



REPORT

EastLink Ventilation Stack Emission Monitoring Report

January - March 2019

Submitted to:

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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 January 2019 to 31st March, 2019 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
January	1084453	1083977
February	1097683	1096597
March	1100559	1100203

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.

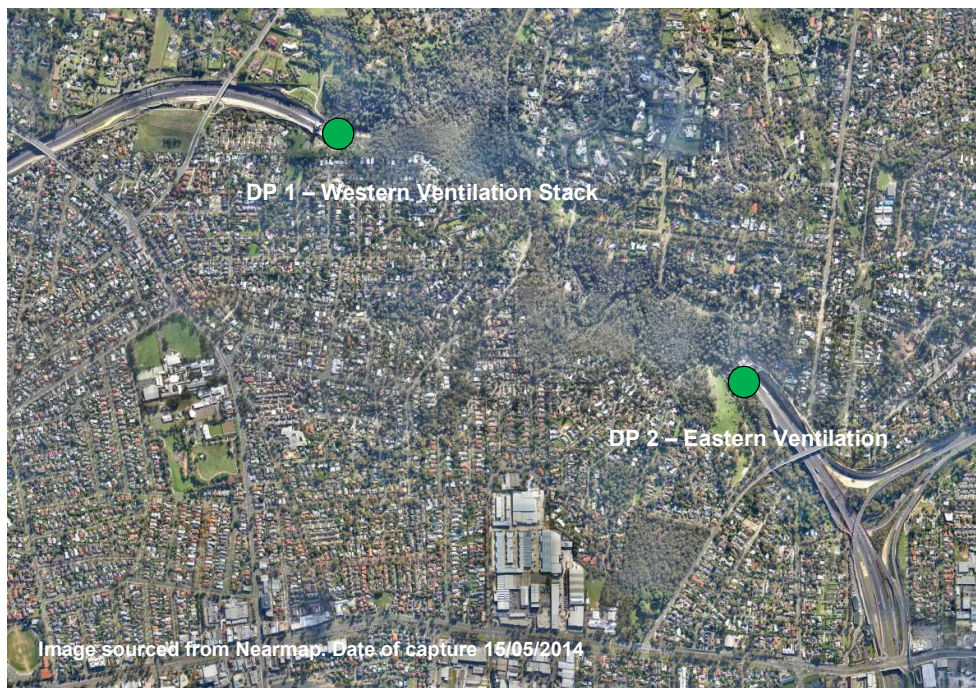


Figure 1: Ventilation Stack Locations

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: 01/01/2019 – 31/01/2019

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 January to 31st January 2019 are shown in Table 3. Averages were only collected for those periods where the 5 minute data constituted 75% data capture. Reduced data capture for NO, NO₂ and NO_x eastern ventilation system was due to air conditioner induced calibration drift.

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	741	744	99.6%
	Western	729	744	98.0%
PM ₁₀	Eastern	710	744	95.4%
	Western	743	744	99.9%
NO, NO ₂	Eastern	559	744	75.1%
	Western	713	744	85.8%
CO	Eastern	711	744	95.6%
	Western	713	744	95.8%

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	0.44	0.14	0.11	0.095	0.068	0.047	0.009
Western	0.21	0.17	0.14	0.092	0.068	0.045	0.017

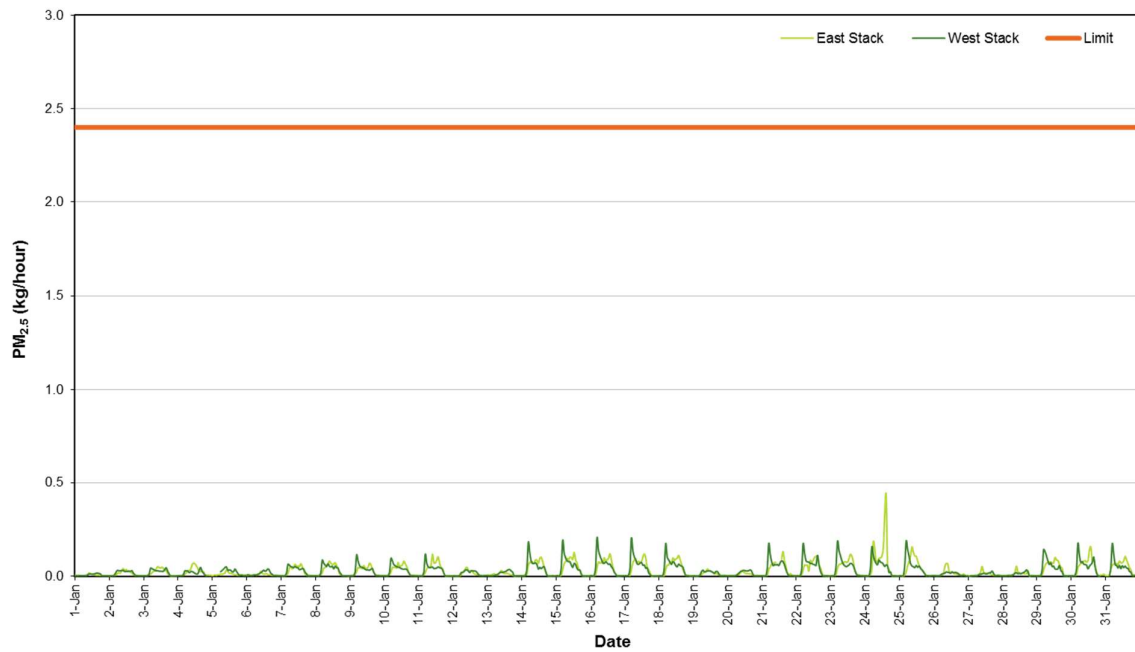


Figure 2: PM_{2.5} Mass Rate (1 Hour Average)

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	7.7	0.26	0.19	0.15	0.12	0.08	0.017
Western	0.58	0.33	0.27	0.16	0.11	0.073	0.030

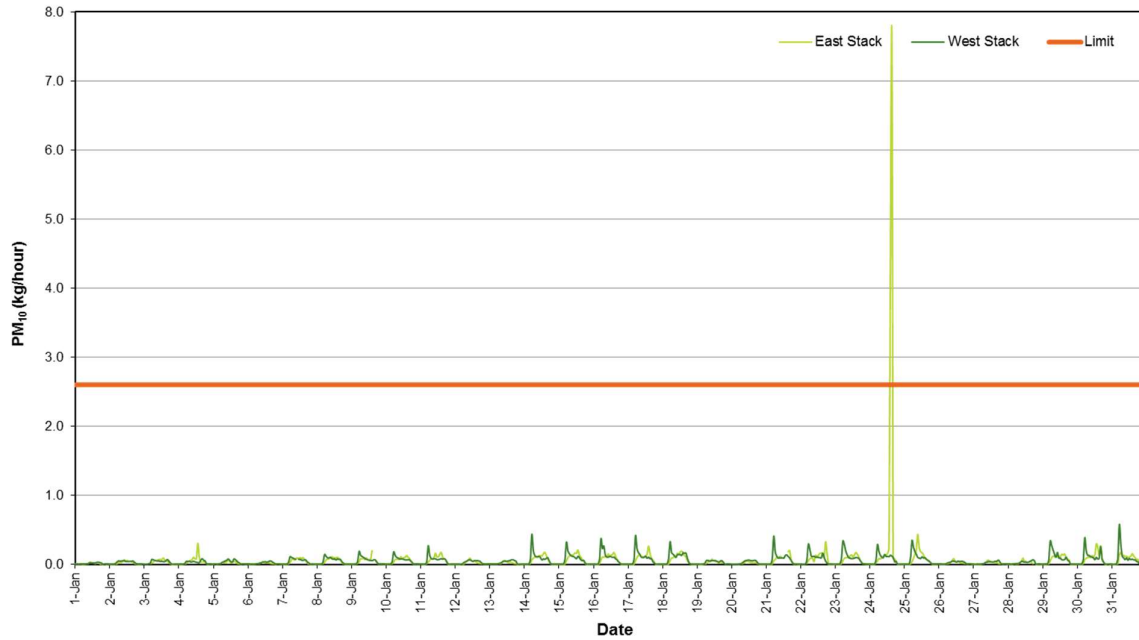


Figure 3: PM₁₀ Mass Rate (1 Hour Average)

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	15	5.9	5.5	4.3	3.3	2.3	0.75
Western	8.5	7.2	6.4	4.9	3.8	2.8	1.6

