REPORT

Tonkin+Taylor

Stella Passage Development

Air quality assessment

Prepared for

Port of Tauranga Limited

Prepared by

Tonkin & Taylor Ltd

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Executive summary

Scope of assessment

Tonkin & Taylor Ltd (T+T) has been engaged by POTL to evaluate the potential air quality effects of discharges to air from ships at the new berths created by the Stella Passage Development ('the Project'). Resource consent is not required for discharges to air from ships as they are expressly permitted under the Resource Management (Marine Pollution) Regulations 1998. However, this air quality assessment has been undertaken to address local concerns about air quality in the Mount Maunganui Airshed and particularly at Whareroa Marae, which is the closest residential area to the Project.

There is at least one full year of air quality monitoring data at Whareroa Marae for all the relevant contaminants.

The modelled impacts of the discharges from ships at the new berths, cumulative with existing air quality, have been assessed against relevant New Zealand air quality standards and guidelines.

The assessment has also considered the effects of the project against the more stringent air quality guidelines published by the World Health Organization (WHO) in 2021. The WHO 2021 guidelines have not yet been formally evaluated by the Ministry for the Environment or Ministry of Health for adoption as New Zealand air quality guidelines or standards, however they have been considered for completeness.

Environmental effects identified

The air quality effects associated with the Project are related to the effects of exhaust emissions from ships at the new berths. While at berth, a ship's energy requirements for heating/cooling and electricity are met either by running auxiliary engines or by running the main engines on low load. The exhaust emissions are combustion products from burning of fuel, particularly sulphur dioxide (SO_2), particulate matter (PM_{10}, $PM_{2.5}$) and nitrogen dioxide (NO_2).

The effects of ships at the new berths have been predicted using dispersion modelling and incorporating a number of conservative assumptions, including:

- The assessment of short-term impacts is based on the ship that has the highest possible emissions (for Sulphur Point this is a large container and for the Mount Maunganui wharves a large bulk tanker).
- The assessment of long-term impacts assumes the new berths are continuously occupied by an average-sized ship.
- That the emissions from these ships are additional to existing shipping.

For context, it is noted that existing air quality at Whareroa Marae meets all of the relevant New Zealand standards and guidelines. PM_{10} air quality at some locations in the Mount Maunganui Airshed does not meet the 24-hour standard set in the Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (NESAQ) and therefore the Airshed is defined as a polluted airshed under the NESAQ. However, PM_{10} concentrations at Whareroa Marae are well within the 24-hour standard set in the NESAQ.

The assessment demonstrates that the cumulative air quality effects of both Stages 1 and 2 of the Project on air quality at Whareroa Marae are generally negligible in comparison to the New Zealand air quality standards and guidelines apart from 1-hour NO_2 and 24-hour $PM_{2.5}$, where the impacts are classed as moderate (using the adopted impact classification scheme). There is a moderate increase (22%) in the predicted worst-case 1-hour average NO_2 concentration, however the cumulative concentration remains well below (less than 50%) the NESAQ. Similarly, there is a small

(11%) increase in the predicted worst-case 24-hour average $PM_{2.5}$ concentration but the cumulative concentration remains well below (less than 60%) the Proposed NESAQ. As cumulative concentrations remain well below the New Zealand standards and guidelines, the overall effects on 1-hour NO_2 and 24-hour $PM_{2.5}$ are assessed as being low.

The effects of the Project have also been compared against the more stringent WHO 2021 air quality guidelines for completeness. For most contaminants and averaging periods, the effects are negligible compared to the WHO 2021 guideline. The exceptions are for the impact on 24-hour SO_2, annual average NO_2 and annual average $PM_{2.5}$ where the impacts are classed as moderate (using the adopted impact classification scheme). There are small increases in the incremental effects on cumulative concentrations with respect to the WHO 2021 guideline (13% for 24-hour average SO_2, 5% for annual average NO_2 and 2% for annual average $PM_{2.5}$). For annual average NO_2 and $PM_{2.5}$, the predicted cumulative concentrations remain below the WHO 2021 guideline (and, in the case of annual average $PM_{2.5}$, the effects are immeasurably small) and therefore the overall effects are assessed as being low.

In regard to 24-hour average SO_2, the background SO_2 air quality at Whareroa Marae was materially different in 2024 compared to all previous years since 2019, with five days exceeding the WHO 2021 guideline (more than the 4 allowable exceedances). As a result, the assessed impacts of the Project differ depending on whether 2021 or 2024 background concentrations are used. The modelling assessment shows that the worst-case assumption of a large bulk tanker continuously present at the new Mount Maunganui wharves would not have had any measurable effect on the day with the highest measured SO_2 concentration. However, it could have contributed to one additional exceedance of the 24-hour WHO 2021 guideline value (i.e. the incremental contribution is relatively small, but enough to increase the daily average concentration on the sixth worst day just above $40 \mu g/m^3$). Taking into account the low frequency of anticipated visits by these very large bulk tankers, the likelihood of a large bulk tanker causing an exceedance of the WHO 2021 guideline is once every 30 years (assuming that future years have the same elevated 24-hour SO_2 concentrations recorded in 2024).

The more likely scenario of a large bulk carrier (e.g. a logging ship) at the new Mount Maunganui wharves (rather than a bulk tanker), would have much smaller effects on 24-hour average SO_2 concentrations (less than 30% compared to a bulk tanker) and would not have caused any additional exceedances of the WHO 2021 guidelines.

Assessment of effects

The overall conclusions of the assessment are that:

- The effects of discharges to air from Stage 1 are assessed as negligible with respect to the New Zealand ambient air quality standards and guidelines, with the exception of 1-hour average NO_2, where the effects are assessed as low.
- Although slightly greater than the effects of Stage 1, the effects of discharges to air from Stage 2 (including the combined effects with Stage 1) are assessed as negligible or low with respect to the New Zealand ambient air quality standards and guidelines and negligible or low with respect to the more stringent WHO 2021 guidelines, except for 24-hour average SO_2.
- Taking into account the scale and likelihood of effects, the effects of discharges to air from Stage 2 (including the combined effects with Stage 1) on 24-hour average SO_2 concentrations are assessed as low with respect to WHO 2021 guidelines.

Recommendations and mitigation measures

Based on the findings of the assessment of effects, no mitigation of air quality effects is recommended.

1 Introduction

Port of Tauranga Limited (POTL) proposes to extend the Sulphur Point and Mount Maunganui wharves at the Port of Tauranga (the Port), along with associated dredging of the shipping channel and reclamation of the coastal marine area, to enable the expansion and ongoing operation of port activities.

The wharf extensions and dredging cater for the trend of increasing vessel sizes that visit the Port and for container ships and bulk carriers to berth further south than at present.

The container terminal at Port of Tauranga is located on the western side of the harbour at Sulphur Point. The Mount Maunganui wharves, on the eastern side of the harbour, provide for bulk carriers, tankers and cruise ships.

The proposed works, as they relate to the provision of additional berthage comprise two stages, broadly described as follows:

Stage 1: 285 m wharf extension at Sulphur Point.

Stage 2: Additional 100 m wharf extension at Sulphur Point and 315 m wharf extension at the Mount Maunganui wharves along with the development of additional mooring and berthing dolphins in lieu of wharf extensions, and minor structures at Butters Landing.

Tonkin & Taylor Ltd (T+T) has been engaged by POTL to evaluate the potential air quality effects of discharges to air from ships at the new berths.

2 Description of the proposal

Port of Tauranga Limited (POTL) is proposing to extend the Sulphur Point and Mount Maunganui wharves, dredge the shipping channel and construct reclamations to enable the expansion and ongoing operation of port activities. The development is in two stages.

<u>Stage 1</u>

Stage 1 includes a 285 m wharf extension at Sulphur Point. This will enable a three-berth operation (as occurred in the past) by catering for the increasing size of container ships visiting the Port (with differing emission rates of contaminants and exhaust configurations compared to current container ships) and the ships will be able to berth further south than occurs at present.

<u>Stage 2</u>

Stage 2 includes an additional 100 m wharf extension to the south at Sulphur Point and a 315 m wharf extension to the south at the Mount Maunganui wharves. The proposed Mount Maunganui wharf extension will provide for bulk carriers to berth between the existing Cement/Bulk Liquids Tanker Berth and the current southernmost bulk carrier berth.

Stage 2 also involves the installation of mooring dolphins north and south of the Tanker Berth. Ancillary vessels such as barges, tugs, bunker barges and dredging vessels would continue to berth south of the existing Tanker Berth.

The project is illustrated in Figure 2-1.

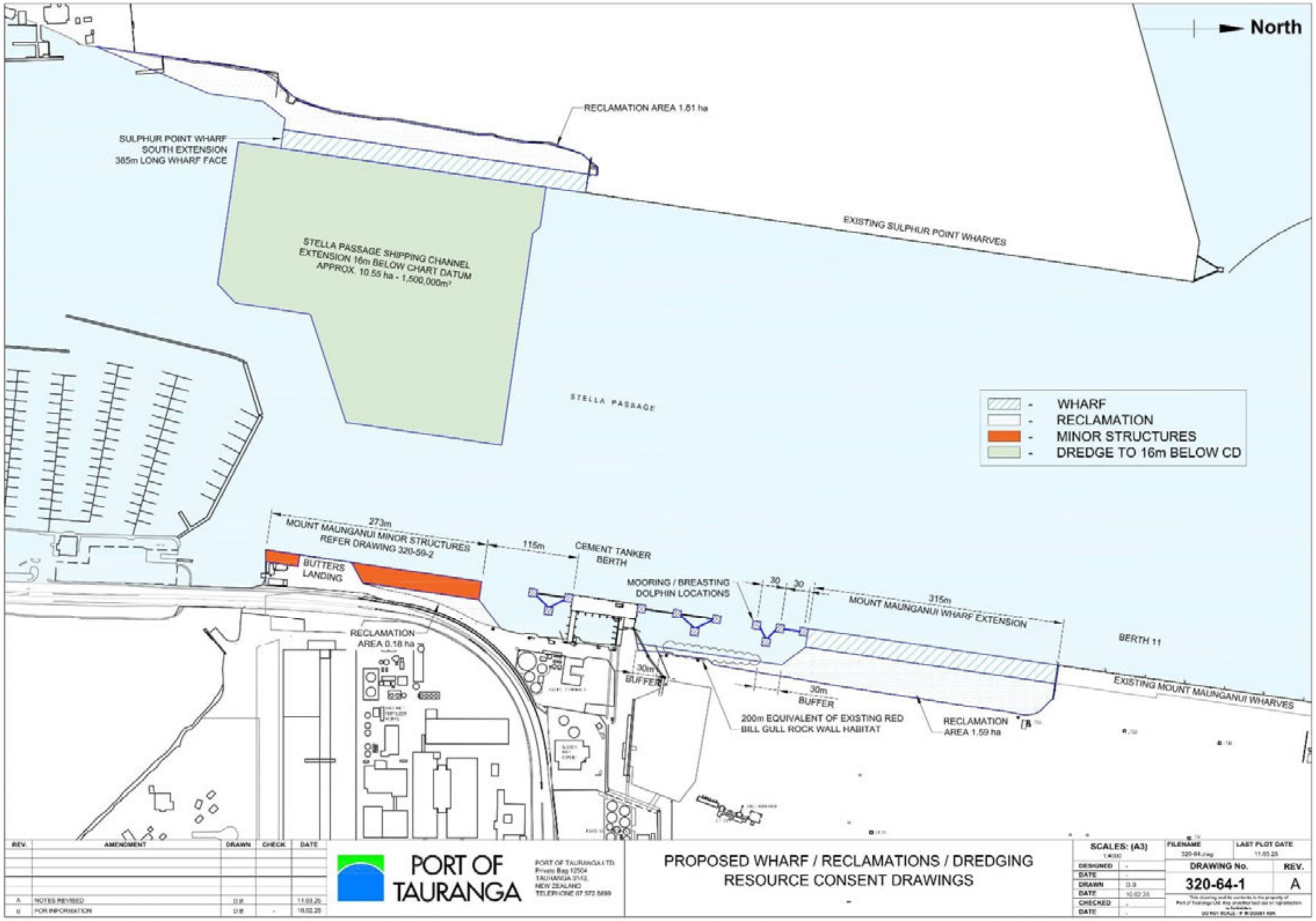

Figure 2-1: Proposed Stella Passage project wharf extensions.

3 Scope of air quality assessment

Resource consent is not required for the discharges to air from ships as they are expressly permitted under the Resource Management (Marine Pollution) Regulations 1998. Furthermore, the presence of vessels, and their movements along the shipping channel, are permitted activities in the Port Zone of the Bay of Plenty Regional Coastal Environment Plan (RCEP).

Resource consents are required for the Project for dredging, the development of structures and reclamation as restricted discretionary activities under rules PZ 8, PZ 10 and PZ 11 of the RCEP.

One of the matters over which these RCEP rules reserve discretion is "*site specific historical or cultural values under ss 6(e) or 7(a) of the RMA*". For this reason, the air quality assessment is focussed on the effects on air quality at Whareroa Marae of emissions from additional shipping movements that would be enabled by the Project. Whareroa Marae is the closest residential activity to the proposed wharf extensions. Therefore, it can be inferred that if air quality effects at Whareroa Marae are acceptable, the effects will also be acceptable at more distant residential locations.

4 Cultural Values Assessments and feedback from and Iwi and hapū hui

T+T participated in hui with iwi and hapū representatives on the 4th March and 20th March 2025. The main feedback received on the air quality assessment was in relation to the scope of the assessment. As outlined above, this assessment focuses on the air quality effects of additional shipping movements that would be enabled by the wharf extensions (notwithstanding that such shipping movements do not require resource consent). A desire was expressed at the hui for the scope of the air quality assessment to be widened to take a more holistic approach and consider the effects of downstream activities enabled by the additional cargo associated with additional shipping. Examples included considering effects of exhaust emissions from potential increases in truck movements associated with greater cargo volumes, air quality effects of fuels brought in through the Port and used in land transport, and effects of handling and processing of raw materials brought in through the Port by downstream industries.

A key challenge of an air quality assessment of the type discussed at the hui is that it would require a large number of assumptions about changes over time in cargo types, quantities, destinations (which may be within or outside the Bay of Plenty region), end uses and emissions controls adopted by the end uses. It would also be important to understand to what extent additional cargo enabled by the Project would contribute to new emissions to air, or whether these emissions would occur in any case (the concept of 'additionality'). For example, if the Port were constrained such that materials (for example fuel or raw materials) could not be brought in through the Port of Tauranga, it is likely that they would be imported through another Port so the use of these fuel/raw materials and associated discharges to air would not change. While it would be technically possible to assess the effects of different scenarios, there would be a high degree of uncertainty.

There is a regulatory context for discharges to air that addresses aspects of the issue raised in the hui. While emissions from land transport are not directly regulated through resource consents, the air quality effects are managed to some extent through national fuel standards and exhaust emission standards for vehicles. Discharges to air from handling and processing of bulk cargo and raw materials in the Bay of Plenty region are managed through the Bay of Plenty Regional Natural Resources Plan, which includes standards and rules for discharges to air from industrial and trade premises.

While T+T understands the reasons for iwi and hapū wanting a broader scope for the air quality assessment, we consider that it would be of limited usefulness because the high degree of uncertainty that any such assessment would entail, and given the other, more appropriate mechanisms for managing downstream air emissions related to cargo brought in through the Port.

In terms of mitigation for the proposed activities, some Cultural Values/Impact Assessments and similar reports (CVA) prepared by iwi/hapū in relation to the Project identify the need for air quality to be managed around the Port. This included recommending that dust generated during construction from reclamation fill or machinery is minimised through dust suppression and modern low emissions equipment. Dust emissions from reclamation are controlled through the proposed conditions of consent proffered by POTL and dust management measures are required to be addressed in the Reclamation and Construction Management Plan that must be prepared and certified in accordance with the proposed conditions of consent. Dust control measures should be consistent with recommendations in the Ministry for the Environment Good Practice Guide for Managing and Assessing Dust (MfE, 2016).

