

NZ Transport Agency Johnstone's Hill Tunnels



Continuous Air Quality Monitoring Report 30 March to 13 July 2010

Prepared for
NZ Transport Agency
By



Laboratory Services
Air Quality Department

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1 Summary

This report contains ambient air quality results at Johnstone’s Hill Tunnels (JHT), Waiwera for NZ Transport Agency (NZTA). The continuous parameters were monitored for three and a half months, or 15 weeks, from 30 March to 13 July 2010. The gaseous monitoring site was located within the north end of the northbound tunnel south of Puhoi. The meteorological monitoring site was positioned on Fowler Access Road above the Johnstone’s Hill Tunnels.

The monitoring was conducted by Watercare Services Ltd, on behalf of the NZTA. The monitoring site was established to measure key air pollutants within the tunnel and forms part of NZTA’s review of existing tunnels in the State Highway Network. The parameters monitored at the Johnstone’s Hill Tunnels were:

- Carbon monoxide
- Nitrogen oxides
- Wind speed
- Wind direction

Data return for the monitoring period was excellent with greater than 98% valid data for all parameters monitored. There were no exceedences of the tunnel guidelines, ambient guidelines or ambient standards.

The CO concentrations were low compared to the NZTA proposed interim air quality guidelines for road tunnels. The 8 hour 99.9th percentile was below 3.3ppm or 11% of the CO tunnel guideline. The 15 minute CO concentrations greater than 5ppm were from an external wind direction of WNW to N. The highest CO concentrations occurred on Saturday 03 April 2010 during the Easter long weekend. On average higher CO concentrations occurred at the start or end of a weekend.

The NO₂ concentrations were low compared to the NZTA proposed interim air quality guidelines for road tunnels. The 15 minute 99.9th percentile was below 0.07ppm or 7% of the NO₂ tunnel guideline. The 15 minute NO₂ concentrations greater than 50ppb were from an external wind direction of WNW to N and ESE to SE. The highest NO₂ concentrations occurred on Friday 07 May 2010. On average higher CO concentrations occurred on weekdays.

2 Introduction

In February 2010, NZ Transport Agency (NZTA) commissioned Watercare Services Ltd to conduct continuous monitoring of carbon monoxide (CO) and oxides of nitrogen (NO_x) within Johnstone’s Hill Tunnels (JHT). The meteorological parameters monitored were wind speed and wind direction. The monitoring was undertaken as part of NZTA’s review of existing tunnels.

Air pollutants arise from a number of different sources. The pollutants monitored at the Johnstone’s Hill Tunnels were:

- Carbon monoxide (CO) – a product of incomplete combustion of carbon containing fuels, especially from motor vehicles
- Nitrogen oxides (NO and NO₂) – mostly from motor vehicle emissions

The Johnstone’s Hill Tunnels at the end of the Northern Gateway Toll Road were completed in January 2009. The 7.5km long toll road bypasses Orewa reducing State Highway (SH) traffic congestion. The two lane twin tunnels are 15m apart, 12m wide, 9m high and 380m long. Currently, the northbound tunnel merges into one lane before the tunnel entrance to accommodate the existing one lane road structure at the tunnel exit. Gaseous parameters were monitored 30m from the northbound tunnel exit and wind parameters were monitored above the Johnstone’s Hill Tunnels on Fowler Access Road.

This report presents a summary of data for three and a half months from 30 March to 13 July 2010 to enable a comparison of weekday and weekend vehicle emissions. Monitoring was undertaken with the intention to measure “typical” and “worst case” air quality in the tunnel.

For the reporting period the gaseous instruments have been adjusted for span and zero instrument drift using the results from automatic and manual calibrations. All data in this report has been validated. Quality assurance checks have been carried out to ensure that invalid and calibration data are not reported.

This report presents the following:

- summary of ambient air quality targets, guidelines and standards
- monitoring site description
- overview of the methods used to monitor selected parameters
- comparison to the relevant ambient air quality targets, guidelines and standards
- data summary and statistics
- analyser instrument history

3 Ambient Air Quality Limits, Guidelines and Standards


The measurements of air quality made at Johnstone’s Hill Tunnels can be compared with various air quality limits, guidelines or standards. The Ministry for the Environment (MfE) National Environmental Standards (NES) for ambient air quality superseded the Ambient Air Quality Guidelines (AAQG) 2002 in some areas. In 2009 NZTA proposed interim air quality guidelines for road tunnels that are similar to other workplace exposure limits. These limits are listed in Table 1.

Table 1: Tunnel Guidelines, AAQG and NES

Parameter	Source	Averaging Period	Limit	Protection/ Environment
Carbon monoxide (CO)	NZTA	15 min	87ppm	General Population
	NZTA	15 min	200ppm	Workplace
	NZTA	8 hr	30ppm	Workplace
	AAQG	1 hr	30mg/m ³	Ambient
	NES	8 hr	10mg/m ³	Ambient
Nitrogen dioxide (NO ₂)	NZTA	15 min	1ppm	Workplace and General Population
	AAQG	24 hr	100µg/m ³	Ambient
	NES	1 hr	200µg/m ³	Ambient

4 Monitoring Sites

A brief description of the monitoring sites at Johnstone’s Hill Tunnels is given below.

Site Name	NZTA – Johnstone’s Hill Tunnels	Site ID	AQGLA059a
Address	Northern Motorway SH1 under SH17 Waiwera, Rodney	Site Class	Peak Traffic
Site Coordinates (NZTM)	E 1750343	N 5955528	
Description			
<p>The two lane Johnstone’s Hill Tunnels are at the end of the Northern Gateway Toll Road south of Puhoi. The air quality station was positioned at the north end of the Johnstone’s Hill Tunnels (see front page). The monitoring site was located 30m inside the northbound of the Johnstone’s Hill Tunnels near the CO tunnel sensor (see photo below). The northbound tunnel merges into one lane before the tunnel entrance to accommodate the one lane road layout at the tunnel exit.</p> <p>The monitoring station was commissioned on 29 March 2010 and decommissioned on the 14 July 2010. Valid data for the three and a half months or 15 weeks commenced 30 March 2010 and ended 13 July 2010. The equipment was owned and operated by Watercare Services Ltd on behalf of NZTA.</p>			
Pollutants Monitored (at 2.0m)	CO and NO _x		
Site Photo			
			


Site Name	NZTA – Johnstone’s Hill Tunnels Met	Site ID	AQGLA059b
Address	Near 20 Fowler Access Road Waiwera Rodney	Site Class	Peak Traffic
Site Coordinates (NZTM)	E 1750473	N 5955473	
Description			
<p>The two lane Johnstone’s Hill Tunnels are at the end of the Northern Gateway Toll Road south of Puhoi. The meteorological station was positioned above Johnstone’s Hill Tunnels (Figure 1). The monitoring site was located in a 50m wide clearing 60m east of the Johnstone’s Hill Tunnels on Fowler Access Road. The photo below shows the telescopic mast with the Waiwera interchange in the background.</p> <p>The monitoring station was commissioned on 29 March 2010 and decommissioned on the 14 July 2010. Valid data for the three and a half months or 15 weeks commenced 30 March 2010 and ended 13 July 2010. The equipment was owned and operated by Watercare Services Ltd on behalf of NZTA.</p>			
Meteorological Parameters Monitored (at 6m)		Wind Speed and Wind Direction	
Site Photo			
			



Figure 1: Location map

5 Methods

This section provides the methodology and quality assurance processes used in the measurement of carbon monoxide, nitrogen oxides and the meteorological parameters.

5.1 Quality assurance

Watercare Laboratory Services is accredited by International Accreditation New Zealand (IANZ) for the following relevant methods:

- AS 3580.7.1 – 1992 ‘Method 7.1: Determination of carbon monoxide – direct-reading instrumental method’.
- AS 3580.5.1 – 1993 ‘Method 5.1: Determination of oxides of nitrogen – chemiluminescence method’.

The station was environmentally controlled ensuring the instrument requirements and relevant standard requirements were within specifications. Checks were made on the internal temperatures daily to ensure that the instruments within the stations continued to operate within pre-determined ranges ($25 \pm 3^{\circ}\text{C}$) throughout the reporting period.

All pollutant results in this report have been calculated to standard temperature (0°C) and pressure (1atm). Watercare Laboratory Services provided the following monitoring services:

- Instrument Operation, Calibration and Maintenance. This includes the use of automatic daily calibration systems for all continuous ambient gas monitors ensuring that the requirements of the relevant Australian Standards for weekly calibration of continuous analysers are met.
- Data Logging, Polling, Checking, Re-scaling, Validation, Ratification and Reporting. This encompasses the entire data quality assurance process ensuring that the final data set reported is correct and valid data capture is achieved.

5.2 Carbon monoxide

Measurements were made in accordance with AS 3580.7.1–1992 using an Ecotech model 9830. The instrument is an infrared absorption gas analyser which continuously measures carbon monoxide. This allows data to be analysed and reported over a variety of average periods, including; 15 minute, 24 hour and one year.

5.3 Nitrogen oxides

Measurements are made in accordance with AS 3580.5.1–1993 using a Teledyne API model 200E. The instrument is a chemiluminescence gas analyser which continuously measures nitrogen oxides. This allows data to be analysed and reported over a variety of average periods, including 15 minute, 24 hour and one year.

5.4 Meteorological parameters

Measurements of wind speed and wind direction are made according to AS 2923 – 1987 ‘Ambient Air – Guide for Measurement of Horizontal Wind for Air Quality Applications’. Wind was recorded on site using a Campbell datalogger and retrieved into the Watercare database and reporting software.

The instruments continuously measure these meteorological parameters. This allows data to be analysed and reported over a variety of average periods, including: 15 minute, 24 hour and one year.

6 Results and Discussion

This section provides the site performance and an overview of the results for carbon monoxide, nitrogen oxides and the meteorological parameters. The pollution rose charts are linked to the meteorological station above the tunnel and relate to the external environment at the time of the pollution level achieved.

6.1 Site performance

The MfE Good Practice Guide for Air Quality Monitoring and Data Management (MfE 2000) suggests that it is difficult to reach anything close to 100% valid data for long-term monitoring. As such site performance has been evaluated against a target of 95%. The percent of valid data is defined as the percent of valid data following quality assurance adjustments.

Data return was excellent (greater than 95%) for all parameters monitored from 30 March to 13 July 2010. Table 2 below shows overall site performance for the reporting period.

Table 2: Percentage valid data 30 March to 13 July 2010

Parameters	Averaging Period	Valid Data (%)	Reasons for Less Than 95% Valid Data
Carbon monoxide	15 minute	98	–
Nitrogen dioxide	15 minute	98	–
Wind speed	15 minute	98	–
Wind direction	15 minute	95	–

6.2 Carbon monoxide (CO)

Table 3 presents a statistical summary of CO 15 minute, 1 hour and 8 hour averages that have been calculated from 15 minute averages. The CO analyser performed well according to the results from automatic and manual calibrations during the monitoring period. The automatic and manual calibrations were within specifications.

There were no exceedences of the tunnel guidelines, ambient guidelines or ambient standards listed in Table 1. The results of CO measured from 30 March to 13 July 2010 are shown graphically in Figure 2 to Figure 7.

The highest recorded CO 15 minute concentration was 9.0ppm on 03 April 2010 13:00. The 8 hour 99.9th percentile was 3.3ppm which is 11% of the CO tunnel guideline (30ppm). The 15 minute CO concentrations greater than 5ppm occurred when the external wind direction was WNW to N.

From the diurnal variation the average weekday CO concentrations peaked at 08:00 and 18:00. The average weekend CO concentrations peaked at 09:00, 15:00 and 21:00 with slight deviations in the afternoon due to the maximum concentrations.

The top 10 highest 15 minute and 1 hour CO concentrations are displayed in Table 4. The higher CO concentrations mainly occurred on 03 April 2010 and are shown graphically in Figure 8 to Figure 9. On 03 April 2010, CO concentrations increased from 10:00 until 11:00 and increased from 12:00 until 13:00. This pattern could be due to the ventilation system. Also on 03 April 2010 the 15 minute CO concentrations greater than 5ppm occurred when the external wind direction was WNW to N.