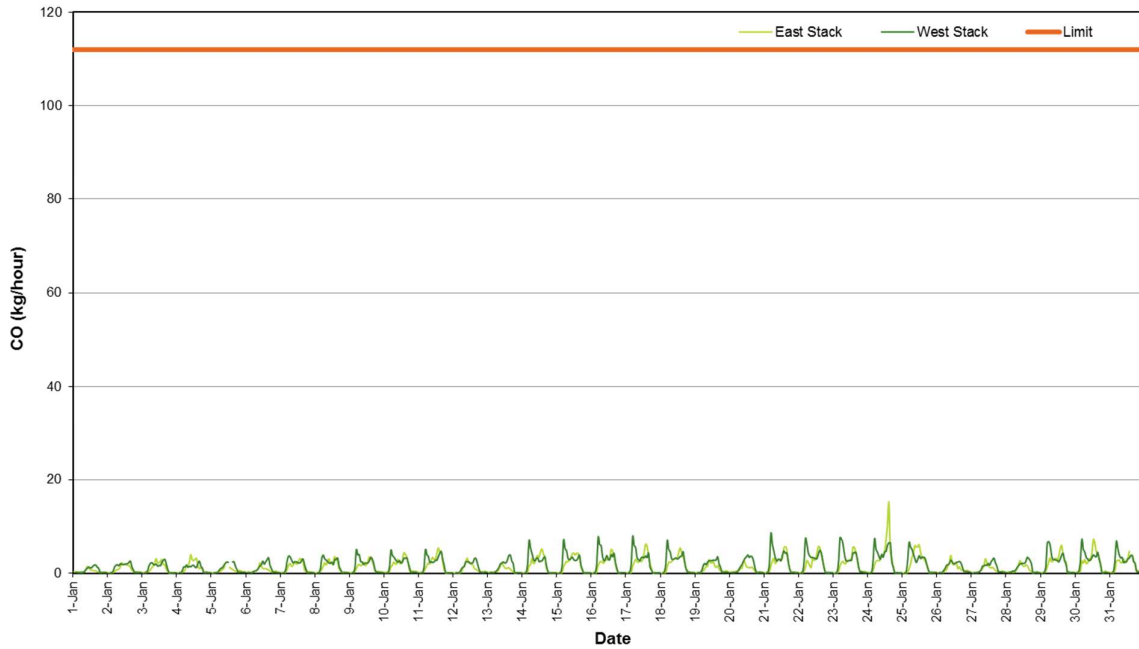


Figure 4: Carbon Monoxide Mass Rate (1 Hour Average)

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	4.8	2.4	2.1	1.8	1.3	0.80	0.16
Western	3.2	2.9	2.3	1.6	1.2	0.90	0.37

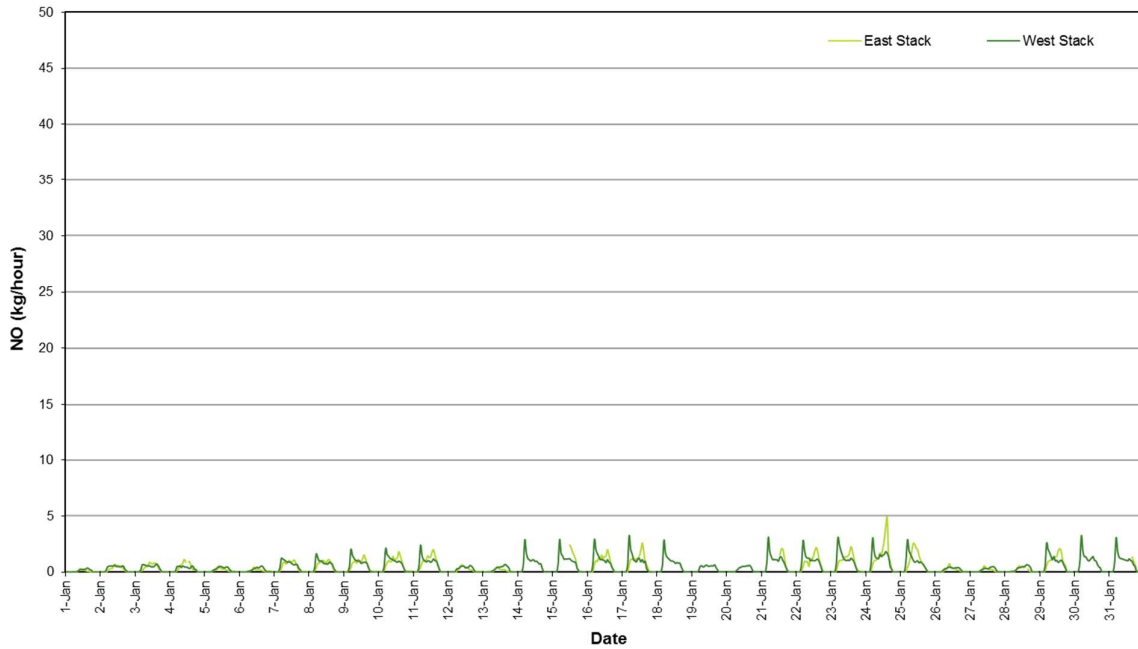


Figure 5: Nitric Oxide Mass Rate (1 Hour Average)

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	1.5	0.74	0.64	0.49	0.33	0.18	0.037
Western	0.73	0.53	0.49	0.34	0.29	0.18	0.088

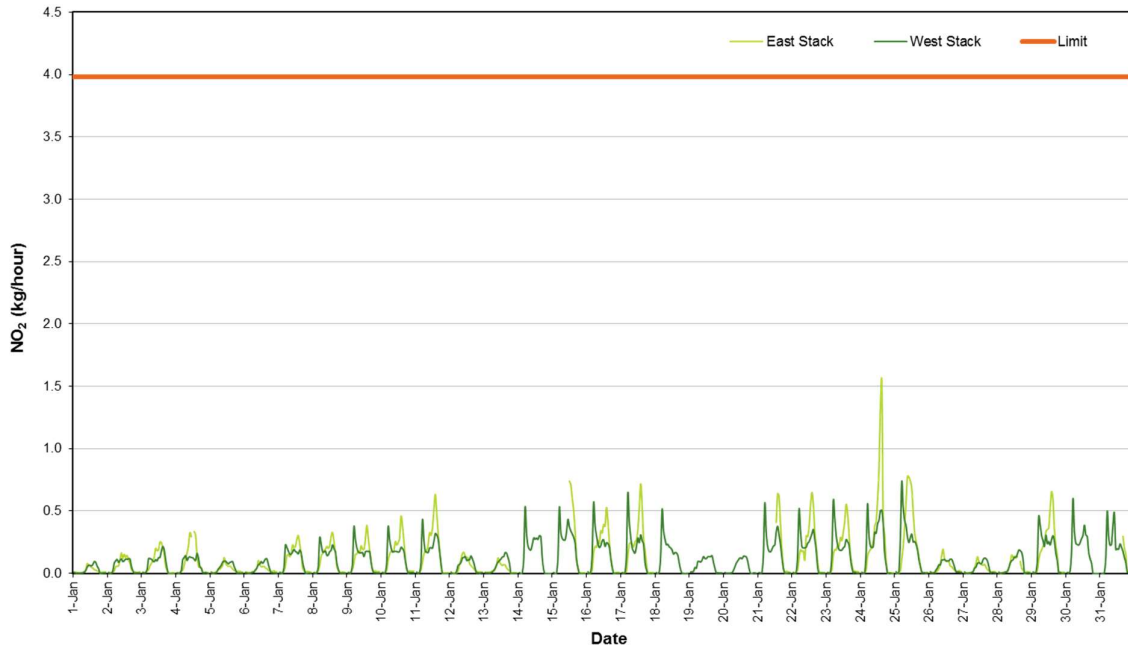


Figure 6: Nitrogen Dioxide Mass Rate (1 Hour Average)

6.2.5 Stack Velocity

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

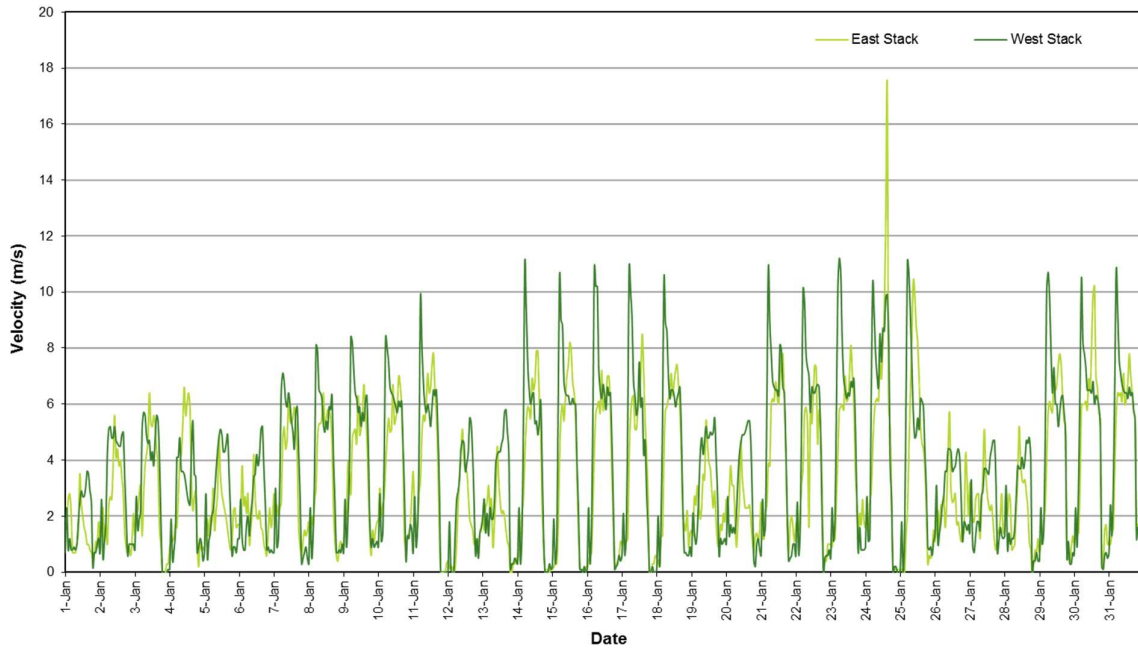


Figure 7: Stack Velocity (1 Hour Average)

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, where valid data is less than 75% of the one hour average. Data during automatic calibrations of the gaseous atmospheric contaminants has also been removed from the data sets.

