



July 2017

BROADSPECTRUM PTY LTD

EastLink Ventilation Stack Emission Monitoring Report April - June 2017

Submitted to:
Broadspectrum Pty Ltd
EastLink Operations Centre,
2 Hillcrest Avenue,
Ringwood, 3134

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.



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REPORT



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APPENDICES

APPENDIX A

Important Information Relating to this Report



1.0 INTRODUCTION

EastLink is a 39 kilometre motorway running between Donvale in Melbourne's north-east to Frankston in Melbourne's south-east with two tunnels under the Mullum Mullum Valley. Broadspectrum Pty Ltd, who are responsible for operation and maintenance of the road, commissioned Golder Associates Pty. Ltd. to provide continuous emission monitoring services for the EastLink motorway project. The services provided include:

- Operations and maintenance services for the EastLink ventilation stack continuous emission monitoring systems (CEMS)
- NATA endorsed emission monitoring reports.

Monitoring commenced on the 29th June, 2008 with the opening of the EastLink motorway. Results for the sampling period 1st April, 2017 to 30th June, 2017 inclusive are contained in the following report.

The work was conducted under the following Broadspectrum Pty Ltd Work Order numbers:

Month	Western Stack	Eastern Stack
April	817284	817239
May	825305	825282
June	836925	836833

Your attention is drawn to the document - "Important Information Relating to this Report" (LEG04, RL2), which is included in Appendix A of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing. We would be pleased to answer any questions the reader may have regarding this document.



2.0 DISCHARGES TO AIR

EastLink has discharges to air servicing two road tunnels. Discharge Point No. 1 (DP1) services the inbound (Melba) tunnel and Discharge Point No. 2 (DP2) services the outbound (Mullum Mullum) tunnel.

The locations of the discharges to air are described in Table 1 and presented in Figure 1.

Table 1: Discharges to Air

Discharge Point No.	Station Name	Location
1	Western ventilation stack	Western end of inbound tunnel (Melba) - Donvale
2	Eastern ventilation stack	Eastern end of outbound tunnel (Mullum Mullum) – Ringwood

Monitoring equipment is housed in temperature controlled cabinets located at the base of each of the ventilation stacks. Particulate matter and gaseous sample inlets are installed inside the plenum chamber of each of the ventilation stacks.

Figure 1: Ventilation Stack Locations





3.0 VENTILATION STACK MONITORING PARAMETERS

The following parameters are monitored continuously, with averages logged at 5 minute intervals:

- Particulate matter with an equivalent aerodynamic diameter less than 2.5 microns (PM_{2.5})
- Particulate matter with an equivalent aerodynamic diameter less than 10 microns (PM₁₀)
- Total oxides of nitrogen (NO_x)
- Nitric oxide (NO)
- Nitrogen dioxide (NO₂)
- Carbon monoxide (CO)
- Stack velocity
- Stack temperature
- Ambient pressure.



4.0 METHODS

4.1 PM_{2.5}

PM_{2.5} concentrations in the tunnel ventilation stacks are determined using 1400 Series Tapered Element Oscillating Microbalance (TEOM) analysers. Sample inlets are located inside the plenum chamber of each ventilation stack.

Exhaust gas is drawn through a PM_{2.5} size selective inlet (PM₁₀ WINS head fitted with a PM_{2.5} sharp cut cyclone (SCC)) at 1 m³/h. The flow is then isokinetically split into two streams; 1 l/min stream which passes through the filter on the mass transducer and a 15.7 l/min bypass stream.

The sample stream is heated to 50°C to maintain a low and therefore relatively constant humidity.

Measurements are made in real-time (2 s intervals) with the 5 minute averages logged. 1 hour averages are then calculated from the logged data.

The PM_{2.5} monitoring method is based on the requirements of Australian Standard AS 3580.9.13, *"Methods for Sampling and Analysis of Ambient Air: Determination of Suspended Particulate Matter – PM_{2.5} Continuous Direct Mass Method Using a Tapered Element Oscillating Microbalance Monitor"*.

4.2 PM₁₀

PM₁₀ concentrations in the tunnel ventilation stacks are determined using 1400 Series Tapered Element Oscillating Microbalance (TEOM) analysers. Sample inlets are located inside the plenum chamber of each ventilation stack.

Exhaust gas is drawn through a PM₁₀ size selective inlet (PM₁₀ WINS head) at 1 m³/h. The flow is then isokinetically split into two streams; 1 l/min stream which passes through the filter on the mass transducer and a 15.7 l/min bypass stream.

The sample stream is heated to 50°C to maintain a low and therefore relatively constant humidity.

Measurements are made in real-time (2 s intervals) with the 5 minute averages logged. 1 hour averages are then calculated from the logged data.

The PM₁₀ monitoring method is based on the requirements of Australian Standard AS 3580.9.8, *"Methods for Sampling and Analysis of Ambient Air: Determination of Suspended Particulate Matter – PM₁₀ Continuous Direct Mass Method Using a Tapered Element Oscillating Microbalance Analyser"*.

4.3 Carbon Monoxide

Carbon monoxide concentrations in the tunnel ventilation stacks are determined by infra-red gas filter correlation analysers.

Automatic calibrations are carried out daily against a NATA certified reference gas mixture. Manual calibrations are conducted at one month intervals.

The carbon monoxide monitoring method is based on the requirements of Australian Standard AS 3580.7.1, *"Determination of Carbon Monoxide – Direct Reading Instrumental Method"*.

4.4 Oxides of Nitrogen

Oxides of nitrogen concentrations in the tunnel ventilation stacks are determined by chemiluminescence gas analysers.

Automatic calibrations are carried out daily against a NATA certified reference gas mixture. Manual calibrations are conducted at one month intervals.

The oxides of nitrogen (NO, NO₂ and NO_x) monitoring method is based on the requirements of Australian Standard AS 3580.5.1, *"Determination of Oxides of Nitrogen – Chemiluminescence Method"*.



4.5 Stack Velocity

Stack gas velocity was determined using an optical flow sensor that complies with USEPA Code of Federal Regulations (CFR 40) Part 75, “Continuous Emission Monitoring” requirements.

5.0 MEASUREMENT UNCERTAINTY

Table 2: Measurement Uncertainty

Parameter	Method	Estimated Uncertainty
PM ₁₀	TEOM	± 5%
PM _{2.5}	TEOM	± 5%
NO, NO ₂ , NO _x	Chemiluminescence	± 10%
CO	Infra-red gas filter correlation	± 10%
Stack velocity	Optical flow sensor	± 0.1 m/s or 5% of reading, whichever is greater
Ambient temperature	Thermocouple (TEOM)	± 2°C
Ambient pressure	TEOM pressure transducer	± 1.5%



6.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/04/2017 – 30/04/2017

6.1 Data Capture

Data capture is defined as the number of valid data periods collected divided by the number of available data periods. Valid data excludes periods where the instrument is unavailable due to calibration and maintenance and excludes periods where the data has been rejected due to quality assurance/data validation procedures.

The data capture statistics for the reporting period 1st April to 30th April, 2017 are shown in Table 3. Averages were only collected for those periods where the 5 minute data constituted 75% data capture.

Section 6.3 provides further information on the reasons for invalid data periods.

Table 3: Data Capture Statistics - 1 Hour Averages

Parameter	Station	Collected Periods	Available Periods	Data Capture
PM _{2.5}	Eastern	718	720	99.7%
	Western	718	720	99.7%
PM ₁₀	Eastern	716	720	99.4%
	Western	717	720	99.6%
NO, NO ₂	Eastern	564	720	78.3%
	Western	655	720	91.0%
CO	Eastern	687	720	95.4%
	Western	627	720	87.1%

6.2 Results

6.2.1 PM_{2.5}

PM_{2.5} (1 hour average) mass rate of emission statistics for the reporting period are given in Table 4. A plot of PM_{2.5} (1 hour average) mass rate of emission for the reporting period is presented in Figure 2.

Table 4: PM_{2.5} Mass Rate Percentiles (1 Hour Average)

Station	PM _{2.5} Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.34	0.27	0.25	0.21	0.19	0.13	0.039
Western	0.39	0.30	0.27	0.19	0.16	0.11	0.043

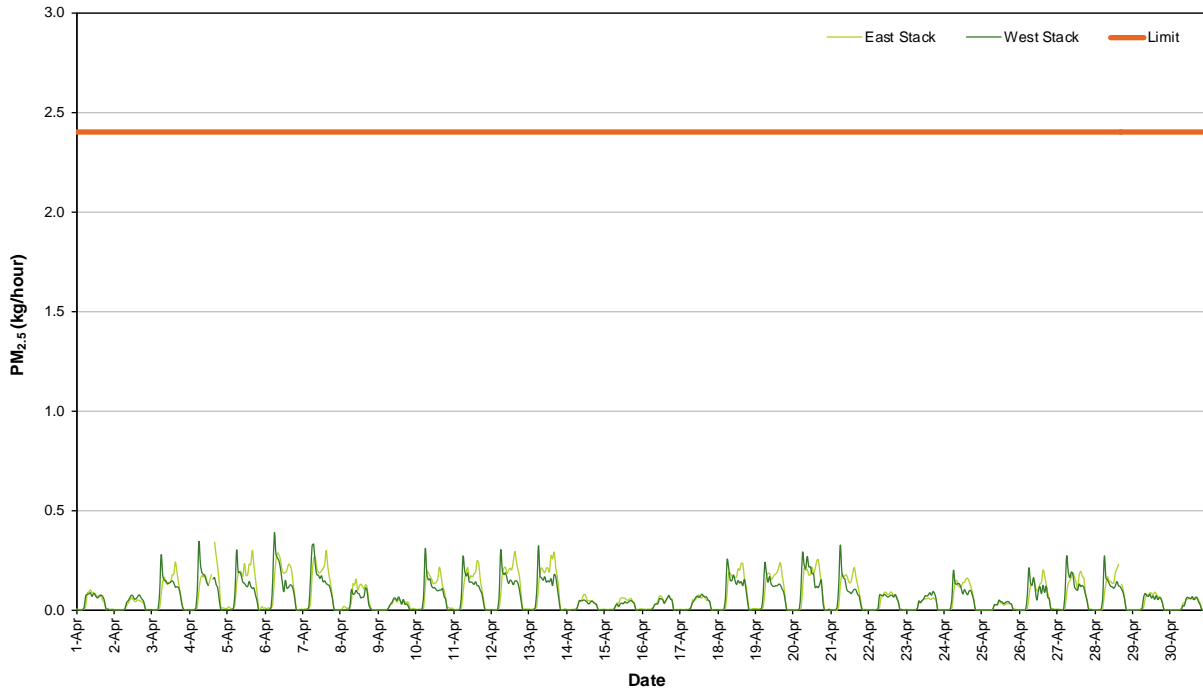


Figure 2: PM_{2.5} Mass Rate (1 Hour Average)

6.2.2 PM₁₀

PM₁₀ (1 hour average) mass rate of emission statistics for the reporting period are given in Table 5. A plot of PM₁₀ (1 hour average) mass rate of emission for the reporting period is presented in Figure 3.

