

Waterview Operational Air Quality Monitoring Report July to September 2018

Document No: [Subject]

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1 INTRODUCTION

1.1 OVERVIEW

The Waterview Tunnel opened on 02 July 2017. This report includes analysis of validated air quality monitoring data for Waterview Tunnel Joint Operations (WTJO) for the period July 2018 to September 2018. This air quality monitoring report has been prepared in accordance with Waterview Connection BOI Operational Air Quality Condition OA.4.

1.2 WATERVIEW OPERATIONAL AIR QUALITY REQUIREMENTS

Waterview Connection BOI Operational Air Quality Conditions OA.2 – OA.8 (refer Appendix A) set out the requirements for monitoring of ambient air quality in the vicinity of the tunnel portals and of emissions from one of the tunnel portals.

Two ambient air quality stations (one near the northern end and one near the southern end of the Waterview Tunnel) and one portal analyser are required to be operated for a minimum period of 2 years. The two ambient stations measure concentrations of particulates (PM_{2.5} & PM₁₀) and nitrogen dioxide (NO₂) as well as wind speed and wind direction. The portal analyser measures concentrations of NO₂.

Condition OA.2 stipulates that the results of ambient monitoring are to be compared with the National Environmental Standards for air quality and Auckland Regional air quality targets, which are shown in Table 1.

Table 1. WTJO ambient air quality criteria

Pollutant	Threshold concentration	Averaging period
Fine particles (PM ₁₀)	50 µg/m ³ 20 µg/m ³	24-hour Annual
Fine particles (PM _{2.5})	25 µg/m ³ 10 µg/m ³	24-hour Annual
Nitrogen dioxide	200 µg/m ³ 100 µg/m ³ 40 µg/m ³	1-hour 24-hour Annual

1-hour average NO₂ concentrations at the portal air quality monitoring station have been expressed as a rolling average, in accordance with condition OA.8.

This monitoring is required to continue until the Air Quality Peer Review Panel (required under condition OA.7) recommend that it is no longer necessary. Results are required to be reported monthly for the first 12 months and quarterly thereafter (OA.4). The Waterview Tunnel has been operational for over 12 months. In accordance with condition OA.4, reporting is now required on a quarterly basis.

1.3 MONITORED PARAMETERS AND LOCATIONS

Monitoring locations are shown in Appendix B. Locations and types of instrumentation have been agreed with Auckland Council and the Air Quality Peer Review Panel.

A portal monitoring station with Cavity Attenuated Phase Shift Spectroscopy (CAPS) NO₂ analyser has been installed at the rear of 93 Hendon Avenue near the Southern portal, to monitor NO₂ in

accordance with the requirements of consent condition OA.2 and to demonstrate compliance with consent condition OA.8. The portal station is located approximately 80 m from the southern tunnel portal on the residential boundary (40 m from SH20). SH20 is screened from the nearest receptors within the southern approach trench.

Two ambient air quality monitoring stations have been installed to monitor particulates (BAM-1020 analysers, PM₁₀ and PM_{2.5}), nitrogen dioxide (Chemiluminescence NO_x analyser), wind speed and wind direction in accordance with conditions OA.2 and OA.3.

The southern ambient air quality station is located in the approximate location of the original pre-construction baseline monitoring for the WTJO, near 5 Barrymore Road. The southern station is also located adjacent to the residential area at Hendon Avenue, approximately 470 m from the southern tunnel portal (25 m from SH20) where SH20 achieves grade.

Under condition OA.2, the northern ambient air quality station is required to be located at Waterview School subject to agreement by the School; this agreement was not secured. The northern station is therefore located in the approximate location of the original pre-construction baseline monitoring for the WTJO, near the operation maintenance building. This station is located approximately 100 m from the northern tunnel portal downwind in the prevailing wind direction (25 m from SH20, 330 m SH16 and 20 m from Great North Road), with no obstruction between the adjacent traffic sources and air quality station. This location is likely to experience higher levels than the proposed location at the School and is therefore considered conservative.

1.4 DATA MANAGEMENT

Data are downloaded and checked daily by suppliers Ecotech and monthly validated reports provided to the WTJO. A daily summary of results (non-validated data) is provided to the WTJO and, in the event that WTJO air quality criteria are exceeded, email/text alerts are sent, so investigation can be initiated.

Ecotech calibrates the air quality stations on a monthly basis, and attends the site if a fault is detected during the daily checks. Calibration and equipment fault reports are forwarded to the WTJO.

The valid data exception reports for July to September 2018 are attached as Appendix C.

2 MONITORING RESULTS AND ANALYSIS

2.1 SUMMARY STATISTICS

Monitoring sites used for compliance monitoring should achieve at least 95% data capture and a minimum of 75% valid data should be collected when calculating averages¹. Where data did not meet the minimum 75% valid data requirement (i.e. due to calibration or data loss), averages were not calculated. As shown in Table 2, data capture meets the minimum requirement for all measured parameters at all air quality monitoring stations for the July 2018 to September 2018 period.

Table 2. Data capture statistics (July to September 2018)

AQ Station	Parameter	% data capture		
		July 2018	August 2018	September 2018
Northern ambient air quality station	Nitrogen dioxide (NO ₂)	99.8	100	100
	Particulate matter (PM _{2.5})	99.7	100	99.9
	Particulate matter (PM ₁₀)	99.6	100	99.9
Southern ambient air quality station	Nitrogen dioxide (NO ₂)	100	100	100
	Particulate matter (PM _{2.5})	99.9	100	99.9
	Particulate matter (PM ₁₀)	99.9	100	99.9
Portal air quality station	Nitrogen dioxide (NO ₂)	99.9	100	100

A comparison of the monitored levels of NO₂, PM_{2.5} and PM₁₀ against the WTJO air quality criteria is shown in Table 3 for July 2018 to September 2018. As requested by the Peer Review Panel, maximum rolling annual average PM₁₀, PM_{2.5} and NO₂ have been included for comparison to the WTJO criteria.

This shows that measured air quality concentrations were below the WTJO ambient air quality criteria. Data measured in previous months is summarised in Appendix D and original baseline data in Appendix F.

Table 3. Air quality monitoring results for July to September 2018

AQ Station	Description	Concentration in µg/m ³			WTJO air quality criteria in µg/m ³
		July 2018	August 2018	September 2018	
Northern ambient air quality station	Maximum 1-hour average NO ₂	101.5	101.1	75.8	200
	Maximum 24-hour average NO ₂	50.3	50.3	44.2	100
	Maximum rolling annual average NO ₂	22.8	22.3	23.4	40
	Maximum daily average PM _{2.5}	19.0	14.8	11.2	25
	Maximum rolling annual average PM _{2.5}	8.0	8.1	8.1	10
	Maximum daily average PM ₁₀	31.4	24.5	22.1	50
	Maximum rolling annual average PM ₁₀	16.5	16.7	16.7	20
Southern ambient air quality station	Maximum 1-hour average NO ₂	73.5	72.7	56.9	200
	Maximum 24-hour average NO ₂	39.7	38.9	27.7	100
	Maximum rolling annual average NO ₂	15.8	16.1	16.3	40
	Maximum daily average PM _{2.5}	21.3	16.1	12.0	25
	Maximum rolling annual average PM _{2.5}	7.3	7.5	7.5	10
	Maximum daily average PM ₁₀	30.2	21.7	18.5	50
	Maximum rolling annual average PM ₁₀	14.3	14.4	14.1	20

¹ Ministry for the Environment. 2009. Good Practice Guide for Air Quality Monitoring and Data Management 2009. Wellington: Ministry for the Environment.

AQ Station	Description	Concentration in $\mu\text{g}/\text{m}^3$			WTJO air quality criteria in $\mu\text{g}/\text{m}^3$
		July 2018	August 2018	September 2018	
Portal air quality station	Maximum rolling 1-hour average NO_2	86.9	75.5	76.1	200
	Maximum rolling annual average NO_2	15.5	16.0	16.1	40

2.2 EXCEEDENCES OF AIR QUALITY CRITERIA

The Waterview Connection BOI Operational Air Quality Condition OA.5 requires that when an exceedance of the WTJO air quality criteria occur, an investigation shall be undertaken into the cause of the exceedance and that this be reported to the Air Quality Peer Review Panel and Auckland Council.