The Easter long weekend was from 02 April to 05 April 2010 but holiday makers may have started their journeys earlier as higher CO concentrations occurred from the first day of monitoring on 30 March 2010. Other noticeable CO concentrations occurred at the start or end of a weekend.

Table 3: Carbon monoxide statistics

Parameters	CO 15 min fixed average (ppm)	CO 8 hr rolling average (ppm)	CO 1 hr fixed average (mg/m ³)	CO 8 hr rolling average (mg/m ³)
Minimum	0.0	0.0	0.0	0.1
Average	0.6	0.6	0.7	0.7
Maximum	9.0 03/04/10 13:00	3.5 03/04/10 17:00	9.0 03/04/10 13:00	4.4 03/04/10 17:00
99.9 th percentile	4.5	3.3	4.1	4.2
Exceedences				
Tunnel Guidelines	Nil	Nil	Not Applicable	Not Applicable
AAQG	Not Applicable	Not Applicable	Nil	Nil
NES	Not Applicable	Not Applicable	Not Applicable	Nil

Table 4: Carbon monoxide highest concentrations

Averaging Period	Date	Time (NZST)	Day	Concentration (ppm)
15 minute	3/04/2010	10:30	Saturday	6.8
	3/04/2010	10:45	Saturday	7.3
	3/04/2010	12:30	Saturday	8.7
	3/04/2010	12:45	Saturday	6.7
	3/04/2010	13:00	Saturday	9.0
	3/04/2010	13:15	Saturday	7.3
	3/04/2010	13:30	Saturday	4.6
	5/04/2010	12:00	Monday	5.3
	4/06/2010	22:15	Friday	4.9
	27/06/2010	19:30	Sunday	5.1
1 hour	30/03/2010	16:00	Tuesday	3.1
	31/03/2010	18:00	Wednesday	2.9
	1/04/2010	17:00	Thursday	2.9
	3/04/2010	11:00	Saturday	5.4
	3/04/2010	12:00	Saturday	3.0
	3/04/2010	13:00	Saturday	7.2
	3/04/2010	14:00	Saturday	4.8
	5/04/2010	13:00	Monday	2.8
	23/05/2010	15:00	Sunday	2.7
	23/05/2010	17:00	Sunday	3.3