Table 9: Data Exceptions - Eastern Ventilation Stack: January 2019

Start	End	Parameter	Reason
1/01/2019 15:35	1/01/2019 16:30	PM ₁₀	Invalid ¹
1/01/2019 20:25	1/01/2019 20:45	PM ₁₀	Invalid ¹
1/01/2019 22:55	1/01/2019 23:10	PM ₁₀	Invalid ¹
2/01/2019 23:40	3/01/2019 03:25	PM ₁₀	Invalid ¹
3/01/2019 07:15	3/01/2019 07:20	PM ₁₀	Invalid ¹
3/01/2019 08:00	3/01/2019 08:05	PM ₁₀	Invalid ¹
4/01/2019 11:45	4/01/2019 12:15	NO, NO ₂ , NO _x	Maintenance / calibration
5/01/2019 01:20	5/01/2019 01:35	PM ₁₀	Invalid ¹
5/01/2019 06:35	5/01/2019 07:00	PM ₁₀	Invalid ¹
6/01/2019 21:25	6/01/2019 21:40	PM ₁₀	Invalid ¹
6/01/2019 23:50	6/01/2019 23:55	PM ₁₀	Invalid ¹
7/01/2019 08:35	7/01/2019 08:45	PM ₁₀	Invalid ¹
9/01/2019 14:50	9/01/2019 16:20	PM ₁₀	Invalid ¹
12/01/2019 03:50	12/01/2019 04:45	PM ₁₀	Invalid ¹
12/01/2019 06:25	12/01/2019 06:25	PM ₁₀	Invalid ¹
12/01/2019 16:00	12/01/2019 16:05	PM ₁₀	Invalid ¹
13/01/2019 16:15	13/01/2019 16:20	PM ₁₀	Invalid ¹
13/01/2019 20:05	13/01/2019 20:45	PM ₁₀	Invalid ¹
15/01/2019 10:35	15/01/2019 11:05	NO, NO ₂ , NO _x	Maintenance / calibration
16/01/2019 21:40	16/01/2019 21:50	PM ₁₀	Invalid ¹
19/01/2019 18:30	19/01/2019 18:55	PM ₁₀	Invalid ¹

Start	End	Parameter	Reason
19/01/2019 20:30	19/01/2019 20:55	PM ₁₀	Invalid ¹
19/01/2019 22:25	19/01/2019 22:40	PM ₁₀	Invalid ¹
20/01/2019 01:00	20/01/2019 04:00	PM ₁₀	Invalid ¹
21/01/2019 01:15	21/01/2019 01:25	PM ₁₀	Invalid ¹
21/01/2019 10:45	21/01/2019 12:20	NO, NO ₂ , NO _x	Maintenance / calibration
21/01/2019 10:45	21/01/2019 11:25	CO	Maintenance / calibration
21/01/2019 11:25	21/01/2019 13:30	PM _{2.5}	Maintenance / calibration
21/01/2019 11:35	21/01/2019 14:20	PM ₁₀	Maintenance / calibration
22/01/2019 01:30	22/01/2019 01:55	PM ₁₀	Invalid ¹
22/01/2019 02:25	22/01/2019 03:25	PM ₁₀	Invalid ¹
23/01/2019 04:55	23/01/2019 05:00	PM ₁₀	Invalid ¹
23/01/2019 15:20	23/01/2019 15:25	PM ₁₀	Invalid ¹
27/01/2019 08:25	27/01/2019 09:10	PM ₁₀	Invalid ¹
27/01/2019 17:55	27/01/2019 18:10	PM ₁₀	Invalid ¹
28/01/2019 13:15	28/01/2019 13:40	PM ₁₀	Invalid ¹
28/01/2019 18:15	28/01/2019 18:35	PM ₁₀	Invalid ¹
30/01/2019 21:10	30/01/2019 21:30	PM ₁₀	Invalid ¹
31/01/2019 04:45	31/01/2019 05:00	PM ₁₀	Invalid ¹
31/01/2019 07:30	31/01/2019 07:35	PM ₁₀	Invalid ¹
31/01/2019 15:05	31/01/2019 15:35	NO, NO ₂ , NO _x	Maintenance / calibration
31/01/2019 15:05	31/01/2019 15:35	CO	Maintenance / calibration
31/01/2019 19:20	31/01/2019 19:30	PM ₁₀	Invalid ¹
31/01/2019 20:55	31/01/2019 21:45	PM ₁₀	Invalid ¹

Notes: ¹ – In the opinion of the reviewer

Table 10: Data Exceptions - Western Ventilation Stack: January 2019

Start	End	Parameter	Reason
4/01/2019 20:50	4/01/2019 23:55	PM _{2.5}	Invalid ¹
5/01/2019 01:00	5/01/2019 05:45	PM _{2.5}	Invalid ¹
7/01/2019 10:15	7/01/2019 10:40	PM ₁₀	Invalid ¹
30/01/2019 21:40	30/01/2019 23:55	PM _{2.5}	Invalid ¹
31/01/2019 01:00	31/01/2019 02:55	PM _{2.5}	Invalid ¹

Notes: ¹ – In the opinion of the reviewer

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 26/01/2019 08:45 – 09:10
- West Ventilation stack 5/01/2019 18:00 – 6/01/2019 06:35

7.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/02/2019 – 28/02/2019

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 February to 28th February 2019 are shown in Table 11. Averages were only collected for those periods where the 5 minute data constituted 75% data capture. Reduced data capture for NO, NO₂ and NO_x at the Eastern ventilation system was primarily due to failure of a vacuum pump that occurred from 9-14/02/2019. The analyser was initially repaired on site but then removed on 19/02/2019 for further repair and bench testing at Golder's air lab.

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	665	672	99.0%
	Western	668	672	99.4%
PM ₁₀	Eastern	657	672	97.8%
	Western	669	672	99.6%
NO, NO ₂	Eastern	438	672	65.2%
	Western	637	672	94.8%
CO	Eastern	642	672	95.5%
	Western	642	672	95.5%

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	0.25	0.16	0.15	0.11	0.082	0.068	0.030
Western	0.20	0.17	0.16	0.12	0.082	0.057	0.030

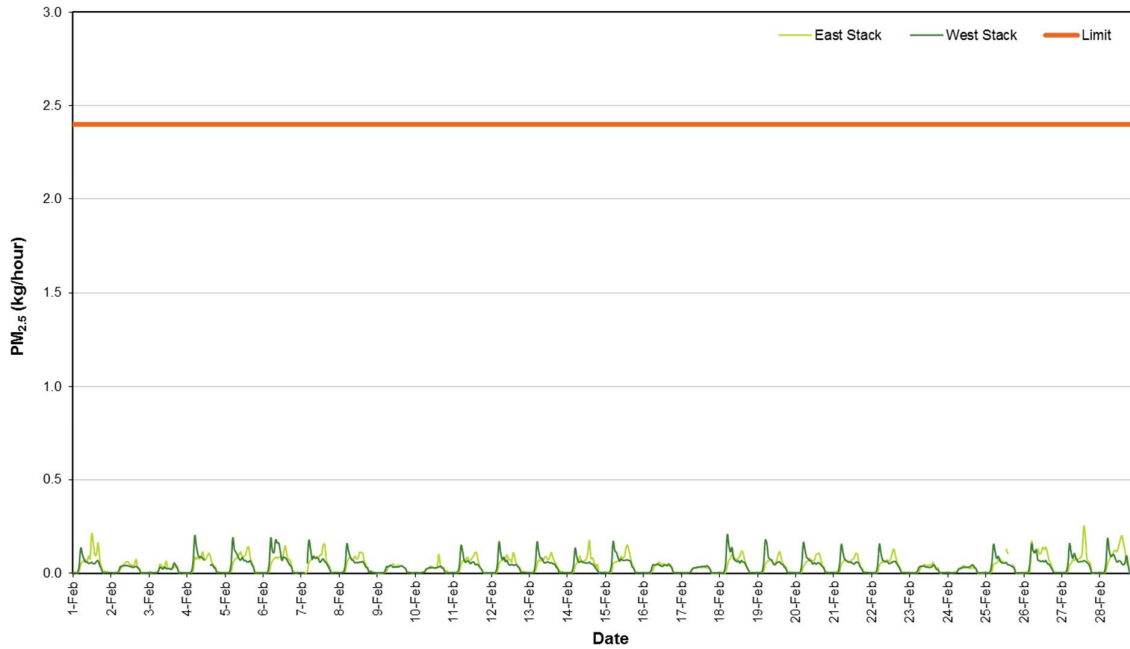


Figure 8: PM_{2.5} Mass Rate (1 Hour Average)