The CVAs also recommend that, given the concerns of the hapū at Whareroa Marae about air quality, it would be prudent to extend air quality monitoring to Sulphur Point and share those results. The Bay of Plenty Regional Council (BOPRC) monitored air quality at Sulphur Point for TSP, PM_{10} and SO_2 from September 2018 to July 2023. The monitoring was disestablished because it did not identify any issues with air quality in comparison to relevant air quality standards and guidelines. Given the large separation distance between the proposed wharf extensions at Sulphur Point and residential areas (in excess of 1 km) T+T does not consider the scale of potential for adverse effects related to the project would warrant reinstatement of air quality monitoring.

5 Nature of discharges to air from ships at berth

5.1 Overview

While at berth, a ship's energy requirements for heating/cooling and electricity are met either by running auxiliary engines or by running the main engines on low load. The emissions from these engines are combustion products from burning of fuel. Boilers are also used to heat the marine fuel to keep it fluid.

The combustion products of most interest from a health perspective are:

- Fine particulate matter (PM_{10} and $PM_{2.5}$).
- Nitrogen dioxide (NO_2).
- Sulphur dioxide (SO_2).

The emission rates of combustion products from the ships' exhausts are related to the rate of fuel consumption (i.e. the energy requirement of the vessel) and, in the case of SO_2, to the sulphur content of the fuel. The physical dimensions of the ship's exhaust and the exit velocity and temperature of the exhaust emissions are relevant to the dispersion characteristics of the plume. The methods used to estimate representative emission rates of contaminants and physical parameters for the dispersion modelling study are set out in Section 9.4.

5.2 Changes in the global marine fuel sulphur limit

SO_2 emissions from shipping are proportional to the sulphur content in the fuel burnt in the ship's engines. On 1 January 2020, an amendment was made to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL). The amendment included a reduction in the limit on sulphur in marine fuel oil from 3.5% w/w to 0.5% w/w. Some ships, particularly cruise ships, have chosen to install scrubbers (exhaust gas cleaning systems) as an alternative way to meet the equivalent reduction in SO_2 emissions.

The change in marine fuel sulphur content has resulted in a significant reduction in SO_2 concentrations at the BOPRC air quality monitoring sites.

The reduction in fuel sulphur content will also reduce fine particulate matter emissions from ships. However, the effect of these reductions will be less apparent in the air quality monitoring data because there is a wide range of sources contributing to measured particulate concentrations and shipping is only a relatively small contribution.

For the purposes of this assessment, it has been assumed that the average fuel sulphur content used in ocean going vessels at the Port of Tauranga is 0.5% w/w sulphur, in accordance with the limit (the actual sulphur content is likely to be vary and may be less than 0.5 % w/w).

6 Air quality assessment criteria

6.1 New Zealand ambient air quality standards and guidelines

To evaluate the potential effects of discharges to air from ships at the proposed wharf extensions, the predicted ground level concentrations of contaminants have been compared against air quality criteria adopted from the following New Zealand sources:

- The Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (NESAQ).
- Proposed changes to the NESAQ (Ministry for the Environment, 2020) - although it is noted these are unlikely to be formally adopted.
- The Ministry for the Environment Ambient Air Quality Guidelines (AAQG).

In accordance with Ministry of the Environment good practice guidance, air quality effects are evaluated against these criteria at off-site locations where a person could reasonably be exposed over the relevant time period. In this instance:

- For 1-hour averages, locations where people can be exposed include the Whareroa Marae, residential dwellings, the Tauranga Bridge Marina, off-site businesses and recreational areas. It does not include enclosed spaces (indoors/inside vehicles) and roadways or over-water areas where occupation by people is likely to be transient.
- For 24-hour and annual averages, the closest location where people could be exposed has been identified as the Whareroa Marae.

The relevant New Zealand ambient air quality standards and guidelines are presented in Table 6-1.

Table 6-1: New Zealand ambient air quality standards and guidelines

Pollutant	Time average	NZ standard/guideline	
		Value ($\mu g/m^3$)	Source
SO_2	1-hour	350 (570)[a]	NESAQ
	24-hour	120	AAQG
PM_{10}	24-hour	50[b]	NESAQ
	Annual	20	AAQG
$PM_{2.5}$	24-hour	25	Proposed NESAQ
	Annual	10	Proposed NESAQ
NO_2	1-hour	200	NESAQ
	24-hour	100	AAQG

a Nine allowable exceedances per year of 350 $\mu g/m^3$ (1-hour average) and no exceedances of 570 $\mu g/m^3$ (1-hour average).

b One allowable exceedance per year.

6.2 World Health Organization guidelines and European limits

In September 2021, the World Health Organization published an updated suite of ambient air quality guidelines ('WHO 2021 guidelines') (World Health Organization, 2021). The guidelines are defined as a level where *"it is assumed that adverse health effects do not occur or are minimal below this concentration level"*.

The WHO 2021 guidelines are intended to be used as science-based recommendations to policymakers at a national or local level for consideration in setting their own standards and frameworks for managing air pollution. They have not yet been formally evaluated by the Ministry for the Environment or Ministry of Health for adoption as New Zealand air quality guidelines or standards. In a recent decision, the Environment Court[1] agreed with the position that it would be premature to adopt the WHO 2021 guidelines as assessment criteria, but that they should be considered to provide a complete assessment. This is the approach taken in this assessment.

Air quality at many urban locations in New Zealand does not (or is unlikely to) meet the WHO 2021 guidelines for NO_2 and annual average $PM_{2.5}$. In the case of $PM_{2.5}$, natural sources of particulate, such as marine aerosols, provide a significant background contribution. The most recent consideration of the WHO 2021 guidelines in setting ambient air quality standards is by the Council of the European Union (EC). The review by the EC highlighted the challenges that would be experienced in Europe in meeting the WHO guidelines, where they found that 71% of monitoring sites would be unable to meet the guidelines with currently available technology. The EC undertook a cost benefit analysis of options from partial to full alignment with the WHO 2021 guidelines by 2030 to inform a new Directive on ambient air quality and cleaner air for Europe, which was adopted in October 2024. The Directive includes air quality limits based on "closer" alignment with the WHO 2021 guidelines. These are presented in Table 6-2 for comparison with the WHO 2021 guidelines.

As with the New Zealand ambient air quality standards and guidelines, the WHO 2021 guidelines are intended to manage exposure to air pollutants and therefore apply in locations where a person could reasonably be exposed over the relevant time period.

Table 6-2: WHO ambient air quality guidelines and EU air quality limits

Pollutant	Time average	WHO 2021 guideline ($\mu g/m^3$)	EU air quality limits ($\mu g/m^3$)
SO_2	10-minute	500	-
	1-hour	-	350
	24-hour	40[a]	50[b]
	Annual	-	20
PM_{10}	24-hour	45[a]	45[b]
	Annual	15	20
$PM_{2.5}$	24-hour	15[a]	25[b]
	Annual	5	10
NO_2	1-hour	200	200[c]
	24-hour	25[a]	50[b]
	Annual	10	20

a 3 to 4 allowable exceedances per calendar year.

b 18 allowable exceedances per calendar year.

c 3 allowable exceedances per calendar year.

[1] Decision [2024] NZEnvC 247.

7 Mount Maunganui airshed

The Port of Tauranga is located in the Mount Maunganui Airshed (see Figure 7-1). The Mount Maunganui Airshed was gazetted in November 2019 and was immediately classified as 'polluted' with respect to PM_{10} in accordance with the NESAQ. The NESAQ places limits on the granting of resource consents for new significant PM_{10}-emitting activities.

However, the normal emissions from ships are expressly permitted under Regulation 15 of the Resource Management (Marine Pollution) Regulations 1998. Regulation 16 prevents any regional coastal plan from including rules relating to the normal emissions from ships.

On this basis, the restrictions on granting consent for new discharges of PM_{10} in a polluted airshed under Regulation 17 of the NESAQ do not apply to this project, as the emissions are expressly allowed.

Figure 7-1: Plan showing extent of Mount Maunganui airshed.

8 Existing air quality

8.1 BOPRC air quality monitoring network

BOPRC expanded its air quality monitoring in the Mount Maunganui area in 2018 and currently operates an extensive network of monitoring stations. The location of BOPRC air quality monitoring stations and the parameters measured are summarised in Figure 8-2 on the following page.

The following sub-sections summarise the historical and existing air quality and briefly comment on some of the key reasons for observed changes in PM_{10}, $PM_{2.5}$, NO_2 and SO_2 air quality over time.

8.2 SO_2 air quality

As discussed in Section 5.2, shipping emissions have historically been a significant source of SO_2 emissions due to the relatively high sulphur content in marine fuel oil. The impacts of the reduction in the global fuel sulphur limit in January 2020 are evident in the air quality monitoring data in Mount Maunganui. This is illustrated in Figure 8-1, which shows the trend in annual average SO_2 concentrations at BOPRC monitoring sites in the Mount Maunganui area. The main reason for the improvement in SO_2 air quality at all locations is almost certainly attributable to the reduction in marine fuel sulphur content for ocean going vessels since 1 January 2020.

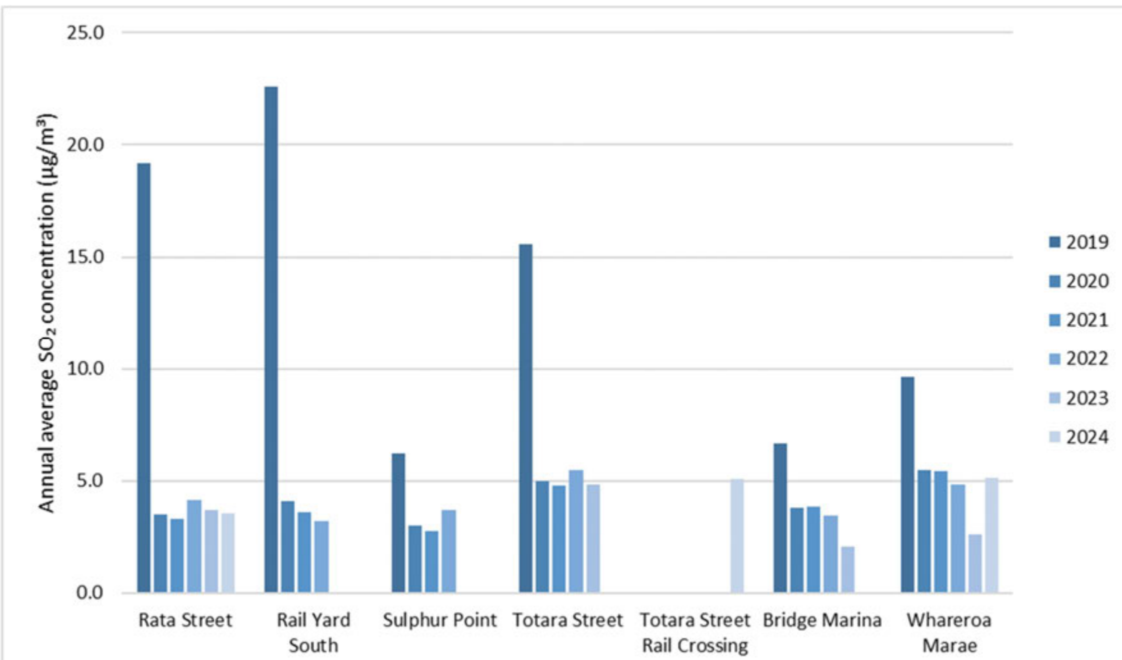

Figure 8-1: Annual average SO_2 concentrations at BOPRC monitoring sites.

Figure 8-2: BOPRC air quality monitoring sites at Mount Maunganui (reproduced from BOPRC Environmental Publication 2023/07 (Iremonger, 2023)
Note: NO_2 and PM_{10} are also monitored at Whareroa Marae.

The relationship between lower measured SO_2 concentrations and the change in marine fuel sulphur content can be illustrated by comparing the average concentrations prior to the change (pre-MARPOL) and after (post-MARPOL), as shown in Table 8-1.

For the Totara Street monitoring data, the influence of stack emissions from industrial sources have been removed from the dataset by excluding the concentrations measured under certain wind directions (winds from 135° to 237° or approximately a southeast to southwest arc). The effects of ship emissions are not easily separable from other sources at the Whareroa Marae and Tauranga Bridge Marina sites, as ship emissions and emissions from industrial sites may occur under overlapping wind directions.

If shipping emissions were the only contributing factor to measured air quality, the reduction in SO_2 concentrations is expected to be of the order of 79% (i.e. the reduction from 2.4 % w/w sulphur to 0.5 % w/w sulphur). The reduction in SO_2 concentrations at Rata Street, Railyard South and the wind-filtered Totara Street data is consistent with the anticipated level of reduction from MARPOL.

Table 8-1: Comparison of pre- and post-MARPOL annual average sulphur dioxide air quality

Year	SO_2 concentration (µg/m^3, annual average)						
	Rata St	Rail Yard South	Sulphur Point	Totara Street[(a)]	Totara Street Rail crossing	Bridge Marina	Whareroa Marae
2018	Insufficient	Insufficient	Insufficient	15.6	-	7.0	10.2
2019	19.2	22.6	6.2	17.6	-	6.7	9.6
Average pre-MARPOL	**19.2**	**22.6**	**6.2**	**16.6**	**-**	**6.9**	**9.9**
2020	3.5	4.1	3.0	4.2	-	3.8	5.5
2021	3.3	3.6	2.8	4.0	-	3.9	5.4
2022	4.1	3.2	3.7	4.8	-	3.5	4.9
2023	3.7	Insufficient	Insufficient	4.2	-	2.1	2.6
2024	3.5	-	-	-	5.1	-	5.1
Average post-MARPOL	**3.6**	**3.6**	**3.2**	**4.3**	**5.1**	**3.3**	**4.7**
Average reduction	81%	84%	48%	74%	-	52%	53%

a Wind directions from 135° to 237° are removed to isolate the effects of shipping emissions.

A lesser reduction in annual average SO_2 concentrations was observed at Sulphur Point, Bridge Marina and Whareroa Marae. For Bridge Marina and Whareroa Marae, the lesser reduction is most likely due to the measurements also being influenced by emissions from industrial sources. The reasons for the apparently lesser reduction in SO_2 at Sulphur Point are less clear, however potential reasons include:

- That container ships, which are the closest shipping sources, were using a "better than average" fuel immediately prior to MARPOL coming into effect; and/or
- That there is some degree of unchanged background influence from another source; and/or
- That it is a function of the low measured concentrations prior to MARPOL, for example the reported average concentration in 2019 may be artificially low; and/or

- The emissions are well mixed prior to measurement at the station, so concentrations are lower and the change is harder to measure.

Time series plots of the 10-minute average SO_2 concentrations at Rata Street provide additional support for the expectation that changes to the fuel sulphur specification are a key factor in the improvements in SO_2 air quality. SO_2 concentrations at Rata Street show a sudden and dramatic reduction at the end of December 2020 aligning with the reduction in global marine fuel sulphur content on 1 January 2020 (Figure 8-3). Cruise ships were still visiting the Port during January to March 2021.

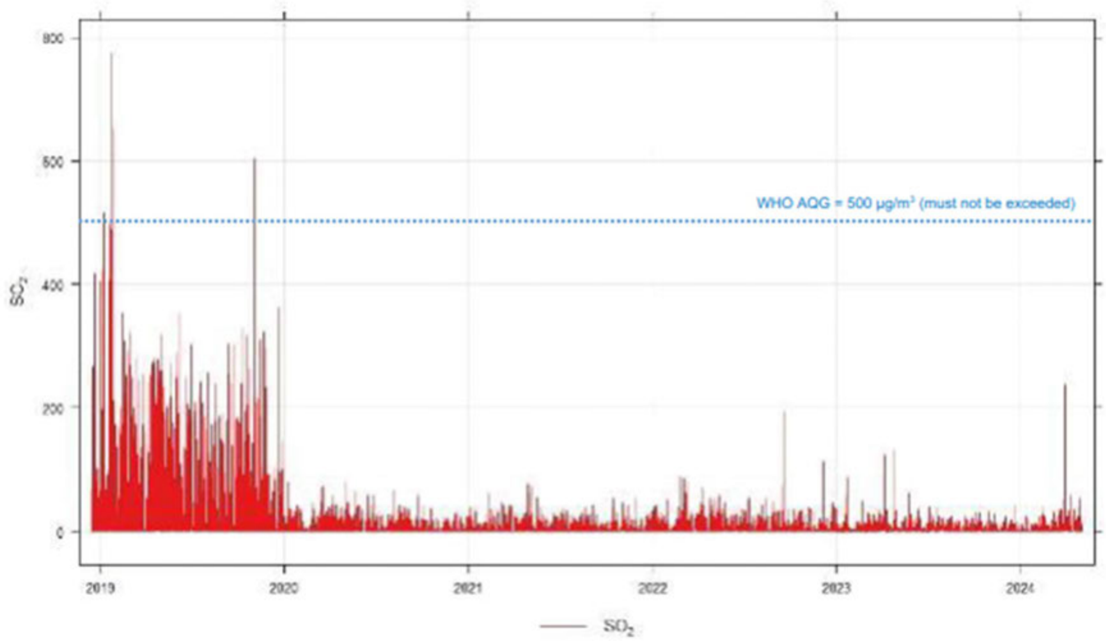

Figure 8-3: 10-minute average SO_2 concentrations measured at Rata Street (reproduced from ESR, 2024).

