.2**	**11.5**
39	**118.1**	**158.2**	**40.0**	**76.9**	**77.5**	**0.6**
41	**134.2**	**178.4**	**44.2**	**101.1**	**138.3**	**37.2**
43	**147.2**	**192.4**	**45.2**	**74.4**	**155.5**	**81.1**
45	**111.9**	**172.3**	**60.4**	**104.6**	**142.4**	**38.3**
47	**137.2**	**181.9**	**44.7**	**114.6**	**166.3**	**51.7**
49	**141.3**	**210.6**	**69.3**	**<L.O.D**	**<L.O.D**	**<L.O.D**
51	**49.1**	**59.8**	**10.7**	**115.1**	**134.4**	**19.3**
53	**140.0**	**184.4**	**44.5**	**<L.O.D**	**<L.O.D**	**<L.O.D**
55	**152.0**	**198.5**	**46.5**	**129.9**	**171.0**	**41.1**
57	**141.8**	**116.1**	**<L.O.D**	**120.7**	**202.2**	**81.5**
59	**141.0**	**188.1**	**47.0**	**<L.O.D**	**<L.O.D**	**<L.O.D**
61	**40.8**	**45.1**	**4.2**	**113.7**	**177.6**	**63.9**
63	**129.2**	**218.6**	**89.4**	**117.5**	**144.7**	**27.3**
65	**142.3**	**172.9**	**30.7**	**122.7**	**169.0**	**46.3**
67	**140.2**	**192.3**	**52.1**	**<L.O.D**	**<L.O.D**	**<L.O.D**
69	**156.3**	**175.6**	**19.3**	**125.9**	**128.3**	**2.4**
71	**56.2**	**79.6**	**23.4**	**36.0**	**43.9**	**7.9**
73	**53.0**	**68.6**	**15.3**	**39.2**	**47.1**	**8.0**
75	**59.2**	**73.0**	**13.8**	**34.0**	**53.0**	**19.0**
77	**48.4**	**72.6**	**24.1**	**24.8**	**35.9**	**11.0**
79	**55.4**	**72.9**	**17.5**	**34.8**	**40.3**	**5.5**
81	**63.0**	**83.6**	**20.6**	**35.3**	**45.5**	**10.2**

