WEST COAST
REGIONAL COUNCIL

State of the environment

West Coast Air Quality

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Prepared by the West Coast Regional Council Environmental Quality Team

West Coast Regional Council

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Executive summary

Poor air quality is a winter problem on the West Coast, and it is caused principally by the burning of solid fuel for domestic home heating. Fine airborne particulate matter (PM) is the main contaminant of concern. This report draws together air quality monitoring undertaken by the West Coast Regional Council over more than three decades: the long continuous record for the Reefton airshed, and the investigative monitoring carried out at Westport, Greymouth and Hokitika as part of the wider West Coast monitoring programme from 2022 to 2025. It reviews that work alongside the historic monitoring of 1994 to 2003, sets out what is now known about the state of air quality in each town, and makes recommendations for future monitoring.

Reefton remains the only gazetted airshed on the West Coast and the only town with a record of breaching the national standard. It is inland and sheltered, with very low wind speeds and frequent winter inversions which trap locally generated emissions. Emissions inventories in 2005, 2012 and 2019 attributed up to 98 per cent of particulate emissions to domestic home heating, the majority from multi-fuel burners. Fewer exceedances of the PM_{10} standard have been recorded since the monitoring site moved in 2016, but spatial surveys and trend assessments indicate that this reflects the change of location rather than an improvement in air quality. Monitoring at both the original and the current site since 2024 will allow that to be tested directly. $PM_{2.5}$ has been measured at Reefton since 2019 and has exceeded the World Health Organisation daily guideline of 15 $\mu g/m^3$ on numerous occasions.

In Westport, continuous monitoring at Club Buller from 2023 to 2025 recorded no exceedances of the PM_{10} daily standard, although the annual average for 2024 exceeded the WHO annual guideline of 15 $\mu g/m^3$ and there were eleven exceedances of the WHO daily guideline of 15 $\mu g/m^3$ for $PM_{2.5}$. Spatial surveys in 2022 and 2023 consistently found higher concentrations in the northern part of the town, and an evaluation following the 2023 survey indicated that the Club Buller site is likely to measure $PM_{2.5}$ at close to half the concentration of the peak area near the northern end of Derby Street. Source apportionment showed biomass combustion from home heating to be the largest contributor to $PM_{2.5}$, at 76 per cent on average, while sea salt accounted for 43 per cent of PM_{10}.

Greymouth (Figure 1) was surveyed in 2023 and 2024 before a continuous instrument was installed at Greymouth High School for winter 2025. No exceedances of the PM_{10} standard were recorded on the reference instrument over that winter. Source apportionment of the 2025 filters confirmed that sea salt contributes a large and at times dominant share of PM_{10}, so that the exceedances measured outside winter are driven by natural rather than anthropogenic sources. The spatial surveys identified areas of elevated PM in central Greymouth, and a second investigative site is being monitored over winter 2026 to test whether concentrations are higher around Alexander and Thompson Streets.

Hokitika was monitored for particulate matter for the first time in 2024 and 2025. Concentrations were the lowest of the towns surveyed, with no exceedances of the WHO daily guideline for $PM_{2.5}$ and only one site marginally above the PM_{10} standard, within the uncertainty of the instrument. Air quality in Hokitika is likely to comply with both the national standard and the WHO guidelines, although reference-grade measurement would be needed to confirm this.

Two findings apply across the region. First, every town monitored has recorded exceedances of the WHO daily average guideline for $PM_{2.5}$, which matters because the proposed amendments to the national standard would shift the basis of regulation from PM_{10} to $PM_{2.5}$. Second, in the coastal towns a large share of PM_{10} is sea salt, so $PM_{2.5}$ is the better measure of the portion of airborne particulate matter that can actually be managed. Sulphur dioxide and nitrogen dioxide were measured at Reefton and Westport and were well below guidelines, and no further monitoring of either was considered necessary at Greymouth or Hokitika.

Figure 1. View of Greymouth from Arnott Heights, 2003.

1. Background

1.1. Rationale

Poor air quality can be an issue in some of the West Coast's urban areas during winter. Fine airborne particulate matter (PM) is the main contaminant of concern. Emissions from domestic home heating are the primary source of PM in West Coast towns. Fine airborne particulate matter can affect human health, exacerbating respiratory and cardio-vascular conditions. Small particles such as PM_{10} and $PM_{2.5}$ (particles <10 and <2.5 microns in size, respectively), can lodge in the upper airways, penetrate the lungs, and in the case of $PM_{2.5}$, can enter the bloodstream. People's health can be at risk from chronic exposure to high levels of PM, especially more vulnerable groups such as the elderly, children and people with respiratory conditions.

The West Coast Regional Council (WCRC) is required to undertake air quality monitoring in accordance with the National Environmental Standard for Air Quality (NESAQ 2004) (Ministry for the Environment, 2004). Councils are required to monitor any airshed where there are likely to be exceedances of the national air quality standard. The national standard in New Zealand is currently a daily average of no more than 50 micrograms/m^3 of PM_{10}, with one allowable exceedance per year.

There is currently no New Zealand standard for $PM_{2.5}$ but there are international guidelines from the World Health Organisation (WHO) (World Health Organization, 2021) for $PM_{2.5}$. Proposed amendments to the NESAQ were released in 2020, in which a change to the triggers for mitigation of PM issues would move from a PM_{10} daily average to a $PM_{2.5}$ annual average (10 $\mu g/m^3$), and a $PM_{2.5}$ daily average standard of 25 $\mu g/m^3$ (with no more than three exceedances per year). At this time, there were indications that the New Zealand standard would be in line with the WHO air quality guidelines. However, the WHO guidelines have been updated since the release of the proposed NESAQ amendments and there is uncertainty whether the proposed levels for PM standards in New Zealand will be brought in line with the latest WHO guidelines. WHO (2021) air quality guideline levels (AQG's) for $PM_{2.5}$ are an annual average under 5 $\mu g/m^3$ and a 99th percentile of daily averages under 15 $\mu g/m^3$. For PM_{10} the WHO annual AQG is currently 15 $\mu g/m^3$ and the daily AQG is 45 $\mu g/m^3$ (as a 99th percentile).

Both natural and anthropogenic sources of PM can be harmful, but it is the anthropogenic sources of particulate emissions that can be managed. A future move from the current PM_{10} standard to a $PM_{2.5}$ standard would allow us to more accurately manage anthropogenic PM sources.

The National Environmental Standard for Air Quality stipulates that air quality monitoring should be undertaken anywhere in a region where air quality is likely to exceed the standard. The Reefton air quality site was established in 2006 with little prior monitoring of air quality on the West Coast since the early 2000's. The West Coast Regional Air Plan (2002) committed to further monitoring for assessing the state of air quality in other West Coast urban centres.

The currently operative Regional Air Quality Plan 2002 is in the early stages of a full review under the Resource Management Act (RMA) (New Zealand Government, 1991). Some issues have been identified, and a discussion document has been drafted for possible public and stakeholder feedback.

A small change was made to the Air Plan in 2024 to give effect to the National Policy Statement (NPS) and National Environmental Standards (NES) for Greenhouse Gas Emissions from Industrial Process Heat (Ministry for the Environment, 2023), (New Zealand Government, 2023). This was a mandatory change required to the Plan which did not need to go through a public submission process under section 55(2A) of the RMA.

The new Resource Management Planning and Natural Environment Bills are due to become law in August 2026. It is likely that these Bills will require one plan per region, with a spatial plan, a land use plan and a natural environment plan. A revised and updated Regional Air Plan will then become part of the Natural Environment Plan, along with the Coastal Plan, and the Land and Water Plan.

WCRC Policy staff understand that changes to the NES for Air Quality will be released in 2027, and any new requirements in this NES will be incorporated into the WCRC Regional Air Plan.

1.2. An overview of West Coast air quality investigations 1994 to 2026

Air quality monitoring has been undertaken at five West Coast towns – Reefton (Figure 2), Westport, Greymouth, Hokitika and Runanga - over more than three decades (Figure 4 & Figure 5). The effort has not been spread evenly between them. It has followed where people live, how they heat their homes, and where there was reason to think the national standard might be breached. Reefton, the region's only gazetted airshed, has a continuous record running from 2006 to the present. The other towns have shorter, mostly investigative records, built up largely since 2022.

Figure 2. View of Reefton, 2003.

This pattern reflects the nature of the problem. Poor air quality on the West Coast is a winter problem, caused principally by the burning of solid fuel for domestic home heating, and it is strongly local. Towns differ in size, in the topography that surrounds them, in their distance from the coast and in the fuels their households burn. Concentrations also vary within a town, sometimes over a few hundred metres, depending on the density of fires and on the way cold air drains and pools on still winter nights. Monitoring has therefore combined a small number of fixed continuous sites, which produce data that can be compared directly with the national standard, with spatial surveys that map how particulate matter varies across a town.

The earliest work was indicative. Smoke and sulphur dioxide were measured in Greymouth in 1994 and 1995, and in Reefton in 1995. Between 2001 and 2003 a five-town winter survey covered Greymouth, Runanga, Reefton, Westport and Hokitika, with monthly average passive sulphur dioxide and BTEX at all five towns, and high-volume PM_{10} sampling, one day in three, over a single winter each at Greymouth in 2001, Westport in 2002 and Reefton in 2003. That work established the broad spatial picture which has shaped the programme since. PM_{10} was highest in Reefton and Westport, both of which recorded samples above the national guideline, and lower in Greymouth. No PM was measured at Hokitika or Runanga. Sulphur dioxide and benzene were below guidelines at every town sampled.

Reefton was the first town to receive sustained attention, because it was the town where air quality was considered to be the poorest. Continuous PM_{10} monitoring began there in May 2006 and $PM_{2.5}$ was added in 2019. Emissions inventories were completed in 2005, 2012 and 2019, each confirming domestic home heating as the dominant source. The monitoring site moved across town in 2016 when the original site was sold, and the spatial surveys of winter 2020 and winter 2021 were undertaken largely to test whether the lower concentrations recorded at the new site represented a real improvement in air quality or simply a quieter location. A passive nitrogen dioxide and sulphur dioxide survey followed in 2022. Since 2024 both Reefton sites have been operating, allowing the two locations to be compared directly.

Following the survey work in Reefton, a wider West Coast monitoring programme was established in consultation with the National Institute of Water and Atmospheric Research (Coulson, Longley, Somervell, Olivares, & Morrish, 2022). This programme extended the investigation of particulate matter to Westport, Greymouth and Hokitika, and added nitrogen dioxide and sulphur dioxide monitoring in Reefton and Westport. These towns were chosen because of their larger populations and the greater number of people therefore exposed to winter air pollution. Westport, Reefton and Greymouth had early surveys of PM, sulphur dioxide and BTEX. Hokitika and Runanga had historic sulphur dioxide and BTEX monitoring but no previous PM monitoring at all. The programme was designed to build on that earlier work and provide an updated picture of the state of air quality across the region.

Particulate matter was the focus of the programme, being the contaminant of most concern based on the earlier data and of what is known about West Coast towns. Traffic volumes are low and there are no large industrial sources, so solid fuel burning for home heating is the likely main source of emissions in each town. The national standard also contains standards for sulphur dioxide and nitrogen dioxide, and these were included to update knowledge of both and to determine whether any further monitoring of them was needed. Benzene, the contaminant of main interest in the earlier BTEX sampling because it is carcinogenic and is produced by burning coal and wood, was found at low levels across all five towns in 2001 to 2003 and has not been sampled since. Nitrogen dioxide had not been monitored on the West Coast before this programme.

Spatial PM surveys use networks of small lower-cost sensors, deployed either in-house by WCRC staff or by a qualified contractor, while sulphur dioxide and nitrogen dioxide have been collected with small diffusion tubes deployed for one-month periods. The low-cost monitors are investigative instruments. Their data are not accurate enough to be compared with the national standard, but they show reliably where concentrations within a town are consistently higher, and so where a reference-grade instrument might be worth installing. Because air quality varies from one winter to the next with meteorology and with burning habits, surveys have generally been repeated over two winters to give more confidence in the pattern they show.

The chronology of this work is summarised in Figure 4 and Figure 5. The sections which follow take each town in turn, setting out the monitoring undertaken there, what it has shown, and what it suggests for future work.

Figure 3. MetOne E-SEQ-FRM (left), minimote unit in Westport 2022 (centre), and SO2 and NO2 diffusion tubes in Reefton 2022 (right).

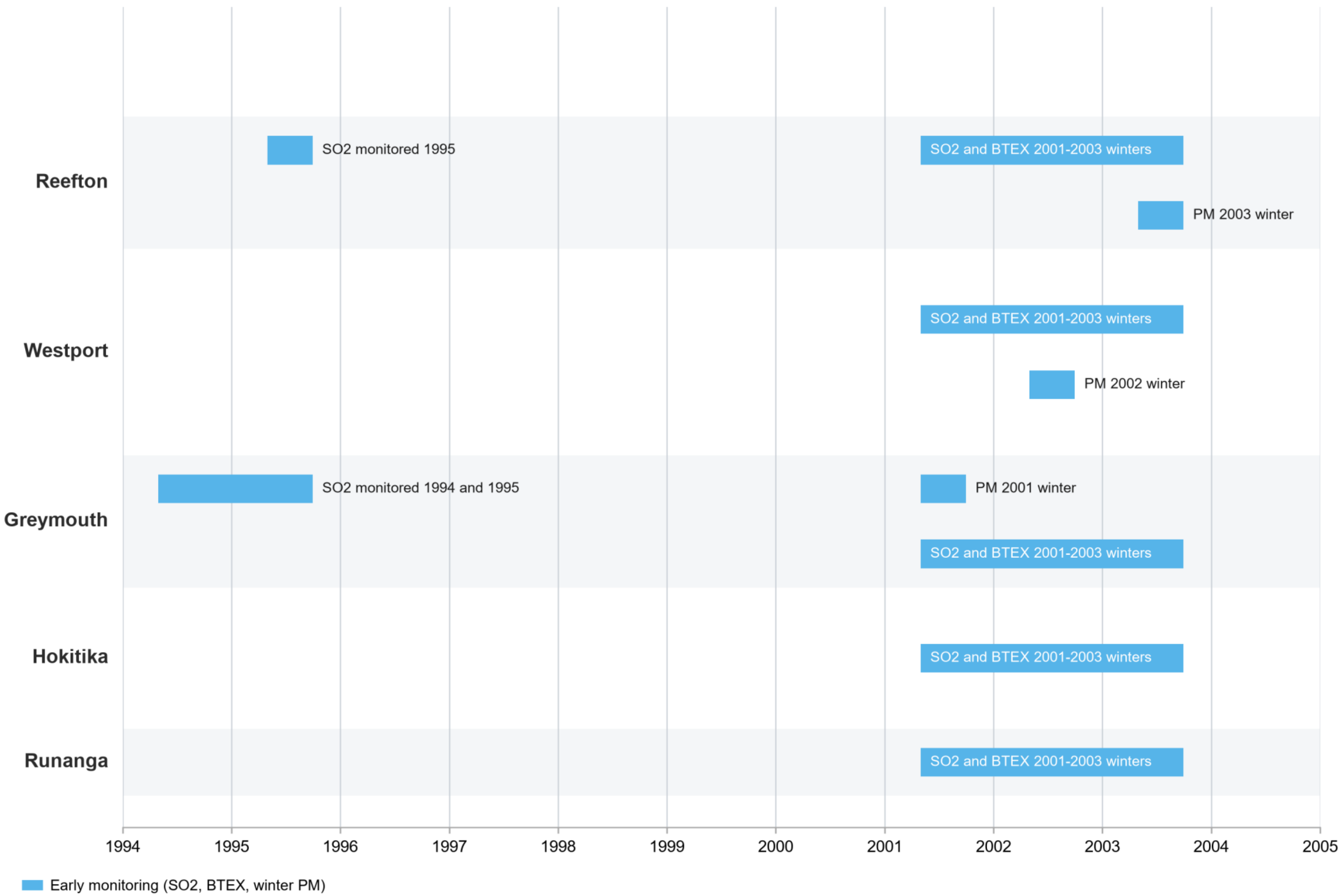

Figure 4. Air quality monitoring undertaken by WCRC at West Coast towns, 1994 to 2004.

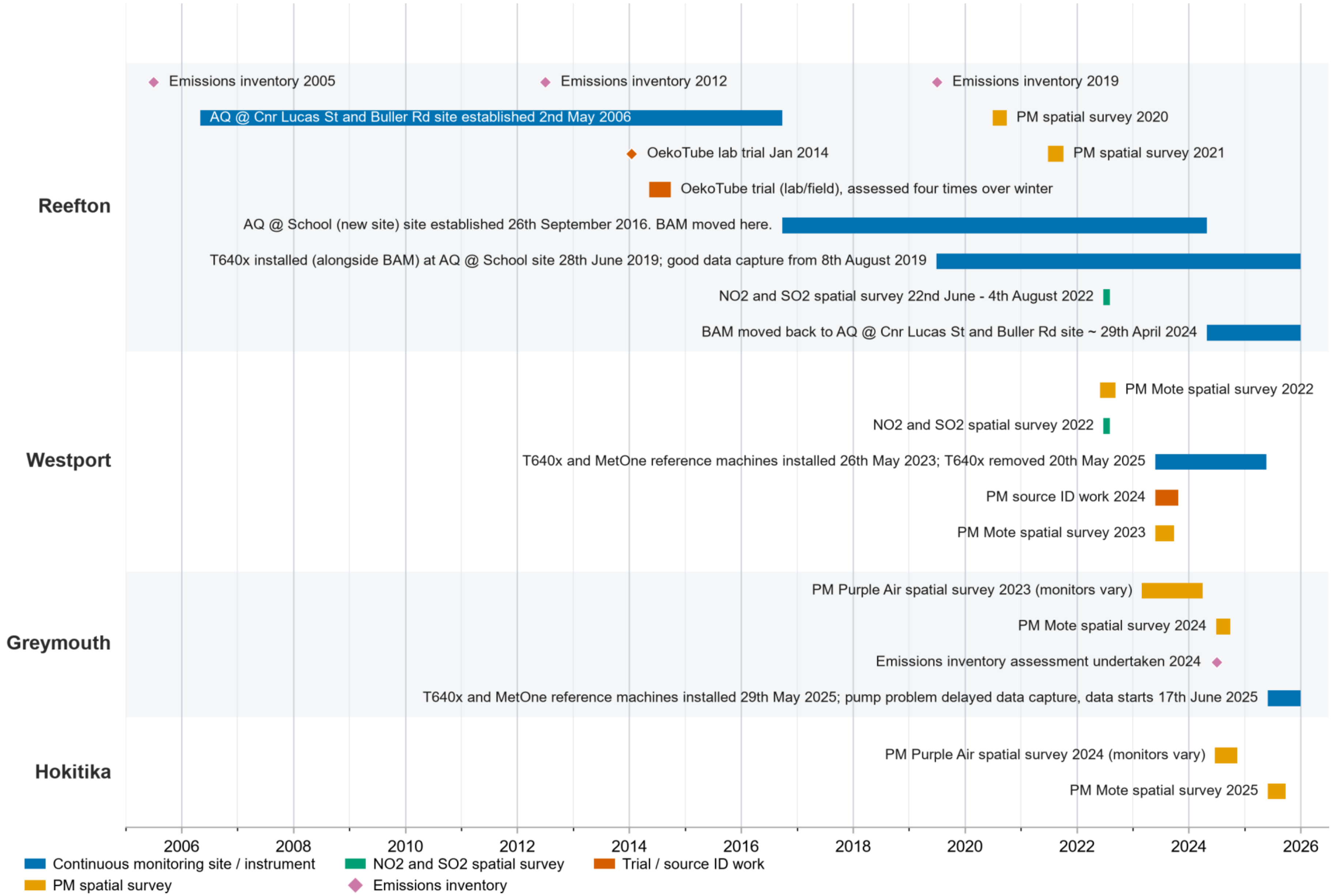

Figure 5. Air quality monitoring undertaken by WCRC at West Coast towns, 2005 to 2025.

1.3. Initial West Coast monitoring prior to 2004

A previous State of the Environment (SOE) report was produced in 2004 detailing monitoring work undertaken during 2001-2003. Over 2001-2003 winters five West Coast towns were monitored for air quality – Greymouth, Runanga, Reefton, Westport and Hokitika. PM_{10} sampling was undertaken during winter months in Greymouth 2001, Westport 2002 and Reefton 2003. 1 day in 3 sampling was carried out using a hi-vol sampler. Continuous SO_2 was monitored in Greymouth in winter 2001 and Reefton in winter 2003. Monthly average (passive) SO_2 and BTEX was measured in all five towns over the three winters sampled.

Westport and Reefton had similar concentrations of PM_{10}, with three and four samples (respectively) above national guidelines. PM_{10} concentrations in Greymouth were much lower with no exceedance of guidelines. No PM was monitored in Hokitika or Runanga however concentrations for Hokitika were thought likely to be intermediate between those measured in Greymouth and in Westport, and in Runanga concentrations were thought likely to be marginally higher than those measured in Greymouth (Stevenson, Hally, Noonan, & James, 2004).

Measured sulphur dioxide concentrations were low in Greymouth, Hokitika and Runanga. Westport and Reefton had similar or higher concentrations but no exceedance of guidelines. No adverse health effects were anticipated from the measured concentrations of sulphur dioxide.

Benzene concentrations were well below the guideline and any risk to human health was considered negligible.

Air pollution in West Coast towns in winter results predominantly from domestic solid fuel burners. Such pollution is strongly affected by meteorological conditions. The 2004 State of the Environment report found that wind speeds in Reefton are generally very low contributing to the formation of temperature inversions during cold winter weather, with light winds and clear skies. These inversions form when air near the ground becomes colder than the air above it, rather than warmer. Because cold air is denser than warm air, the layer becomes stable — turbulence and vertical motion are suppressed. On these nights the warm smoky air from chimneys cools quickly as it rises, both by expanding and by mixing with the cold air around it. Because the surrounding air becomes warmer with height rather than colder, the plume soon reaches a level where it is no longer warmer than its surroundings. There it stops rising and spreads out sideways, forming the shallow smoke layer often seen over the town on calm winter evenings.

Westport generally had the highest wind speeds and lowest frequency of calms compared with Reefton and Greymouth but showed the highest levels of pollution. The prevailing wind in Westport is a light southerly to east-south-easterly, which blows along the long axis of the town. This gives the longest distance of wind travel over built-up areas from which emissions can be accumulated, and this was thought to be a likely factor in the high concentrations found (Stevenson, Hally, Noonan, & James, 2004).

A number of recommendations were made in this 2004 State of the Environment report and many of these have been considered in the design of the more recent monitoring programmes.

Following the earlier work, it was recommended that further analysis of air quality data should include comparison to meteorological factors as this was very limited in the 2004 SOE report. Some assumptions were made based on predominant wind directions and wind speed information however no direct comparisons were carried out with data.

Monitoring data from work done in recent years has been analysed in conjunction with relevant meteorological data which has helped gain a better understanding of the drivers of air quality in Reefton, Westport, Greymouth and Hokitika, especially when source apportionment information is also available.

Figure 6. Air quality monitoring equipment at the Reefton school pool site, 2003.

2. Reefton

2.1. Background

Reefton is a small sub-alpine town on the West Coast which, due to geographic, climatic and anthropogenic factors, experiences intermittent poor air quality over the winter months. The town is surrounded by hills on three sides, restricting the movement of air. Wind speeds tend to be low and predominately blow across the town from east to west, which also aligns with the main built-up areas of the town. These low wind speeds, combined with cold temperatures over winter, lead to the formation of inversion layers which trap airborne particulates from domestic heating sources. Multi-fuel fireplaces are the most common form of heating in Reefton homes with 62% of homes using this as the main source of heating their living areas (2019 emissions inventory). Both wood and coal are commonly used as fuel sources.

Reefton is the only gazetted airshed on the West Coast. There is a long history of monitoring for PM_{10} with $PM_{2.5}$ monitoring being added in more recent times.

Historically, two locations had been used for air quality monitoring in Reefton – the Reefton Bowling Club and the Reefton Primary School, which is a similar location to the Reefton AQ @ Cnr Lucas Street and Buller Rd site (Figure 7). Early monitoring for smoke and sulphur dioxide was undertaken at the Bowling Club site in 1995 and this site was used, along with the Reefton Primary School site, for passive sulphur dioxide and BTEX monitoring over the winters of 2001 – 2003. The addition of the Reefton Area School site helped to assess spatial variability across the town. As well as the SO_2 and BTEX sampling, PM_{10} was monitored at the Reefton Primary School by hi-vol sampler over winter 2003. Four days recorded PM_{10} over 50 µg/m^3.

In this early work SO_2 in Reefton was found to be lower than in Westport but higher than Greymouth, Hokitika or Runanga. Levels of SO_2 and BTEX were generally lower at the bowling club site, which is the more southern of the two sites in the town. Results for SO_2 were generally higher in winter 2003 than in 2001 and 2002, so it is likely that, in this early work, PM was sampled in the winter most likely to have had higher results out of the survey period and at the location more likely to record higher PM_{10} (Stevenson, Hally, Noonan, & James, 2004).

Reefton typically has low wind speeds distributed around the compass (**Error! Reference source not found.**). P redominant winds come from the north-westerly and south-easterly directions which line up with the Inangahua Valley. This feature may be channelling winds across the town. Due to the central location of sites used for monitoring and the somewhat similar distribution of frequencies of wind directions it was thought unlikely that substantially higher long-term average concentrations of pollutants would be measured at other sites around the town.

The prevalence of low wind speeds was determined to be a likely factor contributing to the relatively high PM_{10} concentrations seen in Reefton in this early survey work.

1 Reefton Bowling Club

Historic monitoring site

Instruments Passive sampler (SO2, BTEX)

1995	Smoke and SO2
Jun-Aug 2002	Passive SO2 and BTEX
Jun-Aug 2003	Passive SO2 and BTEX

2 Reefton AQ @ Cnr Lucas St and Buller Rd

Original site

Also the historic Reefton Primary School site. Was itself once named "Reefton Air Quality @ School".

Instruments Hi-vol (PM), passive sampler (SO2, BTEX), API 100 SO2 analyser, BAM

Jun-Aug 2001, 2002, 2003	Passive SO2 and BTEX
Jun-Aug 2003	PM10 by hi-vol, and instrumental SO2
May 2006 - Sept 2016	BAM
May 2024 - present	BAM, returned to this site

3 Reefton Air Quality @ School

New site

The Area School site, the airshed's primary site since 2016.

Instruments BAM, T640x, second T640x

Sept 2016 - May 2024	BAM
June 2019 - present	T640x
June 2026 - present	Second T640x

Figure 7. Locations of Reefton air quality monitoring initiatives, 1995-2026.

2.2. Reefton spatial surveys

Spatial surveys of PM in the Reefton airshed were undertaken over winter 2020 and winter 2021 to understand the spatial distribution of PM over the airshed in winter and how PM varied between the original (Reefton AQ @ Cnr Lucas Street and Buller Rd) site and the Area School site. Following the site relocation in 2016, considerably fewer exceedances of PM_{10} were recorded in Reefton. The assumption was that this change in PM recorded was due to the change in site location rather than any improving trend in PM_{10}. Analysis of PM data against meteorological data indicated some improvement in PM_{10} at the original site in the period 2014 to 2016. The break in the BAM record when the instrument was relocated prevented that analysis being carried further, so it is not known whether the improvement continued (Wilton E., 2013). Trend analysis was assessed for the new Area School site for data from 2017 To 2021 (factoring in meteorology) which indicated no significant improving trend in PM over that timeframe.