Time series plots of the 10-minute average SO_2 concentrations at Bridge Marina and Whareroa Marae are presented in Figure 8-4 and Figure 8-5. These plots show that there were elevated 10-minute concentrations (relative to the WHO 2021 guideline) at Whareroa Marae in 2016 and 2017. These have been attributed by BOPRC to elevated emissions from the nearby Fertiliser Works, and levels have reduced significantly since 2017 when process improvements were undertaken.

Since 2017, there have been two isolated readings of concentrations exceeding the WHO 2021 guideline in February 2023 at Whareroa Marae (1422 $\mu g/m^3$) and August 2021 at Bridge Marina (1246 $\mu g/m^3$). This is the only exceedance that has been recorded at Bridge Marina over the entire monitoring period (since 2016).

Based on wind direction, the exceedance of the WHO 2021 guideline at Wharerora Marae in February 2023 appears to be from a source in the direction of the Fertiliser Works. The 10-minute concentration spike at the Bridge Marina in 2021 was during the COVID lockdown period occurred around 10:30 pm, however slightly elevated 10-minute concentrations were recorded earlier in the day coinciding with the wind turning to a northerly. The BOPRC considers the very high 10-minute reading may be a local source close to the monitor (i.e. around the Marina area). POTL has reviewed shipping information for this day and has confirmed that there were no bulk tankers at the Cement wharf.

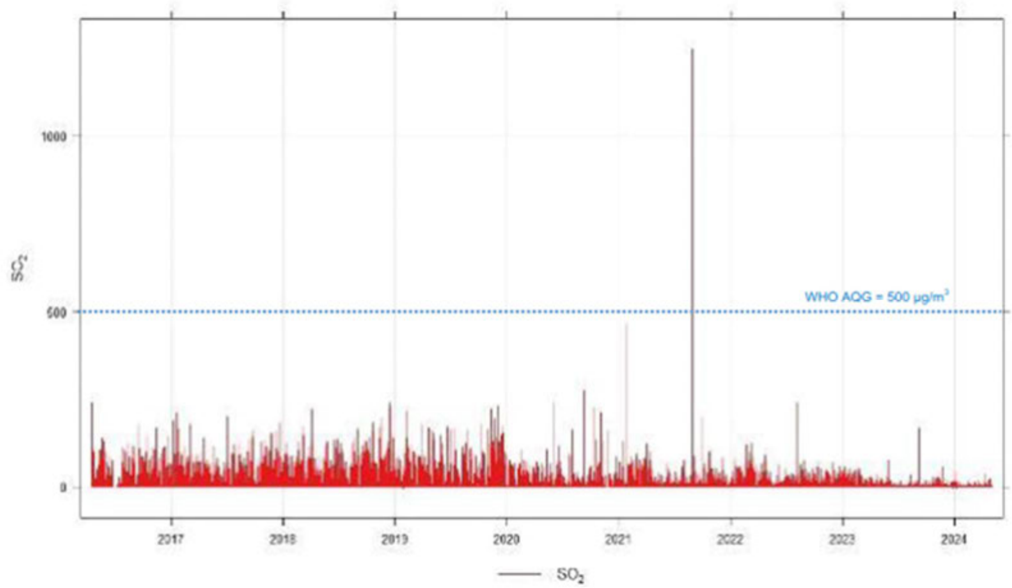

Figure 8-4: 10-minute average SO_2 concentrations measured at Bridge Marina (reproduced from ESR, 2024).

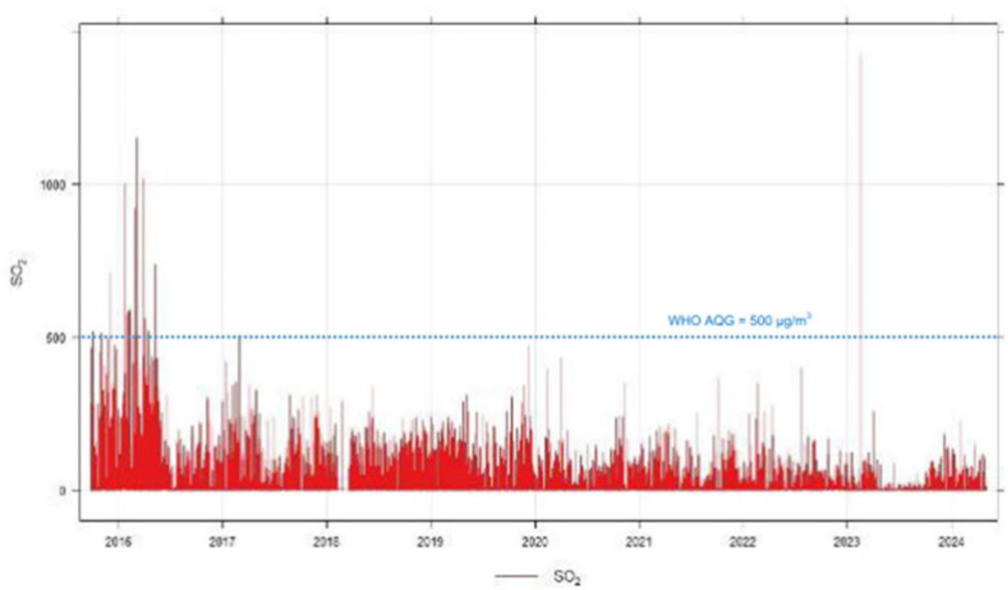

Figure 8-5: 10-minute average SO_2 concentrations measured at Whareroa Marae (reproduced from ESR, 2024).

The assessment criteria for SO_2 in New Zealand are set for 1-hour and 24-hour average exposure periods. The monitoring data at relevant monitoring locations are compared with the New Zealand ambient air quality standard (1-hour average) and guideline (24-hour average), and the WHO 2021 guideline (24-hour average), in Table 8-2.

Since 2016 there have been no measured exceedances of either the upper "never to be exceeded" threshold concentration of 570 µg/m³ (1- hour average) or lower threshold of 350 µg/m³ (1- hour average) set in the NESAQ at any of the monitoring stations.

An unusual feature in this data is that there were five days in 2024 with 24-hour average SO_2 concentrations exceeding the WHO 2021 guideline. There had been no exceedances of this guideline since 2019, when improvements were made at a local industrial site. An inspection of weather conditions on these days suggests that the likely source was a local industrial source.

Table 8-2: SO_2 air quality at relevant BOPRC monitoring sites

Statistical parameter	Year	SO_2 Concentration ($\mu g/m^3$)		
		Totara Street	Whareroa Marae	Tauranga Bridge Marina
Maximum 24-hour average concentration	2016	70.6	74.4	*
	2017	43.2	62.2	34.4
	2018	50.6	71.3	41.5
	2019	54.3	48.8	43.8
	2020	19.3	53.8	53.7
	2021	26.2	41.9	36.3
	2022	27.2	43.6	27.8
	2023	18.8	16.8[1]	21.4
	2024	25.7	86.1	*
Assessment criterion	120 (AAQG)			
Fourth highest 24-hour average concentration	2016	43.9	67.3	*
	2017	39.0	44.0	23.0
	2018	42.5	49.0	27.8
	2019	39.5	43.1	34.6
	2020	14.9	28.0	30.6
	2021	13.6	24.2	24.3
	2022	19.2	25.0	17.1
	2023	14.1	15.0[1]	14.2
	2024	19.4	45.3	*
Assessment criterion	40 (WHO 2021)			
Maximum hourly average concentration	2016	254.6	750.6	*
	2017	129.1	279.8	136.7
	2018	172.8	253.8	126.6
	2019	166.6	206.3	157.5
	2020	63.9	250.6	161.2
	2021	60.1	118.2	122.2
	2022	66.7	204.0	75.6
	2023	53.4	285.6[1]	101.3
	2024	56.7	249	*
Assessment criterion	350 (NESAQ)			

Table Notes:

a MfE (2009) recommends a data capture rate of 95 %. Whareroa Marae data capture rate was 91% for 2023.

* SO_2 monitoring did not commence at Tauranga Bridge Marina until April 2016 and ceased on 29 April 2024.

8.3 PM_{10} air quality

The PM_{10} assessment criteria are set for 24-hour and annual average exposure periods, and therefore compliance with these guidelines is more important in residential locations than in industrial areas where people will not be present continuously.

BOPRC installed PM_{10} ambient air quality monitoring equipment at six locations in the Mount Maunganui area in late 2018 (Figure 8-2). The annual average PM_{10} concentrations are presented graphically in Figure 8-6. Annual average PM_{10} air quality has improved at most sites since 2019 and has improved year-on-year at Whareroa Marae.

Annual average and 24-hour average PM_{10} air quality at Whareroa Marae from 2020 to 2024 met the current New Zealand standards and guidelines and the WHO 2021 guidelines, apart from a single exceedance of the 24-hour AAQS in 2020 (discussed below).

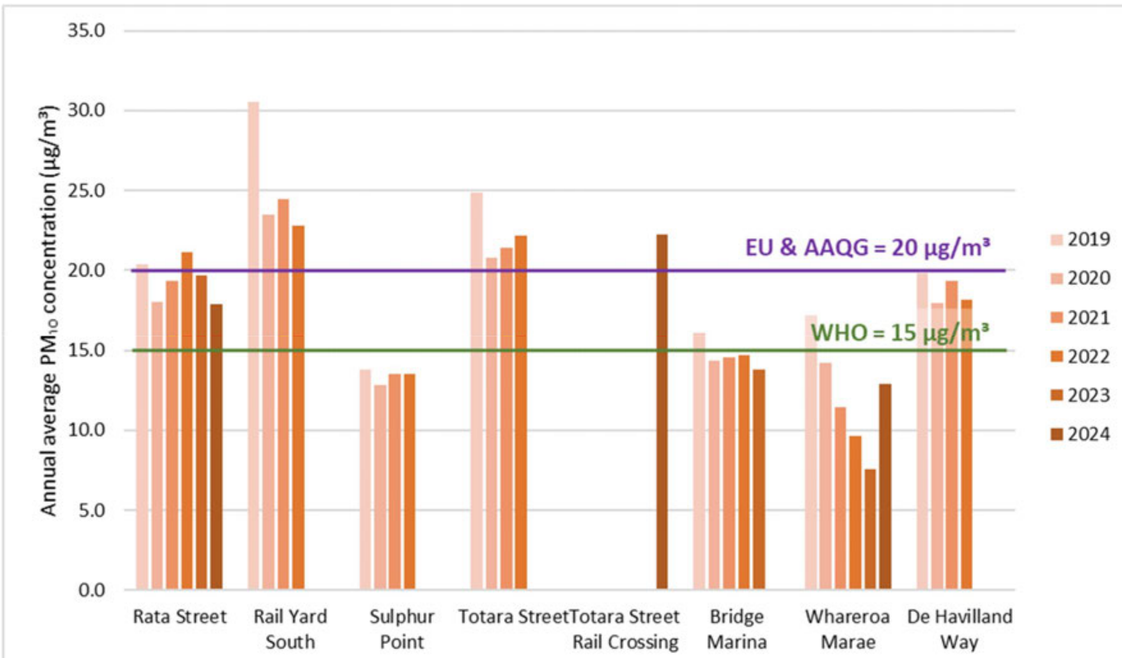

Figure 8-6: Annual average PM_{10} concentrations at monitoring locations in Mount Maunganui.

There have been exceedances of the 24-hour average AAQS at some of the BOPRC monitoring sites. The number of measured exceedances of the AAQS (excluding events that have been confirmed as "exceptional circumstances" by the Minister for the Environment) is presented in Table 8-3. The data show that the number of exceedances has reduced significantly since 2019.

The NESAQ provides for one permissible exceedance of the PM_{10} threshold concentration in any year; more than one exceedance is defined as a breach of the NESAQ standard for PM_{10}. The Mount Maunganui airshed will remain a polluted airshed until there has been 5 years without a breach of this standard.

Table 8-3: Number of exceedances of NESAQ PM_{10} threshold concentration of 50 µg/m³ (24-hour average)[a]

Year	2019	2020	2021	2022	2023	2024
Rata Street	0	2	1	1	1	1
Rail Yard South	16	5	1	0	-[c]	-
Sulphur Point	0	0	0	0	0[d]	-
Totara Street	1	0	1	1	0[d]	-
Totara Street Rail Crossing	-	-	-	-	-	0
Bridge Marina	0	0	0	1	0	1
Whareroa Marae	0	1	0	0	0	0
De Havilland Way	3	0	0	0	1[d]	0
Site Exceedances	20	8	3	2	2	2
Total Exceedancesb	19	7	3	1	2	2
Allowable exceedances (NESAQ)	1	1	1	1	1	1

a Excludes exceptional events approved by the Minister (6 Dec 2019 – all sites, 9-10 Jun 2021 Rata St, 21 April 2022 Rata St and Tauranga Bridge Marina, 18-19 August 2022 five sites: De Havilland Way, Bridge Marina, Railyard South, Rata St, Totara St, 19 April 2023 Rata St).

b Where an exceedance occurs at more than one site on the same day, this is recorded as a single exceedance for the purpose of the NESAQ.

c Monitoring ceased on 27 January 2023.

d Monitoring ceased on 1 August 2023.

Over the 2019 to 2024 period, there has been one exceedance of the ambient air quality standard of 50 µg/m³ (24-hour average) at Whareroa Marae, which occurred on 9 December 2020. On this day there were mostly northwest to northerly winds and the highest 10-minute average concentrations occurred during moderate wind speeds 3 to 4 m/s as shown in Figure 8-7. Although the source/cause of this PM_{10} exceedance cannot be confirmed, the moderate wind speeds suggest a source relatively close to the site and located to the north of the monitor.

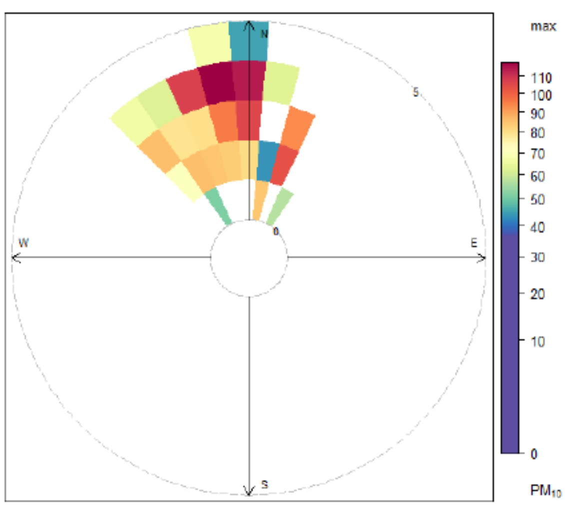

Figure 8-7: Plot showing wind direction, wind speed and 10-minute maximum PM_{10} concentration on 9 December 2020.

There is a much wider range of sources contributing to PM_{10} concentrations in the Mount Maunganui area, compared to SO_2. These sources include industrial combustion emissions, fugitive dust from bulk solids and log handling activities, resuspended road dust, domestic heating emissions and non-anthropogenic sources such as marine aerosols. There has been a significant focus on reducing PM_{10} emissions from bulk solids and log handling activities in the Mount Maunganui airshed, and these are likely to be the main reasons for improvement in PM_{10} air quality, particularly at the Rail Yard South, Rata Street and De Havilland Way monitoring sites.

A reduction in marine fuel sulphur will have a small benefit in reduced particulate emissions from ships, as a proportion of the particulate emitted is in the form of sulphate. However, this improvement is likely to be modest and unlikely to be discernible in the data, particularly considering the reductions in PM_{10} emissions from other sources that have occurred.