Table G6: Diffusion Tube Data for June 2008 - Post NOxer Installation

Exposure Periods	27/05/08 – 09/06/08			09/06/08 – 24/06/08		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1	**37.9**	**77.0**	**39.1**	**89.9**	**102.7**	**12.9**
5	**<L.O.D**	**<L.O.D**	**<L.O.D**	**27.2**	**<L.O.D**	**<L.O.D**
7	**60.9**	**66.8**	**5.8**	**63.7**	**115.3**	**51.6**
9	**60.2**	**87.5**	**27.3**	**53.5**	**64.8**	**11.3**
11	**54.9**	**100.2**	**45.3**	**54.3**	**94.5**	**40.2**
13	**<L.O.D**	**<L.O.D**	**<L.O.D**	**51.9**	**91.5**	**39.6**
15	**56.6**	**78.2**	**21.6**	**54.3**	**71.3**	**17.0**
17	**50.3**	**55.6**	**5.4**	**47.4**	**77.0**	**29.6**
19	**34.3**	**49.6**	**15.3**	**24.1**	**37.1**	**13.0**
21	**43.9**	**60.9**	**16.9**	**36.0**	**75.8**	**39.8**
23	**59.3**	**67.5**	**8.3**	**57.2**	**57.1**	**<L.O.D**
25	**21.7**	**82.0**	**60.2**	**59.4**	**55.1**	**<L.O.D**
27	**54.9**	**77.5**	**22.6**	**53.1**	**<L.O.D**	**<L.O.D**
29	**50.5**	**84.7**	**34.2**	**53.3**	**65.3**	**12.1**
31	**72.6**	**76.9**	**4.4**	**48.6**	**64.1**	**15.5**
33	**53.1**	**88.2**	**35.2**	**47.9**	**49.2**	**1.2**
35	**44.6**	**46.6**	**2.1**	**39.8**	**48.4**	**8.5**
37	**118.1**	**179.0**	**60.9**	**104.9**	**95.0**	**<L.O.D**
39	**116.0**	**249.4**	**133.4**	**82.9**	**73.2**	**<L.O.D**
41	**123.3**	**219.5**	**96.2**	**101.8**	**216.0**	**114.1**
43	**140.8**	**255.1**	**114.3**	**107.9**	**88.2**	**<L.O.D**
45	**119.0**	**239.4**	**120.4**	**95.9**	**150.1**	**54.2**
47	**<L.O.D**	**<L.O.D**	**<L.O.D**	**104.8**	**203.9**	**99.1**
49	**<L.O.D**	**<L.O.D**	**<L.O.D**	**105.5**	**170.8**	**65.3**
51	**124.4**	**265.1**	**140.7**	**92.7**	**231.5**	**138.8**
53	**123.3**	**123.9**	**0.6**	**110.0**	**209.6**	**99.6**
55	**144.2**	**191.0**	**46.8**	**106.2**	**155.7**	**49.5**
57	**134.2**	**223.5**	**89.3**	**107.7**	**187.4**	**79.7**
59	**<L.O.D**	**<L.O.D**	**<L.O.D**	**91.9**	**148.8**	**56.9**
61	**114.8**	**148.1**	**33.3**	**92.5**	**139.7**	**44.2**
63	**137.6**	**191.3**	**53.7**	**98.4**	**72.2**	**<L.O.D**
65	**129.6**	**245.8**	**116.3**	**106.5**	**81.2**	**<L.O.D**
67	**119.5**	**218.0**	**98.5**	**91.8**	**162.7**	**70.9**
69	**127.5**	**142.8**	**15.2**	**107.8**	**248.2**	**140.4**
71	**61.1**	**<L.O.D**	**<L.O.D**	**63.7**	**108.7**	**45.0**
73	**59.7**	**<L.O.D**	**<L.O.D**	**49.4**	**85.6**	**36.2**
75	**69.3**	**76.7**	**7.4**	**57.7**	**71.3**	**13.6**
77	**52.7**	**106.4**	**53.7**	**58.9**	**105.1**	**46.3**
79	**64.6**	**136.6**	**72.1**	**58.4**	**106.2**	**47.9**
81	**55.8**	**140.4**	**84.6**	**58.3**	**145.2**	**86.9**