The spatial surveys undertaken in Reefton showed that although average PM was similar between the two sites, maximum PM was much higher at the original Reefton AQ @ Cnr Lucas Street and Buller Rd site. This suggests, as expected, that air quality differs between the two sites, and that more exceedances of the standard are likely to be recorded at the Reefton AQ @ Cnr Lucas Street and Buller Rd site. Lucas Street is more central, whereas the Area School site sits towards the western edge of the town.

2.3. Continuous PM monitoring in Reefton

Earlier investigative monitoring work identified PM_{10} as the main concern for air quality in Reefton. Following this work, continuous ambient monitoring of PM_{10} was established at Reefton in 2006, with $PM_{2.5}$ data capture beginning in 2019. Reefton is the only gazetted air shed on the West Coast. Data collection in Reefton is undertaken in accordance with the National Environmental Standard for Air Quality and reported as part of the national air quality dataset. The original monitoring site for the Reefton airshed was located at the old school pool site on the corner of Lucas Street and Buller Road. Unfortunately, in 2016, this site was sold, and it was necessary to move our monitoring site to a different location. A new site was established at the Reefton Area School in September 2016.

In 2019 a new air quality monitor was purchased as a backup to the aging BAM instrument. This new T640x monitor can measure both PM_{10} and $PM_{2.5}$ so allowed the establishment of a $PM_{2.5}$ dataset in Reefton from 2019. From 2019-2024 both the BAM and T640x collected data at the Reefton Area School site. A co-location study was undertaken over winter 2021 to determine correction factors for the BAM and T640x to allow these instruments to be operated in different locations. For the co-location work MetOne E-SEQ-FRM reference machines (measuring PM_{10} and $PM_{2.5}$) were run alongside the BAM and T640x at the Area School site. Following this co-location work and landowner approval, the BAM was moved back to the original site on the corner of Lucas Street and Buller Road for the start of winter 2024. The Area School site is the primary monitoring site for Reefton currently, with the Reefton AQ @ Cnr Lucas Street and Buller Rd site providing additional information on conditions in the airshed. Exceedances of the NESAQ recorded at either site are reported to the public.

Continuous monitoring of PM_{10} has shown that Reefton has good air quality most of the time but emissions from domestic heating can cause exceedances of the national standard over the winter months (Figure 8).

Figure 8 shows daily average PM_{10} from 2006 – 2025 at the original monitoring site. Seasonal differences in air quality in Reefton were apparent, for most of the year the daily average PM_{10} is below the national standard (indicated by the red line) but over the winter months there are periodic exceedances of the 50 µg/m^3 daily average standard.

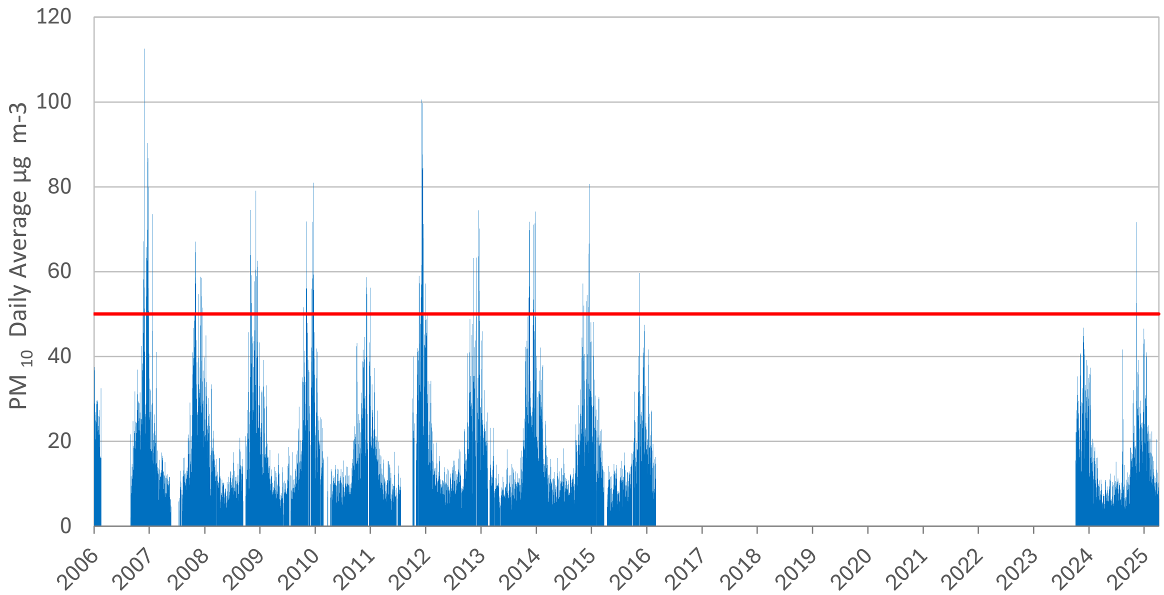

Figure 8. PM_{10} daily average data for Reefton AQ @ Cnr Lucas St and Buller Rd 2006-2025. Note the gap when monitoring was suspended at this site due to the sale of property and relocation of equipment. Red line indicates the NESAQ PM_{10} daily average standard.

Climate and geography exacerbate poorer air quality in the winter months when cold temperatures and reduced air flow cause an inversion layer to form, restricting the movement of polluted air. Figure 9 shows that higher PM_{10} was associated with low wind speeds, indicating local emissions as the main source of PM with some elevated PM_{10} associated with stronger south-easterly and north–westerly winds.

This direction lines up with the Inangahua Valley, which channels wind, and is likely to be transporting pollutants across the town. Figure 10 shows that this association of higher PM with lower wind speed is consistent across the winter months, June to August, with PM generally improving in September. Comparing long-term PM_{10} data with meteorological data has helped to validate some of the assumptions from earlier monitoring in Reefton.

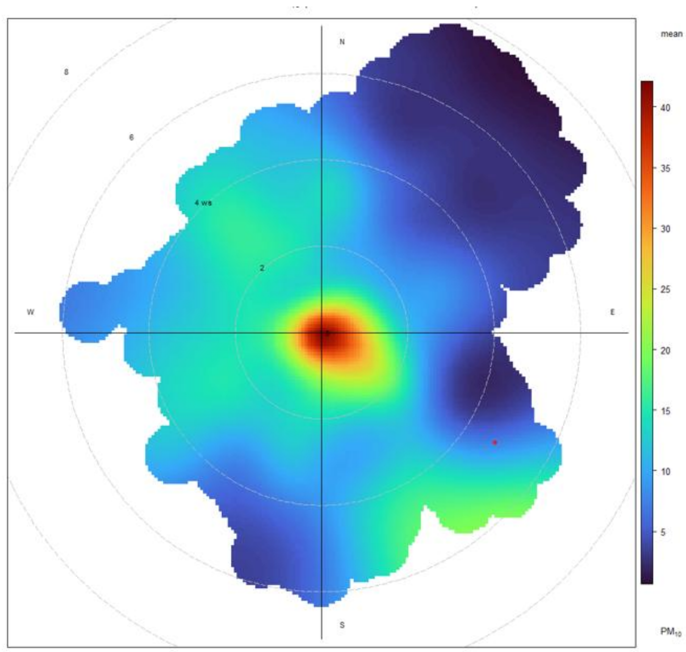

Figure 9. Polar plot showing PM_{10} measured at the Cnr Lucas Street and Buller Rd site compared to wind speed and direction June - Sept 2006 - 2025. Wind speed shown in increments of 2m/s.

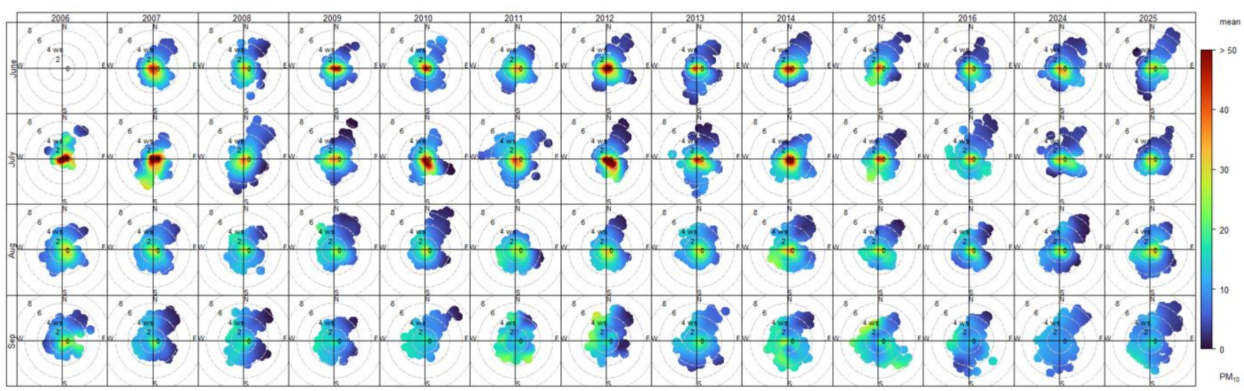

Figure 10. Polar plots for Reefton AQ @ Cnr Lucas St and Buller Rd site 2006 - 2025 showing PM_{10} associated with wind speed and direction by month (June – September). Note gap when machine operating at Area School site was absent. Wind speed shown in increments of 2m/s.

Figure 11 demonstrates a typical pattern associated with domestic home heating as the main source of PM over winter, where increases in PM are seen in the morning and evening when people are stoking up their fires. Comparative graphs are presented for winter months and for the months outside of winter (Figure 12), using the same scales, to show the marked increase in PM_{10} and $PM_{2.5}$ from June to August when colder conditions lead to increased burning for home heating and subsequently increased particulate emissions (Figure 15). Figure 13 and Figure 14 show hourly PM_{10} data at the original Cnr Lucas Street and Buller Rd site, demonstrating a similar trend between the two sites. Both the original site and newer site, show higher PM in the morning and evening regardless of wind direction (Figure 16).

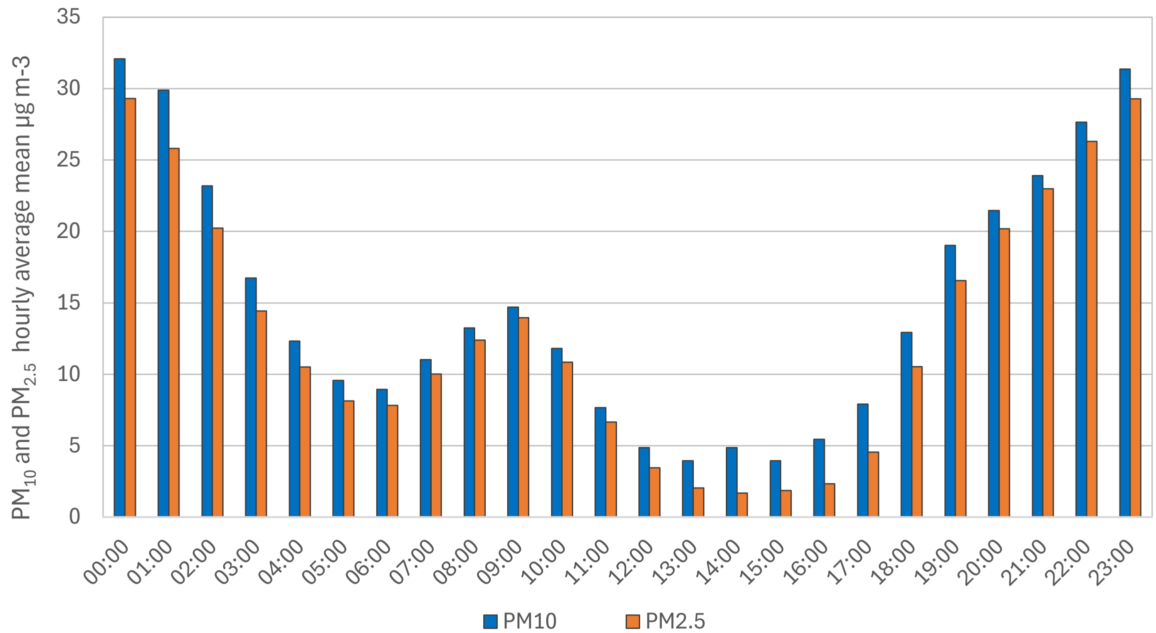

Figure 11. Reefton AQ @ School PM_{10} and $PM_{2.5}$ means of hourly averages for each hour of the day. Data from within the winter months only (Jun-Aug). 2019 – 2025.

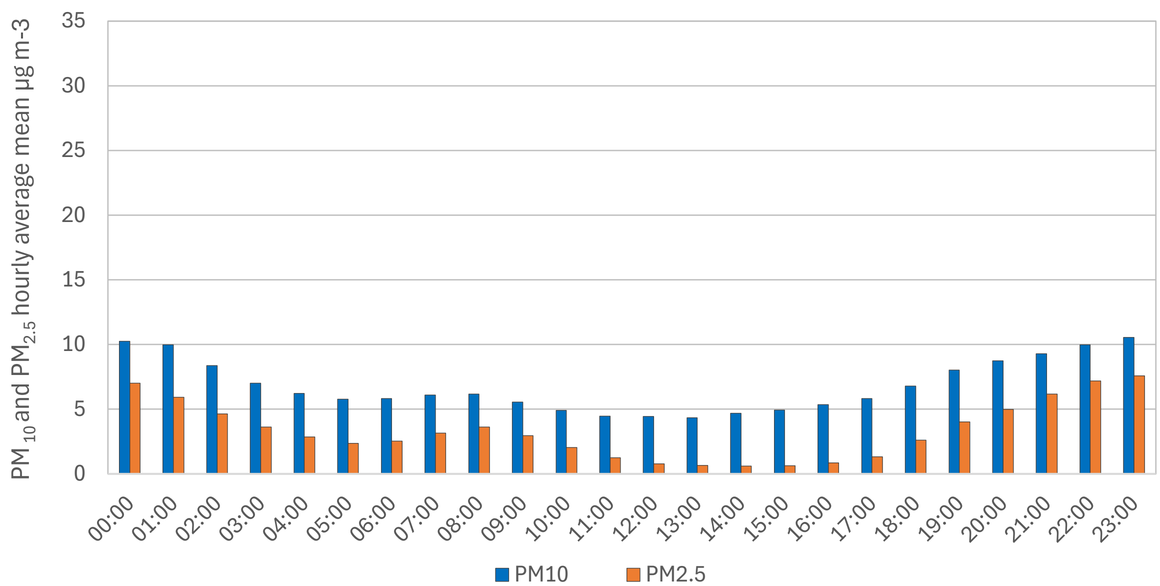

Figure 12. Reefton AQ @ School PM_{10} and $PM_{2.5}$ means of hourly averages for each hour of the day. Data from outside the winter months only, Sept – May. 2019 – 2025.

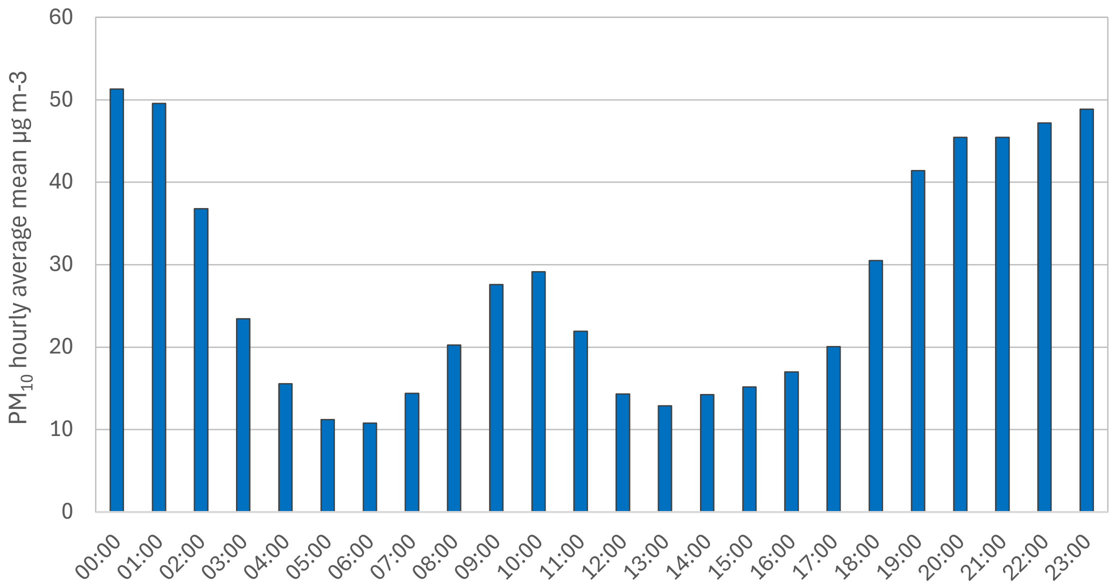

Figure 13. Reefton AQ @ Cnr Lucas St and Buller Rd PM_{10} means of hourly averages for each hour of the day. Data from winter months only (Jun – Aug). Full PM_{10} record from 2006 – 2025.

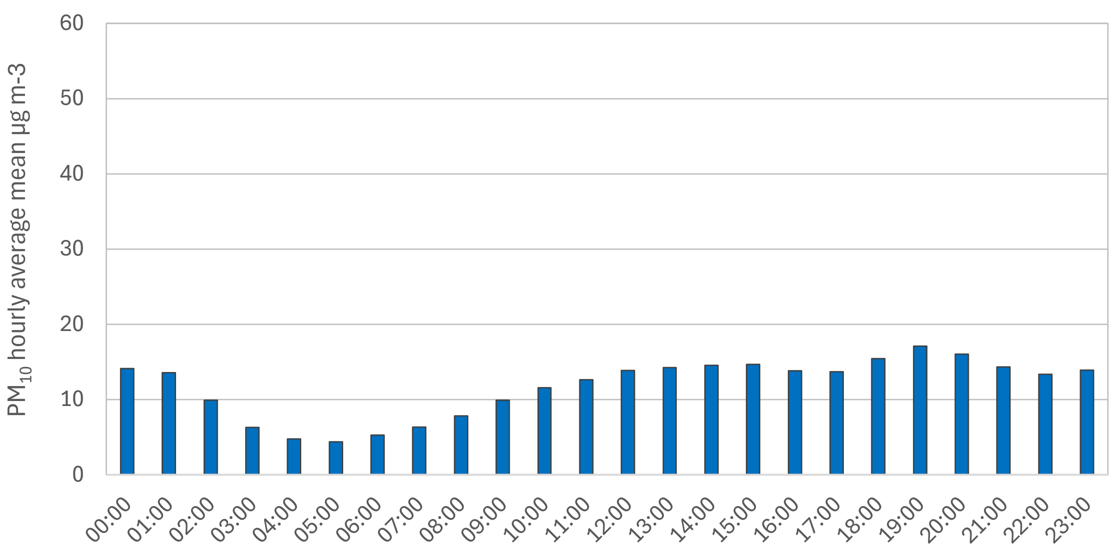

Figure 14. Reefton AQ @ Cnr Lucas St and Buller Rd PM_{10} means of hourly averages for each hour of the day. Data from outside the winter months (Sept-May). 2006 – 2025.

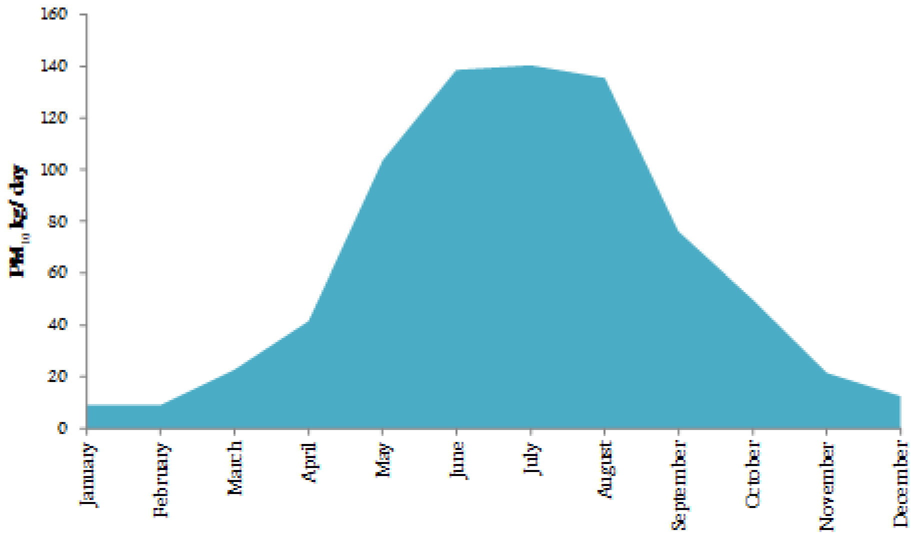

Figure 15. Monthly variations in PM_{10} emissions from domestic heating (Wilton E. , 2019).

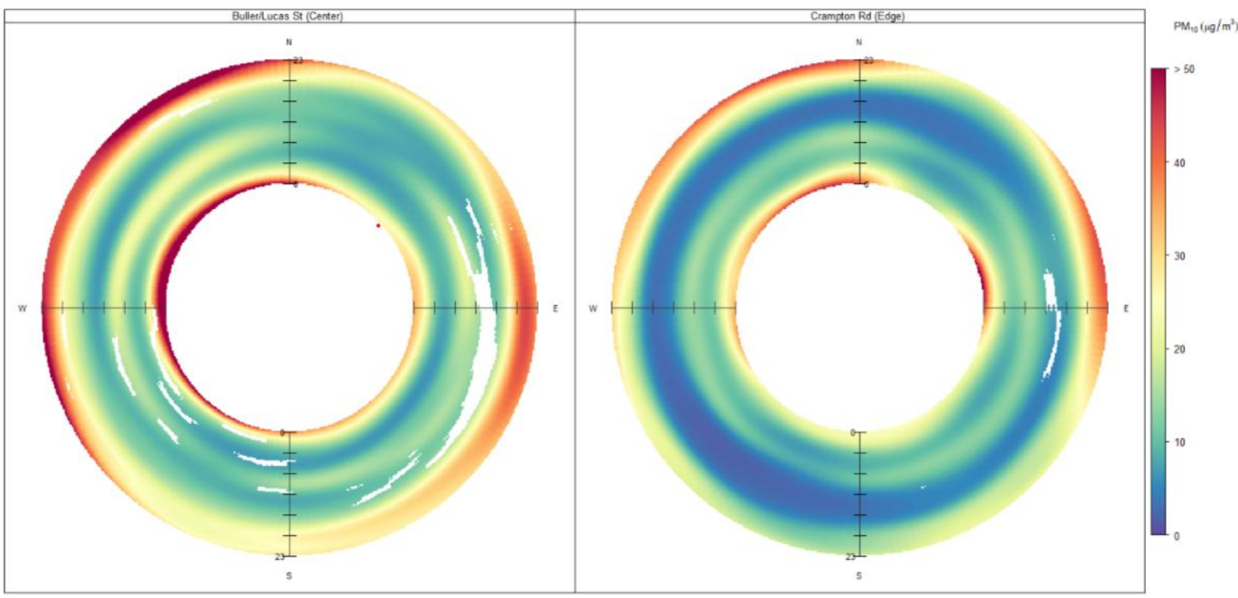

Figure 16. Annulus plot showing hourly PM_{10} compared to wind direction and time of day at the two Reefton air quality sites, Cnr Lucas Street and Buller Rd (left) and Reefton Area School (right). Time is measured from inside of circle to outside in four-hour increments i.e. morning in the middle and evening towards the outside. Note: data ranges differ between the two sites 2006 onwards for Lucas St site and 2019 onwards for Reefton Area School.

Emissions inventories were undertaken in 2005, 2012 and 2019. These demonstrated that the main source of PM_{10} in Reefton has been solid fuel burning for domestic home heating, which accounted for up to 98% of PM_{10} and $PM_{2.5}$ emissions. The emissions inventories suggested that the largest proportion of emissions from domestic home heating were from multi-fuel burners burning coal (Figure 17).

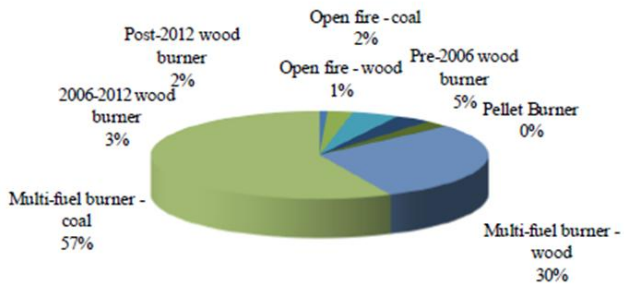

Figure 17. Relative contribution of different heating methods to average daily PM_{10} (winter average) from domestic heating in Reefton (Wilton E. , 2019).

There have been numerous exceedances of the NESAQ in Reefton since 2006, with fewer exceedances measured since the site was relocated to the Reefton Area School in 2016 (Figure 18). Under the NESAQ, there is one allowable exceedance per year, with any further exceedances leading to a breach of the NES. Due to its history of exceedances, the Reefton airshed is classified as a polluted airshed under the NES and requires 5 years of compliance (no more than one exceedance of the daily standard per year) before consideration could be made to cease monitoring in the airshed.

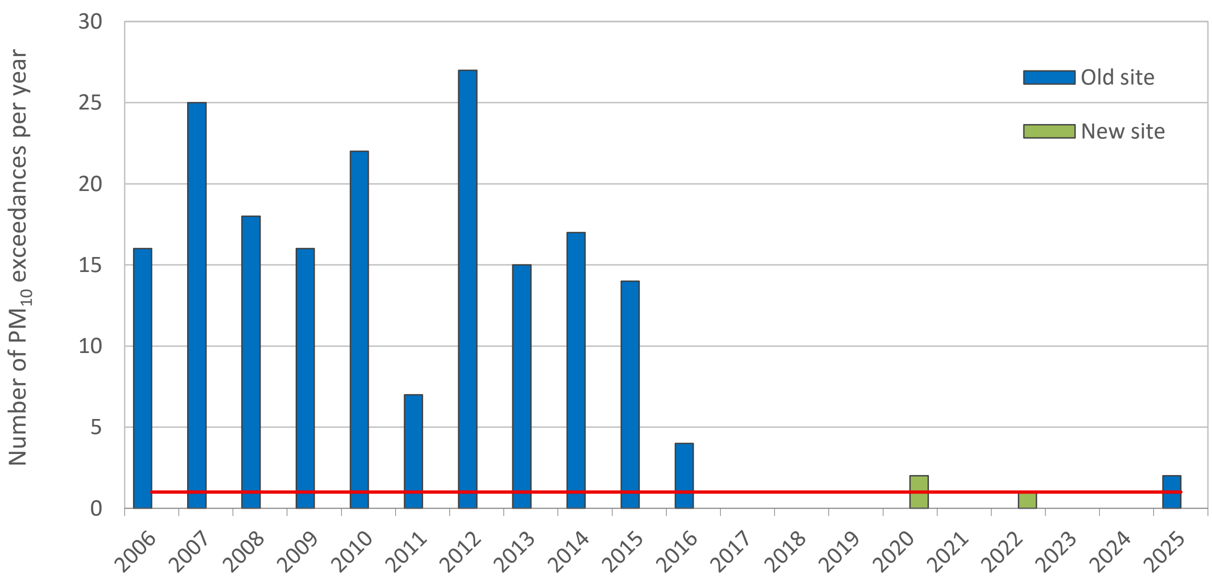

Figure 18. Exceedances of the PM_{10} daily standard measured in Reefton 2006-2025. Note primary site relocated from Cnr Lucas St and Buller Rd to the Reefton Area School September 2016. Therefore, data from 2017 onwards are from the Area School site, with exceedances from the original site shown again in 2025 after monitoring was re-instated here. Red line indicates NESAQ PM_{10} daily average standard.