8.4 $PM_{2.5}$ air quality

As with PM_{10}, the $PM_{2.5}$ assessment criteria are set for 24-hour and annual average exposure periods, so are relevant residential locations.

BOPRC commenced monitoring of $PM_{2.5}$ at the Totara Street monitoring station in 2018. Monitoring at Whareroa Marae commenced on 13 November 2023 and validated data is currently available up to 1 January 2025.

The Ministry for the Environment had proposed adopting standards for $PM_{2.5}$ based on the previous WHO guidelines (which were current at the time the NESAQ changes were being consulted on). These are unlikely to be formally adopted given the more recent publication of the WHO 2021 guidelines.

The $PM_{2.5}$ concentrations measured at Whareroa Marae meet both the Proposed NESAQ and WHO 2021 24-hour average guidelines (see Table 8-4). Annual average $PM_{2.5}$ concentrations meet the Proposed NESAQ and the WHO 2021 guidelines.

Table 8-4: $PM_{2.5}$ air quality at BOPRC monitoring sites

Averaging period	Year	$PM_{2.5}$ concentration (µg/m³)		
		Totara Street	Whareroa Marae	Assessment criterion
Annual average	2019	8.0	-	10 (Proposed NESAQ) 5 (WHO 2021)
	2020	6.2	-	
	2021	6.3	-	
	2022	6.5	-	
	2023	Insufficient	-	
	2024	-	4.8	
Maximum 24-hour average	2019	21.6	-	25 (Proposed NESAQ)
	2020	16.8	-	
	2021	16.1	-	
	2022	18.5	-	
	2023	10.8[a]	-	
	2024	-	10.6	
Fourth highest 24-hour average	2019	15.4	-	15 (WHO 2021)
	2020	13.1	-	
	2021	11.3	-	
	2022	11.5	-	
	2023	10.0[a]	-	
	2024	-	9.9	

a Monitoring ended on 1 August 2023.

8.5 NO_2 air quality

BOPRC started monitoring nitrogen dioxide (NO_2) at the Whareroa Marae on 18 August 2023 and validated data is currently available up to 1 January 2025.

NO_2 air quality readily meets the NESAQ (1-hour average) and current New Zealand ambient air quality guideline (24-hour average).

Table 8-5: NO_2 air quality at Whareroa Marae (µg/m³)

Averaging period	Nitrogen dioxide (NO_2)	Nitrogen dioxide ambient air quality criterion
Maximum 1-hour average	50.8	200 (NESAQ)
Maximum 24-hour average	29.3	100 (AAQG)
Fourth highest 24-hour average	27.9	25 (WHO 2021)
Annual average	10.2	10 (WHO 2021) 20 (EU)

The 24-hour average WHO 2021 ambient air quality guideline allows for 3-4 exceedances of the 24-hour average value over a year. Between 1 January 2024 to 31 December 2024, six exceedances of 25 µg/m³ have been recorded. NO_2 concentrations recorded at Whareroa Marae can be compared with NO_2 air quality elsewhere in New Zealand, for context.

The Ministry for the Environment reports that there are 10 sites across New Zealand where NO_2 is monitored in accordance with the instrumental method required by the NESAQ[2]. While there is a national trend of reducing NO_2 concentrations, measured concentrations exceed the WHO guidelines at a number of these sites (reported in Our Air 2024). Between 2020 and 2023, six of the 10 sites were above the 24-hour WHO guideline for NO_2. Most of the monitoring sites exceeding the guideline were located near busy roads (see Figure 6 of Our Air 2024). The sites with the highest number of days above the guideline per year were Customs Street (Auckland CBD) (196 days), Queen Street (Auckland CBD) (189 days) and Penrose (47 days).

Five of the 10 sites were above the annual WHO guideline for NO_2 at least once between 2020 and 2023. Customs Street (Auckland CBD) had the highest annual average NO_2 concentration (31.5 µg/m^3). Three sites were above the guideline every year during this period: Customs Street (Auckland CBD), Penrose and Takapuna.

[2] NO_2 is monitored at a larger number of locations using less accurate non-reference methods.

9 Dispersion modelling approach

9.1 Overview

Dispersion modelling, using the CALMET/CALPUFF suite of modelling software, has been used to predict changes in air quality at Whareroa Marae from ships at the proposed new berths. Whareroa Marae has been chosen for detailed assessment as it is the closest sensitive residential location to the Port where people may be present for 24-hours per day. As the effects of emissions from ships reduce with increasing distance, it can be inferred that effects on air quality at other residential locations will be lower than at Whareroa Marae.

Where air quality monitoring data is available, recommended good practice is to assess the cumulative effects of emissions to air from a new activity by modelling the emissions contemporaneously with hourly varying background air quality data. The availability of modelling meteorological data and air quality monitoring data has influenced the selection of model years for each contaminant.

9.2 Selection of model years

Modelling meteorological datasets prepared by Atmospheric Science Global Limited for the BOPRC are available for 2014 to 2016 and 2021. The availability of air quality monitoring data for the pollutants selected for this assessment at Whareroa Marae in these years is shown in Table 9.1.

Table 9.1: Availability of monitoring data at Whareroa Marae for the BOPRC meteorological dataset years

BOPRC modelling year	Monitoring data availability			
	SO_2	PM_{10}	$PM_{2.5}$	NO_2
2014	Available	Not available	Not available	Not available
2015	Available	Not available	Not available	Not available
2016	Available	Available	Not available	Not available
2021	Available	Available	Not available	Not available

There is no monitoring data available for NO_2 or $PM_{2.5}$ for the meteorological model years available from BOPRC. Monitoring data for , however monitoring data is available for 2024. Therefore, T+T developed a modelling meteorological dataset for 2024. The details of the model are in Appendix A.

The 2024 model performance was evaluated against the BOPRC meteorological datasets (see Appendix B) to determine if the 2024 meteorological dataset would return comparable results to the BOPRC datasets. The meteorological datasets for 2021 and 2024 generated the highest predicted concentrations at Whareroa Marae. Contemporaneous model results are presented for SO_2 and PM_{10} for 2021 and 2024 and for $PM_{2.5}$ and NO_2 for 2024 only, as background data is not available for $PM_{2.5}$ and NO_2 for 2021.

9.3 Model scenarios

9.3.1 Overview

Ships entering and leaving the Port will go through periods of manoeuvring, docking and being tied up at the wharf. The time for manoeuvring and docking is small in comparison to the time at berth unloading/loading. It has not been attempted to model the effects of ships while they are moving, as this would add significant complexity to the model. The assumption of the berths being continuously occupied by the largest possible ship is considered to be sufficiently conservative to allow for the effects of emissions during these other operational phases.

The modelling assumes that the Port operations continue as they occur at present (the effects of these existing operations are represented by the background air quality data) and that the Project allows for additional ships to be berthed at the proposed wharf extensions. New mooring dolphins at Berth 16 (bulk tanker berth) may allow for larger tankers to berth at this location. However, modelling larger tankers at this location on top of the existing background would result in “double counting” of emissions.

The new structures at Butters Landing will allow for an additional bunker barge to be berthed. However, the size of vessels that this location will be limited by the channel depth. Bunker barges will be connected to shore power and therefore will have minimal emissions while at berth.

9.3.2 Sulphur Point wharf (Stage 1 and 2)

The Sulphur Point wharf extension will cater for the international trend of increasing container vessel size. Therefore, for conservatism the Sulphur Point wharf extension scenario is based on the largest container ship that currently visits the Port (based on information provided by PoTL).

Because of the orientation of the Sulphur Point wharves relative to Whareroa Marae, there is only a relatively small reduction in separation distance between the southernmost container ship and the Marae between Stages 1 and 2 (notwithstanding that Stage 2 increases the length of the wharf by an additional 100 m). Therefore, the air quality effects of Stages 1 and 2 at Sulphur Point have not been modelled separately but have been assumed to be the same (based on Stage 2). As such, the air quality effects of Stage 1 are slightly overstated because the modelling assumes that container ships are located slightly further south than could actually occur.

As previously noted, the effects of Stages 1 and 2 at Sulphur Point have not been modelled separately but have been assessed based on the worst-case, which is a container ship at the southernmost berth under Stage 2.

9.3.3 Mount Maunganui wharves (Stage 2)

The extension of the Mount Maunganui wharves will allow for bulk carriers (for example, logging ships) to berth closer to Whareroa Marae. Alternatively, the new layout would allow a second bulk tanker to berth north of the existing cement/bulk liquids berth.

Very large bulk tankers (referred to as “Long Range Product Carrier” ships) have never visited the Port of Tauranga before and it is likely that, in the future, they would visit the Port less than once a month and maybe only two to three times a year. The emission rates from large bulk tankers and bulk carriers were compared (see Section 9.4) and, for conservatism, it was decided to model short term impacts based on the worst case or a large bulk tanker. This is likely to overstate effects that could occur most of the time.

In summary, the following ships were modelled for Stage 2:

- The largest bulk liquids tanker that is expected to be accommodated at the new berths was modelled to assess worst-case effects on 1-hour average and 24-hour average air quality; and
- An average-sized bulk carrier was modelled to assess worst-case effects on annual average air quality (it would be overly conservative to assume the berth was continuously occupied by the largest possible ship).

9.3.4 Summary

The modelling scenarios are summarised as follows and illustrated in Figure 9-1:

Stage 1 model scenario: Large container ship at the proposed southernmost Sulphur Point Wharf berth under Stage 2 ('Maersk Edinburgh').

Stage 2 model scenario: At the southernmost new berth at the Mount Maunganui wharf (mooring dolphins north of the existing Cement/Bulk Liquids Tanker Berth):

- Large bulk tanker ('Nordneptun') for 1-hour average and 24-hour average model predictions.
- Average bulk carrier ('African Egret') for annual average model predictions.

Stage 1 & 2 model scenario: Cumulative effects of Stage 1 and Stage 2 large container ship and average bulk carrier or large bulk tanker using ships as described above.

These model scenarios are conservative because they assume:

- For the assessment of short-term impacts, that the ship that has the highest possible emissions.
- For the assessment of long-term impacts, that the new berths are continuously occupied by an average-sized ship.
- That the emissions from these ships are additional to existing shipping, i.e. there is no displacement of ships from other existing berths.

Stage 1	Stage 2	Stage 1 and Stage 2

Figure 9-1: Stage 1 and Stage 2 represent proposed new berths (blue). Stack locations are shown with a red cross.

9.4 Emission rates and assumptions

Specific ships representative of the largest container ship, bulk carrier and bulk tanker that are anticipated to visit the Port (and a representative "average" bulk carrier) have been identified in consultation with POTL. Emission rates of pollutants have been estimated based on:

- Engine / boiler loads published in USEPA, 2022
- Emission calculations from Chapter 3 of USEPA, 2022
- Published information including ship length, weight and container volumes for the selected ships

Calculated emission rates are summarised in Table 9-2. Other key assumptions in the dispersion modelling are detailed in Table 9.3. It can be seen from Table 9-2 that the Nordneptun (large bulk tanker) has significantly higher emissions of all contaminants than the Andreas K (large bulk carrier). As previously noted, these large bulk tankers currently do not visit the Port and are expected to do so infrequently in the future (less than monthly and potentially as low as two to three times a year). Consequently, the model results for 1-hour and 24-hour averaging periods presented in Section 10, are unlikely to occur in reality, as they could only occur if a large bulk tanker is at berth under the worst-case meteorological conditions.

Table 9-2: Pollutant emission rates

Ship	Vessel classification	Load during hotelling		Pollutant	Auxiliary engine emission rates (g/s)	Boiler emission rates (g/s)	Combined emission rate (g/s)
		Auxiliary engine (kW) [a]	Auxiliary boiler (kW) [b]				
Large container ship – Maersk Edinburgh	Container Ship - 14,500 TEU	1,200	630	SO_2	0.7	0.5	1.3
				PM_{10}	0.3	0.1	0.4
				$PM_{2.5}$	0.2	0.1	0.4
				NO_x	4.3	0.4	4.7
Worst-case bulk carrier – Andreas K (230 m)	Bulk Carrier - Panamax	600	200	SO_2	0.4	0.2	0.5
				PM_{10}	0.1	0.1	0.2
				$PM_{2.5}$	0.1	0.1	0.2
				NO_x	2.2	0.1	2.3
Worst-case bulk tanker – Nordneptun (230 m)	Oil Tanker - Panamax	750	1,500	SO_2	0.5	1.2	1.7
				PM_{10}	0.2	0.3	0.5
				$PM_{2.5}$	0.1	0.3	0.5
				NO_x	2.7	0.9	3.6
Average bulk carrier – African Egret (180 m)	Bulk Carrier - Handysize	280	50	SO_2	0.2	<0.1	0.2
				PM_{10}	0.1	<0.1	0.1
				$PM_{2.5}$	0.1	<0.1	0.1
				NO_x	1.0	0.1	1.1

a Table E.1 (USEPA, 2022)

b Table E.2 (USEPA, 2022)

Table 9.3: Assumptions used in modelling assessment

Parameter	Assumptions
Time in berth	• Container, bulk and tanker ships have been modelled to be in berth 24-hours a day, 365 days a year to represent a "worst-case" scenario.
Stack emissions	• Emissions from auxiliary engines and boilers are emitted from a combined stack. In reality, there are likely separate stacks, however due to the proximity of these stacks, it is unlikely to significantly affect results. • All stacks are assumed to be vertical.
Terrain and building downwash	Modelling predictions will vary depending on local terrain and building effects: • Terrain effects have been included. • Ship superstructure has been included to allow for building downwash effects.

9.5 Selection of sensitive receptor location

Concentrations were extracted at the modelling receptor closest to the Whareroa Marae monitoring station. This receptor was chosen as it allows for the most accurate representation of cumulative effects. Within the "Urban Marae Community" zone, there are a number of dwellings along Taiaho Place. Although there may be slight differences in background air quality due to localised effects of nearby industry, the modelled incremental effects of shipping emissions do not vary significantly across the Zone and therefore modelled concentrations at the Whareroa Marae monitor are representative of modelled concentrations at the dwellings at Taiaho Place. This is illustrated in the contour plots for select model scenarios and pollutants in Appendix C.

9.6 Evaluation of model performance

The performance of the dispersion model has been evaluated by comparing predicted NOx concentrations at Whareroa Marae because of emissions from ships at the existing southernmost bulk carrier berth at the Mount Maunganui wharves with monitoring data in 2024. Appendix A sets out an evaluation of the performance of the dispersion model.

The evaluation compares model predictions for the five available model meteorological years (2014, 2015, 2016, 2021 and 2024). The contribution of shipping emissions in the monitoring data has been isolated (to the extent possible) by filtering the monitoring data to include only hours where winds are from the direction of the Mount Maunganui wharves.

The key findings of the evaluation of the model performance are that:

- The dispersion model predictions using the 2014 to 2016 meteorological datasets generally underpredict the estimated NO_x contribution based on the monitoring data.
- The model predictions using the 2021 meteorological dataset are relatively close to the estimated contribution from shipping emissions.
- The model predictions using the 2024 meteorological dataset are expected to moderately to significantly overpredict the impacts from the shipping emissions.

10 Air quality impacts at Whareroa Marae

10.1 Introduction

The dispersion modelling has been used to predict the worst-case incremental effects at Whareroa Marae for each of the project stages and for Stages 1 and 2 combined.

To assess cumulative effects, the hourly model predictions of the effects of emissions from ships at the new berths have been added to measured hourly background data at Whareroa Marae for the relevant model year. The worst-case incremental effects of the project commonly do not occur under the same weather conditions as the worst-case background concentrations. This means that the worst-case modelled incremental effects of the project emissions are not additive to the worst-case background. For averaging periods less than the annual average, there is sometimes no change in the worst-case cumulative modelled concentration with the project compared to the maximum background concentration (i.e. without the project).

For completeness, both the 2021 and 2024 contemporaneous model predictions have been considered for SO_2 and PM_{10}.

10.2 Sulphur dioxide

10.2.1 Incremental impacts

The modelled worst-case incremental effects on SO_2 air quality for the 2021 and 2024 model years are summarised in Table 10-1 and Table 10-2 for 10-minute and 24-hour average. In accordance with recommended good practice (MfE, 2016), the maximum modelled 1-hour average results are the ninth highest of the yearly model predictions.