Table G7: Diffusion Tube Data for July 2008 - Post NOxer Installation

Exposure Periods	24/06/08 – 07/07/08			07/07/08 – 21/07/08			21/07/08 – 04/08/08		
	NO_2	NOx	NO	NO_2	NOx	NO	NO_2	NOx	NO
Location									
1	106.4	152.3	45.9	102.1	124.1	22.0	116.3	202.1	85.8
5	109.0	215.1	106.1	83.3	98.9	15.6	109.9	175.6	65.7
7	41.5	75.0	33.6	60.0	71.6	11.7	43.4	75.1	31.7
9	38.6	72.6	33.9	55.6	83.4	27.8	44.9	61.9	17.0
11	38.1	67.3	29.2	52.2	70.1	17.9	40.5	65.3	24.8
13	34.5	55.1	20.6	42.1	58.8	16.8	37.5	63.7	26.1
15	35.7	42.5	6.8	48.5	63.8	15.3	39.3	50.6	11.2
17	42.1	44.0	1.9	<L.O.D	<L.O.D	<L.O.D	38.3	52.5	14.3
19	25.4	31.7	6.3	28.5	41.2	12.7	26.3	39.3	13.0
21	32.8	43.7	10.9	36.2	57.1	20.9	<L.O.D	<L.O.D	<L.O.D
23	<L.O.D	<L.O.D	<L.O.D	56.0	99.2	43.2	47.3	70.6	23.3
25	38.7	50.8	12.1	52.7	94.0	41.4	40.8	67.9	27.1
27	38.0	64.4	26.4	51.7	56.6	4.9	42.0	67.9	26.0
29	36.0	54.3	18.4	45.9	67.3	21.4	36.8	54.3	17.6
31	33.2	55.5	22.3	49.2	94.1	44.9	8.4	68.9	60.5
33	38.8	65.5	26.7	<L.O.D	<L.O.D	<L.O.D	30.2	56.8	26.6
35	30.1	46.2	16.1	38.7	61.3	22.6	39.7	56.1	16.4
37	104.0	192.7	88.7	90.5	166.4	75.9	91.6	180.0	88.4
39	105.1	243.3	138.1	90.2	169.9	79.7	103.0	171.5	68.5
41	125.1	188.8	63.7	94.4	141.8	47.3	115.9	227.9	112.0
43	126.3	238.2	111.9	103.3	145.4	42.1	118.2	243.6	125.4
45	108.0	170.6	62.6	87.9	123.4	35.5	108.2	190.0	81.8
47	111.7	176.1	64.4	94.6	123.8	29.2	115.6	216.5	100.8
49	120.5	194.2	73.8	67.9	159.4	91.5	121.6	231.3	109.8
51	112.5	183.7	71.2	101.2	113.0	11.9	122.9	246.6	123.8
53	112.7	140.4	27.7	93.4	98.5	5.1	108.4	192.8	84.4
55	122.0	220.7	98.8	103.2	177.4	74.2	127.3	239.5	112.2
57	119.1	160.1	41.0	104.2	159.5	55.3	133.4	244.5	111.1
59	122.6	244.9	122.3	98.1	173.4	75.3	123.7	212.9	89.2
61	104.6	178.4	73.8	86.2	102.2	16.0	105.4	184.4	79.0
63	74.7	196.2	121.5	96.5	150.2	53.7	117.8	163.0	45.2
65	120.5	198.5	78.0	102.4	119.1	16.6	125.7	206.8	81.1
67	107.3	183.0	75.7	93.9	141.0	47.1	120.9	236.7	115.8
69	117.7	201.0	83.3	98.6	101.0	2.4	120.2	196.8	76.6
71	35.2	51.1	15.9	57.0	98.5	41.6	50.3	89.4	39.0
73	44.3	68.5	24.3	61.3	75.8	14.5	51.2	90.7	39.5
75	46.2	74.9	28.7	61.1	95.9	34.8	52.8	99.3	46.6
77	39.6	72.3	32.6	<L.O.D	<L.O.D	<L.O.D	46.2	79.0	32.8
79	44.5	65.8	21.4	58.3	91.8	33.5	47.5	80.6	33.1
81	45.7	71.6	25.8	<L.O.D	<L.O.D	<L.O.D	49.5	86.3	36.9