There were no exceedances of the WTJO air quality criteria in the July to September 2018 monitoring period.

2.3 POLLUTION ROSES

Pollution roses based on the hourly monitoring data are provided in Appendix E for July to September 2018.

In summary, the pollution roses show that:

- The highest NO_2 concentrations at the northern station were measured in wind directions ranging from southwest to west-northwest, from the direction of the adjacent SH20 alignment.
- The highest concentrations of PM_{10} and $\text{PM}_{2.5}$ at the northern station were measured in winds from northeast and east-northeast wind directions, from the direction of the Mason Clinic and Unitec campuses (i.e. not from the direction of the SH20 alignment).
- The highest NO_2 concentrations at the portal and southern stations were distributed over a range of directions from southeast to west-southwest from the direction of the SH20 alignment.
- The highest concentrations of PM_{10} and $\text{PM}_{2.5}$ at the southern station were measured in wind directions ranging from northeast to east-northeast, from the direction of the Owairaka residential area (i.e. not from the direction of the SH20 alignment).
- The NO_2 pollution roses indicate that the main source of NO_2 at the monitoring sites is likely to be traffic emissions. The PM_{10} and $\text{PM}_{2.5}$ pollution roses at the monitoring sites indicate that the highest concentrations were measured in winds that were not from the direction of the SH20 alignment and were likely to have been influenced primarily by non-traffic related sources.

2.4 TRAFFIC DATA AND POLLUTANT TRENDS

The daily traffic flow through the Waterview tunnel during July – September 2018 is shown in Figure 1 below with daily average NO_2 concentrations measured at the three stations. The traffic flow shows a distinct weekly pattern, with traffic flows generally increasing from Monday to Friday and dropping off at the weekend, with the lowest traffic flow on Sundays.

The northern air quality station recorded the highest NO_2 concentrations over the period. The northern station is located close to other high traffic routes (330 m SH16 and 20 m from Great North Road). The portal and southern stations show similar NO_2 concentrations.

The weekly pattern of PM_{2.5} and PM₁₀ concentrations show a weak correspondence with daily traffic flows, as shown in Figure 2. PM₁₀ concentrations at the northern station were higher than those measured at the southern station. PM_{2.5} concentrations were similar at the northern and southern stations.

The hourly average diurnal patterns of NO₂ concentrations show a good correspondence with average hourly traffic flow, with the highest concentrations in the morning and afternoon around peak traffic times, as shown in Figure 3. Diurnal patterns of PM_{2.5} and PM₁₀ concentrations show a weak correspondence with traffic flow, as shown in Figure 4. The highest PM_{2.5} and PM₁₀ concentrations are outside of peak traffic times with peak diurnal concentrations measured around 9-10 pm, indicating that peak concentrations are related to domestic heating throughout the cooler months.

Trends in the monthly average NO₂ concentration measured each month since May 2017 are shown in Figure 5. The figure shows the changes in NO₂ after tunnel opening in July 2017 and the seasonality of NO₂ concentrations. Over the July to September 2018 monitoring period monthly average NO₂ concentrations decreased from a mid-winter peak in July 2018. This appeared to continue the seasonal trend in monthly NO₂ concentrations measured over the corresponding period in 2017.

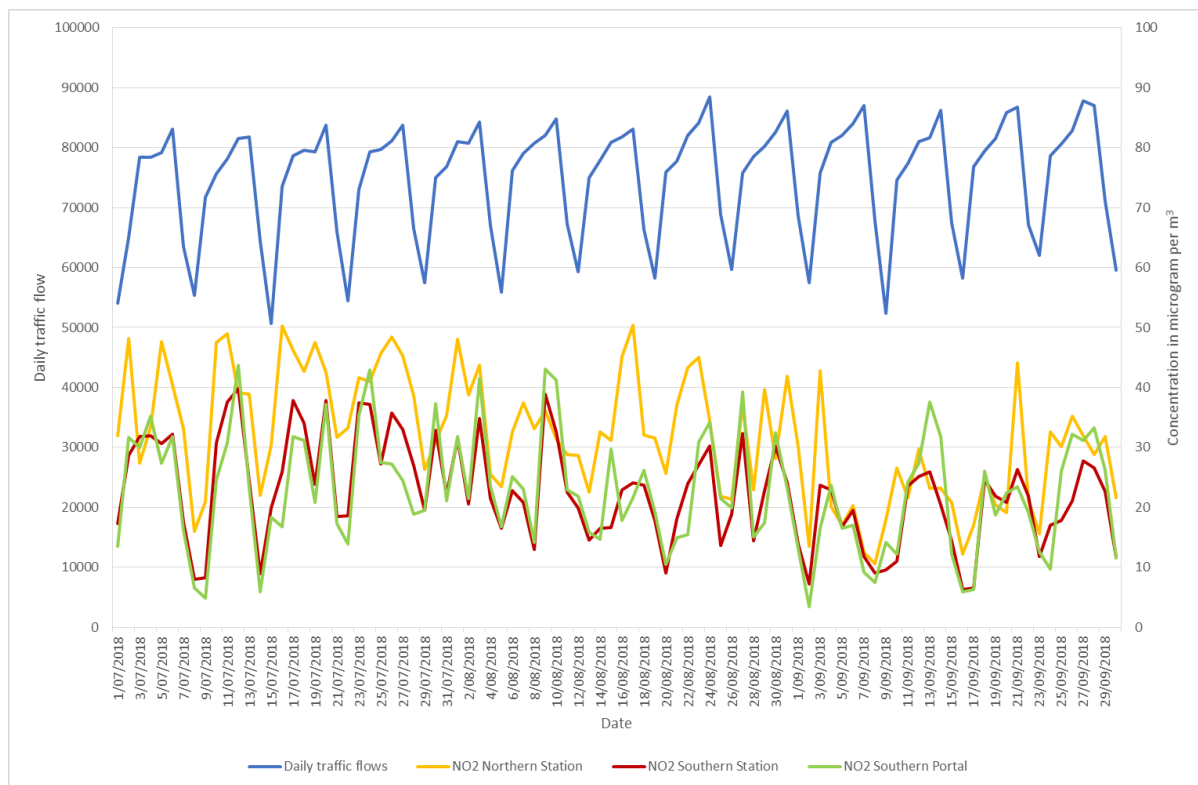


Figure 1: Waterview tunnel daily traffic flows and daily average NO₂, July – September 2018