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	0.37	0.24	0.20	0.16	0.14	0.10	0.054
Western	0.42	0.34	0.30	0.21	0.13	0.092	0.054

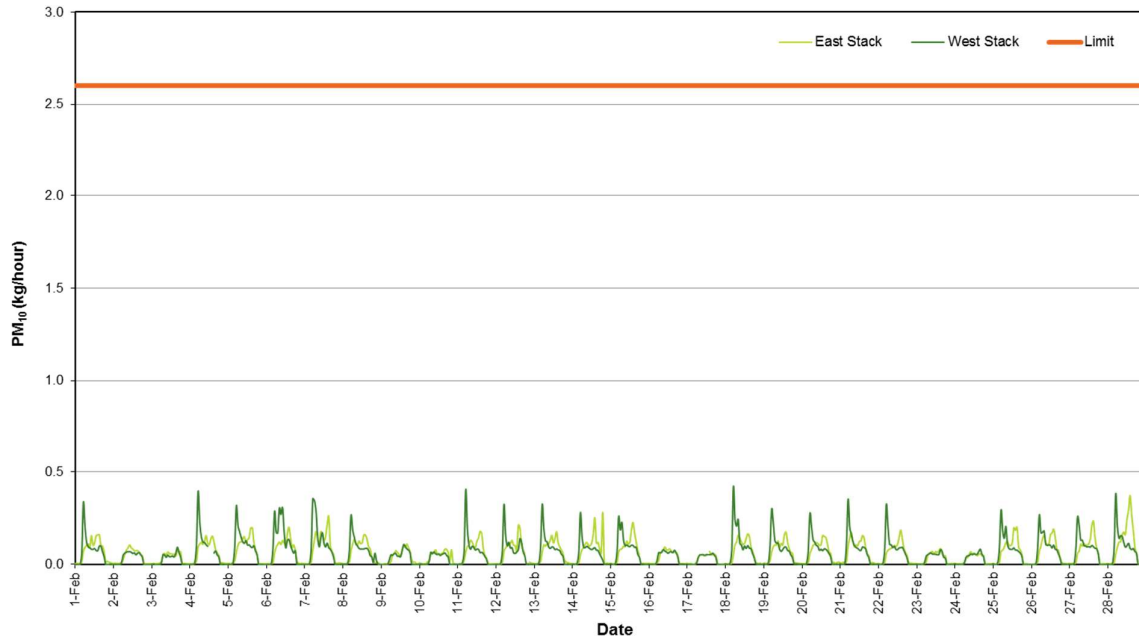


Figure 9: PM₁₀ Mass Rate (1 Hour Average)

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	10	7.6	6.7	5.6	4.4	3.2	2.5
Western	9.4	7.7	7.4	6.4	4.8	3.6	2.6

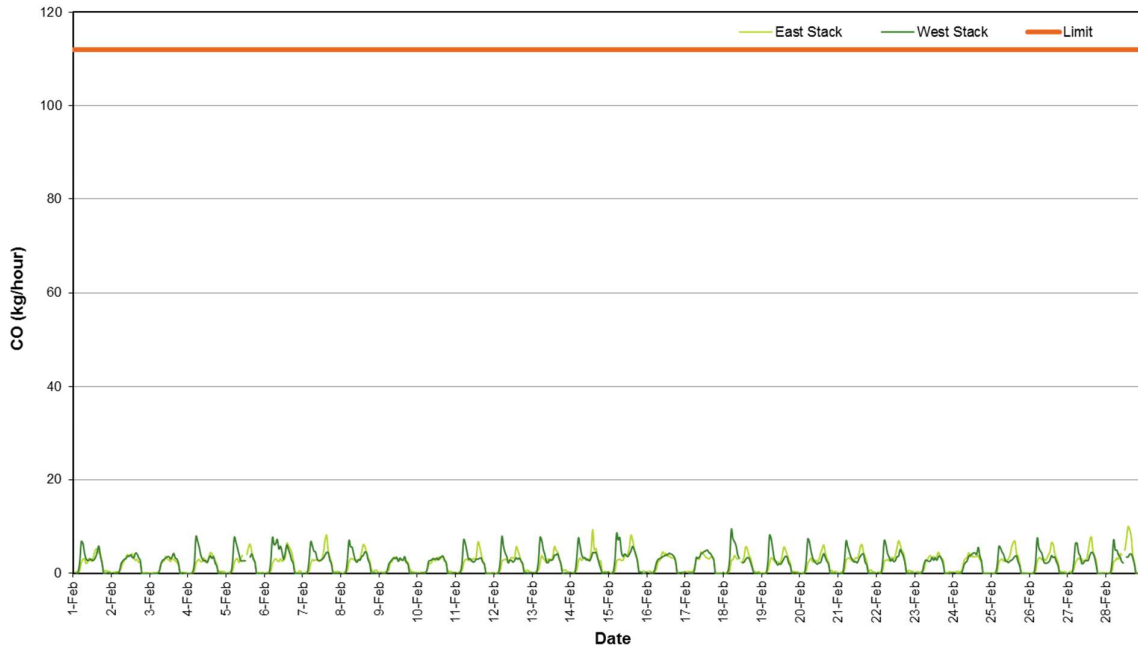


Figure 10: Carbon Monoxide Mass Rate (1 Hour Average)

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	3.9	2.7	2.5	2.0	1.6	1.1	0.58
Western	3.8	3.3	3.1	2.2	1.6	1.2	0.65

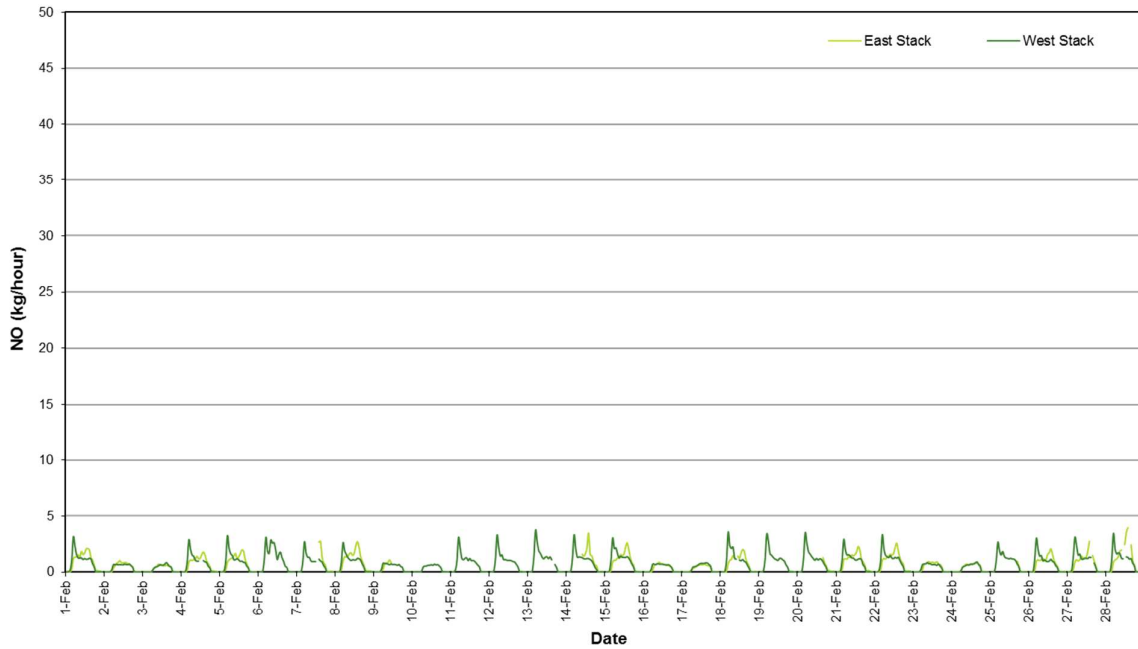


Figure 11: Nitric Oxide Mass Rate (1 Hour Average)

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	1.2	0.78	0.65	0.51	0.37	0.25	0.15
Western	0.70	0.64	0.56	0.41	0.30	0.22	0.14