**NZTA – Johnstone’s Hill Tunnels
CO – 15 Minute Averages
30 March to 13 July 2010**

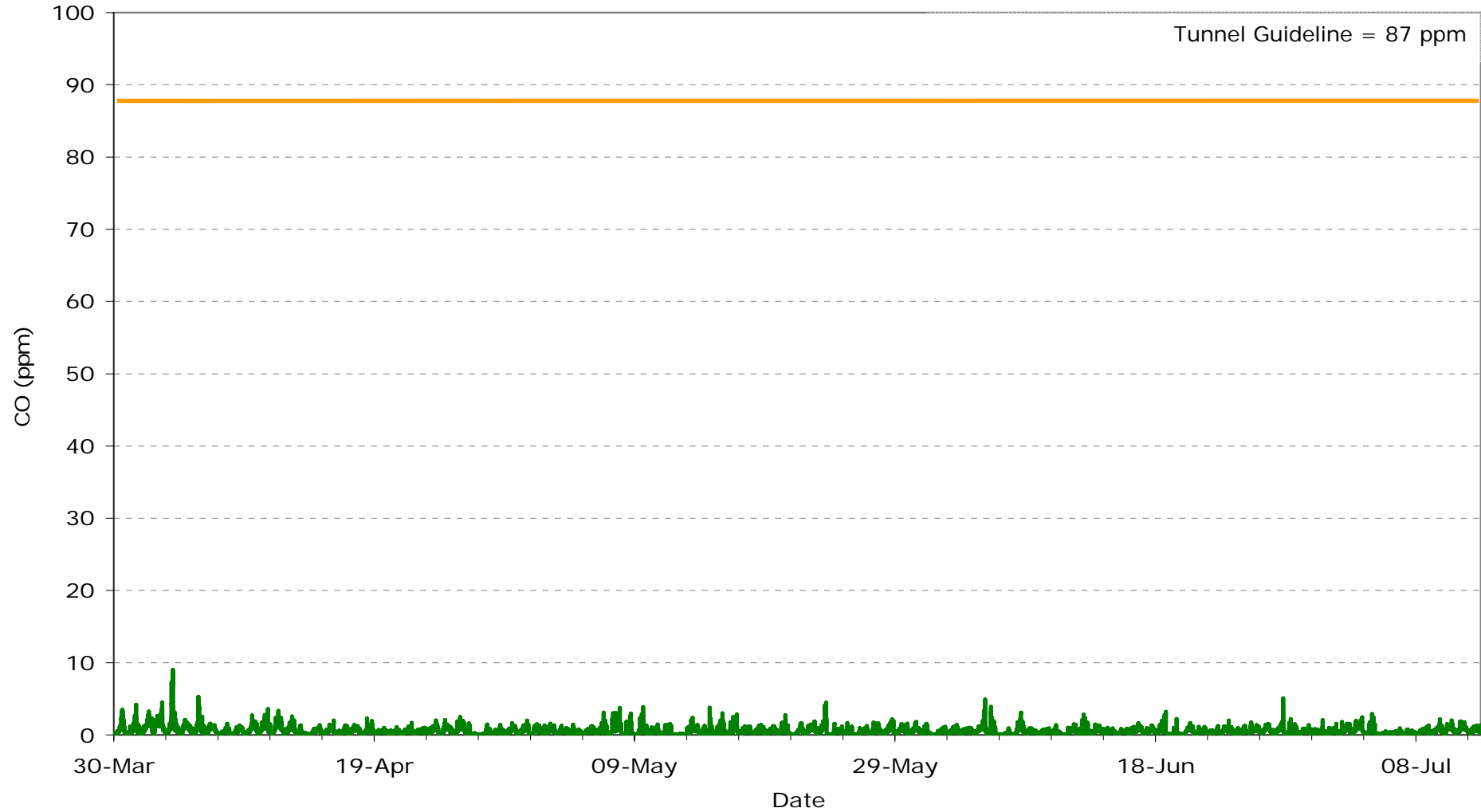


Figure 2: NZTA – Johnstone’s Hill Tunnels: CO (ppm) 15 minute averages

**NZTA – Johnstone’s Hill Tunnels
CO – 8 Hour Rolling Averages
30 March to 13 July 2010**

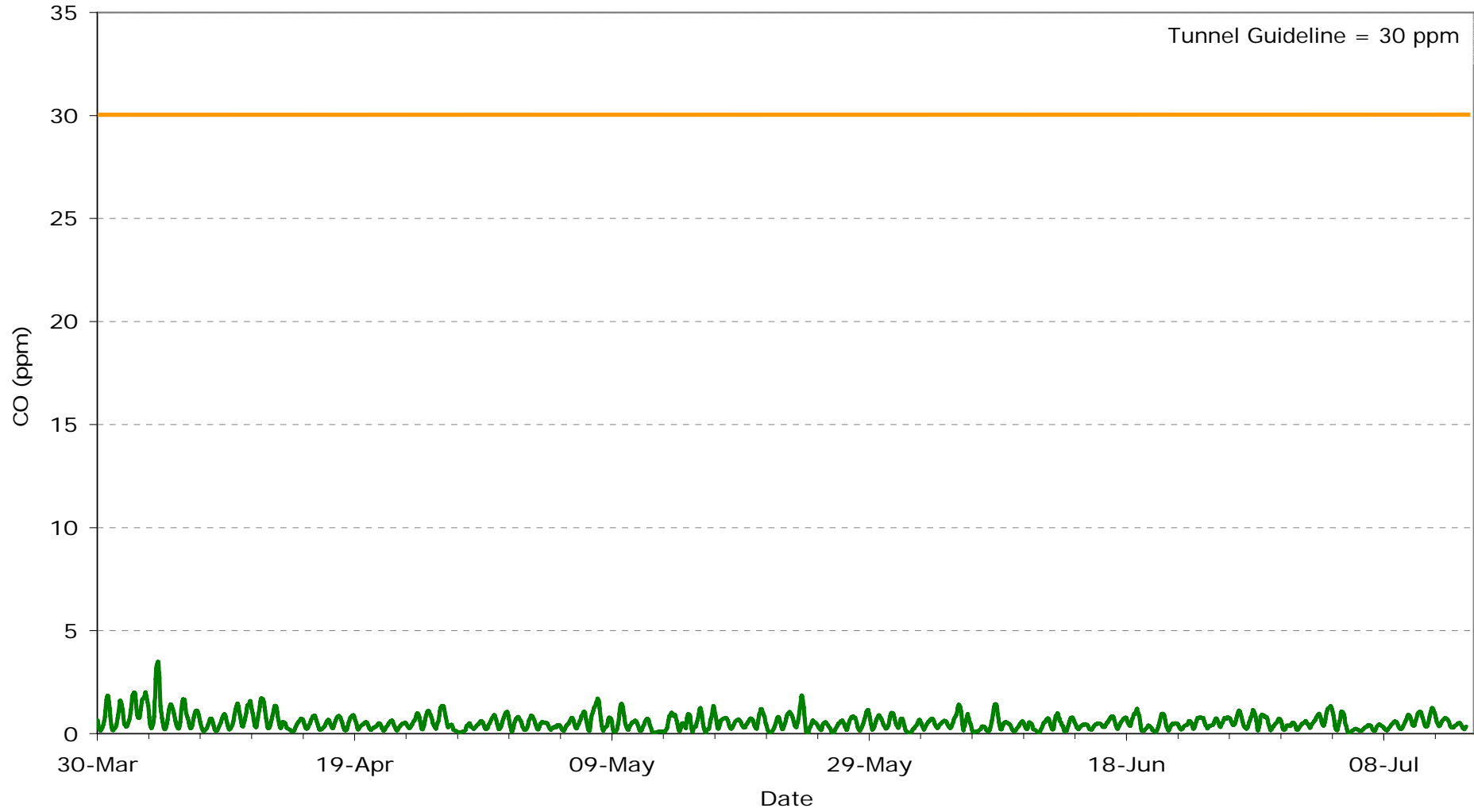


Figure 3: NZTA – Johnstone’s Hill Tunnels: CO (ppm) 8 hour rolling averages

**NZTA – Johnstone’s Hill Tunnels
CO – 1 Hour Averages
30 March to 13 July 2010**

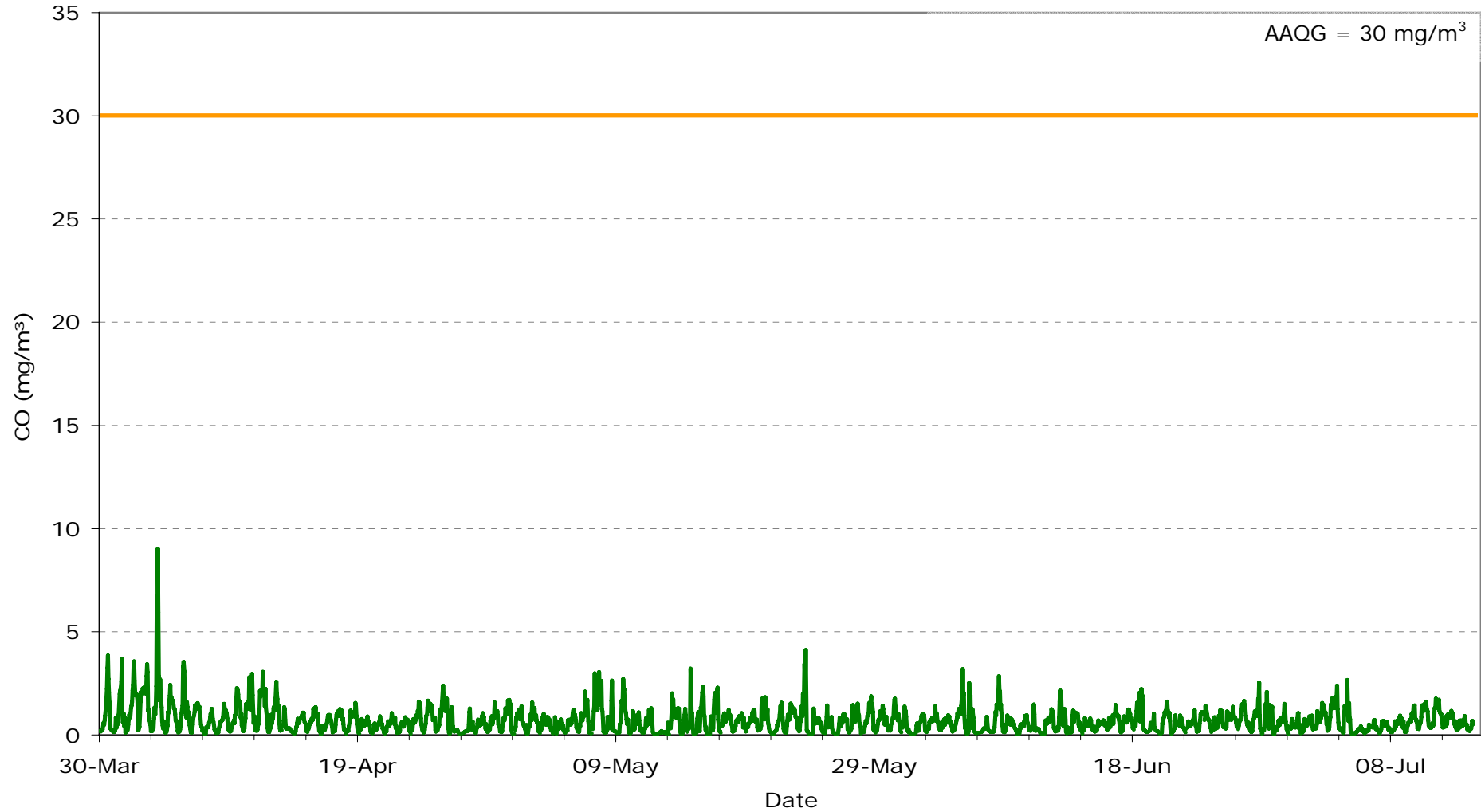


Figure 4: NZTA – Johnstone’s Hill Tunnels: CO (mg/m³) 1 hour averages

**NZTA – Johnstone’s Hill Tunnels
CO– 8 Hour Rolling Averages
30 March to 13 July 2010**

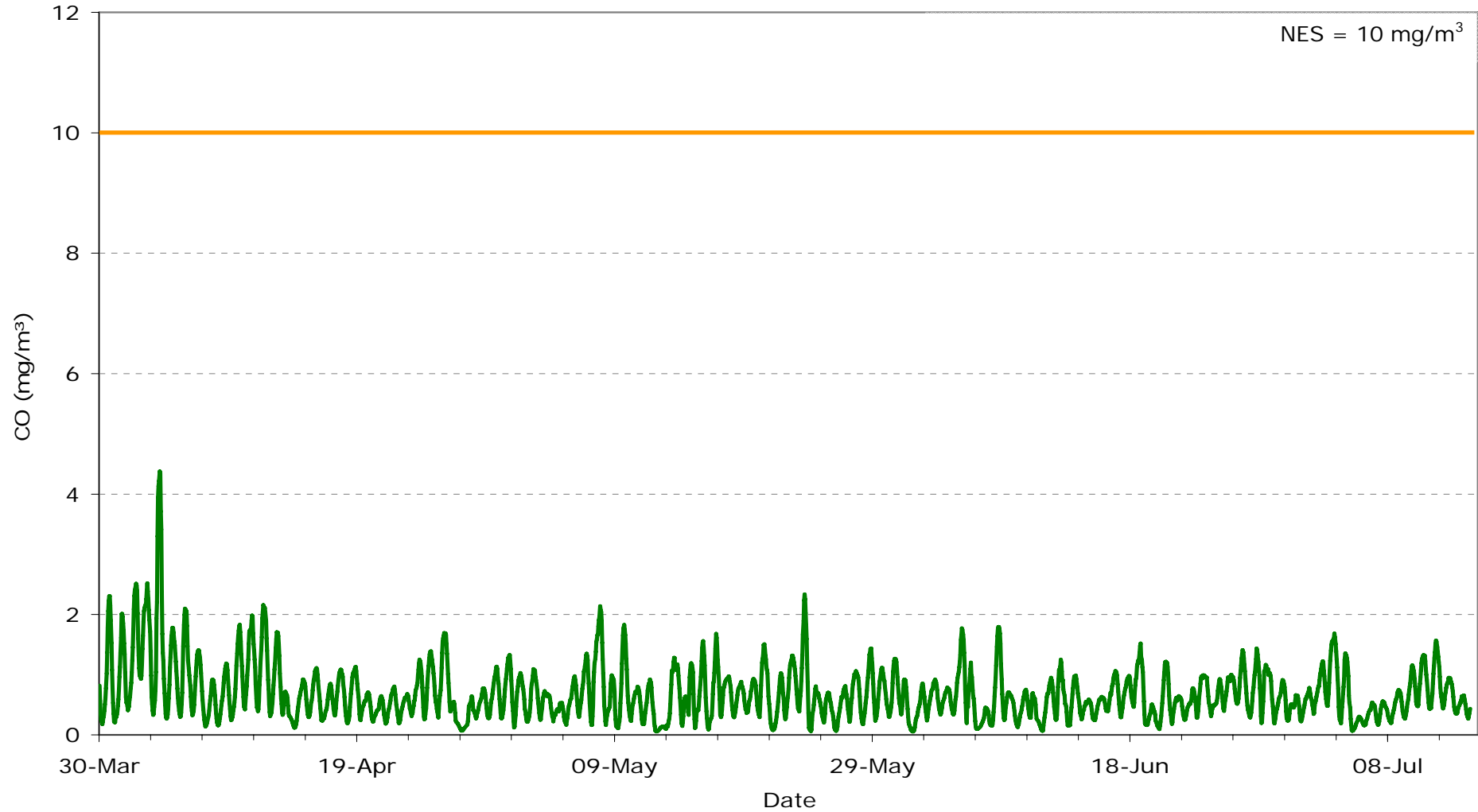


Figure 5: NZTA – Johnstone’s Hill Tunnels: CO (mg/m³) 8 hour rolling averages

**NZTA – Johnstone’s Hill Tunnels
CO Pollution Rose – 15 Minute Averages
30 March to 13 July 2010**

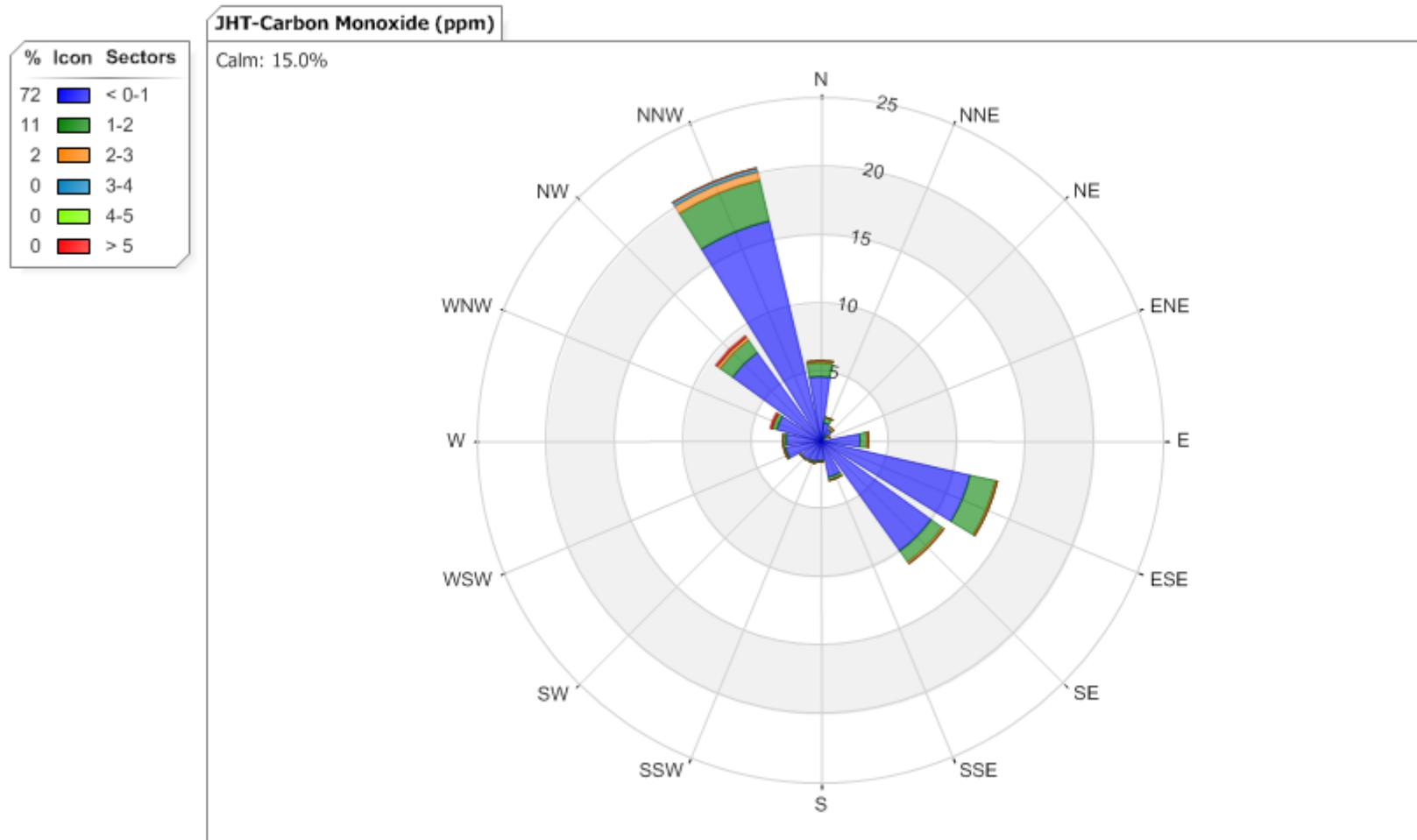


Figure 6: NZTA – Johnstone’s Hill Tunnels: CO (ppm) pollution rose 15 minute averages

