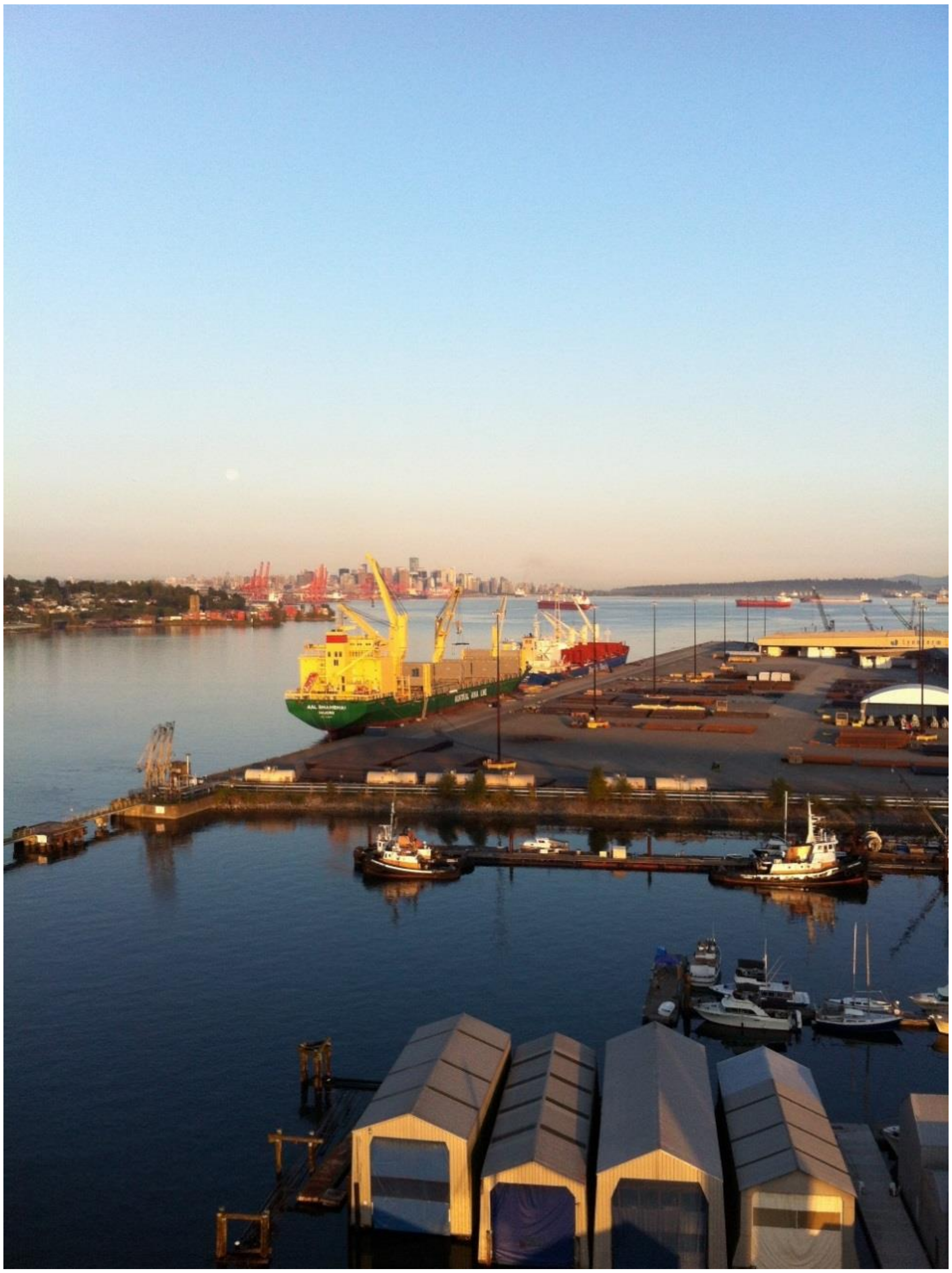
2014 Lower Fraser Valley Air Quality Monitoring Report



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Several government partners are acknowledged for contributing to the monitoring network including: Fraser Valley Regional District, Environment Canada and BC Ministry of Environment. Other partners acknowledged for providing funding to the monitoring network are: Vancouver Airport Authority, Chevron Canada Ltd., Kinder Morgan Canada, and Port Metro Vancouver.

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Summary

This annual report summarizes the air quality monitoring data collected by the Lower Fraser Valley (LFV) Air Quality Monitoring Network in 2014 and describes the air quality monitoring activities and programs conducted during the year. The main focus is to report on the state of ambient (outdoor) air quality in the LFV.

LFV Air Quality Monitoring Network

The LFV Air Quality Monitoring Network includes 28 air quality monitoring stations located from Horseshoe Bay in West Vancouver to Hope. Metro Vancouver operates 22 stations in Metro Vancouver, as well as 6 stations in the Fraser Valley Regional District (FVRD) in partnership with the FVRD.

Air quality and weather data from all but one station are collected automatically on a continuous basis, transmitted to Metro Vancouver's Head Office in Burnaby, and stored in an electronic database. The data are then used to communicate air pollutant information to the public, such as through air quality health index (AQHI) values and on airmap.ca.

Air quality monitoring stations are located throughout the LFV to provide an understanding of the air quality levels that residents are exposed to most of the time. This report shows how these levels have varied throughout the region in 2014 and how these levels have changed over time. Trends in air quality measured by the Air Quality Monitoring Network are used to evaluate the effectiveness of pollutant emission reduction actions undertaken as part of Metro Vancouver's Integrated Air Quality and Greenhouse Gas Management Plan.

Specialized Air Quality Monitoring

In addition to the fixed monitoring network stations, Metro Vancouver deploys portable air quality stations and instruments to conduct specialized monitoring studies. Specialized studies typically investigate suspected problem areas (or "hot spots") at the local, neighbourhood or community level. Three specialized studies were initiated in 2014 that included monitoring in the City of North Vancouver and two studies to assess air quality related to the movement of coal by trains in White Rock and Delta.

Visual Air Quality

Visual air quality (sometimes referred to as visibility or haze) can become degraded in the LFV, causing local views to become partially obscured. Haze may have different characteristics depending on the underlying cause. In much of Metro Vancouver, especially the more urbanized areas to the west, haze can have a brownish appearance. Nitrogen dioxide from transportation sources contributes to this colouration. Further east in the LFV, impaired visibility is often associated with a white haze caused by small particles ($PM_{2.5}$) in the air that scatter light.

Monitoring is conducted to assess visual air quality and includes measurements of $PM_{2.5}$ and particle constituents (for example, particulate nitrate, particulate sulphate, elemental carbon and organic carbon), ammonia and light scattering. Ten automated digital cameras are also operated throughout the LFV to record views along specific lines of sight. By examining photographs alongside the pollutant measurements, visibility impairment can be related to pollutant concentrations and their sources. The data collected provide important information for a multi-agency initiative to develop a visual air quality management strategy for the LFV.

Pollutants Monitored

Pollutants are emitted to the air from a variety of human activities and natural phenomena. Once airborne, the resulting pollutant concentrations are dependent on several factors, including the weather, topography and chemical reactions in the atmosphere.

Common air contaminants, including ozone (O_3), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter, are widely monitored throughout the network. Particulate matter is composed of very small particles that remain suspended in the air. They are further distinguished by their size, which is measured in units of a millionth of a metre (or micrometre).

Particles with a diameter smaller than 10 micrometres are referred to as inhalable particulate (PM_{10}), while those smaller than 2.5 micrometres are termed fine particulate ($PM_{2.5}$). Both PM_{10} and $PM_{2.5}$

concentrations are monitored at stations throughout the LFV.

Other pollutants less widely monitored in the network include ammonia (NH_3), black carbon (BC), volatile organic compounds (VOC), and total reduced sulphur compounds (TRS).

Air Quality Health Index (AQHI)

Developed by Environment Canada and Health Canada, the Air Quality Health Index (AQHI) communicates the health risks associated with a mix of air pollutants to the public and provides guidance on how individuals can adjust their exposure and physical activities as air pollution levels change. The AQHI is calculated every hour using monitoring data from stations in the LFV.

Current AQHI levels in the LFV as well as the AQHI forecasts (for today, tonight and tomorrow) and additional information about the AQHI are available at:

- www.airmap.ca (shown below)
- www.airhealth.ca
- www.bcairquality.ca/readings

Air Quality Objectives and Standards

Several pollutant-specific air quality objectives and standards are used as benchmarks to characterize air quality. They include Metro Vancouver and provincial ambient air quality objectives, and the federal Canadian Ambient Air Quality Standards (for ozone and particulate matter) which replace the previous Canada-Wide Standards.

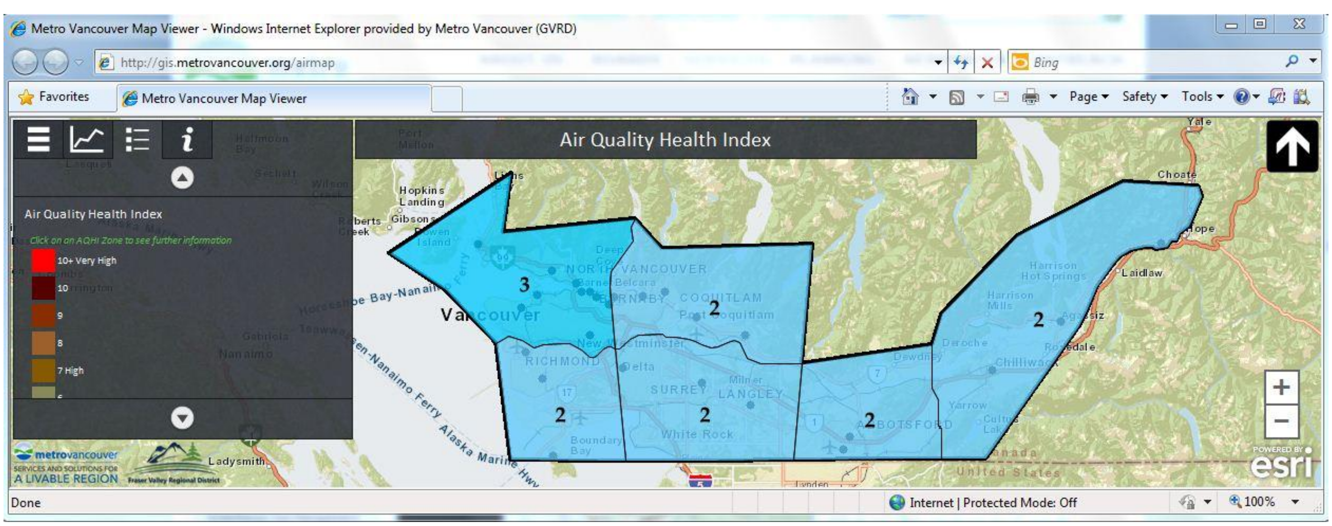
As part of Metro Vancouver's 2005 Air Quality Management Plan, health-based ambient air quality objectives were set for ozone (O_3), particulate matter ($PM_{2.5}$ and PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and carbon monoxide (CO), based on a review of the most stringent objectives of other jurisdictions.

In 2009, the provincial government established air quality objectives for $PM_{2.5}$. The 24-hour objective is numerically the same as Metro Vancouver's objective, however compliance with Metro Vancouver's objective requires no exceedances while the provincial objective allows for some exceedances each year.

The province's annual objective of 8 micrograms per cubic metre and annual planning goal of 6 micrograms per cubic metre are more stringent than the annual objective previously set by Metro Vancouver in 2005.

In the October 2011 Integrated Air Quality and Greenhouse Gas Management Plan, Metro Vancouver tightened its annual objectives for $PM_{2.5}$ aligning them with those set by the province in 2009 as well as adopting a one hour ozone objective of 82 parts per billion.

The federal Canadian Ambient Air Quality Standards (CAAQS) have been established as objectives under Canadian Environmental Protection Act 1999, and replaced Canada-Wide Standards for ozone and fine particulate. In May 2015 Metro Vancouver adopted a 1-hour interim ambient air quality objective for SO_2 of 75 parts per billion, not to be exceeded.



Air Quality Health Index (available at airmap.ca)

Priority Pollutants

Research indicates that adverse health effects can occur at the air contaminant concentrations measured in the LFV. Health experts have identified exposure to ozone and particulate matter as being associated with the most serious health effects. Ozone is a strong oxidant that can irritate the eyes, nose and throat, and reduce lung function. $PM_{2.5}$ particles are small enough to be breathed deeply into the lungs, resulting in impacts to both respiratory and cardiovascular systems. Long-term exposure to these pollutants can aggravate existing heart and lung diseases and lead to premature mortality.

Of particular concern is $PM_{2.5}$ that is emitted from diesel fuel combustion in car, truck, marine, rail and non-road engines. These particles ("diesel PM") are carcinogenic and are believed to contribute significantly to the health effects described above. Instrumentation installed in some air quality monitoring stations in the LFV can be used to estimate the proportion of particles that originate from diesel engines.

Air Quality Advisories

Periods of degraded air quality can occur in the LFV for several reasons, such as summertime smog during hot weather or smoke from forest fires. Air quality advisories are issued to the public when air quality has deteriorated or is predicted to deteriorate within the LFV. In the last ten years, the number of days when air quality advisories were in place ranged from zero to as many as ten days annually.

In 2014, an air quality advisory was issued for two days in July and one day in August. The advisory in July was due to high concentrations of ground-level ozone while the advisory in August was the result of elevated $PM_{2.5}$, primarily due to smoke from wildfires outside our region.

Regional Long-Term Trends

Long-term *regional* trends in air quality are the trends observed within the LFV as a whole. They are determined by averaging measurements from several stations distributed throughout the LFV.

Figures S1 to S4 show the average concentrations and the short-term peak concentrations of four common air contaminants for the last two decades.

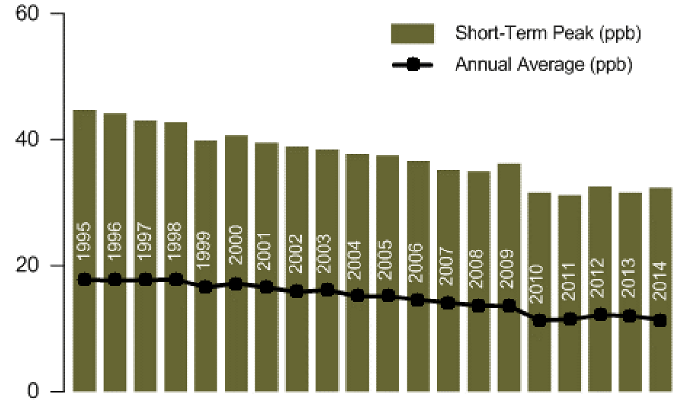


Figure S1: Nitrogen Dioxide Trend

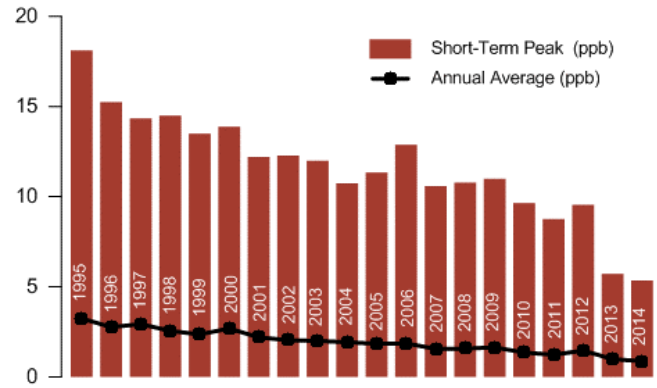


Figure S2: Sulphur Dioxide Trend

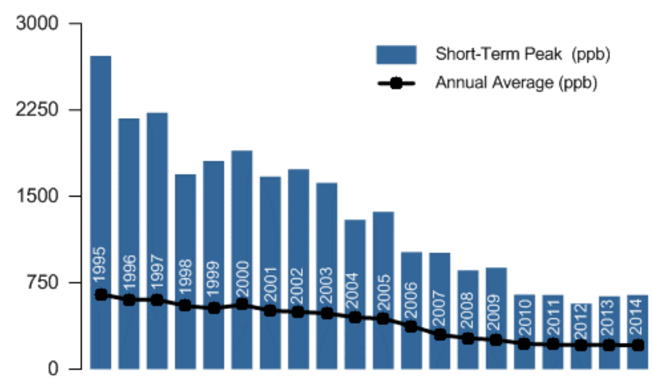


Figure S3: Carbon Monoxide Trend

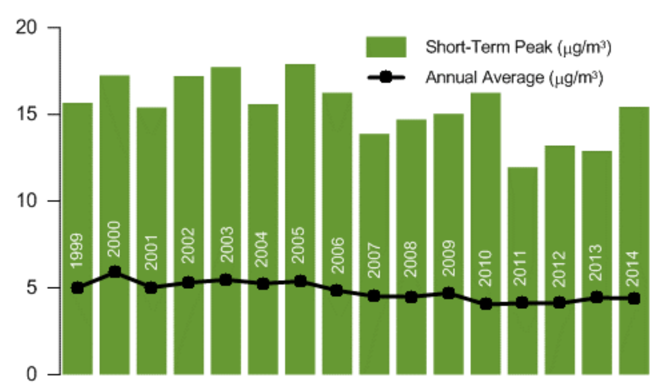


Figure S4: Particulate Matter ($PM_{2.5}$) Trend

Average concentrations represent the ambient concentrations that the region experiences most of the time. Short-term peak concentrations show the relatively infrequent higher concentrations experienced for short periods (on the scale of one hour to one day). Specific locations may have experienced trends that differ slightly from the regional picture.

Improvements have been made over the last two decades for most pollutants, including carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter ($PM_{2.5}$). Both short-term peak and average concentrations have declined since the early nineties for all these pollutants.

Despite significant population growth in the region over the same time period, actions to reduce emissions across a variety of sectors have brought about these improvements in air quality. Stricter vehicle emission standards and the AirCare program are largely responsible for lower carbon monoxide (CO) and nitrogen dioxide (NO_2) levels.

Reduced sulphur in marine, on-road and off-road fuels, the shutdown of two refineries in Metro Vancouver and reduced emissions from the cement industry have led to the measured improvements in sulphur dioxide (SO_2) levels. Emission reductions from light duty and heavy duty vehicles, wood products sectors, and petroleum refining have contributed to the decline in $PM_{2.5}$ levels.

The regional $PM_{2.5}$ trends since 1999, when continuous $PM_{2.5}$ monitoring became prevalent throughout the LFV, are illustrated in Figure S4. These data also indicate that peak $PM_{2.5}$ levels have been relatively constant in recent years, although with some year-to-year variability. Figure S5 shows long-term $PM_{2.5}$ trends from a single monitoring station with a long record of non-continuous filter-based monitoring at the Port Moody station.

For ozone, the same improvements seen for other pollutants have not been observed. In contrast, average regional ozone levels (Figure S6) have shown a slight increasing trend. Research suggests that background ozone concentrations are rising and are one reason for the observed increase in average levels.

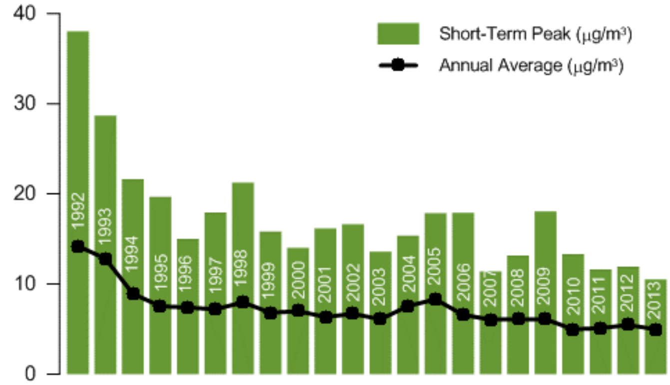


Figure S5: Port Moody $PM_{2.5}$ Trends

Regionally averaged short-term peak ozone trends are shown in Figure S6 and display year to year variability. The severity of peak ozone episodes greatly diminished in the 1980s, however short-term peak ozone levels have been mainly unchanged during the last two decades, despite large reductions in emissions of pollutants that contribute to ozone formation.

In 2014, Metro Vancouver and the Fraser Valley Regional District endorsed the Regional Ground-Level Ozone Strategy, which provides strategic policy direction for ozone management in the LFV based on local scientific research. Research indicates that a spatial understanding of the ratio of concentrations of nitrogen oxides (NO_X) and volatile organic compounds (VOC), two precursor pollutants that react to form ozone, is key to determining which precursors to reduce in order to maintain and improve air quality in our region.