The Reefton air quality site was relocated in 2016 due to the sale of the original site. Unfortunately, due to timeframes and resources, co-location monitoring between the old and new sites was not possible at the time. There were challenges to finding suitable locations for permanent air quality monitoring sites such as the requirement for mains power and a secure site. The new site location at the Reefton Area School was determined to be the best available option at the time, however it was uncertain what difference there may be in the air quality between the sites.

PM_{10} was found to be much lower at the new site (Figure 19), with a breach of the NES only recorded in one winter of monitoring so far (Figure 18).

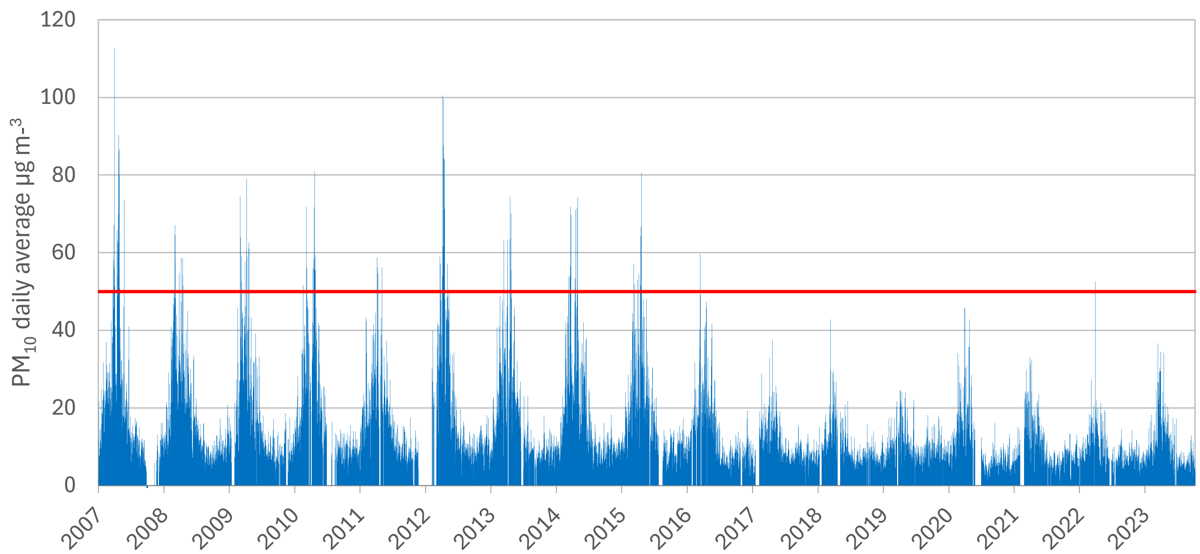

Figure 19. BAM PM_{10} daily average data record showing step down in data when instrument moved from the corner of Lucas St and Buller Rd to the Reefton Area School site in 2016.

A trend assessment was undertaken in 2013 to investigate whether there was any significant improving trend in PM_{10} in Reefton, at the original site location. Data was analysed in association with meteorological data to identify meteorological conditions with the potential for higher PM_{10} concentrations. The meteorological conditions with the potential for the highest PM_{10} concentrations in Reefton were:

- 24-hour average wind speed less than 0.9 ms-1.
- 24-hour average temperature less than 4.5 degrees.
- Difference between the maximum hourly temperature on the sample day and the preceding day of more than 10.6 degrees.

When meteorological conditions were accounted for, there was no significant trend in PM_{10} (Wilton E. , 2013).

In 2019 a new T640x air quality monitor was purchased as a back-up for the ageing BAM. A dual channel monitor was chosen which enabled collection of both PM_{10} and $PM_{2.5}$ data, allowing for continuation of the PM_{10} record and establishment of $PM_{2.5}$ monitoring for Reefton.

Initially the T640x PM_{10} data was quite different to the BAM and it was necessary to undertake a co-location study with reference instruments to establish correction factors which then allowed for comparison of data between these instruments.

PM_{10} data from the Area School site has mostly been below guidelines (Figure 20), however the $PM_{2.5}$ data collected has shown numerous exceedances of the World Health Organisation guidelines for $PM_{2.5}$ (Figure 21). There is no current New Zealand standard for $PM_{2.5}$ however proposed changes to the NESAQ were released in 2020 and one of the proposed changes is to move from a PM_{10} standard to a $PM_{2.5}$ standard so this may be an area where more work could be required in future.

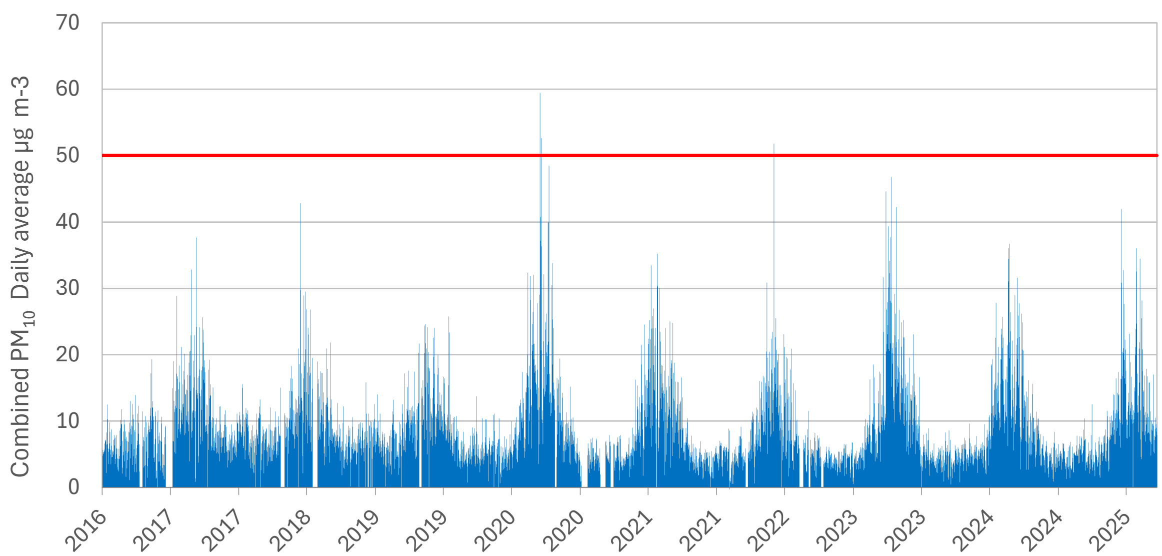

Figure 20. Reefton Air Quality @ School PM_{10} daily average. This graph combines BAM PM_{10} data from 2016-2019 with T640x PM_{10} data from 2019 onwards as the T640x only started monitoring in 2019. The BAM was relocated to this site prior to the T640x being purchased. Red line shows current NESAQ PM_{10} 24-hour standard.

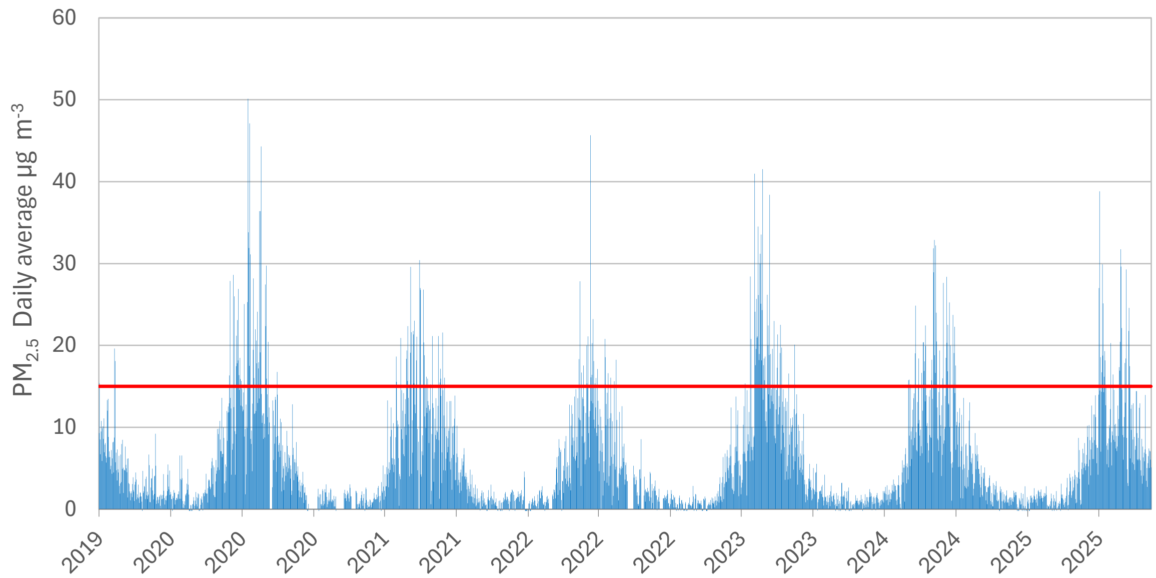

Figure 21. Reefton Air Quality @ School $PM_{2.5}$ daily average. 2019 – 2025. Red line shows the WHO 24-hour average air quality guideline.

2.4. PM spatial survey work

Spatial PM surveys were undertaken in Reefton to help understand the variation in PM levels across the town over winter months and provide data to support the assumption that 'improved' PM measured at the Reefton Area School site was a result of the change in monitoring location rather than an overall improvement in air quality in the town.

An initial spatial survey was undertaken in Reefton over winter 2020 by NIWA. 18 ODIN units were located around the town, however data capture was sporadic due to insufficient solar power so results of the study were limited.

A subsequent spatial survey was undertaken by Mote over winter 2021, using 15 dustmote and minimote devices, deployed in Reefton between 25 June and 6 October 2021. Data capture over this survey period was much more successful at 94%.

The study found that while there was day to day variation in PM concentrations across the town, overall concentrations of particulate matter were reasonably consistent throughout central Reefton with higher concentrations typically measured near the centre of town and concentrations decreasing towards the edges of the town (Baynham P. , 2021).

Comparing meteorological data from winter 2021 to several previous years showed similar conditions were present and indicated that 2021 winter was generally representative of a normal winter in Reefton (Baynham P. , 2021).

This provided support for the assumption that the differences seen in air quality between the original Lucas Street site and the newer Area School sites was not related to an improving trend in air quality in Reefton but rather just spatial variation in PM across the town.

Although average $PM_{2.5}$ was similar between the two sites, maximum $PM_{2.5}$ was higher around the original site (Figure 22). This may indicate the potential for more exceedances to be measured at the site on the corner of Lucas Street and Buller Road.

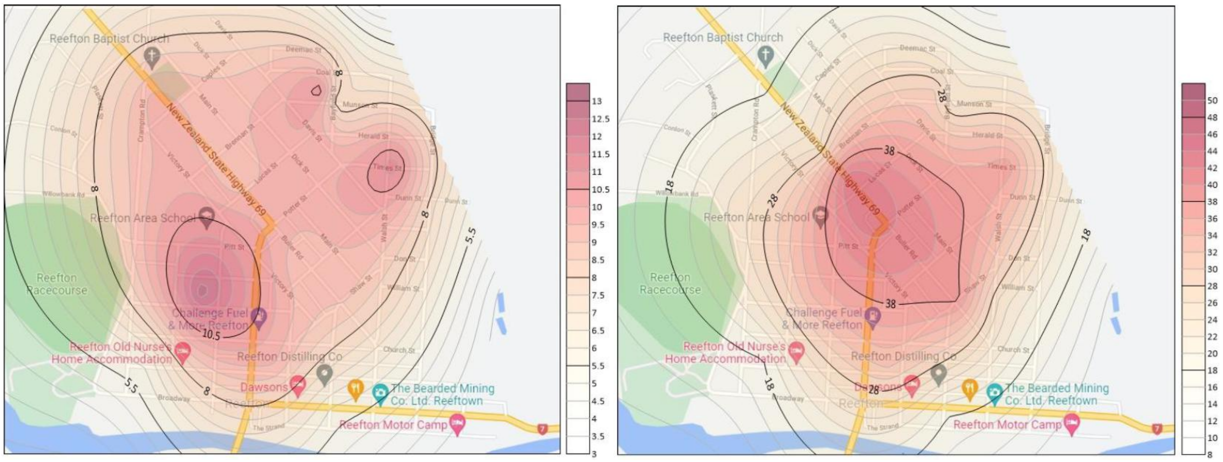

Figure 22. Reefton 2021 daily average $PM_{2.5}$ (left) and $PM_{2.5}$ daily maximums (right) from spatial survey undertaken by Mote Ltd. 15 July – 6 October 2021 (Baynham P. , 2021).

An updated trend assessment was carried out in 2021 to look at whether lower numbers of exceedances measured at the Area School site since 2017 may have been related to an improving trend of PM in Reefton. Analysis of PM data adjusted for the impacts of meteorology showed no improving trend for PM from 2017 – 2021. The highest pollution potential days were found to relate to low wind speeds, specifically 24 – hour wind speed less than 0.74m/s. Analysis was also updated for the Lucas Street site to cover the few years (2014-2016) prior to the site relocation that were not assessed in the 2013 report. This showed there may have been some improvement in PM between 2014 – 2016 however, due to the relocation of the monitoring site this trend was unable to be assessed further (Wilton E. , 2021).

In 2024, following the co-location work with reference machines (and spatial surveys showing variation of air quality between the old and new sites), the BAM PM_{10} monitor was moved back to the original location at the corner of Lucas Street and Buller Road.

Collecting PM data at the old and new site now will allow for comparison between these sites with data being able to be compared to the national standard (as opposed to investigative instruments) and will assist with re-evaluating trends in future. To date, instruments have operated at both sites over two winters with a breach of the NES being recorded at the original Lucas Street site in winter 2025. No exceedance has been recorded at the Area School site in winter 2024 or 2025.

Figure 23. BAM, MetOne reference samplers and T640x at the Reefton AQ @ Area School site, 2021.

2.1. Sulphur dioxide and nitrogen dioxide monitoring

A recommendation from the 2004 State of the Environment report was to undertake further monitoring of SO_2 in Reefton, at the Area School site. In winter 2022 a survey of sulphur dioxide and nitrogen dioxide was undertaken at 15 sites around Reefton, with levels of both gases below health guidelines.

NO_2 was chosen for inclusion in this survey as, like SO_2, it can also be a product of the combustion of fossil fuels and long -term exposure has been associated with increased cancer risk. Figure 24 to Figure 27 show the spatial distribution of SO_2 and NO_2 at 15 sites around the Reefton township.

SO_2 concentrations were higher around central parts of the town and lower towards the edges of town, generally highest along the main road through Reefton – Buller Rd or SH6.

Nitrogen dioxide showed a similar pattern to sulphur dioxide and may be related to traffic emissions, however maximum $PM_{2.5}$ was highest in central parts of the town so there could be a combination of sources contributing to the overall concentrations. Emissions inventories undertaken for Reefton have attributed most SO_2 to domestic heating with somewhat similar contributions to NO_2 from home heating and traffic sources (Wilton E. , 2005), (Wilton E. , 2012), (Wilton E. , 2019).

Figure 24. Map showing passive SO_2 concentrations from 22 June-14 July 2022 in Reefton. Scale of increasing concentrations shown by light to dark dot colouration.

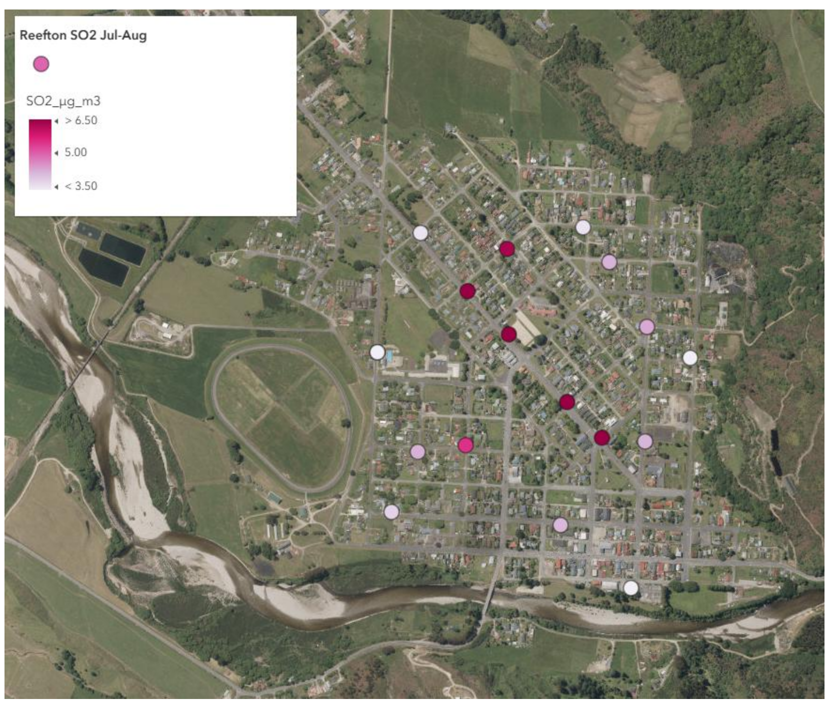

Figure 25. Map showing passive SO_2 concentrations from 14 July-04 Aug 2022 in Reefton. Scale of increasing concentrations shown by light to dark dot colouration.

Figure 26. Map showing passive NO_2 concentrations from 22 June- 14 July 2022 in Reefton. Scale of increasing concentrations shown by light to dark dot colouration.

Figure 27. Map showing passive NO_2 concentrations from 14 July-04 August 2022 in Reefton. Scale of increasing concentrations shown by light to dark dot colouration.

2.5. Engagement and policy work

A community working group was set up in Reefton in 2012 to investigate options for improving the Reefton airshed. The group was established in response to the ongoing breaches of the NES during the winter months. Council and community members worked together to provide education on the air quality issue in the Reefton airshed and explored options for methods to reduce particulate emissions. One option tested was an electrostatic precipitation device. The group undertook field and lab trials of this device, which can be installed into existing chimneys to reduce particulate emissions (Applied Research Services Limited, 2014). The group was in place until 2014 by which time there was talk of a change to the National Standard to one based on $PM_{2.5}$. Work regarding management options for the Reefton airshed was put on hold awaiting changes to national direction in air quality.

2.6. Reefton summary

In summary, recent work carried out in the Reefton airshed has shown that the main driver of PM concentrations is emissions from domestic home heating and low wind speeds, typical of Reefton, are unable to disperse air pollutants well. Reefton generally has very low wind speeds, lower than Westport, Greymouth and Hokitika. Comparing to meteorological data has indicated that higher levels of airborne particulates are locally generated rather than carried from elsewhere (such as sea salt). Emissions from home heating, identified by emissions inventories as the main source of PM in Reefton, are, at times, trapped by inversion layers and unable to disperse quickly.

No source apportionment work has been undertaken for Reefton, however this work could be carried out on filters from reference machines used for co-location work In Reefton over winter 2021. Although not a high priority, this information would be useful to determine the proportion of particulate derived from home heating sources. Given Reefton's inland location, it would be expected that contributions from marine aerosols would be much lower than Westport and Greymouth.

Levels of PM recorded in Reefton have been lower in more recent years however trend assessments undertaken have so far shown no significant improving trend in Reefton air quality. The lower PM_{10} recorded at the newer Area School site is most likely attributed to the change in Reefton monitoring site in 2016, from a more central location (which historically also showed higher levels of pollutants) to a location more on the fringe of the town.

Despite fewer exceedances of the PM_{10} standard since 2016, there have been numerous exceedances of the $PM_{2.5}$ WHO guideline since this monitoring began in 2019.

Figure 28. T640x air quality monitor, Reefton AQ @ Area School.

3. Westport

3.1. Background

Some early monitoring of air quality was undertaken in Westport from 2001-2003. Monthly average sulphur dioxide and BTEX were monitored in each of these years at (or near) Hagedorn Funeral Directors, on the corner of Derby and Wakefield Street, while PM_{10} was monitored with a hi-vol sampler at this site 1 day in 3 over winter 2002. A second site, at the Buller District Council (BDC) depot on Peel Street (between Mill and Bentham Streets) was used for SO_2 and BTEX monitoring in winter 2002 to investigate spatial variability. Three exceedances of the PM_{10} national standard were recorded in Westport (compared to Reefton which recorded four in winter 2003). SO_2 and benzene (the main focus of the BTEX monitoring) were below guidelines. Of the three winters monitored for SO_2, levels were lowest in 2002 when PM_{10} sampling was also carried out. Due to this, it was suggested that PM levels could be higher in other years compared to the 2002 results (Stevenson, Hally, Noonan, & James, 2004).

One of the recommendations to come out of the 2004 SOE report was that further winter monitoring for PM_{10} in Westport should be undertaken at a location more towards the northern end of the town as the predominant wind blows across the town from the south or south-east and may carry more accumulated particulates to the northern part of town compared to the Derby Street site, which is only about half way across the town.

It was also suggested that further passive sampling for SO_2 be undertaken in Westport at the Derby Street location as well as the proposed more northern PM site. The winter 2002 monitoring showed SO_2 was generally higher at the Derby Street site compared to the BDC depot, which along with the meteorological data suggested the potential for higher SO_2 and PM in more northern parts of the town.

Westport was chosen as part of the Wider West Coast monitoring programme due to having previously recorded PM_{10} exceedances along with the understanding that there was the potential for higher PM to be recorded in another part of the town due to spatial variation and the understanding of meteorology in Westport. The lower SO_2 measured in 2002 compared to the other winters monitored also indicated the potential for higher PM based on temporal variation.

3.2. Fine particulate matter spatial survey 2022

WCRC engaged Mote Ltd to undertake a spatial survey of $PM_{2.5}$ in Westport over winter 2022 to investigate variation across the town. 15 minimote units were installed around Westport from 31 May to 8 September 2022.

Generally, concentrations of $PM_{2.5}$ were higher in central areas and lower towards the edges of town. Over the period of this survey, the eight sites which recorded the highest daily average $PM_{2.5}$ concentration all occurred at sites either on or north of Brougham Street (Figure 29) with the highest concentrations seen in the north-west corner of town near the intersection of Cobden Street and Russell Street.

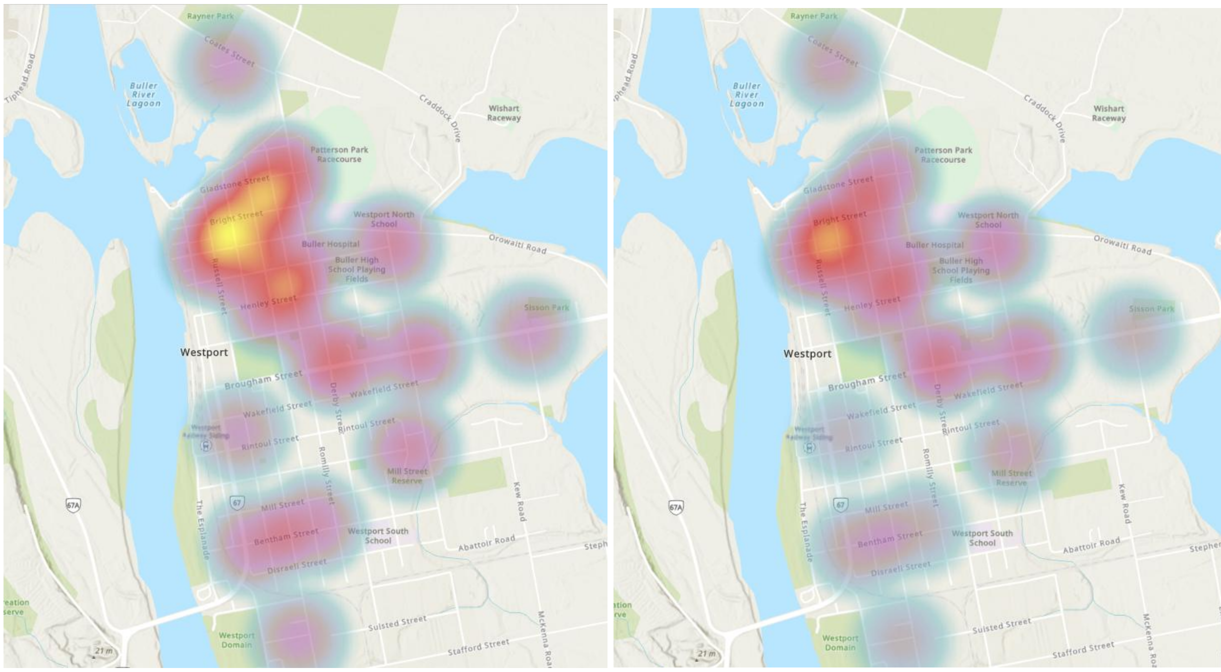

Figure 29. Westport 2022 spatial survey $PM_{2.5}$ daily average plot (left) and $PM_{2.5}$ daily maximums plot (right).

It is possible that this may be due to cold flow katabatic air coming down the Buller River which could transport emissions from the south of Westport to the north. The 2004 SOE report suggested the potential for higher PM concentrations in more northern parts of the town due to the predominant southerly winds and this was a reason for including sites to the northern extent of the town in the 2022 survey. However, the monitoring data doesn't appear to support this theory sufficiently. The northernmost site did not record the highest concentrations and when emissions for all sites were compared on the 3rd and 4th of July 2022, a period of elevated $PM_{2.5}$ concentrations across Westport, it showed that elevated concentrations generally occurred at similar times at all sites. If these elevated concentrations were due to wind direction it would be expected that there would be a lag for the more northern sites and improved air quality at the sites in the southern part of town (Baynham P. , 2022).

There could be a combination of factors contributing to elevated PM concentrations in the northern parts of town including meteorology and point source discharges (more emission sources and/or higher emissions). The lower emissions at the most northern Forbes / Coates St site could likewise be indicative of the lower density of fires in this area. The predominant southerly winds tend to be low in speed so may not disperse particulates well (Figure 30). The calm conditions associated with the southerly winds may lead to elevated concentrations generally across the town rather than causing increased concentrations from south to north as wind blows particles in a northerly direction.

The wind rose below illustrates that winds from a southerly direction were dominant over the 2022 survey. However very strong winds (>12 m/s) from northwest, northeast and southeast also occurred.

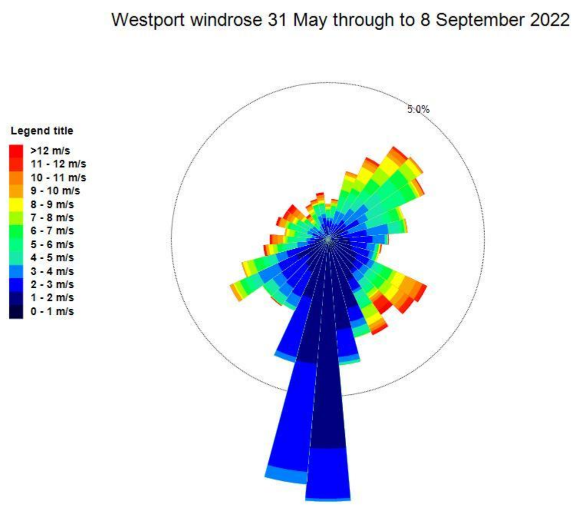

Figure 30. Wind rose for Westport 31 May to 8th September 2022 (Baynham P. , 2022).

Meteorological conditions during winter 2022 were determined to be similar to the previous four years' winters (Baynham, 2022) which suggested that winter 2022 was representative of a typical winter in Westport.

3.3. Continuous sampling of PM – comparison to 2023 survey and emissions assessments

The results of the 2022 winter survey in Westport indicated that there were areas of the town with higher levels of PM which could have the potential to exceed the national standard. Subsequently, it was decided to install a temporary continuous monitoring site at Club Buller. This site was chosen as it was in between areas which had recorded higher PM in the 2022 survey. It can be difficult to find suitable locations for air quality instruments due to requirements for mains power, security, access etc. Hence it is not always possible to locate instruments in the ideal location. The Club Buller site was the best available option identified at the time. An alternative location was investigated but that was slightly to the southwest, on Lyndhurst Street, so further away from areas of higher PM.