**NZTA – Johnstone’s Hill Tunnels
CO Diurnal Variation – 1 Hour Averages
30 March to 13 July 2010**

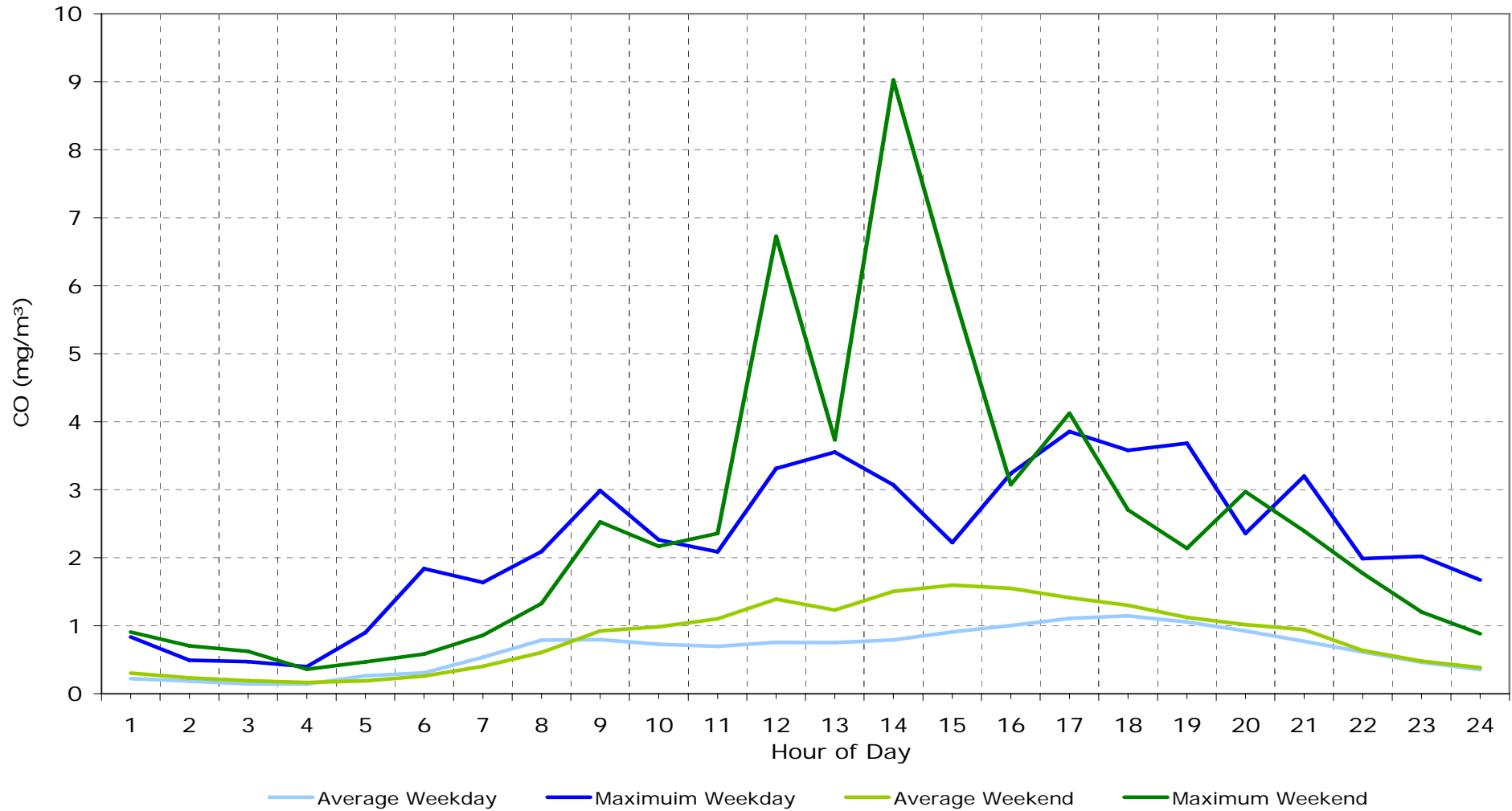


Figure 7: NZTA – Johnstone’s Hill Tunnels: CO (mg/m³) diurnal variation (1 hour averages time ending)

**NZTA – Johnstone’s Hill Tunnels
NO₂ – 15 Minute Averages
03 April 2010**

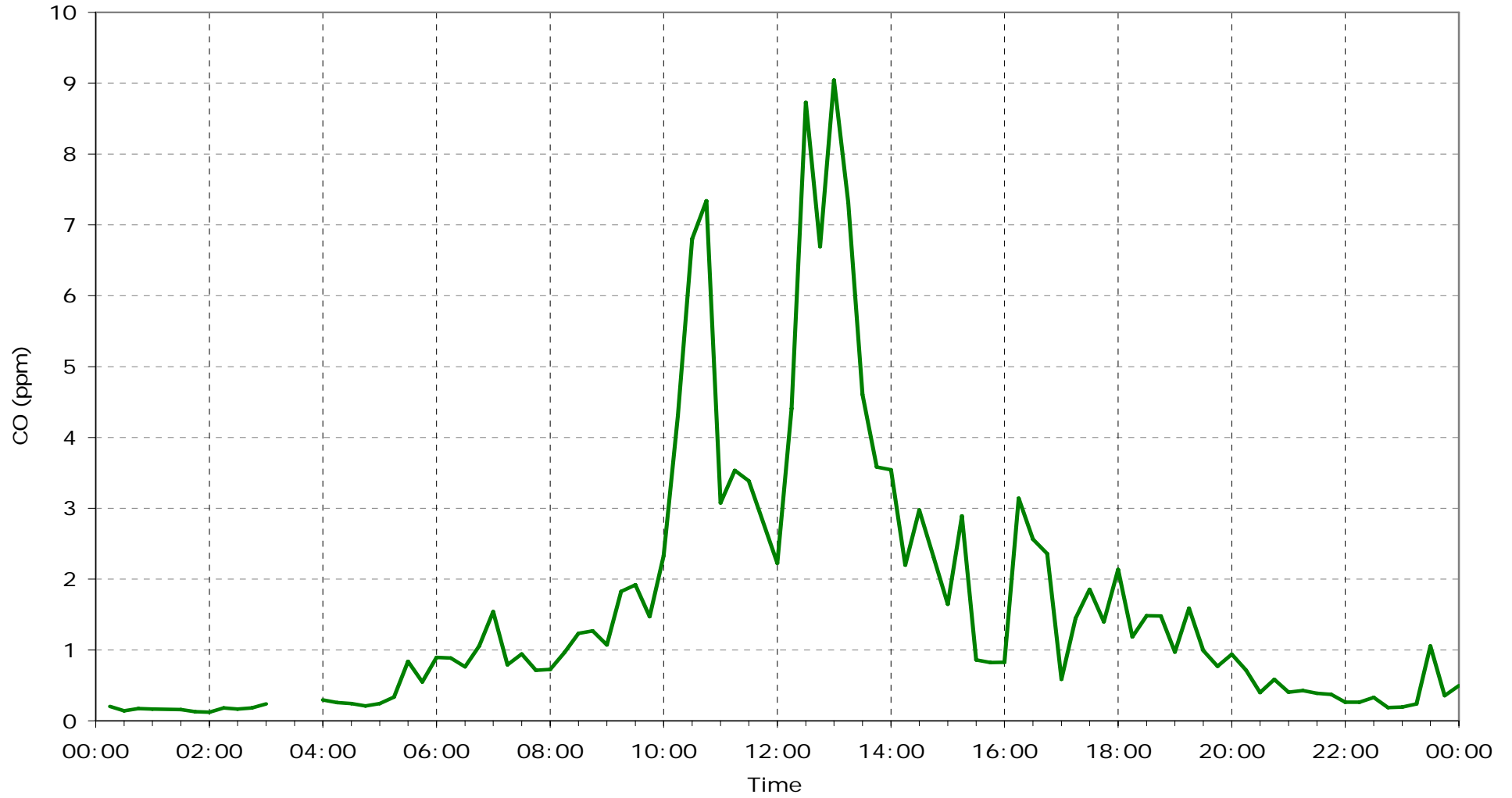


Figure 8: NZTA – Johnstone’s Hill Tunnels: CO (ppm) highest daily concentration (15 minute averages)

**NZTA – Johnstone’s Hill Tunnels
CO Pollution Rose – 15 Minute Averages
03 April 2010**

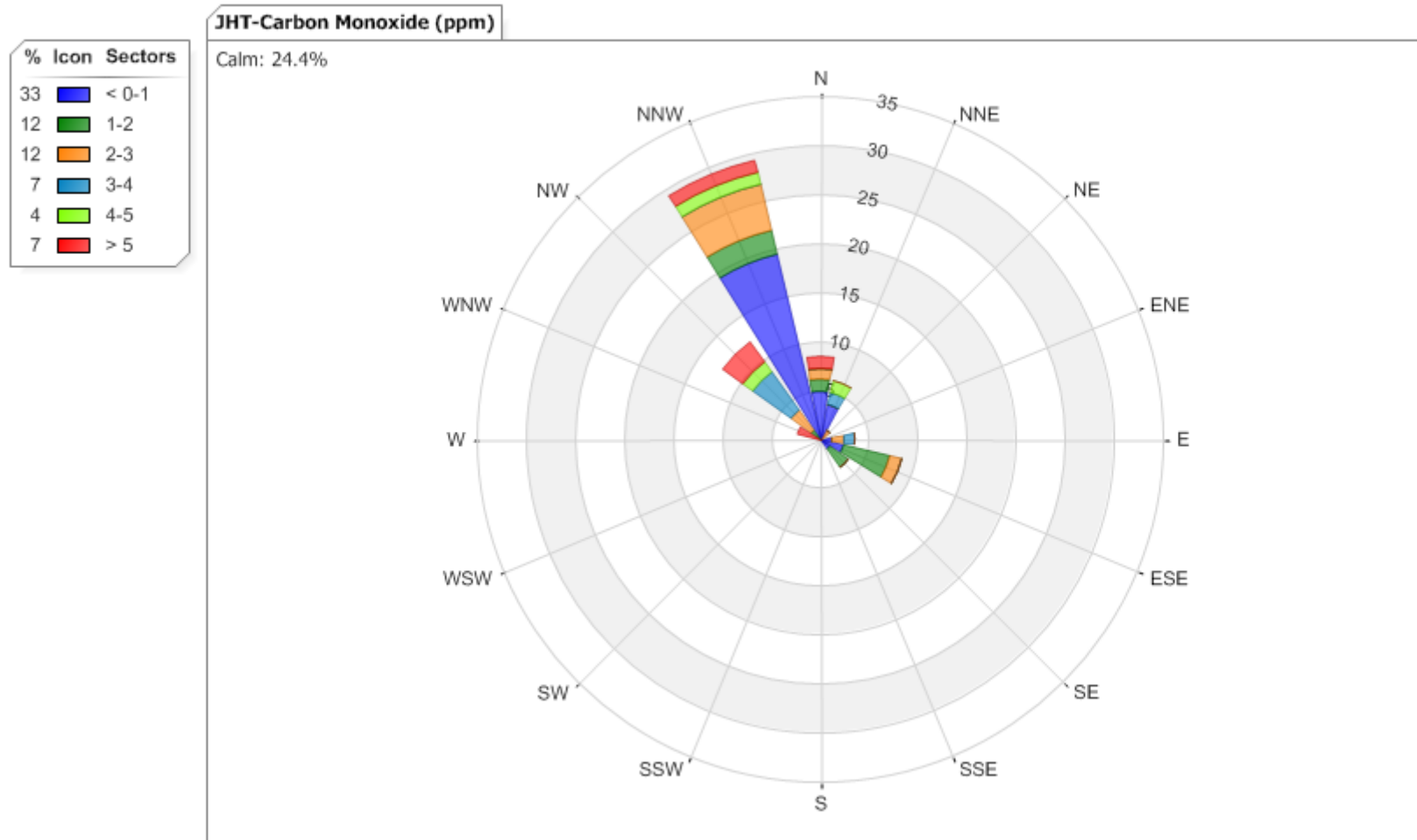


Figure 9: NZTA – Johnstone’s Hill Tunnels: CO (ppm) pollution rose highest daily concentration 15 minute averages

6.3 Nitrogen oxides (NO₂ and NO)

Table 5 presents a statistical summary of nitrogen dioxide 15 minute, 1 hour and 24 hour averages that have been calculated from 15 minute averages. The NO₂ analyser performed well according to the results from automatic and manual calibrations during the monitoring period. The automatic and manual calibrations were within specifications.

There were no exceedences of the tunnel guidelines, ambient guidelines or ambient standards listed in Table 1. The results of NO₂ measured from 30 March to 13 July 2010 are shown graphically in Figure 10 to Figure 15.

The highest recorded NO₂ 15 minute concentration was 0.08ppm on 20 May 2010 14:00. The 15 minute 99.9th percentile was 0.07ppm which is 7% of the NO₂ tunnel guideline (1ppm). The 15 minute NO₂ concentrations greater than 60ppb occurred when the external wind direction was WNW to N and ESE to SE.

From the diurnal variation the average weekday NO₂ concentrations peaked from 06:00 until 20:00 with slight deviations from 09:00 to 13:00 due to the maximum concentrations. During the weekend there was a peak from 10:00 until 19:00. The maximum concentrations mainly occurred on weekdays.

The top ten highest 15 minute and 1 hour NO₂ concentrations along with the two highest 24 hour NO₂ concentrations are displayed in Table 6. The higher daily NO₂ concentrations occurred on 07 May 2010 and are shown graphically in Figure 16 to Figure 17. On 07 May 2010 NO₂ concentrations increased from 04:00 until 12:00 and increased from 12:30 until 20:00. Also on 07 May 2010 the 15 minute NO₂ concentrations greater than 60ppb occurred when the external wind direction was NNW to N.