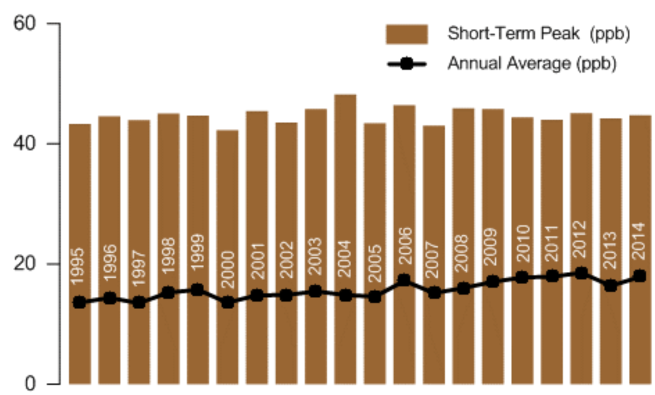


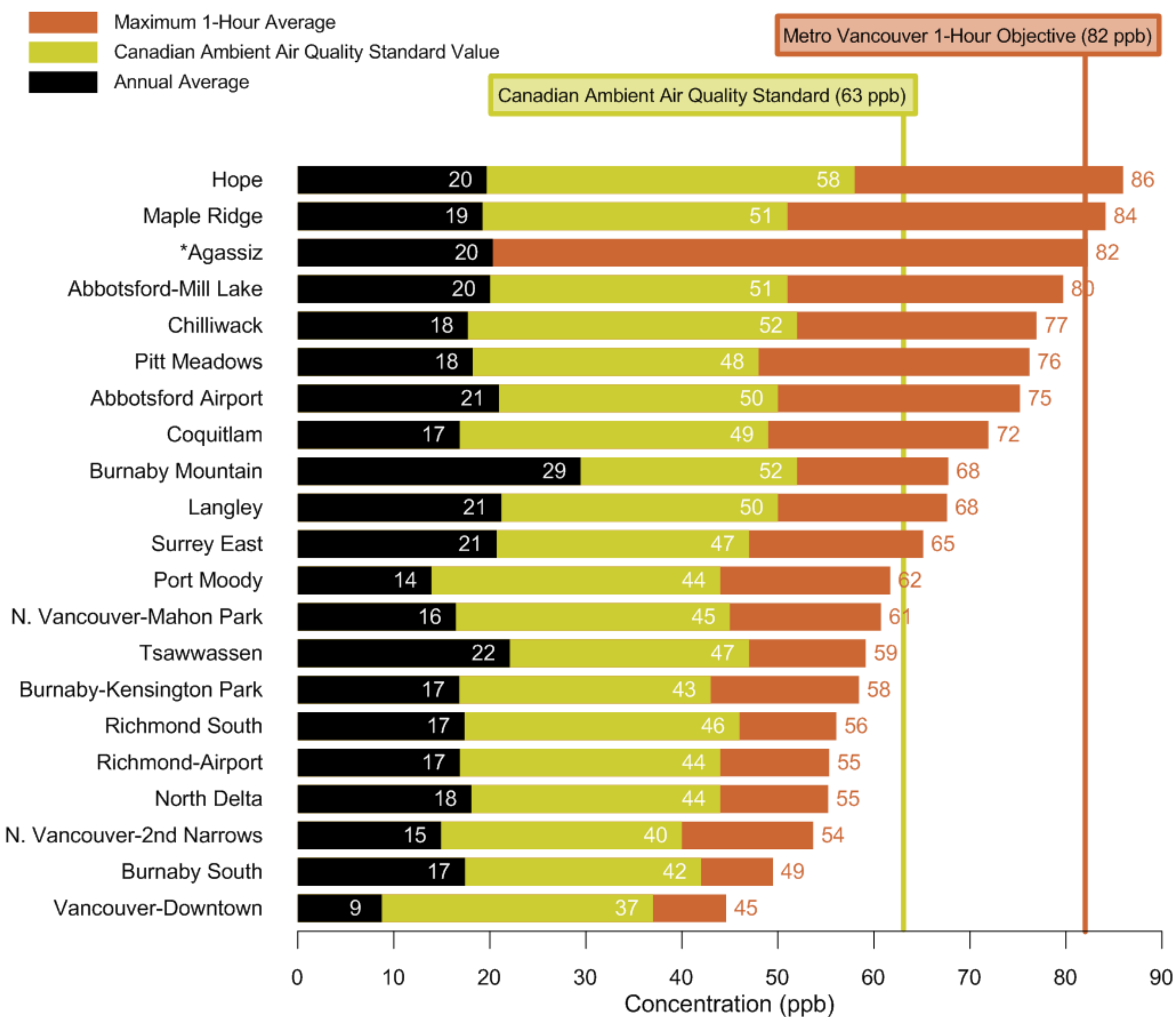
Figure S6: Ozone Trends

Ground-Level Ozone – 2014

Monitoring results for all ozone monitoring stations with sufficient data coverage during 2014 are shown in Figure S7. The data show that peak ozone levels, as measured by the Canadian Ambient Air Quality Standard and maximum 1-hour average values, occurred in the eastern parts of Metro Vancouver and in the FVRD during sunny and hot weather.

In 2014, the Canadian Ambient Air Quality Standard for ozone was met at all monitoring stations. However, Metro Vancouver's 1-hour objective was exceeded at Hope, Maple Ridge and Agassiz on July 13 and an air quality advisory was issued on this day. The advisory was continued on July 14, on a precautionary basis, however levels were less than anticipated and objectives were not exceeded. The 8-hour Metro Vancouver objective was exceeded on July 13 at six stations and on August 11 at a new monitoring station in Mission (not shown, as it only operated for part of the year).

> Ground-level ozone is a secondary pollutant formed in the air from other contaminants such as nitrogen oxides (NO_X) and volatile organic compounds (VOC). The highest concentrations of ozone occur during hot sunny weather.
>
> NO_X emissions are dominated by transportation sources, with nearly 80% of emissions coming from cars, trucks, marine vessels, and non-road engines. VOC are emitted from natural sources (e.g., trees), cars, light trucks, and solvents found in industrial, commercial and consumer products.



*The Agassiz station started operation in June 2013 and has not operated long enough to calculate the 3-year CAAQS value.

Figure S7: Ozone (O_3) 2014.

Fine Particulate Matter ($PM_{2.5}$) – 2014

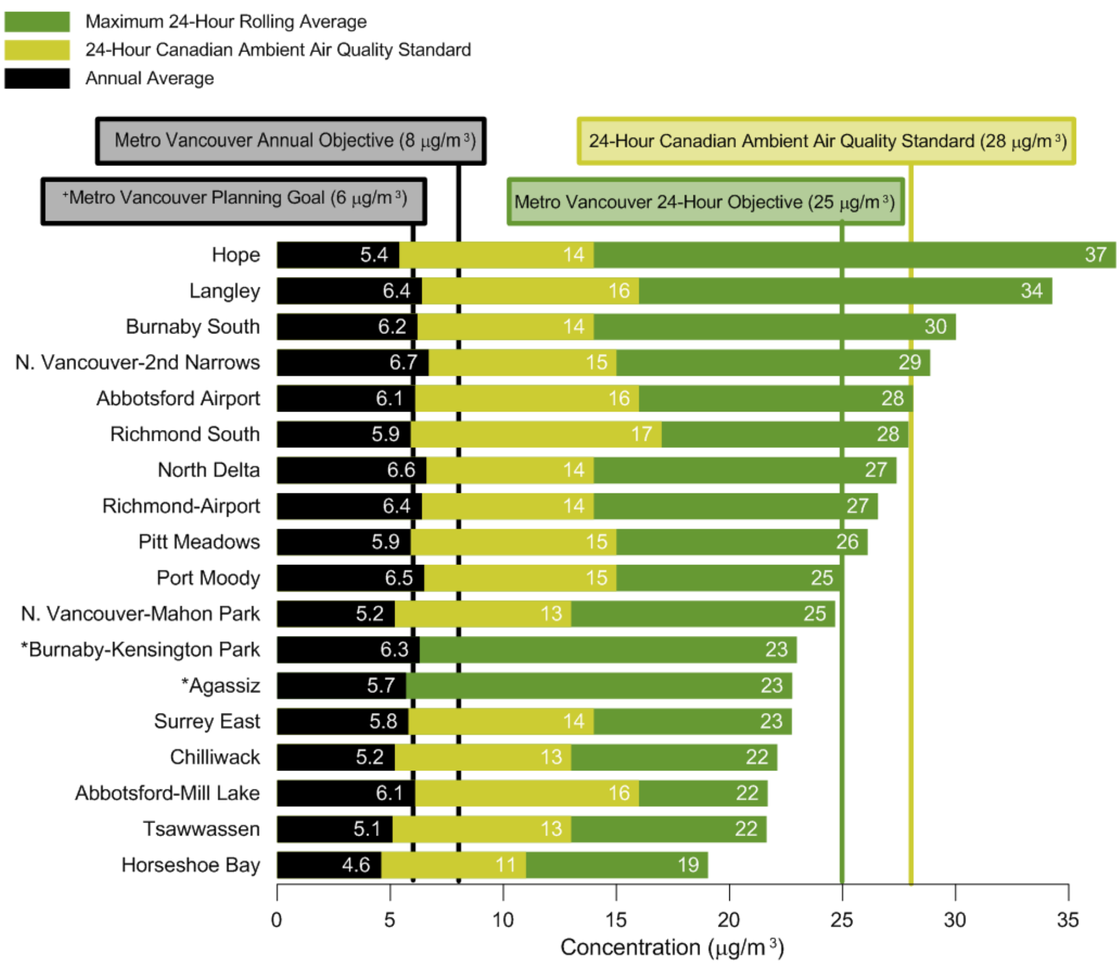
Results for all $PM_{2.5}$ monitoring stations with sufficient data coverage during 2014 are shown in Figure S8. The Canadian Ambient Air Quality Standard values for two stations are not shown in Figure S8 because the data are incomplete for the year.

All stations were well below (i.e., better than) the Canadian Ambient Air Quality Standard for $PM_{2.5}$. All stations were below the Metro Vancouver annual objective of 8 µg/m^3 and half of the stations were below the planning goal of 6 µg/m^3.

Exceedances of Metro Vancouver's 24-hour $PM_{2.5}$ objective occurred at eleven stations during 2014. The objective was exceeded in Hope on August 12 and North Vancouver on August 12 and 13. An air quality advisory was initiated on August 12 for Metro Vancouver and the FVRD because of elevated $PM_{2.5}$, primarily due to smoke from wildfires outside our region.

Fine particulate matter ($PM_{2.5}$) emissions are dominated by transportation, wood and natural gas heating, and industrial sources. $PM_{2.5}$ is also formed by reactions of nitrogen oxides (NO_X) and sulphur dioxide (SO_2) with ammonia in the air. $PM_{2.5}$ produced in this manner is called secondary $PM_{2.5}$ and accounts for a significant portion of $PM_{2.5}$ in summer.

Numerous $PM_{2.5}$ exceedances were measured regionally during a seven day period from November 14 to 20 at a total of nine stations. During this time a persistent high pressure weather system caused stagnant weather conditions that limited dispersion. Given the stagnant conditions it is likely that local or nearby emission sources were largely responsible for the exceedances at this time.



*Data completeness criteria for the 3-year CAAQS value were not met.

+Metro Vancouver's Planning Goal of 6 µg/m^3 is a longer term aspirational target to support continuous improvement.

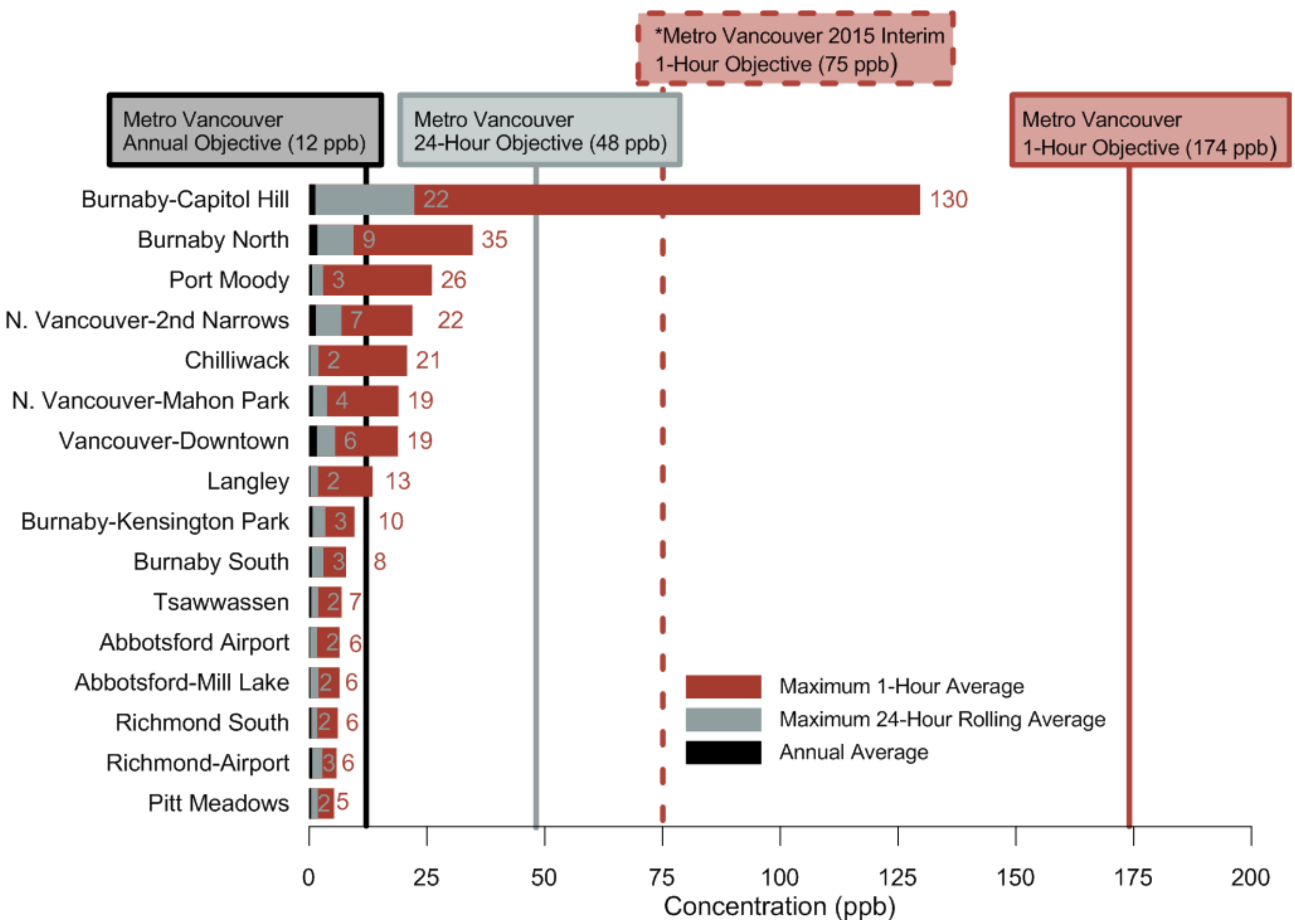
Figure S8: Fine Particulate Matter ($PM_{2.5}$) 2014.

Sulphur Dioxide – 2014

Monitoring results for sulphur dioxide (SO_2) monitoring stations in 2014 are shown in Figure S9. Sulphur dioxide levels were below the annual, hourly and 24-hour objectives at all stations in 2014.

With the exception of Burnaby-Capitol Hill all stations were below Metro Vancouver's new Interim 1-Hour Objective of 75 ppb adopted by Metro Vancouver in May 2015. The interim objective was exceeded at the Burnaby-Capitol Hill station for a total of four hours which occurred on January 23, 24, and 26 and May 1. These exceedances were likely the result of stagnant weather and poor dispersion conditions coupled with nearby emissions from the Chevron refinery and marine vessels in Burrard Inlet.

Sulphur dioxide is formed primarily by the combustion of fossil fuels containing sulphur. The largest sources in the LFV are marine vessels (mainly ocean-going vessels) and the petroleum products industry. As a result, the highest sulphur dioxide levels are typically measured near the Burrard Inlet area. Away from the Burrard Inlet area, sulphur dioxide levels are considerably lower.



*Metro Vancouver adopted a new Interim 1-hour objective of 75 ppb for SO_2 in May, 2015.

Figure S9: Sulphur Dioxide (SO_2) 2014.

Nitrogen Dioxide – 2014

Results for nitrogen dioxide (NO_2) monitoring in 2014 are shown in Figure S10. All stations experienced nitrogen dioxide levels that were below Metro Vancouver's 1-hour objective. Annual averages were also below Metro Vancouver's annual objective at all stations with sufficient data completeness. In 2014, as in past years, the highest average nitrogen dioxide levels were measured in downtown Vancouver, in a dense urban environment close to a busy street.

As nitrogen dioxide emissions are dominated by transportation sources, the highest average nitrogen dioxide concentrations are measured in the more densely trafficked areas and near busy roads. Lower concentrations are observed where these influences are less pronounced, such as the eastern parts of Metro Vancouver and in the FVRD.