A Teledyne T640x optical air quality monitoring instrument, measuring PM_{10} and $PM_{2.5}$, was installed on the 26th of May 2023 and operated at the site until it was relocated to Greymouth in May 2025. In winter 2023, two MetOne E-SEQ-FRM reference machines were run alongside the T640x. These machines collect particulates on filters which are then lab analysed. The data from these machines was used to determine correction factors for the T640x data, which typically overread in New Zealand conditions. Although these instruments have USEPA Federal Equivalency Method accreditation, the data requires correction to be more accurate for monitoring in New Zealand airsheds.

No exceedances of the PM_{10} daily average standard were recorded on the T640x or the MetOne reference machine measuring PM_{10} for the duration of the monitoring (Figure 31 and Figure 32). There were eleven exceedances of the World Health Organisation daily average guidelines for $PM_{2.5}$ (Figure 33). PM_{10} and $PM_{2.5}$ both exceeded the annual WHO guideline values for 2024. The higher frequency continuous T640x data showed a typical emissions pattern for domestic home heating being a significant source, with generally higher PM_{10} and $PM_{2.5}$ seen over the winter months (Figure 32 and Figure 33).

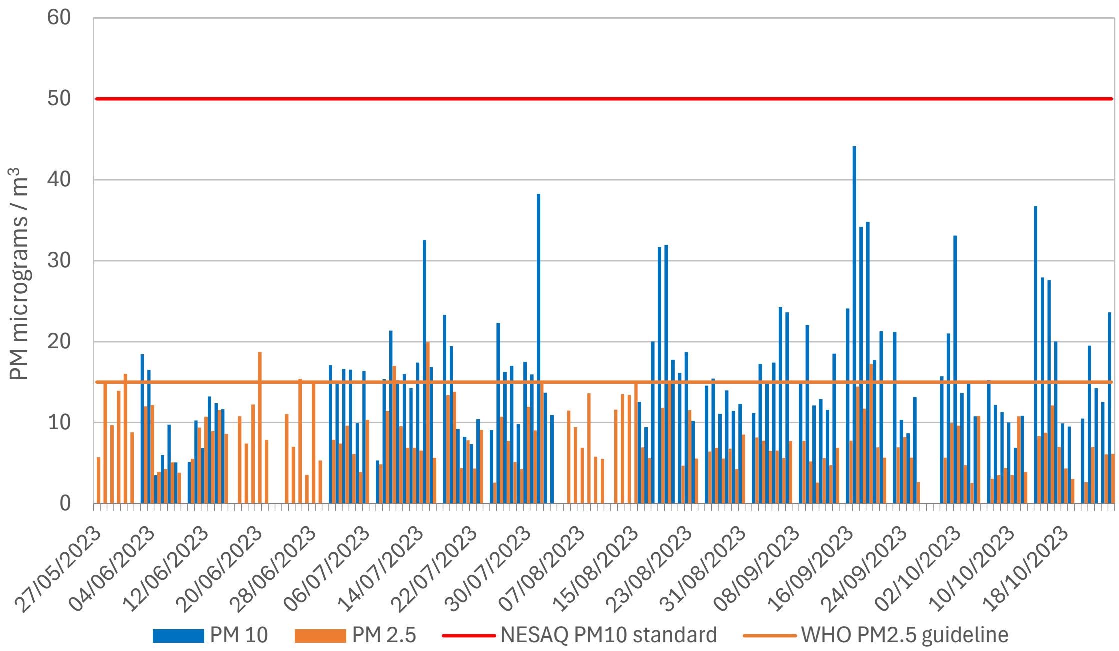

Figure 31. MetOne daily average PM_{10} and $PM_{2.5}$ for Westport winter 2023. Note there are a few gaps in the PM_{10} data due to instrument faults, $PM_{2.5}$ data is available for most of these gap periods.

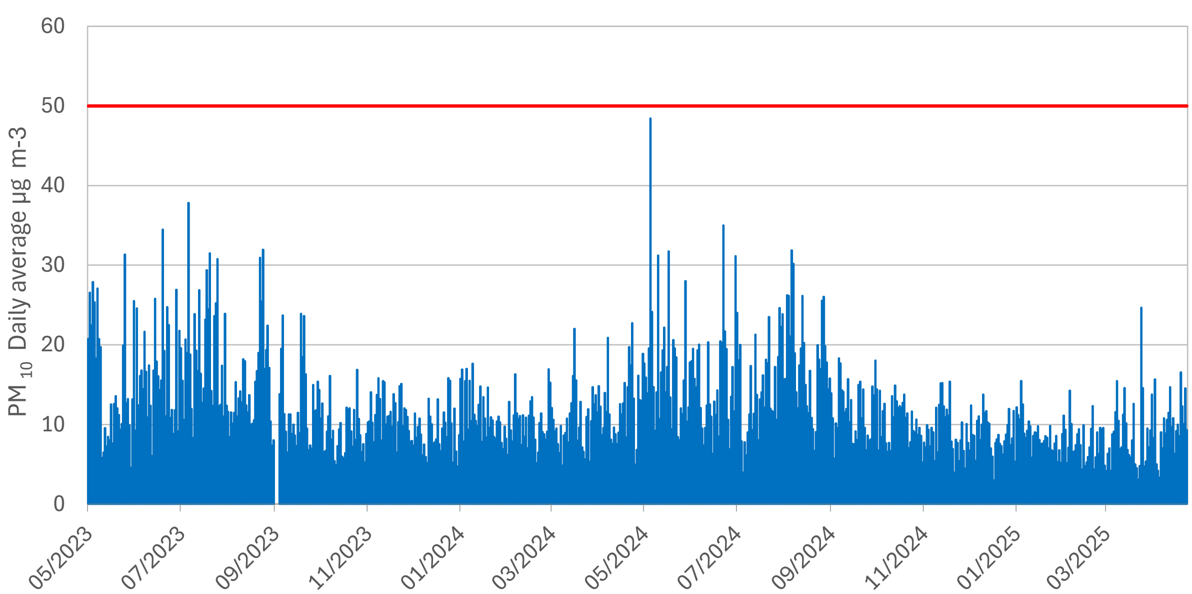

Figure 32. Westport T640x daily average PM_{10} 2023 - 2025. Red line indicates NESAQ PM_{10} daily average standard.

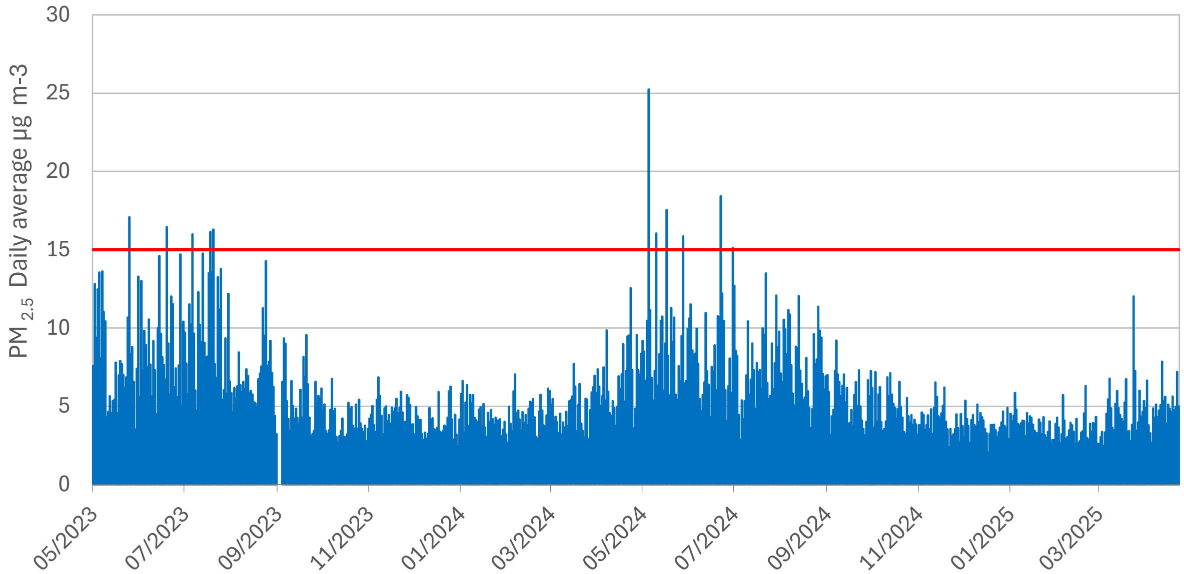

Figure 33. Westport T640x daily average $PM_{2.5}$ 2023 - 2025. Red line indicates WHO 2021 daily $PM_{2.5}$ guideline.

Hourly average data shows PM peaks in the morning and evening, which is usually when people stoke up their fires (Figure 34). Both PM_{10} and $PM_{2.5}$ are lower outside of winter, and the pattern of home heating influence is reduced (Figure 35).

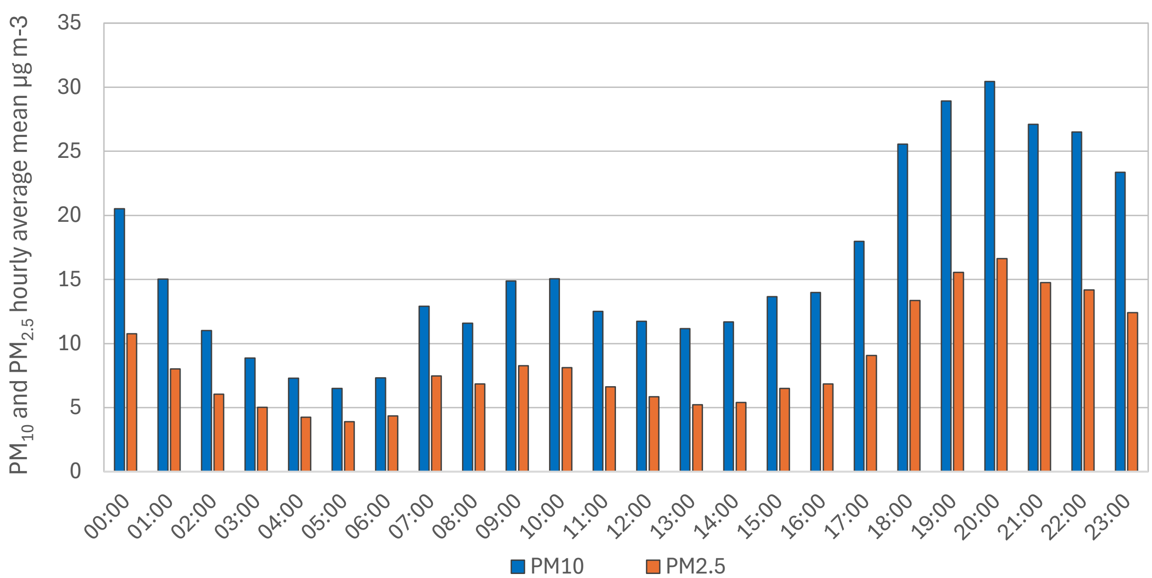

Figure 34. Westport PM_{10} and $PM_{2.5}$ mean hourly averages for winter months (June-August) 2023-2024.

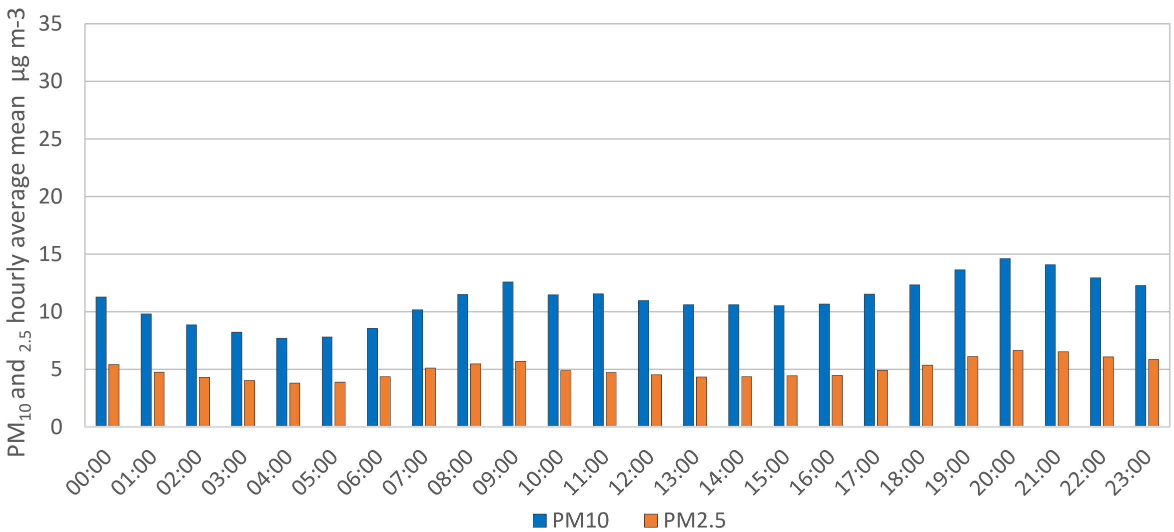

Figure 35. Westport PM_{10} and $PM_{2.5}$ mean hourly averages for non-winter months (Sept-May). 2023-2024.

Analysis of winter data from the T640x for 2023 indicated higher PM_{10} concentrations occur under low wind speeds from east and south directions with highest concentrations occurring during the evening period (Figure 36). Elevated concentrations under high wind speeds occur from the northwest which likely reflects marine aerosol contributions (Wilton & Zawar Reza, 2024), this was also seen in winter 2024 (Figure 38). Source apportionment work has shown that north-westerly winds are associated with higher contributions of sea salt (Figure 44).

Analysis of wind data associated with the T640x deployment from 2023-2025 shows that there is a slight change in predominant wind direction in Westport after winter with the predominant wind direction changing from southerly to south-westerly from September through to March (Figure 37), with a lower frequency of calm southerly's occurring outside of winter.

Due to Westport's proximity to the coast and the somewhat consistent contributions of winds from around the compass, with the exception of more southerly winds over the winter months, it may be that sea salt contributions to PM are similar across seasons but emissions from home heating, combined with a higher frequency of calm conditions, increase ambient PM_{10} and $PM_{2.5}$ over winter months.

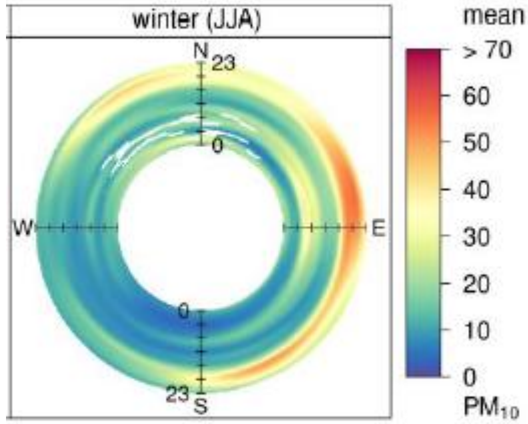

Figure 36. Plot showing PM_{10}, wind direction and time of day for winter months (June, July, August) 2023. Morning to night shown from inside of doughnut to outside (Wilton & Zawar Reza, 2024).

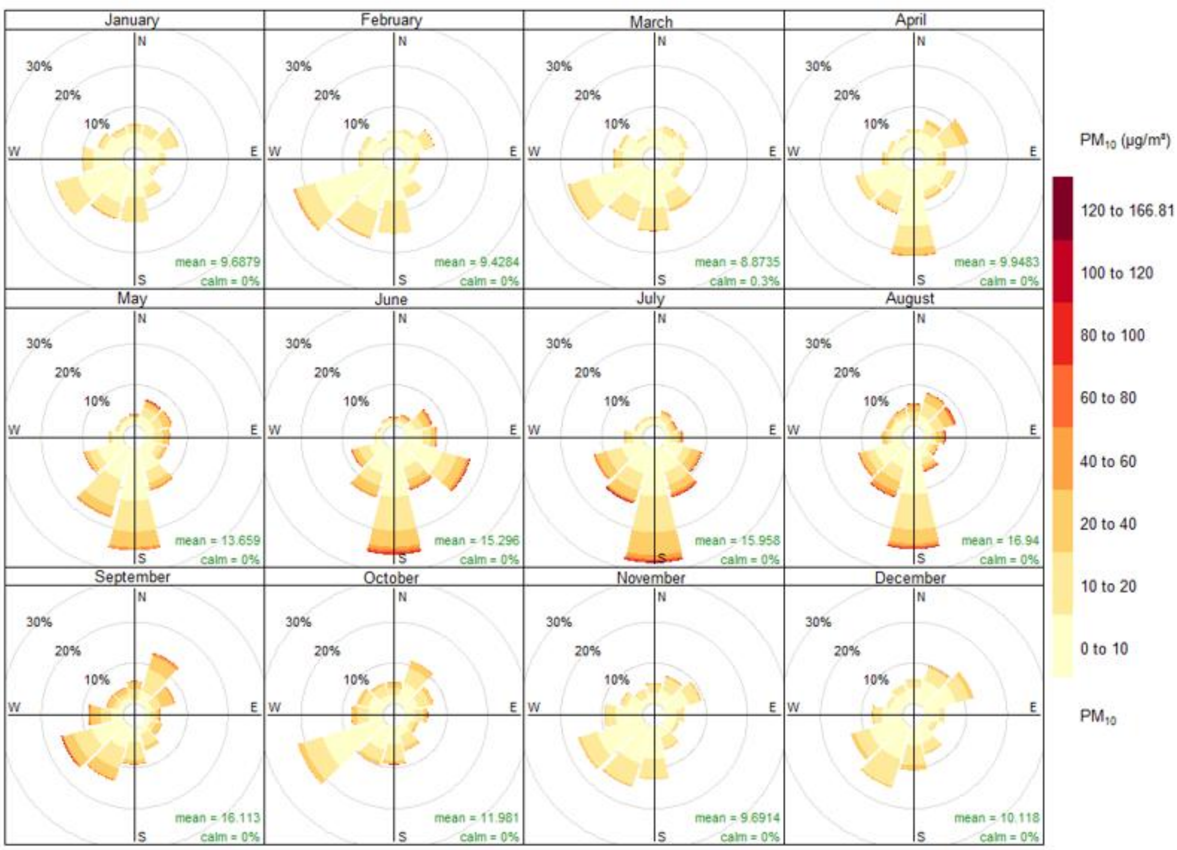

Figure 37. Westport PM_{10} compared to wind direction. May 2023 – May 2025.

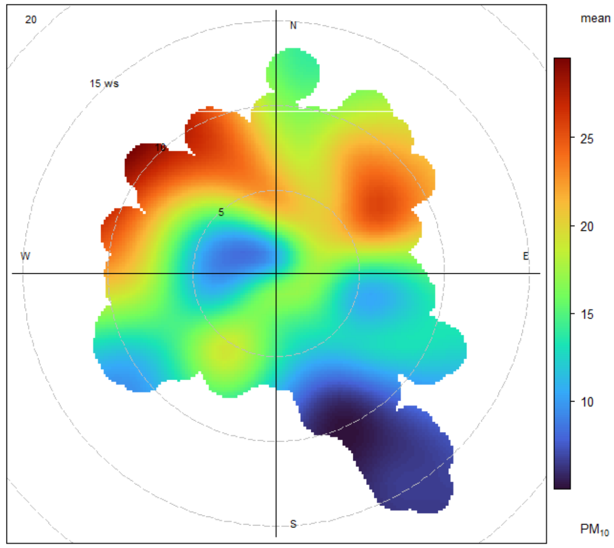

Figure 38. Polar plot showing PM_{10} associated with wind speed and direction for June - Sept 2023 and 2024 combined. Wind speed in 5m/s increments.

An emissions density assessment for Westport was undertaken in 2023 to help identify priority locations for monitoring when considered alongside the 2022 spatial monitoring data. This work assessed emissions from key sources of particulates in Westport (domestic heating, motor vehicles, commercial/industrial activities and outdoor burning) to identify possible areas of higher concentrations. This work identified domestic heating as the main contributor of $PM_{2.5}$ emissions in Westport and noted two main areas of potential higher concentrations – one in the north of the town bordered by Queen St, Derby St, Cobden St and Gladstone St and another in the southern part of town around Wakefield and Fonblanque Streets (Wilton & Zawar Reza, Air Quality Monitoring strategy for Westport, 2023). When compared to the 2022 spatial data and consideration given to appropriate site locations and meteorology, it was recommended that a location near the rugby grounds or trotting club on Derby Street would be the best option for a longer-term monitoring site. Unfortunately, due to required timeframes for establishing monitoring, a site at Club Buller had already been established before receipt of this report.

A second spatial survey was undertaken by Mote Limited over winter 2023. 17 Instruments were deployed from 25 May to 21 September. For this survey an additional two monitors were used (compared to the 2022 survey) to improve data for modelling.

Concentrations were found to be higher near the centre of the town and lower on the town boundaries (as with the 2022 survey) with highest concentrations occurring at the northern end of town and on the west side adjacent to the river (Figure 39).

The highest average and maximum 24-hour $PM_{2.5}$ concentrations in Westport were measured at a site located along Derby Street near to the Trotting Club and Rugby Club grounds. This is the same area that was recommended for a monitoring site in the $PM_{2.5}$ monitoring evaluation report (Wilton & Zawar Reza, Air Quality Monitoring strategy for Westport, 2023).

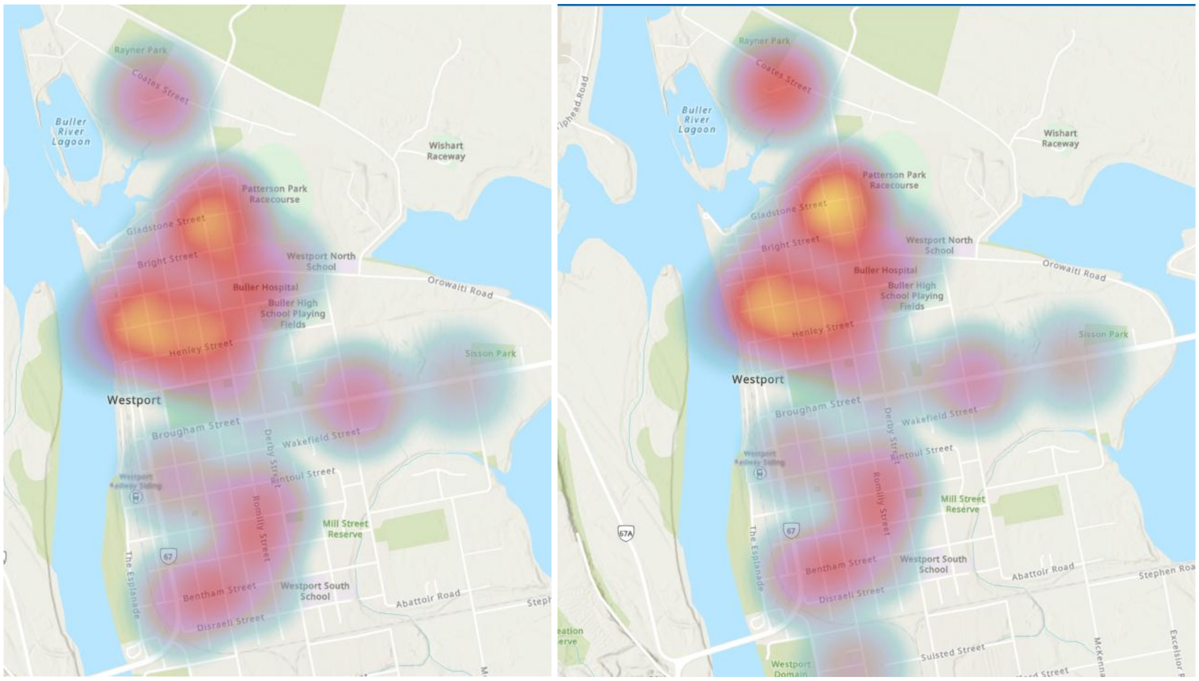

Figure 39. Westport spatial survey 2023 $PM_{2.5}$ daily average plot (left) and $PM_{2.5}$ daily maximums plot (right).

An evaluation of spatial variability in $PM_{2.5}$ concentrations following the 2023 survey found that the Club Buller site is likely to measure $PM_{2.5}$ concentrations almost a factor of two lower than the peak area, which was a location at the northern end of Derby Street. Concentrations at the northern Derby Street site appear to be almost twice as high as those measured at the Club Buller air quality monitoring site (Wilton & Zawar Reza, 2024).

It may be that further monitoring at a location more to the north-east of town is required to better assess potential compliance with the national standard for PM_{10} so this could be an option for future monitoring in Westport.

3.4. Source apportionment

One of the recommendations from the 2004 SOE report was to undertake summer sampling for PM_{10} and chloride to determine levels of sea salt contributions to PM_{10}, recognising that this may influence higher PM results in Westport due to its coastal location. As part of the Wider West Coast survey, source apportionment analysis was undertaken by GNS Science (now Earth Science New Zealand). This involved using XRF to analyse filters used in the MetOne reference samplers over winter 2023 at the Club Buller site to determine relevant contributions to airborne particulate matter from different sources. This type of source apportionment study had not been undertaken anywhere on the West Coast before, and the results provide a much better understanding of the natural and anthropogenic contributions to PM_{10} and $PM_{2.5}$ in Westport.

The source apportionment assessment showed there were four main sources of PM (Figure 40). These included: biomass combustion from domestic heating; sea salt; soil; and motor vehicles. The largest contributor to $PM_{2.5}$ in Westport was biomass combustion from domestic heating (76% on average), followed by sea salt (17% on average). For PM_{10} concentrations, however, sea salt accounted for, on average, 43% of the PM_{10} measured in Westport, with the next highest contributors to ambient PM_{10} composition being biomass combustion (35%) and soil (18%). Sea salt is likely to be less harmful but can form a significant part of PM_{10} during certain weather conditions (Davy & Trompetter, 2024).

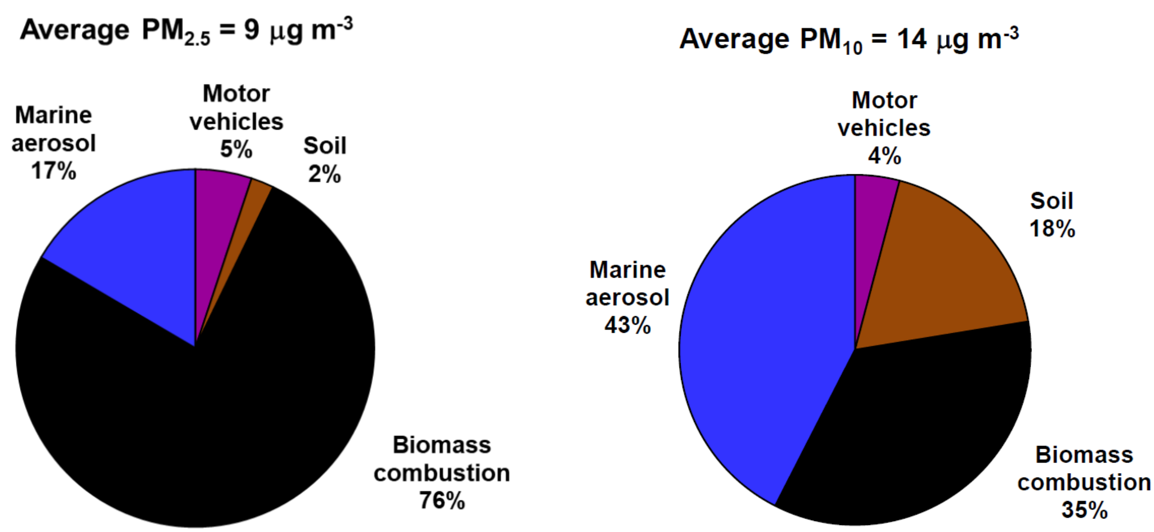

Figure 40. Average source mass contributions to $PM_{2.5}$ and PM_{10} at Westport over the winter monitoring period, 2023 (Davy & Trompetter, 2024).