Table 5: PM₁₀ Mass Rate Percentiles (1 Hour Average)

Station	PM ₁₀ Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.72	0.53	0.44	0.38	0.33	0.20	0.055
Western	1.1	0.56	0.45	0.33	0.26	0.19	0.072

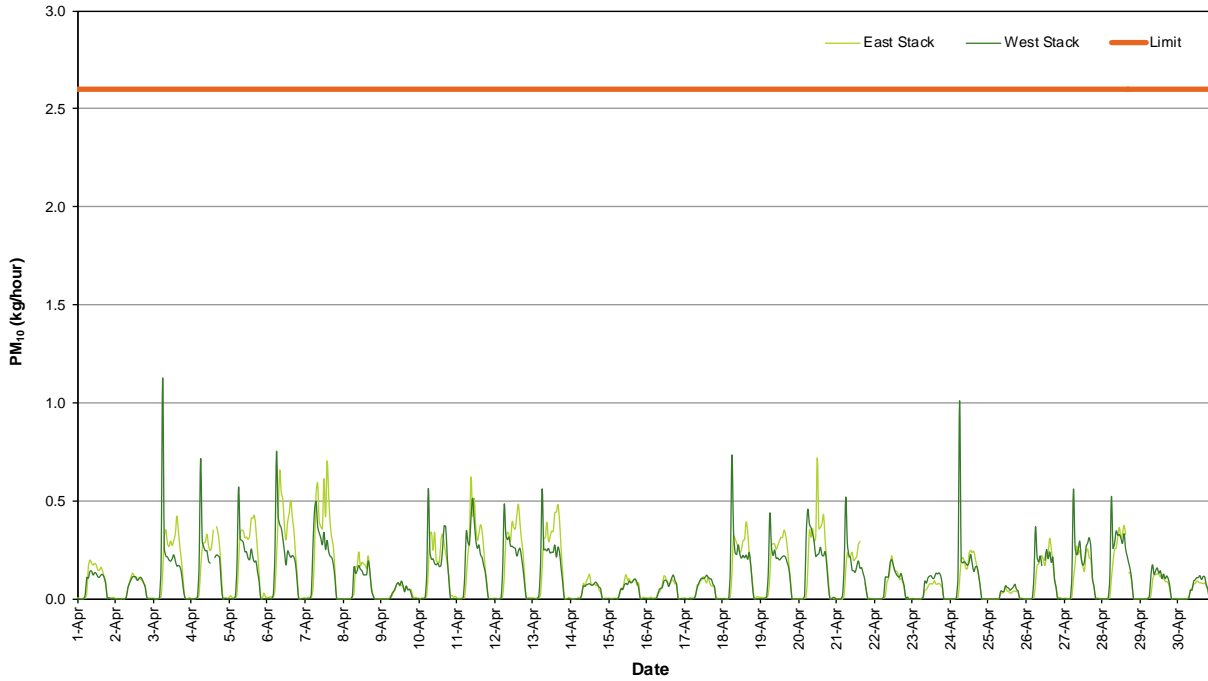


Figure 3: PM₁₀ Mass Rate (1 Hour Average)

6.2.3 Carbon Monoxide

Carbon monoxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 6. A plot of carbon monoxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 4.

Table 6: Carbon Monoxide Mass Rate Percentiles (1 Hour Average)

Station	Carbon Monoxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	16	14	13	12	9.4	7.1	4.7
Western	16	14	12	10	8.7	7.1	5.0

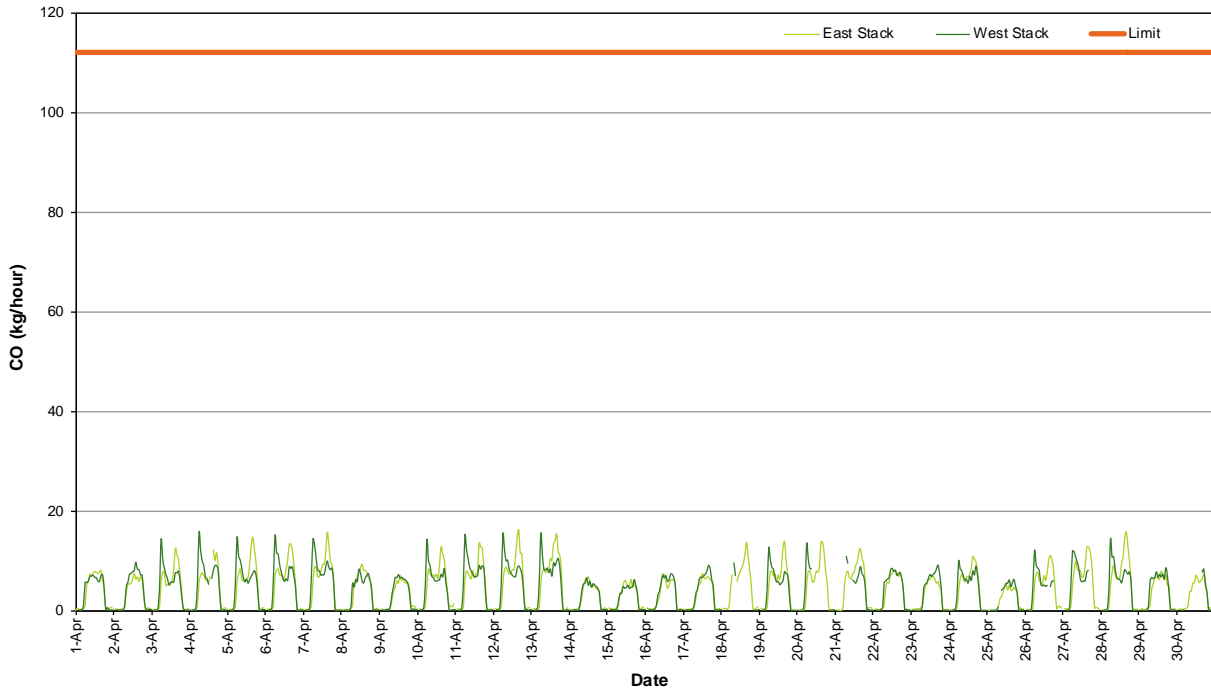


Figure 4: Carbon Monoxide Mass Rate (1 Hour Average)

6.2.4 Oxides of Nitrogen

6.2.4.1 Nitric Oxide

Nitric oxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 7. A plot of nitric oxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 5.

Table 7: Nitric Oxide Mass Rate Percentiles (1 Hour Average)

Station	Nitric Oxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	5.0	4.2	4.0	3.6	3.3	2.6	1.0
Western	5.7	4.9	4.0	3.0	2.6	2.0	1.0

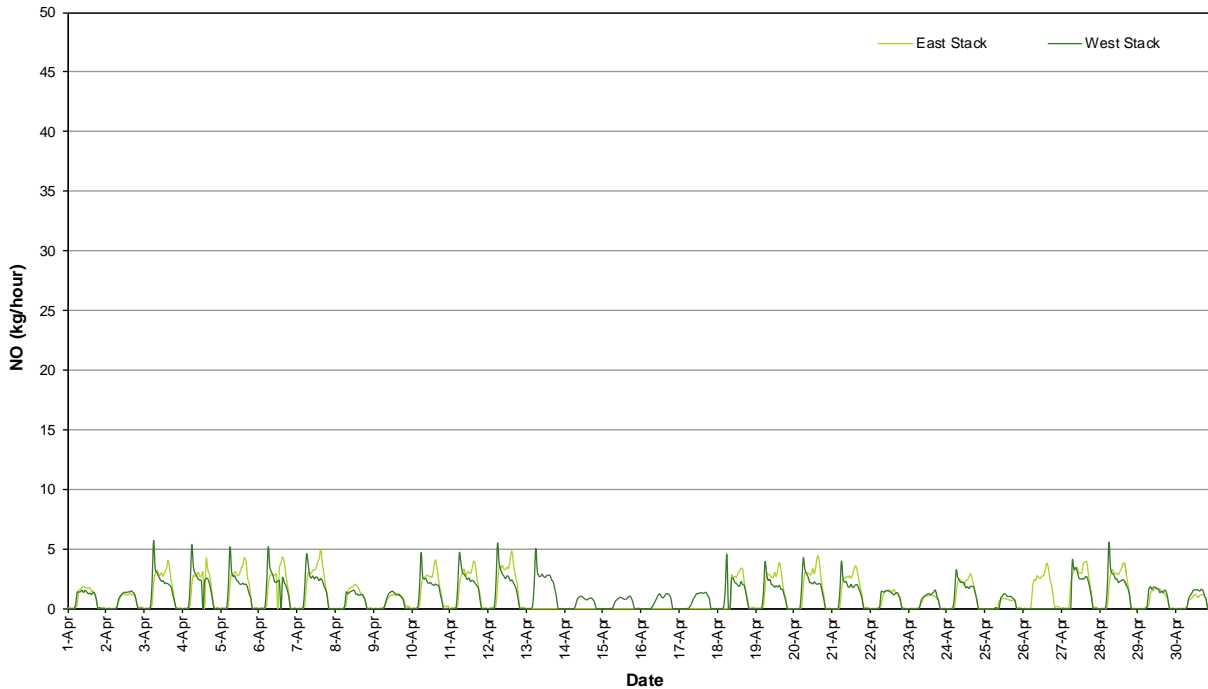


Figure 5: Nitric Oxide Mass Rate (1 Hour Average)

6.2.4.2 Nitrogen Dioxide

Nitrogen dioxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 8. A plot of nitrogen dioxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 6.