Table 10-1: Maximum predicted incremental increase in 1-hour average SO_2 concentrations at Whareroa Marae (µg/m³)[a]

Emission source	2021	2024
Stage 1 – Large container ship at Sulphur Point extension	22.8	14.5
Stage 2 – Large bulk tanker at Mount Maunganui wharf extension	43.8	48.9
Combined Stage 1 and 2[b]	43.8	48.9
Assessment criteria (for cumulative effects)	350	

a Ninth highest 1-hour average modelled concentration.

Table 10-2: Maximum predicted incremental increase in 24-hour average SO_2 concentrations at Whareroa Marae ($\mu g/m^3$)[a]

Emission source	2021	2024
Stage 1 – Large container ship at Sulphur Point extension	4.4	2.6
Stage 2 – Large bulk tanker at Mount Maunganui wharf extension	11.5	14.1
Combined Stage 1 and 2b	11.5	14.1
Assessment criteria (for cumulative effects)	120 (WHO 40[a])	

a Fourth highest 24-hour average concentration.

b Modelled 24-hour incremental impacts of Stage 1 and Stage 2 are not additive as they occur under different weather conditions (i.e. not at the same time).

10.2.2 Cumulative effects

The cumulative effects of SO_2 emissions from ships at the new wharves with existing air quality have been estimated by adding the model predictions to contemporaneous hourly measured SO_2 concentrations in 2021 and 2024.

The cumulative effects on worst-case 1-hour and 24-hour SO_2 concentrations at Whareroa Marae are presented in Table 10-3**Error! Reference source not found.** to Table 10-5. The NESAQ allows for nine exceedances per year of the threshold concentration therefore, the 1-hour average results presented are the ninth highest hour. Similarly, the WHO 2021 24-hour guidelines allow three to four exceedances per year, so the assessment considers the fourth highest cumulative modelled concentration.

Table 10-3: Maximum predicted change in worst-case cumulative 1-hour average SO_2 concentrations at Whareroa Marae ($\mu g/m^3$)[a]

Parameter	2021			2024		
	Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2
Worst-case background concentration	99.2			191.3		
Worst-case cumulative modelled concentration	99.2	111.0	111.0	191.3	192.3	192.3
Assessment criterion	350					
Cumulative concentration as a percentage of assessment criterion	*28%*	*32%*	*32%*	*55%*	*55%*	*55%*

a Ninth highest value.

Table 10-4: Maximum predicted change in worst-case cumulative 24-hour average SO_2 concentrations at Whareroa Marae (µg/m³)

Parameter	2021			2024		
	Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2
Background concentration	41.9			86.1		
Worst-case cumulative modelled concentration	44.0	42.5	44.6	86.1	86.1	86.2
Assessment criterion	120 (AAQG)					
Cumulative concentration as a percentage of assessment criterion	*37%*	*35%*	*37%*	*72%*	*72%*	*72%*

Table 10-5: Maximum predicted change in fourth highest cumulative 24-hour average SO_2 concentrations at Whareroa Marae (µg/m³)

Parameter	2021			2024		
	Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2
Background concentration	24.2			45.3		
Worst-case cumulative modelled concentration	25.4	28.7	29.2	45.9	49.0	49.6
Assessment criterion	40 (WHO)					
Cumulative concentration as a percentage of assessment criterion	*64%*	*72%*	*73%*	*115%*	*123%*	*124%*

10.2.3 Discussion of effects on 10-minute average concentrations

As discussed in Section 6.2, the WHO 2021 air quality guidelines include a 10-minute guideline for SO_2. Modelling 10-minute average concentrations would require a sub-hourly meteorological dataset (the available datasets are hourly), so it is not possible to directly model 10-minute average concentrations associated with the project. It would be possible to scale the 1-hour average model predictions to estimate 10-minute average concentrations using a power law equation. However, there would be a high degree of uncertainty in these estimates, and they do not account for sub-hourly variation in emission rates. For this reason, effects on 10-minute average concentrations have been assessed using a qualitative approach.

Existing 10-minute SO_2 air quality at both Whareroa Marae and Bridge Marina (further to the west) include the impacts of existing shipping emissions as well as industrial sources. The existing concentrations are generally well below the WHO 2021 guideline, with two isolated exceedances since 2017 that appear to be unrelated to shipping emissions (Section 8.2).

Although there is likely to be more variability in short term average concentrations, it is likely that the same meteorological conditions that give rise to peak 1-hour average SO_2 concentrations are the same conditions that give rise to peak 10-minute average SO_2 concentrations. Peak 1-hour average impacts of ship exhaust emissions at Whareroa Marae generally do not overlap with peak background concentrations (as shown in Table 10-3), which are related to local industry. Consequently, it can be inferred that the same is true of impacts on cumulative 10-minute SO_2 concentrations. Given existing concentrations re well below the WHO 2021 guidelines, it is therefore unlikely that shipping emissions would cause exceedances of the 10-minute average WHO 2021 guideline at Whareroa Marae.

10.2.4 Key findings

The maximum incremental impacts of Stage 1 and Stage 2 on SO_2 concentrations at Whareroa Marae are low (less than 15%) compared to the 24-hour average New Zealand ambient air quality standard.

Predicted cumulative SO_2 concentrations for both Stage 1 and Stage 2 (taking into account cumulative effects with Stage 1) are well below the New Zealand ambient air quality standard (1-hour) and guideline (24-hour).

The findings of the assessments of effects on 24-hour SO_2 concentrations are materially different for the 2021 and 2024 model years and background data. This difference relates to the occurrence in 2024 of some days with elevated 24-hour SO_2 concentrations (with respect to the WHO 2021 guideline). If there are years in the future with similarly elevated background 24-hour SO_2 concentrations, as were recorded in 2024, the assessment shows that:

- A large bulk tanker at the new wharves would not have any measurable effect on the day with the highest measured SO_2 concentration.
- A large bulk tanker at the new wharves could have contributed to one additional exceedance of the 24-hour WHO 2021 guideline value (i.e. an increase from five exceedances to six exceedances in a year, compared to the four allowable exceedances[3]).
- The more likely scenario of a large bulk carrier (e.g. a logging ship) at the new Mount Maunganui wharves (rather than a bulk tanker), would have much smaller effects on 24-hour average SO_2 concentrations (less than 30% compared to a bulk tanker) and would not have caused any additional exceedances of the WHO 2021 guidelines.

Assuming that a large bulk tanker was in Port for 12 days per year, and that there is only one day each year where the ship could cause an additional exceedance of the WHO 2021 guideline, this equates to a "return period" of over 30 years. In other words, the likelihood of a large bulk tanker causing an exceedance of the WHO guideline is once every 30 years (assuming that future years have the same elevated 24-hour SO_2 concentrations recorded in 2024).

[3] The incremental contribution is relatively small, but enough to increase the daily average concentration on the sixth worst day just above 40µg/m^3

10.3 PM_{10} particulate matter

10.3.1 Incremental impacts

The modelled worst-case 24-hour average incremental effects on PM_{10} air quality are summarised in Table 10-6. The annual average incremental effects on PM_{10} air quality are summarised in Table 10-7.

Table 10-6: Maximum predicted 24-hour average incremental increase in PM_{10} concentrations at Whareroa Marae (µg/m³)

Emission source	2021	2024
Stage 1 – Large container ship at Sulphur Point extension	1.4	0.8
Stage 2 – Large bulk tanker at Mount Maunganui wharf extension	3.3	4.1
Combined Stage 1 and 2[a]	3.4	4.2
Assessment criteria	50 (WHO 45)	

a Modelled 24-hour incremental impacts of Stage 1 and Stage 2 are not additive as they occur under different weather conditions (i.e. not at the same time).

Table 10-7: Predicted annual average incremental increase in PM_{10} concentrations at Whareroa Marae (µg/m³)

Emission source	2021	2024
Stage 1 – Large container ship at Sulphur Point extension	<0.1	<0.1
Stage 2 – Large bulk tanker at Mount Maunganui wharf extension	<0.1	<0.1
Combined Stage 1 and 2	0.1	0.1
Assessment criteria	(WHO 15)	

10.3.2 Cumulative effects

The cumulative effects of PM_{10} emissions from ships at the new wharves with existing air quality have been estimated by adding the model predictions to contemporaneous measured PM_{10} concentrations for contemporaneous data years of 2021 and 2024.

Table 10-8 and Table 10-9 show the predicted impact on cumulative 24-hour average concentrations. The annual average PM_{10} concentrations are shown in Table 10-10.

Table 10-8: Maximum 24-hour average predicted change in worst-case cumulative PM_{10} concentrations at Whareroa Marae (µg/m³)

Parameter	2021			2024		
	Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2
Background concentration	33.8			37.1		
Worst-case cumulative modelled concentration	33.8	33.8	33.8	37.1	37.1	37.1
Assessment criterion	50 (NESAQ)					
Cumulative concentration as a percentage of assessment criterion	*68%*	*68%*	*68%*	*74%*	*74%*	*74%*

Table 10-9: Fourth highest 24-hour average predicted change in worst-case cumulative PM_{10} concentrations at Whareroa Marae (µg/m³)

Parameter	2021			2024		
	Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2
Background concentration	25.4			32.2		
Worst-case cumulative modelled concentration	25.4	25.5	25.5	32.2	32.3	32.3
Assessment criterion	45 (WHO)					
Cumulative concentration as a percentage of assessment criterion	*56%*	*57%*	*57%*	*56%*	*57%*	*57%*

Table 10-10: Annual average predicted change in worst-case cumulative PM_{10} concentrations at Whareroa Marae (µg/m³)

Parameter		2021			2024		
		Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2
Background concentration		11.5			13.2		
Worst-case cumulative modelled concentration		11.6	11.6	11.6	13.2	13.2	13.3
Assessment criterion		20 (AAQG) / 15 (WHO)					
Cumulative concentration as a percentage of assessment criterion	*AAQG*	*58%*	*58%*	*58%*	*66%*	*66%*	*67%*
	WHO	*77%*	*77%*	*77%*	*88%*	*88%*	*89%*

10.3.3 Key findings

The maximum incremental impacts of both Stage 1 and Stage 2 on PM_{10} concentrations at Whareroa Marae are low (less than 10%) compared to the 24-hour average New Zealand ambient air quality standard. The worst-case impacts of the project do not occur under the same weather conditions that give rise to elevated background concentrations. Therefore, the emissions from Stage 1 and Stage 2 are not predicted to cause any measurable increase in worst case 24-hour PM_{10} concentrations.

Cumulative PM_{10} concentrations (taking into account cumulative effects with Stage 1 as well as the existing background) are predicted to be well below the New Zealand air quality standard (24-hour) and guideline (annual average) and the more stringent WHO 2021 guidelines for both Stages 1 and 2.

10.4 $PM_{2.5}$ particulate matter

10.4.1 Incremental impacts

The modelled worst-case incremental effects on $PM_{2.5}$ air quality for the 2024 model year are summarised in Table 10-11.

Table 10-11: Maximum predicted incremental increase in $PM_{2.5}$ concentrations at Whareroa Marae (2024 model year)

Emission source	Maximum 24-hour average (µg/m³)	Annual average (µg/m³)
Stage 1 – Large container ship at Sulphur Point extension	0.7	<0.1
Stage 2 – Large bulk tanker at Mount Maunganui wharf extension	3.8	<0.1
Combined Stage 1 and 2b	3.8	0.1
Assessment criteria	25 (proposed NESAQ) (15 WHO[a])	10 (proposed NESAQ) (5 WHO)

a Fourth highest 24-hour average.

b Modelled 24-hour incremental impacts of Stage 1 and Stage 2 are not additive as they occur under different weather conditions (i.e. not at the same time).

10.4.2 Cumulative effects

The cumulative effects of $PM_{2.5}$ emissions from ships at the new wharves with existing air quality have been estimated by adding the model predictions to contemporaneous measured $PM_{2.5}$ concentrations in 2024, as shown in Table 10-12.

10.4.3 Key findings

The maximum incremental impacts of both Stage 1 and Stage 2 on $PM_{2.5}$ concentrations at Whareroa Marae are small (at most 15%) compared to the 24-hour average Proposed New Zealand ambient air quality standard.

Cumulative $PM_{2.5}$ concentrations (taking into account cumulative effects with Stage 1 as well as the existing background) are predicted to remain well below the Proposed New Zealand air quality standards (24-hour and annual average) and the more stringent WHO 2021 guidelines.

Table 10-12: Maximum predicted change in worst-case cumulative $PM_{2.5}$ concentrations at Whareroa Marae (2024 model year)

Parameter	Maximum 24-hour average			4th highest 24-hour average			Annual average		
	Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2
Background concentration	10.6			9.9			4.8		
Worst-case cumulative modelled concentration	10.6	13.4	13.4	10.0	10.1	10.3	4.8	4.8	4.9
Assessment criterion	25 (proposed NESAQ)			15 (WHO)			10 (proposed NESAQ) / 5 (WHO)		
Cumulative concentration as a percentage of assessment criterion	*42%*	*54%*	*54%*	*67%*	*67%*	*69%*	*48%/96%*	*48%/96%*	*49%/98%*

10.5 Nitrogen dioxide

10.5.1 Method to account for atmospheric chemistry

10.5.1.1 Approach

NO_x emissions from shipping and other combustion sources comprises primarily nitric oxide (NO) with a smaller component of NO_2. NO_2 is the contaminant of interest with respect to potential health effects and, for this reason, air quality guidelines are set for NO_2 rather than NO_x or NO.

One of the challenges of estimating the effects of NO_x emissions on NO_2 concentrations is accounting for the extent of atmospheric conversion of emitted NO to NO_2. This conversion is related to the availability of ozone and is sunlight-dependant. At high NO_x concentrations, the relationship will be ozone-limited, meaning there is not enough ozone to convert NO to NO_2.

Guidance from MfE (MfE, 2016) recommends several methods for estimating the downwind conversion of NO to NO_2. The guidance recommends a tiered approach from simple to complex. The methods recommended by MfE often significantly overpredict NO_2 concentrations when compared to measured values and therefore an alternative approach has been adopted for this assessment.

Where measured NO_x and NO_2 data is available, it can be used to develop a best-fit relationship between NO_x and NO_2. This best-fit relationship can be applied to the cumulative NO_x concentrations (i.e. modelled NO_x contribution plus NO_x background) to estimate the cumulative NO_2 concentration.

10.5.1.2 Best fit relationship for 1-hour NO_2/NO_x ratio

For 1-hour average concentrations (see Figure 10-1), the data is “noisy” and there is no consistent relationship between NO_2 and NO_x concentrations. However, at NO_x concentrations greater than 80 µg/m³, the NO_2/NO_x ratio does not exceed 0.6, and at concentrations greater than approximately 95 µg/m³, the ratio does not exceed 0.4.

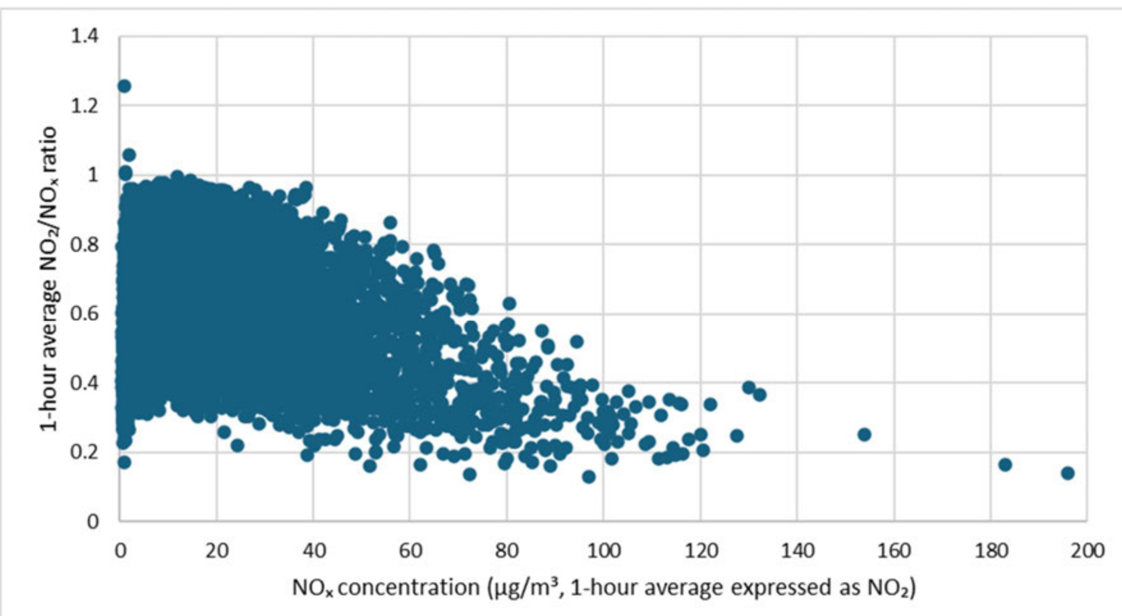

Figure 10-1: Relationship between 1-hour average NO_2/NO_x ratio and NO_x concentration at Whareroa Marae for all recorded data.