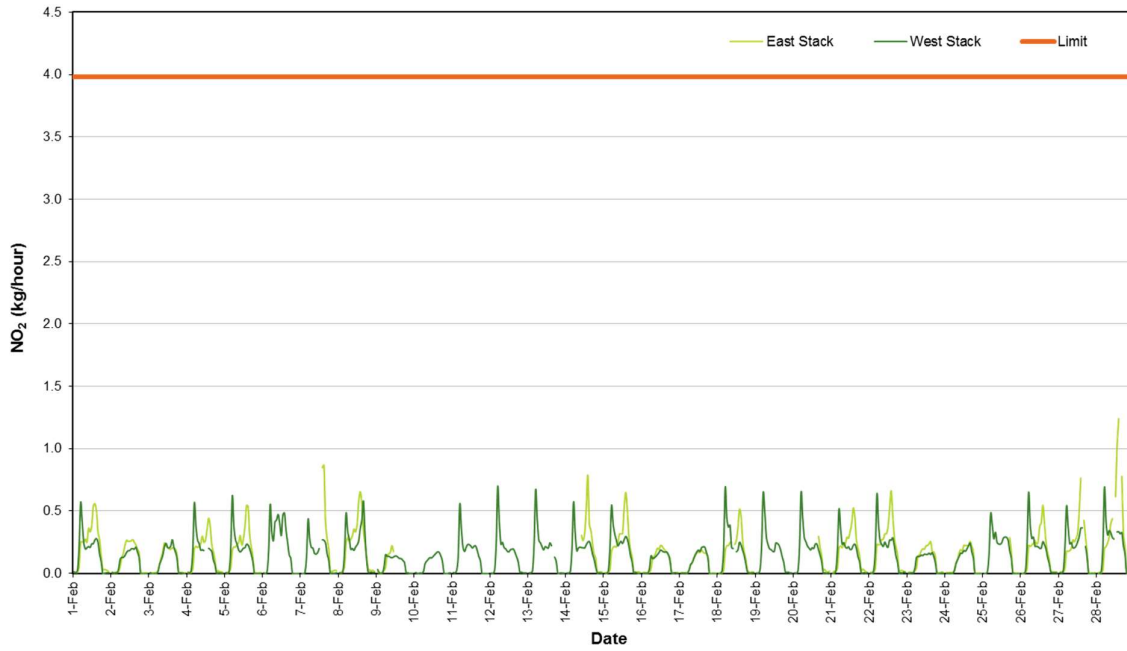


Figure 12: Nitrogen Dioxide Mass Rate (1 Hour Average)

7.2.5 Stack Velocity

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

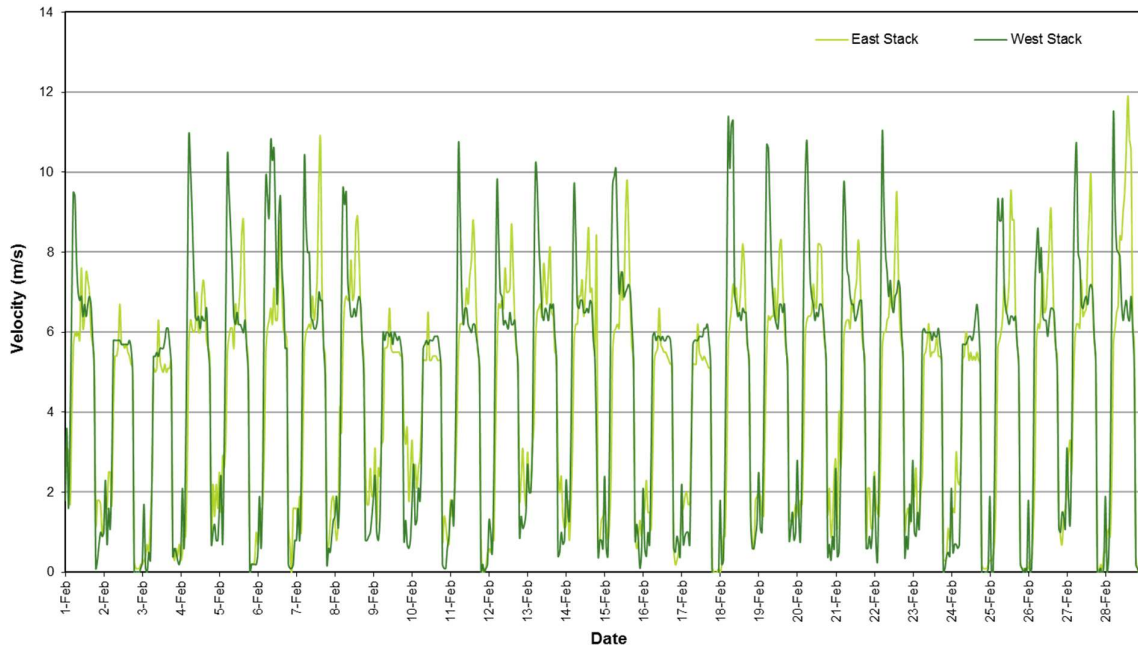


Figure 13: Stack Velocity (1 Hour Average)

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, where valid data is less than 75% of the one hour average. Data during automatic calibrations of the gaseous atmospheric contaminants has also been removed from the data sets.

Table 17: Data Exceptions - Eastern Ventilation Stack: February 2019

Start	End	Parameter	Reason
1/02/2019 13:35	1/02/2019 13:45	PM ₁₀	Invalid ¹
2/02/2019 02:20	2/02/2019 02:30	PM ₁₀	Invalid ¹
3/02/2019 20:20	3/02/2019 20:25	PM ₁₀	Invalid ¹
5/02/2019 03:50	5/02/2019 04:00	PM ₁₀	Invalid ¹
7/02/2019 12:30	7/02/2019 12:50	NO, NO ₂ , NO _x	Maintenance / calibration
7/02/2019 20:25	7/02/2019 20:30	PM ₁₀	Invalid ¹
8/02/2019 14:50	8/02/2019 15:05	PM ₁₀	Invalid ¹
8/02/2019 18:05	8/02/2019 18:10	PM ₁₀	Invalid ¹

Start	End	Parameter	Reason
9/02/2019 08:45	9/02/2019 09:05	PM ₁₀	Invalid ¹
9/02/2019 09:00	9/02/2019 09:20	PM _{2.5}	Invalid ¹
9/02/2019 17:40	9/02/2019 19:15	PM _{2.5}	Invalid ¹
9/02/2019 12:40	14/02/2019 10:00	NO, NO ₂ , NO _x	Analyser repair
10/02/2019 23:05	11/02/2019 01:05	PM ₁₀	Invalid ¹
11/02/2019 02:45	11/02/2019 02:50	PM ₁₀	Invalid ¹
12/02/2019 19:05	12/02/2019 21:10	PM ₁₀	Invalid ¹
15/02/2019 17:10	15/02/2019 17:20	PM ₁₀	Invalid ¹
15/02/2019 19:15	15/02/2019 20:05	PM ₁₀	Invalid ¹
17/02/2019 03:50	17/02/2019 04:20	PM ₁₀	Invalid ¹
17/02/2019 13:35	17/02/2019 13:50	PM ₁₀	Invalid ¹
17/02/2019 17:30	17/02/2019 17:40	PM ₁₀	Invalid ¹
17/02/2019 20:15	17/02/2019 21:15	PM ₁₀	Invalid ¹
18/02/2019 10:35	18/02/2019 11:10	NO, NO ₂ , NO _x	Maintenance / calibration
18/02/2019 10:40	18/02/2019 11:05	CO	Maintenance / calibration
18/02/2019 23:35	19/02/2019 00:05	PM ₁₀	Invalid ¹
19/02/2019 09:25	20/02/2019 15:25	NO, NO ₂ , NO _x	Analyser repair
19/02/2019 19:35	19/02/2019 19:45	PM ₁₀	Invalid ¹
25/02/2019 01:00	25/02/2019 16:30	NO, NO ₂ , NO _x	Maintenance / calibration
25/02/2019 02:40	25/02/2019 02:55	PM ₁₀	Invalid ¹
25/02/2019 12:40	25/02/2019 16:20	PM _{2.5}	Maintenance / calibration
25/02/2019 22:50	25/02/2019 23:55	PM ₁₀	Invalid ¹
26/02/2019 01:00	26/02/2019 01:25	PM ₁₀	Invalid ¹
27/02/2019 15:25	27/02/2019 15:45	NO, NO ₂ , NO _x	Maintenance / calibration
28/02/2019 11:15	28/02/2019 11:50	NO, NO ₂ , NO _x	Maintenance / calibration
28/02/2019 11:15	28/02/2019 11:45	CO	Maintenance / calibration

Note: ¹ – In the opinion of the reviewer.

Table 18: Data Exceptions - Western Ventilation Stack: February 2019

Start	End	Parameter	Reason
4/02/2019 12:20	4/02/2019 14:55	PM _{2.5}	Maintenance / calibration
4/02/2019 12:20	4/02/2019 15:10	PM ₁₀	Maintenance / calibration
4/02/2019 12:40	4/02/2019 13:35	NO, NO ₂ , NO _x	Maintenance / calibration
4/02/2019 12:50	4/02/2019 13:10	CO	Maintenance / calibration
7/02/2019 02:55	7/02/2019 03:35	PM _{2.5}	Invalid ¹
7/02/2019 06:45	7/02/2019 06:50	PM _{2.5}	Invalid ¹
7/02/2019 12:55	7/02/2019 13:30	NO, NO ₂ , NO _x	Maintenance / calibration
13/02/2019 16:00	13/02/2019 16:25	NO, NO ₂ , NO _x	Maintenance / calibration
18/02/2019 11:15	18/02/2019 12:00	NO, NO ₂ , NO _x	Maintenance / calibration
18/02/2019 11:15	18/02/2019 12:00	CO	Maintenance / calibration
27/02/2019 15:55	27/02/2019 16:15	NO, NO ₂ , NO _x	Maintenance / calibration
28/02/2019 12:05	28/02/2019 12:25	NO, NO ₂ , NO _x	Maintenance / calibration
28/02/2019 12:05	28/02/2019 12:20	CO	Maintenance / calibration

Note: ¹ – In the opinion of the reviewer.