Table 8: Nitrogen Dioxide Mass Rate Percentiles (1 Hour Average)

Station	Nitrogen Dioxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	1.1	1.0	0.92	0.82	0.66	0.51	0.24
Western	1.1	1.0	0.78	0.58	0.52	0.42	0.22

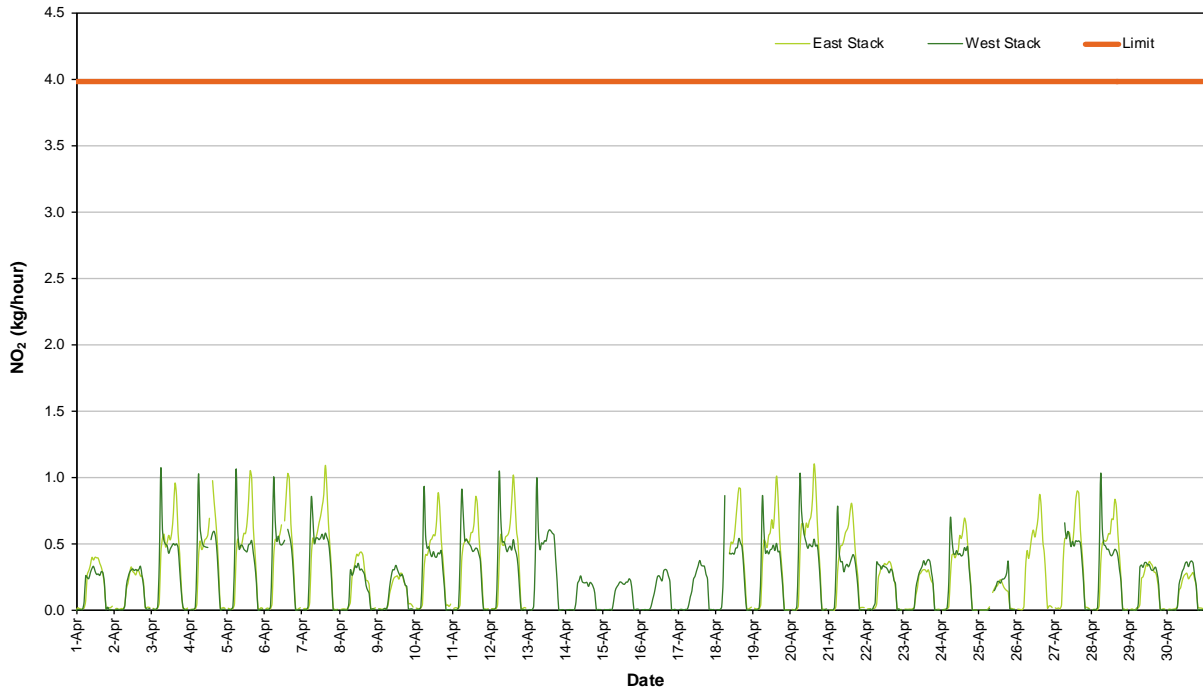


Figure 6: Nitrogen Dioxide Mass Rate (1 Hour Average)

6.2.5 Stack Velocity

The stack velocity (1 hour average) plot for the reporting period is presented in Figure 7.

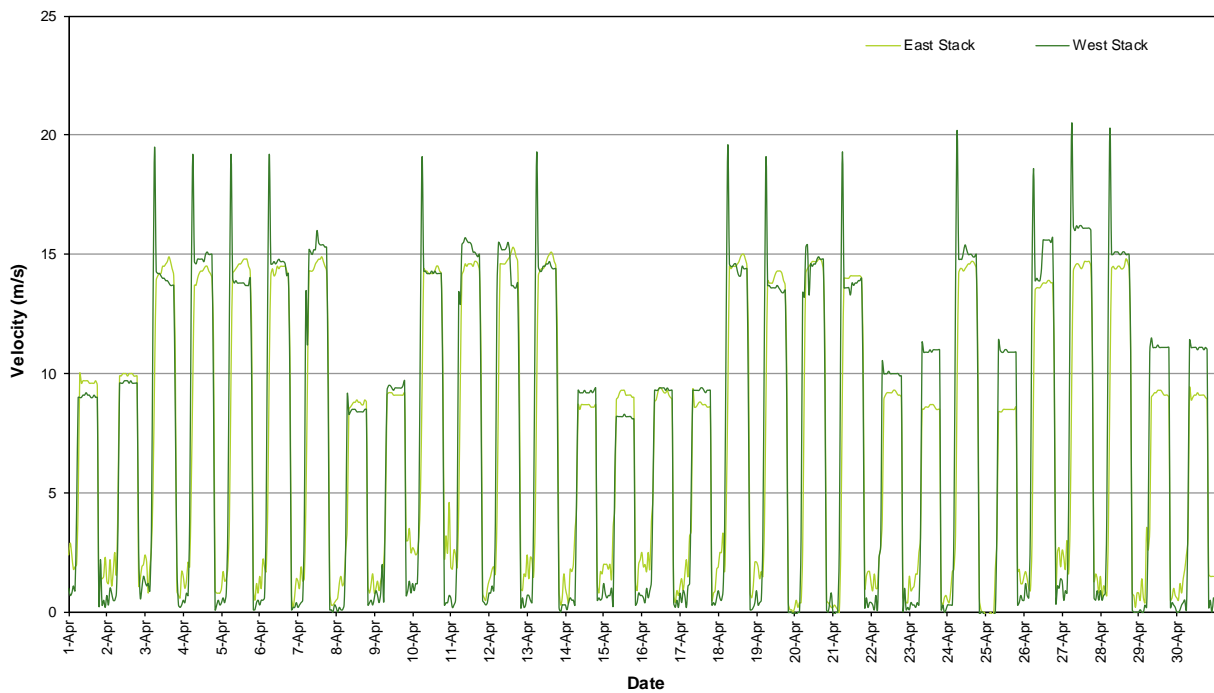


Figure 7: Stack Velocity (1 Hour Average)



6.3 Data Validation and Exceptions

Data contained in the report has been validated against performance and calibration requirements for each instrument. Data during maintenance and calibration periods has been removed from the validated data sets. Tables 9 and 10 list the data exceptions for the eastern and western ventilation stacks respectively. Data during automatic calibrations of the gaseous atmospheric contaminants has also been removed from the data sets.

Table 9: Data Exceptions - Eastern Ventilation Stack: April 2017

Start	End	Parameter	Reason
4/04/2017 14:25	4/04/2017 14:45	CO	Maintenance/ calibration
4/04/2017 14:25	4/04/2017 14:45	NO, NO ₂ , NO _x	Maintenance/ calibration
4/04/2017 14:50	4/04/2017 15:25	PM _{2.5}	Maintenance/ calibration
4/04/2017 14:55	4/04/2017 15:30	PM ₁₀	Maintenance/ calibration
6/04/2017 12:10	6/04/2017 12:55	NO, NO ₂ , NO _x	Maintenance/ calibration
8/04/2017 20:45	8/04/2017 20:50	PM ₁₀	Invalid data ¹
8/04/2017 20:45	8/04/2017 20:50	PM _{2.5}	Invalid data ¹
9/04/2017 21:30	9/04/2017 21:30	PM ₁₀	Invalid data ¹
9/04/2017 21:50	9/04/2017 21:50	PM ₁₀	Invalid data ¹
13/04/2017 01:00	18/04/2017 08:35	NO, NO ₂ , NO _x	Invalid data – span drift
14/04/2017 02:45	14/04/2017 02:50	PM ₁₀	Invalid data ¹
14/04/2017 06:55	14/04/2017 07:00	PM ₁₀	Invalid data ¹
15/04/2017 22:00	15/04/2017 22:05	PM ₁₀	Invalid data ¹
16/04/2017 02:25	16/04/2017 02:25	PM ₁₀	Invalid data ¹
16/04/2017 02:50	16/04/2017 02:50	PM ₁₀	Invalid data ¹
16/04/2017 03:25	16/04/2017 03:30	PM ₁₀	Invalid data ¹
17/04/2017 01:30	17/04/2017 01:35	PM ₁₀	Invalid data ¹
17/04/2017 04:40	17/04/2017 04:45	PM ₁₀	Invalid data ¹
17/04/2017 05:55	17/04/2017 06:00	PM ₁₀	Invalid data ¹
18/04/2017 08:40	18/04/2017 09:25	CO	Maintenance/ calibration
21/04/2017 11:40	21/04/2017 11:45	PM ₁₀	Invalid data ¹
21/04/2017 16:25	21/04/2017 17:55	PM ₁₀	Invalid data ¹
25/04/2017 07:40	25/04/2017 07:50	PM ₁₀	Invalid data ¹
25/04/2017 08:35	25/04/2017 09:10	NO, NO ₂ , NO _x	Maintenance/ calibration
26/04/2017 05:40	26/04/2017 05:50	PM ₁₀	Invalid data ¹
26/04/2017 05:45	26/04/2017 05:45	PM _{2.5}	Invalid data ¹
26/04/2017 10:45	26/04/2017 10:45	PM _{2.5}	Invalid data ¹



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26/04/2017 10:50	26/04/2017 10:50	PM ₁₀	Invalid data ¹
28/04/2017 16:30	28/04/2017 17:05	PM ₁₀	Maintenance/ calibration
28/04/2017 16:30	28/04/2017 17:00	PM _{2.5}	Maintenance/ calibration

Notes: ¹ – In the opinion of the reviewer

Table 10: Data Exceptions - Western Ventilation Stack: April 2017

Start	End	Parameter	Reason
4/04/2017 13:10	4/04/2017 13:40	NO, NO ₂ , NO _x	Maintenance/ calibration
4/04/2017 13:35	4/04/2017 14:40	PM _{2.5}	Maintenance/ calibration
4/04/2017 13:40	4/04/2017 14:15	PM ₁₀	Maintenance/ calibration
6/04/2017 13:50	6/04/2017 14:20	NO, NO ₂ , NO _x	Maintenance/ calibration
8/04/2017 20:45	8/04/2017 20:50	PM _{2.5}	Invalid data ¹
8/04/2017 21:35	8/04/2017 21:40	PM _{2.5}	Invalid data ¹
9/04/2017 20:15	9/04/2017 20:25	PM _{2.5}	Invalid data ¹
9/04/2017 20:20	9/04/2017 20:30	PM ₁₀	Invalid data ¹
10/04/2017 01:45	10/04/2017 01:55	PM _{2.5}	Invalid data ¹
18/04/2017 02:40	18/04/2017 07:20	CO	Invalid data ²
18/04/2017 07:35	18/04/2017 08:25	NO, NO ₂ , NO _x	Maintenance/ calibration
18/04/2017 07:40	18/04/2017 07:40	CO	Invalid data ²
18/04/2017 08:50	18/04/2017 08:50	CO	Invalid data ²
18/04/2017 09:45	18/04/2017 20:30	CO	Invalid data ²
20/04/2017 10:10	20/04/2017 20:30	CO	Invalid data ²
20/04/2017 20:55	20/04/2017 20:55	CO	Invalid data ²
20/04/2017 21:10	20/04/2017 21:15	CO	Invalid data ²
20/04/2017 22:10	20/04/2017 22:15	CO	Invalid data ²
21/04/2017 02:10	21/04/2017 02:10	CO	Invalid data ²
21/04/2017 02:25	21/04/2017 06:30	CO	Invalid data ²
21/04/2017 09:30	21/04/2017 10:25	CO	Maintenance/ calibration
25/04/2017 07:40	25/04/2017 07:50	PM _{2.5}	Invalid data ¹
25/04/2017 07:40	25/04/2017 07:50	PM ₁₀	Invalid data ¹
25/04/2017 08:35	25/04/2017 09:15	NO, NO ₂ , NO _x	Maintenance/ calibration
25/04/2017 08:35	25/04/2017 09:05	CO	Maintenance/ calibration
25/04/2017 15:00	25/04/2017 15:00	CO	Invalid data ²