Table G8: Diffusion Tube Data for August 2008 - Post NOxer Installation

Exposure Periods	04/08/08 – 15/08/08			15/08/08 – 10/09/08		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1	**103.9**	**224.2**	**120.3**	**67.0**	**145.6**	**78.6**
5	**103.7**	**203.0**	**99.3**	**74.5**	**176.8**	**102.3**
7	**52.2**	**84.2**	**31.9**	**41.6**	**18.7**	**<L.O.D**
9	**47.7**	**87.3**	**39.6**	**38.0**	**63.2**	**25.2**
11	**48.1**	**72.0**	**23.9**	**37.3**	**54.1**	**16.8**
13	**45.0**	**88.8**	**43.8**	**38.4**	**56.8**	**18.4**
15	**42.0**	**73.7**	**31.7**	**39.7**	**60.7**	**20.9**
17	**<L.O.D**	**<L.O.D**	**<L.O.D**	**54.7**	**44.7**	**<L.O.D**
19	**40.7**	**54.0**	**13.3**	**26.5**	**40.9**	**14.4**
21	**31.4**	**45.4**	**13.9**	**34.3**	**39.5**	**5.2**
23	**49.7**	**97.0**	**47.3**	**30.4**	**36.5**	**6.1**
25	**46.5**	**89.0**	**42.5**	**40.0**	**30.3**	**<L.O.D**
27	**44.8**	**78.4**	**33.6**	**<L.O.D**	**<L.O.D**	**<L.O.D**
29	**42.6**	**69.7**	**27.1**	**32.6**	**54.9**	**22.3**
31	**42.4**	**72.4**	**30.0**	**33.2**	**50.1**	**16.9**
33	**47.0**	**88.4**	**41.4**	**40.0**	**46.8**	**6.8**
35	**37.9**	**54.9**	**17.0**	**28.8**	**36.5**	**7.7**
37	**106.7**	**137.5**	**30.8**	**80.6**	**144.9**	**64.3**
39	**99.9**	**89.1**	**<L.O.D**	**82.6**	**185.8**	**103.2**
41	**128.3**	**215.7**	**87.4**	**101.7**	**181.9**	**80.2**
43	**116.7**	**229.6**	**112.9**	**98.0**	**107.8**	**9.8**
45	**103.3**	**220.6**	**117.3**	**76.6**	**196.8**	**120.2**
47	**112.7**	**89.9**	**<L.O.D**	**99.3**	**128.8**	**29.5**
49	**111.0**	**212.3**	**101.2**	**96.1**	**136.6**	**40.5**
51	**116.5**	**175.9**	**59.4**	**96.9**	**158.8**	**61.9**
53	**106.4**	**235.3**	**128.9**	**92.3**	**210.1**	**117.8**
55	**<L.O.D**	**224.9**	**224.9**	**101.0**	**168.2**	**67.1**
57	**116.0**	**192.0**	**76.0**	**94.7**	**167.4**	**72.6**
59	**113.6**	**201.6**	**88.0**	**100.1**	**146.2**	**46.1**
61	**103.0**	**204.0**	**101.0**	**88.5**	**105.5**	**17.1**
63	**113.8**	**240.2**	**126.4**	**91.3**	**186.2**	**94.8**
65	**122.9**	**132.4**	**9.5**	**100.3**	**189.9**	**89.6**
67	**109.4**	**252.4**	**142.9**	**96.2**	**189.3**	**93.1**
69	**113.4**	**234.5**	**121.1**	**94.2**	**168.7**	**74.6**
71	**51.4**	**113.9**	**62.5**	**45.7**	**91.0**	**45.3**
73	**53.5**	**95.8**	**42.3**	**41.5**	**28.9**	**<L.O.D**
75	**58.8**	**73.8**	**15.1**	**44.2**	**98.6**	**54.4**
77	**51.0**	**108.1**	**57.1**	**43.4**	**69.4**	**26.0**
79	**53.6**	**96.1**	**42.5**	**42.2**	**62.5**	**20.4**
81	**55.7**	**104.4**	**48.8**	**48.8**	**73.4**	**24.6**

Table G9: Diffusion Tube Data for September 2008 - Post NOxer Installation

Exposure Periods	10/09/08 – 29/09/08			29/09/08 – 13/10/08		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1				**121.9**	**203.5**	**81.6**
5				**114.3**	**221.4**	**107.1**
7				**<L.O.D**	**<L.O.D**	**<L.O.D**
9				**54.7**	**105.7**	**51.0**
11				**61.0**	**116.1**	**55.0**
13				**<L.O.D**	**<L.O.D**	**<L.O.D**
15				**54.2**	**106.2**	**52.0**
17				**51.9**	**84.9**	**33.0**
19				**38.3**	**86.0**	**47.8**
21				**60.1**	**64.2**	**4.1**
23				**<L.O.D**	**<L.O.D**	**<L.O.D**
25				**50.5**	**79.8**	**29.3**
27				**59.1**	**124.8**	**65.7**
29				**56.1**	**104.2**	**48.0**
31				**50.6**	**66.8**	**16.2**
33				**48.7**	**82.4**	**33.7**
35				**64.1**	**99.2**	**35.1**
37				**<L.O.D**	**<L.O.D**	**<L.O.D**
39				**120.2**	**249.1**	**128.8**
41		Tubes lost in transit		**<L.O.D**	**<L.O.D**	**<L.O.D**
43				**164.2**	**169.6**	**5.4**
45				**123.9**	**131.0**	**7.1**
47				**<L.O.D**	**<L.O.D**	**<L.O.D**
49				**134.5**	**159.3**	**24.8**
51				**<L.O.D**	**<L.O.D**	**<L.O.D**
53				**133.1**	**243.1**	**110.0**
55				**149.3**	**154.3**	**5.0**
57				**<L.O.D**	**<L.O.D**	**<L.O.D**
59				**138.8**	**145.2**	**6.4**
61				**127.5**	**178.1**	**50.5**
63				**124.6**	**176.6**	**52.1**
65				**<L.O.D**	**<L.O.D**	**<L.O.D**
67				**130.9**	**145.8**	**14.9**
69				**138.8**	**152.0**	**13.1**
71				**63.8**	**134.9**	**71.1**
73				**68.7**	**101.1**	**32.5**
75				**83.5**	**148.4**	**64.9**
77				**63.9**	**113.7**	**49.8**
79				**<L.O.D**	**<L.O.D**	**<L.O.D**
81				**71.3**	**74.4**	**3.1**