10.5.1.3 Best fit relationship for 24-hour and annual average NO_2/NO_x ratios

For 24-hour and annual averaging periods, relationships have been developed using data from four monitoring sites in the Auckland region and the data from Whareroa Marae. The Auckland data is considered appropriate to use to develop a relationship applicable to Mount Maunganui for the following reasons:

- The Auckland data includes a mix of industrial, residential and rural monitoring locations.
- The main contributions to NO_x concentrations in both locations are combustion sources.
- The ozone concentrations in Tauranga and Auckland are expected to be similar due to the similar latitude and atmospheric conditions at the two locations.

Figure 10-2 shows the relationship between 24-hour average NO_2 and NO_x concentrations. There is a reasonable linear correlation for 24-hour average NO_x concentrations of less than approximately 70 µg/m³. At higher NOx concentrations, a polynomial relationship provides a better fit for the data.

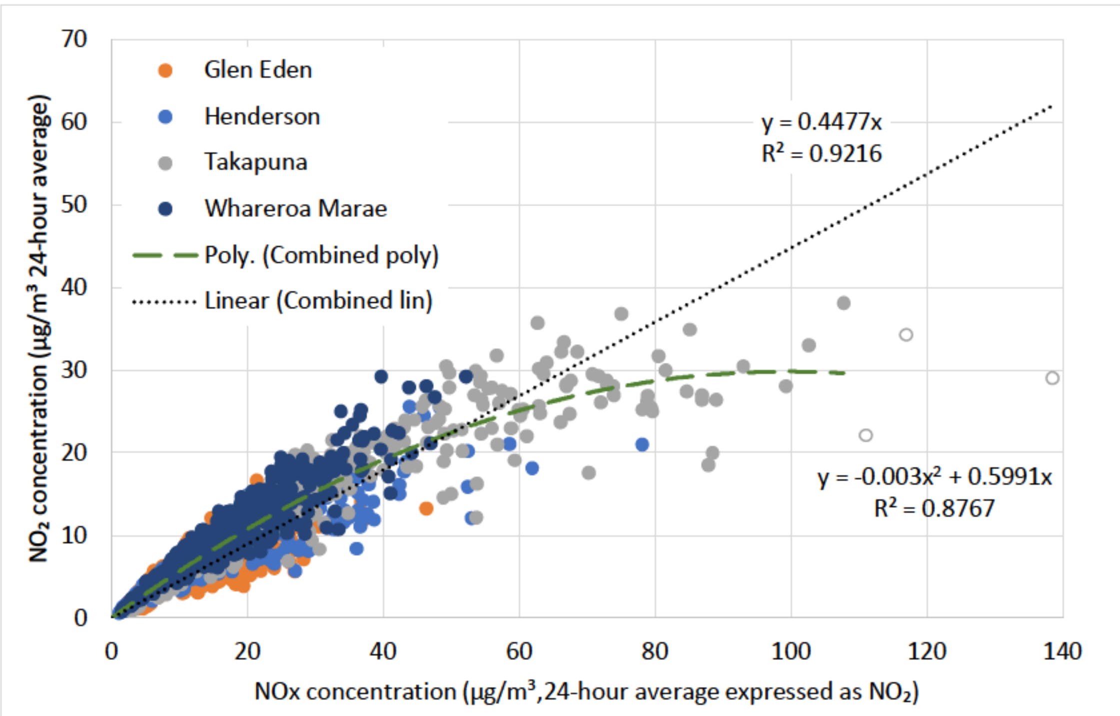

Figure 10-2: Relationship between 24-hour average NO_2 concentration and NO_x concentration at Auckland monitoring sites (2023) including Whareroa Marae data points (Aug 2023 – Dec 2024).

The annual average NO_2/NO_x ratio and NO_x concentration at Auckland monitoring stations is in Figure 10-3. A single data point is available for Whareroa and is included on Figure 10-3. NO_x and NO_2 concentrations at Whareroa Marae are at the lower end of the measured concentrations across these sites and are most similar to Glen Eden, which is classed as a suburban residential monitoring location.

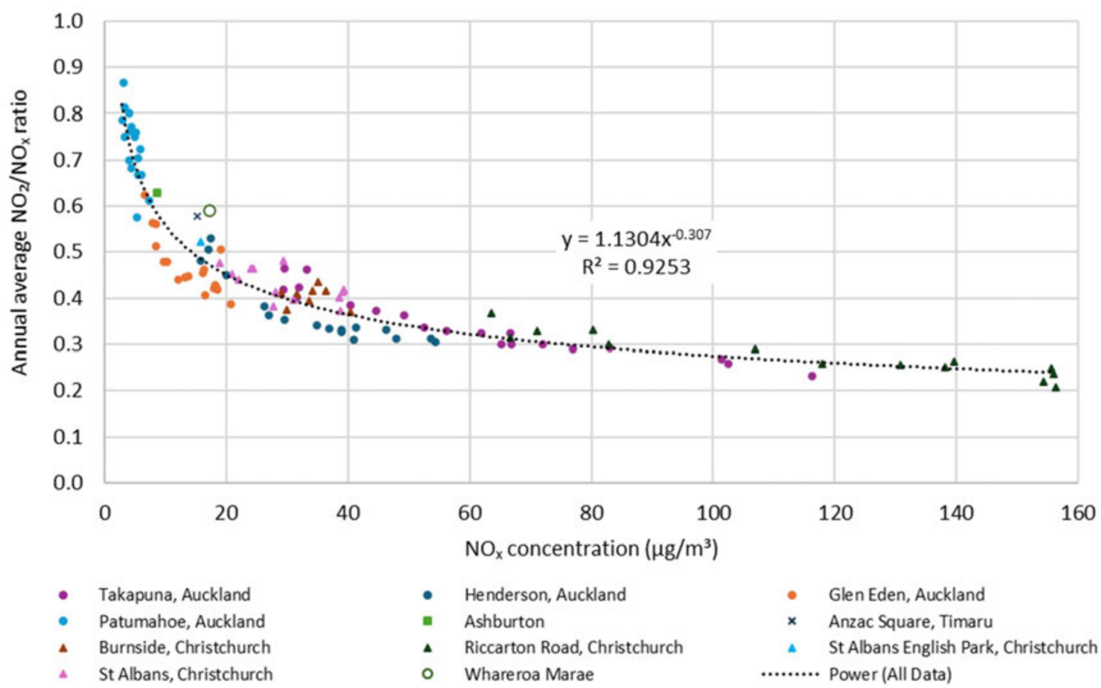

Figure 10-3: Relationship between annual average NO_2/NO_x ratio and NO_x concentration at Auckland monitoring sites including Whareroa Marae data point.

10.5.2 Cumulative effects

10.5.2.1 Introduction

As discussed in Section 10.5.1, the effects of ship exhaust emissions on NO_2 concentrations have been estimated by modelling cumulative NO_x concentrations (contemporaneous modelling of ship emissions plus background) and then using the relationship between NO_2 and NO_x to estimate the NO_2 concentration. As such, this section of the report (assessing NO_2 air quality) is structured differently to the previous sections and presents the cumulative effects first followed by incremental effects on NO_2 concentrations.

10.5.2.2 Cumulative effects on 1-hour average NO_2

The effects of the Project on worst case cumulative 1-hour average NO_x and NO_2 concentrations at Whareroa Marae are presented in Table 10-13. A NO_2/NO_x ratio of 0.4 has been used to estimate cumulative NO_2 concentrations, based on the data presented in Table 10-3.

Table 10-13: Maximum predicted increase in worst-case cumulative 1-hour NO_2 concentrations at Whareroa Marae (model years 2024)

Parameter	Stage 1	Stage 2	Combined Stage 1 and 2
Worst-case background NO_2 concentration (µg/m³)	50.8		
Worst-case background NO_x concentration (µg/m³)	196.0		
Worst-case cumulative modelled NO_x concentration (µg/m³)	196.0	238.7	238.7
NO_2/NO_x ratio from Figure 10-1	0.4	0.4	0.4
Estimated cumulative modelled NO_2 concentration (µg/m³)	78.4	95.5	95.5
Assessment criterion	200 (NESAQ)		
Cumulative concentration as a percentage of assessment criterion	*39%*	*48%*	*48%*

a Ninth percentile modelled concentration.

10.5.2.3 Cumulative effects on 24-hour average NO_2

The effects of the Project on worst case cumulative 24-hour NO_2 concentrations at Whareroa Marae are presented in Table 10-14. The NO_2/NO_x ratio has been estimated using the linear relationship shown in Figure 10-2. This is appropriate as the cumulative NO_x concentrations are generally below 70 µg/m³ (24-hour average), where the linear relationship is a good fit.

Table 10-14: Maximum predicted increase in worst-case cumulative 24-hour NO_2 concentrations at Whareroa Marae (model years 2024)

Parameter	Maximum 24-hour average			4th highest 24-hour average		
	Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2
Background NO_2 concentration (µg/m³)	29.3			27.9		
Background NO_x concentration (µg/m³)	52.0			46.3		
Worst-case cumulative modelled NO_x concentration (µg/m³)	53.1	65.4	65.4	47.0	55.4	55.6
NO_2/NO_x ratio from Figure 10-2	0.45			0.45		
Estimated cumulative modelled NO_2 concentration (µg/m³)	29.3[a]	29.3	29.3	27.9[a]	27.9[a]	27.9[a]
Assessment criterion	100 (AAQG)			25 (WHO)		
Cumulative concentration as a percentage of assessment criterion	*29%*	*29%*	*29%*	*112%*	*112%*	*112%*

a There is no material change to the estimated NO_2 concentration using the linear relationship method therefore the estimated cumulative concentration is assumed to be the same as the existing background concentration.

10.5.2.4 Cumulative effects on annual average NO_2

The cumulative effects on annual average NO_x and NO_2 concentrations at Whareroa Marae are presented in Table 10-15.

The NO_2/NO_x ratio in the 12 months of monitoring data at Whareroa Marae is 0.58. As shown in Figure 10-3, this is within the expected range based on monitoring data at other locations.

Table 10-15: Predicted increase in worst-case cumulative annual NO_2 concentrations at Whareroa Marae (model years 2024)

Parameter		Stage 1	Stage 2	Combined Stage 1 and 2
Measured background NO_2 concentration(μg/m³)			10.2	
Measured background NO_x concentration(μg/m³)			17.4	
Worst-case cumulative modelled NO_x concentration (μg/m³)		17.9	17.9	18.5
Measured NO_2/NO_x ratio			0.58	
Estimated cumulative modelled NO_2 concentration (μg/m³)		10.4	10.4	10.7
Assessment criterion			10 (WHO)	
Cumulative concentration as a percentage of assessment criterion	*WHO*	*104%*	*104%*	*107%*
	EU	*52%*	*52%*	*54%*

a There is no material change to the estimated NO_2 concentration using the linear relationship method therefore the estimated cumulative concentration is assumed to be the same as the existing background concentration.

10.5.3 Incremental impacts on NO_2 concentrations

The modelled worst-case incremental effects of ship exhausts on NO_2 air quality are summarised in the following tables.

Table 10-16: Predicted incremental contribution to worst-case 1-hour NO_2 concentrations at Whareroa Marae (model year 2024)

Parameter	Stage 1	Stage 2	Combined Stage 1 and 2
Worst-case background NO_2 concentration (μg/m³)		50.8	
Estimated worst case cumulative NO_2 concentration (μg/m³)	78.4	95.5	95.5
Incremental NO_2 concentration (μg/m³)	27.6	44.7	44.7
Assessment criterion		200 (NESAQ)	
Incremental concentration as a percentage of assessment criterion	*14%*	*22%*	*22%*

Table 10-17: Predicted incremental contribution to worst-case 24-hour NO_2 concentrations at Whareroa Marae (model year 2024)

Parameter	Maximum 24-hour average			4th highest 24-hour average		
	Stage 1	Stage 2	Combined Stage 1 and 2	Stage 1	Stage 2	Combined Stage 1 and 2
Background NO_2 concentration (µg/m³)	29.3			27.9		
Estimated worst case cumulative NO_2 concentration (µg/m³)	29.3[a]	29.3[a]	29.3[a]	27.9[a]	27.9[a]	27.9[a]
Incremental NO_2 concentration (µg/m³)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Assessment criterion	100 (AAQG)			25 (WHO)		
Incremental concentration as a percentage of assessment criterion	*<0.1%*	*<0.1%*	*<0.1%*	*<0.1%*	*<0.1%*	*<0.1%*

a There is no material change to the estimated NO_2 concentration using the linear relationship method.

Table 10-18: Predicted incremental increase in annual average NO_2 concentrations at Whareroa Marae (model year 2024)

Parameter		Stage 1	Stage 2	Combined Stage 1 and 2
Measured background NO_2 concentration (µg/m³)		10.2		
Estimated worst case cumulative NO_2 concentration (µg/m³)		10.4	10.4	10.7
Incremental NO_2 concentration (µg/m³)		0.2	0.2	0.5
Assessment criterion		10 (WHO)		
Incremental concentration as a percentage of assessment criterion	*WHO*	*2%*	*2%*	*5%*

10.5.4 Key findings

The maximum incremental impacts of Stage 1 and Stage 2 on NO_2 concentrations at Whareroa Marae are moderate (at most 22%) compared to the 1-hour average New Zealand ambient air quality standard.

Predicted cumulative effects on NO_2 concentrations for both Stage 1 and Stage 2 (taking into account cumulative effects with Stage 1) are well below the New Zealand ambient air quality standard (1-hour) and guideline (24-hour).

As discussed in Section 8.5, in 2024 existing air quality at Whareroa Marae exceeded the more stringent WHO 2021 guidelines for NO_2 (24-hour and annual average). Six exceedances of 24-hour average 25 µg/m³ WHO 2021 guideline were recorded at Whareroa Marae. There is not predicted to be any measurable effect of the project on worst-case 24-hour average NO_2 concentrations and the project would not cause any further exceedances of the WHO 2021 guideline. The incremental additional effect of the project on annual average NO_2 concentrations is small (5%) compared to the WHO 2021 guideline.

10.6 Summary of air quality impacts at Whareroa Marae

10.6.1 Impact descriptors

In the absence of New Zealand guidance, impact descriptors developed by the UK Institute of Air Quality Management (IAQM) have been used to summarise the impact of the project on air quality (Institute of Air Quality Management, 2017). The descriptors are as shown in Table 10-19.

These impact descriptors were designed to be used to describe the impact on cumulative annual average concentrations, with reference to relevant air quality guidelines (described as the Air Quality Assessment Level). For this assessment, the descriptors have also been applied to other averaging periods to provide a consistent basis for comparison.

As these impact descriptors were developed in a different context, it is important to recognise that they are only to be used as an indicator of when further analysis is required to determine the overall effect. For example, a finding of a Substantial effect using these descriptors may not indicate a significant adverse effect on air quality depending on the circumstances.

The table is intended to be used by rounding the change in percentage pollutant concentration to whole numbers, which then makes it clearer which cell the impact falls within. Changes of 0%, i.e. less than 0.5%, will be described as Negligible regardless of the background concentration.

Table 10-19: Air quality impact descriptors for individual receptors (reproduced from IAQM, 2017)

Long term average Concentration at receptor in assessment year	% Change in concentration relative to Air Quality Assessment Level (AQAL)			
	1	2-5	6-10	>10
75% or less of AQAL	Negligible	Negligible	Slight	Moderate
76-94% of AQAL	Negligible	Slight	Moderate	Moderate
95-102% of AQAL	Slight	Moderate	Moderate	Substantial
103-109% of AQAL	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Moderate	Substantial	Substantial	Substantial

The following tables present the impact descriptors in relation to the New Zealand ambient air quality standards and guidelines and the WHO 2021 guidelines. The results are presented separately for the 2021 (SO_2 and PM_{10} only) and 2024 model years. The calculations/assignments based on the monitoring data presented in the previous sub-sections are summarised in Appendix D.