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 1/02/2019 11:50 – 12:25
- East Ventilation stack 2/02/2019 15:55 – 16:15
- East Ventilation stack 26/02/2019 05:10 – 07:15

8.0 VENTILATION STACK EMISSION MONITORING PERIOD: 01/03/2019 – 31/03/2019

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 March to 31st March 2019 are shown in Table 19. Averages were only collected for those periods where the 5 minute data constituted 75% data capture. Reduced data capture for NO, NO₂ and NO_x eastern ventilation system was due to air conditioner induced calibration drift.

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

Table 19: Data Capture Statistics - 1 Hour Averages

Parameter	Station	Collected Periods	Available Periods	Data Capture
PM _{2.5}	Eastern	720	744	96.8%
	Western	692	744	93.0%
PM ₁₀	Eastern	683	744	91.8%
	Western	692	744	93.0%
NO, NO ₂	Eastern	596	744	80.1%
	Western	708	744	95.2%
CO	Eastern	711	744	95.6%
	Western	711	744	95.6%

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 20: 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	0.17	0.14	0.13	0.11	0.092	0.065	0.028
Western	0.21	0.18	0.14	0.12	0.092	0.057	0.027

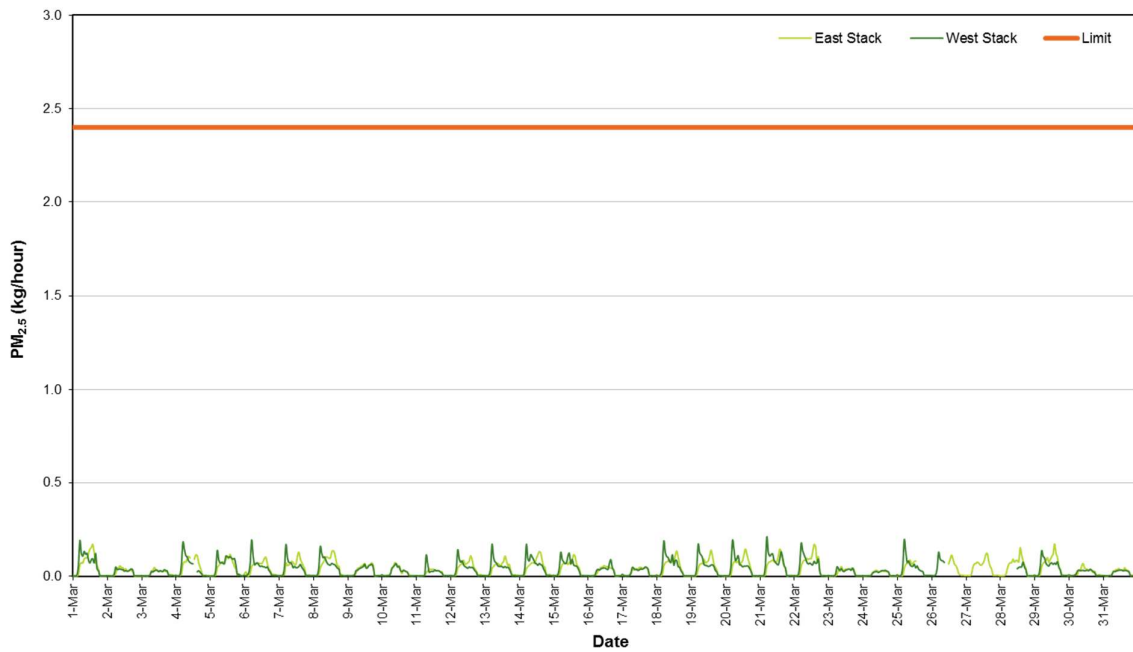


Figure 14: PM_{2.5} Mass Rate (1 Hour Average)

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 21: 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	0.56	0.26	0.22	0.19	0.15	0.11	0.054
Western	0.70	0.35	0.29	0.20	0.14	0.093	0.054

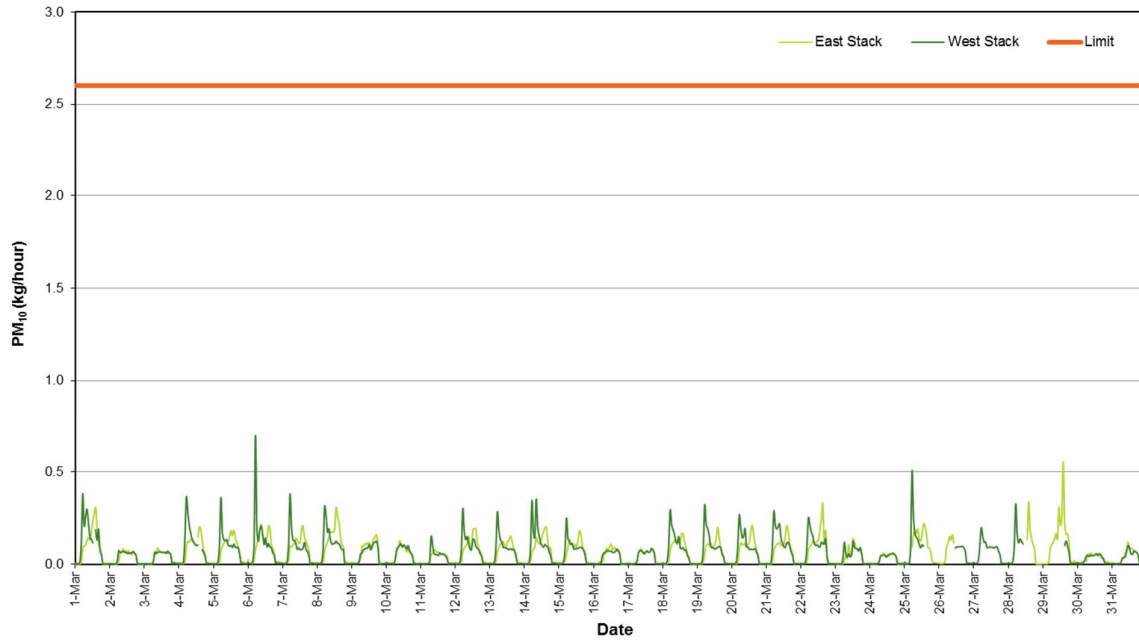


Figure 15: PM₁₀ Mass Rate (1 Hour Average)

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 22: 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	11	7.5	6.8	5.7	4.2	3.3	2.5
Western	9.3	7.9	7.3	6.1	5.0	3.6	2.7

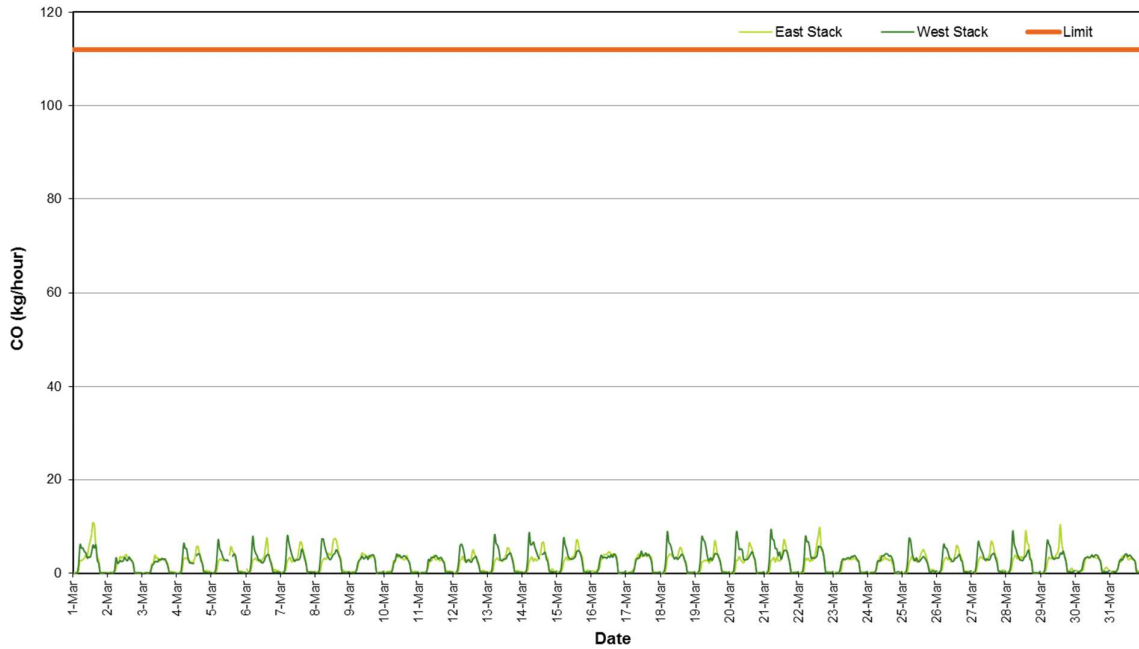


Figure 16: Carbon Monoxide Mass Rate (1 Hour Average)