Higher NO₂ concentrations also occurred on 20 May 2010 and although not shown the NO₂ concentrations increased from 06:30 and obtained high concentrations intermittently during the afternoon. The Easter long weekend was from 02 April to 05 April 2010 but holiday makers may have started their journeys earlier as higher NO₂ concentrations occurred from 31 March 2010. Besides 03 April 2010 and 07 May 2010 other notable NO₂ concentrations did not relate to weekend traffic.

Table 5: Nitrogen dioxide statistics

Parameters	NO ₂ 15 min fixed average (ppm)	NO ₂ 1 hr fixed average (µg/m ³)	NO ₂ 24 hr fixed average (µg/m ³)
Minimum	0.00	0.4	6.7
Average	0.02	47.5	47.4
Maximum	0.08 20/05/10 14:00	130.5 20/05/10 11:00	78.1 07/05/2010
99.9 th percentile	0.07	113.8	77.2
Exceedences			
Tunnel Guideline	Nil	Not Applicable	Not Applicable
AAQG	Not Applicable	Not Applicable	Nil
NES	Not Applicable	Nil	Not Applicable

Table 6: Nitrogen dioxide highest concentrations

Averaging Period	Date	Time (NZST)	Day	Concentration (ppb)
15 minute	3/04/2010	10:30	Saturday	71.0
	3/04/2010	13:15	Saturday	79.1
	6/05/2010	11:45	Thursday	72.6
	7/05/2010	15:30	Friday	74.5
	11/05/2010	11:30	Tuesday	76.1
	20/05/2010	9:30	Thursday	76.1
	20/05/2010	10:15	Thursday	70.3
	20/05/2010	11:00	Thursday	70.4
	20/05/2010	14:00	Thursday	81.8
	31/05/2010	11:45	Monday	70.4
1 hour	31/03/2010	18:00	Wednesday	55.8
	6/05/2010	15:00	Thursday	52.8
	7/05/2010	10:00	Friday	53.6
	7/05/2010	16:00	Friday	54.6
	7/05/2010	17:00	Friday	54.3
	7/05/2010	18:00	Friday	53.1
	20/05/2010	8:00	Thursday	55.0
	20/05/2010	10:00	Thursday	55.2
	20/05/2010	11:00	Thursday	63.7
	20/05/2010	14:00	Thursday	56.1
24 hour	07/05/2010	-	Friday	38.1
	29/06/2010	-	Tuesday	33.7