10.6.2 Impacts with respect to New Zealand ambient air quality standards and guidelines

Table 10-20: Summary of impacts in relation to New Zealand ambient air quality standards and guidelines (model year 2021)

Parameter	Averaging period	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	1-hour	Negligible	Negligible	Negligible
	24-hour	Negligible	Negligible	Negligible
PM_{10}	24-hour	Negligible	Negligible	Negligible
	Annual	Negligible	Negligible	Negligible

Table 10-21: Summary of impacts in relation to New Zealand ambient air quality standards and guidelines (model year 2024)

Parameter	Averaging period	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	1-hour	Negligible	Negligible	Negligible
	24-hour	Negligible	Negligible	Negligible
PM_{10}	24-hour	Negligible	Negligible	Negligible
	Annual	Negligible	Negligible	Negligible
$PM_{2.5}$	24-hour	Negligible	Moderate	Moderate
	Annual	Negligible	Negligible	Negligible
NO_2	1-hour	Moderate	Moderate	Moderate
	24-hour	Negligible	Negligible	Negligible

10.6.3 Impacts with respect to WHO 2021 guidelines

Table 10-22: Summary of impacts in relation to WHO 2021 ambient guidelines (model year 2021)

Parameter	Averaging period	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	24-hour	Negligible	Moderate	Moderate
PM_{10}	24-hour	Negligible	Negligible	Negligible
	Annual	Negligible	Negligible	Negligible

Table 10-23: Summary of impacts in relation to WHO 2021 ambient guidelines (model year 2024)

Parameter	Averaging period	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	24-hour	Moderate	Substantial	Substantial
PM_{10}	24-hour	Negligible	Negligible	Negligible
	Annual	Negligible	Negligible	Negligible
$PM_{2.5}$	24-hour	Negligible	Negligible	Negligible
	Annual	Negligible	Negligible	Moderate[a]
NO_2	24-hour	Negligible	Negligible	Negligible
	Annual	Moderate	Moderate	Moderate

Table Notes:

a. The increase from negligible impact for Stages 1 and 2 to moderate impact for cumulative effects is due to the very low assessment criterion for annual average $PM_{2.5}$. The incremental impact of Stages 1 and 2 combined is 0.1 µg/m^3, which increases the modelled annual average concentration from 4.8 to 4.9 µg/m^3. This level effect is immeasurable.

11 Conclusions

The assessment considers the effects of exhaust emissions from ships at the proposed new berths for Stage 1 and Stage 2 of the Project on concentrations of:

- Fine particulate matter (PM_{10} and $PM_{2.5}$).
- Nitrogen dioxide (NO_2).
- Sulphur dioxide (SO_2).

Whareroa Marae has been chosen for detailed assessment as it is the closest sensitive residential location where people may be present continuously.

The modelling assessment uses contemporaneous model predictions and hourly background data to assess the cumulative effects of the discharges on air quality. Modelling meteorological datasets prepared by Atmospheric Science Global Limited are available from the BOPRC for 2014 to 2016 and 2021. T+T has also prepared a modelling meteorological dataset for 2024. The predictions using the 2021 and 2024 meteorological datasets generated the most conservative (highest) results. 2024 was the first full year of monitoring at Whareroa Marae for $PM_{2.5}$ and NO_2.

The modelling adopts conservative assumptions, including that the new berths for Stage 1 and Stage 2 of the project are continuously occupied by the largest ship foreseeable (or an average ship when considering effects on long term air quality) and that these emissions are additive to background air quality (which includes the effects of existing shipping). The impacts on air quality of Stage 2 are greater than Stage 1, because the new Mount Maunganui wharves are located closer to Whareroa Marae than the new Sulphur Point wharves.

The assessment demonstrates that the cumulative air quality effects of both Stages 1 and 2 of the Project on air quality at Whareroa Marae are generally negligible in comparison to the New Zealand air quality standards and guidelines apart from 1-hour NO_2 and 24-hour $PM_{2.5}$, where the impacts are classed as moderate (using the adopted impact classification scheme). There is a moderate increase (22%) in the predicted worst-case 1-hour average NO_2 concentration, however the cumulative concentration remains well below (less than 50%) the NESAQ. Similarly, there is a small (11%) increase in the predicted worst-case 24-hour average $PM_{2.5}$ concentration but the cumulative concentration remains well below (less than 60%) the Proposed NESAQ. As cumulative concentrations remain well below the New Zealand standards and guidelines, the overall effects on 1-hour NO_2 and 24-hour $PM_{2.5}$ are assessed as being low.

The effects of the Project have also been compared against the more stringent WHO 2021 air quality guidelines for completeness. For most contaminants and averaging periods, the effects are negligible compared to the WHO 2021 guideline. The exceptions are for the impact on 24-hour SO_2, annual average NO_2 and annual average $PM_{2.5}$ where the impacts are classed as moderate (using the adopted impact classification scheme). There are small increases in the incremental effects on cumulative concentrations with respect to the WHO 2021 guideline (13% for 24-hour average SO_2, 5% for annual average NO_2 and 2% for annual average $PM_{2.5}$). For annual average NO_2 and $PM_{2.5}$, the predicted cumulative concentrations remain below the WHO 2021 guideline (and, in the case of annual average $PM_{2.5}$, the effects are immeasurably small) and therefore the overall effects are assessed as being low.

In regard to 24-hour SO_2, the background SO_2 air quality at Whareroa Marae was materially different in 2024 compared to all previous years since 2019, with five days exceeding the WHO 2021 guideline (more than the 4 allowable exceedances). As a result, the assessed impacts of the Project differ depending on whether 2021 or 2024 background concentrations are used. The modelling assessment shows that the worst-case assumption of a large bulk tanker continuously present at the new Mount Maunganui wharves would not have had any measurable effect on the day with the highest measured SO_2 concentration. However, it could have contributed to one additional exceedance of the 24-hour WHO 2021 guideline value (i.e. the incremental contribution is relatively small, but enough to increase the daily average concentration on the sixth worst day just above 40µg/m^3). Taking into account the low frequency of anticipated visits by these very large bulk tankers, the likelihood of a large bulk tanker causing an exceedance of the WHO 2021 guideline is once every 30 years (assuming that future years have the same elevated 24-hour SO_2 concentrations recorded in 2024).

The more likely scenario of a large bulk carrier (e.g. a logging ship) at the new Mount Maunganui wharves (rather than a bulk tanker), would have much smaller effects on 24-hour average SO_2 concentrations (less than 30% compared to a bulk tanker) and would not have caused any additional exceedances of the WHO 2021 guidelines.

The overall conclusions of the assessment are that:

- The effects of discharges to air from Stage 1 are assessed as negligible with respect to the New Zealand ambient air quality standards and guidelines, with the exception of 1-hour average NO_2, where the effects are assessed as low.
- Although slightly greater than the effects of Stage 1, the effects of discharges to air from Stage 2 (including the combined effects with Stage 1) are assessed as negligible or low with respect to the New Zealand ambient air quality standards and guidelines and negligible or low with respect to the more stringent WHO 2021 guidelines, except for 24-hour average SO_2.
- Taking into account the scale and likelihood of effects, the effects of discharges to air from Stage 2 (including the combined effects with Stage 1) on 24-hour average SO_2 concentrations are assessed as low with respect to WHO 2021 guidelines.

12 References

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13 Applicability

This report has been prepared for the exclusive use of our client Port of Tauranga Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
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Appendix A Dispersion modelling configuration

A1 Overview

Atmospheric dispersion modelling, utilising the CALPUFF dispersion model (version 7) has been used to assess the air quality effects associated with the proposed Stella Passage Development. The CALPUFF model is a widely used dispersion model in New Zealand.

The dispersion modelling assessment has focused on predicting key contaminant concentrations and how those concentrations would change as a result of the proposed site changes. The scenarios modelled and associated emission parameters used as input to the model have been summarised in Section 9.

The following sections provide details on the model configuration.

A2 Meteorological modelling

A2.1 Overview

A three-dimensional meteorological dataset for one modelling year (2024) was prepared using the CALMET model (version 7). As discussed in Section 9, the year 2024 was selected to enable a comparison of modelled concentrations to ambient monitoring measurements.

The CALMET model domain was set up to be the same extent as the BOPRC CALMET datasets for Tauranga, i.e., comprise a 42.66 km by 35.64 km grid with a grid resolution of 180 m. Inputs into the CALMET model included the following:

- An output from the Weather Research and Forecasting (WRF) model,
- Measurements from two surface stations (see Appendix A Table 1).
- The BOPRC provided Tauranga GEO.DAT file (2021 version).

Further details on the WRF data and surface stations are provided in the sections below.

A2.2 Surface stations

Measurements from two surface stations were used to inform surface meteorological conditions (wind speed, wind direction, temperature, pressure, and relative humidity) in the CALMET model. Details on these surface stations is summarised in Appendix A Table 1. The two surface stations were selected for the following reason:

- The Tauranga Airport station records measurements at 10 m above ground level. Measurements at this height are considered best practice for monitoring meteorological conditions.
- BOPRC has three meteorological stations that were operated for the full year of 2024 within the Mt Maunganui peninsula: Rata St, Totara Street, and Whareroa Marae. Including all these stations in the CALMET would likely give rise to a 'bulls eye' effect due to differences in wind directions recorded at each station (unless a very small RMAX1 value was used)[4]. Because of this, only measurements from the BOPRC Rata St station were included in the CALMET model to allow measurements from each surface station and WRF data to be appropriately blended. The Rata St station was chosen due to being located the furthest from the Tauranga Airport station.

[4] A 'bulls eye' effect refers to the phenomenon where wind fields artificially show highly localized wind conditions around meteorological stations that are inconsistent with the broader wind field.

Appendix A Table 1: Surface stations used in CALMET dataset

ID	Station name	Operating authority	Parameters measured	Mast height
S1	Tauranga Airport	MetService	WS, WD, T, P, RH	10 m
S2	Rata Street	BOPRC	WS, WD, T, P, RH	5 m

Notes: WS = wind speed, WD = wind direction, T = temp, P = pressure, RH = relative humidity.

A2.3 WRF data

Outputs from WRF modelling was used to inform the upper air meteorological conditions and surface conditions where surface observations were not available (i.e., at distances greater than 2 km from the surface stations. The upper air meteorological dataset was produced using best practice prognostic modelling using the WRF model. The WRF data was provided by Lakes Environmental, who modelled to a resolution of 1 km over the model domain area.

A2.4 CALMET configuration

Appendix A Table 2 summarises key inputs to the CALMET configuration, where they differ from BOPRC 2021 CALMET.

Appendix A Table 2: Differences between BOPRC 2021 CALMET and T+T 2024 CALMET

Parameter	BOPRC	T+T	Comments
No. Surface Stations	6	2	See discussion in Section A1
R1	1.5	1.0	The two surface stations are located 3.5 km. These values were chosen to allow sufficient blending between the Surface stations and WRF data.
RMAX1	3.0	2.0	
RMAX2	4.0	2.0	No upper air stations used so same value as RMAX1 is considered appropriate.
TERRAD	4.0	2.0	The difference in TERRAD is unlikely to make any material difference as the terrain across the model domain is relatively flat (apart from Mauao, which is unlikely materially influence wind patterns in the area of interest).
BIAS	-1, -0.5, 0, 0, 0, 0, 0, 0, 0, 0, 1.0, 1.0	-1.0, -0.7, -0.5, -0.4, 0.0, 0.4, 0.7, 1.0, 1.0, 1.0, 1.0, 1.0	Smaller increments were used to allow better blending between surface stations and upper air (WRF) data. The 8th vertical layer is 820 m above the surface. It considered highly unlikely that surface stations will have any influence from this height. Consequently, a value of 1.0 has been used from this height and above.

Notes: WS = wind speed, WD = wind direction, T = temp, RH = relative humidity.

A2.5 Comparison of CALMET model to station observations

To confirm the representativeness of the modelled wind fields, Appendix A Table 3 compares the modelled wind conditions to historic wind measurements from:

- Tauranga Airport,
- Rata St, and
- BOPRC Totara St Railing Crossing monitoring station (which was not included as input to the CALMET model).

Overall, the wind rose generated from the CALMET dataset compares well to the wind roses generated for the surface observation data.

Appendix A Table 3: Comparison of wind roses

1 Outputted for the location of the BOPRC Totara St Rail Crossing monitoring station.

2 Measurements at this station commenced on January 19 2024.

A3 Receptor configuration

CALPUFF was configured to predict contaminant ground level concentrations at gridded receptors using a number of nested grids centred on the Site as shown in Figure Appendix A.1.

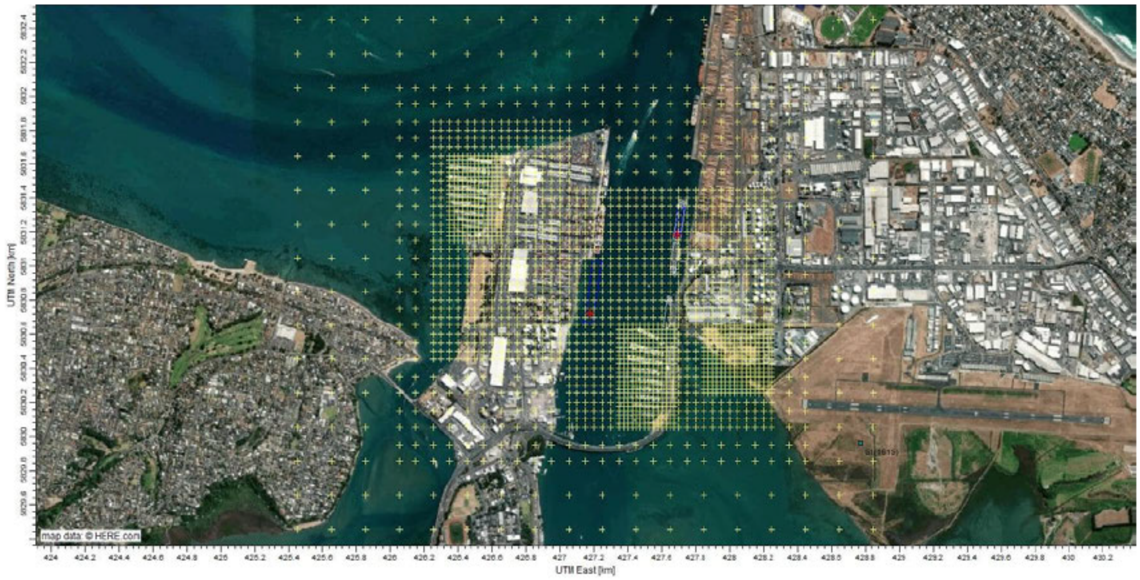

Figure Appendix A.1: Nested receptor grid configuration (yellow crosses).

A4 Building downwash and stack information

The presence of buildings and other structures close to stack discharges can result in building downwash effects on plumes, where wind eddies in the wake of a building can impact on plume dispersion. To account for this effect, the ship superstructures were included in the CALPUFF model. The effect of building downwash was accounted for using the PRIME building downwash algorithm[5]. The establishment of further buildings or structures further afield in the future are unlikely to materially influence building downwash effects beyond those immediate buildings and structures including in the modelling assessment.

Stack and building downwash information is shown in Table Appendix A.4. Stack information was approximated from publicly available information on the ships and using a combustion calculation from first principals to approximate efflux velocity.

Table Appendix A.4 : Summary of the stack discharge parameters

Parameter	Maersk Edinburgh	Andreas K	Nordneptun	African Egret
Stack height	48.0 m	35.0 m	35.0 m	25.3 m
Stack diameter	0.9 m	0.43 m	0.43 m	0.36 m
Stack efflux temperature	300°C	500 C	500 C	500°C
Stack efflux velocity	16 m/s	20.5 m/s	20.5 m/s	21 m/s
Superstructure dimensions	48 m wide x 366 m long x 11 m high	37 m wide x 25 m long x 34 m high	37 m wide x 25 m long x 34 m high	18 m wide x 12.7 m long x 20.4 m high

[5] This is the recommended option for use with dispersion models (MfE, 2004).