Comparison of biomass combustion contribution to $PM_{2.5}$ and PM_{10} at the Club Buller monitoring site to wind speed and direction showed that contribution from biomass combustion was greatest under light winds from the south-east (Figure 41). This is a similar pattern to that seen with the T640x PM data. Once again this is indicating that elevated PM is likely associated with a lack of dispersion of airborne particulates from domestic home heating emissions during katabatic flows.

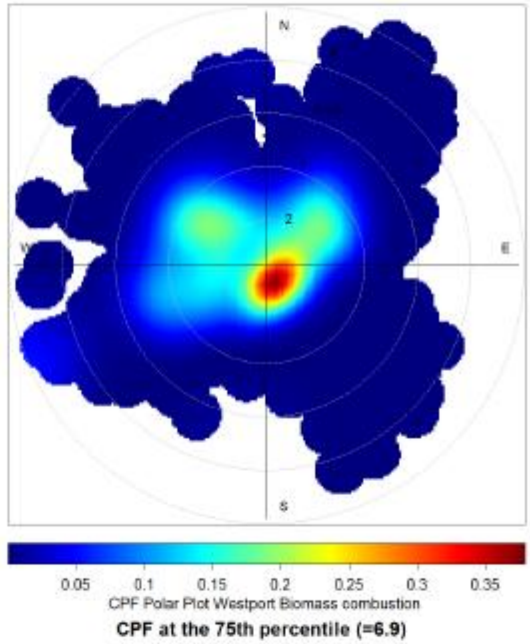

Figure 41. Polar plot showing the relative contribution of PM_{10} and $PM_{2.5}$ (from biomass combustion sources) to wind speed and direction for Westport over winter 2023 (Davy & Trompetter, 2024).

Wilton *et al.* demonstrated that elevated PM_{10} were, at times, associated with strong north-west winds which was thought to indicate possible higher contributions from sea salt on those occasions. Figure 42 shows the contributions of sea salt (and other sources) to daily PM_{10} concentrations over winter 2023. In contrast, Figure 43 shows the lesser contributions from sources other than biomass combustion to $PM_{2.5}$ concentrations.

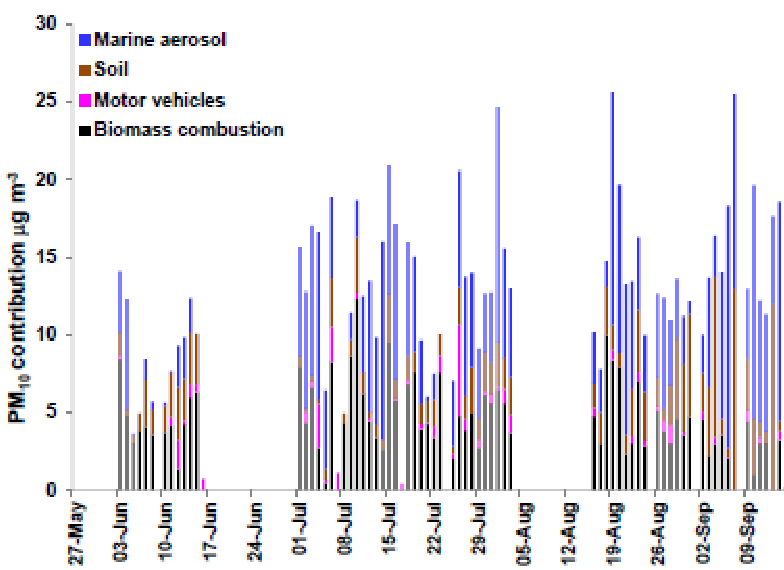

Figure 42. Temporal variations in relative source contributions to daily average PM_{10} mass at Club Buller monitoring site in Westport (Davy & Trompetter, 2024).

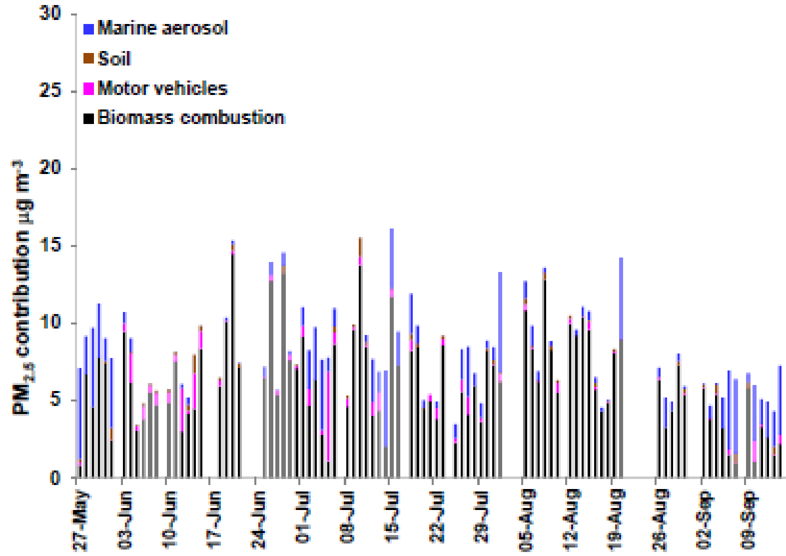

Figure 43. Temporal variations in relative source contributions to daily average $PM_{2.5}$ mass at Club Buller monitoring site in Westport (Davy & Trompetter, 2024).

The source apportionment work showed that contributions from sea salt were greatest during northerly and south-westerly directions, which aligns with winds blowing marine aerosols from the Tasman Sea and Southern Ocean (Figure 44).

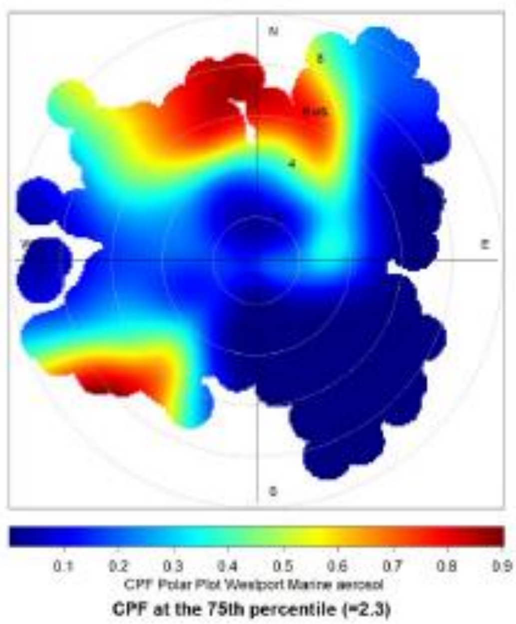

Figure 44. Polar plot of marine aerosol contributions to PM_{10} and $PM_{2.5}$ concentrations compared to wind speed (2 m/s increments) and direction at the Club Buller monitoring site over winter 2023. Contour colours indicate relative contribution of marine aerosols to wind direction/speed (Davy & Trompetter, 2024).

On the peak PM_{10} day in Westport (01/08/2023) of 35.1 micrograms/m^3 PM_{10}, analysis showed that 60% of the particulate source was attributed to sea salt (Figure 45). Toxic arsenic and lead were also detected in the filter analysis process which indicates the opportunistic burning of treated timber and old painted timber.

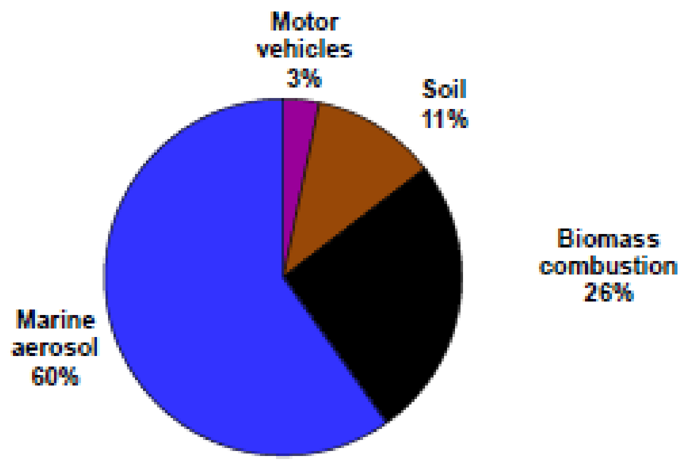

Figure 45. Source mass contributions to PM_{10} on peak event 01/08/2023 at the Club Buller monitoring site in Westport (Davy & Trompetter, 2024)

3.5. Sulphur dioxide and nitrogen dioxide monitoring

Spatial NO_2 and SO_2 surveys were included in the monitoring programme for Westport in winter 2022 due to the recommendations for further SO_2 monitoring in the 2004 SOE report. NO_2 was chosen, as like SO_2, it can be a product of the combustion of fossil fuels like coal. SO_2 emissions are related to the sulphur content of fuels. NO_2 emissions are largely a function of combustion temperature and pressure and is predominantly produced by diesel vehicles. Small tubes were installed on poles at the same locations as the PM survey units and these collected diffuse NO_2 and SO_2 over 1-month periods. Two deployments were undertaken over winter. One in June – July and one in July-August. Data collected from this survey showed low levels of both SO_2 and NO_2.

SO_2 concentrations were lowest on the southern and eastern edges of the town and higher in central and northern areas (Figure 46 and Figure 47). Figure 47 shows that SO_2 was generally higher in Jul-Aug and, interestingly, areas of highest SO_2 align with emission density assessment and PM spatial survey results for areas of higher concentrations. This indicates that the potential main source of SO_2 may also be domestic home heating.

Figure 46. Westport SO_2 Jun-Jul 2022. Scale of increasing monthly passive SO_2 is shown by light to darker dots.

Figure 47. Westport SO_2 Jul-Aug 2022. Scale of increasing monthly passive SO_2 is shown by light to darker dots.

NO_2 results showed higher concentrations in more central areas with lower concentrations towards the edges of town (Figure 48 and Figure 49). Although there were some similarities, results for NO_2 didn't align as well with high PM areas like SO_2. This suggested that NO_2 concentrations were related to a source like vehicle movements. NO_2 is almost entirely related to (diesel) vehicle emissions. Both Westport and Greymouth are on the low end of the scale for NO_2 which is not particularly surprising given their modest traffic densities.

Figure 48. Westport NO_2 Jun-Jul 2022. Scale of increasing monthly passive NO_2 shown by light to darker dots.

Figure 49. Westport NO_2 Jul-Aug 2022. Scale of increasing monthly passive NO_2 shown by light to darker dots.

Due to the low levels measured in Westport, no further monitoring of SO_2 or NO_2 was undertaken in Greymouth or Hokitika as these towns had recorded lower levels than Reefton and Westport in the earlier surveys.

3.6. Summary

Monitoring in Westport over 2022 – 2025 has shown higher PM in more northern parts of the town, especially the north-west corner of the town and further north-east around the trotting club. Earlier monitoring sites were located south of Brougham Street and assumptions, based on data collected at that time, were that higher results may be recorded further north based on the predominant wind direction being from the south / south-east.

Continuous monitoring has shown to be typical of domestic home heating as a main PM source over the winter months, in both daily and annual patterns, with higher PM generally seen from June – August.

There may be a combination of factors contributing to areas of higher PM. Calm conditions associated with the predominant winds may be conducive to higher PM across the town and variation in the number and type of emissions in localised areas may also lead to differences spatially across Westport. Wind strength and direction influences the source of particulates measured under different conditions and different times of the year. Sea salt and biomass combustion were the highest contributors to PM source measured over winter 2023, sea salt was particularly high with south-east and north-west winds. Sea salt and biomass combustion are very unlikely to peak at the same time.

Despite some exceedances of the standard being recorded in the early 2000's, no exceedances of the PM_{10} standard were recorded with the continuous monitoring undertaken from 2023 – 2025 at the Club Buller site

(Figure 50). Although there were no exceedances of the PM_{10} daily standard, the annual average for 2024 did exceed the WHO annual guideline and this may be influenced by the sea salt contributions in Westport.

$PM_{2.5}$ measured at the Club Buller site did exceed the WHO daily guideline on a number of occasions and this may be something to keep in mind when considering future monitoring implications of changes to the air quality legislation. It may be that more monitoring may be necessary in Westport in future, especially for $PM_{2.5}$.

SO_2 and NO_2 were below previous levels and not of concern. SO_2 showed some similarities to PM spatial variation while NO_2 may have been more influenced by other sources such as traffic.

Figure 50. Monitoring instruments at the Club Buller site, Westport, 2023.

4. Greymouth

4.1. Background

Three sites were monitored historically in Greymouth over winter 2001 to 2003 – Palmerston St, Greymouth bowling club and Cobden bowling club, as well as a site at the Runanga pool. SO_2 (continuous) and BTEX was undertaken over all three winters at the Palmerston Street site, with PM_{10} (1 day in 3) being monitored over winter 2001 only. Monthly SO_2 and BTEX were monitored at the Cobden bowling club and Greymouth bowling club sites in winter 2001 and 2003 respectively and over all three winters at Runanga (Grey District Council swimming pool). Some earlier sampling for smoke concentrations and SO_2 was also undertaken in Greymouth in 1994 and 1995.

PM_{10} in Greymouth (2001) was found to be much lower than Reefton and Westport, with no exceedances of the standard. Although PM was not measured in Runanga, it was thought likely that the fuel mix burned in Runanga was similar to that used in Greymouth and, if so, levels of PM were predicted to be lower than in Greymouth, as monthly SO_2 results were lower in Runanga. The monitoring site in Runanga was situated towards the northern end of the town, and it was thought most likely that the prevailing light winds would be south - southeasterly land breezes flowing down the valley. Therefore, it was thought that the monitoring site could be expected to show about the maximum concentrations (Stevenson, Hally, Noonan, & James, 2004).

Of the Greymouth sites, Palmerston Street generally recorded poorer air quality based on comparisons of $S0_2$. No comparative PM monitoring was carried out.

Sulphur dioxide concentrations were low in both Greymouth and Runanga and determined to not be an issue.

In a feedback document relating to the 2004 SOE report (Air & Environmental Services Limited, 2004) comment is made regarding a highly visible smoke haze over the houses in the Lydia St to Alexander St area. This was thought likely to be smoke rather than mist due to its colour, and odour at ground level in the mornings and evenings. However, the passive SO_2 and BTEX results for the Greymouth bowling club site (central in the location of the smoke haze) sampled in 2003 were not significantly different from the Palmerston St site which indicated that PM_{10} levels may not be much higher than Palmerston St levels (Stevenson, Hally, Noonan, & James, 2004). There was no further monitoring undertaken of PM following the 2001-2003 work to confirm this assumption.

Greymouth was included in the Wider West Coast sampling plan due to being the largest town on the West Coast and no monitoring had been undertaken here since 2003. Although early monitoring work did not indicate any issues at the time, data collection was limited to a small number of sites and limited sampling days. Advances in technology and resourcing have allowed for more thorough monitoring to be undertaken to update our knowledge on the state of Greymouth air quality.

4.2. PM spatial surveys and emission density mapping

Investigative spatial surveys of PM_{10} and $PM_{2.5}$ were undertaken in Greymouth over winter 2023 and 2024. Initial findings from the 2023 survey indicated that there may be air quality issues that require further investigation.

For this initial survey, six monitors were located in central Greymouth, Cobden, Runanga and South Beach. Although data cannot be accurately compared to guidelines it is useful as an indication of areas that may need further investigation and provide an updated spatial assessment of Greymouth air quality.

Data from these instruments recorded higher than the PM_{10} daily average standard more often at the Kilgour Road, Sturgeon Park and South Beach locations (Figure 51). However, higher PM_{10} was recorded outside of the winter months at the South Beach site so it is likely that sea salt is contributing more to the higher results here.

Runanga and Cobden recorded less exceedances of the daily PM_{10} standard, however there were still numerous exceedances of WHO $PM_{2.5}$ guidelines.

Greymouth, being a coastal town, was believed likely to have a significant contribution of sea salt to its aerosol make up, as seen in Westport. XRF analysis of filters from the winter 2025 sampling has now provided quantitative data on the relative contributions of different sources to the airborne particulate make up in Greymouth.

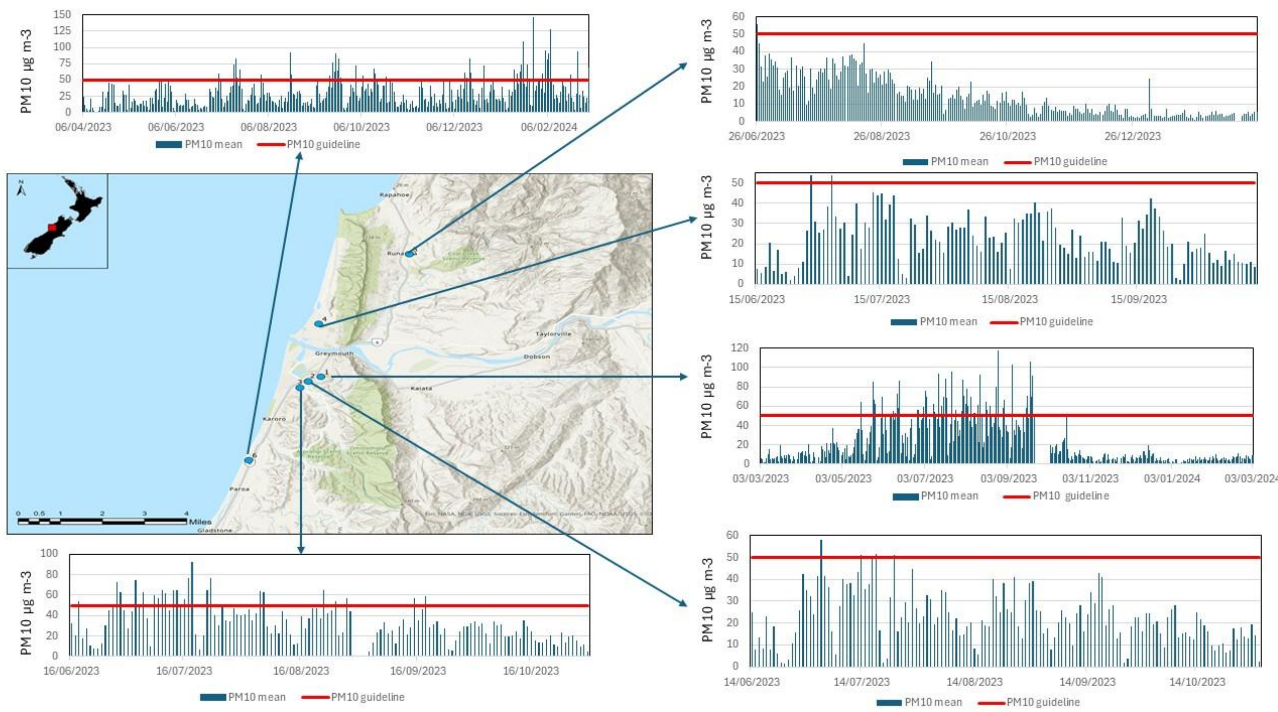

*Figure 51. **Greymouth Purple Air spatial survey 2023 individual site daily average PM_{10} data.** Comparison to guidelines / standards is indicative only as Purple Air devices are used for investigative monitoring and are not considered NES standard instruments.*

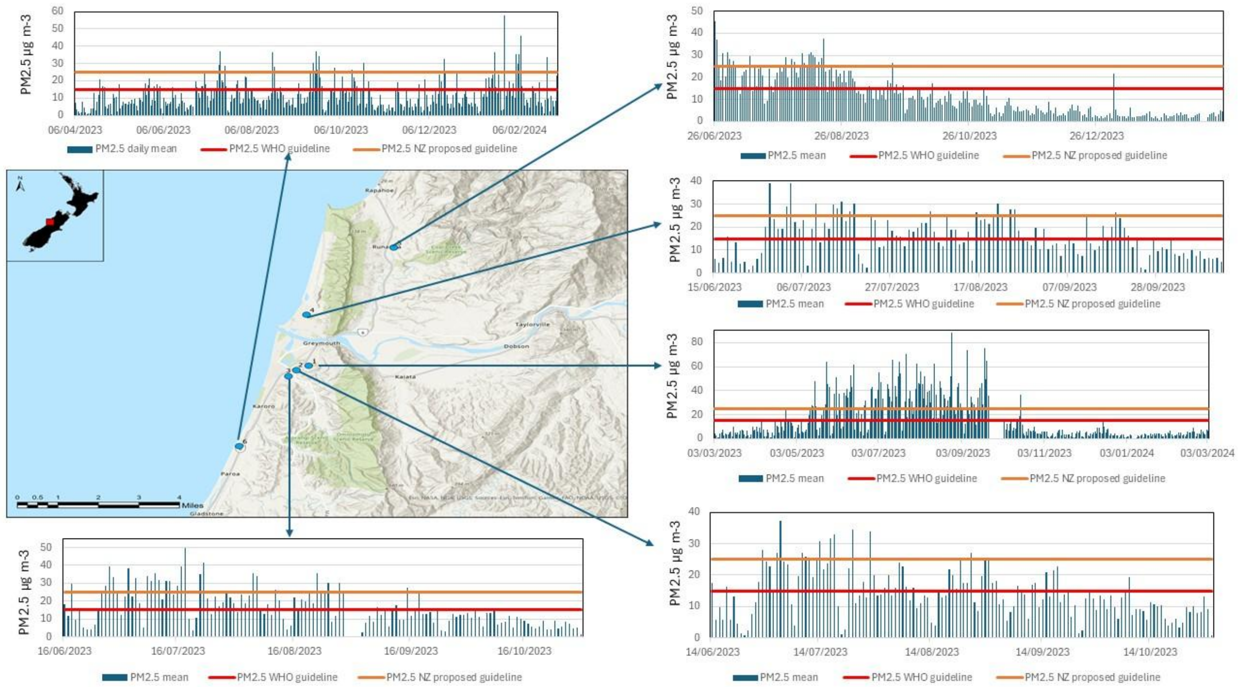

Figure 52. Greymouth Purple Air spatial survey 2023 individual site daily average $PM_{2.5}$ data. Comparison to guidelines / standards is indicative only as Purple Air devices are used for investigative monitoring and are not considered NES standard instruments.

An emissions density assessment was also undertaken for Greymouth in 2023. This work assessed emissions from key sources of particulates (domestic heating, motor vehicles, commercial/industrial activities and outdoor burning) to identify possible areas of higher concentrations under stagnant conditions. This survey uses information collected from census, consents, NZTA vehicle data, and household data to calculate potential emission concentrations. This type of assessment focuses on anthropogenic sources and doesn't account for natural PM sources.

Results of this work identified domestic heating as the main source of both anthropogenic $PM_{2.5}$ and PM_{10} emissions in central Greymouth (Wilton & Zawar Reza, 2024). The highest emission density areas were identified between Milton Road and High Street and areas around Grey Main School and along Marlborough Street / Marsden Road (Figure 53).

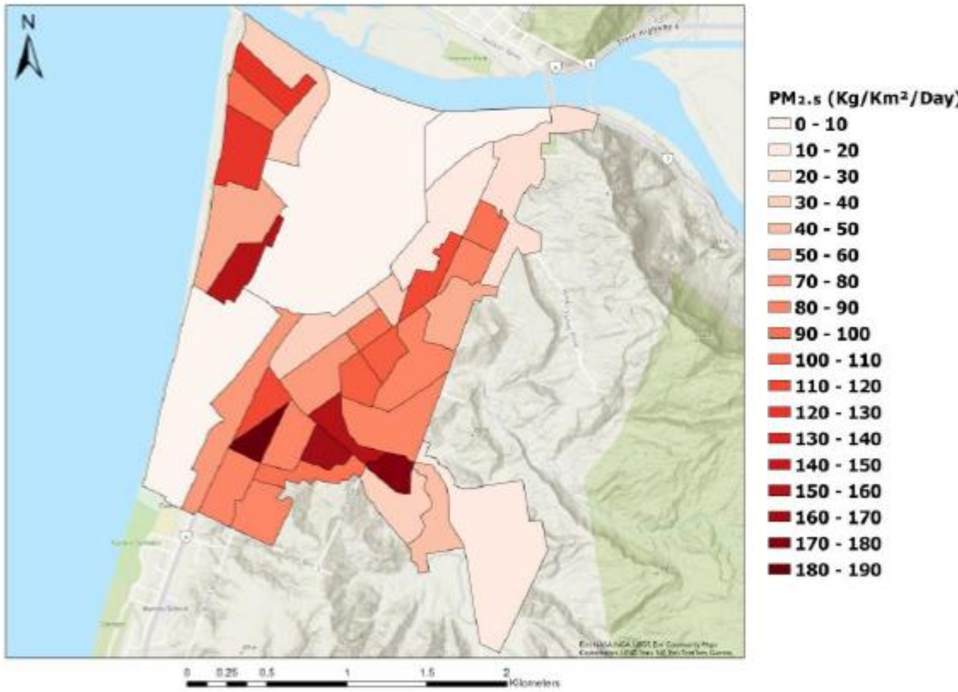

Figure 53. Map of Greymouth showing results of the emissions density assessment 2023. The darker coloured areas indicate potential for higher $PM_{2.5}$ emissions.

A more comprehensive spatial survey of 14 sites was undertaken in Greymouth in winter 2024 by Mote Ltd. Information gained from the 2023 survey and the emissions density assessment helped to determine potential monitoring sites for this survey. The 2024 survey was concentrated on more central areas of Greymouth, rather than outer suburbs.

Average daily $PM_{2.5}$ was highest around the area of Marsden Road adjacent to Leith Crescent and near the High Street roundabout / southern end of Shakespeare Street, showing some similarities to the emissions density assessment.

Average daily $PM_{2.5}$ was also elevated near the High Street / Marlborough Street roundabout and around Alexander / Thompson Streets (Figure 54). Interestingly, this area of higher concentrations around Alexander Street is similar to the area discussed in the 2004 SOE report, where it was thought that katabatic drainage could be responsible for a visible smoke haze in this area and potentially higher PM at times.

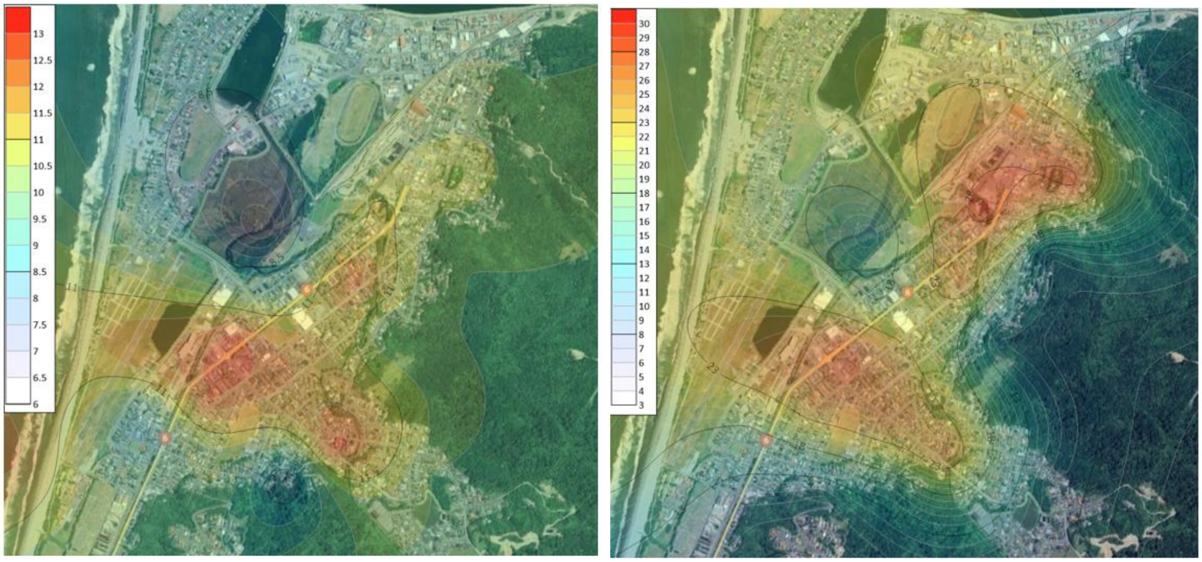

Figure 54. Greymouth 2024 spatial survey average $PM_{2.5}$ concentrations (left) and second highest $PM_{2.5}$ concentrations (right) for 28 June – 29 September monitoring period.