**NZTA – Johnstone’s Hill Tunnels
NO₂ – 15 Minute Averages
30 March to 13 July 2010**

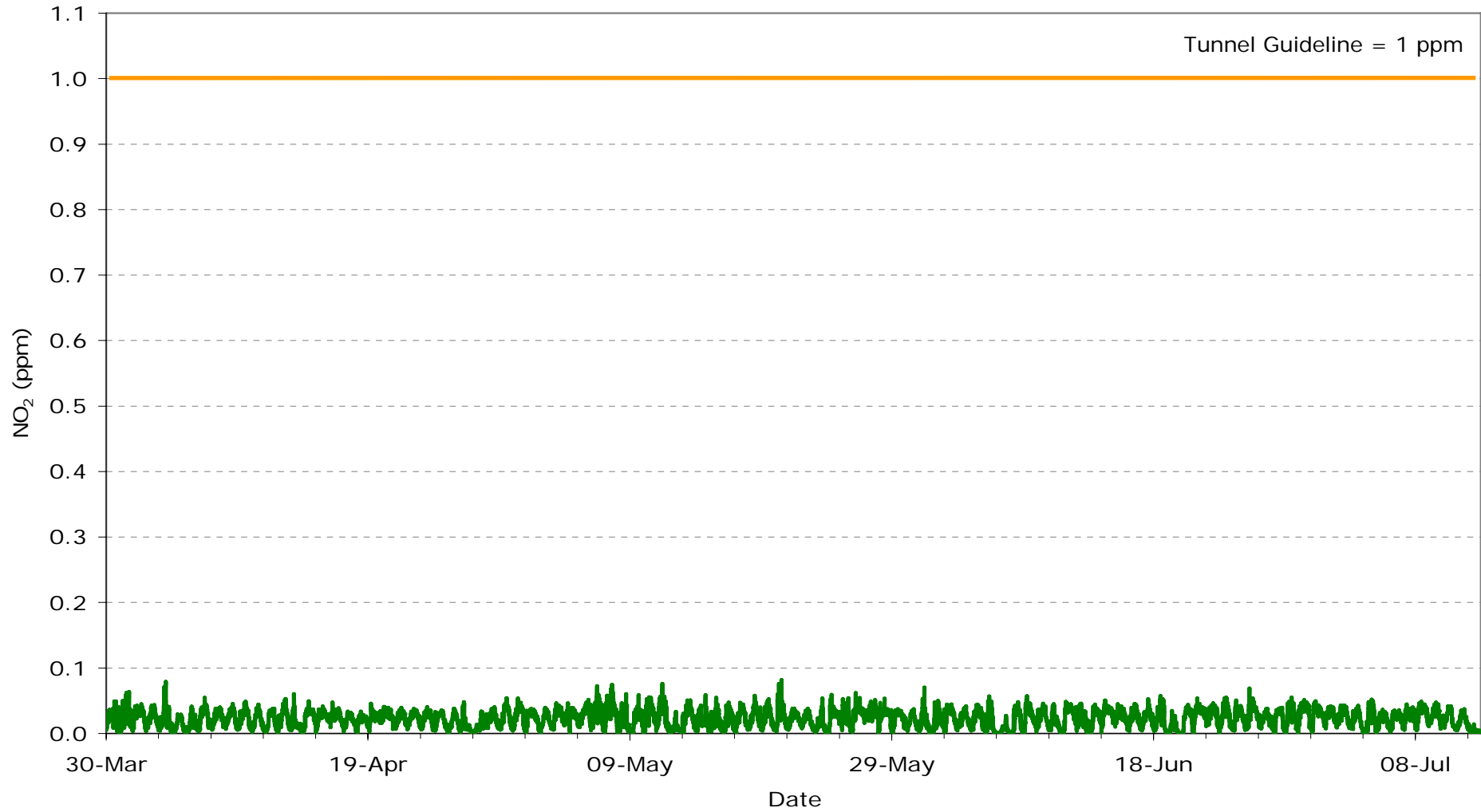


Figure 10: NZTA – Johnstone’s Hill Tunnels: NO₂ (ppm) 15 minute averages

**NZTA – Johnstone’s Hill Tunnels
NO₂ – 1 Hour Averages
30 March to 13 July 2010**

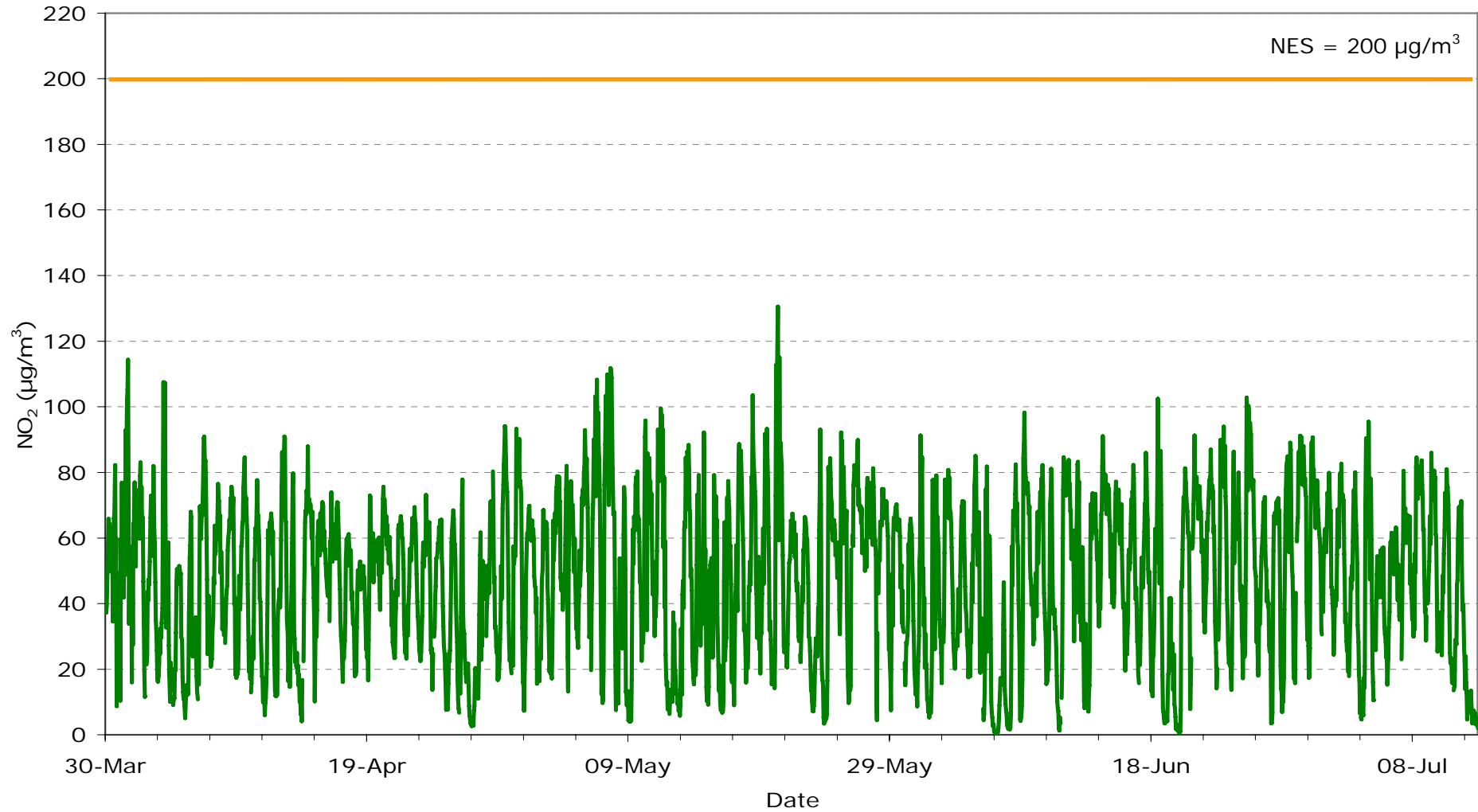


Figure 11: NZTA – Johnstone’s Hill Tunnels: NO₂ (µg/m³) 1 hour averages

NZTA – Johnstone’s Hill Tunnels
NO₂ – 24 Hour Averages
30 March to 13 July 2010

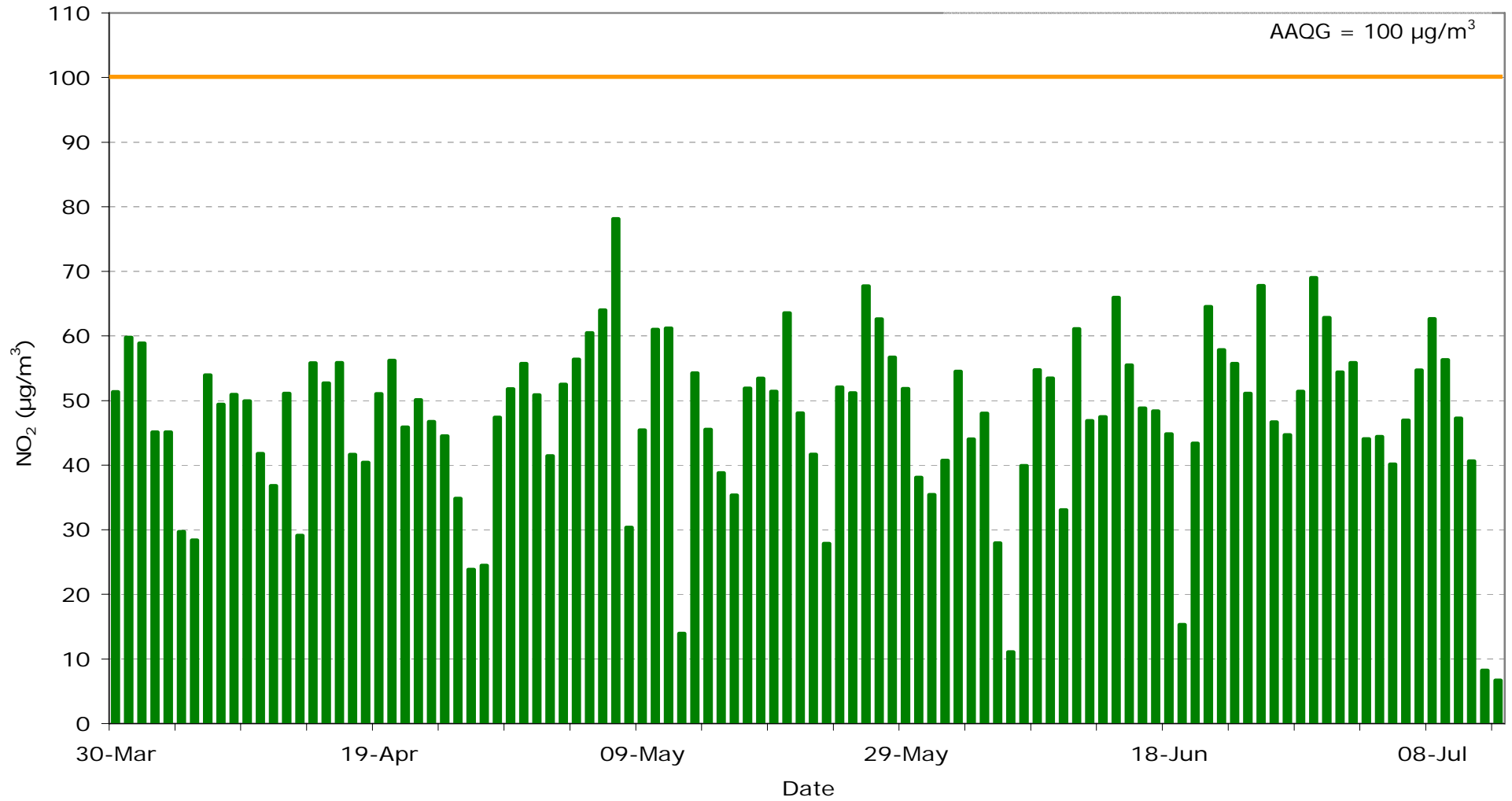


Figure 12: NZTA – Johnstone’s Hill Tunnels: NO₂ (µg/m³) 24 hour averages

**NZTA – Johnstone’s Hill Tunnels
NO – 1 Hour Averages
30 March to 13 July 2010**

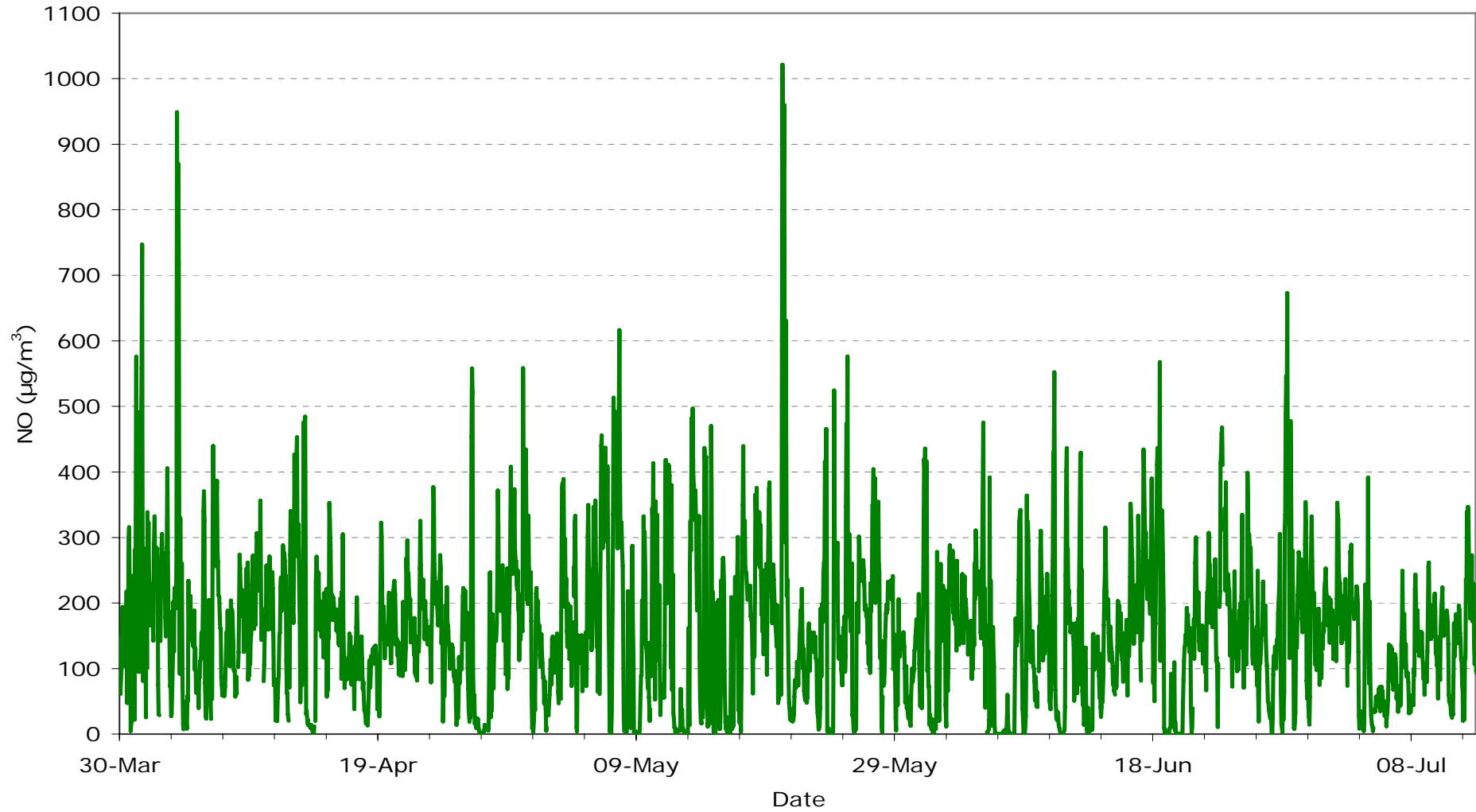


Figure 13: NZTA – Johnstone’s Hill Tunnels: NO (µg/m³) 1 hour averages

**NZTA – Johnstone’s Hill Tunnels
NO₂ Pollution Rose – 15 Minute Averages
30 March to 13 July 2010**

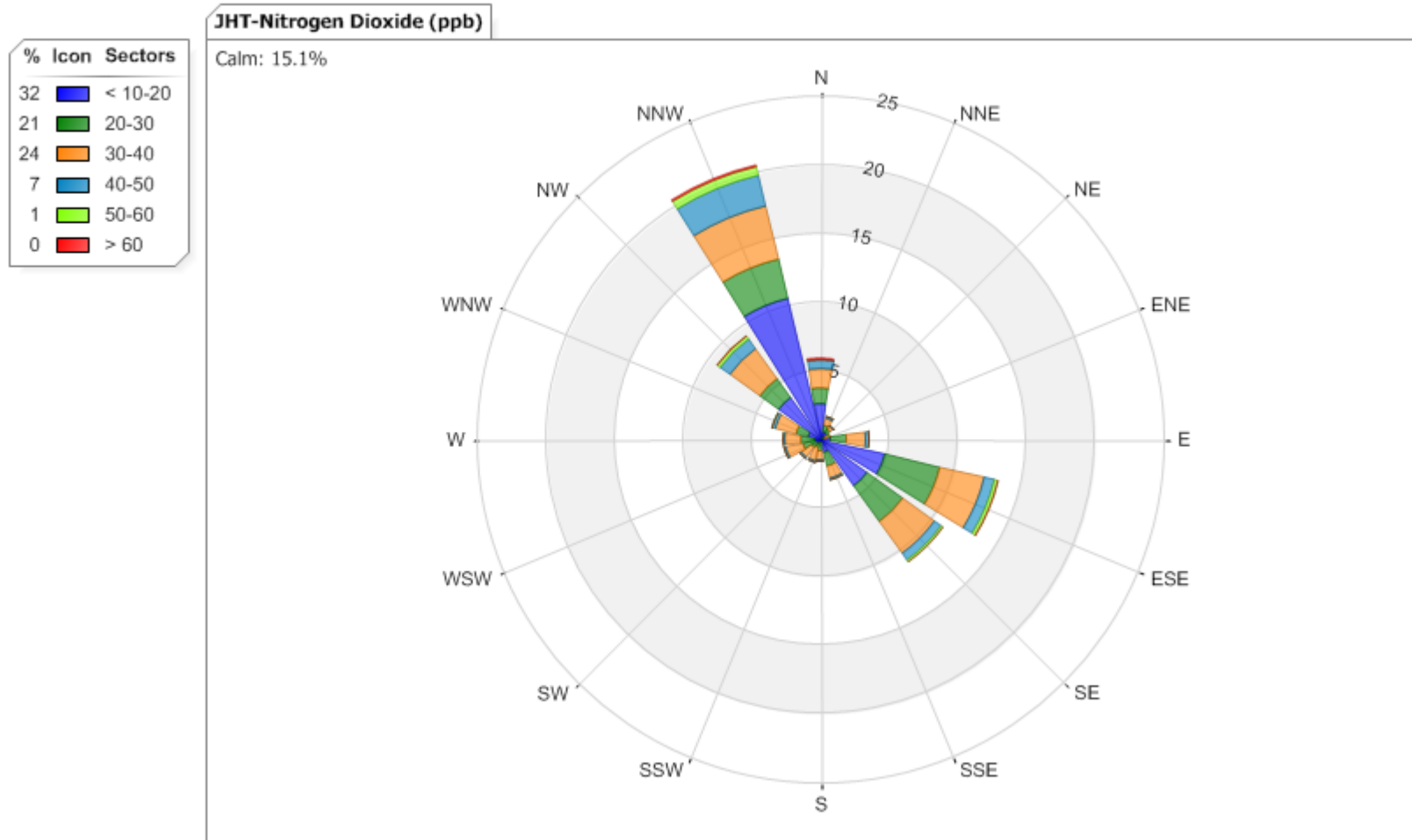


Figure 14: NZTA – Johnstone’s Hill Tunnels: NO₂ (ppb) pollution rose 15 minute averages