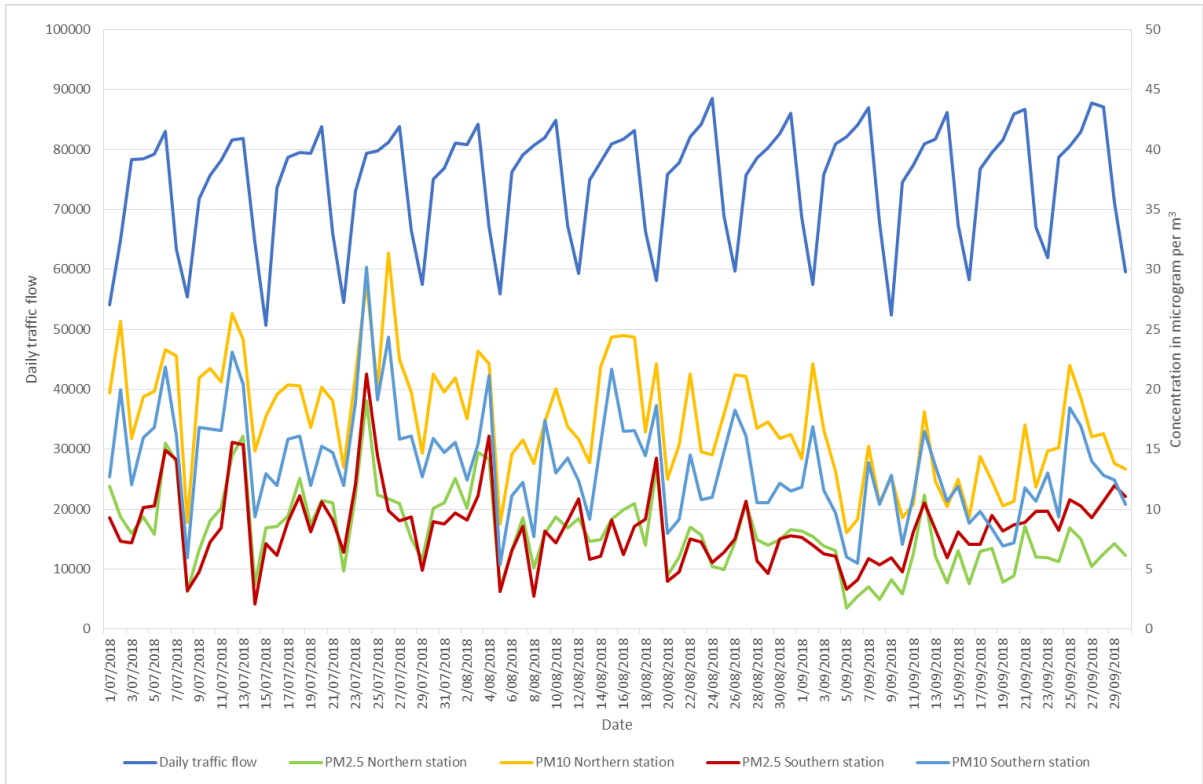


Figure 2: Waterview tunnel daily traffic flows and daily average PM_{2.5} and PM₁₀, July – September 2018

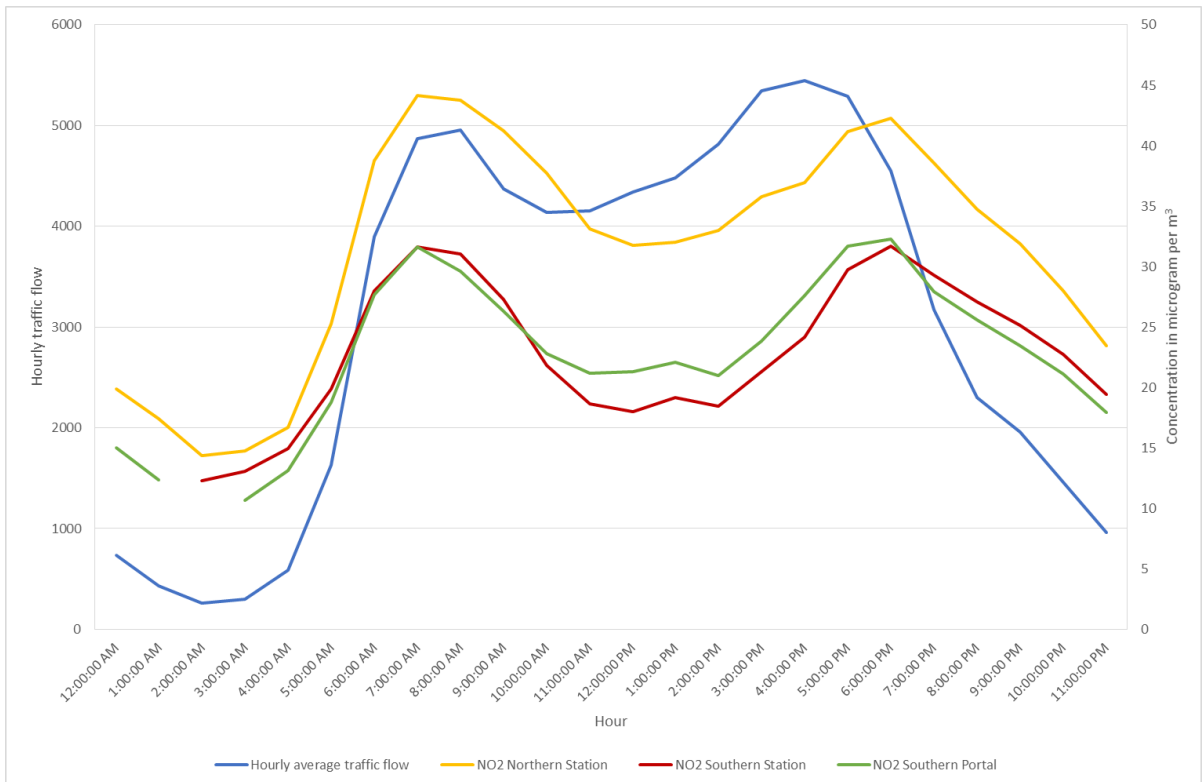


Figure 3: Diurnal hourly average traffic flow and nitrogen dioxide concentrations

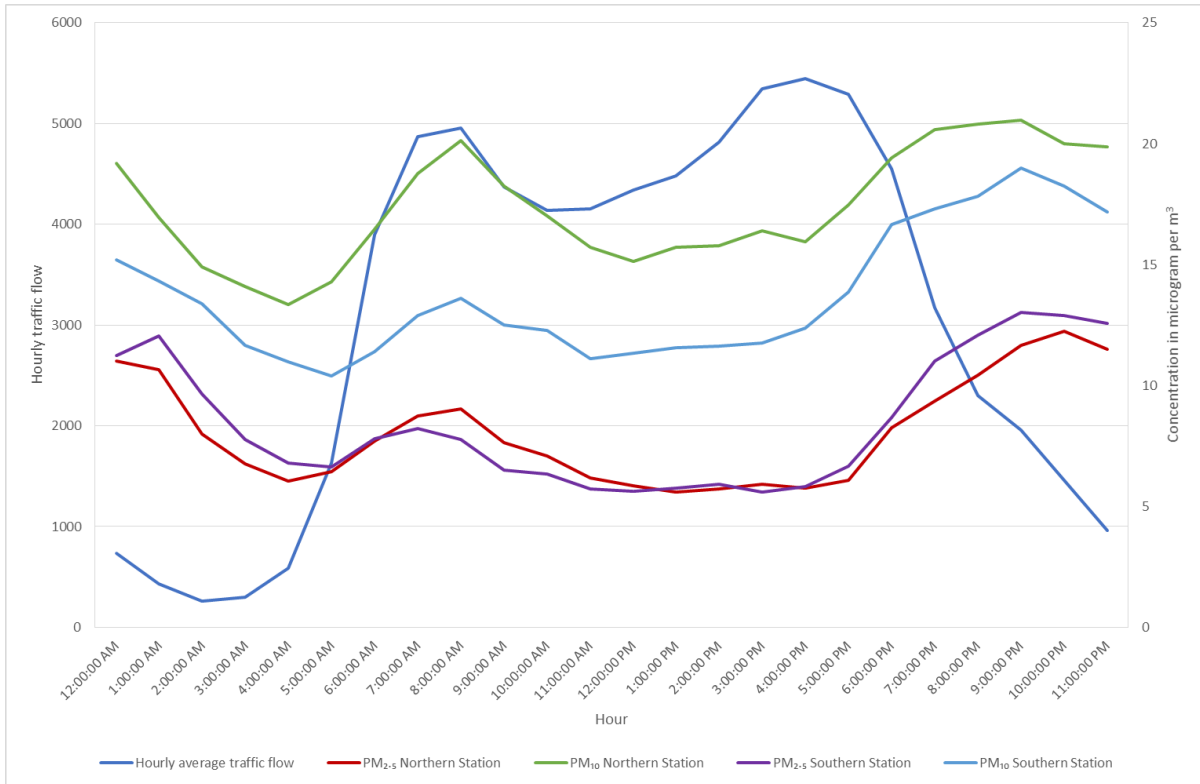


Figure 4: Diurnal hourly average traffic flow and PM_{2.5} and PM₁₀ concentrations