Table G10: Diffusion Tube Data for October 2008 - Post NOxer Installation

Exposure Periods	13/10/08 – 27/10/08		
	NO_2	NOx	NO
Location			
1	**87.9**	**124.2**	**36.2**
5	**81.8**	**146.1**	**64.3**
7	**44.5**	**100.2**	**55.7**
9	**44.5**	**90.4**	**45.9**
11	**42.1**	**75.1**	**33.1**
13	**40.2**	**48.0**	**7.2**
15	**41.8**	**56.7**	**14.9**
17	**35.8**	**52.1**	**16.4**
19	**28.4**	**56.1**	**27.6**
21	**39.8**	**81.9**	**42.2**
23	**47.5**	**84.7**	**37.2**
25	**36.9**	**66.1**	**29.2**
27	**38.7**	**49.1**	**10.4**
29	**34.5**	**77.8**	**43.2**
31	**37.9**	**83.4**	**45.6**
33	**33.7**	**65.0**	**31.3**
35	**42.0**	**60.3**	**18.3**
37	**94.5**	**148.3**	**53.8**
39	**87.8**	**148.8**	**61.1**
41	**<L.O.D**	**<L.O.D**	**<L.O.D**
43	**88.3**	**129.2**	**40.9**
45	**<L.O.D**	**<L.O.D**	**<L.O.D**
47	**88.0**	**104.5**	**16.6**
49	**98.2**	**109.9**	**11.7**
51	**87.5**	**141.8**	**54.3**
53	**91.5**	**168.0**	**76.5**
55	**98.3**	**128.1**	**29.8**
57	**109.6**	**177.4**	**67.8**
59	**89.8**	**135.7**	**46.0**
61	**79.5**	**155.2**	**75.7**
63	**100.7**	**127.2**	**26.4**
65	**101.7**	**192.4**	**90.8**
67	**98.1**	**192.2**	**94.1**
69	**95.7**	**115.3**	**19.6**
71	**50.1**	**94.4**	**44.3**
73	**47.5**	**99.2**	**51.7**
75	**52.5**	**91.2**	**38.8**
77	**<L.O.D**	**<L.O.D**	**<L.O.D**
79	**46.3**	**109.3**	**63.0**
81	**51.7**	**99.4**	**47.7**