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 23: 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	3.8	2.8	2.3	1.9	1.6	1.1	0.52
Western	4.1	3.3	3.0	2.2	1.8	1.2	0.61

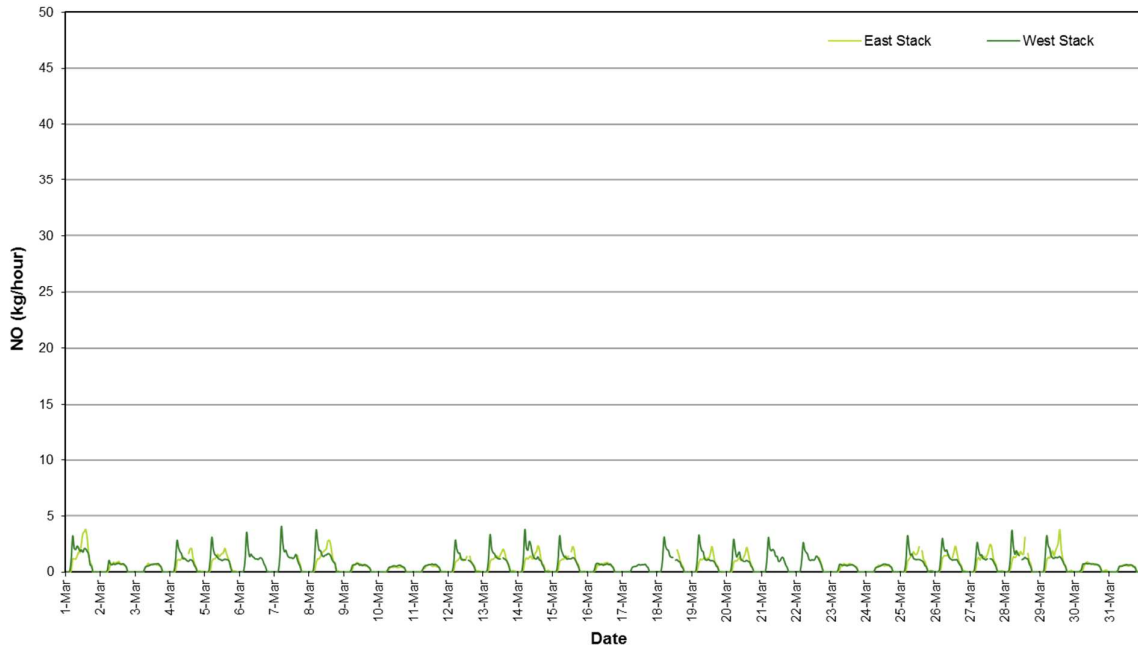


Figure 17: Nitric Oxide Mass Rate (1 Hour Average)

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 24: 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	0.69	0.58	0.45	0.34	0.23	0.13
Western	0.73	0.62	0.55	0.41	0.30	0.22	0.14

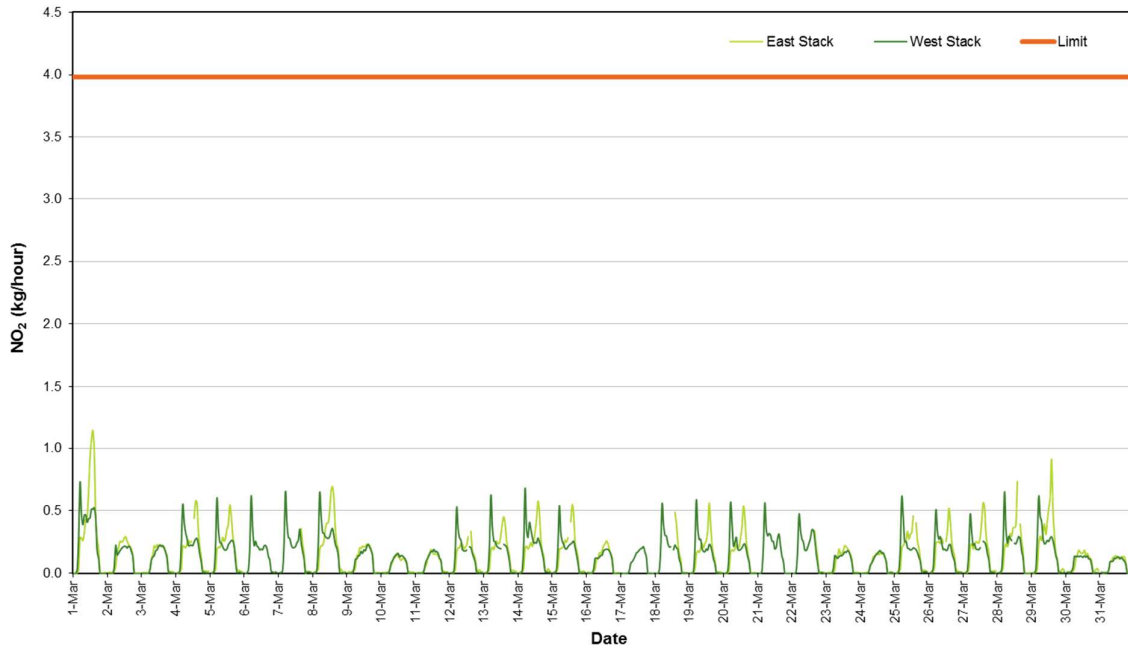


Figure 18: Nitrogen Dioxide Mass Rate (1 Hour Average)

8.2.5 Stack Velocity

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

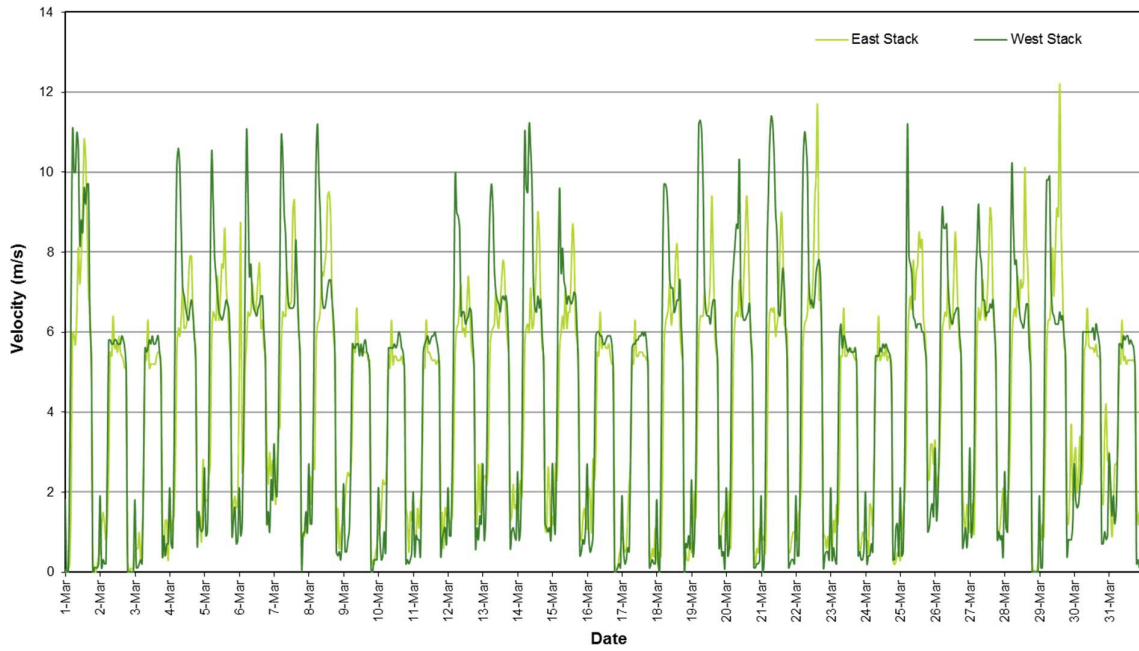


Figure 19: Stack Velocity (1 Hour Average)

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, where valid data is less than 75% of the one hour average. Data during automatic calibrations of the gaseous atmospheric contaminants has also been removed from the data sets.