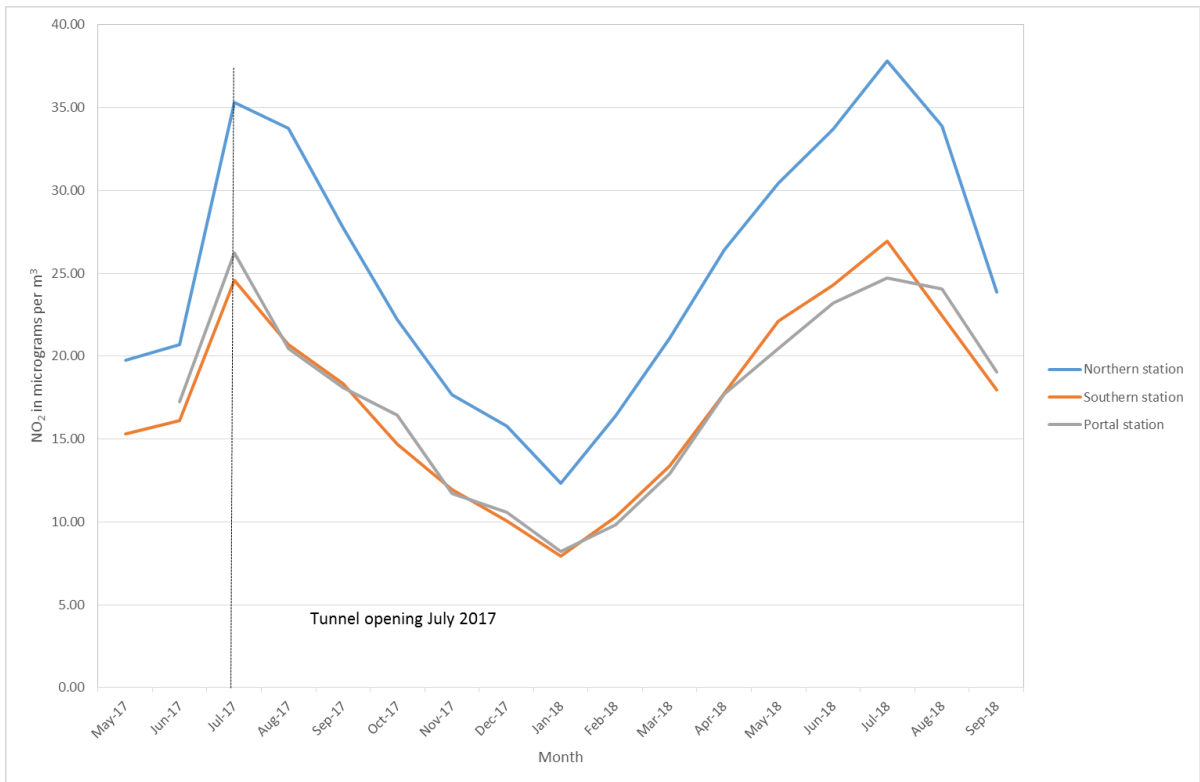


Figure 5: Monthly average nitrogen dioxide concentrations

3 CONCLUSION

This air quality monitoring report has been prepared in accordance with Waterview Connection BOI Operational Air Quality Condition OA.4, and includes analysis of validated air quality monitoring data for July to September 2018.

The Waterview Tunnel has been operational for over 12 months. In accordance with condition OA.4, reporting is now required on a quarterly basis.

The analysis of NO₂, PM_{2.5} and PM₁₀ data for the two ambient air quality stations and NO₂ data for the portal air quality station has shown that measured air quality concentrations were below the WTJO ambient air quality criteria for the period July 2018 to September 2018.

The recommended minimum data capture rate of 95% was achieved at all locations for the period July 2018 to September 2018.

The highest concentrations of NO₂ were recorded at the northern station. This station is located closer to major traffic sources than the other two stations and has no obstruction between the adjacent sources and air quality station. The concentrations of PM₁₀ were slightly higher at the northern station than the southern station. PM_{2.5} concentrations were similar at the northern and southern stations.

Analysis of NO₂ pollution roses and diurnal trends indicates that the main source of NO₂ concentrations is traffic emissions.

The highest concentrations of PM_{2.5} and PM₁₀ were measured in winds that were not from the direction of the SH20 alignment. Additionally, diurnal PM_{2.5} and PM₁₀ concentration patterns do not correspond strongly with traffic flow patterns. This indicates that traffic-related emissions from SH20 are unlikely to be the main contributor to particulate concentrations measured in the area over the July - September 2018 period.

APPENDIX A: AIR QUALITY CONDITIONS

OA.1 The vents used to discharge emissions in the tunnels shall discharge vertically into air at a height of 15m, as follows: (a) The northern ventilation stack will be at a height of 15m. This height shall be calculated from the lowest existing ground level along the Great North Road boundary, adjacent to the ventilation stack; and (b) The southern ventilation stack will be at a height of 15m calculated from the post-construction ground level of the Alan Wood Reserve averaged at a distance of 10m from the exterior walls the ventilation stack location and shall not be impeded by any obstruction that may in the opinion of the Peer Review Panel (Condition OA. 7) decrease the vertical efflux velocity (in other words, the average velocity of material emitted into the atmosphere).

OA.2 Prior to the tunnels becoming operational, the NZTA shall establish two ambient air quality monitoring stations and one portal air quality monitoring station. The location and types of these monitoring stations shall be selected by the NZTA in consultation with the Auckland Council and Peer Review Panel (Condition OA.7), providing that one ambient monitoring station will be located within the Waterview Primary School (subject to agreement by the School).

Ambient air quality shall be monitored continuously in real time, to monitor potential effects associated with the operation of the ventilation system from the tunnels. Ambient monitoring shall include fine particulates (PM₁₀ and PM_{2.5}) and nitrogen dioxide. Portal monitoring shall include nitrogen dioxide. Results shall be compared with the relevant National Environmental Standards for air quality and Auckland Regional air quality targets (as identified in Chapter 4 of the Auckland Regional Plan: Air, Land and Water, 2010). Monitoring shall be undertaken at each site until the Peer Review Panel recommends that monitoring is no longer necessary. The locations, operation and maintenance schedules of the continuous monitors shall, as far as practicable, comply with the requirements of AS/NZ 3580.1.1: 2007 Method for Sampling and Analysis of Ambient Air – Guide to Siting Air Monitoring Equipment, and with methods specified in the National Environment Standards.

OA.3 Continuous monitoring of wind speed and direction shall be undertaken at each ambient air quality monitoring location as required by Condition OA.2. The locations of wind speed and direction monitors shall, as far as practicable, comply with the requirements of AS 2923:1987 Ambient Air – Guide for the Measurement of Horizontal Wind for Air Quality Applications.

OA.4 For the first 12 months of tunnel operation, the results of the ambient air quality monitoring shall be reported via validated reports and issued for information via the Project website (monthly). Following this period, and for a period of at least 12 months, reporting shall take place quarterly as follows: Quarter 1 (December to February) by 31 March, Quarter 2 (March to May) by 30 June, Quarter 3 (June to August) by 30 September and Quarter 4 (September to December) by 31 December.

OA.5. If the monitoring required by Condition OA.2 shows that concentrations of contaminants in ambient air at the monitoring locations exceeds the relevant National Environmental Standards for air quality, or Regional Air Quality Targets (as identified in Chapter 4 of the Auckland Regional Plan: Air, Land and Water), the NZTA shall undertake an investigation into the cause of the exceedance and report this to the Peer Review Panel (Condition OA.7) and the Major Infrastructure Team Manager, Auckland Council.

OA.6. The air quality monitoring shall be undertaken in general accordance with the Operational Air Quality Management Procedure (Appendix O of Technical Report G.1 Assessment of Air Quality Effects) submitted with this application.

OA.7. A Peer Review Panel shall be appointed by NZTA with the agreement of Major Infrastructure Team Manager, Auckland Council for the purpose of reviewing the ambient air quality monitoring programme and results. The Peer Review Panel shall consist of two independent experts in air quality with experience in ambient air quality monitoring and emissions from motor vehicles. The Peer Review Panel shall review all ambient monitoring, relevant traffic data and tunnel emissions and provide a summary report including any interpretation and recommendations to NZTA, Auckland Council and the Community Liaison Group(s) within 6 months of the tunnels becoming operational and annually thereafter.