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25/04/2017 15:10	25/04/2017 15:10	CO	Invalid data ²
26/04/2017 01:00	27/04/2017 06:25	NO, NO ₂ , NO _x	Invalid data ²
26/04/2017 11:00	26/04/2017 11:05	PM _{2.5}	Invalid data ²
26/04/2017 11:05	26/04/2017 11:25	PM ₁₀	Invalid data ²
26/04/2017 14:25	26/04/2017 14:25	CO	Invalid data ²
26/04/2017 14:45	26/04/2017 14:45	CO	Invalid data ²
26/04/2017 15:05	26/04/2017 15:25	CO	Invalid data ²
26/04/2017 16:00	26/04/2017 16:05	CO	Invalid data ²
26/04/2017 16:50	26/04/2017 16:50	CO	Invalid data ²
26/04/2017 18:05	26/04/2017 18:05	CO	Invalid data ²
26/04/2017 18:50	26/04/2017 18:50	CO	Invalid data ²
26/04/2017 19:35	27/04/2017 06:15	CO	Invalid data ²
27/04/2017 06:45	27/04/2017 06:45	CO	Invalid data ²
27/04/2017 17:00	27/04/2017 23:55	CO	Invalid data ²
28/04/2017 13:50	28/04/2017 14:05	CO	Invalid data ²
28/04/2017 14:55	28/04/2017 14:55	CO	Invalid data ²
30/04/2017 04:45	30/04/2017 15:20	CO	Invalid data ²
30/04/2017 16:00	30/04/2017 16:05	CO	Invalid data ²
30/04/2017 20:30	30/04/2017 20:30	CO	Invalid data ²
30/04/2017 21:05	30/04/2017 21:05	CO	Invalid data ²

Notes: 1 – In the opinion of the reviewer
2 – Signal intensity out of specification

A number periods occurred where PM_{2.5} concentrations were greater than the corresponding PM₁₀ concentrations. If no valid reason was found to exclude the data, the data was left unchanged in the data set. Examples of such occurrences are listed below:

- East Ventilation stack 6/05/2017 07:50 – 14:00
- East Ventilation stack 9/05/2017 19:30 – 23:55



7.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/05/2017 – 31/05/2017

7.1 Data Capture

Data capture is defined as the number of valid data periods collected divided by the number of available data periods. Valid data excludes periods where the instrument is unavailable due to calibration and maintenance and excludes periods where the data has been rejected due to quality assurance/data validation procedures.

The data capture statistics for the reporting period 1st May to 31st May, 2017 are shown in Table 11. Averages were only collected for those periods where the 5 minute data constituted 75% data capture.

Section 7.3 provides further information on the reasons for invalid data periods.

Table 11: Data Capture Statistics - 1 Hour Averages

Parameter	Station	Collected Periods	Available Periods	Data Capture
PM _{2.5}	Eastern	743	744	99.9%
	Western	741	744	99.6%
PM ₁₀	Eastern	743	744	99.9%
	Western	740	744	99.5%
NO, NO ₂	Eastern	712	744	95.7%
	Western	678	744	91.1%
CO	Eastern	712	744	95.7%
	Western	677	744	91.0%

7.2 Results

7.2.1 PM_{2.5}

PM_{2.5} (1 hour average) mass rate of emission statistics for the reporting period are given in Table 12. A plot of PM_{2.5} (1 hour average) mass rate of emission for the reporting period is presented in Figure 8.

Table 12: PM_{2.5} Mass Rate Percentiles (1 Hour Average)

Station	PM _{2.5} Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.29	0.25	0.24	0.22	0.19	0.16	0.057
Western	0.36	0.26	0.23	0.17	0.15	0.11	0.056

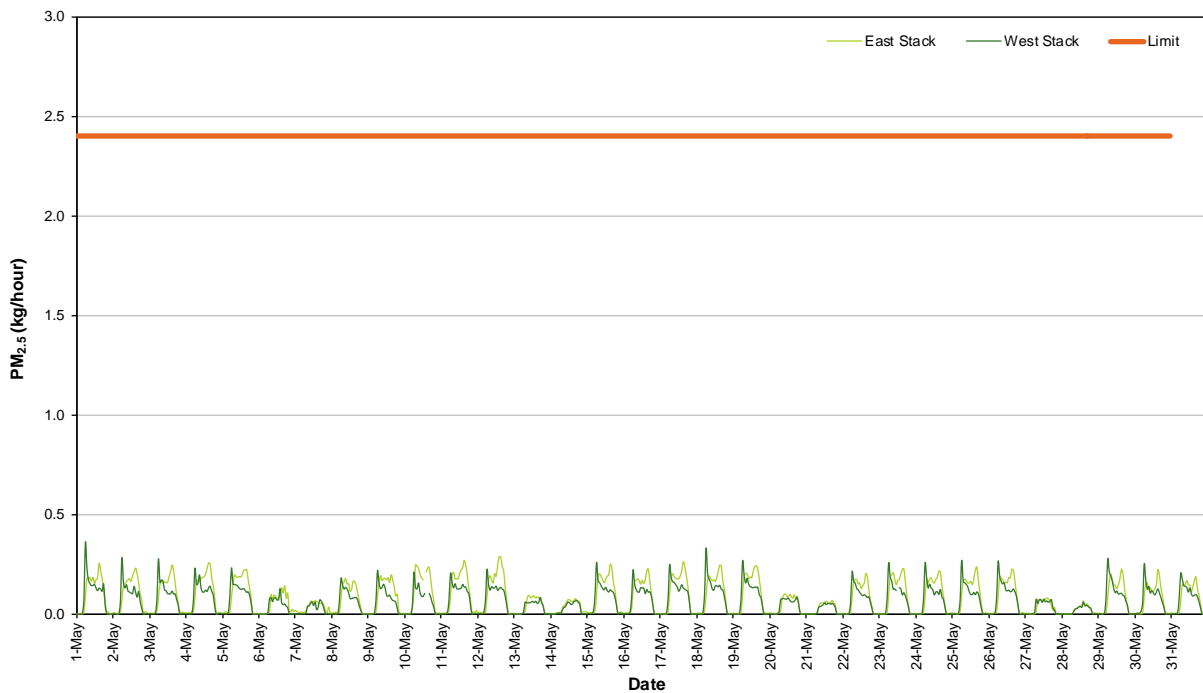


Figure 8: PM_{2.5} Mass Rate (1 Hour Average)

7.2.2 PM₁₀

PM₁₀ (1 hour average) mass rate of emission statistics for the reporting period are given in Table 13. A plot of PM₁₀ (1 hour average) mass rate of emission for the reporting period is presented in Figure 9.

Table 13: PM₁₀ Mass Rate Percentiles (1 Hour Average)

Station	PM ₁₀ Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.59	0.46	0.44	0.40	0.37	0.29	0.098
Western	1.0	0.59	0.50	0.33	0.28	0.22	0.10

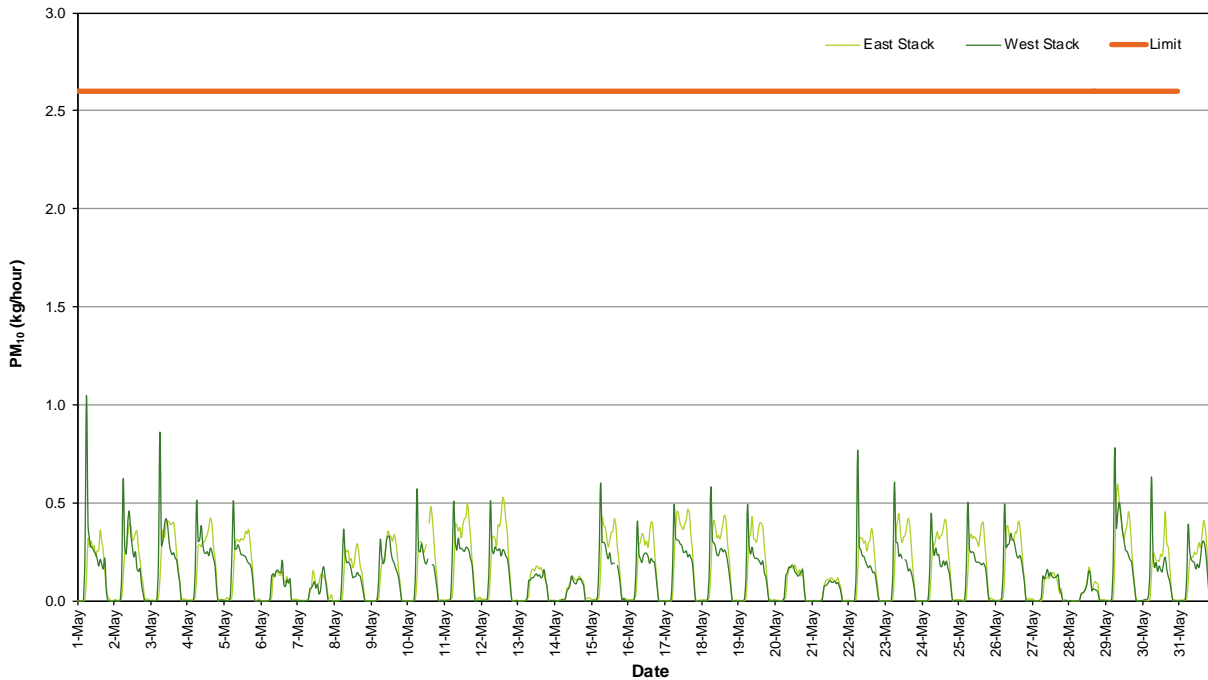


Figure 9: PM₁₀ Mass Rate (1 Hour Average)

7.2.3 Carbon Monoxide

Carbon monoxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 14. A plot of carbon monoxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 10.

Table 14: Carbon Monoxide Mass Rate Percentiles (1 Hour Average)

Station	Carbon Monoxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	15	14	14	13	10	7.6	5.6
Western	17	13	11	9.7	8.4	6.2	4.2

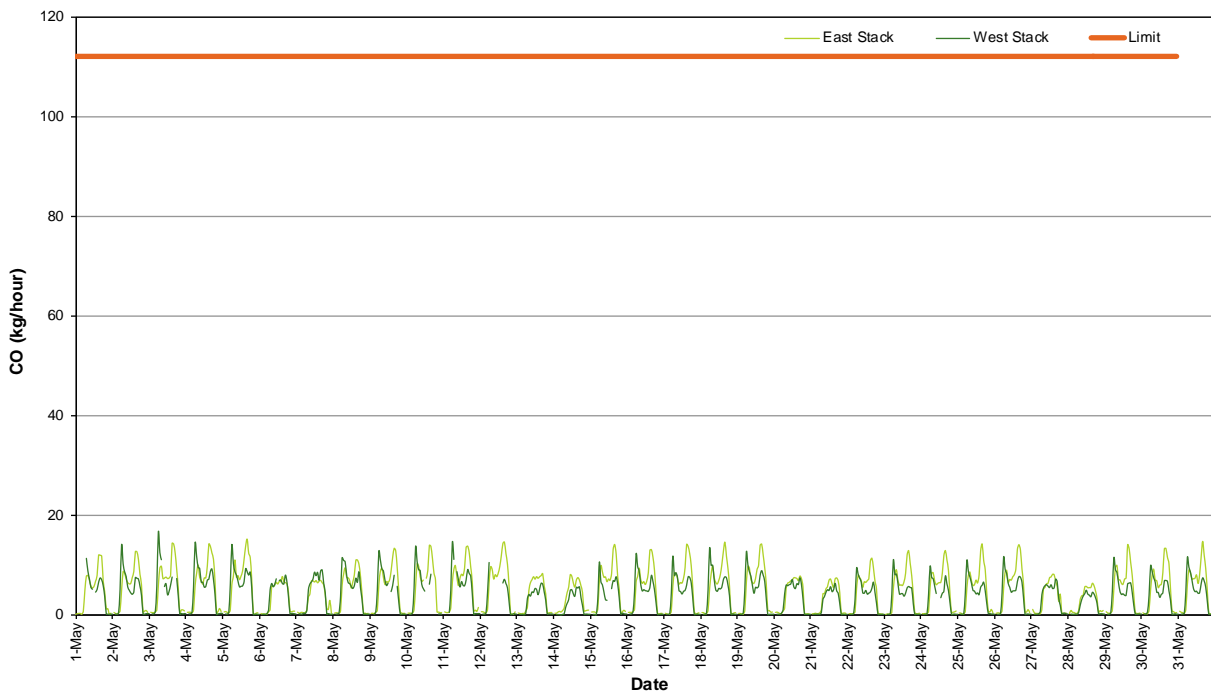


Figure 10: Carbon Monoxide Mass Rate (1 Hour Average)

7.2.4 Oxides of Nitrogen

7.2.4.1 Nitric Oxide

Nitric oxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 15. A plot of nitric oxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 11.