**NZTA – Johnstone’s Hill Tunnels
NO₂ Diurnal Variation – 1 Hour Averages
30 March to 13 July 2010**

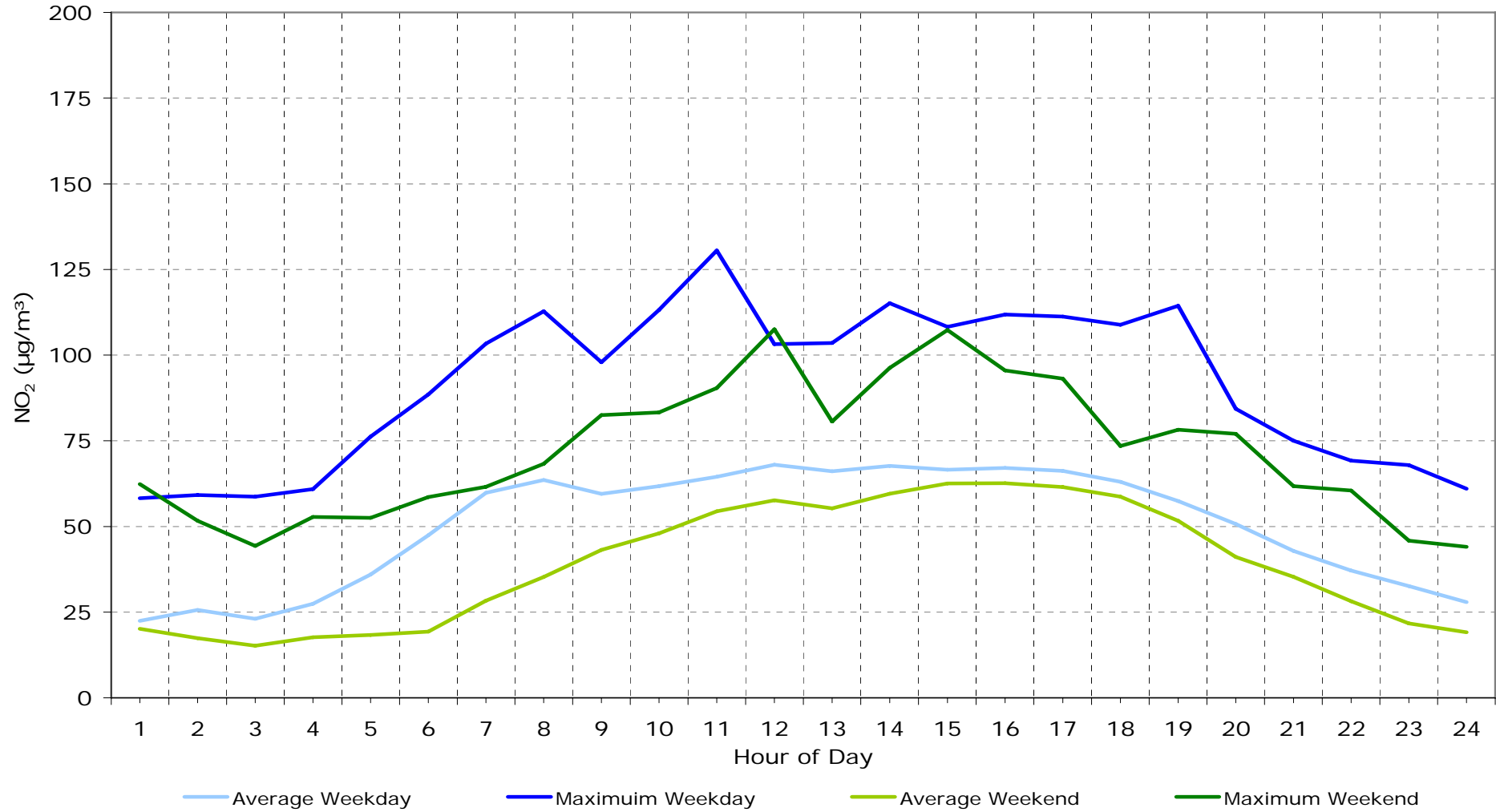


Figure 15: NZTA – Johnstone’s Hill Tunnels: NO₂ (µg/m³) diurnal variation (1 hour averages time ending)

NZTA – Johnstone’s Hill Tunnels
NO₂ – 15 Minute Averages
07 May 2010

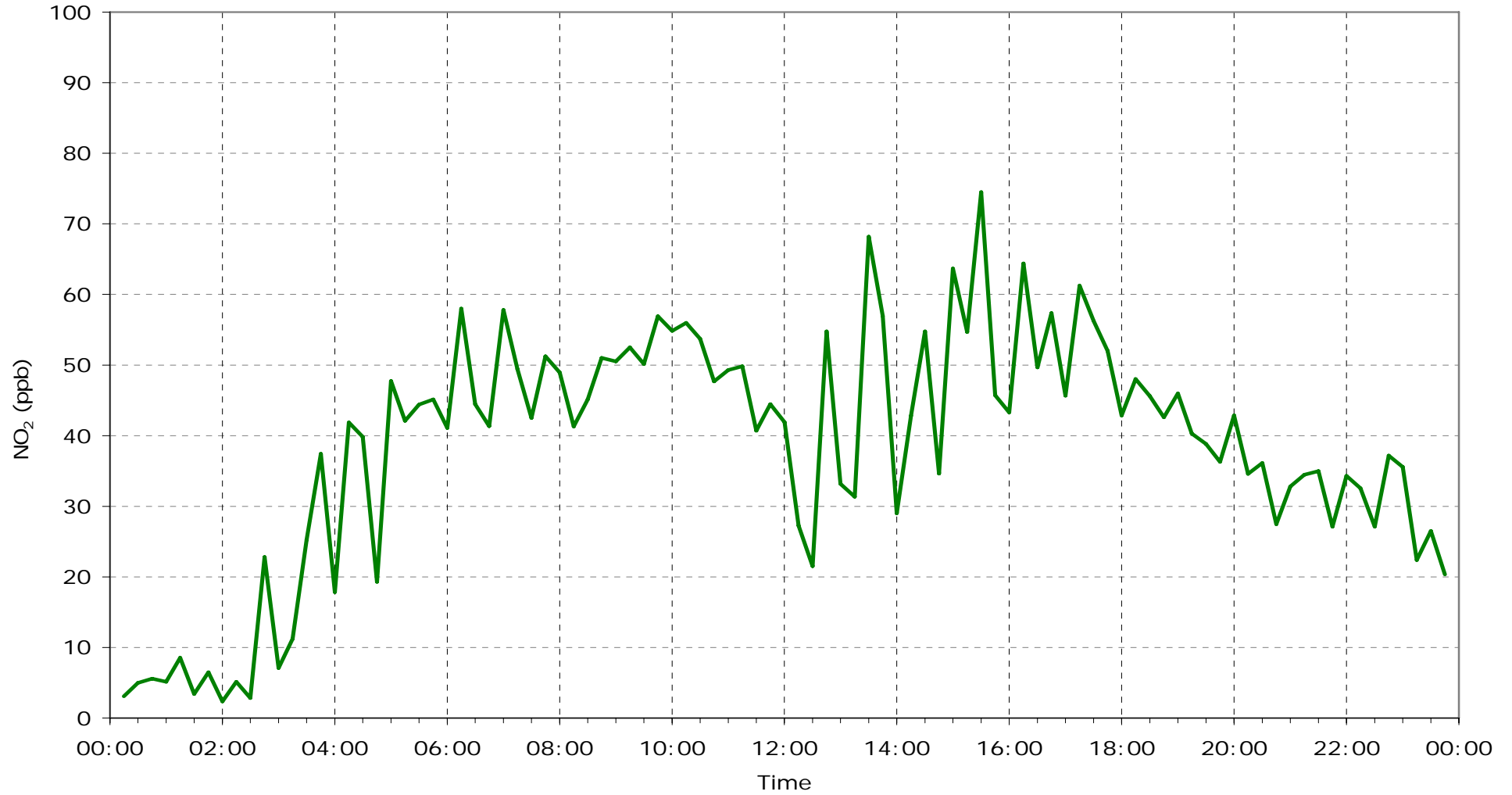


Figure 16: NZTA – Johnstone’s Hill Tunnels: NO₂ (ppb) highest daily concentration (15 minute averages)

**NZTA – Johnstone’s Hill Tunnels
NO₂ Pollution Rose – 15 Minute Averages
07 May 2010**

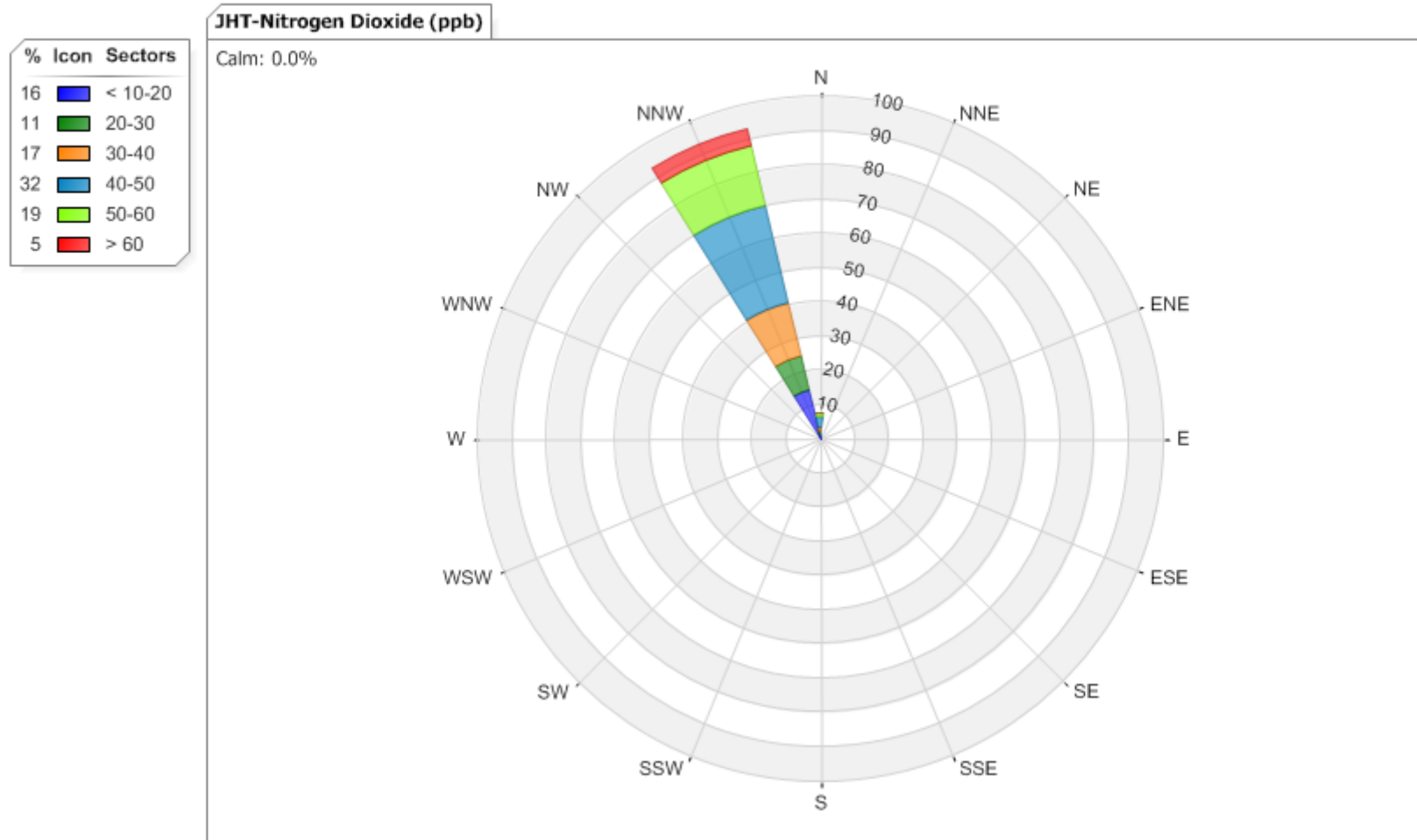


Figure 17: NZTA – Johnstone’s Hill Tunnels: NO₂ (ppb) pollution rose highest daily concentration 15 minute averages

6.4 Meteorological parameters

Table 7 presents a summary of meteorological parameters based on 1 hour that have been calculated from 15 minute averages recorded by the instruments.

The results of meteorological parameters measured from 30 March to 13 July 2010 are shown graphically in Figure 18 to Figure 20.