O.A.8 The tunnel ventilation system shall be designed and operated to ensure that any air emitted from the tunnel portals does not cause the concentration of nitrogen dioxide (NO₂) in ambient air to exceed 200 micrograms per cubic metre, expressed as a rolling 1 hour average, at any point beyond the designation boundary that borders an air pollution sensitive land use.

Advice Note: The above standard reflects the National Environmental Standard for Nitrogen Dioxide (NO₂) concentration in ambient air.

APPENDIX B: MONITORING LOCATIONS

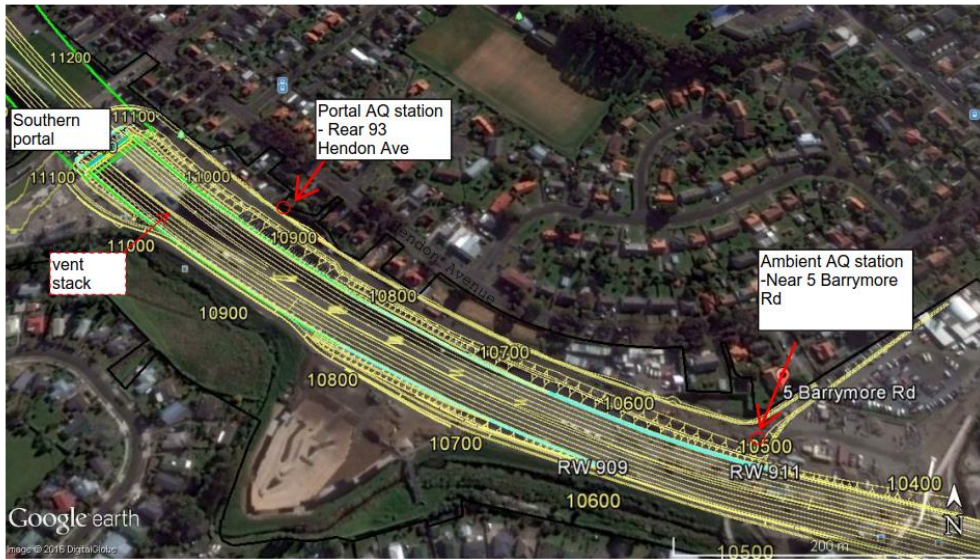


Figure B 1: Southern area stations



Figure B 2: Northern area station

APPENDIX C: VALID DATA EXCEPTION REPORT

North ambient air quality station

Start Date	End Date	Reason	Change Details	User Name	Change Date
01/07/2018 1:00	31/07/2018 1:40	Automatic overnight span calibration check from approximately 1:00 - 1:40	NO, NO ₂ , NO _x	AH	10/08/2018
04/07/2018 9:00	04/07/2018 10:15	Scheduled monthly maintenance	NO, NO ₂ , NO _x , PM ₁₀ , PM _{2.5}	AH	10/08/2018
05/07/2018 9:50	05/07/2018 10:50	Unscheduled maintenance - logger clock corrected by +50 minutes	NO, NO ₂ , NO _x , WS, WD	AH	10/08/2018
06/07/2018 0:00	06/07/2018 0:00	Instrument fault - beta count error	PM ₁₀ , PM _{2.5}	AH	10/08/2018
06/07/2018 22:00	06/07/2018 22:00	Instrument fault - flow fault	PM ₁₀	AH	10/08/2018
24/07/2018 1:00	24/07/2018 1:10	Brief power interruption and instrument stabilisation. NO _x automatic calibration cycle interrupted and did not run correctly	All parameters	AH	10/08/2018
26/07/2018 10:00	26/07/2018 12:55	Scheduled monthly maintenance	All parameters	AH	10/08/2018
01/08/2018 1:00	31/08/2018 1:40	Automatic overnight span calibration check from approximately 1:00 - 1:40	NO, NO ₂ , NO _x	AH	13/09/2018
01/09/2018 1:00	30/09/2018 1:40	Automatic overnight span calibration check from approximately 1:00 - 1:40	NO, NO ₂ , NO _x	AH	11/10/2018
07/09/2018 10:00	07/09/2018 11:35	Scheduled 3-monthly maintenance	NO, NO ₂ , NO _x , PM ₁₀ , PM _{2.5}	AH	11/10/2018
23/09/2018 16:00	23/09/2018 16:00	Unrealistic data spike	PM ₁₀	AH	11/10/2018

South ambient air quality station

Start Date	End Date	Reason	Change Details	User Name	Change Date
01/07/2018 1:00	31/07/2018 1:30	Automatic overnight span calibration check from approximately 1:00 - 1:30	NO, NO ₂ , NO _x	AH	10/08/2018
04/07/2018 12:00	04/07/2018 16:00	Scheduled monthly maintenance and instrument stabilisation	PM ₁₀ , PM _{2.5}	AH	10/08/2018
04/07/2018 12:35	04/07/2018 13:25	Scheduled monthly maintenance	NO, NO ₂ , NO _x	AH	10/08/2018
05/07/2018 0:00	05/07/2018 0:00	Instrument fault - beta count error	PM _{2.5}	AH	10/08/2018
05/07/2018 8:20	05/07/2018 8:40	Unscheduled maintenance - connection and instrument check. No data affected	-	AH	10/08/2018
07/07/2018 0:00	07/07/2018 0:00	Instrument fault - beta count error	PM ₁₀	AH	10/08/2018
10/07/2018 1:55	10/07/2018 1:55	Unrealistic data - negative NO ₂ value to due rapidly changing conditions	NO, NO ₂ , NO _x	AH	10/08/2018
26/07/2018 12:00	26/07/2018 14:05	Scheduled monthly maintenance	All parameters	AH	10/08/2018

Start Date	End Date	Reason	Change Details	User Name	Change Date
01/08/2018 1:00	31/08/2018 1:30	Automatic overnight span calibration check from approximately 1:00 - 1:30	NO, NO ₂ , NO _x	AH	13/09/2018
01/09/2018 1:00	30/09/2018 1:30	Automatic overnight span calibration check from approximately 1:00 - 1:30	NO, NO ₂ , NO _x	AH	11/10/2018
05/09/2018 1:00	05/09/2018 1:00	Instrument fault - flow fault	PM _{2.5}	AH	11/10/2018
07/09/2018 12:00	07/09/2018 16:00	Scheduled 3-monthly maintenance and subsequent instrument stabilisation	NO, NO ₂ , NO _x , PM ₁₀ , PM _{2.5}	AH	11/10/2018
17/09/2018 8:00	17/09/2018 8:00	Brief power interruption and subsequent instrument stabilisation	PM ₁₀	AH	11/10/2018

Portal air quality station

Start Date	End Date	Reason	Change Details	User Name	Change Date
01/07/2018 0:40	31/07/2018 0:40	Automatic background check, nightly for 5 minutes	NO ₂	AH	10/08/2018
01/07/2018 2:00	31/07/2018 2:30	Automatic overnight span calibration check from approximately 2:00 - 2:30	NO ₂	AH	10/08/2018
04/07/2018 12:40	26/07/2018 16:10	Intermittent additional automatic background checks	NO ₂	AH	10/08/2018
04/07/2018 15:15	04/07/2018 16:10	Scheduled monthly maintenance	NO ₂	AH	10/08/2018
05/07/2018 8:20	05/07/2018 8:40	Unscheduled maintenance - connection and instrument check. No data affected	-	AH	10/08/2018
26/07/2018 13:45	26/07/2018 14:40	Scheduled monthly maintenance	NO ₂	AH	10/08/2018
01/08/2018 0:40	31/08/2018 0:40	Automatic background check, nightly for 5 minutes	NO ₂	AH	13/09/2018
01/08/2018 2:00	31/08/2018 2:30	Automatic overnight span calibration check from approximately 2:00 - 2:30	NO ₂	AH	13/09/2018
06/08/2018 13:05	06/08/2018 13:20	Unscheduled maintenance - remote calibration of co-located NO _x analyser. NO ₂ data unaffected	-	AH	13/09/2018
01/09/2018 0:40	30/09/2018 0:40	Automatic background check, nightly for 5 minutes	NO ₂	AH	11/10/2018
01/09/2018 2:00	30/09/2018 2:30	Automatic overnight span calibration check from approximately 2:00 - 2:30	NO ₂	AH	11/10/2018
07/09/2018 14:50	07/09/2018 15:25	Scheduled 3-monthly maintenance	NO ₂	AH	11/10/2018
07/09/2018 18:05	07/09/2018 18:05	Additional automatic background check	NO ₂	AH	11/10/2018