Table G11: Diffusion Tube Data for November 2008 - Post NOxer Installation

Exposure Periods	27/10/08 – 17/11/08			17/11/08 – 01/12/08		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1	**108.0**	**139.4**	**31.4**	**115.9**	**116.2**	**0.4**
5	**99.6**	**54.0**	**<L.O.D**	**95.1**	**139.3**	**44.2**
7	**46.2**	**59.3**	**13.1**	**61.7**	**70.1**	**8.4**
9	**46.3**	**68.5**	**22.3**	**65.6**	**42.1**	**<L.O.D**
11	**42.3**	**15.9**	**<L.O.D**	**58.5**	**65.6**	**7.2**
13	**42.7**	**44.2**	**1.5**	**43.0**	**96.5**	**53.6**
15	**48.6**	**56.0**	**7.4**	**59.2**	**70.4**	**11.1**
17	**41.3**	**29.7**	**<L.O.D**	**51.6**	**42.4**	**<L.O.D**
19	**31.9**	**49.6**	**17.7**	**44.5**	**46.9**	**2.5**
21	**42.3**	**63.1**	**20.8**	**52.2**	**87.3**	**35.2**
23	**47.3**	**67.8**	**20.6**	**61.1**	**93.7**	**32.5**
25	**47.3**	**78.9**	**31.6**	**65.9**	**56.5**	**<L.O.D**
27	**45.3**	**69.7**	**24.4**	**64.1**	**111.8**	**47.7**
29	**43.6**	**41.7**	**<L.O.D**	**55.4**	**102.5**	**47.2**
31	**36.4**	**63.7**	**27.3**	**53.2**	**84.1**	**30.9**
33	**34.0**	**57.0**	**23.0**	**42.2**	**60.8**	**18.5**
35	**38.9**	**62.7**	**23.8**	**58.2**	**95.6**	**37.4**
37	**83.6**	**83.2**	**<L.O.D**	**97.9**	**164.1**	**66.2**
39	**87.9**	**146.6**	**58.7**	**99.8**	**156.6**	**56.9**
41	**100.6**	**220.4**	**119.8**	**111.4**	**156.0**	**44.6**
43	**94.8**	**132.4**	**37.6**	**111.5**	**151.5**	**40.0**
45	**88.9**	**100.3**	**11.4**	**103.6**	**130.1**	**26.6**
47	**99.8**	**200.8**	**101.0**	**112.7**	**48.6**	**<L.O.D**
49	**106.4**	**124.6**	**18.2**	**115.5**	**140.8**	**25.3**
51	**101.1**	**127.8**	**26.7**	**98.0**	**213.5**	**115.5**
53	**97.1**	**150.1**	**53.0**	**98.9**	**191.4**	**92.6**
55	**106.8**	**134.9**	**28.0**	**114.4**	**150.3**	**35.9**
57	**108.1**	**164.9**	**56.8**	**103.9**	**200.9**	**97.0**
59	**112.7**	**158.8**	**46.1**	**109.3**	**181.2**	**71.9**
61	**88.1**	**155.3**	**67.2**	**98.8**	**168.6**	**69.8**
63	**94.0**	**175.3**	**81.3**	**109.6**	**116.1**	**6.4**
65	**117.1**	**115.4**	**<L.O.D**	**107.5**	**212.2**	**104.7**
67	**104.8**	**179.4**	**74.6**	**113.1**	**182.4**	**69.3**
69	**113.8**	**166.6**	**52.8**	**94.5**	**212.8**	**118.2**
71	**50.3**	**64.1**	**13.8**	**65.9**	**103.5**	**37.7**
73	**54.8**	**99.2**	**44.4**	**66.5**	**33.5**	**<L.O.D**
75	**54.0**	**58.4**	**4.4**	**67.2**	**99.1**	**31.8**
77	**45.3**	**46.4**	**1.1**	**62.8**	**112.8**	**50.0**
79	**49.8**	**30.5**	**<L.O.D**	**63.9**	**87.8**	**23.9**
81	**50.0**	**41.7**	**<L.O.D**	**67.0**	**82.1**	**15.1**