Table 7: Meteorological parameters (1 hour averages)

Meteorological Parameters	Summary 1 hr average
Wind Speed	Range 0.0 – 6.2 m/s
Wind Direction	Predominant wind NNW

**NZTA – Johnstone’s Hill Tunnels
Wind Speed – 1 Hour Averages
30 March to 13 July 2010**

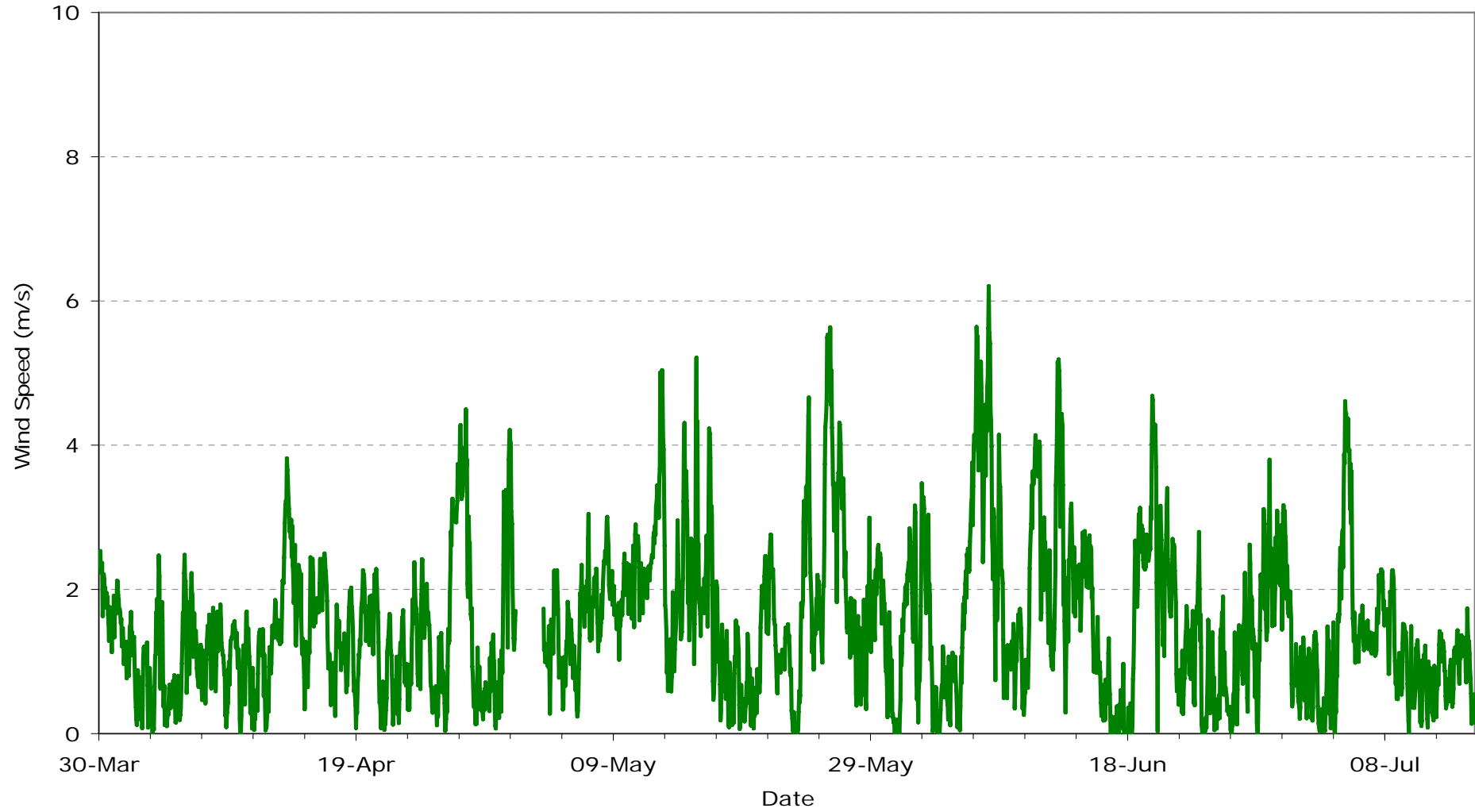


Figure 18: NZTA – Johnstone’s Hill Tunnels: Wind speed (1 hour averages)

**NZTA – Johnstone’s Hill Tunnels
Wind Direction– 1 Hour Averages
30 March to 13 July 2010**

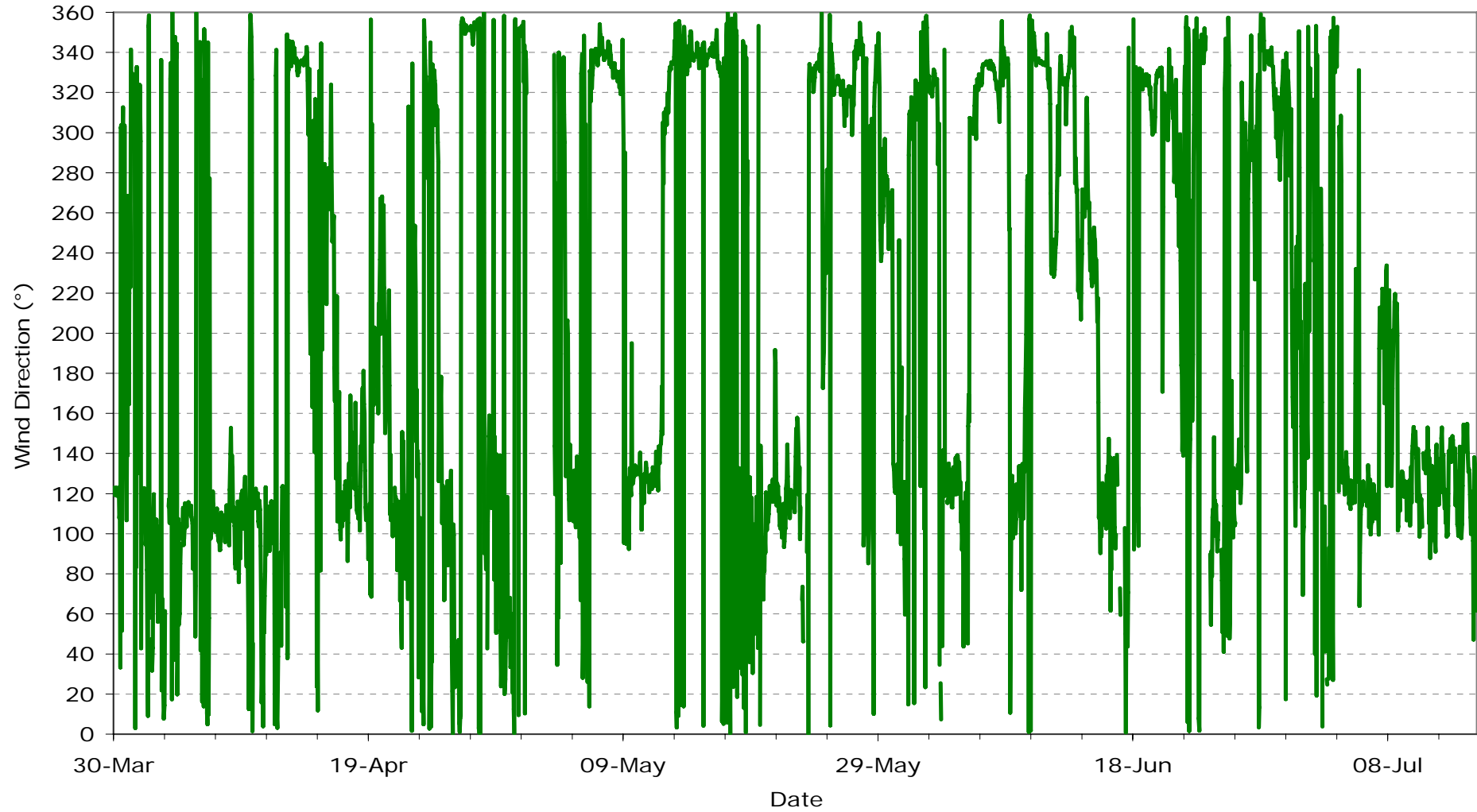


Figure 19: NZTA – Johnstone’s Hill Tunnels: Wind direction (1 hour averages)

**NZTA – Johnstone’s Hill Tunnels
Wind Rose – 1 Hour Averages
30 March to 13 July 2010**

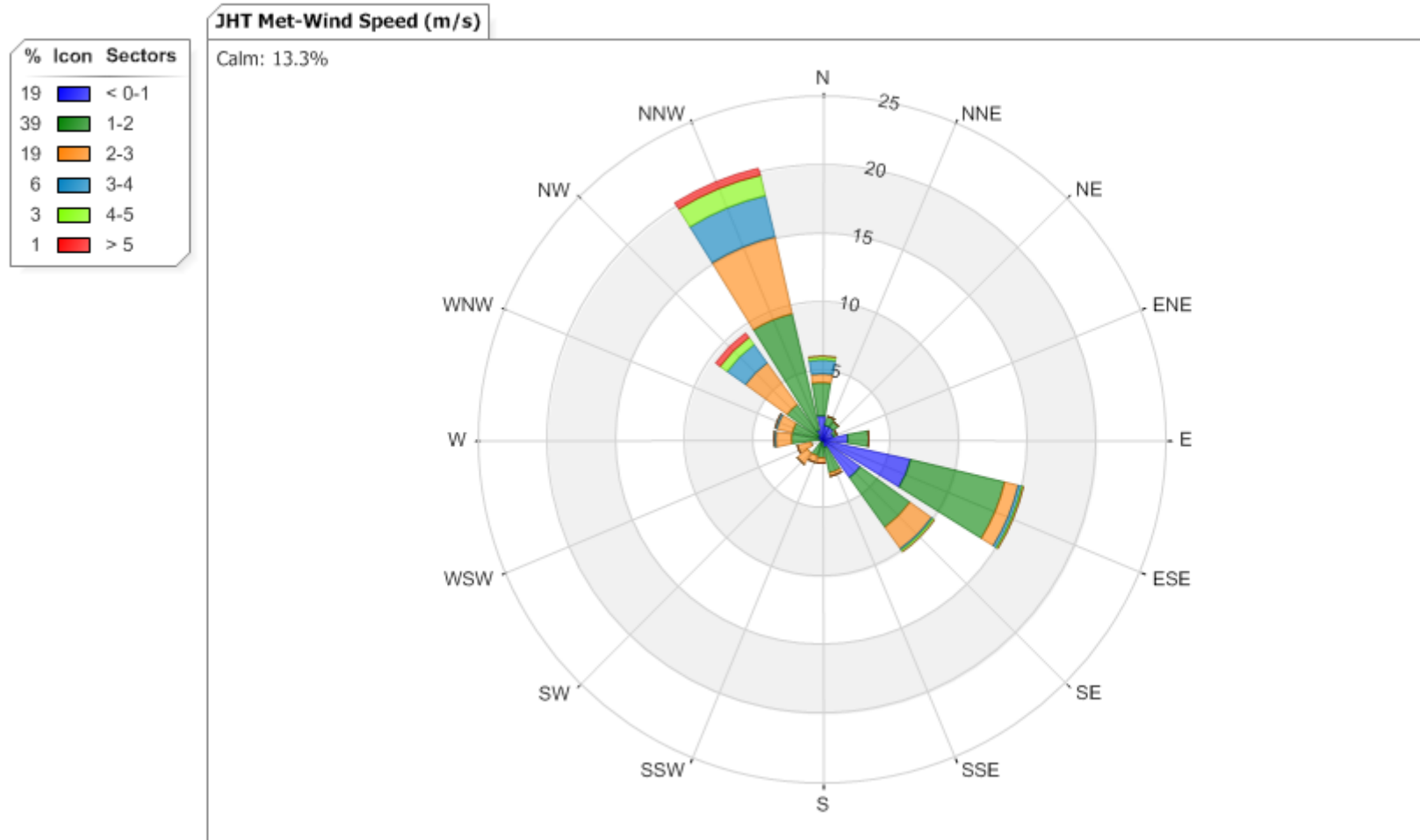


Figure 20: NZTA – Johnstone’s Hill Tunnels: Wind rose (1 hour averages)

6.5 Instrument history

CO Analyser Ecotech 9830

<i>Date</i>	<i>AQG</i>	<i>Instrument Status</i>
29/03/10	1065	Instrument installed and calibrated
24/04/10	1065	Monthly calibration and maintenance
26/05/10	1065	Monthly calibration and maintenance
23/06/10	1065	Monthly calibration and maintenance
14/07/10	1065	Instrument calibrated and site decommissioned

NO_x Analyser API 200E

<i>Date</i>	<i>AQG</i>	<i>Instrument Status</i>
29/03/10	1561	Instrument installed and calibrated
24/04/10	1561	Monthly calibration and maintenance
26/05/10	1561	Monthly calibration and maintenance
23/06/10	1561	Monthly calibration and maintenance
14/07/10	1561	Instrument calibrated and site decommissioned

Wind Sensor

<i>Date</i>	<i>AQG</i>	<i>Instrument Status</i>
29/03/10	1914	Instrument installed and calibrated
27/08/10	1914	Instrument calibrated and site decommissioned