APPENDIX D: PREVIOUS MONTHLY DATA

AQ Station	Description	Pre Tunnel Opening Concentration in $\mu\text{g}/\text{m}^3$		Post Tunnel Opening Concentration in $\mu\text{g}/\text{m}^3$															Project air quality criteria in $\mu\text{g}/\text{m}^3$
		May 2017	June 2017	July 2017	Aug 2017	Sept 2017	Oct 2017	Nov 2017	Dec 2017	Jan 2018	Feb 2018	Mar 2018	Apr 2018	May 2018	June 2018	July 2018	Aug 2018	Sept 2018	
Northern ambient air quality station	Maximum 1-hour average NO_2	65.5	58.2	96.8	93.2	91.3	77.9	62.1	57.8	53.6	62.9	62.1	69.8	83.5	87.5	101.5	101.1	75.8	200
	Maximum 24-hour average NO_2	30.2	36.9	46.4	54.1	44.8	39.4	26.5	31.7	24.7	30.2	34.3	42.7	46.4	45	50.3	50.3	44.2	100
	Maximum daily average $\text{PM}_{2.5}$	32.7	24.9	24.8	16.9	14.0	10.5	11.3	10.8	16.0	13.1	11.3	14.4	21.8	27	19	14.8	11.2	25
	Maximum daily average PM_{10}	35.7	33.3	31.0	26.4	26.9	31.3	35.1	24.4	36.0	27.6	31	32.8	29.9	36.8	31.4	24.5	22.1	50
Southern ambient air quality station	Maximum 1-hour average NO_2	64.1	70.3	73.3	63.5	73.4	61.9	50.5	44.7	32.8	51.7	41.1	57.0	64.8	62.4	73.5	72.7	56.9	200
	Maximum 24-hour average NO_2	30.0	30.8	38.2	34.7	27.4	25.5	20.7	16.9	18.5	17.9	22.8	29.6	36.5	38.8	39.7	38.9	27.7	100
	Maximum daily average $\text{PM}_{2.5}$	23.2	19.1	26.5	12.6	12.1	13.3	9.8	8.1	14.0	9.8	11	15.9	21.9	26.4	21.3	16.1	12	25
	Maximum daily average PM_{10}	35.8	31.8	31.8	28.8	31.6	37.9	22.0	20.1	34.0	26.7	23.9	27.3	26.5	34.1	30.2	21.7	18.5	50
Portal air quality station	Maximum rolling 1-hour average NO_2	70.8	80.6	86.9	73.8	84.9	62.6	63.5	51.2	46.7	46	51	67.4	78.7	87.8	86.9	75.5	76.1	200

It should be noted that construction activities on site in the vicinity of the stations, including vehicle movements on haul roads, will have contributed to measured particulate levels pre tunnel opening. Baseline measurements of $\text{PM}_{2.5}$ were also elevated in May 2017 during the night time due to domestic smoke from adjacent residential properties.