Table 25: Data Exceptions - Eastern Ventilation Stack: March 2019

Start	End	Parameter	Reason
1/03/2019 00:20	1/03/2019 00:30	PM _{2.5}	Invalid ¹
3/03/2019 01:00	3/03/2019 01:55	PM ₁₀	Invalid ¹
3/03/2019 22:20	3/03/2019 22:30	PM ₁₀	Invalid ¹
4/03/2019 10:45	4/03/2019 12:40	PM _{2.5}	Maintenance / Calibration
4/03/2019 11:45	4/03/2019 12:15	NO, NO ₂ , NO _x	Maintenance / Calibration
4/03/2019 12:15	4/03/2019 12:55	PM ₁₀	Invalid ¹
6/03/2019 01:00	6/03/2019 01:30	PM ₁₀	Invalid ¹
7/03/2019 01:00	7/03/2019 01:00	PM ₁₀	Invalid ¹
7/03/2019 03:00	7/03/2019 03:00	PM ₁₀	Invalid ¹
7/03/2019 04:30	7/03/2019 04:35	PM ₁₀	Invalid ¹
7/03/2019 14:05	7/03/2019 14:30	NO, NO ₂ , NO _x	Maintenance / Calibration
12/03/2019 14:30	12/03/2019 14:45	NO, NO ₂ , NO _x	Maintenance / Calibration
15/03/2019 03:25	15/03/2019 03:45	PM ₁₀	Invalid ¹
15/03/2019 05:10	15/03/2019 5:10	PM ₁₀	Invalid ¹
15/03/2019 12:15	15/03/2019 12:40	NO, NO ₂ , NO _x	Maintenance / Calibration
16/03/2019 02:10	16/03/2019 02:45	PM ₁₀	Invalid ¹
17/03/2019 11:40	17/03/2019 11:40	PM ₁₀	Invalid ¹
17/03/2019 20:10	17/03/2019 20:15	PM ₁₀	Invalid ¹
17/03/2019 22:20	17/03/2019 22:25	PM ₁₀	Invalid ¹
18/03/2019 11:30	18/03/2019 12:15	NO, NO ₂ , NO _x	Maintenance / Calibration
18/03/2019 11:35	18/03/2019 12:10	CO	Maintenance / Calibration
19/03/2019 03:50	19/03/2019 03:55	PM ₁₀	Invalid ¹

Start	End	Parameter	Reason
19/03/2019 04:35	19/03/2019 04:40	PM ₁₀	Invalid ¹
20/03/2019 04:30	20/03/2019 04:40	PM ₁₀	Invalid ¹
22/03/2019 14:10	22/03/2019 14:35	NO, NO ₂ , NO _x	Maintenance / Calibration
23/03/2019 21:45	23/03/2019 21:50	PM ₁₀	Invalid ¹
25/03/2019 02:55	25/03/2019 04:55	PM ₁₀	Invalid ¹
25/03/2019 13:55	26/03/2019 12:05	PM _{2.5}	Yearly zero test
25/03/2019 14:15	25/03/2019 14:55	NO, NO ₂ , NO _x	Maintenance / Calibration
26/03/2019 10:55	26/03/2019 11:35	NO, NO ₂ , NO _x	Maintenance / Calibration
26/03/2019 10:55	26/03/2019 11:35	CO	Maintenance / Calibration
26/03/2019 11:25	28/03/2019 12:45	PM ₁₀	Yearly zero test
29/03/2019 21:10	29/03/2019 21:15	PM ₁₀	Invalid ¹
30/03/2019 03:50	30/03/2019 04:05	PM ₁₀	Invalid ¹
30/03/2019 05:35	30/03/2019 05:50	PM ₁₀	Invalid ¹
31/03/2019 01:05	31/03/2019 01:20	PM ₁₀	Invalid ¹
31/03/2019 02:10	31/03/2019 02:35	PM ₁₀	Invalid ¹
31/03/2019 16:50	31/03/2019 17:40	PM ₁₀	Invalid ¹

Note: ¹ – In the opinion of the reviewer.

Table 26: Data Exceptions - Western Ventilation Stack: March 2019

Start	End	Parameter	Reason
1/03/2019 13:35	1/03/2019 14:00	PM ₁₀	Invalid ¹
4/03/2019 13:20	4/03/2019 13:55	CO	Maintenance / Calibration
4/03/2019 13:40	4/03/2019 15:00	PM _{2.5}	Maintenance / Calibration
4/03/2019 14:10	4/03/2019 15:20	PM ₁₀	Invalid ¹
12/03/2019 13:30	12/03/2019 14:00	NO, NO ₂ , NO _x	Maintenance / Calibration
13/03/2019 13:15	13/03/2019 13:50	NO, NO ₂ , NO _x	Maintenance / Calibration
14/03/2019 12:45	14/03/2019 13:25	CO	Maintenance / Calibration

Start	End	Parameter	Reason
18/03/2019 12:35	18/03/2019 13:05	NO, NO ₂ , NO _x	Maintenance / Calibration
25/03/2019 13:55	26/03/2019 10:55	PM ₁₀	Yearly zero test
26/03/2019 10:25	28/03/2019 11:55	PM _{2.5}	Yearly zero test
27/03/2019 13:40	27/03/2019 14:10	NO, NO ₂ , NO _x	Maintenance / Calibration
28/03/2019 11:10	28/03/2019 11:45	NO, NO ₂ , NO _x	Maintenance / Calibration
28/03/2019 11:15	29/03/2019 15:00	PM ₁₀	Yearly zero test

Note: ¹ – In the opinion of the reviewer.

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:

- East Ventilation stack 21/03/2019 22:25 – 22:45
- West Ventilation stack 15/03/2019 10:25 – 11:55

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 27: Maximum (1 Hour Average) Mass Rate (01/01/2019 - 31/03/2019)

Discharge Point No.	Discharge Description	Compound	Mass Rate (kg/h)	Licence Limit (kg/h)
1	Western ventilation stack	PM _{2.5}	0.21	2.4
		PM ₁₀	0.70	2.6
		NO ₂	0.73	3.98
		CO	9.4	112
2	Eastern ventilation stack	PM _{2.5}	0.44	2.4
		PM ₁₀	7.7	2.6
		NO ₂	1.5	3.98
		CO	15	112

There were no exceedences of the licence limits for DP1 during the reporting period. The PM₁₀ licence limit for DP2 was exceeded on 24/01/2019 between 14:00 hours to 16:00 hours. This event coincided with maximum stack velocity. All other parameters for DP1 complied with their respective licence limits.

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

There was one exceedance of the PM₁₀ TEOM mass rate compliance levels for DP2 during the reporting period. The PM_{2.5} TEOM mass rate for DP2 complied with the compliance level.

9.2 Data Capture Year to Date

Data capture statistics for 2019 year to date (01/01/2019 – 31/03/2019) are presented in Table 28.

Table 28: Data Capture Year to Date (%)

Station	NO ₂	CO	PM _{2.5}	PM ₁₀	Velocity
Eastern	75.4%	97.4%	98.6%	95.4%	100%
Western	96.9%	97.1%	96.8%	97.5%	100%

1.1 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 (1/07/2018 to 31/03/2019) are shown in Table 29.

Table 29: Ventilation Stack Emissions 1/07/2018 – 31/03/2019 (tonnes/year)

Station	NO ₂	CO	PM _{2.5}	PM ₁₀
Eastern	0.77	11	0.21	0.35
Western	0.80	13	0.19	0.34
Total	1.6	24	0.40	0.70
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.

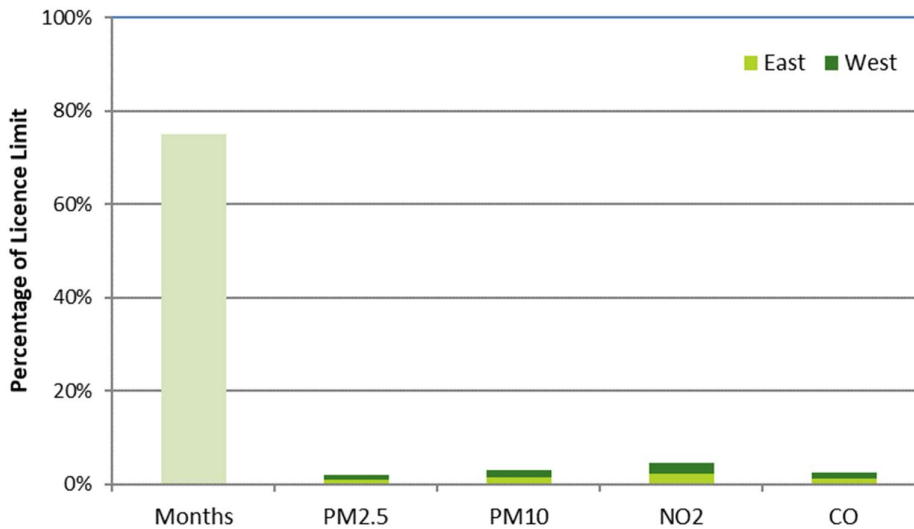


Figure 20: Ventilation Stack Emissions as Percentage of Licence Limit (1/07/2018 – 31/03/2019)

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

Signature Page

Golder Associates Pty Ltd



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Senior Environmental Technician



Mark Tulau
Senior Air Quality Specialist

AM/MDT/am

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APPENDIX A

**Important Information Relating to
this Report**



IMPORTANT INFORMATION RELATING TO 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.

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