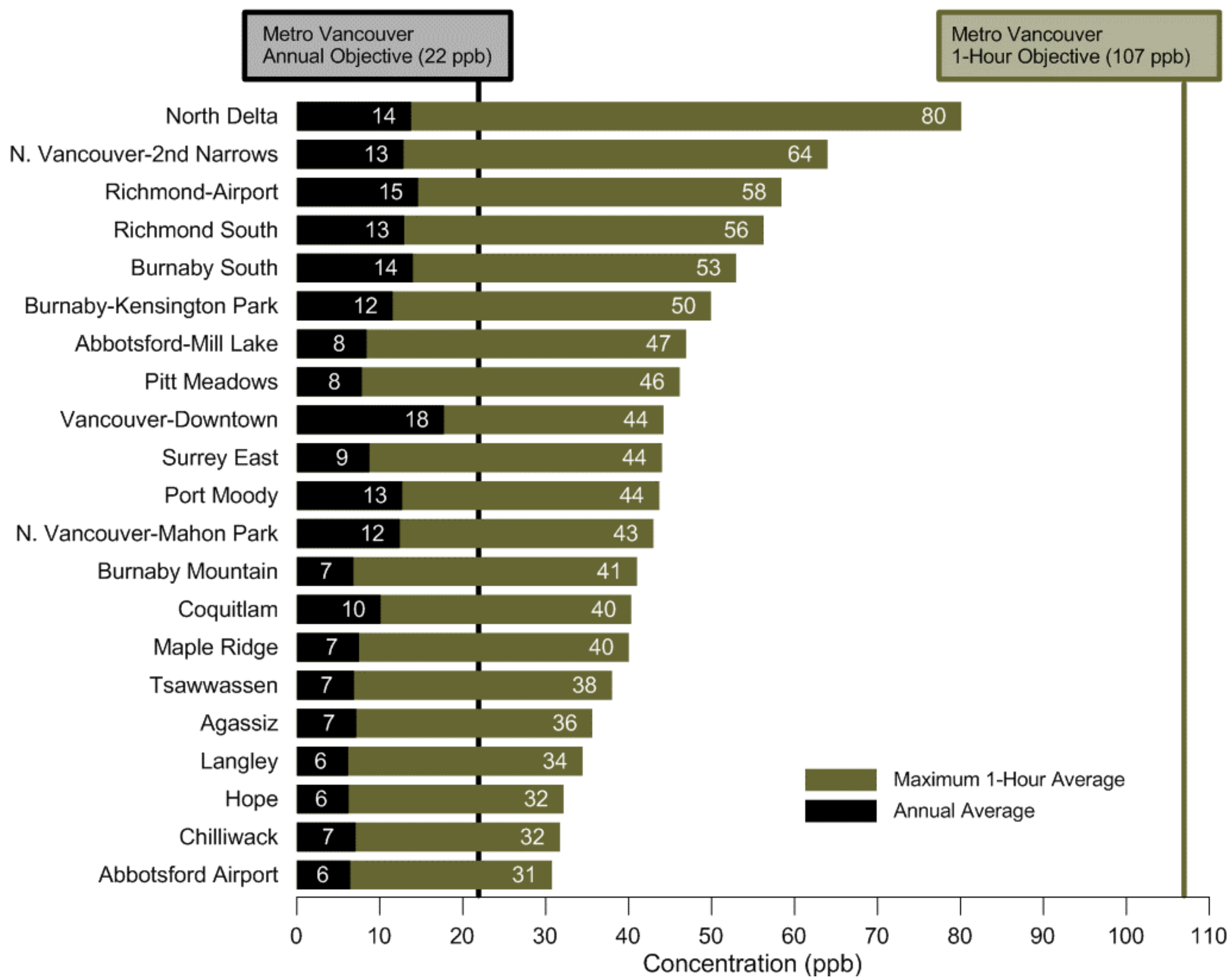
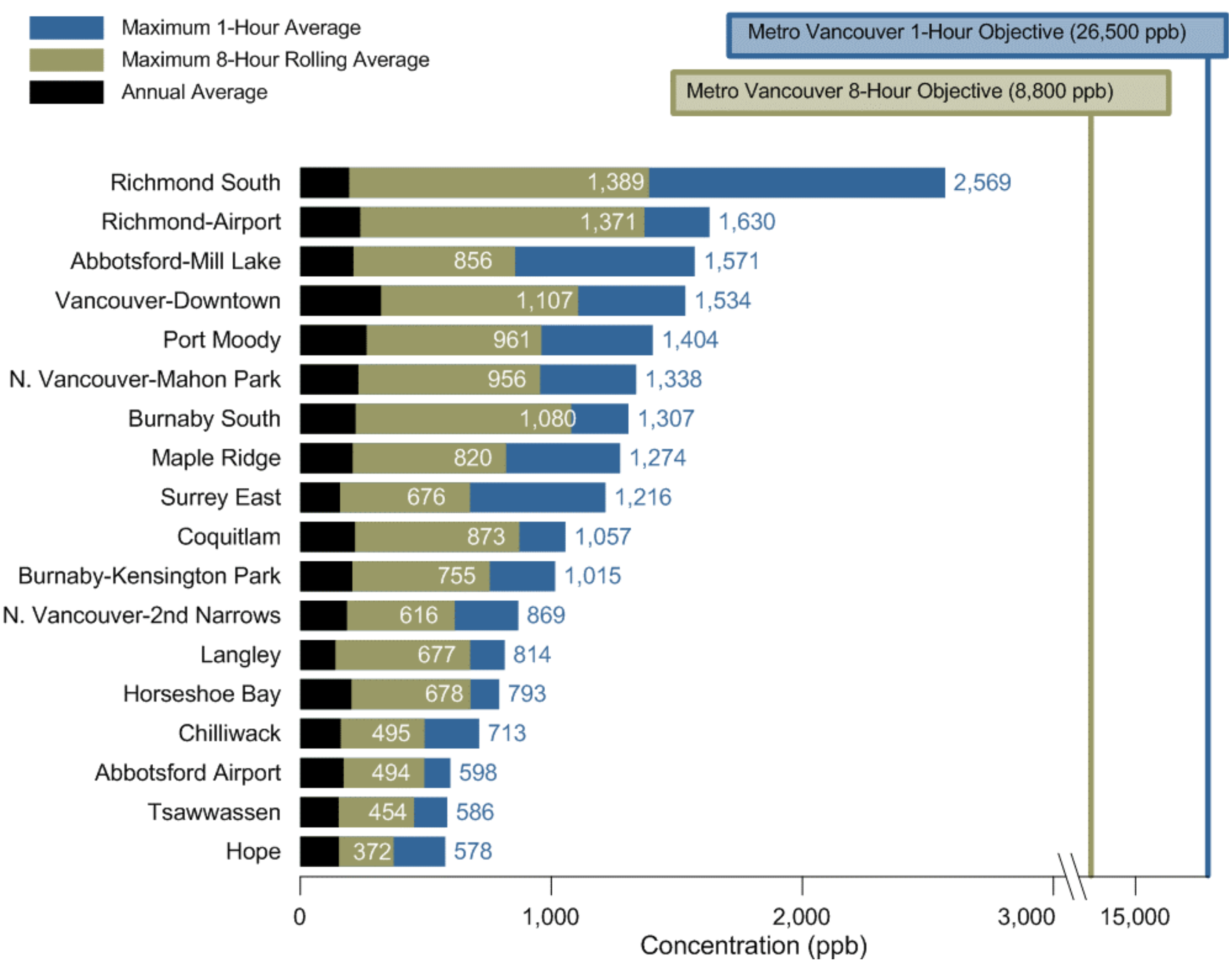


Figure S10: Nitrogen Dioxide (NO_2) 2014.

Carbon Monoxide – 2014

Carbon monoxide (CO) monitoring results for 2014 are shown in Figure S11. Carbon monoxide levels were all well below the relevant Metro Vancouver air quality objectives at all stations throughout the LFV. The principal source of carbon monoxide continues to be emissions from motor vehicles.

Higher concentrations generally occur close to major roads during peak traffic periods. Like nitrogen dioxide, the highest average carbon monoxide concentrations are measured in the more densely trafficked areas and near busy roads. Lower concentrations are observed where these influences are less pronounced, such as the suburban and rural parts of Metro Vancouver and the FVRD.



Note: The scale is broken in the x-axis between 3,000 and 8,000 ppb. The highest concentration measured is almost ten times less than the objective.

Figure S11: Carbon Monoxide (CO) 2014.

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List of Acronyms

AQHI	Air Quality Health Index
BIALAQS	Burrard Inlet Area Local Air Quality Study
BC	Black Carbon
BCVCC	BC Visibility Coordinating Committee
CCME	Canadian Council of Ministers of the Environment
CAAQS	Canadian Ambient Air Quality Standard
CO	Carbon Monoxide
FEM	Federal Equivalent Method
FVRD	Fraser Valley Regional District
LFV	Lower Fraser Valley
MAMU	Mobile Air Monitoring Unit
NAPS	National Air Pollution Surveillance
NO_X	Nitrogen oxides
NO_2	Nitrogen dioxide
NO	Nitric oxide
NH_3	Ammonia
O_3	Ozone
PM	Particulate matter
PM_{10}	Inhalable particulate matter (particles smaller than 10 micrometres in diameter)
$PM_{2.5}$	Fine particulate matter (particles smaller than 2.5 micrometres in diameter)
SO_X	Sulphur oxides
SO_2	Sulphur dioxide
THC	Total hydrocarbons
TRS	Total reduced sulphur compounds
VOC	Volatile organic compounds

Section A – Introduction

This report summarizes data collected from air quality stations in the Lower Fraser Valley (LFV) Air Quality Monitoring Network in 2014 and describes the air quality monitoring activities and programs conducted during the year. The focus is to report on the state of ambient (outdoor) air quality in the LFV.

Metro Vancouver maintains one of the most comprehensive air quality networks in North America serving a population of 2.8 million with 28 air quality stations located from Horseshoe Bay in West Vancouver to Hope in 2014. Pollutants monitored by the network include both gases and particulate matter. Common air contaminants include ozone (O_3), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter. These are all widely monitored throughout the network.

Particulate matter consists of very small solid and liquid material suspended in the air. This air pollutant is characterized by size and measured in units of a millionth of a metre, or micrometre (µm). Particles with a diameter smaller than 10 micrometres are referred to as inhalable particulate (PM_{10}), while those smaller than 2.5 micrometres are termed fine particulate ($PM_{2.5}$). Both PM_{10} and $PM_{2.5}$ concentrations are monitored throughout the LFV.

Other pollutants monitored by the network include ammonia, volatile organic compounds (VOC), black carbon, and odourous total reduced sulphur compounds (TRS). Additional information Metro Vancouver collects to help monitor air quality conditions includes weather (meteorological) data and images recording visual air quality conditions (visibility).

Priority Pollutants

Research indicates that adverse health effects can occur at air quality levels commonly measured in the LFV. Health experts have identified exposure to ozone and particulate matter as being associated with serious health effects. Ozone is a strong oxidant that can irritate the eyes, nose and throat, and reduce lung function. Fine particulate ($PM_{2.5}$) is small enough to be breathed deeply into the lungs, resulting in impacts to both respiratory and cardiovascular systems. Long-term exposure to these pollutants can aggravate existing heart and lung diseases and lead to premature mortality.

Of particular concern is $PM_{2.5}$ that is emitted from diesel fuel combustion in car, truck, marine, rail and non-road engines. These particles ("diesel PM") are carcinogenic and are believed to contribute significantly to the health effects described above. Instrumentation installed in some air quality monitoring stations in the LFV can be used to estimate the proportion of particles that originate from diesel engines.

Air Quality Trends

Improvements have been made in air quality over the last two decades for most pollutants, including nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), volatile organic compounds (VOC) and fine particulate matter ($PM_{2.5}$). Despite significant population growth in the region over the same time period, emission reductions across a variety of sectors have brought about these improvements. The population increased in Metro Vancouver and the FVRD by about 50% from 1991 to 2014, from approximately 1.8 million to 2.8 million residents.

The long-term regional trends for ground-level ozone show a different story. Long-term trends of peak ozone concentrations show yearly variability with levels currently lower than those experienced in the 1980s. Short-term or "peak" levels have been largely unchanged over the last fifteen to twenty years. Average concentrations of ground-level ozone however have increased over the same period.

In 2014, Metro Vancouver and the Fraser Valley Regional District endorsed the Regional Ground-Level Ozone Strategy, which provides strategic policy direction for ozone management in the LFV based on local scientific research. Research indicates that a spatial understanding of the ratio of concentrations of nitrogen oxides (NO_X) and volatile organic compounds (VOC), two precursor pollutants that react to form ozone, is key to determining which precursors to reduce in order to maintain and improve air quality in our region.

Trends in air pollutants are discussed further by pollutant in Section D.

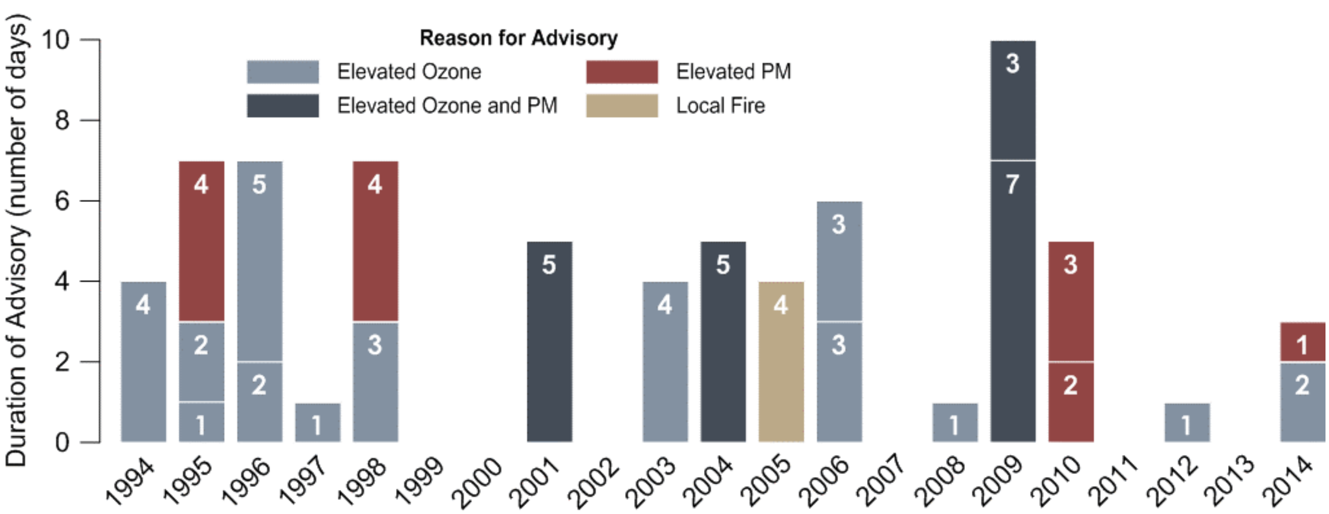
Air Quality Advisories

In 2014, an air quality advisory was issued in July for two days for eastern parts of Metro Vancouver and the Fraser Valley because of high concentrations of ground-level ozone. In August an air quality advisory was issued for one day in Metro Vancouver and the Fraser Valley Regional District because of elevated $PM_{2.5}$, primarily due to smoke from wildfires outside our region.

Periods of degraded air quality can occur in the LFV for several reasons, such as summertime smog during hot weather, smoke from forest fires and winter inversions preventing dispersion of emitted air contaminants. In cooperation with partner agencies, including the Fraser Valley Regional District, Vancouver Coastal Health Authority, Fraser Health Authority, Environment Canada and the B.C. Ministry of Environment, Metro Vancouver operates an air quality advisory program.

Air quality advisories are issued to the public when air quality has deteriorated or is forecast to deteriorate significantly within the LFV. Typically air quality advisories are issued when a pollutant exceeds or is predicted to exceed an air quality objective or standard at more than one monitoring location.

In the last ten years, the number of days on which air quality advisories were in place has ranged from zero to ten days annually. Shown in Figure 1 is the historical trend of the number of days the LFV was under an advisory. The total number of advisory days is shown as a bar while the number of consecutive days of an advisory period is given by the number in white.



Notes:

- Trigger levels for advisories have changed over the years; care must be taken when interpreting advisory trends.
- The advisory in 2005 was the result of a large fire in Burns Bog.

Figure 1: Number of days of air quality advisories in the LFV.

Air Quality Health Index (AQHI)

The national health-based Air Quality Health Index (AQHI), developed by Environment Canada and Health Canada, has been in use since 2008. The AQHI communicates the health risks associated with a mix of air pollutants to the public and provides guidance on how individuals can adjust their exposure and physical activities as air pollution levels change.

The AQHI is calculated every hour using monitoring data from stations in the LFV. Current AQHI levels in the LFV, AQHI forecasts (for *today*, *tonight*, and *tomorrow*) and additional information about the AQHI are available at:

www.airmap.ca (shown below)
www.airhealth.ca
www.bcairquality.ca/readings

Environment Canada's Weatheroffice forecast web pages also publish the AQHI.

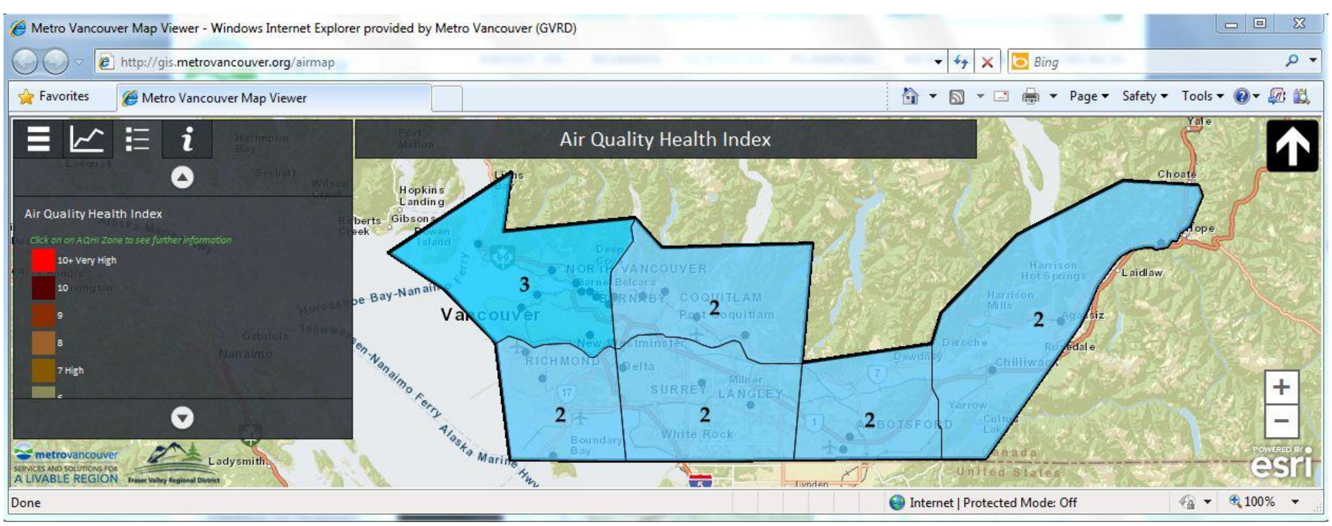
Visual Air Quality

Degraded air quality can cause views to be partially or fully obscured by haze at times in the LFV. This is referred to as visual air quality impairment.

The appearance of haze is affected by the nature of the air pollutants causing it. For example, in more urbanized areas in the west, haze may have a brownish colour. Nitrogen dioxide emissions from transportation sources contribute to this brown appearance. Further east in the LFV, a white haze can sometimes be observed as a result of small particles in the air ($PM_{2.5}$) scattering light. Secondary $PM_{2.5}$, such as that formed by reactions of NO_X and SO_2 with ammonia, contributes to this haze. Smoke and windblown dust and soil particles can also affect visual air quality at times.

In 2014, ten automated digital cameras in seven locations were used to record visual air quality conditions. Images from the cameras show views along specific lines-of-sight with recognizable topographical features at known distances. The images are archived for various uses such as:

- relating air contaminant measurements to visual range under a variety of air quality and meteorological conditions;
- assessing public perception of the range of visual air quality conditions found in the LFV;
- developing visual air quality measurement metrics.



Images from each location were also available online in near-real time through www.clearairbc.ca

Characterization of air contaminants in the LFV is being used to understand visual air quality impairment and develop tools to evaluate visual air quality impairment quantitatively. Data collected in 2014 as part of the visual air quality monitoring program include measurements of nitrogen dioxide and $PM_{2.5}$, measurements of the constituents of particulate matter (for example particulate nitrate, particulate sulphate, elemental carbon and organic carbon) and the optical properties of particulate matter (light scattering and absorption). These data provide important information to a multi-agency initiative to develop a visual air quality management strategy for the LFV. Visual air quality is further discussed in Section F.

Air Quality Measurements

The LFV Air Quality Monitoring Network primarily employs continuous monitors which provide data in real-time every minute of the day. The network also contains specialized air quality monitors that sample the air non-continuously. Non-continuous 24-hour (daily) samples are collected on filters and/or in canisters every sixth or twelfth day depending on the site. The sampling is scheduled in accordance with the National Air Pollution Surveillance (NAPS) program. After sample collection, filters and canisters are analyzed in a federal laboratory to determine pollutant concentrations.

Non-continuous samples of Volatile Organic Compounds (VOC) are collected at seven sites throughout the LFV. VOC refers to a group of organic chemicals. A large number of chemicals are included in this group but each individual chemical is generally present at relatively low concentrations in air compared to other common air contaminants.

Non-continuous particulate samples are collected at four monitoring stations in the LFV where pollutant concentrations are determined. A detailed analysis is conducted by the federal laboratory for three of these stations (Port Moody, Burnaby South and Abbotsford Airport).

Chemicals contained in $PM_{2.5}$ and VOC samples are identified and quantified at a federal laboratory. These data can then be used to help determine the emission sources contributing to the contaminants in the air.

Non-continuous measurements are discussed in Section E.

Section B – Air Quality Objectives and Standards

Several air quality objectives and standards are used as benchmarks to characterize air quality including the federal Canadian Ambient Air Quality Standards (CAAQS), and Metro Vancouver's ambient air quality objectives. Metro Vancouver's ambient air quality objectives are shown in Table 1. The objective or standard is achieved if the ambient concentration is lower than (i.e., better than) the objective.

The federal Canadian Ambient Air Quality Standards (CAAQS) have been established as objectives under Canadian Environmental Protection Act 1999, and replaced the Canada-Wide Standards for fine particulate matter and ground-level ozone. The new CAAQS are to be implemented by 2015 for particulate matter (PM) and ozone (O_3). These set specific limits for $PM_{2.5}$ and O_3 based on concentrations averaged over a three year period.

The CAAQS for $PM_{2.5}$ is a value that is calculated by taking an annual 98th percentile value using daily averages, averaged over three consecutive years. Achievement of the $PM_{2.5}$ CAAQS is attained when the CAAQS value is less than or equal to 28 μg/m^3.

The CAAQS for ozone is a value that is calculated by the 4th highest annual 8-hour daily maximum, averaged over three consecutive years. Achievement of the ozone CAAQS is attained when the CAAQS value is less than or equal to 63 ppb.

In October 2005, as part of the Air Quality Management Plan, Metro Vancouver adopted health-based ambient air quality objectives for ozone (O_3), particulate matter ($PM_{2.5}$ and PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and carbon monoxide (CO). Metro Vancouver's $PM_{2.5}$ objectives adopted in 2005 were established in advance of any provincial objectives.

An objective or standard is achieved if the ambient concentration is lower than (i.e., better than) the objective.