APPENDIX E: POLLUTION ROSES

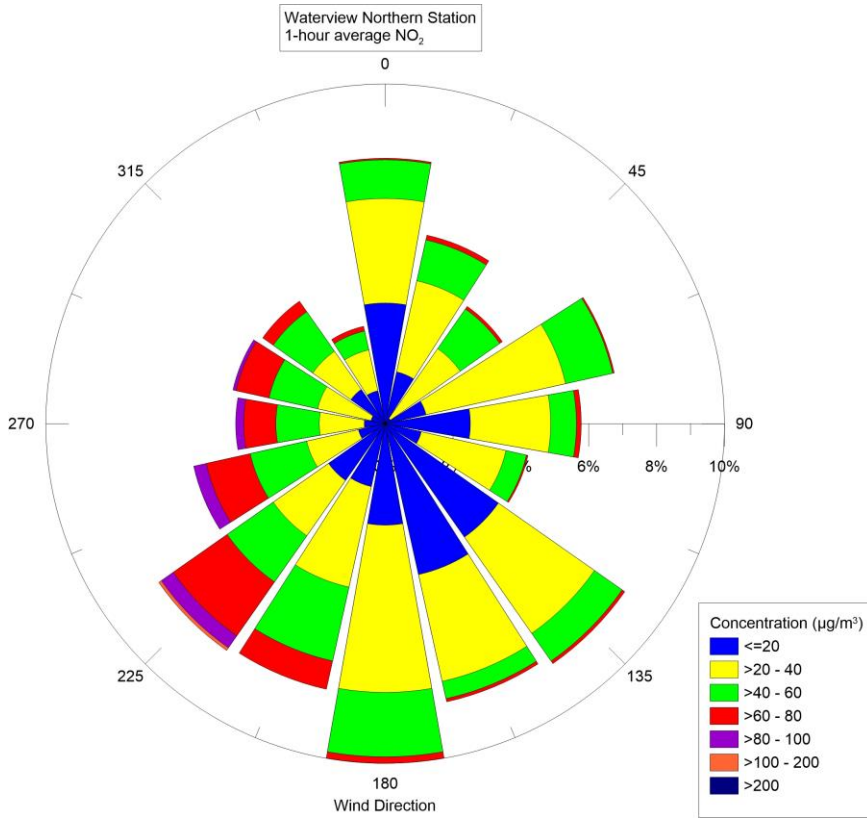


Figure D 1: Northern station 1-hour average NO₂, July – September 2018

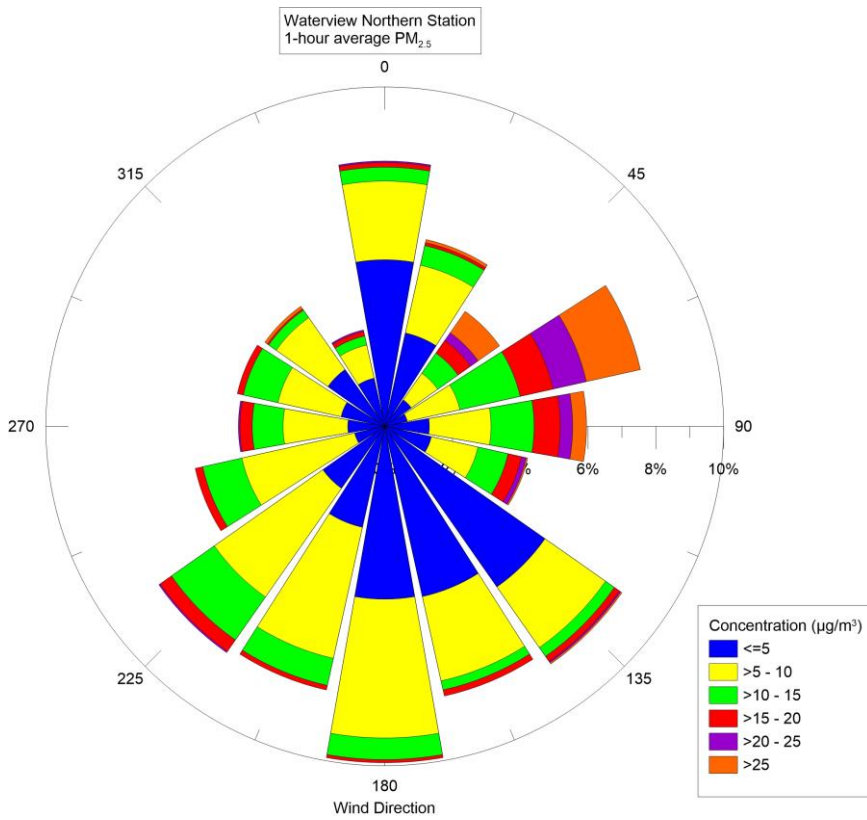


Figure D 2: Northern station 1-hour average PM_{2.5}, July – September 2018

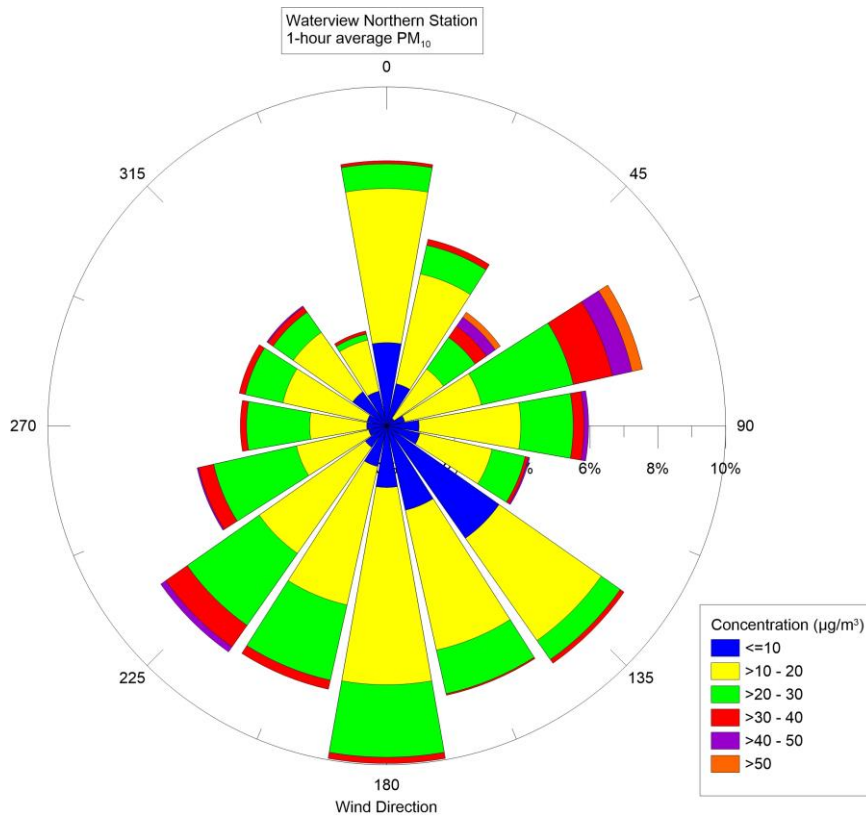


Figure D 3: Northern station 1-hour average PM₁₀, July – September 2018

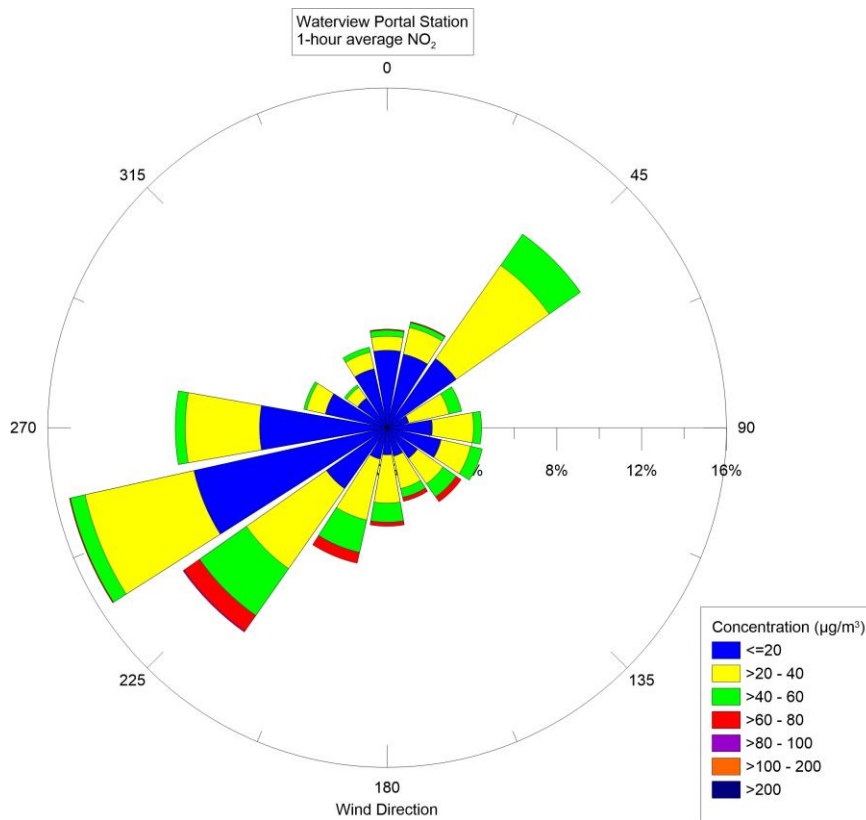


Figure D 4: Portal station 1-hour average NO₂, July – September 2018

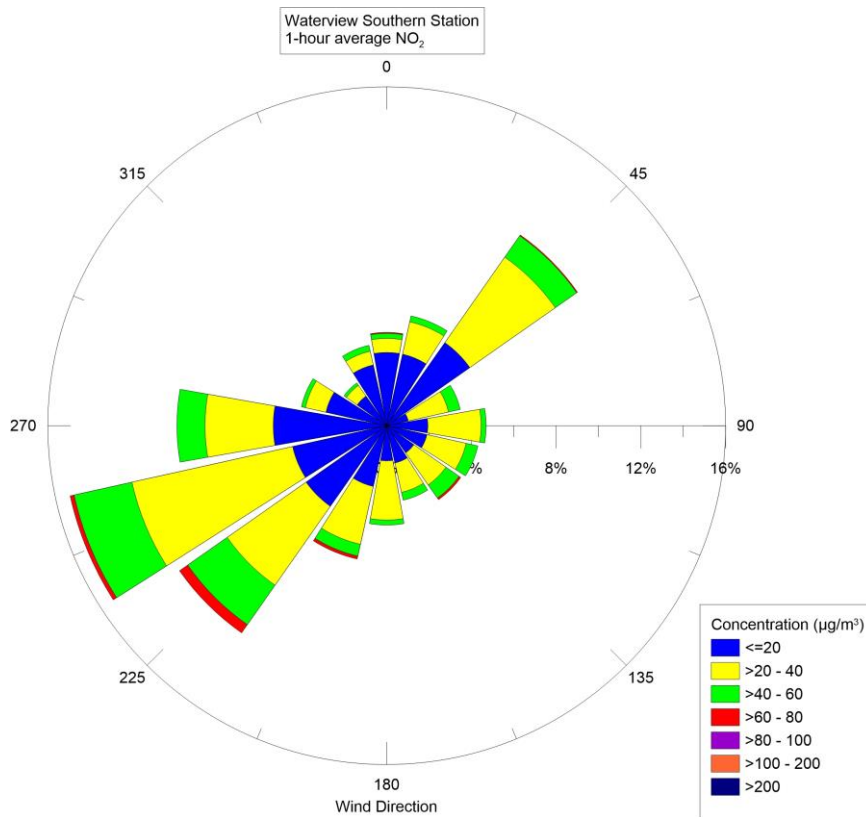


Figure D 5: Southern station 1-hour average NO₂, July – September 2018

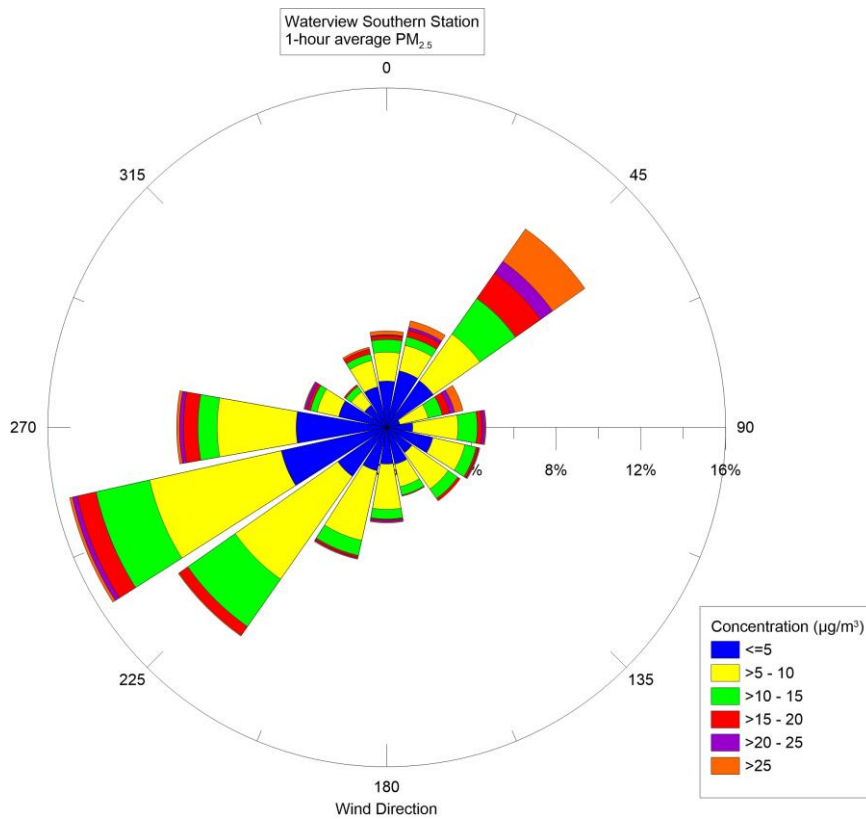


Figure D 6: Southern station 1-hour average PM_{2.5}, July – September 2018

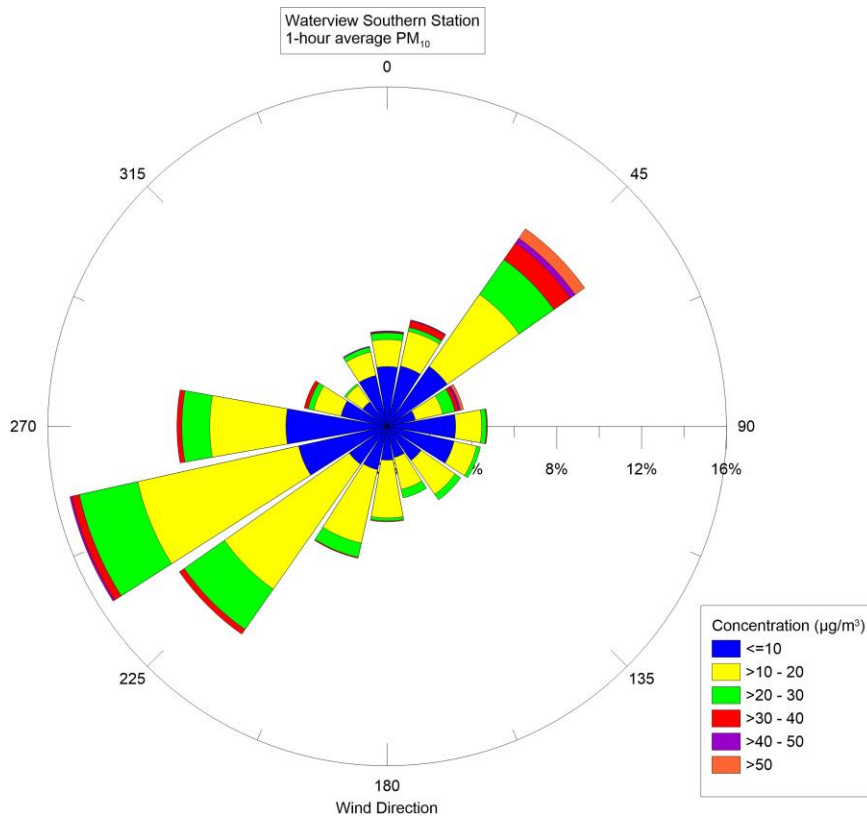


Figure D 7: Southern station 1-hour average PM_{10} , July – September 2018

APPENDIX F: ORIGINAL BASELINE MONITORING DATA

Air Quality Station	Description	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06					
Northern Area - Cowley St air quality station	Maximum rolling 1-hour average NO ₂												
	Maximum 24-hour average NO ₂												
	Maximum daily average PM _{2.5}												
	Maximum daily average PM ₁₀												
Southern Area - Alan Wood air quality station	Maximum rolling 1-hour average NO ₂	55	59	59	53	112	39	57					
	Maximum 24-hour average NO ₂	25	34	31	26	86	17	19					
	Maximum daily average PM _{2.5}												
	Maximum daily average PM ₁₀	32	44	23	22	19	63	22					
Air Quality Station	Description	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07
Northern Area - Cowley St air quality station	Maximum rolling 1-hour average NO ₂								55	66	61	50	44
	Maximum 24-hour average NO ₂								29	36	28	30	23
	Maximum daily average PM _{2.5}												
	Maximum daily average PM ₁₀								25	32	28	28	24
Southern Area - Alan Wood air quality station	Maximum rolling 1-hour average NO ₂	28	35	37	53	56	56	61	51	61	44	42	38
	Maximum 24-hour average NO ₂	10	13	15	27	34	32	28	20	25	18	17	13
	Maximum daily average PM _{2.5}												