Table G12: Diffusion Tube Data for December 2008 - Post NOxer Installation

Exposure Periods	01/12/08 – 16/12/08			16/12/08 – 06/01/09		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1				105.2	130.9	25.7
5				93.7	174.2	80.4
7				48.0	81.7	33.7
9				45.6	85.5	39.8
11				40.9	75.3	34.3
13				43.6	95.7	52.1
15				48.9	42.7	<L.O.D
17				50.0	50.1	0.1
19				46.0	50.1	4.0
21				48.0	45.6	<L.O.D
23				51.4	75.0	23.7
25				46.3	52.1	5.8
27				48.0	48.0	<L.O.D
29				41.7	49.5	7.9
31				40.3	51.0	10.8
33				35.0	40.8	5.8
35				49.6	55.5	5.9
37				90.9	158.8	67.9
39	Tubes left unexposed in error by			87.5	82.1	<L.O.D
41	subcontractor for this period			111.6	159.3	47.7
43				99.6	93.9	<L.O.D
45				85.8	147.7	61.9
47				88.1	113.0	25.0
49				105.0	209.2	104.2
51				102.9	223.0	120.0
53				97.7	110.3	12.6
55				91.3	182.2	90.9
57				112.6	94.7	<L.O.D
59				107.2	110.7	3.5
61				90.8	87.4	<L.O.D
63				92.2	101.3	9.1
65				105.7	112.7	7.0
67				96.3	170.8	74.6
69				113.2	108.9	<L.O.D
71				52.5	74.2	21.6
73				51.9	51.6	<L.O.D
75				51.8	63.9	12.1
77				51.9	44.5	<L.O.D
79				53.7	59.3	5.5
81				53.8	67.1	13.3

Table G13: Diffusion Tube Data for January 2009 - Post NOxer Installation

Exposure Periods	06/01/09 – 12/01/09			12/01/09 – 26/01/09		
	NO_2	NOx	NO	NO_2	NOx	NO
Location						
1	500.9	479.6	<L.O.D	42.1	61.2	19.1
5	473.0	456.3	<L.O.D	111.1	222.0	111.0
7	226.5	314.6	88.1	54.7	87.2	32.5
9	230.6	189.9	<L.O.D	45.5	106.3	60.8
11	217.7	234.1	16.4	46.9	75.2	28.3
13	21.0	238.9	29.4	45.8	75.9	30.1
15	228.9	256.3	27.4	49.3	81.0	31.7
17	225.8	225.7	<L.O.D	50.9	84.3	33.4
19	214.2	215.7	1.5	46.4	71.0	24.6
21	248.6	177.7	<L.O.D	46.7	76.7	30.0
23	237.4	310.8	73.5	58.2	90.4	32.1
25	228.1	158.2	<L.O.D	49.8	83.8	34.1
27	210.5	253.9	43.3	53.0	80.2	27.2
29	207.9	215.3	7.5	47.8	75.4	27.6
31	221.2	288.9	67.7	50.3	91.0	40.8
33	169.6	334.8	165.2	108.0	190.5	82.5
35	239.5	326.9	87.5	53.2	87.3	34.1
37	424.2	528.3	104.2	120.5	191.5	71.0
39	506.9	651.5	144.6	117.0	211.7	94.7
41	514.9	657.7	142.8	129.9	188.1	58.2
43	473.3	615.7	142.5	141.0	225.7	84.7
45	483.5	374.7	<L.O.D	107.9	217.9	110.0
47	521.3	498.7	<L.O.D	117.1	238.5	121.4
49	545.4	507.1	<L.O.D	119.2	243.0	123.8
51	510.7	648.5	137.9	129.2	226.4	97.2
53	448.6	885.0	436.4	114.9	228.2	113.3
55	511.2	390.0	<L.O.D	122.6	242.6	120.0
57	499.8	269.4	<L.O.D	136.5	231.0	94.5
59	534.1	809.3	275.2	128.2	247.9	119.7
61	476.5	489.3	12.8	112.8	223.8	111.0
63	464.9	353.1	<L.O.D	119.7	236.7	117.0
65	493.8	685.6	191.9	121.5	219.4	97.9
67	505.9	493.8	<L.O.D	120.7	221.8	101.2
69	573.0	749.0	176.1	140.9	252.3	111.4
71	259.1	226.3	<L.O.D	60.5	110.9	50.4
73	255.7	305.2	49.5	58.1	123.0	64.9
75	266.1	267.7	1.6	59.4	109.7	50.4
77	224.7	332.9	108.3	46.4	89.0	42.6
79	253.1	272.1	19.0	53.7	96.2	42.6
81	265.0	236.7	<L.O.D	55.1	88.4	33.3