In April 2009 the provincial government established new air quality objectives for $PM_{2.5}$. The province's annual target of eight micrograms per cubic metre (μg/m^3) and annual planning goal of six micrograms per cubic metre for $PM_{2.5}$ were more stringent than the annual objective previously set by Metro Vancouver in 2005.

In the October 2011 Integrated Air Quality and Greenhouse Gas Management Plan, Metro Vancouver tightened its annual objectives for $PM_{2.5}$, aligning them with those set by the province in 2009 as well as adopting a one hour ozone objective of 82 parts per billion.

Metro Vancouver's 24-hour $PM_{2.5}$ objective of 25 μg/m^3 is numerically the same as the province, but compliance with Metro Vancouver's objective requires that there are no exceedances and is applied as a rolling average.

In addition to the $PM_{2.5}$ annual objective of eight micrograms per cubic metre, the $PM_{2.5}$ annual planning goal of six is a longer term aspirational target to support continuous improvement.

In May 2015, Metro Vancouver adopted a 1-hour interim ambient air quality objective for SO_2 of 75 parts per billion not to be exceeded. The objective will be used for air quality reporting, episode management and as a tool for assessments of new and significantly modified sources. The interim objective for SO_2 will be replaced when the federal government establishes a new CAAQS for SO_2.

Several of Metro Vancouver's objectives are intended to be compared with *rolling averages*. A *rolling average* is an average that is calculated by averaging the concentrations from a number of previous consecutive hours. For example, a 24-hour rolling average is calculated by averaging the concentrations measured during the previous 24 hours. A 24-hour rolling average is calculated for each hour of the day. Similarly an 8-hour rolling average is calculated by averaging the concentrations from the previous 8 hours.

Table 1: Metro Vancouver's ambient air quality objectives.

Contaminant	**Averaging Period**	**Units**	
		µg/m³	**ppb**
Carbon monoxide	1-hour	30,000	26,500
	8-hour	10,000	8,800
Nitrogen dioxide	1-hour	200	107
	Annual	40	22
Sulphur dioxide	1-hour	196*	75*
	24-hour	125	48
	Annual	30	12
Ozone	1-hour	160	82
	8-hour	126	65
Inhalable particulate matter (PM_{10})	24-hour	50	
	Annual	20	
Fine particulate matter ($PM_{2.5}$)	24-hour	25	
	Annual	8 (6)**	
Total reduced sulphur	1-hour (acceptable)	14	10
	1-hour (desirable)	7	5

Note: The 8-hour and 24-hour objectives are intended to be compared against concentrations calculated as a rolling average. Metro Vancouver objectives are "not to be exceeded", meaning the objective is achieved if 100% of the validated measurements are at or below the objective level.

* This 1-hour SO2 objective is **interim** and is intended to apply to all applications for new or significantly modified discharge authorizations under GVRD Air Quality Management Bylaw No. 1082 made on or after May 15, 2015 but not intended to apply to existing facilities. "Significantly modified" refers to an increase in authorized quantity of emission of greater than 10%. The interim SO2 objective will be revisited after the Canadian Council of Ministers of the Environment adopts a new Canadian Ambient Air Quality Standard, likely in 2016.

** Metro Vancouver's Annual PM2.5 Planning Goal of 6 $\mu g/m^3$ is a longer term aspirational target to support continuous improvement.

Section C – Lower Fraser Valley Air Quality Monitoring Network

Metro Vancouver operates the LFV Air Quality Monitoring Network which consists of air quality monitoring sites located between Horseshoe Bay in West Vancouver and Hope. The locations of the monitoring stations operated in 2014 are shown in Figure 2 while the pollutants and meteorology measured at each station are identified in Table 2.

In 2014, there were 28 fixed air quality monitoring stations in the network which includes 22 stations located in Metro Vancouver and 6 stations located in the FVRD. There are also 2 stations in Metro Vancouver that provide only weather data. Air quality and weather data are collected automatically on a continuous basis, transmitted to Metro Vancouver's head office in Burnaby, and stored in a database. The data are then used to provide information to the public through the AQHI, Metro Vancouver's website, the BC air quality website, and reports. At one of the fixed stations (White Rock) particulate matter is sampled throughout the year on a defined periodic schedule. These non-continuous data are not collected automatically to the database.

Many pollutants measured are discussed in this report with a focus on common air contaminants: particulate matter (PM_{10} and $PM_{2.5}$), ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

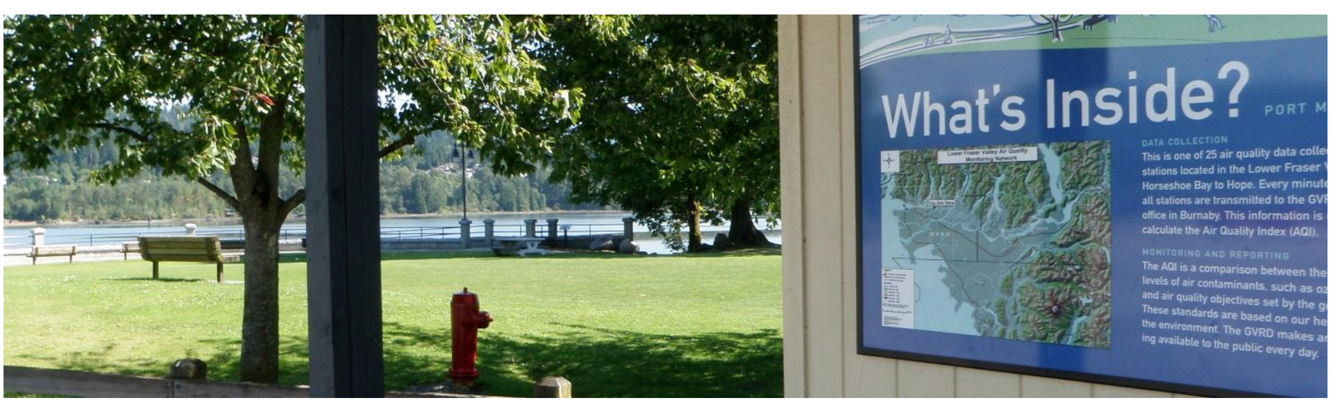
Comparisons of measured levels of these air contaminants with federal, provincial and Metro Vancouver air quality objectives and standards and an assessment of regional trends are provided in Section D. The locations of SO_2, O_3, NO_2 and $PM_{2.5}$ monitoring in 2014 are shown in Figures 3 to 6.

Portable equipment was used to carry out short-term air quality monitoring studies (specialized studies) in 2014. The equipment employed in specialized studies includes Metro Vancouver's Mobile Air Monitoring Unit (MAMU) which is capable of monitoring gaseous and particulate pollutants in the same way as fixed monitoring stations. Specialized studies and other monitoring activities undertaken are described in Sections G, H and I.

Real-time data from the LFV Air Quality Monitoring Network can be accessed on Metro Vancouver's website at: www.airmap.ca

Additional information on the LFV Air Quality Monitoring Network is available in the 2012 report "Station Information: Lower Fraser Valley Air Quality Monitoring Network". This report is available at: www.metrovancouver.org

Data completeness for the year 2014 is shown in Table 3. In Table 3 the annual completeness is provided numerically while each quarter shown as green if completeness for that quarter is greater than or equal to 75% and red if not.



Network Changes

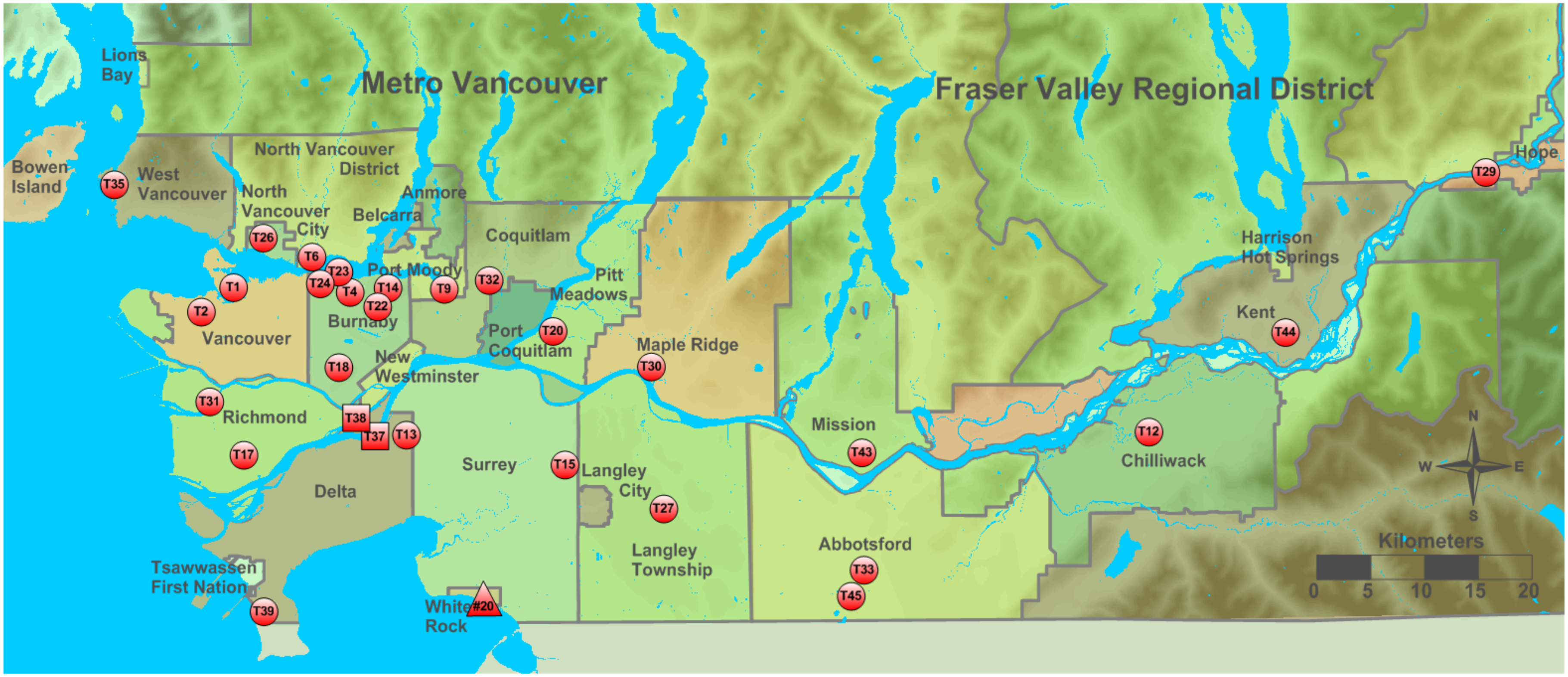
There are ongoing enhancements to stations and equipment that occur throughout the air quality monitoring network.

Improvements and changes to the air quality network are necessary to adapt to changes in technology, population, and demographics.

Network improvement highlights for 2014 included the establishment of a new fixed monitoring network station in Mission, establishment of a passive SO_2 network near Burrard Inlet and improvements to the visual air quality monitoring.

Changes to the network in 2014 include:

- The new Mission (T43) station became operational in August 2014 (shown below). The station, which monitors ground-level ozone, fine particulate matter, nitrogen oxides and meteorology will provide important information on air quality for the Mission community and improve our understanding of how pollutants form and move around the region.
- In September of 2014 a passive SO_2 network was established near the south shore of Burrard Inlet. The passive network, funded by Port Metro Vancouver and operated by Metro Vancouver, is intended to track improvements brought on by a reduction in sulphur content in marine shipping fuels.
- Improvements to visual air quality monitoring continued with the addition of carbon measurements in Pitt Meadows (T20) and a visual air quality camera was added in Richmond.
- Work continued to establish a new fixed monitoring network station in New Westminster and two new meteorological stations (one in East Vancouver and one at the Port near Canada Place).



T1	Vancouver-Downtown	T18	Burnaby South	T32	Coquitlam
T2	Vancouver-Kitsilano	T20	Pitt Meadows	T33	Abbotsford-Mill Lake
T4	Burnaby-Kensington Park	T22	Burnaby-Burmount	T35	Horseshoe Bay
T6	N. Vancouver-2nd Narrows	T23	Burnaby-Capitol Hill	T37	Alex Fraser Bridge
T9	Port Moody	T24	Burnaby North	T38	Annacis Island
T12	Chilliwack	T26	N. Vancouver-Mahon Park	T39	Tsawwassen
T13	North Delta	T27	Langley	T43	Mission
T14	Burnaby Mountain	T29	Hope	T44	Agassiz
T15	Surrey East	T30	Maple Ridge	T45	Abbotsford Airport
T17	Richmond South	T31	Richmond-Airport	#20	White Rock

Continuous Station

Non-Continuous Station

Meteorological Station Only

Figure 2: Lower Fraser Valley air quality monitoring network, 2014.

Table 2: Air quality monitoring network, 2014.

Stations		Air Quality Monitors														Meteorology					
		Continuous											Non-Continuous								
		Gases							Particulate Matter												
ID	Name	SO_2	TRS	NO_2	CO	O_3	THC	NH_3	PM_{10}	$PM_{2.5}$	CARB	NEPH	VOC	SP	D	Wind	T_{air}	SR	RH	BP	Precip
T1	Vancouver-Downtown	√		√	√	√															
T2	Vancouver-Kitsilano	√		√	√	√				√						√	√		√	√	√
T4	Burnaby-Kensington Park	√	√	√	√	√			√	√						√	√		√		
T6	N. Vancouver-2nd Narrows	√		√	√	√				√	√					√					
T9	Port Moody	√	√	√	√	√			√	√	√		√		√	√	√	√	√		√
T12	Chilliwack	√		√	√	√		√	√	√	√	√	√			√	√	√	√	√	√
T13	North Delta			√		√				√						√	√		√		√
T14	Burnaby Mountain			√		√										√	√		√		√
T15	Surrey East			√	√	√				√						√	√				√
T17	Richmond South	√		√	√	√				√						√	√		√		√
T18	Burnaby South	√		√	√	√			√	√	√	√	√	√	√	√	√		√	√	√
T20	Pitt Meadows	√		√		√				√	√					√	√		√	√	√
T22	Burnaby-Burmount		√				√						√			√	√				
T23	Burnaby-Capitol Hill	√	√													√	√		√		
T24	Burnaby North	√	√				√		√				√			√	√		√		√
T26	N. Vancouver-Mahon Park	√		√	√	√				√						√	√	√	√	√	√
T27	Langley	√		√	√	√			√	√						√	√		√	√	√
T29	Hope			√	√	√			√	√						√	√		√		√
T30	Maple Ridge			√	√	√										√	√		√		√
T31	Richmond-Airport	√		√	√	√			√	√	√	√	√			√	√	√	√	√	√
T32	Coquitlam			√	√	√										√	√	√	√	√	√
T33	Abbotsford-Mill Lake	√		√	√	√		√	√	√						√	√		√		√
T35	Horseshoe Bay				√					√						√	√		√		√
T37	Alex Fraser Bridge	Station temporarily out of service																			
T38	Annacis Island															√	√		√		√
T39	Tsawwassen	√		√	√	√				√						√	√		√		√
T43	Mission			√		√				√						√	√		√		√
T44	Agassiz			√		√				√						√	√		√		√
T45	Abbotsford Airport	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√
#20	White Rock														√						
Total Monitoring Units		**17**	**5**	**23**	**19**	**23**	**2**	**3**	**10**	**20**	**7**	**4**	**7**	**2**	**4**	**27**	**26**	**6**	**24**	**9**	**23**

SO_2 = sulphur dioxide; TRS = total reduced sulphur; NO_2 = nitrogen dioxide; CO = carbon monoxide; O_3 = ozone; THC = total hydrocarbon; NH_3 = ammonia; PM_{10} = inhalable particulate matter;

$PM_{2.5}$ = fine particulate matter; NEPH = particulate light scattering; VOC = volatile organic compounds; SP = particulate speciation; D = dichotomous particulate; CARB = Carbon.

Wind = wind speed and wind direction; T_{air} = air temperature; SR = incoming solar radiation; RH = relative humidity; BP = barometric pressure; Precip = precipitation.

√ = monitored at this location.

Table 3: Annual and quarterly data completeness, 2014.

ID	Station Name	SO_2	TRS	NO_2	CO	O_3	THC	NH_3	PM_{10}	$PM_{2.5}$	BC	Wind Spd	Wind Dir	Tair	SR	RH	BP	Precip
T01	Vancouver-Downtown	93		98	96	97												
T02	Vancouver-Kitsilano	37		37	35	37				27		38	38	38		38	38	38
T04	Burnaby-Kensington Park	98	95	97	90	98			96	96		100	100	100		100		
T06	N. Vancouver-2nd Narrows	97		96	96	96				98	97	97	97					
T09	Port Moody	97	97	97	97	97			99	95	98	94	94	94	93	94		95
T12	Chilliwack	97		97	97	83		96	99	99	100	88	88	100	100	100	100	100
T13	North Delta			98		98				95		100	100	100		100	100	100
T14	Burnaby Mountain			97		98						100	100	100		100		100
T15	Surrey East			96	97	98				85		100	100	100				100
T17	Richmond South	98		98	97	97				93		99	99	99		99		99
T18	Burnaby South	97		97	95	97			99	93	98	99	99	99		95	99	99
T20	Pitt Meadows	92		98		98				98	62	97	97	100		100	100	100
T22	Burnaby-Burmount		97				99					99	99	99				
T23	Burnaby-Capitol Hill	98	94									99	99	99		99		
T24	Burnaby North	98	96				90		20			100	100	100		100		93
T26	N. Vancouver-Mahon Park	98		97	96	97				99		99	99	98	99	98	99	99
T27	Langley	92		94	91	95			96	93		96	96	97		97	97	97
T29	Hope			84	91	95			98	87		98	98	98		98		98
T30	Maple Ridge			98	98	97						100	100	100		100		100
T31	Richmond-Airport	97		96	98	97			99	97	98	100	100	100	100	100	100	100
T32	Coquitlam			98	98	98						100	100	100	100	100	100	100
T33	Abbotsford-Mill Lake	96		95	91	96		90	98	92		98	98	99		99		99
T35	Horseshoe Bay				97					99		100	100	100		99		100
T37	Alex Fraser Bridge																	
T38	Annacis Island											81	81	80		80		86
T39	Tsawwassen	95		96	91	92				98		100	100	100		100		100
T43	Mission			40		39				33		38	38	38		38		38
T44	Agassiz			98		98				97		100	100	100		100		100
T45	Abbotsford Airport	97		97	93	97		97	92	95	99	99	99	99	99	99	99	99

Note: Quarterly completeness ≥ 75% is shown in green and < 75% is shown in red, while annual completeness is shown numerically.

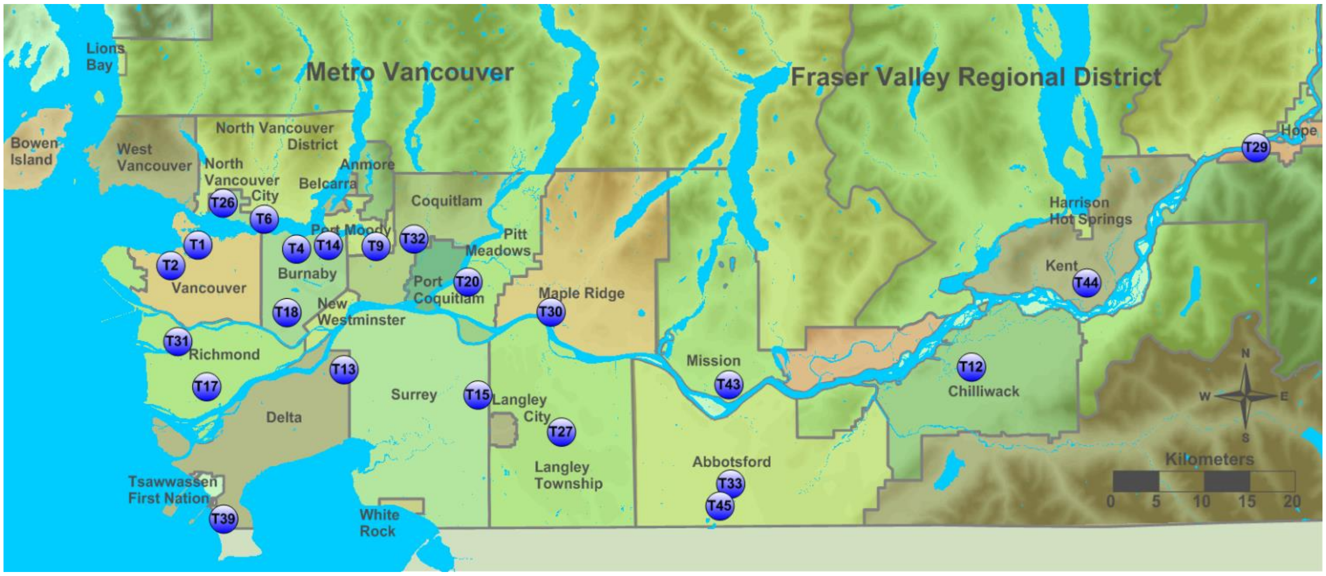


Figure 3: Ground-level ozone monitoring stations, 2014.