	Maximum daily average PM ₁₀	21	19	19	19	32	35	22	31	17	24	24	14
Air Quality Station	Description	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
Northern Area - Cowley St air quality station	Maximum rolling 1-hour average NO ₂	38	43	46	57	71	71	81	71	62	66	119	62
	Maximum 24-hour average NO ₂	20	23	27	27	39	42	41	38	34	35	35	30
	Maximum daily average PM _{2.5}												
	Maximum daily average PM ₁₀	29	21	22	24	37	31	33	16	18	20	27	18
Southern Area - Alan Wood air quality station	Maximum rolling 1-hour average NO ₂	26	38	42	54	59	67	58	52	45	43	34	36
	Maximum 24-hour average NO ₂		20	19	25	30	38	32	21	21	16	13	14
	Maximum daily average PM _{2.5}												
	Maximum daily average PM ₁₀	24	18	21	19	37	27	30	17	15	19	22	15

Air Quality Station	Description	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
Northern Area - Cowley St air quality station	Maximum rolling 1-hour average NO ₂	74	265				55	103	99	77	93	83	80
	Maximum 24-hour average NO ₂	37	48				26	56	48	44	45	30	39
	Maximum daily average PM _{2.5}												
	Maximum daily average PM ₁₀	20	29	26	29	27	50	43	32	135	31	33	25
Southern Area - Alan Wood air quality station	Maximum rolling 1-hour average NO ₂	29	32	38	40	51	62	44	51	37			
	Maximum 24-hour average NO ₂	9	15	18	20	24	30	22	20	18			
	Maximum daily average PM _{2.5}												
	Maximum daily average PM ₁₀	17	26	20	21	25	38	30	28	117			
Air Quality Station	Description	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10
Northern Area - Cowley St air quality station	Maximum rolling 1-hour average NO ₂	52	57	58	56	55	23	265	70	41	93	101	85
	Maximum 24-hour average NO ₂	29	30	33	33	28	11	46	22	22	30	34	27
	Maximum daily average PM _{2.5}						16	29	34	10	10	13	8
	Maximum daily average PM ₁₀	21	27	23	20	28	20	35	39	26	27	22	30
Southern Area - Alan Wood air quality station	Maximum rolling 1-hour average NO ₂												
	Maximum 24-hour average NO ₂												
	Maximum daily average PM _{2.5}												
	Maximum daily average PM ₁₀						44	40	37	24	26	22	30

Results taken from: *Ambient Air Quality Monitoring Summary Report, Beca 09 May 2011.*