Table 15: Nitric Oxide Mass Rate Percentiles (1 Hour Average)

Station	Nitric Oxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	4.7	4.4	4.2	3.9	3.6	3.1	1.2
Western	6.5	5.6	5.2	3.6	3.1	2.4	1.4

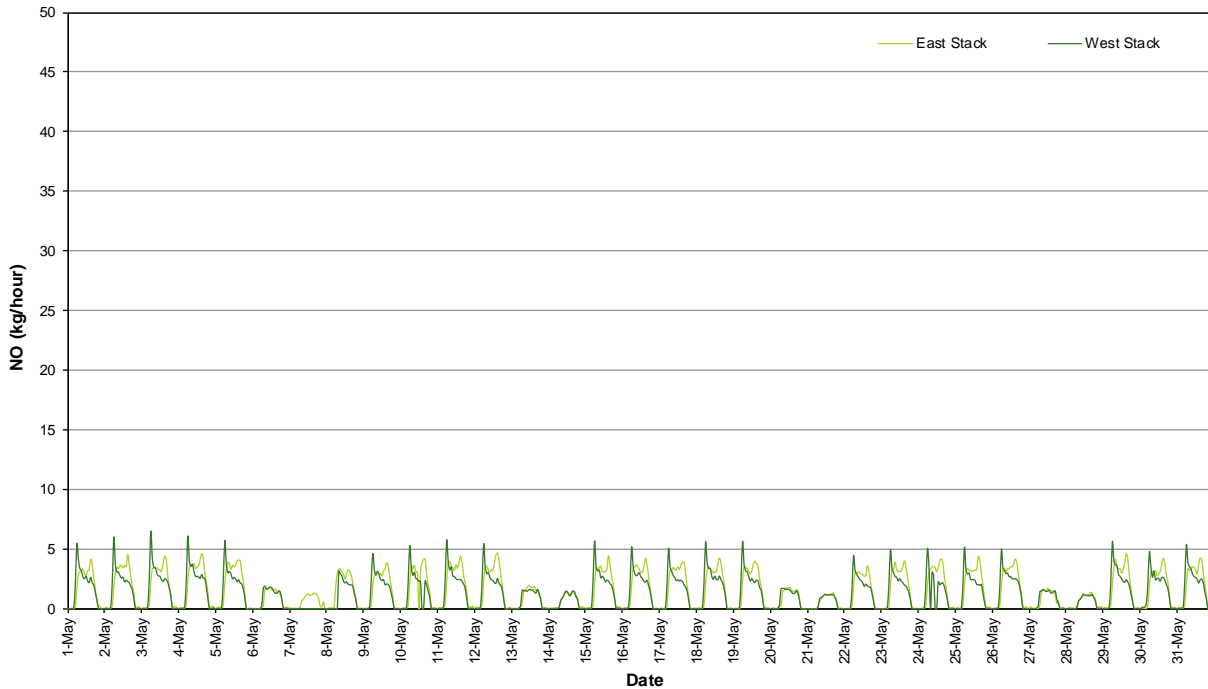


Figure 11: Nitric Oxide Mass Rate (1 Hour Average)

7.2.4.2 Nitrogen Dioxide

Nitrogen dioxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 16. A plot of nitrogen dioxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 12.

Table 16: Nitrogen Dioxide Mass Rate Percentiles (1 Hour Average)

Station	Nitrogen Dioxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	1.0	0.92	0.89	0.81	0.66	0.54	0.27
Western	1.2	1.0	0.97	0.65	0.53	0.46	0.29

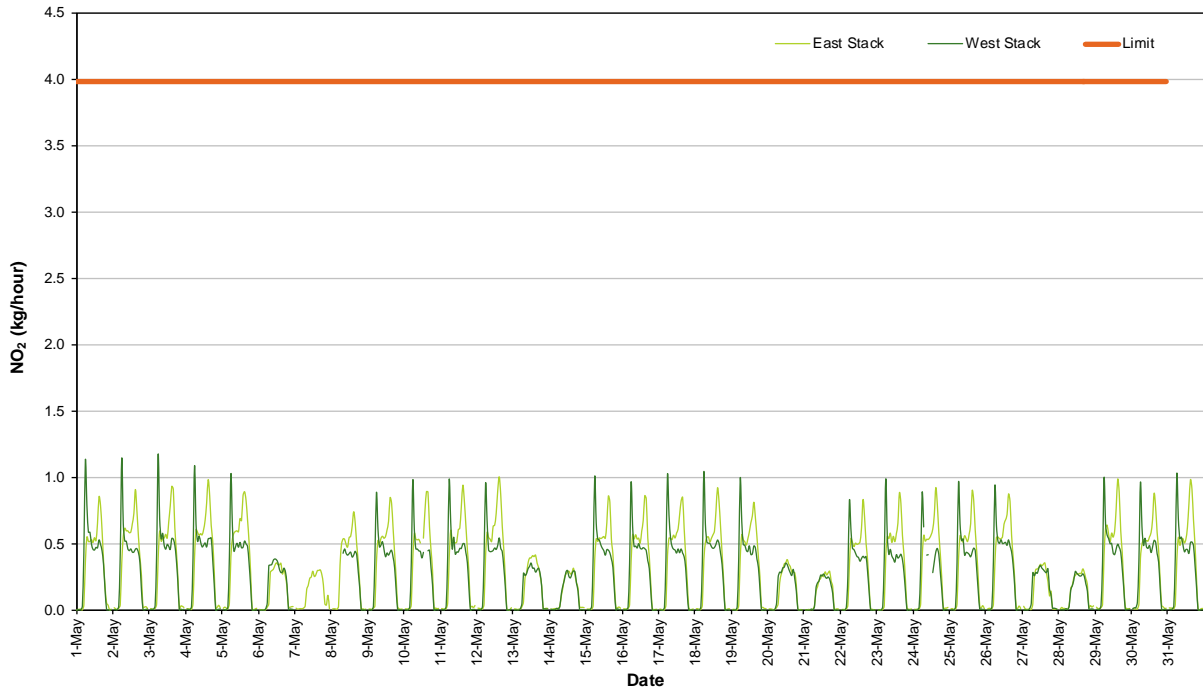


Figure 12: Nitrogen Dioxide Mass Rate (1 Hour Average)

7.2.5 Stack Velocity

The stack velocity (1 hour average) plot for the reporting period is presented in Figure 13.

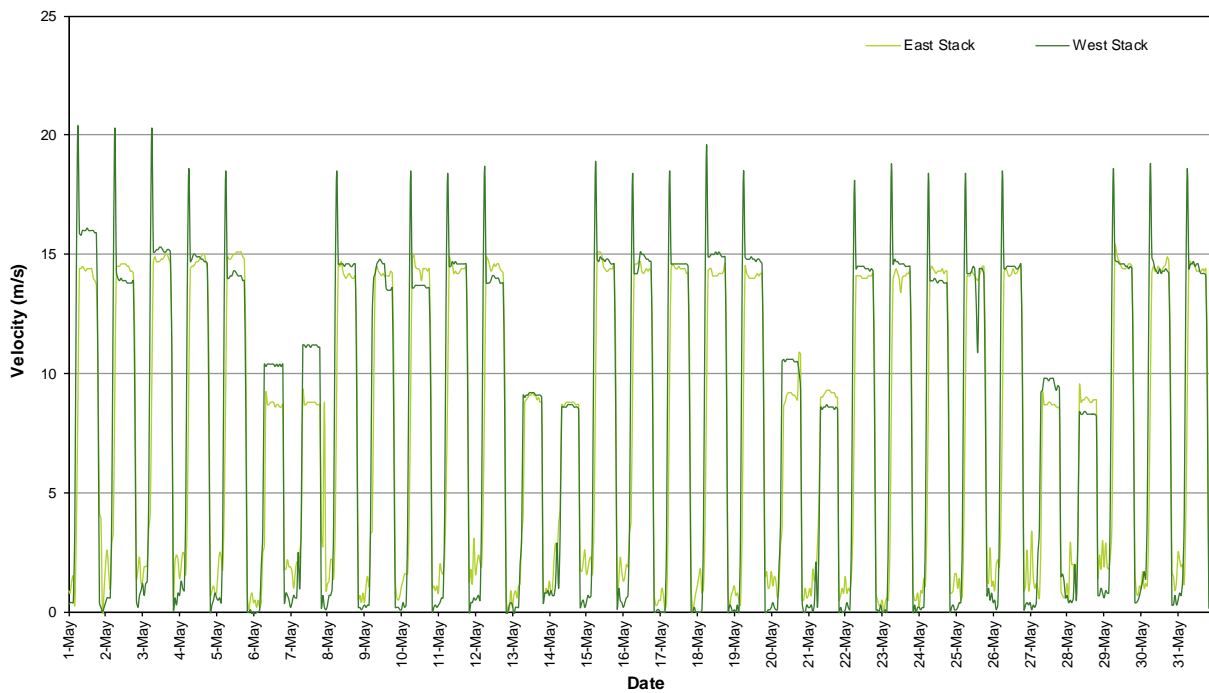


Figure 13: Stack Velocity (1 Hour Average)



7.3 Data Validation and Exceptions

Data contained in the report has been validated against performance and calibration requirements for each instrument. Data during maintenance and calibration periods has been removed from the validated data sets. Tables 17 and 18 list the data exceptions for the eastern and western ventilation stacks respectively. Data during automatic calibrations of the gaseous atmospheric contaminants has also been removed from the data sets.