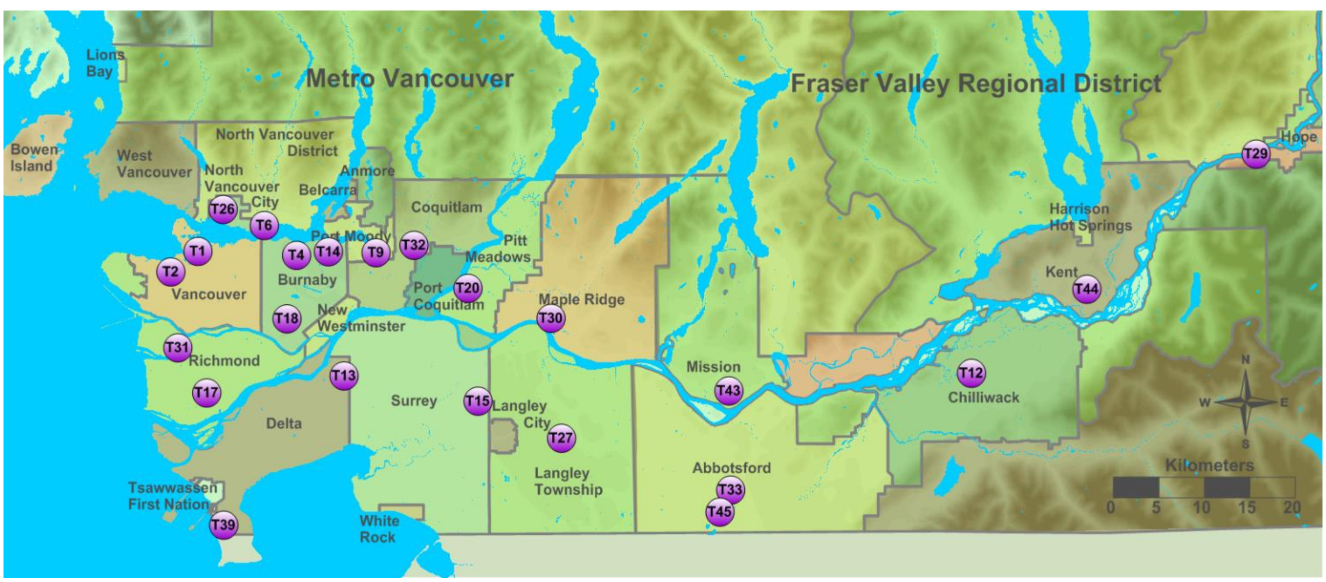


Figure 4: Nitrogen dioxide monitoring stations, 2014.

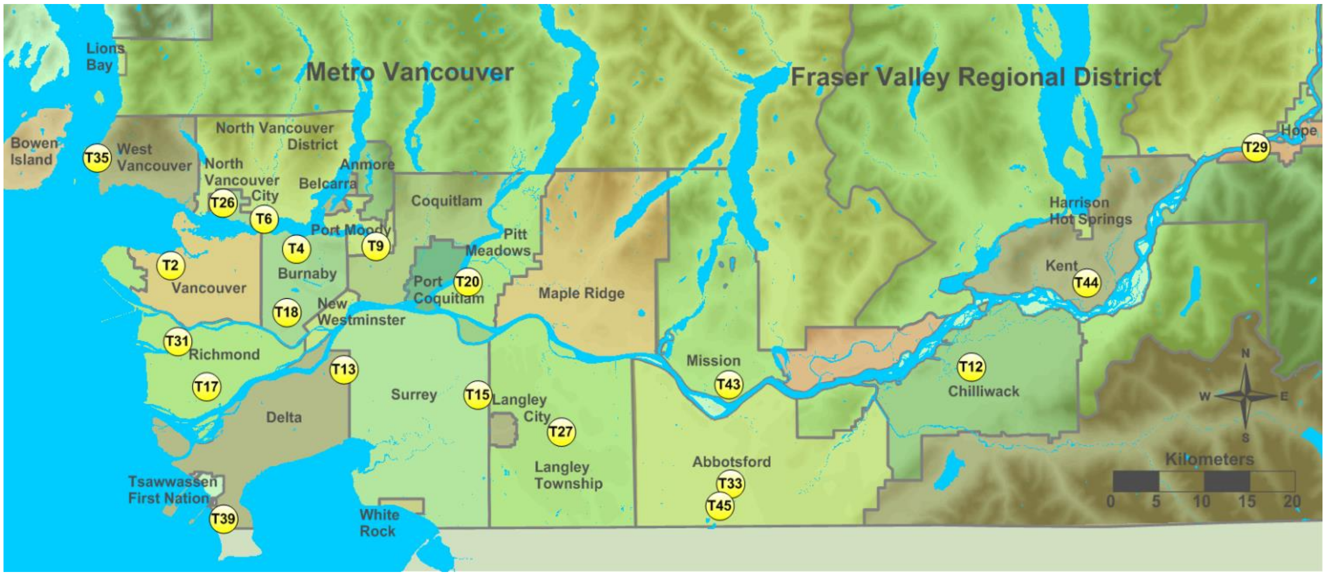


Figure 5: Fine particulate ($PM_{2.5}$) monitoring stations, 2014.

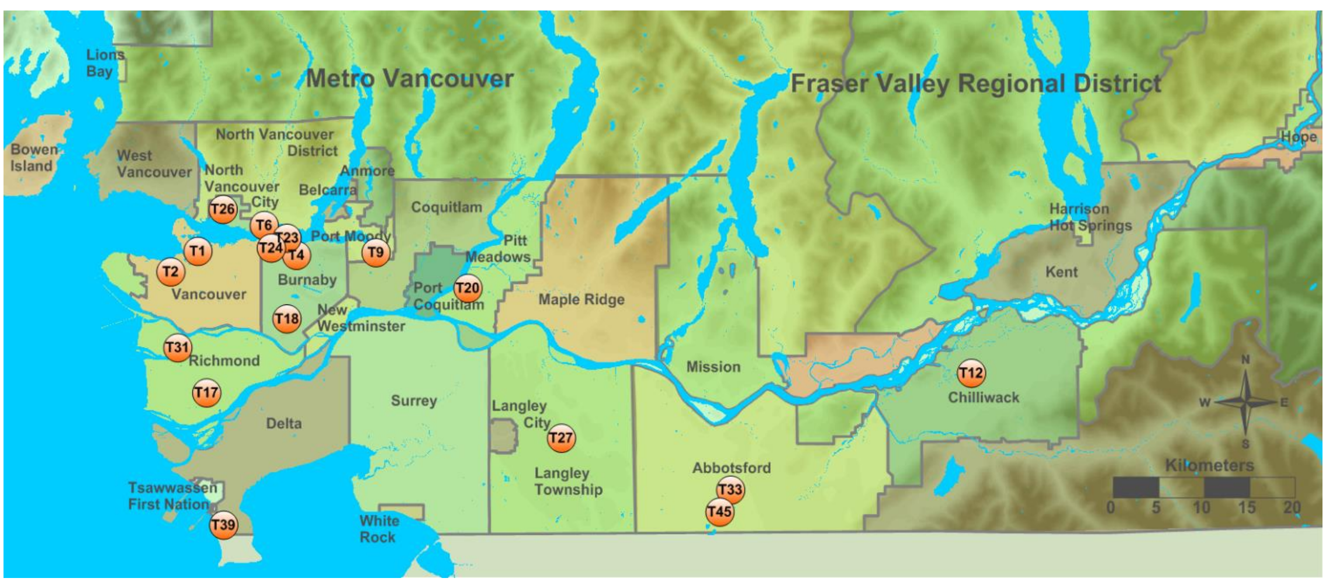


Figure 6: Sulphur dioxide monitoring stations, 2014.

Section D – Continuous Pollutant Measurements

Sulphur Dioxide (SO_2)

Characteristics

Sulphur dioxide (SO_2) is a colourless gas with a pungent odour. It reacts in the air to form acidic substances such as sulphuric acid and sulphate particles.

Brief exposure to high concentrations of SO_2 and its by-products can irritate the upper respiratory tract and aggravate existing cardiac and respiratory disease in humans. Long-term exposure may increase the risk of developing chronic respiratory disease.

The environmental effects of SO_2 and its reactive products have been studied for many years. These compounds can cause damage to vegetation and buildings, they play a role in the formation of acid rain and they may affect the natural balance of waterways and soils. Sulphur oxides (SO_X) including SO_2 can also combine with other air contaminants to form the fine particulates ($PM_{2.5}$) that are thought to be one of the contributing factors in the degradation of visual air quality in the region.

Sources

Sulphur dioxide is emitted when fossil fuels containing sulphur are burned. The largest source of SO_2 emissions in the region is the marine sector, mostly ocean-going vessels. The major industrial source of SO_2 in this region is an oil refinery located in the Burrard Inlet area. Other significant sources contributing to the measured ambient SO_2 concentrations include non-road engines, industry, heating and transportation (motor vehicles, aircraft and trains).

Local SO_2 emissions are low relative to other cities of similar size because natural gas, rather than coal or oil, is used in almost all residential, commercial and industrial heating in the region.

Monitoring Results

Sulphur dioxide levels measured in 2014 are shown in Figure 7. Figure 7 displays the value of the maximum 1-hour and 24-hour rolling average as well as the annual average for each SO_2 monitoring location. The same values are represented spatially in Figures 8, 9 and 10.

Average SO_2 levels were below the Metro Vancouver annual objective (12 ppb) with relatively low levels of less than 2 ppb recorded at all stations.

Sulphur dioxide is more prevalent near the Burrard Inlet area as a result of emissions from ocean-going vessels and an oil refinery.

Hourly and 24-hour rolling average SO_2 concentrations were below Metro Vancouver existing objectives at all stations. With the exception of Burnaby-Capitol Hill all stations were below Metro Vancouver's new Interim 1-Hour Objective adopted by the Metro Vancouver in 2015. The interim objective was exceeded at the Burnaby-Capitol Hill station for a total of four hours which occurred on January 23, 24, and 26 and May 1. These exceedances were likely the result of stagnant weather, poor dispersion conditions and nearby emissions from the Chevron refinery.

The highest levels of SO_2 are typically measured in the north-west (Figures 8, 9 and 10), particularly close to the dominant sources of SO_2 emissions (i.e., marine vessels, port areas and an oil refinery) in the Burrard Inlet area.

Figures 11 and 12 show the seasonal trend of SO_2 with the monthly average shown in Figure 11 and the highest 1-hour concentration from each month shown in Figure 12. In both figures, concentrations from six selected stations are shown alongside the range of concentrations measured at all stations (shown as a grey band). There is little or no discernible trend in SO_2 concentrations throughout the year. The Downtown-Vancouver station experienced the highest average concentrations through most of the year while the highest 1-hour measurements were recorded at Burnaby-Capitol Hill in January, May and September.

The values in Tables 4 and 5 represent the frequency distribution or count of how many hourly and 24-hour rolling average measurements were in the specified ranges, respectively. It can be seen that stations located near the Burrard Inlet area experience a greater occurrence of higher concentrations compared with areas away from the Inlet.

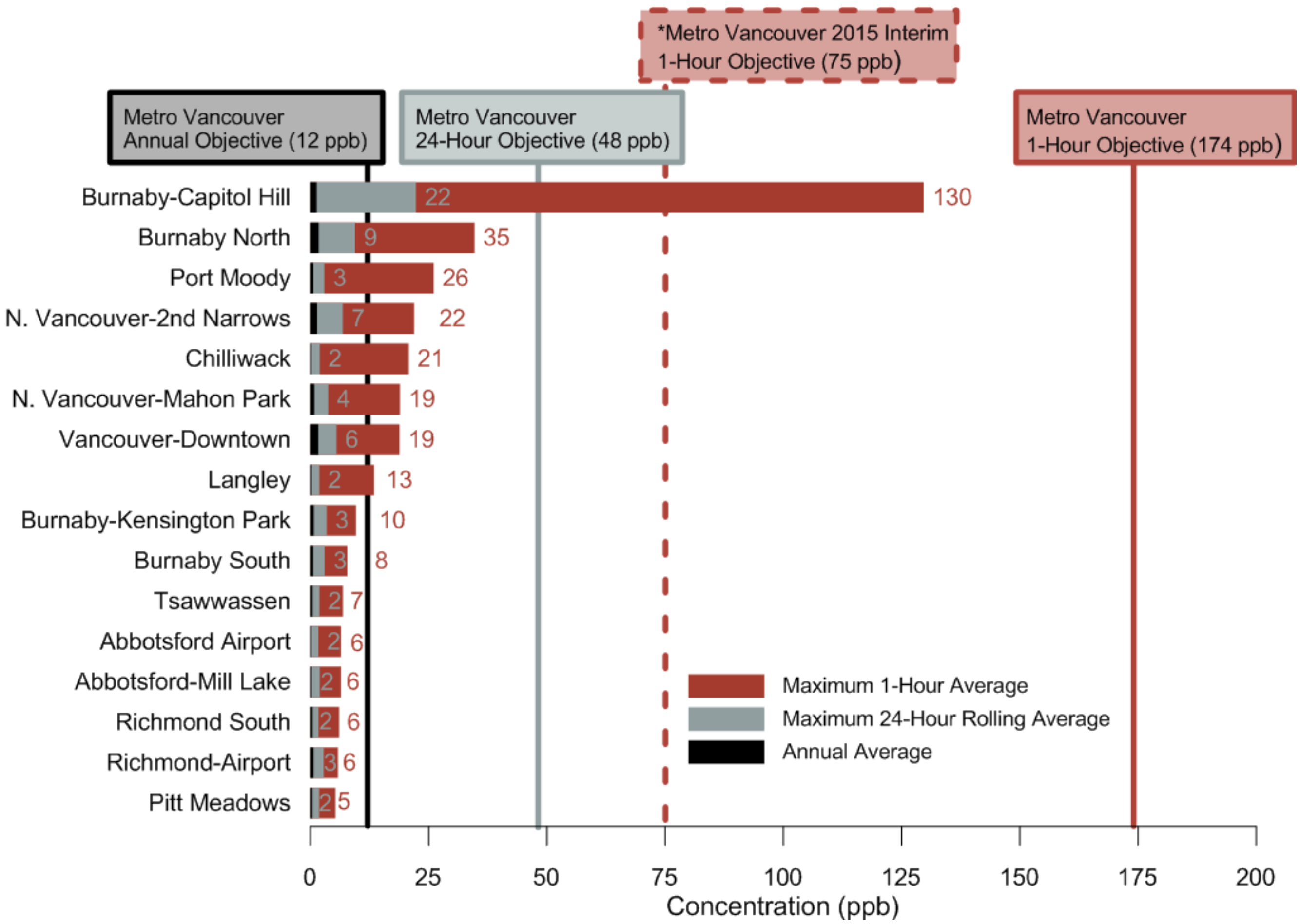
A series of diurnal plots are shown in Figure 13 for each SO_2 monitoring station. The plots demonstrate the differences between weekdays and weekends along with differences between summer and winter. Stations located away from Burrard Inlet show little diurnal variation while stations located near the inlet show trends indicative of local emission sources.

Both North Vancouver stations, N. Vancouver-2nd Narrows and N. Vancouver-Mahon Park, observe a single winter peak around noon and both morning and evening peaks in summer. These two stations located close to Burrard Inlet are thought to be mainly influenced by emissions from ocean-going vessels.

The Burnaby-Capitol Hill station shows peak SO_2 concentrations during the morning periods when mixing layer depth is reduced and dispersion is limited. Measurements of SO_2 at this station are influenced by its proximity to the oil refinery.

The long-term SO_2 trends in the LFV are shown in Figures 14 and 15. The annual average trend is given in Figure 14 with the short-term peak trend given in Figure 15 for the last two decades. The yearly variation can be attributed in part to meteorological variability while the major long-term changes in air quality are mainly a result of changes in emissions.

Long-term trends provide information to help assess the impact of emission reduction efforts, policy changes and technology advances. For example, emissions of SO_2 declined during the early 1990s due to reduced sulphur content in on-road fuels, the shutdown of several refineries, and reduced emissions from the cement industry. In recent years measurements of both the annual short-term peak (99^{th} percentile of the 1-hour values) and the annual average are markedly lower than they were in the early 1990s.



*Metro Vancouver adopted a new Interim 1-hour objective of 75 ppb for SO_2 in May, 2015.

Figure 7: Sulphur dioxide monitoring, 2014.

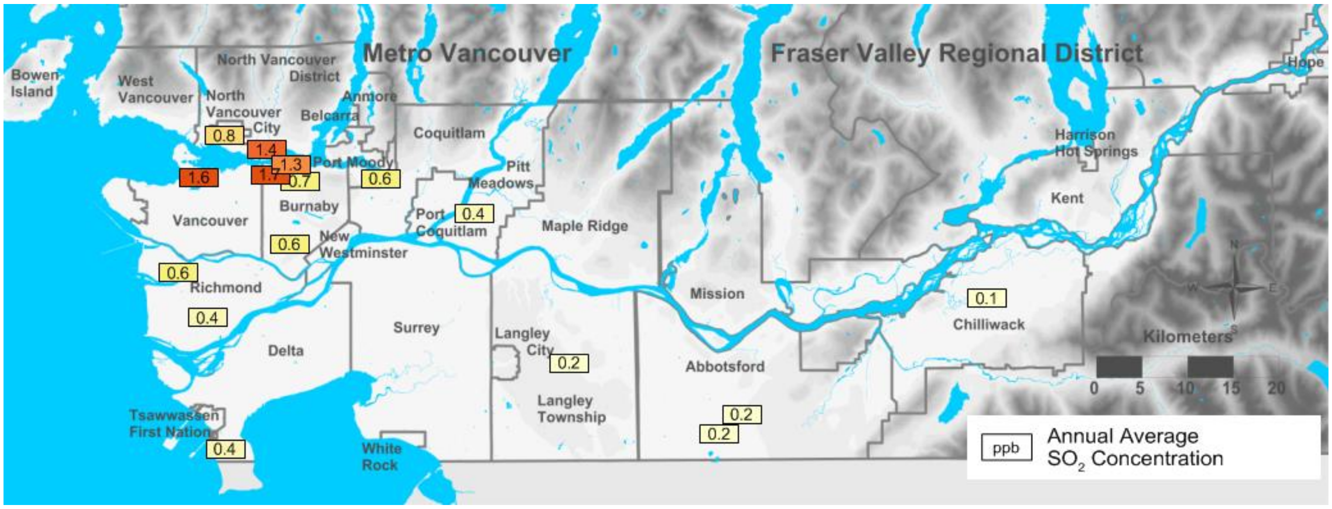


Figure 8: Annual average sulphur dioxide in the LFV, 2014.