Analysis of wind data for Greymouth over the survey period in 2024 showed winds spread around the compass, however predominantly low speed winds were from the north-east, with stronger winds more so from the east at times (Figure 55).

As with other West Coast towns monitored, this high frequency of low wind speeds will reduce the dispersal of airborne particles at times over winter leading to smoky conditions on cold, calm days. Winds coming from the north-east will be potentially accumulating particles from built up areas as they move across residential areas to the south, contributing to higher PM around the southern end of Shakespeare Street and Marsden Rd.

There may be other geographical or anthropogenic factors causing variations to PM, such as cold-flow drainage from the hills behind the Alexander Street area or differences in burning practices.

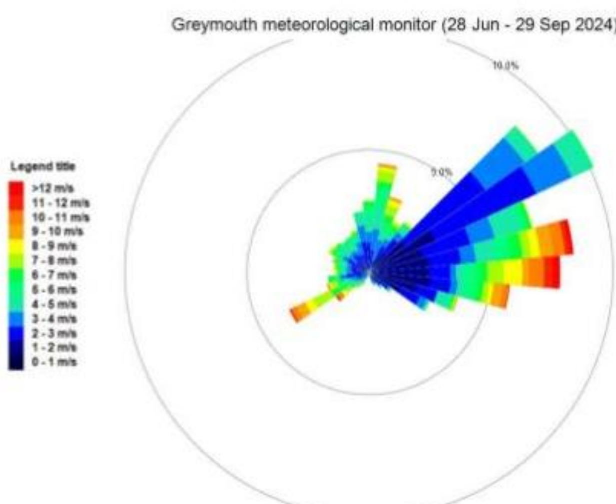

Figure 55. Greymouth wind rose for winter 2024 spatial survey period.

Comparative PM_{10} monitoring is being undertaken over winter 2026 at a location around the Alexander / Thompson Street area (along with continued monitoring at the Greymouth High School site) to assess levels of PM at this location and determine whether PM may, at times, be higher than at the Grey High site.

4.3. Continuous PM sampling

Data from the 2023 and 2024 spatial surveys and information from the emissions assessment were considered when determining an appropriate location to install a continuous T640x instrument for a winter 2025 deployment in Greymouth. Although the emissions assessment proposed Grey Main School as a potential location, the 2024 survey results showed higher PM for the part of town closer towards Greymouth High School so this location was chosen for a temporary continuous monitoring site.

The T640x instrument was installed in Greymouth on 28 May 2025. Two MetOne E-SEQ-FRM reference machines were installed alongside, measuring both PM_{10} and $PM_{2.5}$. Data from the MetOne machines can be compared directly to the daily average standard and are also used to determine correction factors for PM_{10} and $PM_{2.5}$ T640x data. Co-location assessment undertaken on the T640x data compared to the MetOne reference machine data showed that no correction of T640x data is required. The instrument was the same T640x that had been operating at the Club Buller site in Westport and was relocated to Greymouth for the winter 2025 deployment.

Due to technical issues with the T640x, reliable data collection did not start until 17 June. There were a few gaps in MetOne data associated with filter changeovers and lab hold ups.

No exceedances of the PM_{10} daily standard were recorded over winter on the MetOne reference instrument (Figure 56). There were four exceedances recorded in September on both the MetOne and T640x instruments. In addition, there were five exceedances of the NESAQ daily standard in October and one in December (Figure 57), measured on the T640x (the MetOne instruments were only operational until the end of September whereas the T640x monitoring continued).

There were four exceedances of the WHO daily average guideline for $PM_{2.5}$ measured over winter on the MetOne reference instrument (Figure 56) and eleven measured on the T640x (Figure 58). Like with PM_{10}, there were further exceedances outside the winter months.

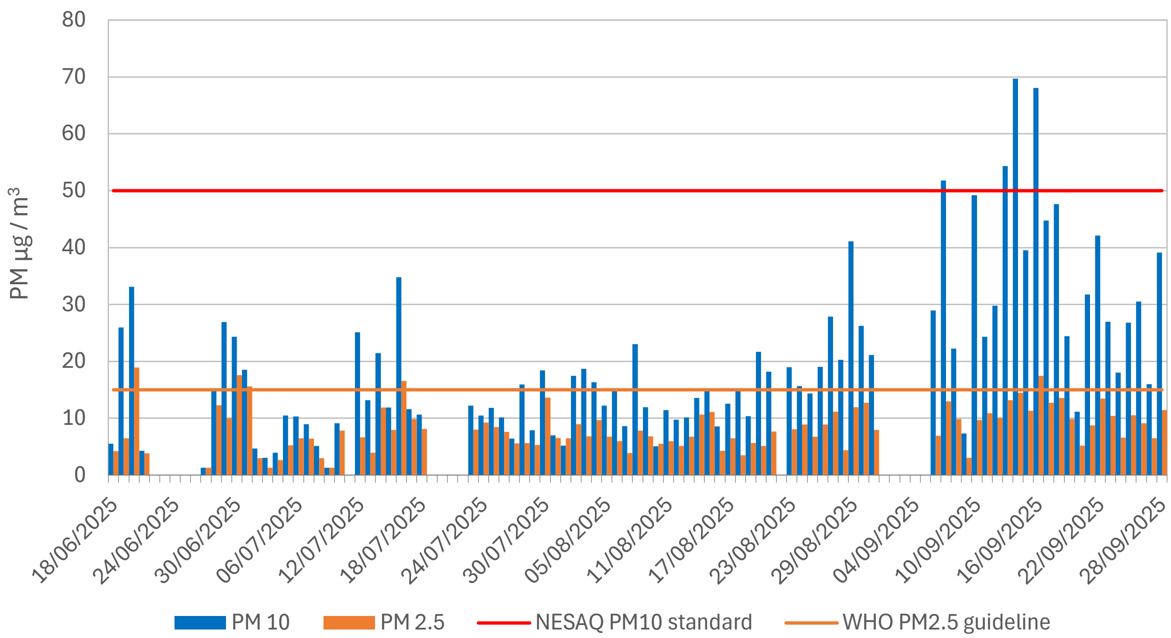

Figure 56. MetOne daily average PM_{10} and $PM_{2.5}$ for Greymouth winter 2025. Note there are a few gaps in the PM_{10} data due to issues with filter availability.

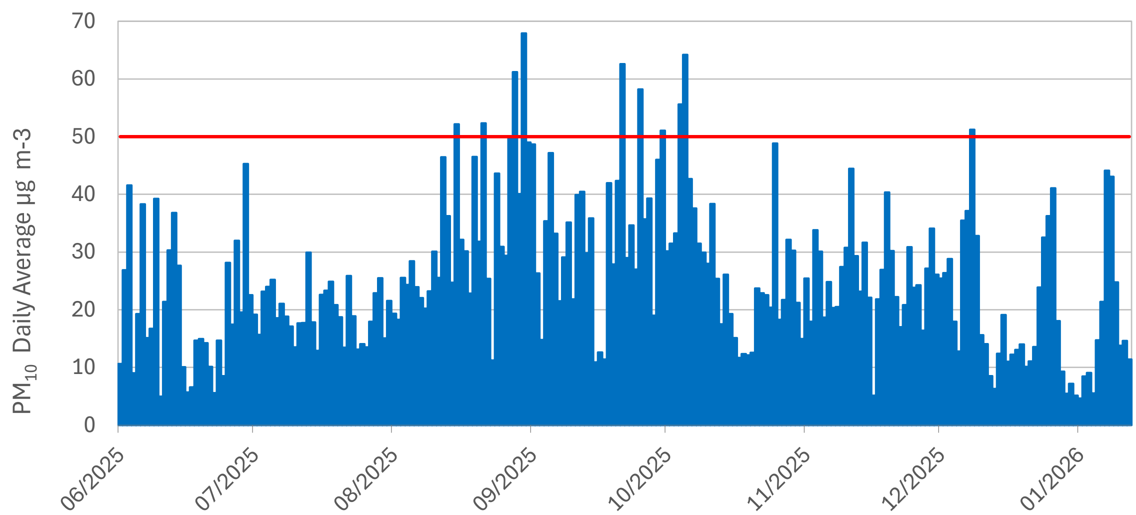

Figure 57. Greymouth T640x daily average PM_{10} June 2025 – January 2026. Red line indicates the NESAQ PM_{10} limit.

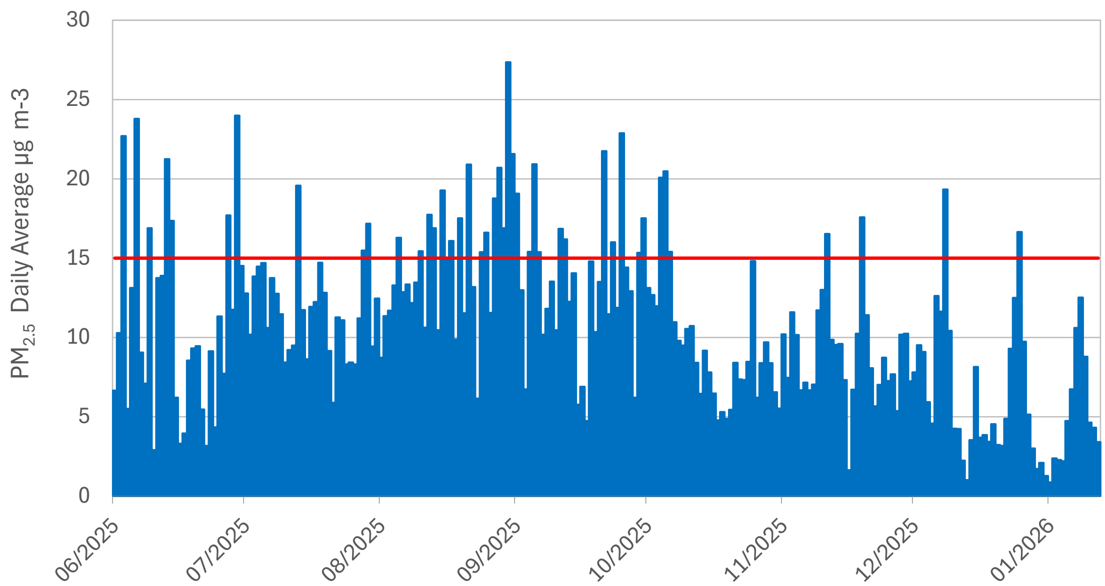

Figure 58. Greymouth T640x daily average $PM_{2.5}$ June 2025 - January 2026. Red line indicates the WHO $PM_{2.5}$ guideline value.

Analysis of temperature and wind data for Greymouth from 2021 to 2025 has shown that winter 2025 was generally representative of a typical Greymouth winter, with wind speed and temperature over June, July and August within similar ranges to the previous four winters (Figure 59 and Figure 60).

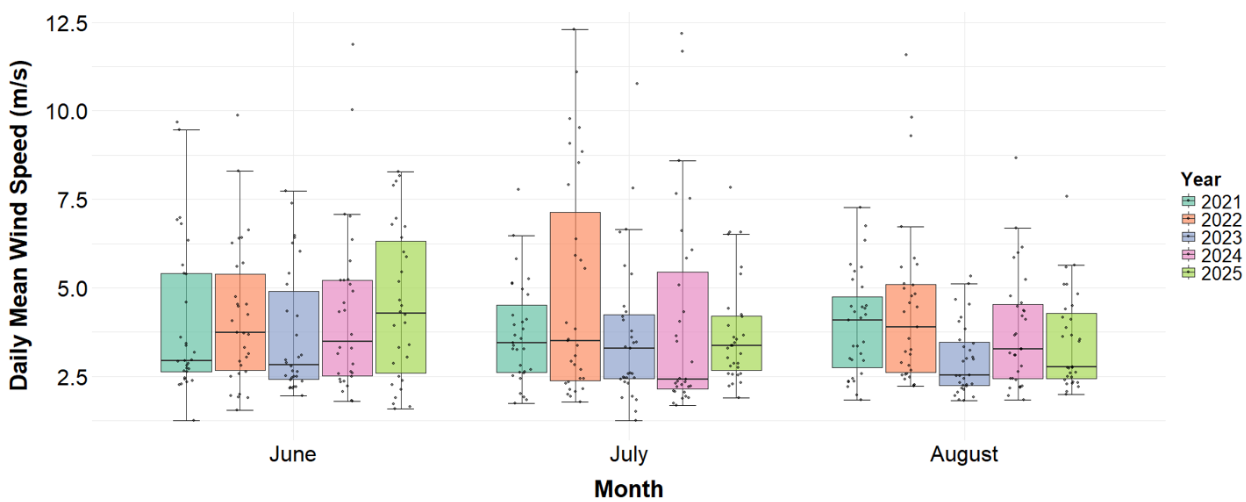

Figure 59. Greymouth mean daily wind speed for winter months 2021 - 2025

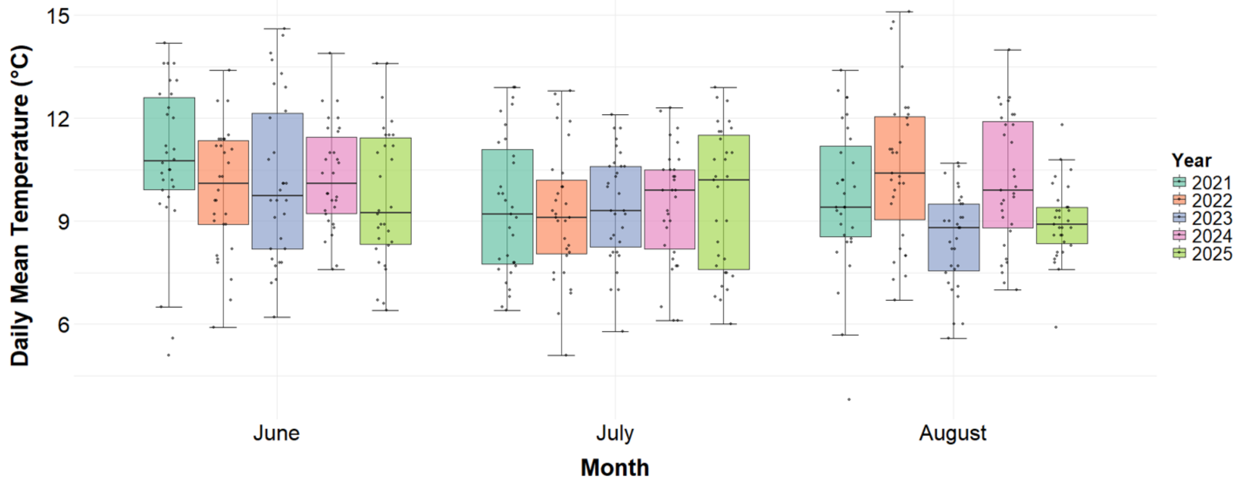

Figure 60. Greymouth daily mean temperature for winter months 2021 - 2025.

T640x data has shown the typical pattern of domestic home heating as a dominant winter source of PM. Emissions tend to increase at times of the day when people are more likely to be using fireplaces such as in the morning and early evening and are lower during the day (Figure 61 and Figure 62). Lower PM is also often associated with north-easterly winds (generally low speed) which may include lower contributions of sea salt (Figure 61),

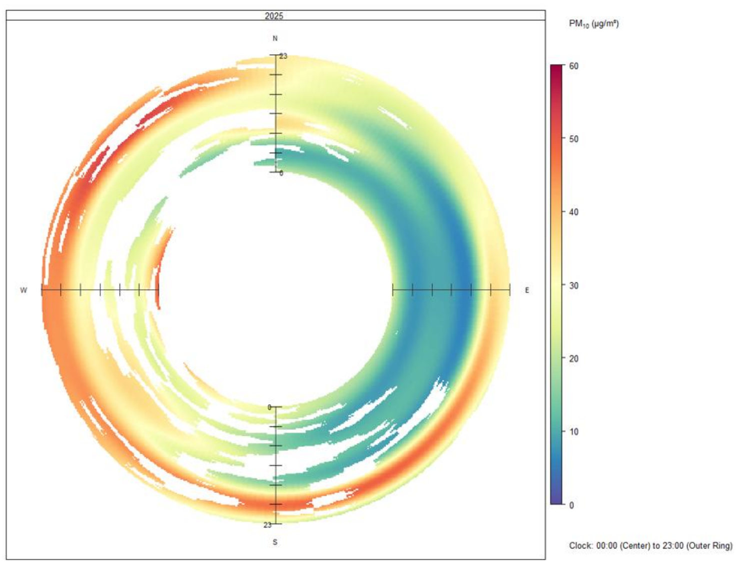

Figure 61. Annulus plot showing PM_{10}, wind direction and time of day for winter months (June, July, August) 2025 in Greymouth. Morning to night shown from inside of doughnut to outside.

PM_{10}, unusually compared to other towns monitored so far, was more consistently elevated outside of the winter months (Figure 63) with $PM_{2.5}$ less so, indicating more contributions from coarser fractions e.g. sea salt outside winter months.

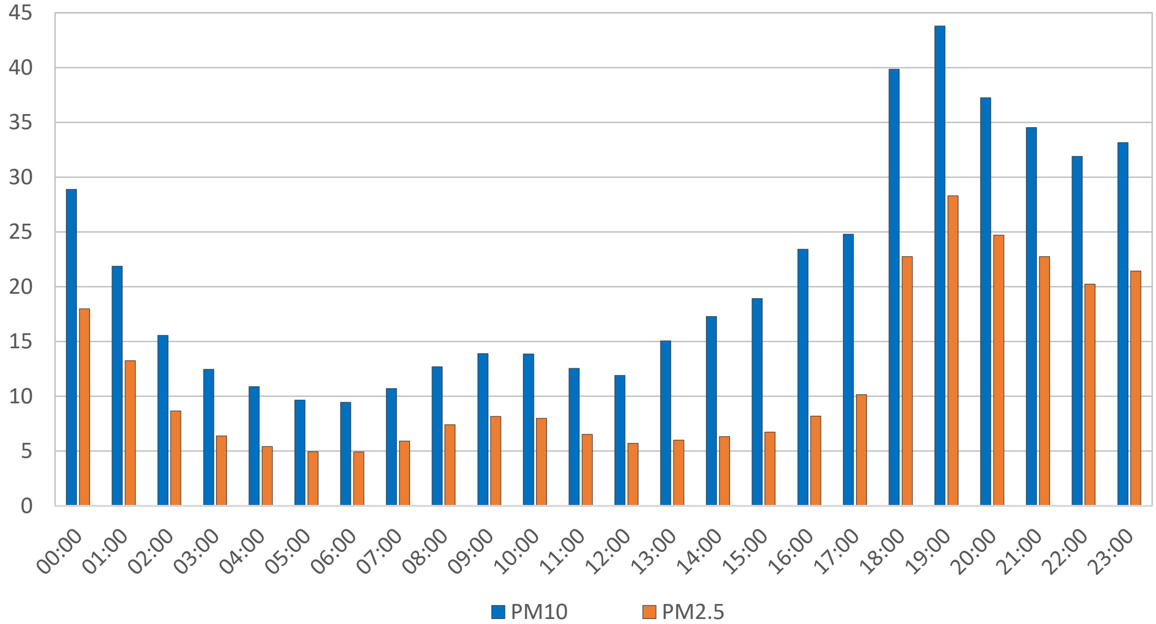

Figure 62. Mean of hourly totals for PM_{10} and $PM_{2.5}$ at Greymouth June - August 2025.

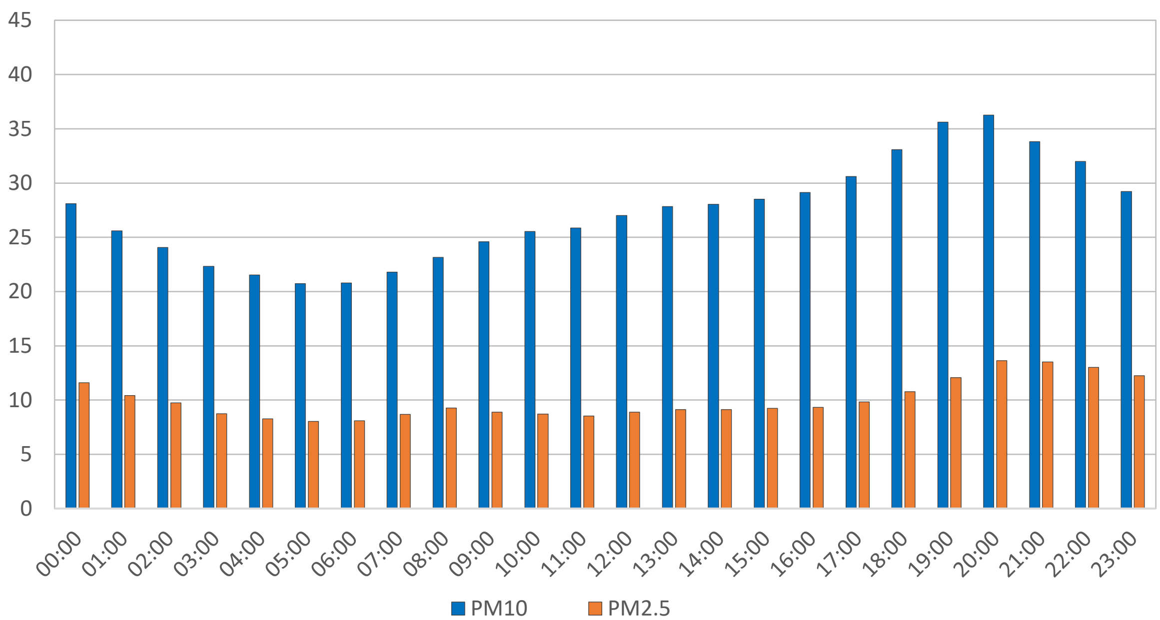

Figure 63. Mean of hourly totals for PM_{10} and $PM_{2.5}$ at Greymouth September 2025 - January 2026.

In Westport, source apportionment work showed a significant proportion of PM_{10} was from marine aerosols (sea salt). A change in predominant wind direction in September, from north-east to south-west, is associated with the higher daily PM_{10} measurements in spring (Figure 64) and Figure 65 shows higher PM_{10} is associated with stronger winds from the west or south-west, and more so in September, likely showing contributions of sea salt from the Tasman Sea.

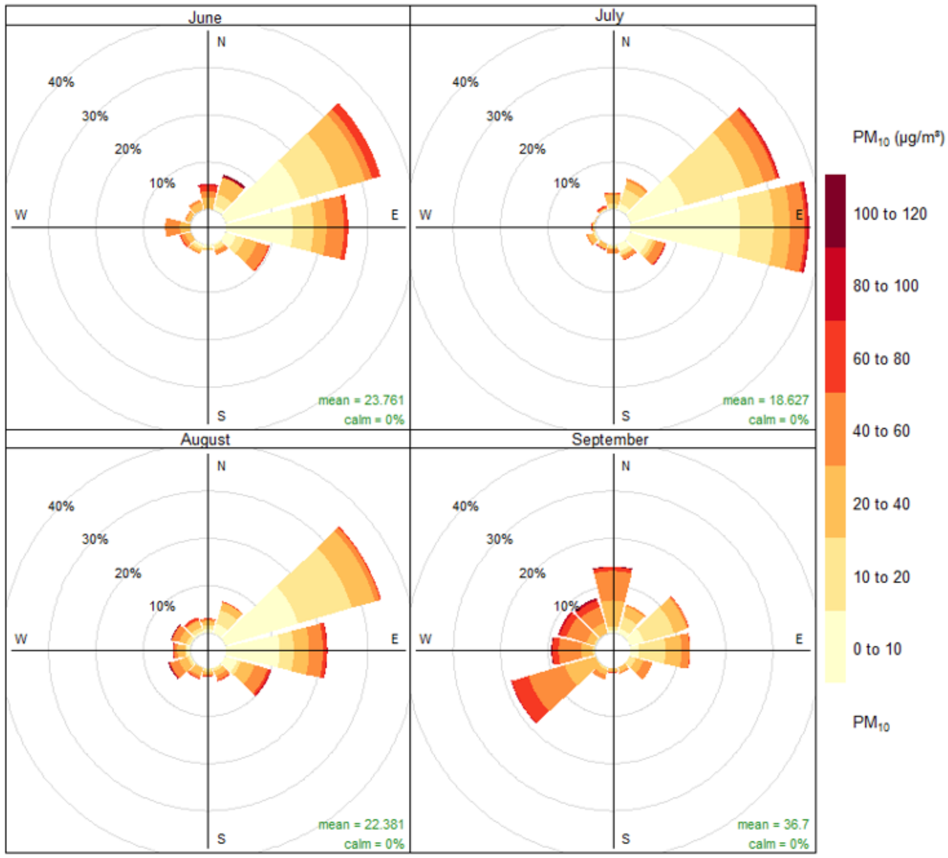

Figure 64. PM_{10} concentration in Greymouth by wind direction for winter 2025 monitoring period.

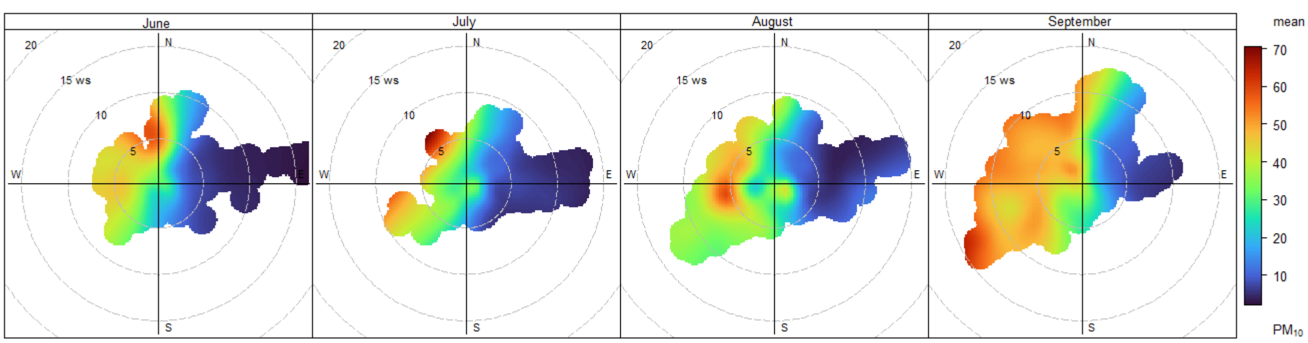

Figure 65. Polar plot showing T640x PM_{10} data associated with wind speed and direction for June - September 2025. Wind speed shown in increments of 5 m/s.

Source apportionment analysis has confirmed that this change in predominant wind direction is associated with a greater presence of marine aerosols in PM_{10} samples in Greymouth (Figure 67).