Table 17: Data Exceptions - Eastern Ventilation Stack: May 2017

Start	End	Parameter	Reason
10/05/2017 12:15	10/05/2017 12:45	NO, NO ₂ , NO _x	Maintenance/ calibration
10/05/2017 12:15	10/05/2017 12:45	CO	Maintenance/ calibration
10/05/2017 12:45	10/05/2017 13:40	PM _{2.5}	Maintenance/ calibration
10/05/2017 12:45	10/05/2017 13:20	PM ₁₀	Maintenance/ calibration

Table 18: Data Exceptions - Western Ventilation Stack: May 2017

Start	End	Parameter	Reason
1/05/2017 01:00	1/05/2017 06:50	CO	Invalid data ²
1/05/2017 12:10	1/05/2017 12:25	CO	Invalid data ²
3/05/2017 09:35	3/05/2017 09:50	CO	Invalid data ²
3/05/2017 13:20	3/05/2017 13:20	CO	Invalid data ²
3/05/2017 13:50	3/05/2017 13:50	CO	Invalid data ²
3/05/2017 14:25	3/05/2017 14:25	CO	Invalid data ²
3/05/2017 16:40	3/05/2017 18:10	CO	Invalid data ²
6/05/2017 12:10	6/05/2017 12:45	CO	Invalid data ²
7/05/2017 01:00	8/05/2017 07:25	NO, NO ₂ , NO _x	Invalid data – span drift
9/05/2017 11:30	9/05/2017 11:35	CO	Invalid data ²
9/05/2017 13:40	9/05/2017 13:55	CO	Invalid data ²
9/05/2017 14:55	9/05/2017 15:00	CO	Invalid data ²
9/05/2017 17:20	9/05/2017 17:45	CO	Invalid data ²
10/05/2017 13:35	10/05/2017 14:55	CO	Maintenance/ calibration
10/05/2017 13:45	10/05/2017 15:15	NO, NO ₂ , NO _x	Maintenance/ calibration
10/05/2017 14:25	10/05/2017 15:15	PM _{2.5}	Maintenance/ calibration
10/05/2017 14:30	10/05/2017 15:30	PM ₁₀	Maintenance/ calibration
10/05/2017 15:30	10/05/2017 15:30	CO	Invalid data ²
10/05/2017 16:55	10/05/2017 17:00	CO	Invalid data ²
10/05/2017 17:25	10/05/2017 17:25	CO	Invalid data ²
10/05/2017 17:35	10/05/2017 17:40	CO	Invalid data ²
10/05/2017 18:30	10/05/2017 20:25	CO	Invalid data ²



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10/05/2017 23:55	10/05/2017 23:55	CO	Invalid data ²
11/05/2017 01:00	11/05/2017 03:45	CO	Invalid data ²
11/05/2017 08:30	11/05/2017 08:55	CO	Maintenance/ calibration
12/05/2017 06:50	12/05/2017 14:15	CO	Invalid data ²
15/05/2017 12:15	15/05/2017 13:30	CO	Maintenance/ calibration
15/05/2017 12:30	15/05/2017 12:30	NO, NO ₂ , NO _x	Missing data
15/05/2017 12:30	15/05/2017 12:30	PM _{2.5}	Missing data
15/05/2017 12:30	15/05/2017 12:30	PM ₁₀	Missing data
15/05/2017 12:30	15/05/2017 12:30	Velocity	Missing data
15/05/2017 15:55	15/05/2017 16:15	PM ₁₀	Invalid data ¹
23/05/2017 07:25	23/05/2017 07:35	NO, NO ₂ , NO _x	Maintenance/ calibration
23/05/2017 12:35	23/05/2017 13:10	PM _{2.5}	Maintenance/ calibration
23/05/2017 12:35	23/05/2017 12:55	PM ₁₀	Maintenance/ calibration
24/05/2017 08:00	24/05/2017 08:15	NO, NO ₂ , NO _x	Maintenance/ calibration
24/05/2017 08:00	24/05/2017 08:10	CO	Maintenance/ calibration
24/05/2017 10:55	24/05/2017 12:40	NO, NO ₂ , NO _x	Maintenance/ calibration
24/05/2017 10:55	24/05/2017 12:25	CO	Maintenance/ calibration

A number of periods occurred where PM_{2.5} concentrations were greater than the corresponding PM₁₀ concentrations. If no valid reason was found to exclude the data, the data was left unchanged in the data set. Examples of such occurrences are listed below:

- West Ventilation stack 22/06/2017 18:55 – 19:05
- West Ventilation stack 30/06/2017 17:20 – 17:35



8.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/06/2017 – 30/06/2017

8.1 Data Capture

Data capture is defined as the number of valid data periods collected divided by the number of available data periods. Valid data excludes periods where the instrument is unavailable due to calibration and maintenance and excludes periods where the data has been rejected due to quality assurance/data validation procedures.

The data capture statistics for the reporting period 1st June to 30th June, 2017 are shown in Table 19. Averages were only collected for those periods where the 5 minute data constituted 75% data capture.

Section 8.3 provides further information on the reasons for invalid data periods.

Table 20: Data Capture Statistics - 1 Hour Averages

Parameter	Station	Collected Periods	Available Periods	Data Capture
PM _{2.5}	Eastern	666	720	92.5%
	Western	684	720	95.0%
PM ₁₀	Eastern	696	720	96.7%
	Western	636	720	88.3%
NO, NO ₂	Eastern	688	720	95.6%
	Western	652	720	90.6%
CO	Eastern	690	720	95.8%
	Western	689	720	95.7%

8.2 Results

8.2.1 PM_{2.5}

PM_{2.5} (1 hour average) mass rate of emission statistics for the reporting period are given in Table 20. A plot of PM_{2.5} (1 hour average) mass rate of emission for the reporting period is presented in Figure 14.

Table 21: PM_{2.5} Mass Rate Percentiles (1 Hour Average)

Station	PM _{2.5} Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.23	0.21	0.20	0.17	0.15	0.11	0.041
Western	0.39	0.26	0.23	0.19	0.15	0.10	0.046

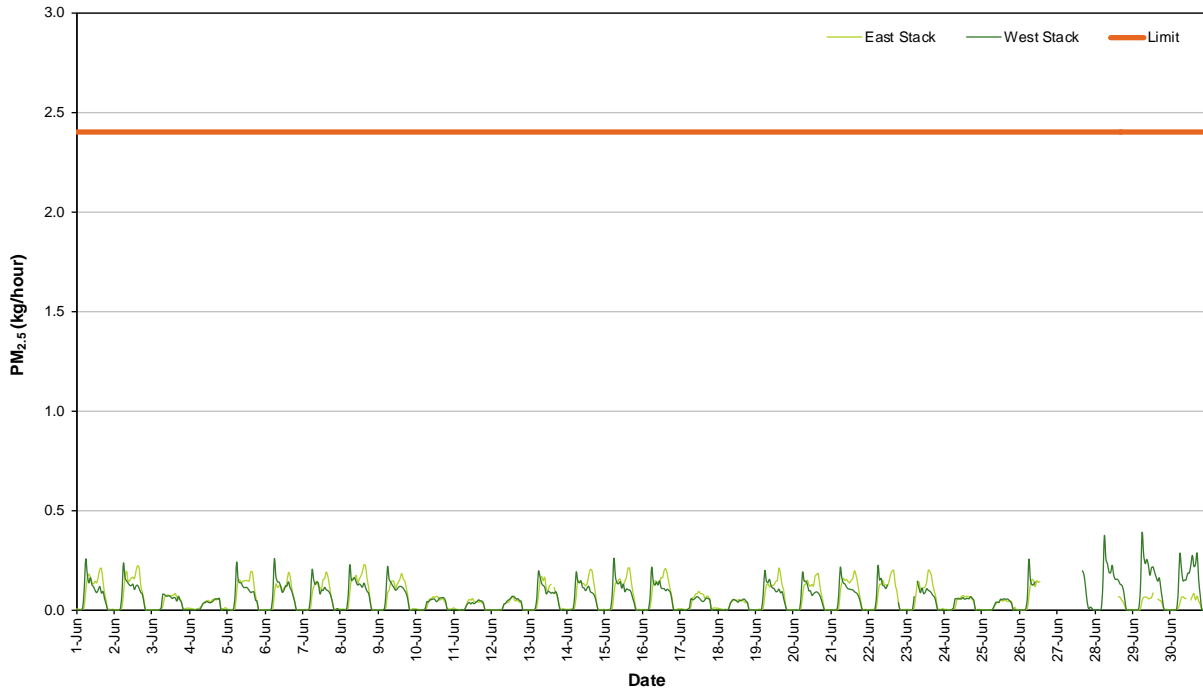


Figure 14: PM_{2.5} Mass Rate (1 Hour Average)

8.2.2 PM₁₀

PM₁₀ (1 hour average) mass rate of emission statistics for the reporting period are given in Table 21. A plot of PM₁₀ (1 hour average) mass rate of emission for the reporting period is presented in Figure 15.

Table 22: PM₁₀ Mass Rate Percentiles (1 Hour Average)

Station	PM ₁₀ Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.53	0.46	0.44	0.38	0.33	0.25	0.087
Western	0.78	0.53	0.44	0.30	0.26	0.18	0.097

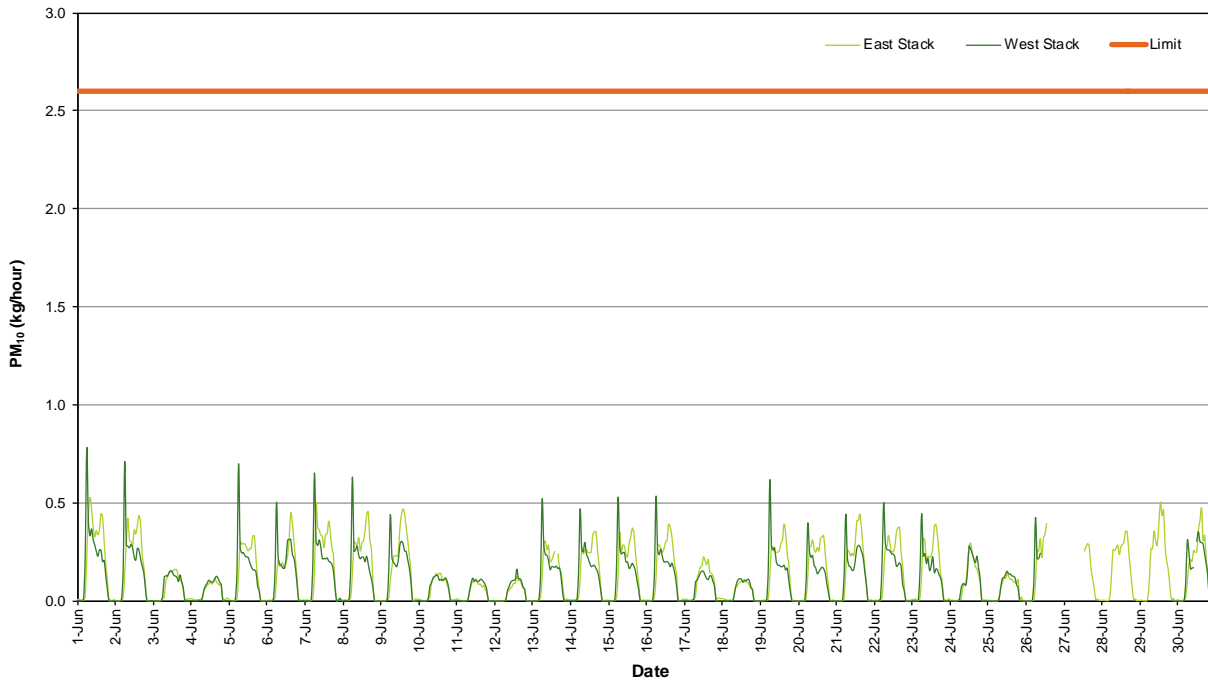


Figure 15: PM₁₀ Mass Rate (1 Hour Average)

8.2.3 Carbon Monoxide

Carbon monoxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 22. A plot of carbon monoxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 16.