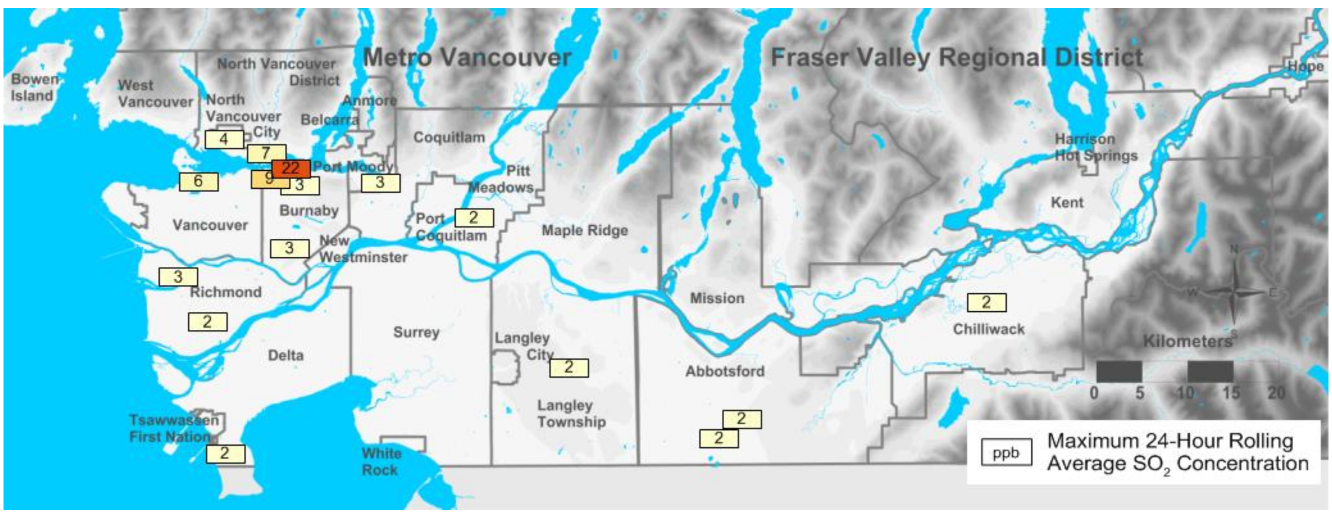


Figure 9: Short-term peak (maximum 24-hour) sulphur dioxide in the LFV, 2014.

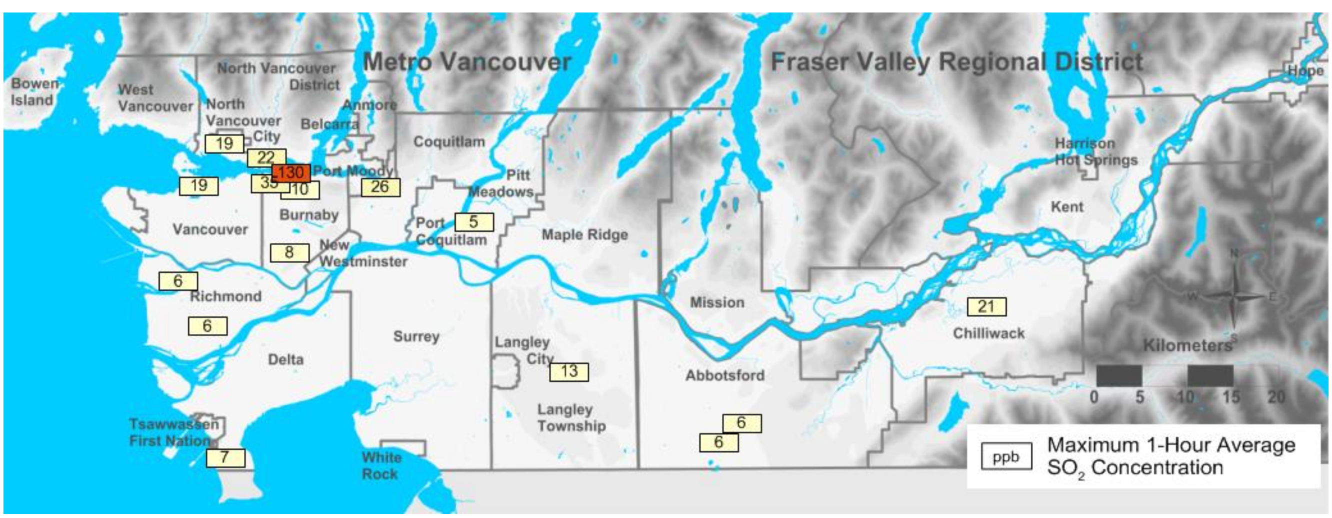


Figure 10: Short-term peak (maximum 1-hour) sulphur dioxide in the LFV, 2014.

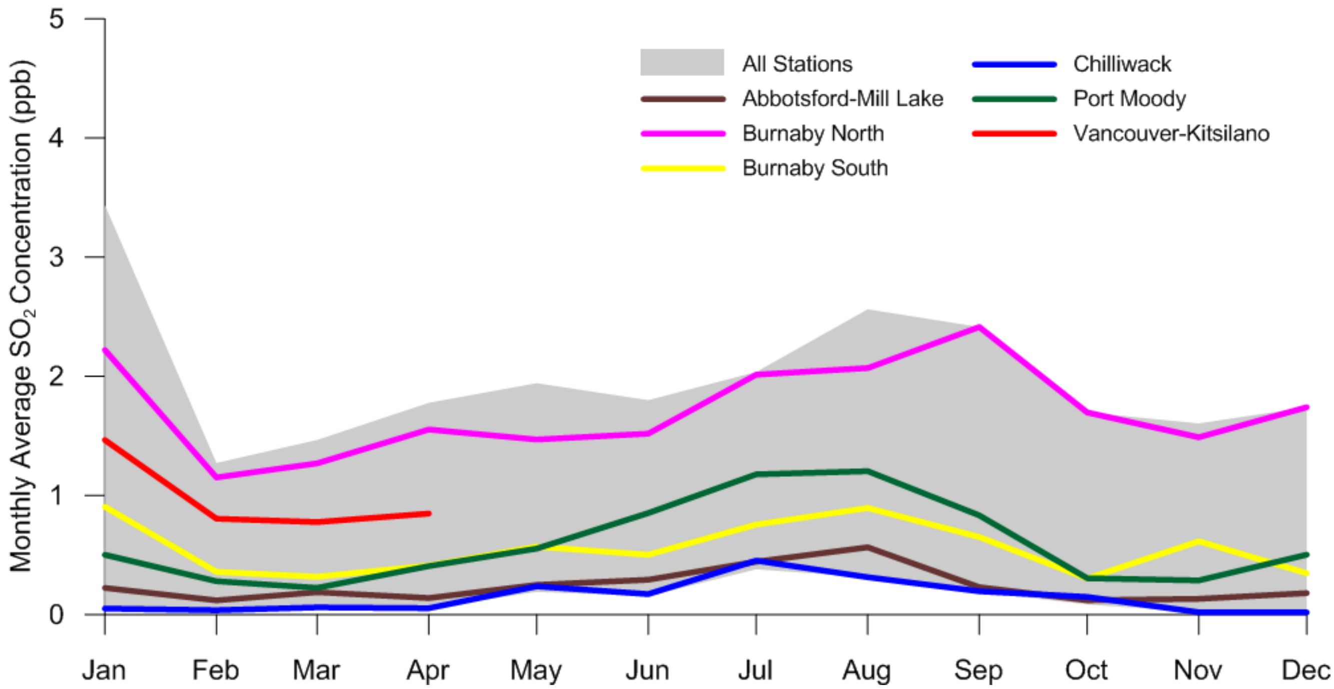


Figure 11: Monthly average sulphur dioxide, 2014.

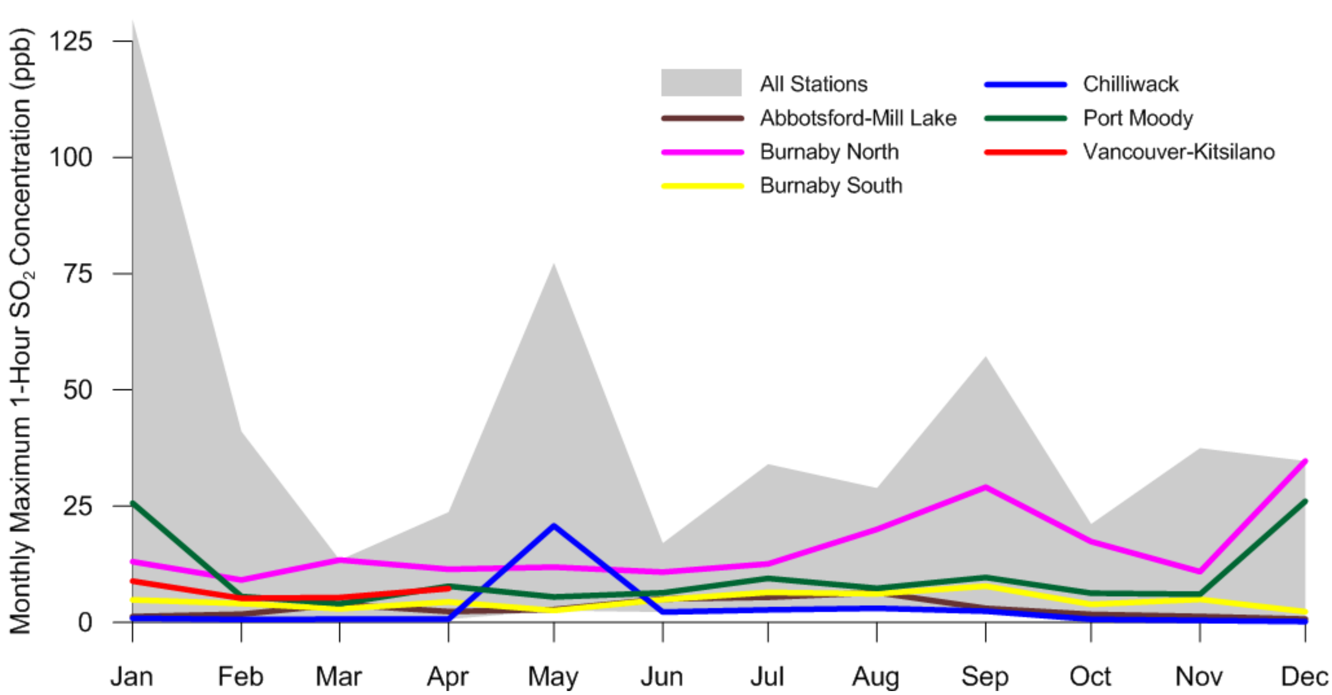


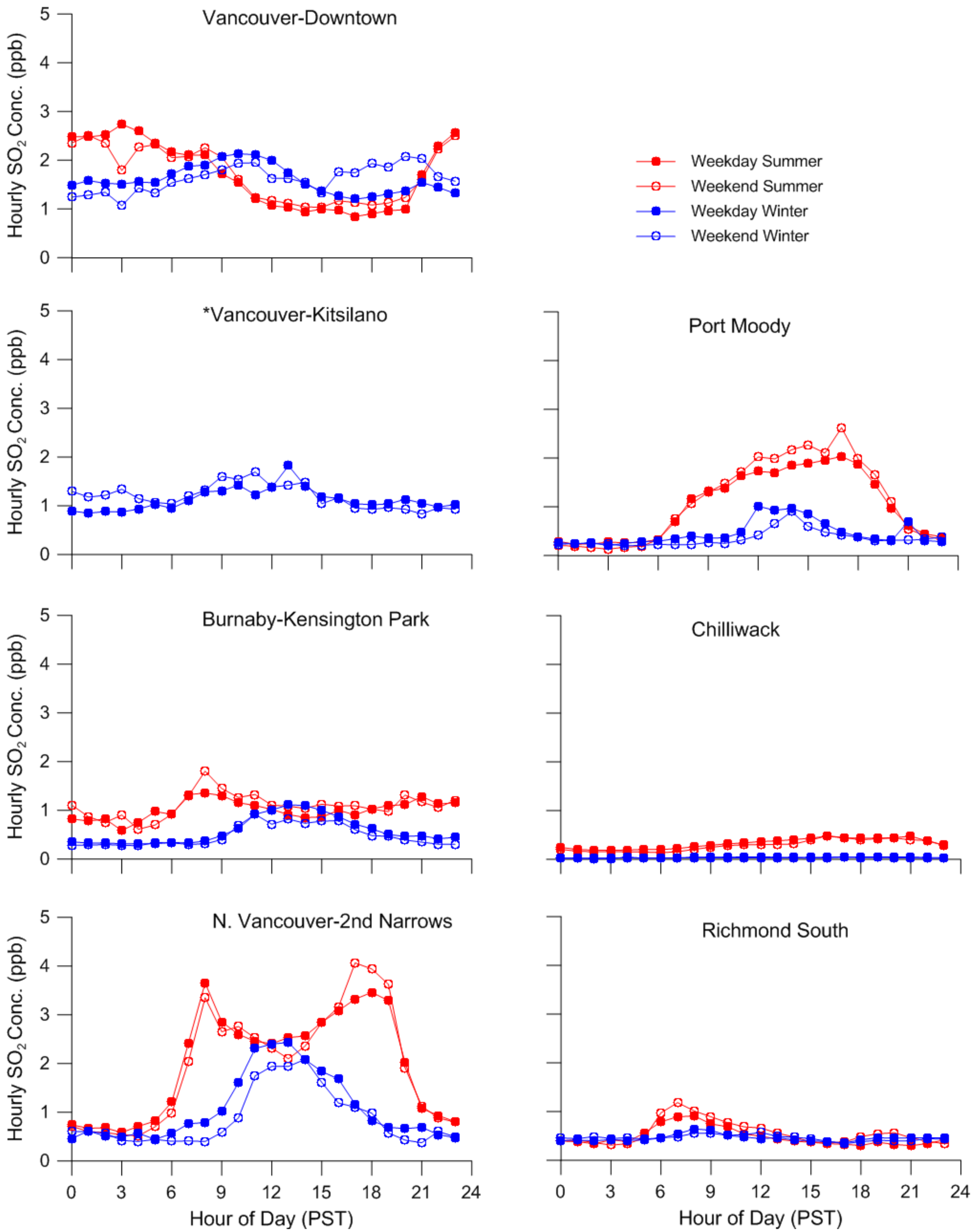
Figure 12: Monthly short-term peak sulphur dioxide, 2014.

Table 4: Frequency distribution of hourly sulphur dioxide, 2014.

SO_2 Conc. (ppb)	Vancouver-Downtown	Vancouver-Kitsilano	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	Richmond South	Burnaby South	Pitt Meadows	Burnaby-Capitol Hill	Burnaby North	N. Vancouver-Mahon Park	Langley	Richmond-Airport	Abbotsford-Mill Lake	Tsawwassen	Abbotsford Airport
0 to 5	7762	3215	8363	7992	7963	7367	8512	8417	7845	8033	8033	7835	7868	8431	8252	8194	7854
5 to 10	311	25	69	429	95		3	7	2	255	450	136	10	8	7	10	3
10 to 15	13			53						62	47	15	1				
15 to 20	1			8						27	5	3					
20 to 25				1		2				16	4						
25 to 30					2					6	2						
30 to 35										11	1						
35 to 40										2							
40 to 45										2							
45 to 50										6							
50 to 55										1							
55 to 60										2							
60 to 65										1							
65 to 70																	
70 to 75										1							
75 to 80										3							
80 to 85																	
85 to 90																	
90 to 95																	
95 to 100																	
100 to 105																	
105 to 110																	
>=110										1							
Missing	646	5495	176	243	250	262	196	247	681	142	164	213	671	250	377	433	229
Data Completeness	93%	37%	98%	97%	97%	97%	98%	97%	92%	98%	98%	97%	92%	97%	96%	95%	97%

Table 5: Frequency distribution of 24-hour rolling average sulphur dioxide, 2014.

SO_2 Conc. (ppb)	Vancouver-Downtown	Vancouver-Kitsilano	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	Richmond South	Burnaby South	Pitt Meadows	Burnaby-Capitol Hill	Burnaby North	N. Vancouver-Mahon Park	Langley	Richmond-Airport	Abbotsford-Mill Lake	Tsawwassen	Abbotsford Airport
0 to 2	5747	3119	8316	6557	8166	7821	8681	8544	8110	7154	5822	7992	8026	8579	8464	8401	8213
2 to 4	2310	188	375	1857	419			86		1042	2543	616		68			
4 to 6	150			166						309	309						
6 to 8				17						103	24						
8 to 10										54	26						
10 to 12										17							
12 to 14										9							
14 to 16										3							
16 to 18										13							
18 to 20										26							
>=20										5							
Missing Data	553	5453	69	163	115	132	79	130	594	17	36	91	690	113	279	359	105
Completeness	94%	38%	99%	98%	99%	98%	99%	99%	93%	100%	100%	99%	92%	99%	97%	96%	99%



*Data completeness requirements were not met at this site in summer.

Figure 13: Diurnal trends sulphur dioxide, 2014.

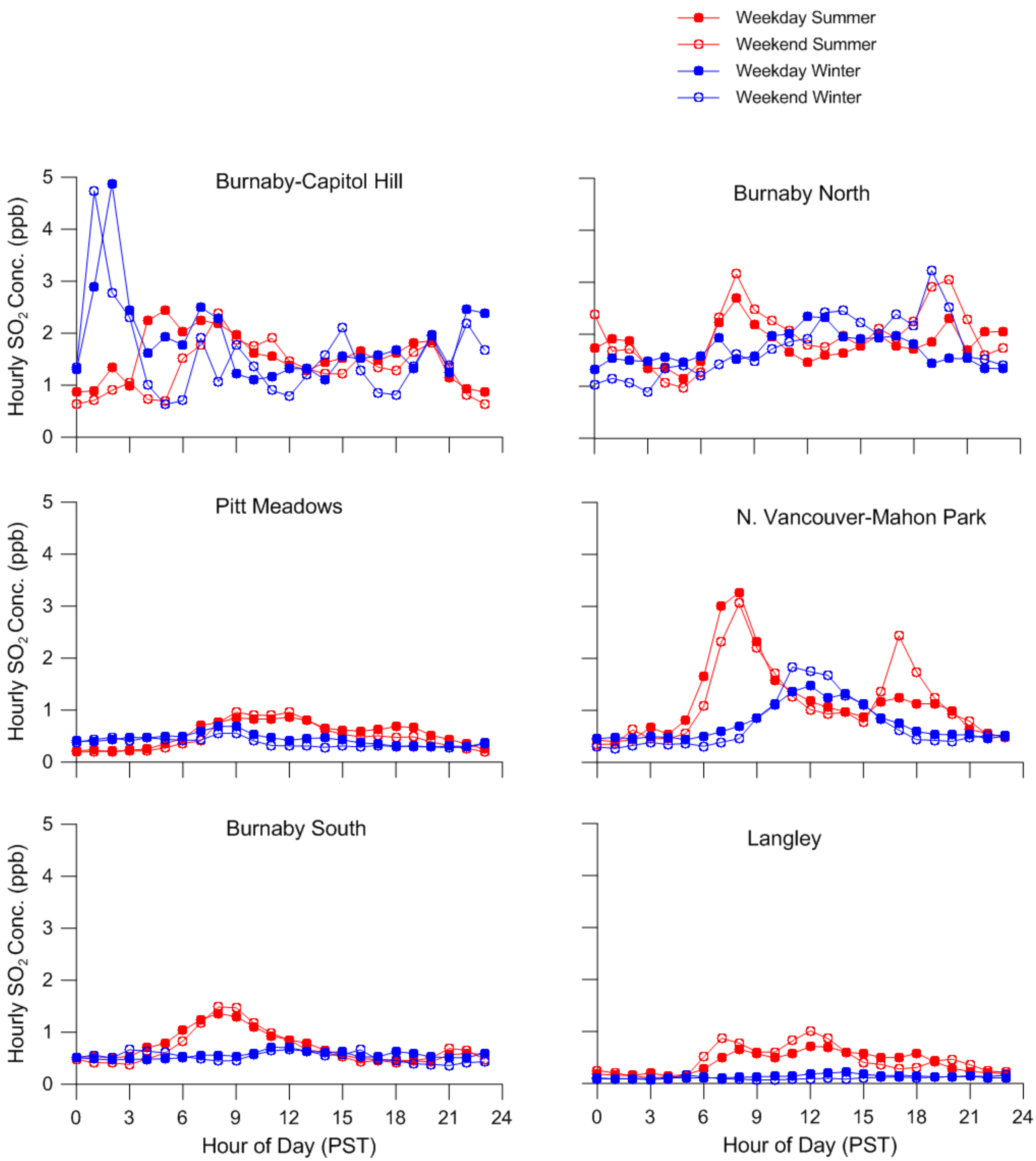


Figure 13: Cont. diurnal trends sulphur dioxide, 2014.