4.4. Source apportionment

Source apportionment analysis has been carried out on MetOne filters from winter 2025 which has assisted in understanding contributions of different sources to PM measured in Greymouth (Figure 66). The breakdown of relative contributions from different particulate sources to daily PM shows the contribution of various particulate sources to the daily average PM, which is particularly useful for understanding the drivers of elevated PM on days where the standard was exceeded (Figure 67 and Figure 68).

One of the recommendations from the 2004 Air Quality SOE report was summer sampling for PM_{10} and chloride in PM_{10} to determine sea salt contributions. Sampling for PM_{10} and chloride was undertaken at the Palmerston Street site over February and March 2004 to measure summer levels of PM and assess contributions of sea salt to PM_{10}. Three samples were analysed for chloride and, although there was some uncertainty with results, indications were that sea salt was a significant contributor to PM (Stevenson, Hally, Noonan, & James, 2004). The source apportionment work undertaken from 2025 sampling has provided more information on marine aerosol contributions to the overall makeup of airborne particulate mass and provide a better understanding of the sources related to PM in Greymouth.

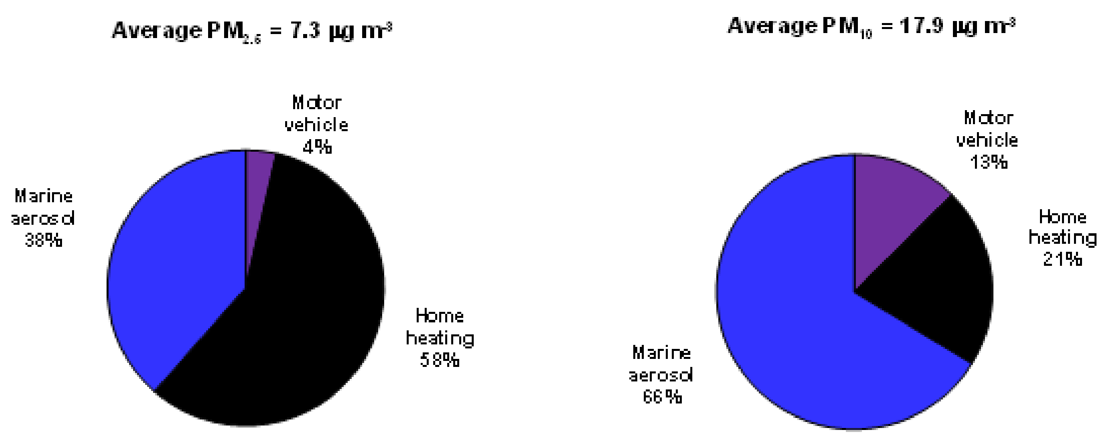

Figure 66. Average source mass contributions to $PM_{2.5}$ (left) and PM_{10} (right) at Greymouth June - September 2025 (Davy, 2026).

Figure 67 shows that higher daily average PM_{10} in Greymouth is associated with higher contributions of sea salt (Davy, 2026) so exceedances are a result of natural sources rather than anthropogenic sources such as home heating.

$PM_{2.5}$, representing smaller particle size fractions, shows less influence from sea salt however we still see the greater contribution of sea salt in September compared to winter months (Figure 68), which correlates with the change in predominant wind direction in spring from north-east to south-west (Figure 69).

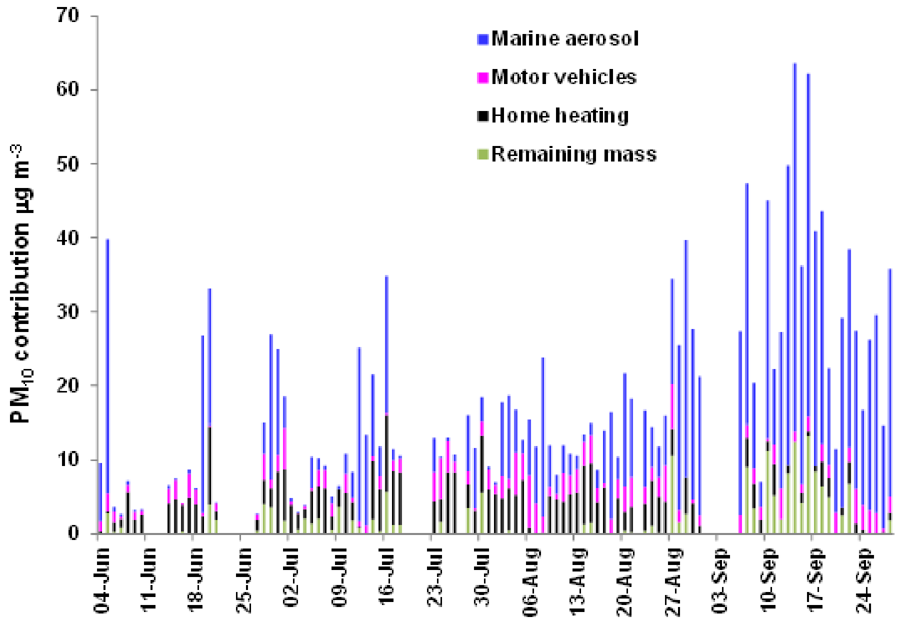

Figure 67. Contributions of different particulate sources to PM_{10} measured in Greymouth June- September 2025 (Davy, 2026).

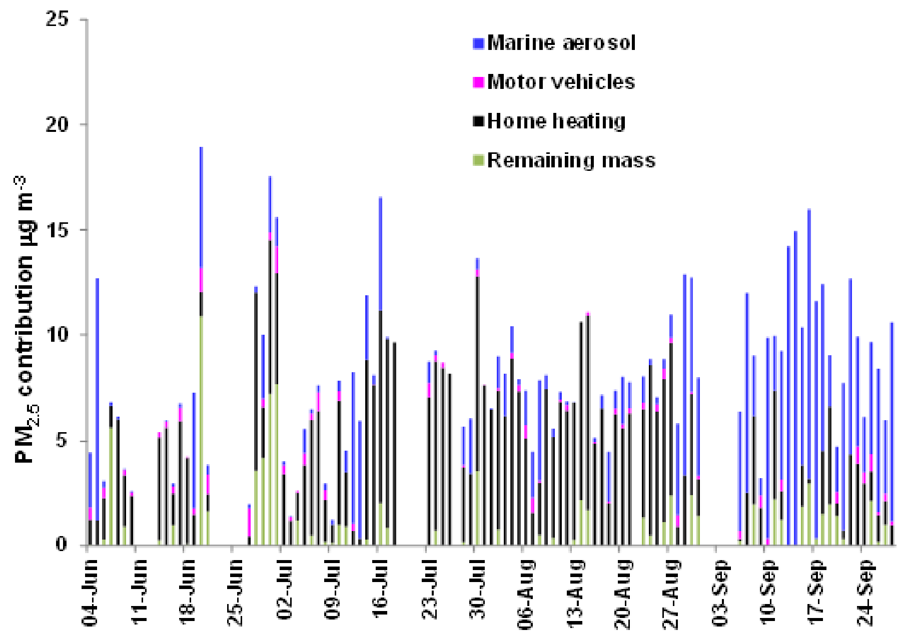

Figure 68. Contributions of different particulate sources to $PM_{2.5}$ measured in Greymouth June- September 2025 (Davy, 2026).

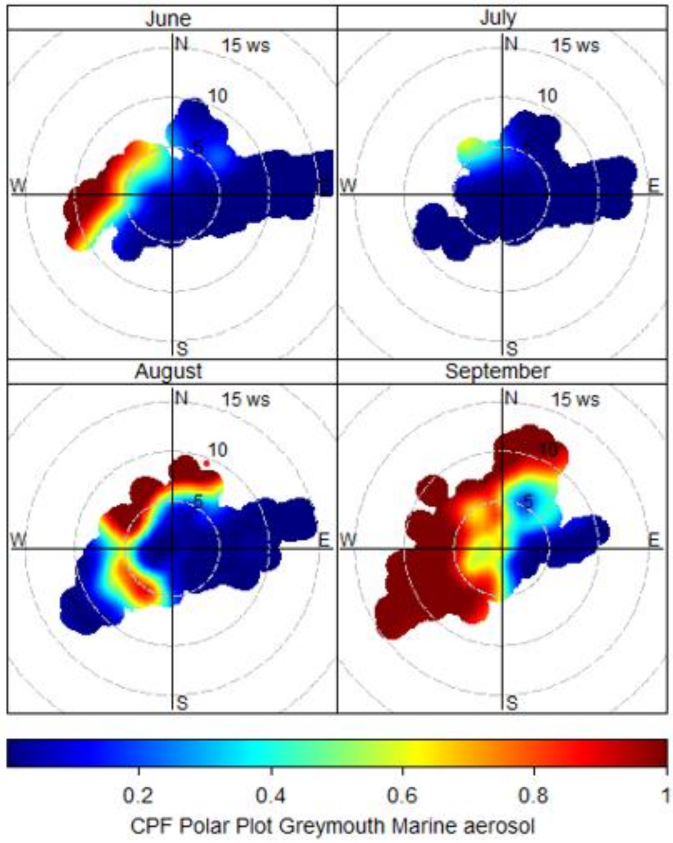

Figure 69. Polar plots showing marine aerosol contributions (to PM_{10} and $PM_{2.5}$ concentrations) compared to wind speed and direction for Greymouth over winter 2025.

Analysis of source contributions to PM on days with higher levels of PM_{10} and $PM_{2.5}$ have shown significant contributions of sea salt on most of these days (Figure 70 and Figure 71), with the PM aerosol mix on some days being made up of almost 100% sea salt and with home heating and motor vehicle emissions contributing lesser amounts, especially to PM_{10}. $PM_{2.5}$ showed much less sea salt on three of the higher PM days over winter 2025, PM on these days was more strongly related to home heating. This may have been due to meteorological variation such as a difference in predominant wind direction on those days.

These graphs demonstrate how $PM_{2.5}$ is a better measure of anthropogenic source PM, for which mitigation measures could be applied if required.

Contributions of home heating and vehicle sources to PM_{10} and $PM_{2.5}$ are highest under calm conditions (Figure 72), although vehicle emissions are a less significant source than home heating emissions (Figure 66). Vehicle contributions to PM, shown in Figure 72, align with the north-east to south-west direction of SH6 which passes in front of the high school. Home heating emission contributions are slightly more prominent from a south-east direction which could indicate an influence of cold flow drainage from the Sawyers Creek valley.

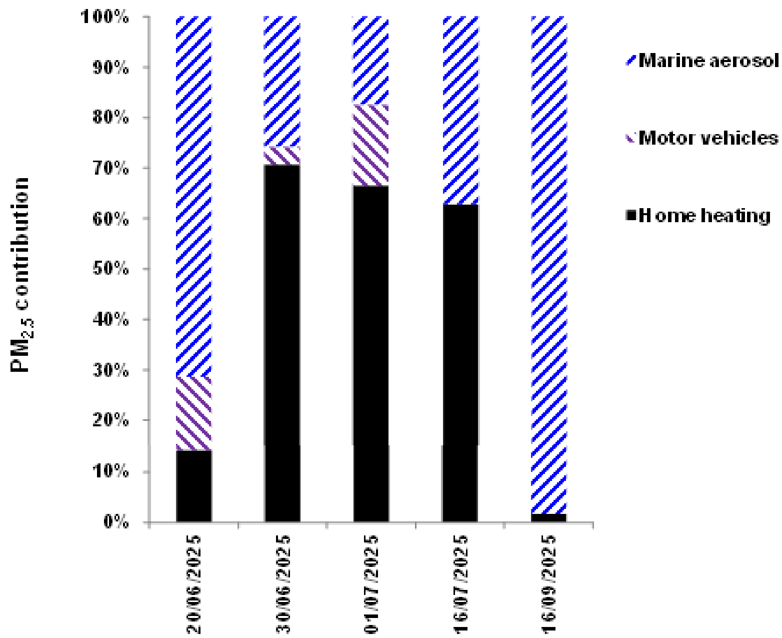

Figure 70. Contributions of different sources to peak $PM_{2.5}$ events in Greymouth over winter 2025 (Davy, 2026).

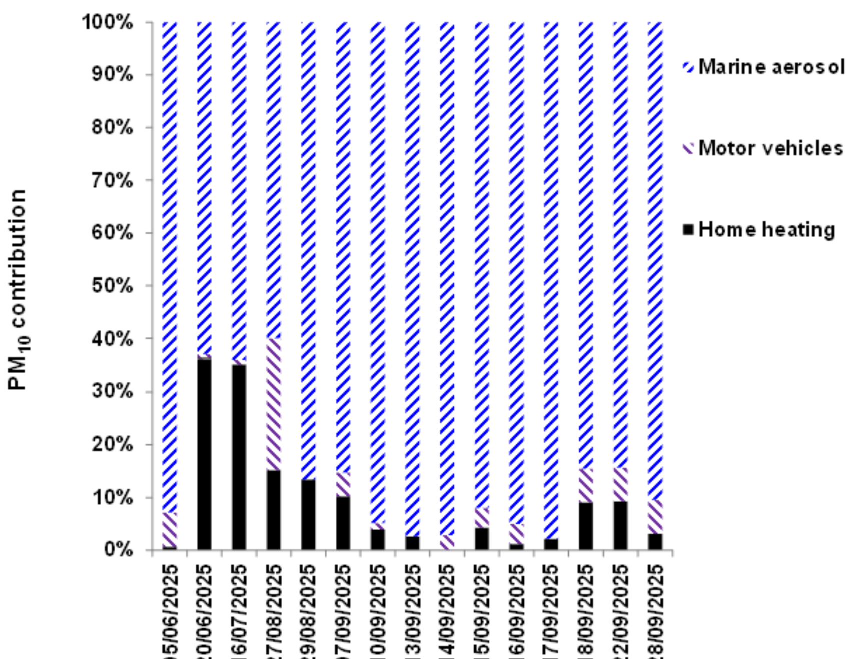

Figure 71. Contributions of different sources to peak PM_{10} events in Greymouth over winter 2025 (Davy, 2026).

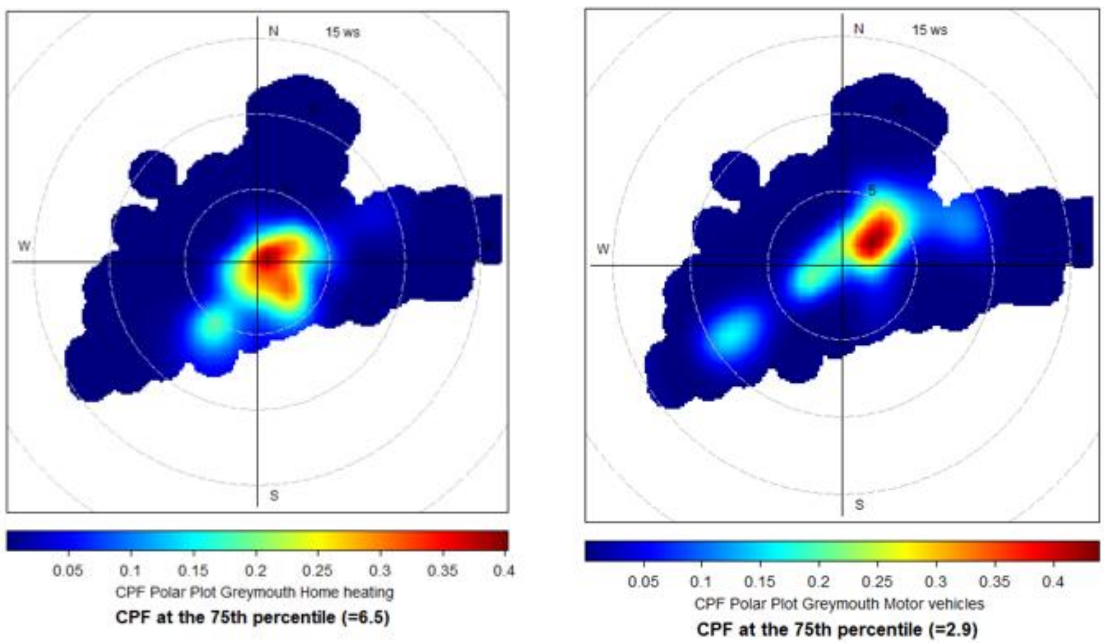

Figure 72. Polar plots showing home heating (left) and vehicle (right) contributions (to PM_{10} and $PM_{2.5}$ concentrations) compared to wind speed and direction for Greymouth over winter 2025 (Davy, 2026).

4.5. Summary

Early air quality monitoring in Greymouth showed air quality to be better than Reefton or Westport, with no exceedances of the standard measured. More recent survey work has updated our knowledge of wider Greymouth air quality and indicated some areas of the town to be more susceptible to elevated airborne particulate matter over winter.

Continuous monitoring at the Greymouth High School, near one of these “hot spots”, recorded no exceedances of the NESAQ over winter 2025.

It is possible that air quality may be poorer in a different location, such as further north around Alexander / Thompson Street where maximum PM showed a ‘hot spot’ in the 2024 spatial survey.

At present, monitoring is proposed to continue at the Greymouth High School (Figure 73) for at least another winter (2027) to assess any variation due to meteorological conditions between winters. A second investigative monitoring site at the Greymouth RSA on Thompson Street, is to be monitored over winter 2026 to determine whether there could be higher PM at times in this area of town. This is a similar area to where anecdotal information previously suggested may experience poorer air quality at times. This collection of data at two sites in the same winter will help determine whether there is a need for any further work in Greymouth.

Source apportionment analysis has shown that sea salt contributes significantly to the aerosol mix in Greymouth and can, at times, make up almost all of the PM on high PM days. It may be that a set of variables could be determined to assess the likely sea salt contributions to exceedances measured in future.

As with Reefton and Westport, Greymouth has shown to exceed the current WHO $PM_{2.5}$ daily average guideline which may be relevant if there changes to national standards. However, like Westport, Greymouth can account for a significant proportion of PM due to contributions of sea salt.

No PM data had previously been collected in Runanga or Cobden. The 2023 Greymouth spatial survey included one site in both towns to provide an indication of whether there was likely to be any issues here that may require further investigation. PM_{10} measured in these outer suburbs was lower than central Greymouth so no further monitoring was deemed necessary at the time.

A more comprehensive spatial survey of Runanga is planned for winter 2026, this survey will also include Dunollie, which has not had any air quality monitoring in the past.

Due to only having sampled at one location in Cobden it may be useful in future, if resourcing allowed, to monitor at additional sites in this suburb. This would provide a better overview of spatial variation in PM and the state of air quality in Cobden.

Figure 73. Monitoring equipment at the Greymouth High School site, winter 2025.

5. Hokitika

5.1. Background

In earlier monitoring, one site in Hokitika, located at the Westland High School, was monitored for monthly average SO_2 and BTEX over 2001-2003 winter months. No PM monitoring had historically been carried out in Hokitika. SO_2 and benzene measured from 2001-2003 was below the guideline and determined not to be an issue. The 2004 Air Quality State of the Environment report recommended that if there was to be further monitoring of SO_2 in Hokitika, a site further to the west of the town would be ideal to determine if the additional distance across town would produce higher concentrations. PM monitoring was also recommended.

Air quality monitoring was undertaken in Hokitika over winter 2024 and 2025. No SO_2 or NO_2 monitoring was undertaken as levels measured in Reefton and Westport were low. However, PM has been monitored, for the first time, at a number of locations in the town. PM sampling was proposed following the early survey work but was not a priority. The recent Wider West Coast sampling programme included Hokitika as it is one of the largest towns on the West Coast and there had been no further monitoring undertaken in the town since 2003.

5.2. PM surveys

A preliminary investigative spatial survey of PM_{10} and $PM_{2.5}$ were undertaken in Hokitika in winter 2024. WCRC Purple Air monitors were installed at five locations around the town. Due to technical issues with some of the instruments, data collection was not consistent across sites however Initial findings from this survey indicated that there may be air quality issues that require further investigation (Figure 74 and Figure 75).

Purple Air devices are used for investigative purposes and are not considered accurate enough to compare to standards however they are useful for looking at spatial variation. Although indicative only, the maps below show $PM_{2.5}$ and PM_{10} exceedances of guidelines at sites around Hokitika, especially in central Hokitika. This showed that further investigation of PM could be beneficial to gaining a better understanding of the state of Hokitika air quality

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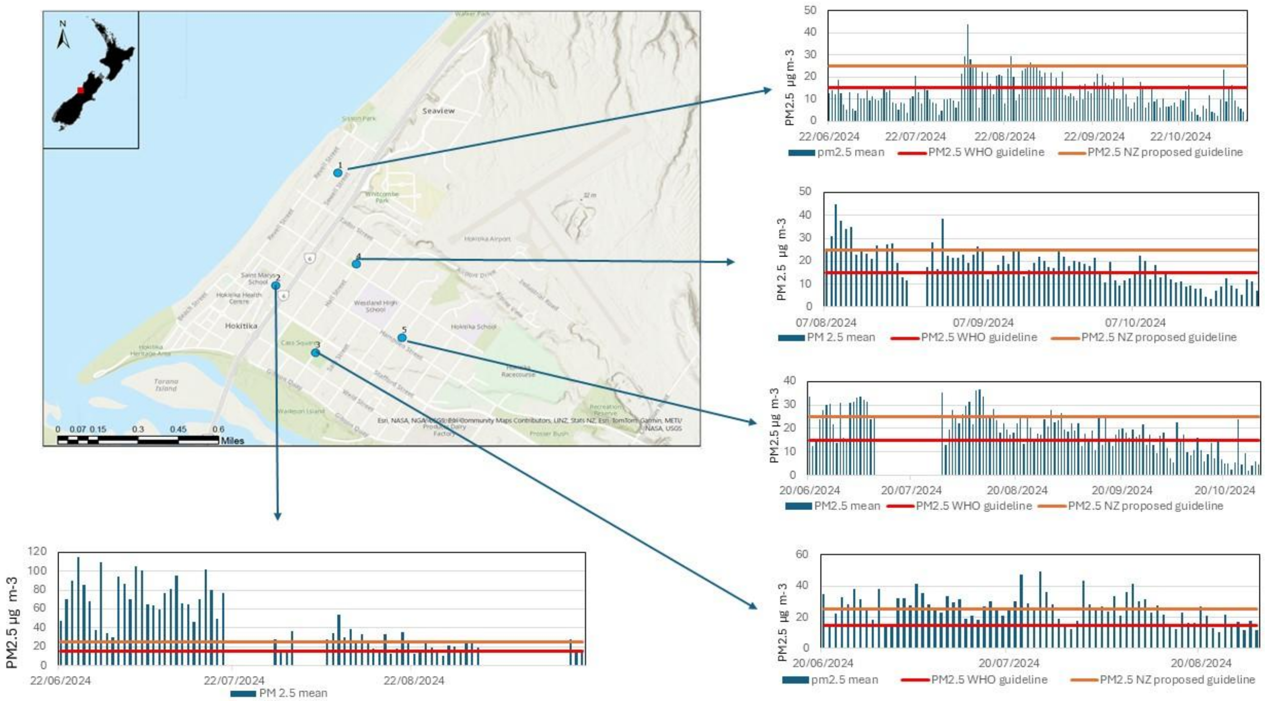

Figure 74. Map showing Hokitika monitoring site locations from winter 2024 Purple Air spatial survey and associated daily average $PM_{2.5}$ data. Comparison to guidelines / standards is indicative only as Purple Air devices are used for investigative monitoring and are not considered NES standard instruments.

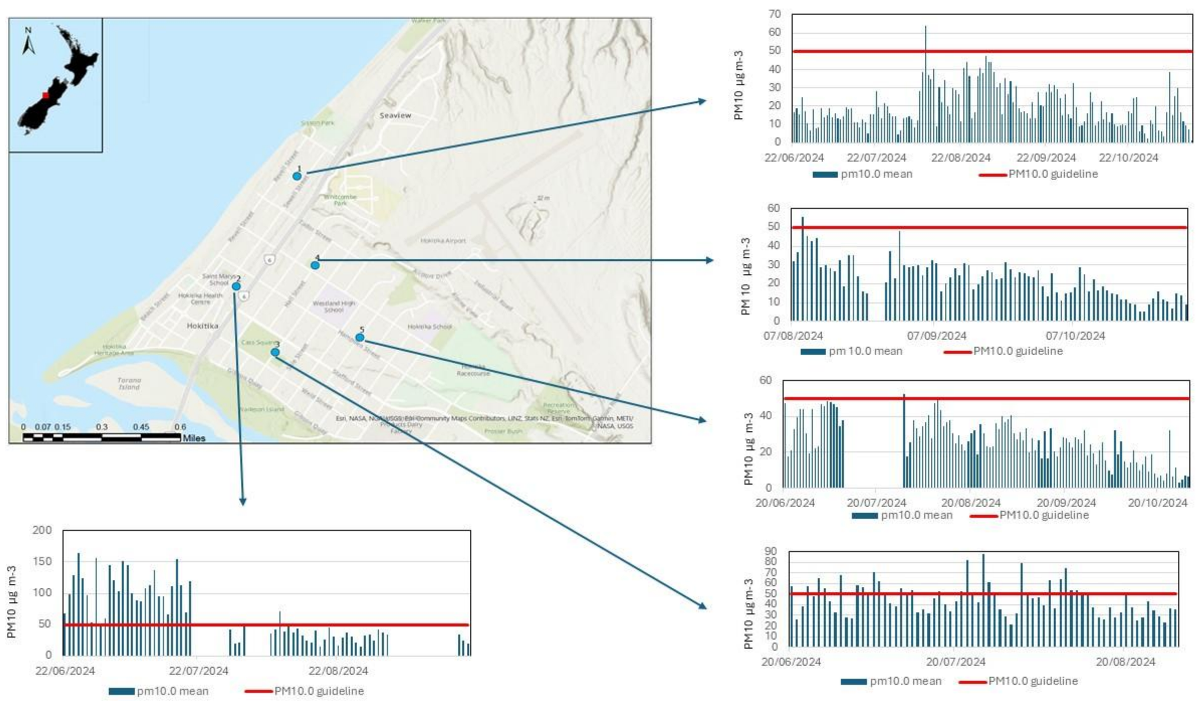

Figure 75. Map showing Hokitika monitoring site locations from winter 2024 Purple Air spatial survey and associated daily average PM_{10} data. Comparison to guidelines / standards is indicative only as Purple Air devices are used for investigative monitoring and are not considered NES standard instruments.

A more comprehensive survey was subsequently undertaken in Hokitika in winter 2025. This survey was carried out by Mote Ltd. Twelve minimote units were distributed around the town to provide improved spatial coverage. Data from both surveys have shown the typical pattern of PM being related to the burning of solid fuels for domestic heating. Figure 76, for example, shows the typical diurnal pattern of PM measured at all minimote units in a particular week in winter 2025.

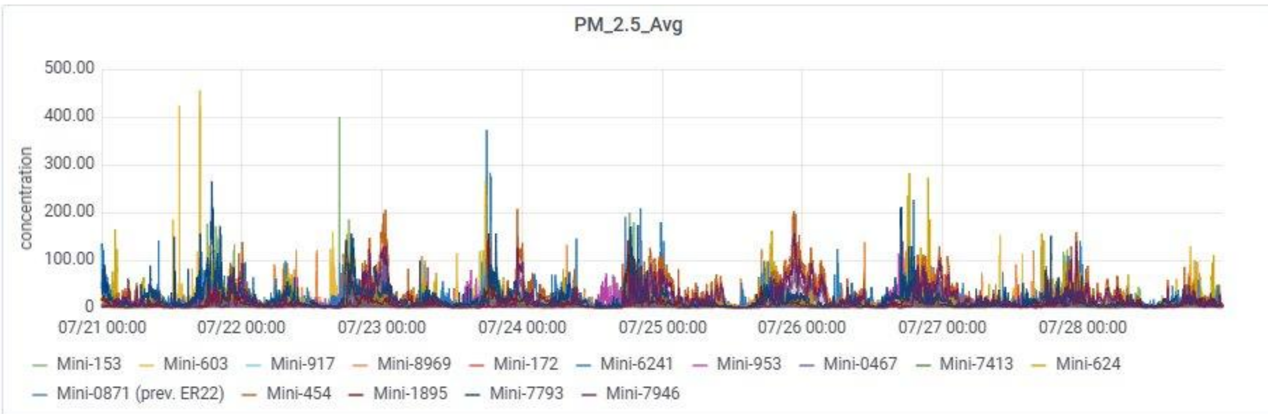

Figure 76. Map showing Hokitika continuous $PM_{2.5}$ data collected over an example week in winter 2025 (21-28 July). Data shows diurnal changes typical of a domestic home heating source.