Appendix B Evaluation of model performance

B1 Overview

Modelling meteorological datasets are available from BOPRC for the years 2014 - 2016 and 2021. A further modelling meteorological dataset was produced by T+T for 2024. The model predictions for 2021 and 2024 are markedly higher than for 2014 to 2016. For this reason, further work has been carried out to understand the performance of the dispersion modelling.

The approach to model evaluation has been to attempt to isolate the existing effects of bulk carriers at the Mount Maunganui wharves in the monitoring data at Whareroa Marae and compare this with the modelled impacts of ships at the proposed new berths. To undertake this comparison, it has been necessary to account for the greater separation distance between existing bulk carriers (at the current closest berth) and Whareroa Marae, compared to the new berths.

B2 Selection of representative contaminant to evaluate model performance

Monitoring data is available at Whareroa Marae for oxides of nitrogen (NO_x), NO_2, SO_2, $PM_{2.5}$ and PM_{10}. NO_x was chosen as the most useful contaminant for the evaluation of model performance the following reasons:

- SO_2 is not suitable as an indicator contaminant as the effects of SO_2 from shipping cannot be readily separated from the potential effects of emissions from Ballance Agrinutrients, which is in the same upwind direction from the monitor.
- PM_{10} and $PM_{2.5}$ are also not suitable as indicator contaminants because there are multiple sources within the airshed and the emissions from shipping are not able to be easily isolated.
- NO_x is a more useful indicator contaminant than NO_2 because it is not necessary to account for atmospheric chemistry when considering total NO_x. Ballance Agrinutrients is not a significant source of NO_x emissions. There will be some overlapping influence of NO_x from road traffic emissions, however these effects are likely to be relatively consistent when comparing times when ships are present and not present.

The main limitation of using NO_x as the indicator contaminant for evaluating model performance is that monitoring data is only available for 2024, which may not be representative of all meteorological conditions.

B3 Impact of existing bulk carrier at Berth 11

The contribution from ships at the existing southernmost bulk carrier berth to the measured NO_x concentrations at Whareroa Marae have been estimated as follows:

- Berth 11 occupancy data was obtained for 1 September 2023 to 30 August 2024, corresponding with the period of monitoring data at Whareroa Marae.
- Measured NO_x concentrations have been filtered to include only times when the wind direction was from Berth 11 towards Whareroa Marae.
- Measured NO_x concentrations at Whareroa Marae have been separated into times when ships are at berth and when ships are not at berth.
- The average ship is assumed to be at berth (i.e. African Egret).

To investigate whether there is a statistically significant difference in the average concentration when there are ships at Berth 11 compared to no ships at Berth 11, a Wilcoxon-Mann-Whitney (WMW) statistical test was performed. The WMW test is a non-parametric method and is appropriate as only one of the datasets (concentrations when no ship present) is normally distributed.

The WMW test indicated that there was a statistically significant difference in the measured concentrations for the two datasets at the 95th percentile confidence interval (with $p < 0.05$) and that the average concentration when there is a ship at berth is greater than when there is not a ship at berth.

The results are summarised in Table Appendix B.1, which indicates that NO_x concentrations at Whareroa Marae are, on average, 5.1 µg/m³ higher when ships are at Berth 11 and the wind is blowing towards Whareroa Marae compared to times when there are no ships at Berth 11 under these same wind conditions. Berth 11 is approximately 1,140 to 1,300 m from Whareroa Marae.

Table Appendix B.1 : Average measured NO_x concentration at Whareroa Marae for wind direction filtered data

Berth status	Average measured NO_x concentration (µg/m³)
No ships at Berth 11	27.7
Ships at Berth 11	32.8
Difference in concentration	**5.1**

B4 Modelled impact of ships at Berth 11

Ships using the existing southernmost bulk carrier wharf (Berth 11) may be oriented with their stacks either to the north or south. For a large ship, this equates to approximately 160 m difference in separation distance between the ship stack and Whareroa Marae depending on orientation.

Table Appendix B.2 presents the model results for NO_x filtered by wind direction, to estimate the average predicted concentration when the wind is blowing towards the Whareroa Marae air quality monitor.

Table Appendix B.2 : Annual average modelled NO_x concentration at Whareroa Marae for average ship at Berth 11

Modelling year	Average modelled NO_x concentration (µg/m³)	
	North orientation	South orientation
Distance to Whareroa Marae	900 m	740 m
2014	1.9	2.6
2015	1.7	3.2
2016	2.8	4.1
2021	6.1	9.7
2024	6.8	11.7

The modelled NO_x contributions are expected to be similar to the estimated contribution from the monitoring data for ships at Berth 11 (approximately 5.1 µg/m³), as the modelling is based on the average bulk carrier.

Assuming all ships at Berth 11 are oriented with their stacks to the north (farthest from Whareroa Marae), the dispersion model predictions using the 2014 to 2016 meteorological datasets are significantly lower than the modelled concentrations for 2021 and 2024.

The model prediction for 2021 are lower than those for the 2024 modelling year. For the 2024 model prediction the results are 35% and 130% higher than the monitoring data for the north and south orientations, respectively.

Based on the modelling results and the distance from Whareroa Marae for the modelling versus the measured data, the 2024 modelling is expected to overpredict the impacts of ships at the proposed new Mount Maunganui berths.

B5 Conclusions in relation to model performance

Using the 2014 to 2016 meteorological datasets, the model generally underpredicts the average contribution of shipping to NO_x concentrations at Whareroa Marae. The 2021 dataset is approximately representative to moderately conservative of the measured concentrations at Whareroa Marae. The 2024 is expected to overpredict the impacts from the proposed new Mount Maunganui berths.

Appendix C Concentration contour plots

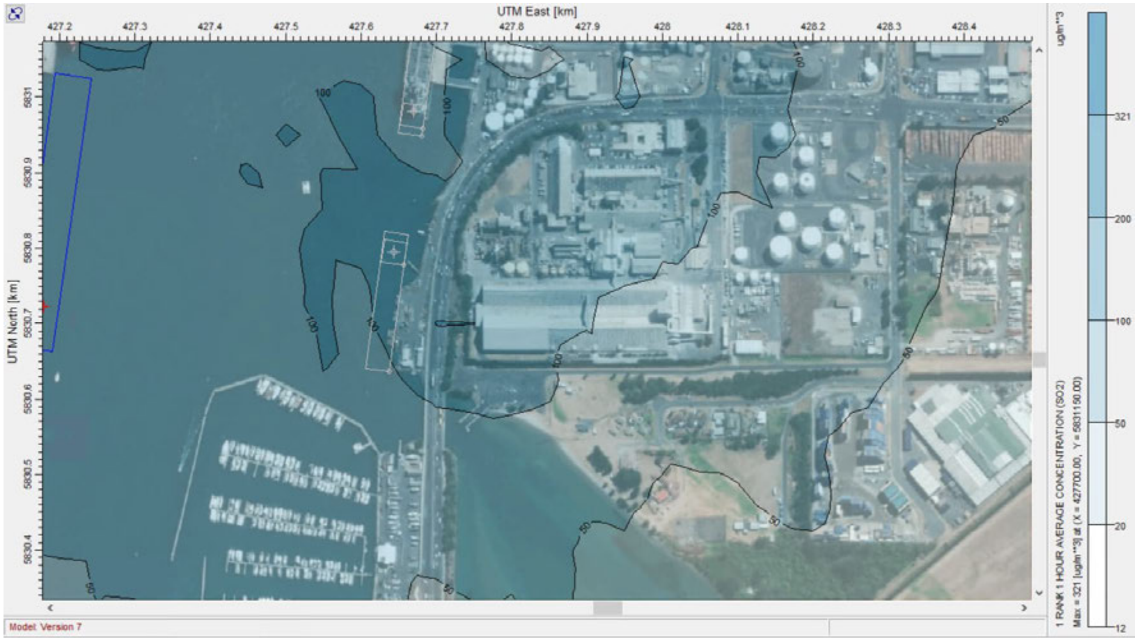

Figure AppendixC.1: Maximum 1-hour average SO_2 concentration for Stage 1 and Stage 2

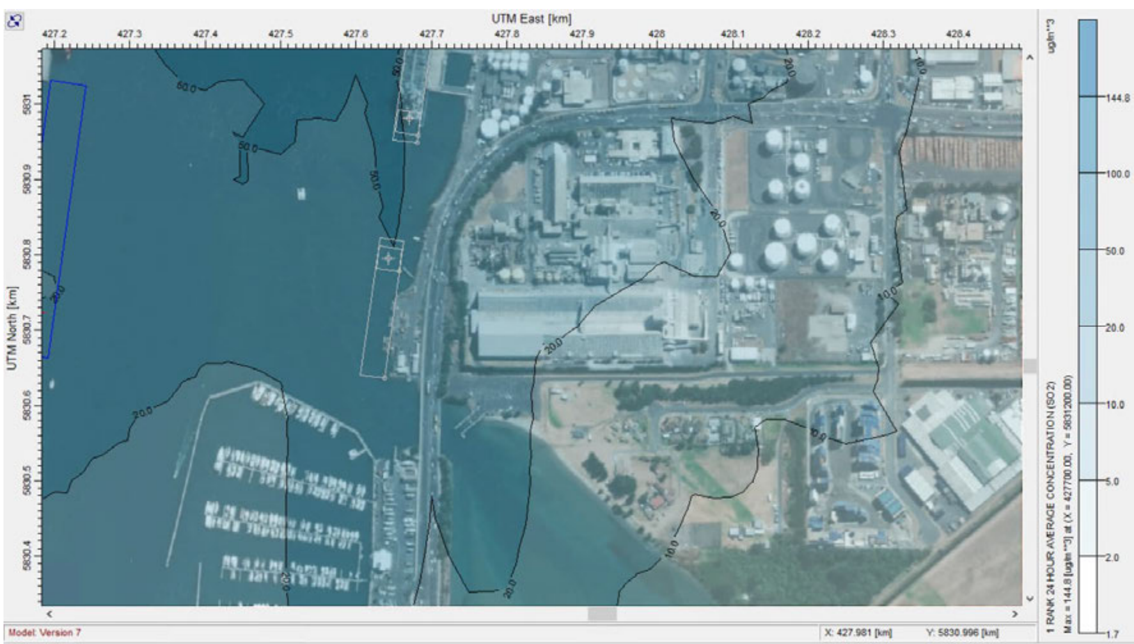

Figure Appendix C2: Maximum 24-hour average SO_2 concentration for Stage 1 and Stage 2

Appendix D IAQM air quality impact descriptors

This Appendix sets out the calculations used to determine the impact description presented in Section 10.6.

D1 New Zealand ambient air quality standards and guidelines

D1.1 Model year 2021

Table Appendix D.1 : Incremental change in cumulative concentrations

Parameter	Averaging period		Assessment criterion	Background	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	1-hour	9th high	350	99.2	0.0	11.8	11.8
	24-hour	Max	120	41.9	2.1	0.6	2.7
PM_{10}	24-hour	Max	50	33.8	0.0	0.0	0.0
	Annual		20	11.5	0.1	0.1	0.1

Table Appendix D.2 : Percentage change compared to assessment criteria

Parameter	Averaging period		Background	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	1-hour	9th highest	28%	0%	3%	3%
	24-hour	Max	35%	2%	1%	2%
PM_{10}	24-hour	Max	68%	0%	0%	0%
	Annual		58%	0%	0%	0%

Table Appendix D.3 : IAQM air quality impact descriptor

Parameter	Averaging period		Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	1-hour	9th highest	Negligible	Negligible	Negligible
	24-hour	Max	Negligible	Negligible	Negligible
PM_{10}	24-hour	Max	Negligible	Negligible	Negligible
	Annual		Negligible	Negligible	Negligible

D1.2 Model year 2024

Table Appendix D.4 : Incremental change in cumulative concentrations

Parameter	Averaging period		AQAL	Background	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	1-hour	9th high	350	191.3	0.0	1.0	1.0
	24-hour	Max	120	86.1	0.0	0.0	0.1
PM_{10}	24-hour	Max	50	37.1	0.0	0.0	0.0
	Annual		20	13.2	0.0	0.0	0.1
$PM_{2.5}$	24-hour	Max	25	10.6	0.0	2.8	2.8
	Annual		15	4.8	0.0	0.0	0.1
NO_2	1-hour	9th high	200	50.8	27.6	44.7	44.7
	24-hour	Max	100	29.3	0.0	0.0	0.0

Table Appendix D.5 : Percentage change compared to assessment criteria

Parameter	Averaging period		Background	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	1-hour	9th high	55%	0%	0%	0%
	24-hour	Max	72%	0%	0%	0%
PM_{10}	24-hour	Max	74%	0%	0%	0%
	Annual		66%	0%	0%	0%
$PM_{2.5}$	24-hour	Max	42%	0%	1%	1%
	Annual		32%	0%	0%	0%
NO_2	1-hour	9th high	25%	14%	22%	22%
	24-hour	Max	29%	0%	0%	0%

Table Appendix D.6 : IAQM air quality impact descriptor

Parameter	Averaging period		Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	1-hour	9th high	Negligible	Negligible	Negligible
	24-hour	Max	Negligible	Negligible	Negligible
PM_{10}	24-hour	Max	Negligible	Negligible	Negligible
	Annual		Negligible	Negligible	Negligible
$PM_{2.5}$	24-hour	Max	Negligible	Moderate	Moderate
	Annual		Negligible	Negligible	Negligible
NO_2	1-hour	9th high	Moderate	Moderate	Moderate
	24-hour	Max	Negligible	Negligible	Negligible

D2 WHO 2021 ambient guidelines

D2.1 Model year 2021

Table Appendix D.7 : Incremental change in cumulative concentrations

Parameter	Averaging period		AQAL	Background	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	24-hour	4th high	40	24.2	1.2	4.5	5.0
PM_{10}	24-hour	4th high	45	25.4	0.0	0.1	0.1
	Annual		15	11.5	0.1	0.1	0.1

Table Appendix D.8 : Percentage change compared to assessment criteria

Parameter	Averaging period		Background	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	24-hour	4th high	61%	3%	11%	13%
PM_{10}	24-hour	4th high	56%	0%	0%	0%
	Annual		77%	1%	1%	1%

Table Appendix D.9 : IAQM air quality impact descriptor

Parameter	Averaging period		Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	24-hour	4th high	Negligible	Moderate	Moderate
PM_{10}	24-hour	4th high	Negligible	Negligible	Negligible
	Annual		Negligible	Negligible	Negligible

D2.2 Model year 2024

Table Appendix D.10 : Incremental change in cumulative concentrations

Parameter	Averaging period		AQAL	Background	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	24-hour	4^{th} high	40	45.3	0.6	3.7	4.3
PM_{10}	24-hour	4^{th} high	45	32.2	0.0	0.1	0.1
	Annual		15	13.2	0.0	0.0	0.1
$PM_{2.5}$	24-hour	4^{th} high	15	9.9	0.1	0.2	0.4
	Annual		5	4.8	0.0	0.0	0.1
NO_2	24-hour	4^{th} high	25	27.9	0.0	0.0	0.0
	Annual		10	10.2	0.2	0.2	0.5

Table Appendix D.11 : Percentage change compared to assessment criteria

Parameter	Averaging period		Background	Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	24-hour	4^{th} high	113%	1%	9%	11%
PM_{10}	24-hour	4^{th} high	72%	0%	0%	0%
	Annual		88%	0%	0%	1%
$PM_{2.5}$	24-hour	4^{th} high	66%	1%	1%	3%
	Annual		96%	0%	0%	2%
NO_2	24-hour	4^{th} high	112%	0%	0%	0%
	Annual		102%	2%	2%	5%

Table Appendix D.12 : IAQM air quality impact descriptor

Parameter	Averaging period		Stage 1	Stage 2	Combined Stage 1 and 2
SO_2	24-hour	4^{th} high	Moderate	Substantial	Substantial
PM_{10}	24-hour	4^{th} high	Negligible	Negligible	Negligible
	Annual		Negligible	Negligible	Negligible
$PM_{2.5}$	24-hour	4^{th} high	Negligible	Negligible	Negligible
	Annual		Negligible	Negligible	Moderate
NO_2	24-hour	4^{th} high	Negligible	Negligible	Negligible
	Annual		Moderate	Moderate	Moderate

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