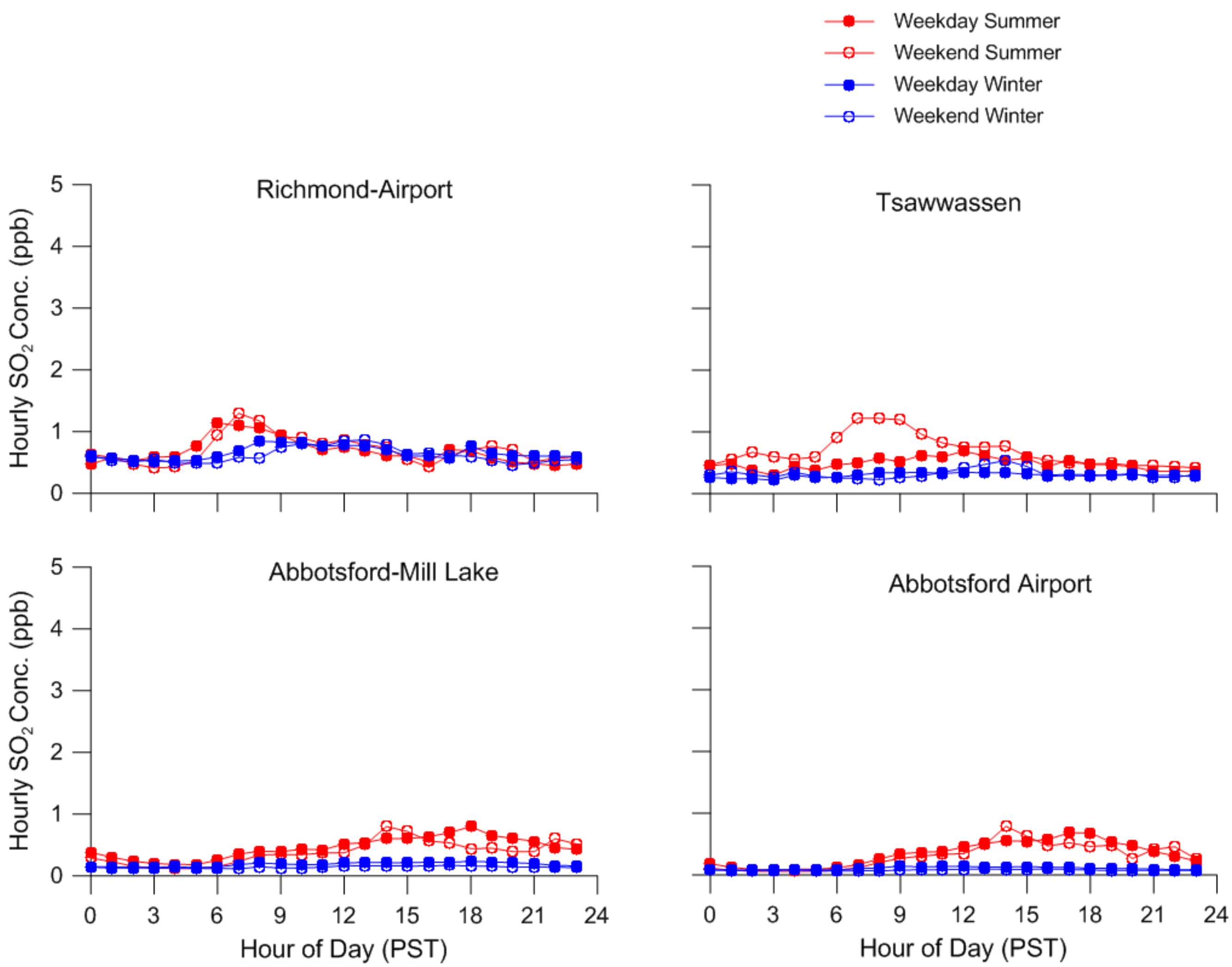


Figure 13: Cont. diurnal trends sulphur dioxide, 2014.

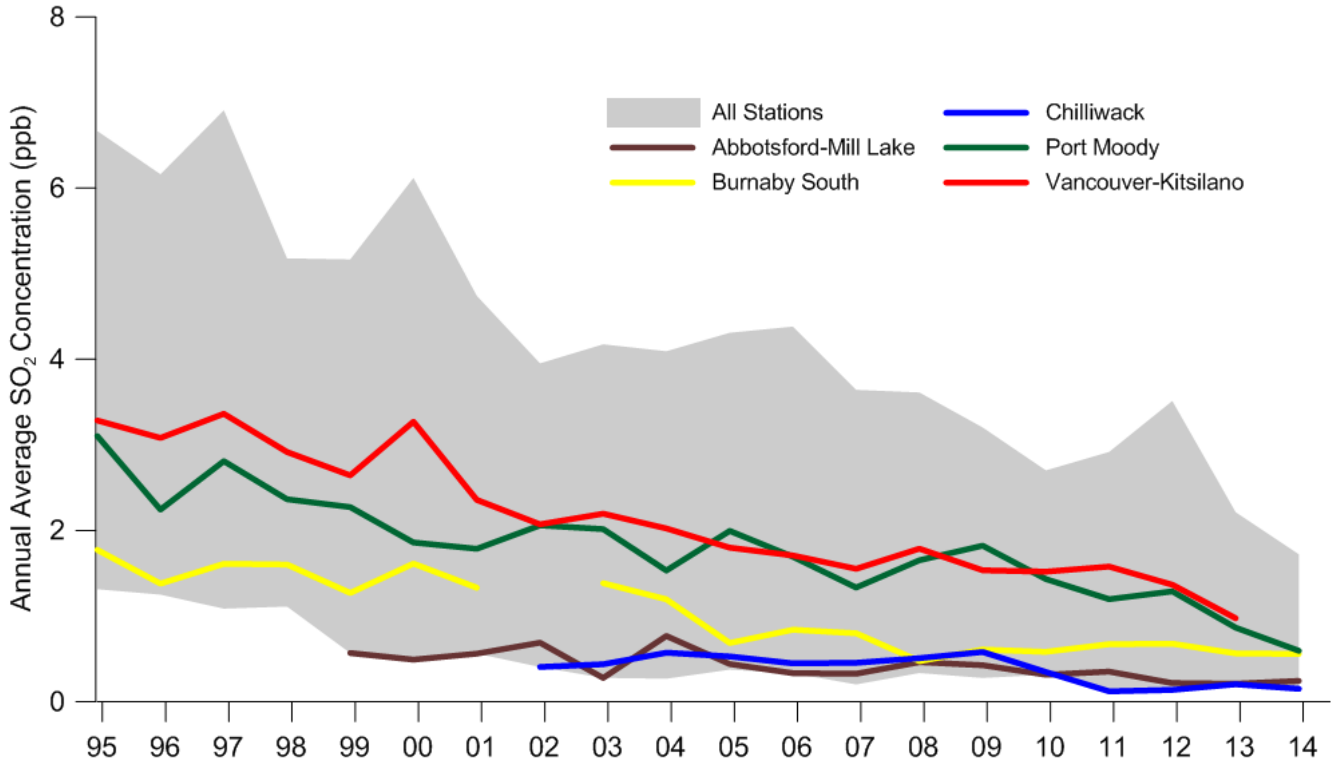


Figure 14: Annual sulphur dioxide trend, 1995 to 2014.

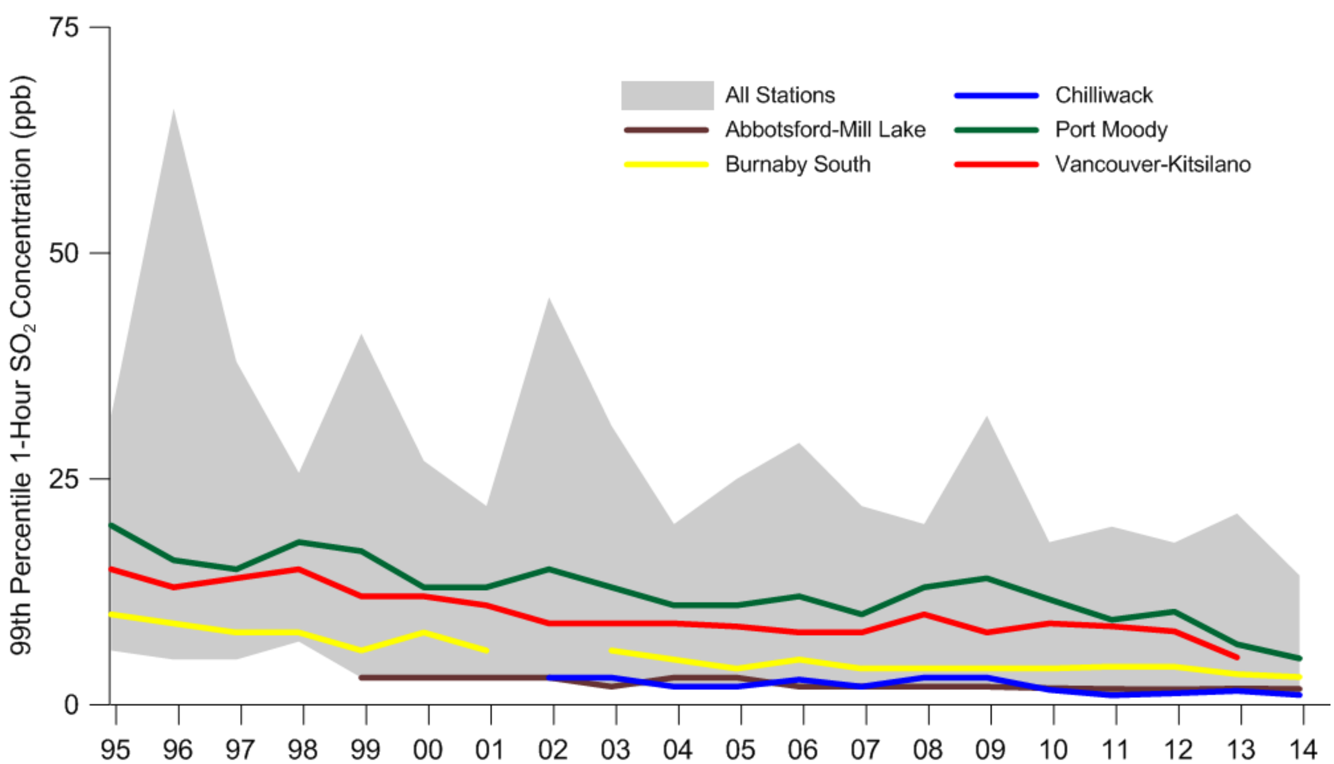


Figure 15: Short-term peak sulphur dioxide trend, 1995 to 2014.

Nitrogen Dioxide (NO_2)

Characteristics

Of all the different oxides of nitrogen (NO_X), nitric oxide (NO) and nitrogen dioxide (NO_2) are of most concern in ambient air quality. Both are produced by the high temperature combustion of fossil fuels, and are collectively referred to as NO_X. Nitric oxide generally predominates in combustion emissions but rapidly undergoes chemical reactions in the atmosphere to produce NO_2.

Nitrogen dioxide is a reddish-brown gas with a pungent, irritating odour. It has been implicated in acute and chronic respiratory disease and in the creation of acid rain. It also plays a major role in ozone formation, and as a precursor to secondary particulate formation ($PM_{2.5}$), both of which can affect visual air quality in the region.

Sources

Common NO_X sources include boilers, building heating systems and internal combustion engines. In the LFV, transportation sources account for approximately 63% of NO_X emissions, with stationary and area sources contributing the remainder.

Monitoring Results

Figure 16 shows NO_2 monitoring levels in 2014, while Figures 17 and 18 shows the same values spatially.

All 1-hour NO_2 concentrations continued to be below the Metro Vancouver objective at all times in 2014. Average levels for the year were also below Metro Vancouver's annual objective.

Emissions affecting NO_2 concentrations are dominated by transportation sources, which is indicated by the locations of the highest concentrations. The highest concentrations are measured in more densely trafficked areas near busy roads. Lower concentrations were observed where traffic influences were less pronounced, such as the eastern parts of Metro Vancouver and in the FVRD.

The seasonal trend for NO_2 in 2014 is demonstrated by plotting monthly averages in Figure 19 and the monthly maximum 1-hour concentrations in Figure 20. Overall, NO_2 concentrations were higher in the winter and lower in the summer. This seasonal trend is typical of the region and is the result of lower atmospheric mixing heights in winter along with increased residential, commercial and industrial heating.

The frequency distribution of hourly concentrations measured in 2014 is given in Table 6.

The majority of nitrogen oxides are from transportation sources such as cars, trucks, rail, planes and ships. These sources play a large role in ozone formation in the summer, which can lead to an air quality advisory.

A series of diurnal plots are shown in Figure 21 for each station that monitors NO_2. The plots demonstrate the differences between weekdays and weekends along with differences between summer and winter. Most stations exhibit higher concentrations on weekdays compared with weekends and show a peak in the morning along with a peak in the afternoon. Higher concentrations correspond relatively well with traffic volume patterns.

The long-term NO_2 trends are shown in Figures 22 and 23. The annual average trend is given in Figure 22 with the short-term peak trend given in Figure 23 for the last two decades.

The trend for average and peak (99th percentile of 1-hour) concentrations continued to decline, showing constant improvement in NO_2 levels since the early 1990's. Long-term changes in air quality can be attributed to changes in emissions while the yearly variation is likely attributable to meteorological variability. The improvements in the long-term trends shown here are thought to be largely due to improved vehicle emission standards and the AirCare program.

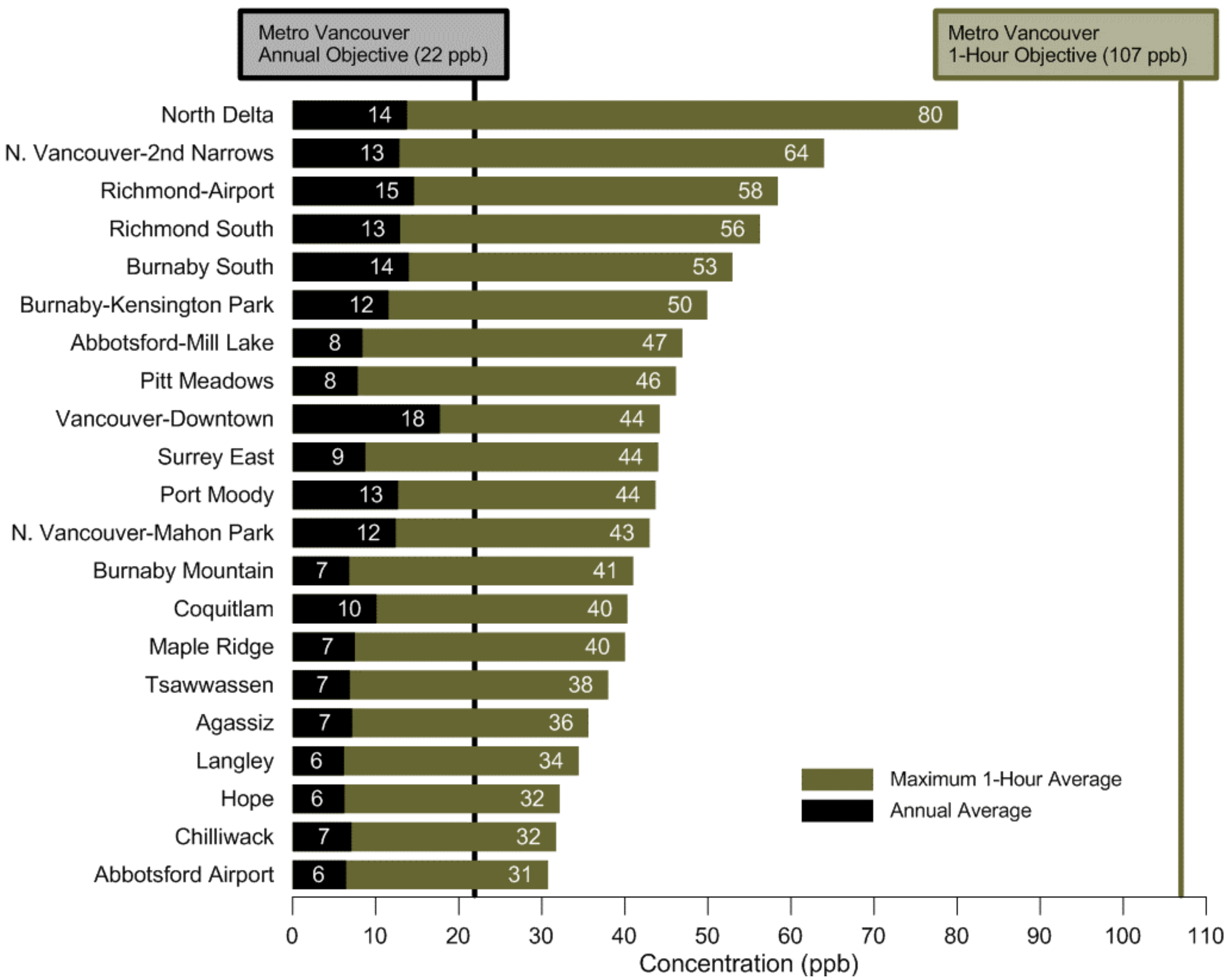


Figure 16: Nitrogen dioxide monitoring, 2014.

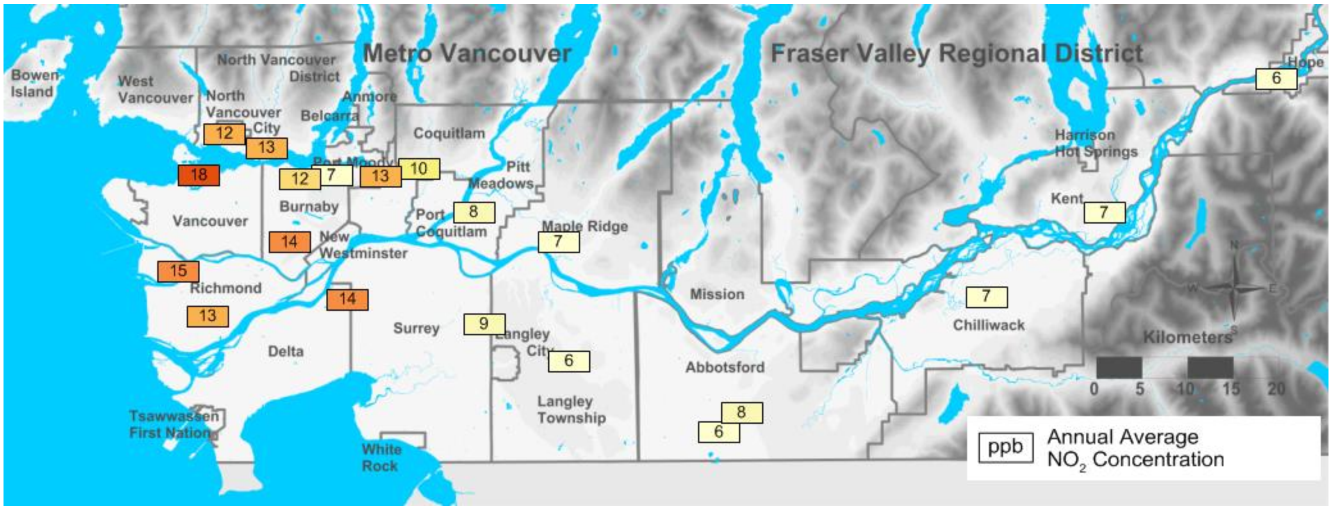


Figure 17: Annual average nitrogen dioxide in the LFV, 2014.

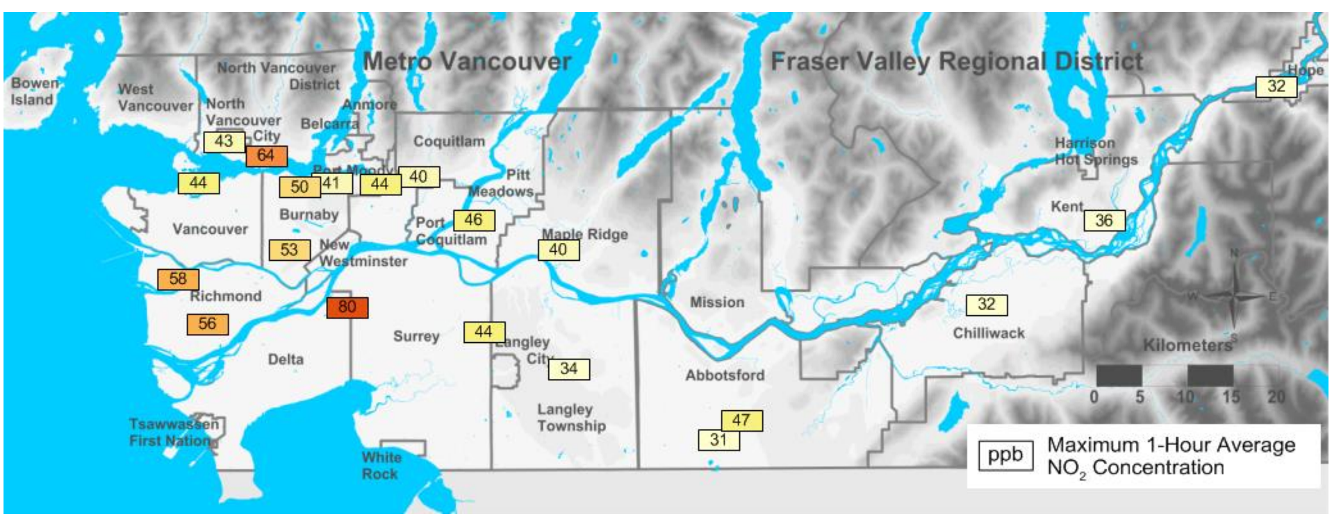


Figure 18: Short-term peak (maximum 1-hour) nitrogen dioxide in the LFV, 2014.