Appendix H: Runoff Data

All results are nitrates as NO_3 mg/l

	July			August	September	October		November	Nov/Dec
Site	**24/06 to 07/07**	**07/07 to 21/07**	**21/07 to 04/08**	**04/08 to 15/08**	**25/09 to 10/10**	**29/09 to 13/10**	**13/10 to 27/10**	**27/10 to 15/11**	**15/11 to 16/12**
Standard Barrier Water Only	<0.5	1.9	2.5	<5.0	<5	0.4	0.8	<5.0	5.3
Standard Barrier with Bleach	<0.5	<20	4.1	0.4	3.4	<2.0	2.3	<5.0	<5.0
Noxer Barrier Water Only		1.7	3.9	<5.0	8.5	3.6	10	<5.0	<5.0
Noxer Barrier with Bleach		<20	11.0	7.2		4.4	10	<5.0	<5.0

IS = Insufficient Sample

Appendix I: Periods of Consistent Performance

Table I1- Periods of consistent performance (concentrations lower at NOxer© barrier)

Period	NOxer© NO_2 conc. minus Standard NO_2 conc. ($\mu g/m^3$)	Wind direction (°)	Wind speed (m/s)	Solar radiation (W/m^2)	Temperature (°C)	Rainfall (mm/hr)	Length of period (hr)	Episode consistency (% +ve Δ))
01/06/08 – 01/07/08	-36.3	203.3	4.1	61.5	14.0	0.072	785	98.47
09/07/08 – 23/07/08	-23.9	243.7	4.0	45.9	14.9	0.167	337	98.52
04/09/08 – 14/09/08	-24.2	191.6	3.5	30.4	14.3	0.200	230	97.83
27/09/08 – 05/10/08	-12.6	236.2	4.4	33.8	10.0	0.419	195	95.90
09/10/08 – 28/10/08	-16.6	209.3	4.8	19.3	10.8	0.185	449	97.33
15/12/08 – 25/12/08	-33.5	180.9	4.0	6.1	7.3	0.081	234	96.15
02/01/09 – 28/01/09	-40.8	158.3	4.3	9.7	3.4	0.092	628	96.66
02/02/09 – 13/02/09	-27.5	181.2	3.2	18.2	1.0	0.026	254	95.67

Table I2 - Periods of inconsistent performance

Period	NOxer© NO_2 conc. minus Standard NO_2 conc. (µg/m^3)	Wind direction (°)	Wind speed (m/s)	Solar radiation (W/m^2)	Temperature (°C)	Rainfall (mm/hr)	Length of period (hr)	Episode consistency (% +ve ∆))
29/04/08 – 01/06/08	-2.1	106.3	4.2	60.5	13.4	0.057	797	37.64
04/07/08 – 09/07/08	-2.6	174.0	4.3	51.5	14.4	0.190	124	61.29
23/07/08 – 04/08/08	-0.4	171.3	3.9	52.5	18.6	0.082	282	47.16
14/09/08 – 27/09/08	-1.4	117.3	2.6	40.4	13.4	0.005	310	57.42
05/10/08 – 09/10/08	-1.9	171.1	4.1	32.2	10.2	0.082	98	59.18
28/10/08 – 15/12/08	**31.1**	**182.8**	**3.9**	**10.3**	**5.0**	**0.094**	**1166**	**14.32**
25/12/08 – 02/01/09	-8.4	70.5	2.5	9.5	0.4	0.000	202	61.88
29/01/09 – 02/02/09	-1.9	108.7	5.8	11.2	2.8	0.010	116	64.66

Table I3 - Summary of average conditions over consistent and inconsistent periods

Period	NOxer© NO_2 conc. minus Standard NO_2 conc. ($\mu g/m^3$)	Wind direction (°)	Wind speed (m/s)	Solar radiation (W/m^2)	Temperature (°C)	Rainfall (mm/hr)
Consistent	-29.6	197.3	4.1	31.5	9.7	0.131
Inconsistent	9.7	144.7	3.9	32.5	9.4	0.069