Results from the surveys have shown that there is spatial variation in PM around the town. Data from the more comprehensive winter 2025 survey has shown higher levels of PM_{10} and $PM_{2.5}$ on the western side of the town.

Following co-location work to assess the accuracy of minimote instruments, data from the minimote units were adjusted using the correction factors applied to the Westport T640x as aerosol conditions in Hokitika were deemed more similar to Westport than Reefton (being more inland and with a lower influence of sea salt). Any comparison to guidelines and/or standards is indicative only as these investigative instruments are not normally used for NES monitoring.

There were no exceedances of the current WHO daily average guideline for $PM_{2.5}$ (15 µg/m^3) at any of the Hokitika sites. Based on the modest winter levels of $PM_{2.5}$ it is likely that Hokitika would also meet the WHO annual guideline (5 µg/m^3) as levels of PM outside winter months is generally lower. For PM_{10} data, only one site (Stafford Street) recorded a breach of the NESAQ daily average standard (50 µg/m^3) with measurements of 50.6 µg/m^3 and 52.7 µg/m^3. Both these values are within the instrument level of uncertainty (Baynham P. , 2025).

Overall, air quality in Hokitika is likely to comply with both the NESAQ and the WHO guidelines, however data collection with a higher quality instrument would be required to provide greater certainty around this.

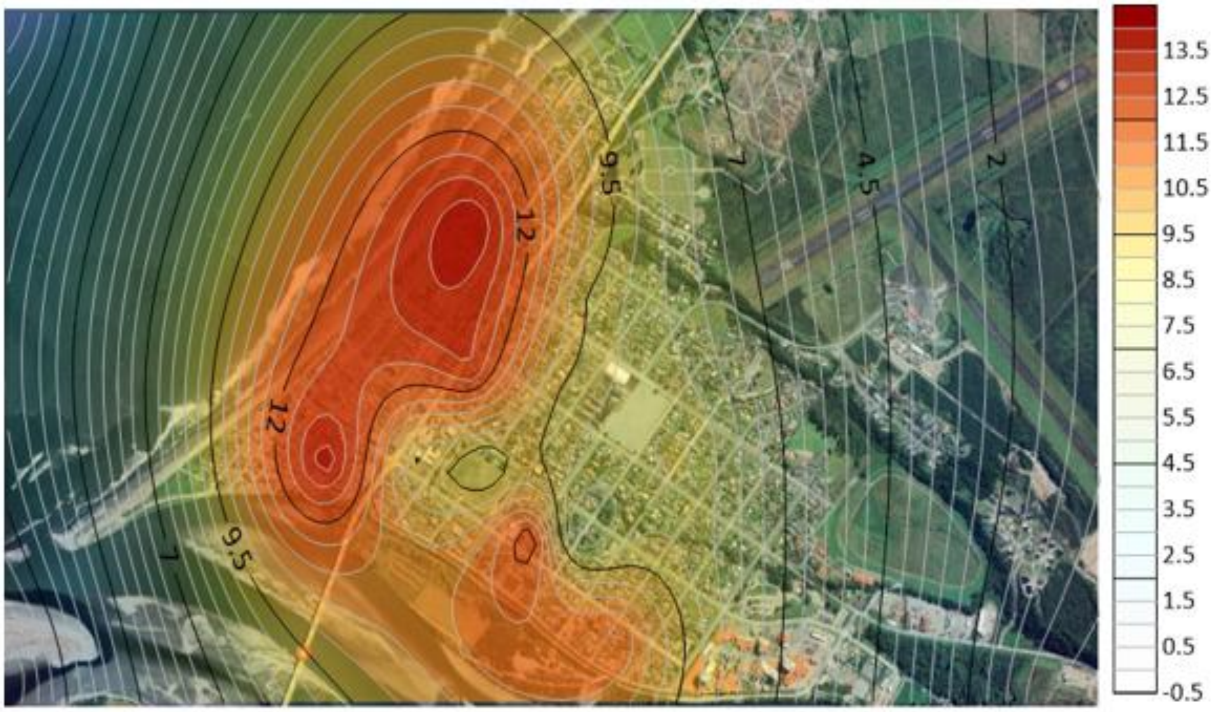

Figure 77. Map showing 95th percentile daily $PM_{2.5}$ concentrations measured across all sites in Hokitika 31st May to 24th September 2025. Note that concentrations depicted did not all occur on the same day (Baynham P. , 2025).

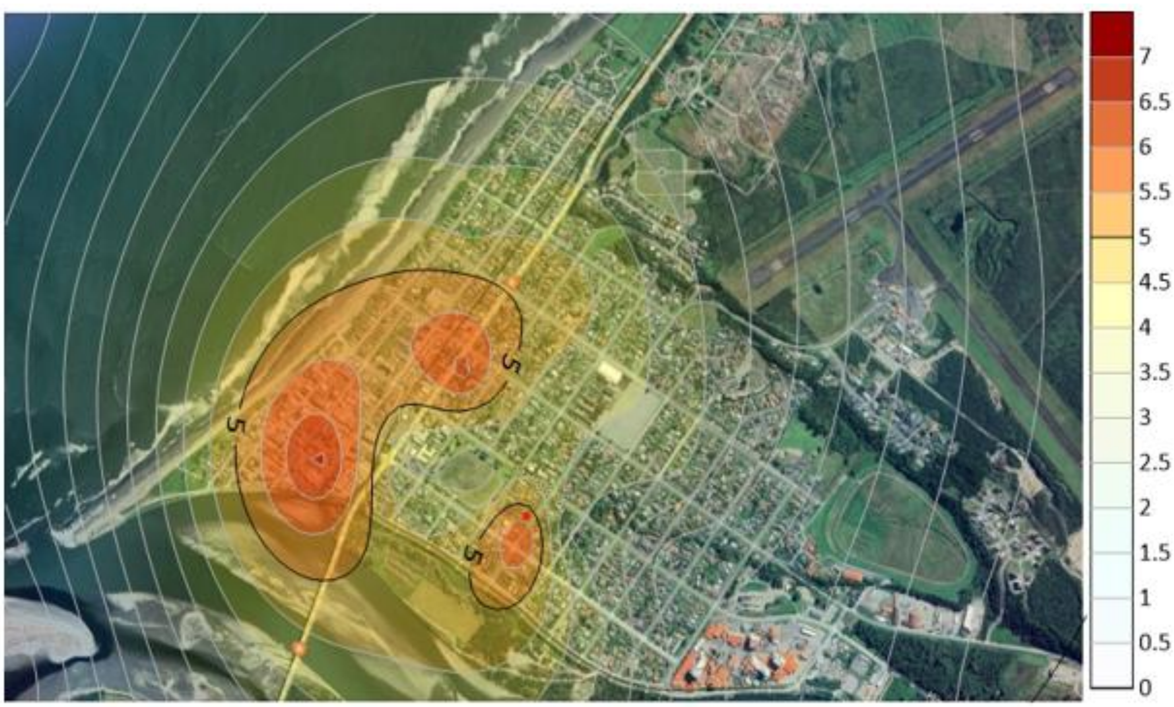

Figure 78. Map showing mean daily $PM_{2.5}$ concentrations across all sites in Hokitika 31st May to 24th September 2025. Note that concentrations depicted did not all occur on the same day (Baynham P. , 2025).

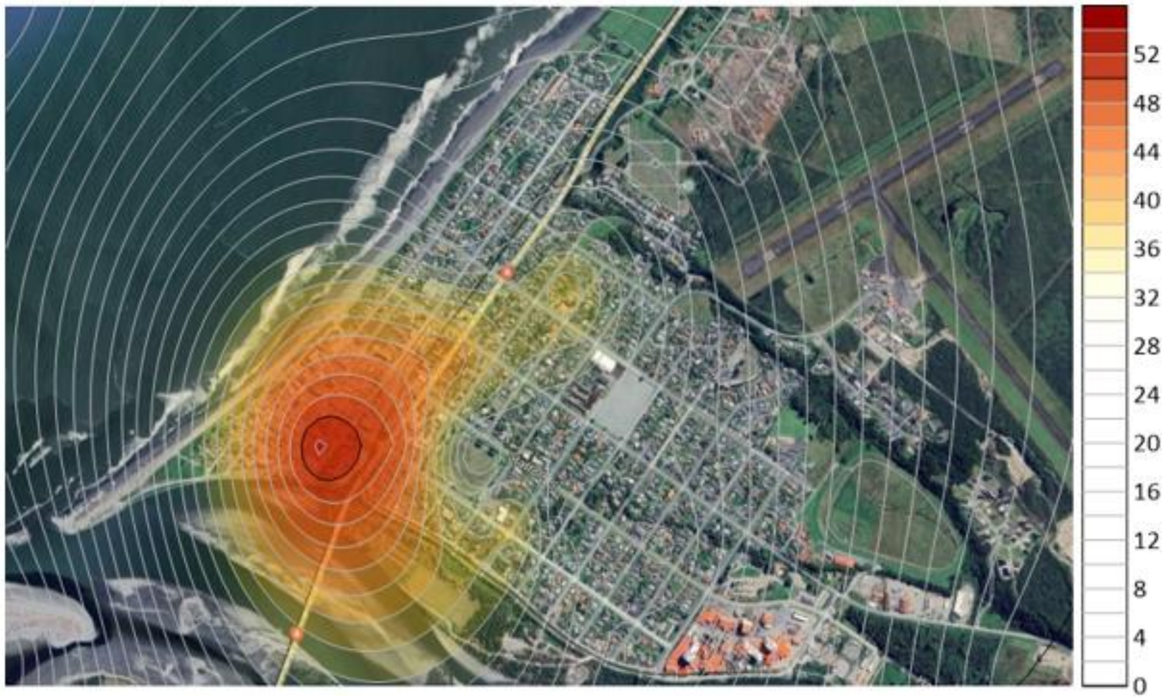

Figure 79. Map showing 95th percentile of PM_{10} daily concentrations measured across all sites in Hokitika 31st May to 24th September 2025. Note that concentrations depicted did not all occur on the same day (Baynham P. , 2025).

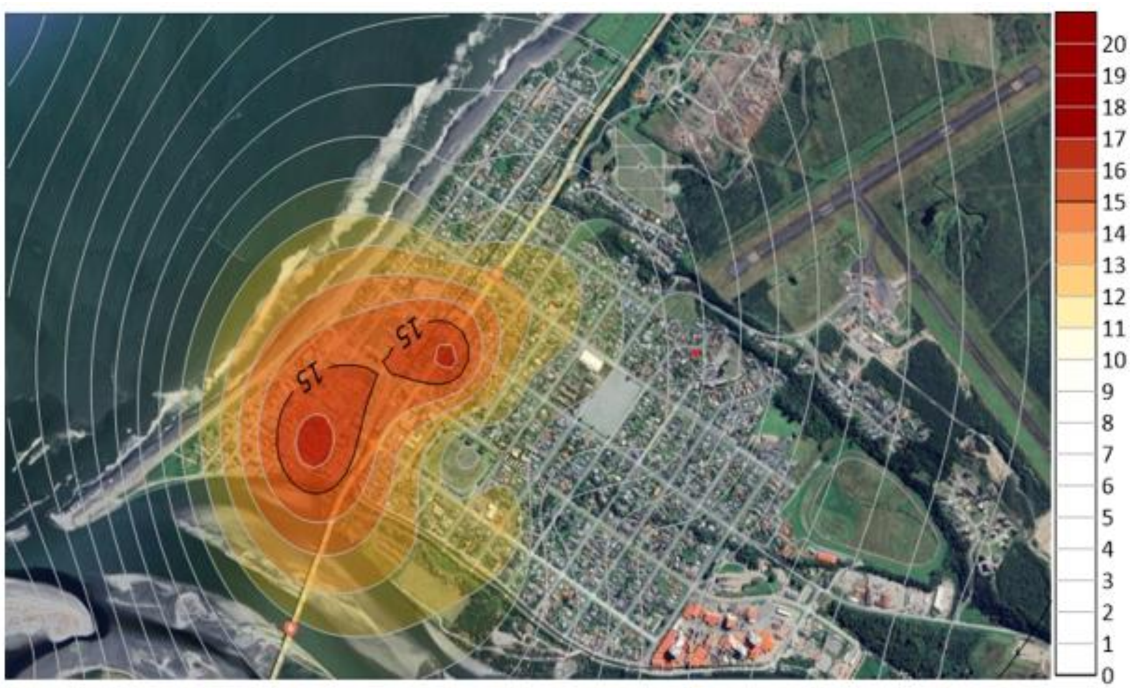

Figure 80. Map showing mean PM_{10} daily concentrations across all sites in Hokitika 31st May to 24th September 2025. Note that concentrations depicted did not all occur on the same day (Baynham P. , 2025).

Source apportionment of particulates collected on filters in Westport and Greymouth showed significant contributions of sea salt to the aerosol mix in these coastal towns. It is very likely that sea salt is contributing significantly to PM in Hokitika, especially the PM_{10} size fraction, due to the town's location very close to the coast.

Generally, the higher areas of PM_{10} and $PM_{2.5}$ also align with higher traffic areas around the main state highway through the town as well as around the central business district. Emissions from motor vehicles may be a contributing factor to PM in these areas.

Analysis of particle source would be needed to determine relative contributions of sources such as sea salt, motor vehicles and black carbon to the aerosol mix in Hokitika. This work could be undertaken in future if deemed necessary.

Analysis of wind data (Figure 81) has shown that the predominant wind direction over winter at Hokitika is easterly, with a change in direction to more south-westerly in September. The easterly wind direction would align with drainage from the Hokitika Valley. Airborne particulates would be carried across the town in a westerly direction towards the Tasman Sea, helping to disperse air pollutants. In September there could be an increase in sea salt contributions with the greater prevalence of south-westerly winds.

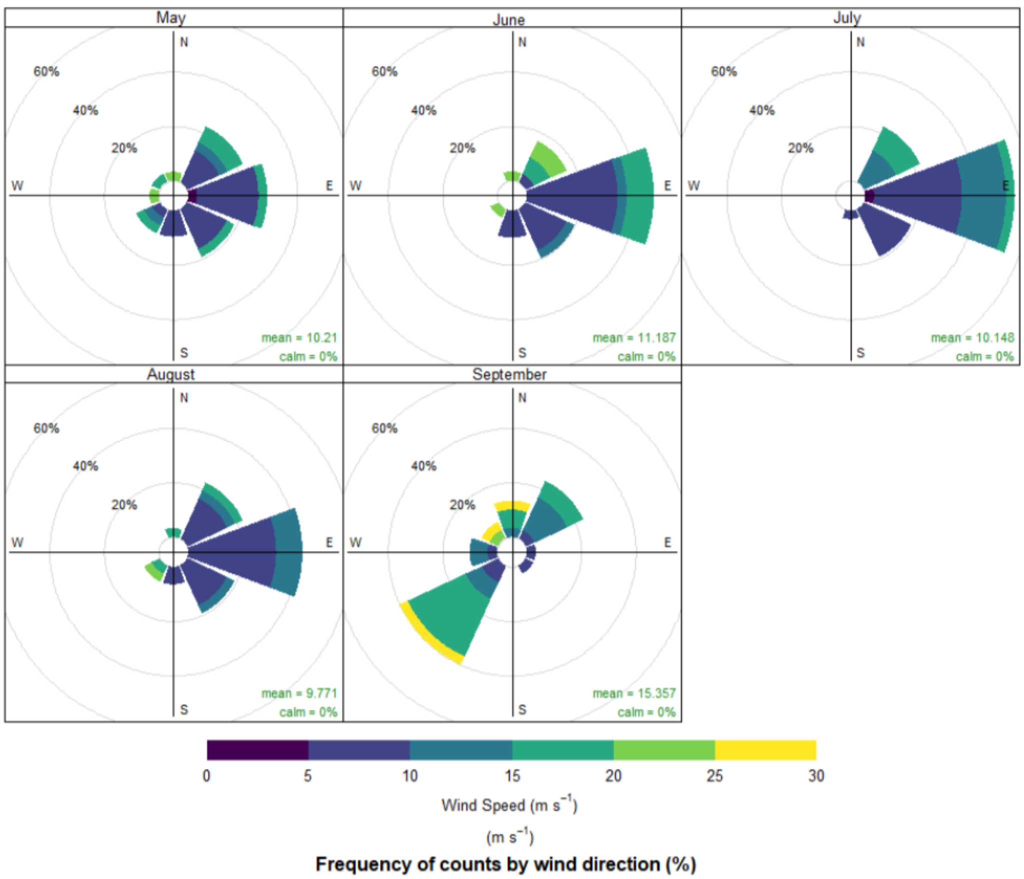

Figure 81. Wind rose showing daily average wind direction and speed for Hokitika May - September 2025.

Analysis of temperature and wind data for Hokitika from 2021 to 2025 has shown that 2024 and 2025 winters were generally representative of a typical Hokitika winter, with wind speed and temperature over June, July and August within similar ranges to the previous four winters (Figure 82 and Figure 83).

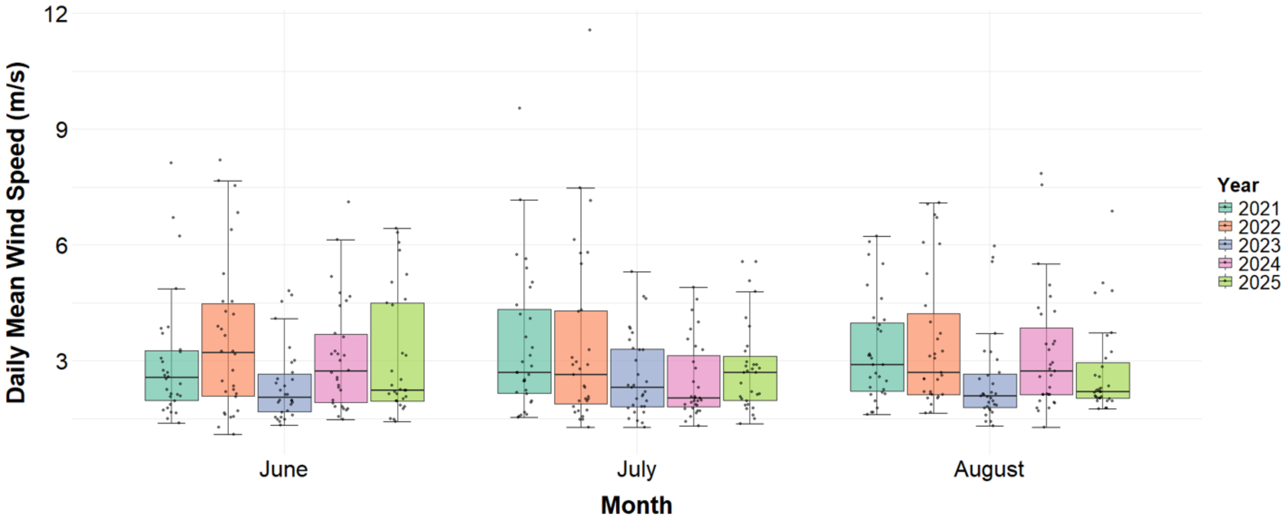

Figure 82. Hokitika daily mean wind speed June to August 2021 - 2025.

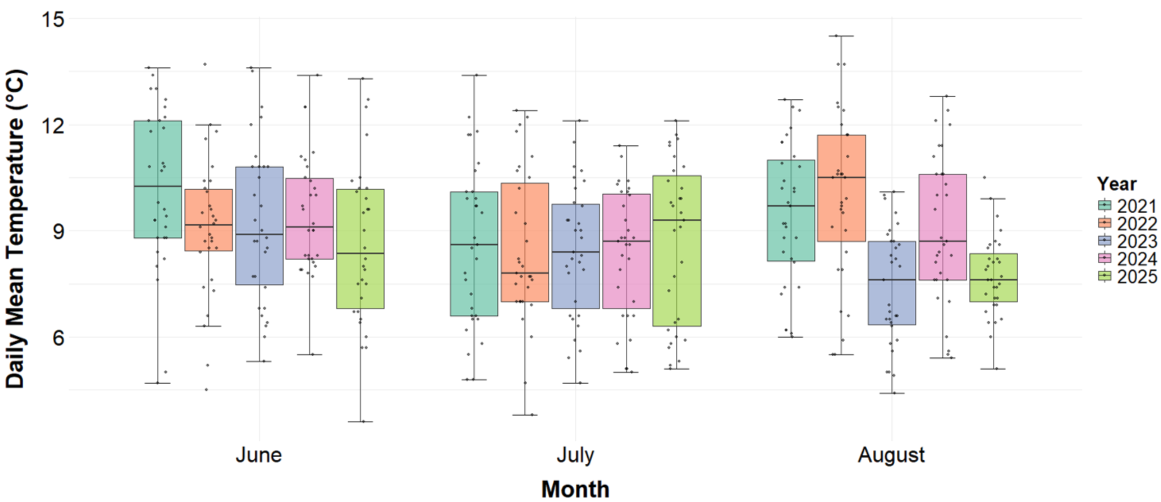

Figure 83. Hokitika daily mean temperature June - August 2021-2025.

5.3. Summary

Future monitoring in Hokitika could involve the temporary installation of reference or NES quality instruments to further investigate the potential for exceedances of the national standard and WHO guidelines. However, based on the 2025 survey data it is unlikely there is a significant PM issue in Hokitika. There is the potential for a localised area of elevated PM_{10}, but this is likely not indicative of the wider Hokitika air quality. Given the lower levels of PM recorded with the investigative instruments in Hokitika compared to other towns, further monitoring in this town may not be a priority.

6. Conclusions and recommendations

The long-term record for the Reefton airshed, together with the investigative monitoring undertaken at Westport, Greymouth and Hokitika between 2022 and 2025, provides the first regional picture of air quality on the West Coast. The conclusions below set out what that evidence now supports.

Domestic home heating is confirmed as the dominant source of particulate matter in the towns monitored. Continuous data from Reefton, Westport and Greymouth, and investigative data from Hokitika, all show the daily and seasonal patterns characteristic of solid fuel burning, with concentrations rising in the morning and evening and over the winter months. Source apportionment of filters from Westport and Greymouth places this beyond inference: biomass combustion from home heating was the largest single contributor to $PM_{2.5}$ at both sites.

$PM_{2.5}$ is a better measure of manageable air pollution on the West Coast than PM_{10}. Filter analysis showed that PM_{10} in the coastal towns contains a high proportion of sea salt and soil, both natural sources that cannot be managed and that on some days account for most of the measured mass. PM_{10} therefore overstates the pollution available to be reduced, whereas $PM_{2.5}$ tracks the anthropogenic fraction and is also the fraction of greatest concern for human health. The proposed shift of the national standard to a $PM_{2.5}$ basis is well supported by the West Coast data.

Measured against the current standard the region is compliant outside Reefton; measured against $PM_{2.5}$ guidelines it is not. Reefton remains the only gazetted airshed and the only town with a record of breaching the national standard, and monitoring must continue there for at least a further five years. No exceedance of the PM_{10} daily standard was recorded with NES quality instruments at any other town over the 2022 to 2025 winters. The World Health Organisation daily guideline for $PM_{2.5}$ of 15 $\mu g/m^3$ was, however, exceeded at Westport and Greymouth as well as at Reefton. This distinction matters because the proposed amendments to the NESAQ would move regulation onto a $PM_{2.5}$ basis, and the Greymouth record is not yet long enough to calculate an annual average for comparison with the proposed annual standard.

The apparent improvement in Reefton air quality since 2016 is attributable to the change of monitoring site rather than to a real reduction in emissions. Fewer exceedances have been recorded at the Reefton Area School site, but the spatial surveys of 2020 and 2021, and the trend assessments of 2013 and 2021, all indicate that this reflects the more sheltered and less central position of that site. Operating both sites since 2024 allows the difference between them to be quantified directly.

Air quality varies spatially and temporally across towns so investigative surveys are useful to help determine the best location for continuous monitoring sites, which should be indicative of the worst case air quality in a town / airshed. Every spatial survey found concentrations differing markedly over a few hundred metres, consistently higher in the more built-up central areas and lower towards the town edges. Finding appropriate locations for siting air quality instruments can be challenging and at Westport, the evaluation following the 2023 survey indicated that the Club Buller site, chosen following the 2022 survey, is likely to measure $PM_{2.5}$ at close to half the concentration of the peak area of winter 2023 at the northern end of Derby Street.

Climate and geography account for much of the difference between towns. Reefton's low wind speeds and enclosing hills suppress dispersion and trap locally generated emissions, which is why it is the town with a history of exceedances. The coastal towns disperse emissions more readily but receive substantial marine aerosol, which raises measured PM_{10} without indicating a problem that can be managed.

Air quality in Hokitika is unlikely to be a problem based on sampling to date. Concentrations were the lowest of the towns surveyed, with no exceedance of the WHO daily guideline for $PM_{2.5}$ and a single site marginally above the PM_{10} standard, within the uncertainty of the instruments. This conclusion rests on investigative grade instruments and firming it up would require further sampling using reference grade instruments.

6.1. Recommendations for future sampling:

- Continue monitoring the Reefton airshed as required under the NESAQ, maintaining both the Cnr Lucas Street and Buller Road site and the Area School site so that the effect of the 2016 relocation can be resolved.
- Continue monitoring at the Greymouth High School site for at least one further winter, to assess the variation between winters arising from meteorological conditions.
- Complete the winter 2026 comparative monitoring at the second Greymouth site to the north-east, to establish which part of the town has the greater potential for elevated PM and whether further monitoring is required.
- In Westport, undertake comparative monitoring between the Club Buller site and a location further to the north-east, to determine whether air quality is poorer in that part of the town.
- Use MetOne E-SEQ-FRM reference machines at two locations in Hokitika to allow comparison with the national standard and further assess the potential for exceedances.
- Undertake source apportionment for Hokitika, restricting the analysis to black carbon if cost needs to be reduced.
- Undertake source apportionment analysis of the Reefton filters held in storage from the 2021 co-location work. This would help to confirm assumptions around the difference in sources between Reefton and other coastal towns.
- Undertake an updated Reefton emissions inventory to identify any change in heating methods and fuel use in the airshed since 2019.
- Undertake a more comprehensive investigative survey in Cobden, where only one site was monitored as part of the 2022 wider Greymouth survey.
- Complete the winter 2026 spatial survey of Runanga and Dunollie and use the results to determine whether further monitoring is required in those areas.
- Undertake basic emission density mapping or emissions inventory work for a priority list of smaller townships such as Dobson, to inform planning for future monitoring.
- Explore the use of a black carbon monitor alongside PM sampling at coastal sites, to better quantify the contribution of home heating emissions to PM_{10} and $PM_{2.5}$, particularly on days when the national standard is exceeded.
- Provide for $PM_{2.5}$ monitoring capability in future air quality monitoring strategies, in anticipation of the proposed move to a $PM_{2.5}$ based national standard.

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7.1. Table of Figures