Table 23: Carbon Monoxide Mass Rate Percentiles (1 Hour Average)

Station	Carbon Monoxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	15	14	14	13	10	8.0	5.6
Western	13	13	12	9.4	7.9	6.1	4.6

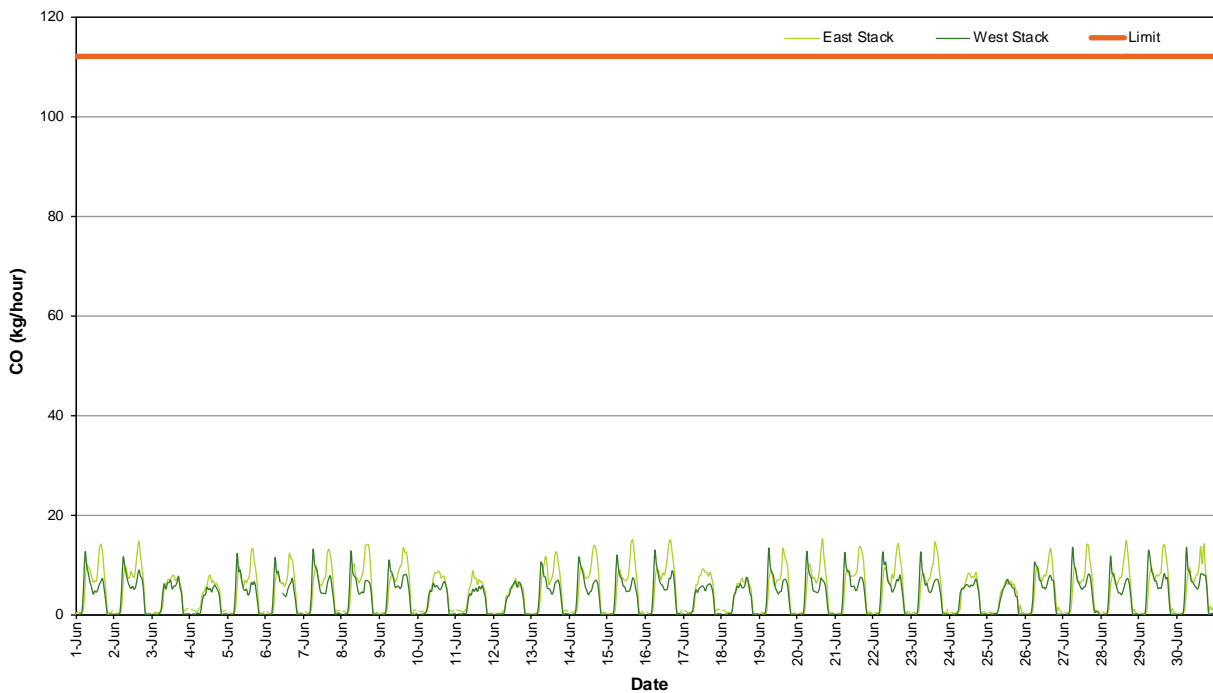


Figure 16: Carbon Monoxide Mass Rate (1 Hour Average)

8.2.4 Oxides of Nitrogen

8.2.4.1 Nitric Oxide

Nitric oxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 23. A plot of nitric oxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 17.

Table 24: Nitric Oxide Mass Rate Percentiles (1 Hour Average)

Station	Nitric Oxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	4.5	4.4	4.3	3.9	3.6	3.1	1.1
Western	5.6	5.4	5.2	3.5	3.0	2.3	1.3

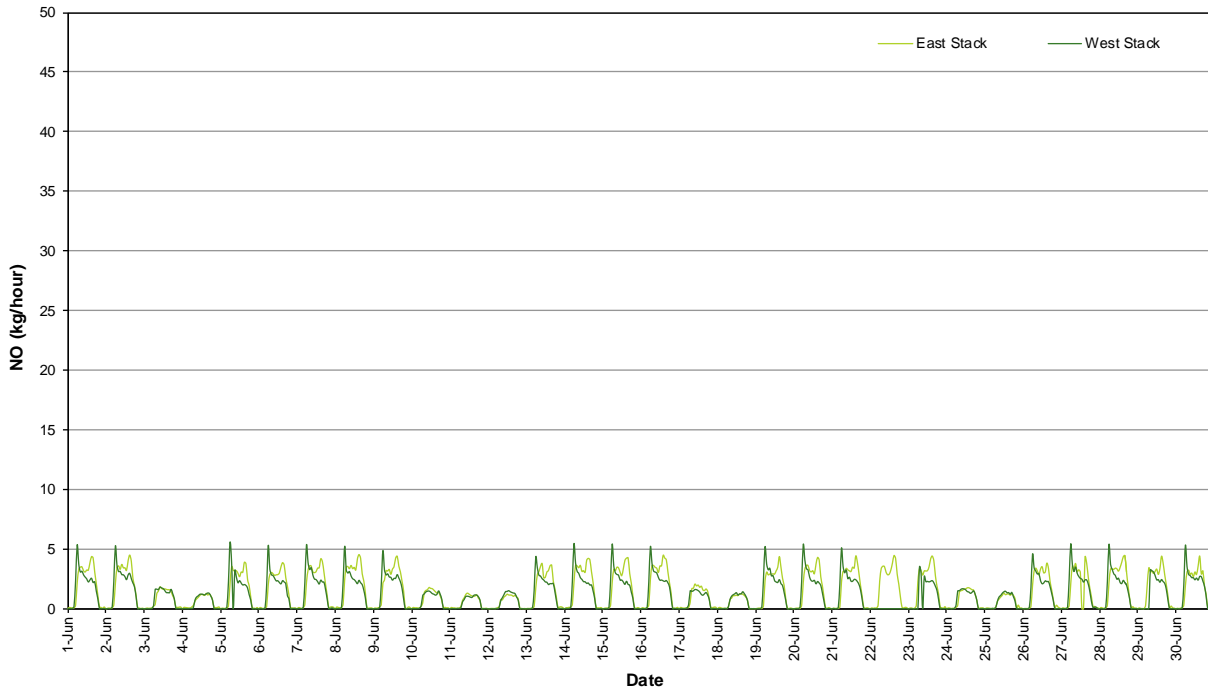


Figure 17: Nitric Oxide Mass Rate (1 Hour Average)

8.2.4.2 Nitrogen Dioxide

Nitrogen dioxide (1 hour average) mass rate of emission statistics for the reporting period are given in Table 24. A plot of nitrogen dioxide (1 hour average) mass rate of emission for the reporting period is presented in Figure 18.

Table 25: Nitrogen Dioxide Mass Rate Percentiles (1 Hour Average)

Station	Nitrogen Dioxide Mass Rate (kg/h) (1 Hour Average)						
	Maximum	99 th	98 th	95 th	90 th	75 th	50 th
Eastern	0.97	0.83	0.75	0.57	0.47	0.22	0.091
Western	1.0	0.95	0.90	0.60	0.49	0.43	0.26

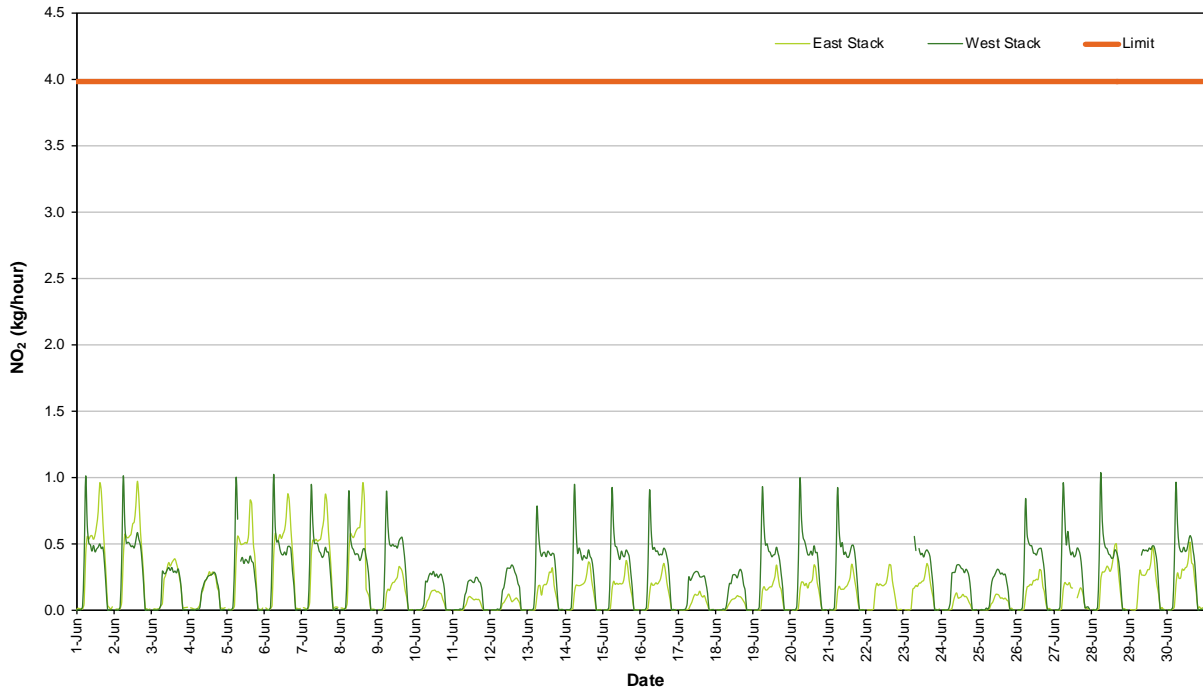


Figure 18: Nitrogen Dioxide Mass Rate (1 Hour Average)

8.2.5 Stack Velocity

The stack velocity (1 hour average) plot for the reporting period is presented in Figure 19.

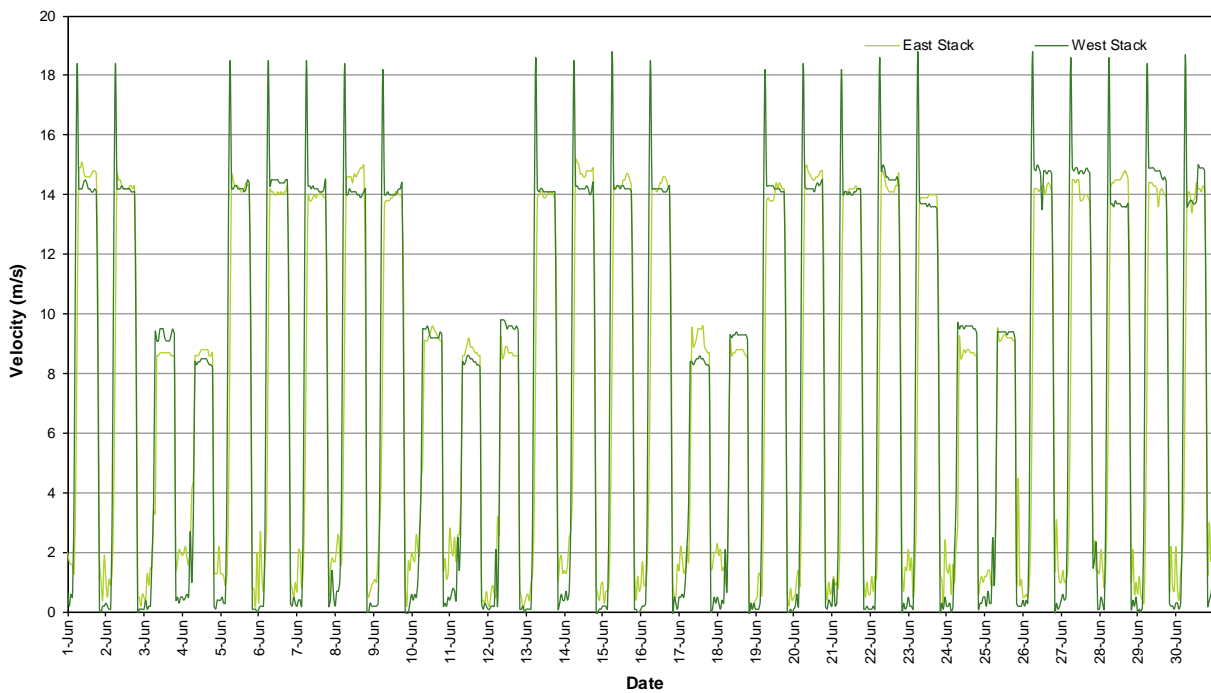


Figure 19: Stack Velocity (1 Hour Average)



8.3 Data Validation and Exceptions

Data contained in the report has been validated against performance and calibration requirements for each instrument. Data during maintenance and calibration periods has been removed from the validated data sets. Tables 25 and 26 list the data exceptions for the eastern and western ventilation stacks respectively. Data during automatic calibrations of the gaseous atmospheric contaminants has also been removed from the data sets.

Table 26: Data Exceptions - Eastern Ventilation Stack: June 2017

Start	End	Parameter	Reason
4/06/2017 04:50	4/06/2017 04:50	PM ₁₀	Invalid data ¹
13/06/2017 15:05	13/06/2017 15:40	PM _{2.5}	Maintenance/ calibration
13/06/2017 15:10	13/06/2017 15:45	PM ₁₀	Maintenance/ calibration
26/06/2017 14:20	28/06/2017 15:05	PM _{2.5}	Maintenance/ calibration
26/06/2017 14:20	27/06/2017 13:05	PM ₁₀	Maintenance/ calibration
27/06/2017 13:05	27/06/2017 15:00	NO, NO ₂ , NO _x	Maintenance/ calibration
27/06/2017 19:20	27/06/2017 19:25	PM ₁₀	Invalid data ¹
28/06/2017 09:50	28/06/2017 10:05	NO, NO ₂ , NO _x	Maintenance/ calibration
28/06/2017 09:55	28/06/2017 10:05	CO	Maintenance/ calibration
29/06/2017 13:55	29/06/2017 15:15	PM _{2.5}	Maintenance/ calibration
30/06/2017 11:35	30/06/2017 12:45	PM _{2.5}	Maintenance/ calibration

Note: ¹ – In the opinion of the reviewer.

Table 27: Data Exceptions - Western Ventilation Stack: June 2017

Start	End	Parameter	Reason
5/06/2017 07:50	5/06/2017 08:30	NO, NO ₂ , NO _x	Maintenance/ calibration
6/06/2017 09:50	6/06/2017 10:20	CO	Maintenance/ calibration
22/06/2017 01:00	23/06/2017 06:40	NO, NO ₂ , NO _x	Invalid data - Span drift
22/06/2017 13:05	22/06/2017 18:15	PM _{2.5}	Maintenance/ calibration
23/06/2017 06:35	23/06/2017 07:05	PM _{2.5}	Invalid data ¹
23/06/2017 09:40	23/06/2017 09:55	NO, NO ₂ , NO _x	Maintenance/ calibration
26/06/2017 10:30	29/06/2017 21:10	PM ₁₀	Maintenance/ calibration
26/06/2017 11:35	27/06/2017 15:50	PM _{2.5}	Maintenance/ calibration
29/06/2017 01:00	29/06/2017 07:35	NO, NO ₂ , NO _x	Invalid data ¹
30/06/2017 06:00	30/06/2017 06:00	PM ₁₀	Invalid data ¹
30/06/2017 10:50	30/06/2017 11:35	PM ₁₀	Maintenance/ calibration

Note: ¹ – In the opinion of the reviewer.



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A number of periods occurred where $PM_{2.5}$ concentrations were greater than the corresponding PM_{10} concentrations. If no valid reason was found to exclude the data, the data was left unchanged in the data set. Examples of such occurrences are listed below:

- East Ventilation stack 29/06/2017 06:10 – 06:15
- West Ventilation stack 5/06/2017 19:40 – 20:00
- West Ventilation stack 22/06/2017 18:55 – 19:05
- West Ventilation stack 30/06/2017 17:20 – 17:35



9.0 DISCUSSION

9.1 Comparison with Licence Limits

EastLink emissions to air from the road tunnel ventilation stacks DP1 and DP2 are subject to the licence requirements contained in Environment Protection Authority (Victoria) Environmental Licence No. 2043 (The Licence).

The maximum measured 1 hour average mass rate for each parameter is compared with the applicable licence limit in Table 27.

Table 28: Maximum (1 Hour Average) Mass Rate (01/04/2017 - 30/06/2017)

Discharge Point No.	Discharge Description	Compound	Mass Rate (kg/h)	Licence Limit (kg/h)
1	Western ventilation stack	PM _{2.5}	0.39	2.4
		PM ₁₀	1.1	2.6
		NO ₂	1.2	3.98
		CO	17	112
2	Eastern ventilation stack	PM _{2.5}	0.34	2.4
		PM ₁₀	0.72	2.6
		NO ₂	1.1	3.98
		CO	16	112

There were no exceedences of the licence limits for DP1 and DP2 during the reporting period.

The procedure for reporting of particulate matter results from the TEOMs and assessment of licence compliance is outlined in the EastLink Particulate Matter Protocol (PMP) dated 17/6/2013 (Golder Reference 107613157-020-R-Rev0). The PMP requires validated uncorrected TEOM one hour clock average data to be reported and compared to the following TEOM mass rate compliance limits for both DP1 and DP2:

- PM_{2.5} (DP1, DP2): 2.0 kg/h
- PM₁₀ (DP1, DP2): 2.0 kg/h

There was no exceedences of the PM₁₀ or PM_{2.5} TEOM mass rate compliance levels for DP1 during the reporting period.

There was no exceedences of the PM₁₀ or PM_{2.5} TEOM mass rate compliance levels for DP2 during the reporting period.

9.2 Data Capture Year to Date

Data capture statistics for 2017 year to date (01/01/2017 – 30/06/2017) are presented in Table 28.

Table 29: Data Capture Year to Date (%)

Station	NO ₂	CO	PM _{2.5}	PM ₁₀	Velocity
Eastern	94.4	97.5	98.6	99.2	100
Western	93.8	95.0	98.9	97.9	100



9.3 Bubble Licence

The Licence contains a Bubble Limit which specifies the annual discharge limits of each parameter for each ventilation stack. Annual emission rates are calculated from 1st July to 30th June each year to coincide with the Annual Performance Statement (APS) reporting period. Ventilation stack emission rates year to date (1/07/2016 to 30/06/2017) are shown in Table 29.

Table 30: Ventilation Stack Emissions 1/07/2016 – 30/06/2017 (tonnes/year)

Station	NO ₂	CO	PM _{2.5}	PM ₁₀
Eastern	2.3	42	0.65	1.2
Western	2.3	39	0.57	1.0
Total	4.6	81	1.2	2.2
Licence limit	35	980	21	23

Figure 20 presents the ventilation stack emissions of each parameter as a percentage of the Licence limit compared with the percentage of APS reporting period elapsed.

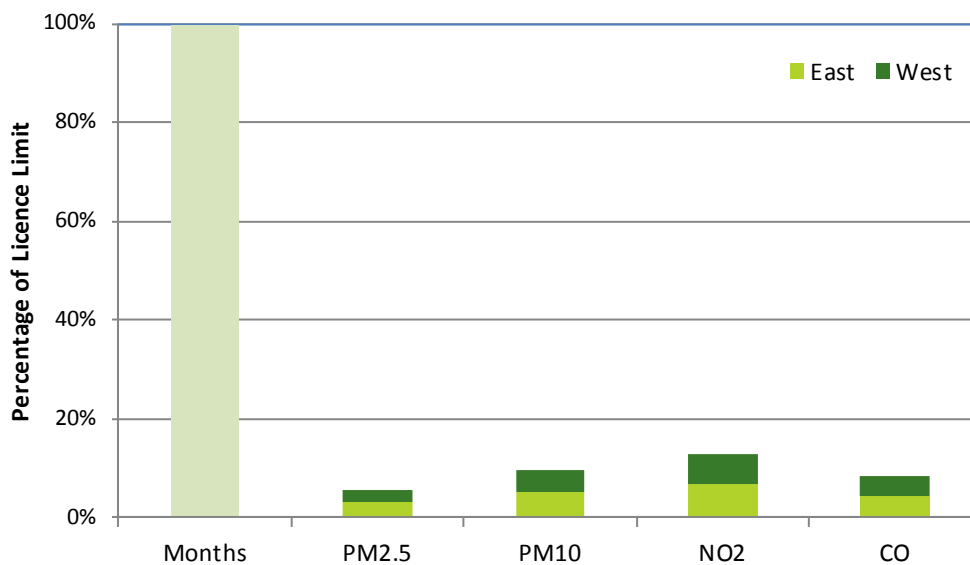


Figure 20: Ventilation Stack Emissions as Percentage of Licence Limit (1/07/2016 – 30/06/2017)

The corresponding bubble limits for uncorrected PM_{2.5} and PM₁₀ TEOM data are:

- PM_{2.5} (DP1 and DP2): 17.5 tonnes/year
- PM₁₀ (DP1 and DP2): 17.5 tonnes/year



Report Signature Page

GOLDER ASSOCIATES PTY LTD

Handwritten signature of Dearne Cook in black ink.

Dearne Cook
Environmental Scientist

Handwritten signature of Mark Tulau in black ink.

Mark Tulau
Senior Air Quality Specialist

DLC/MDT/dlc

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APPENDIX A

Important Information Relating to this Report



IMPORTANT INFORMATION RELATING TO THIS REPORT

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At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

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Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification.

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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