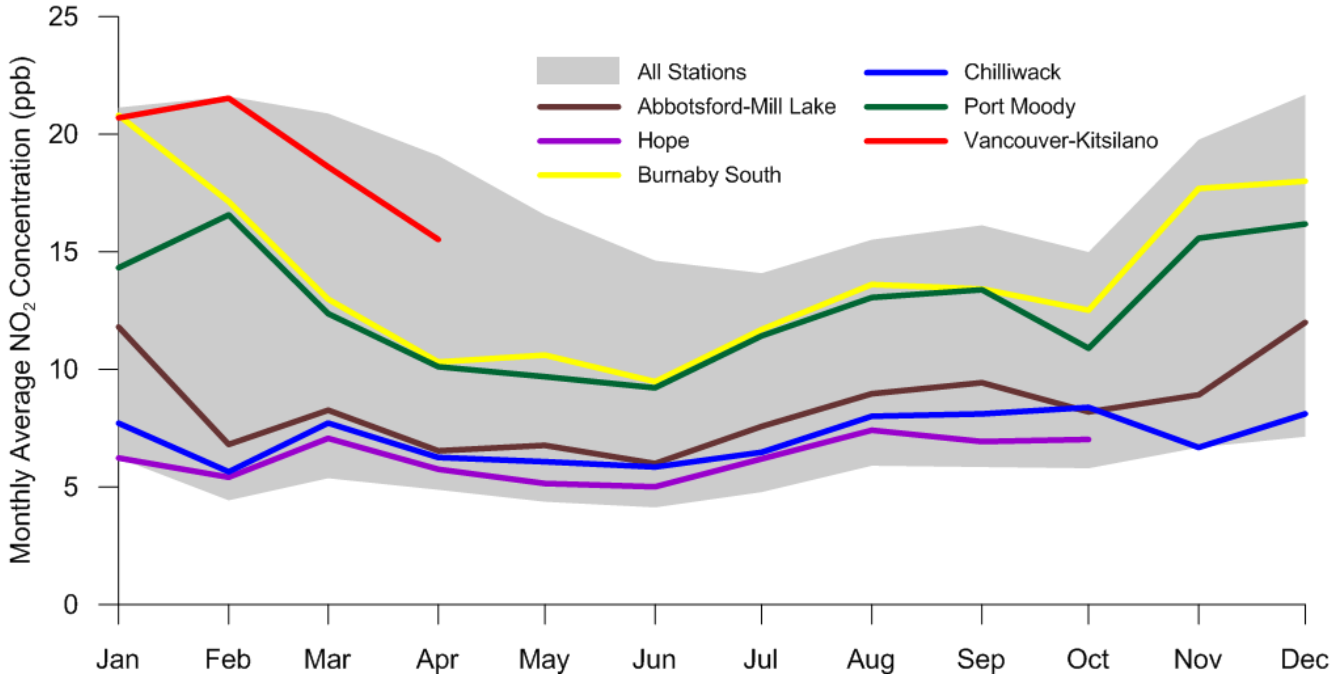


Figure 19: Monthly average nitrogen dioxide, 2014.

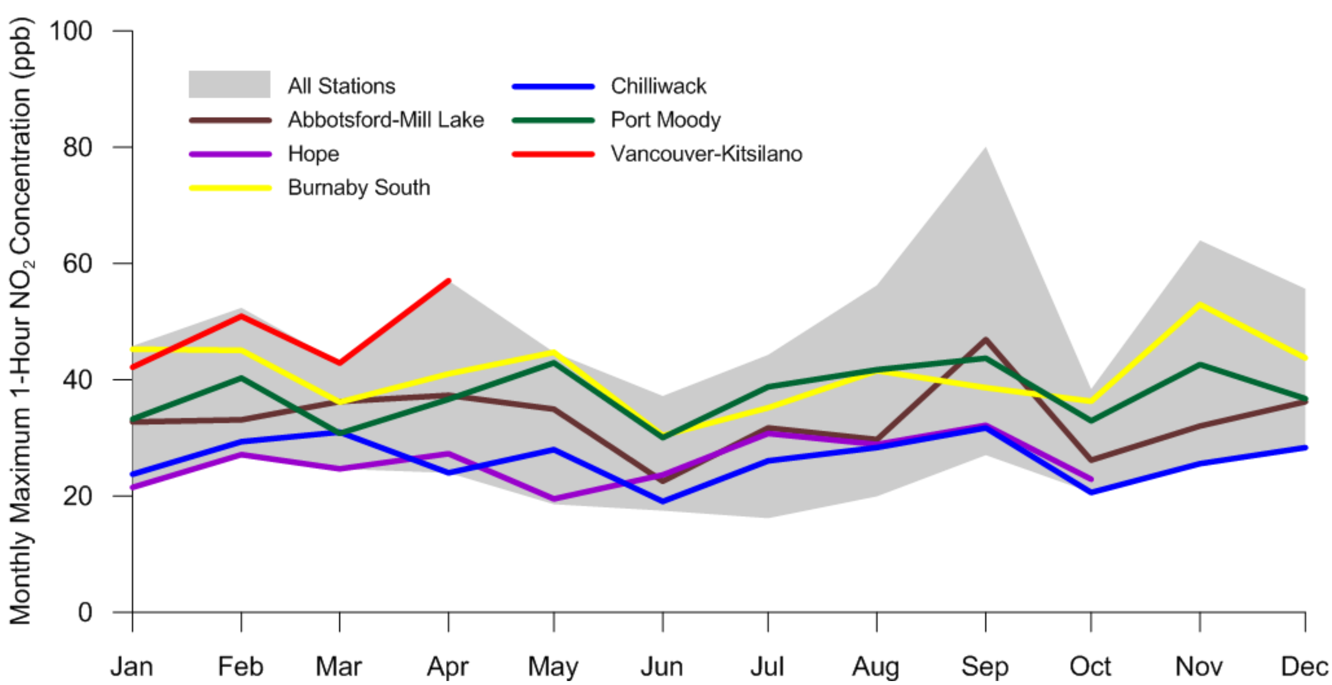
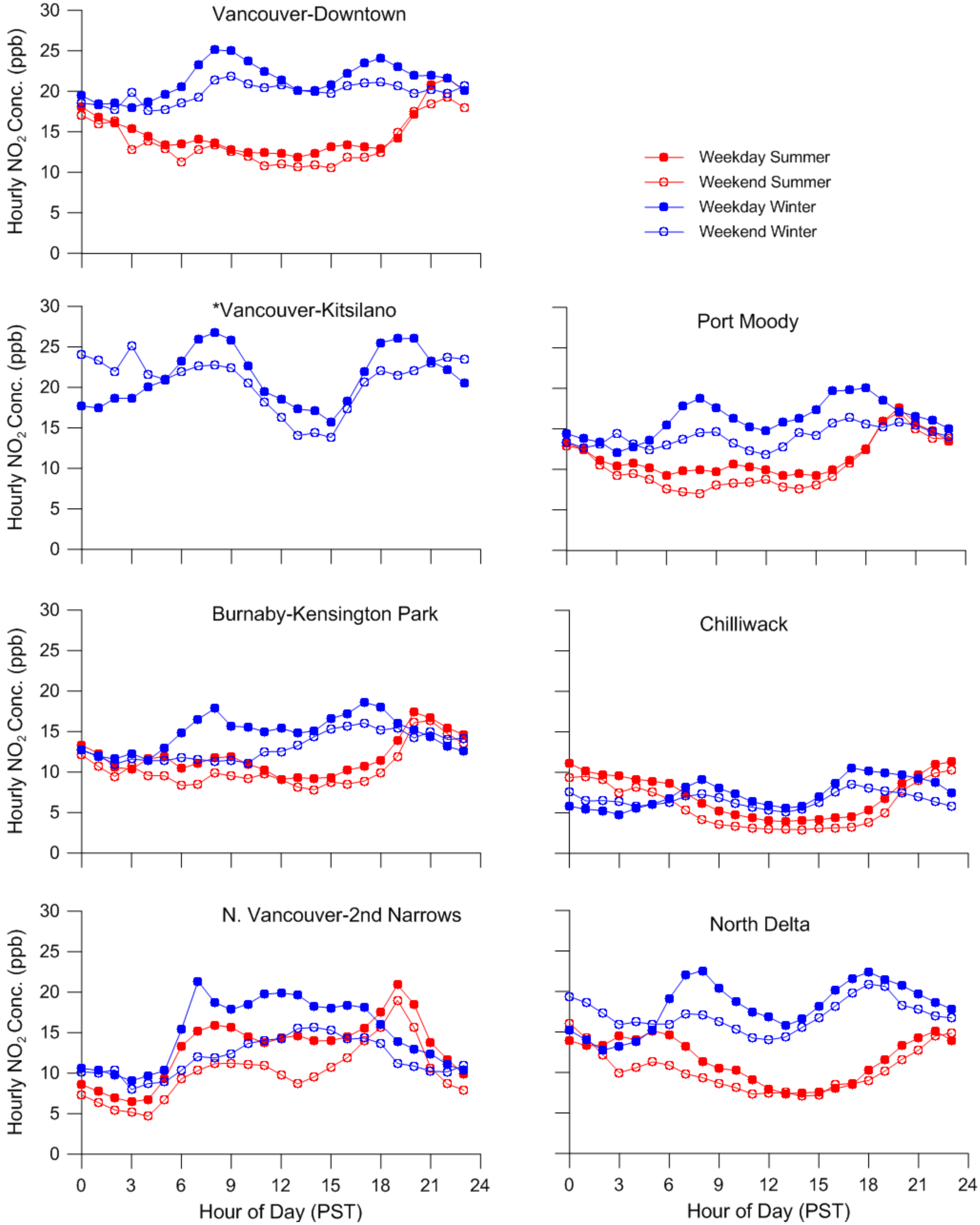


Figure 20: Monthly short-term peak nitrogen dioxide, 2014.

Table 6: Frequency distribution of hourly nitrogen dioxide, 2014.

NO_2 Conc. (ppb)	Vancouver-Downtown	Vancouver-Kitsilano	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	North Delta	Burnaby Mountain	Surrey East	Richmond South	Burnaby South	Pitt Meadows	N. Vancouver-Mahon Park	Langley	Hope	Maple Ridge	Richmond-Airport	Coquitlam	Abbotsford-Mill Lake	Tsawwassen	Agassiz	Abbotsford Airport
0 to 5	64	360	1319	966	921	3284	1431	3761	3076	1951	761	3463	1384	4305	3771	3596	1251	2187	3130	4291	3814	4271
5 to 10	1050	486	2955	2593	2592	3337	2357	3069	2644	1951	2540	2504	2675	2584	2275	2825	2079	2886	2600	2232	2665	2394
10 to 15	2233	438	2067	2141	2240	1344	1605	1069	1335	1495	2108	1456	1746	847	846	1284	1540	1733	1392	929	1409	1197
15 to 20	2097	525	1142	1383	1506	380	1217	368	685	1252	1281	704	1189	335	307	631	1329	971	730	517	525	455
20 to 25	1752	581	565	735	723	95	836	116	394	920	876	282	793	120	102	184	978	524	293	286	152	129
25 to 30	943	444	269	338	366	21	573	55	154	590	477	94	445	48	15	67	614	225	106	122	41	40
30 to 35	309	246	128	156	127	3	305	32	82	286	288	39	201	14	3	23	392	60	52	20	4	2
35 to 40	83	117	43	76	28		181	18	28	86	121	15	60			5	179	24	11	2	2	
40 to 45	13	45	14	23	6		72	2	7	19	51	2	5			1	70	1	2			
45 to 50		5	4	9			11			2	3	1					10		1			
50 to 55		1		4			4			2	1						4					
55 to 60		1		1			1			1							1					
60 to 65				1			1															
65 to 70																						
70 to 75																						
75 to 80																						
>=80							1															
Missing	216	5511	254	334	251	293	165	269	355	205	253	197	262	507	1441	144	313	149	443	361	148	272
Data Completeness	98%	37%	97%	96%	97%	97%	98%	97%	96%	98%	97%	98%	97%	94%	84%	98%	96%	98%	95%	96%	98%	97%



*Data completeness requirements were not met at this site in summer.

Figure 21: Diurnal trends nitrogen dioxide, 2014.

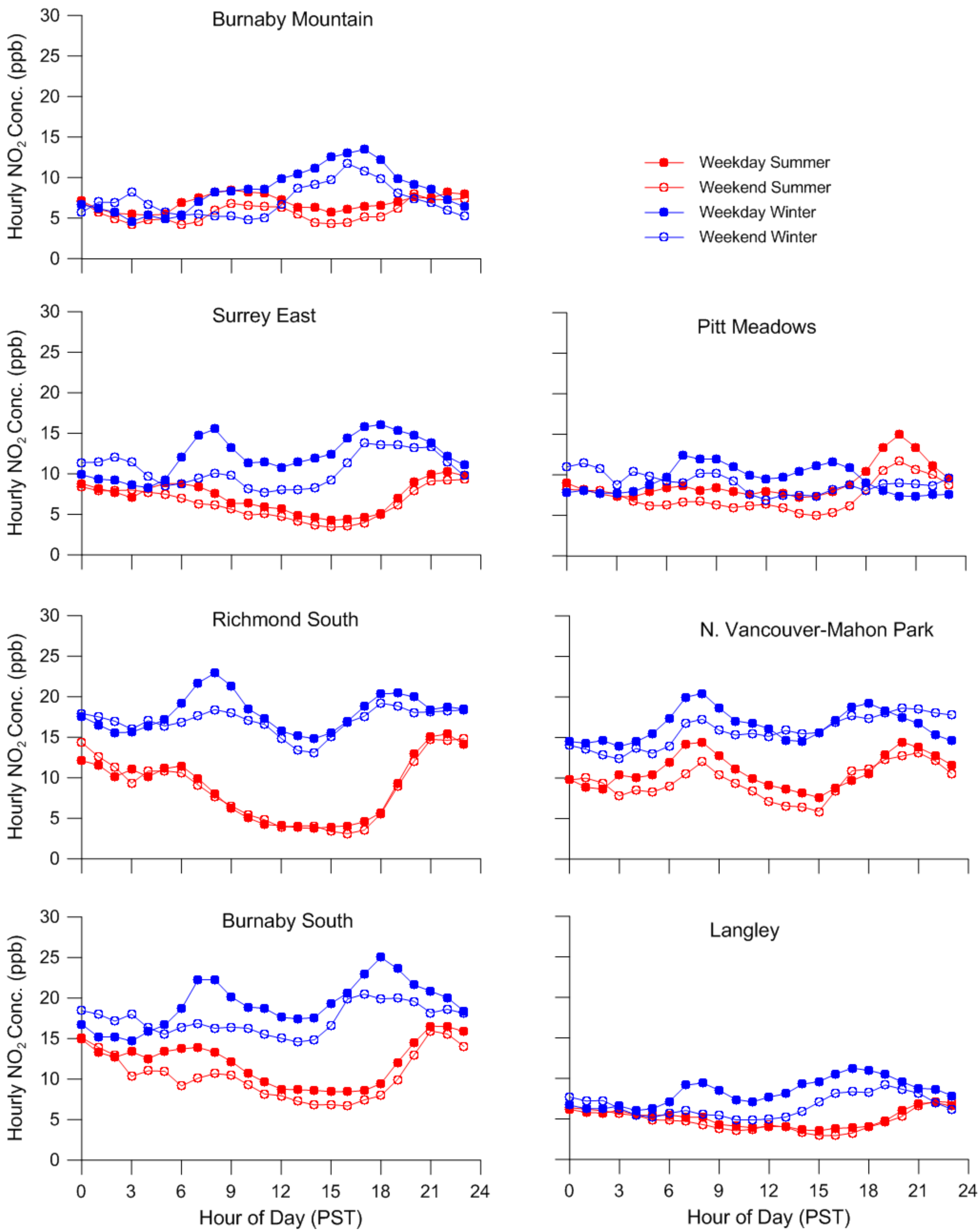


Figure 21: Cont. Diurnal trends nitrogen dioxide, 2014.

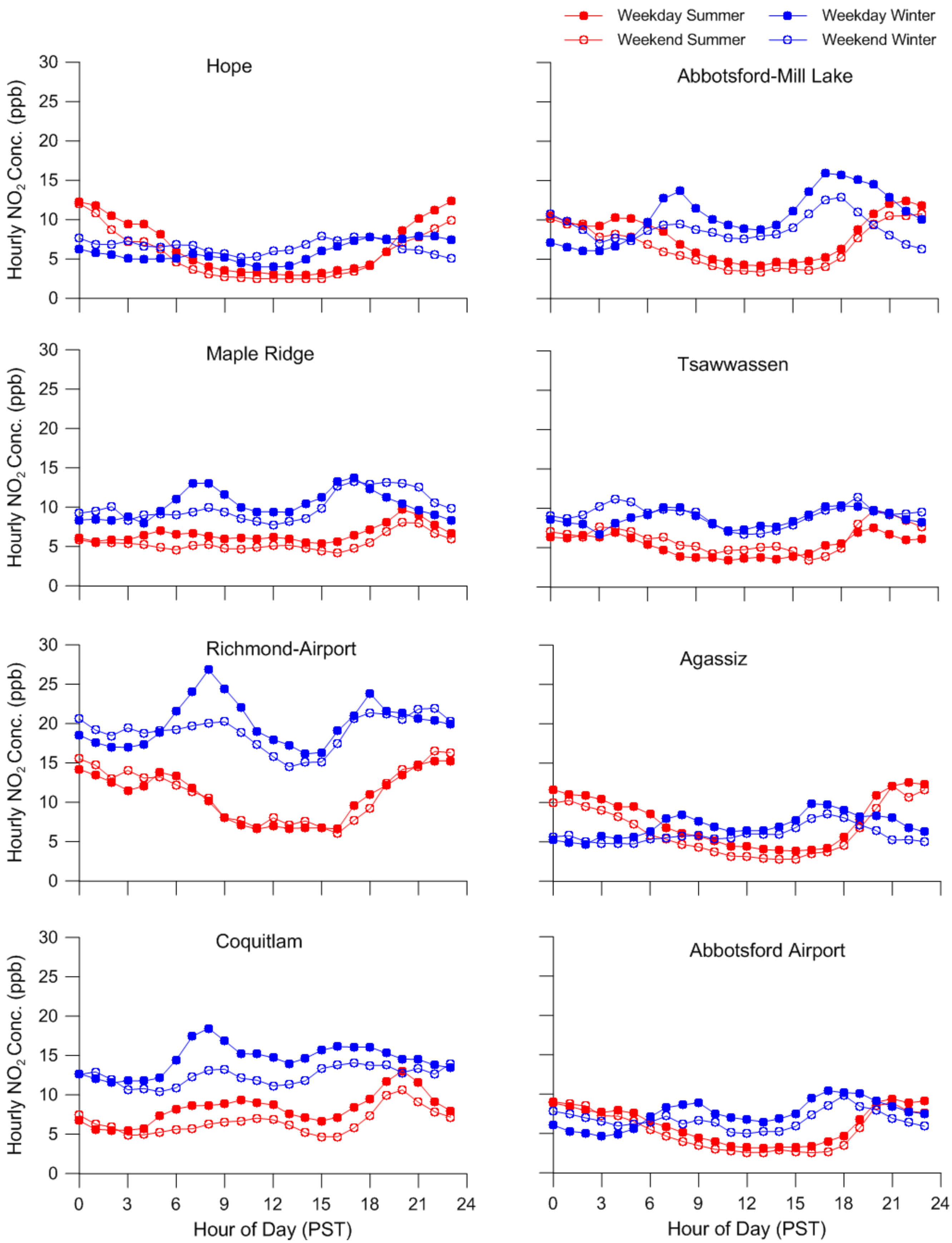


Figure 21: Cont. Diurnal trends nitrogen dioxide, 2014.

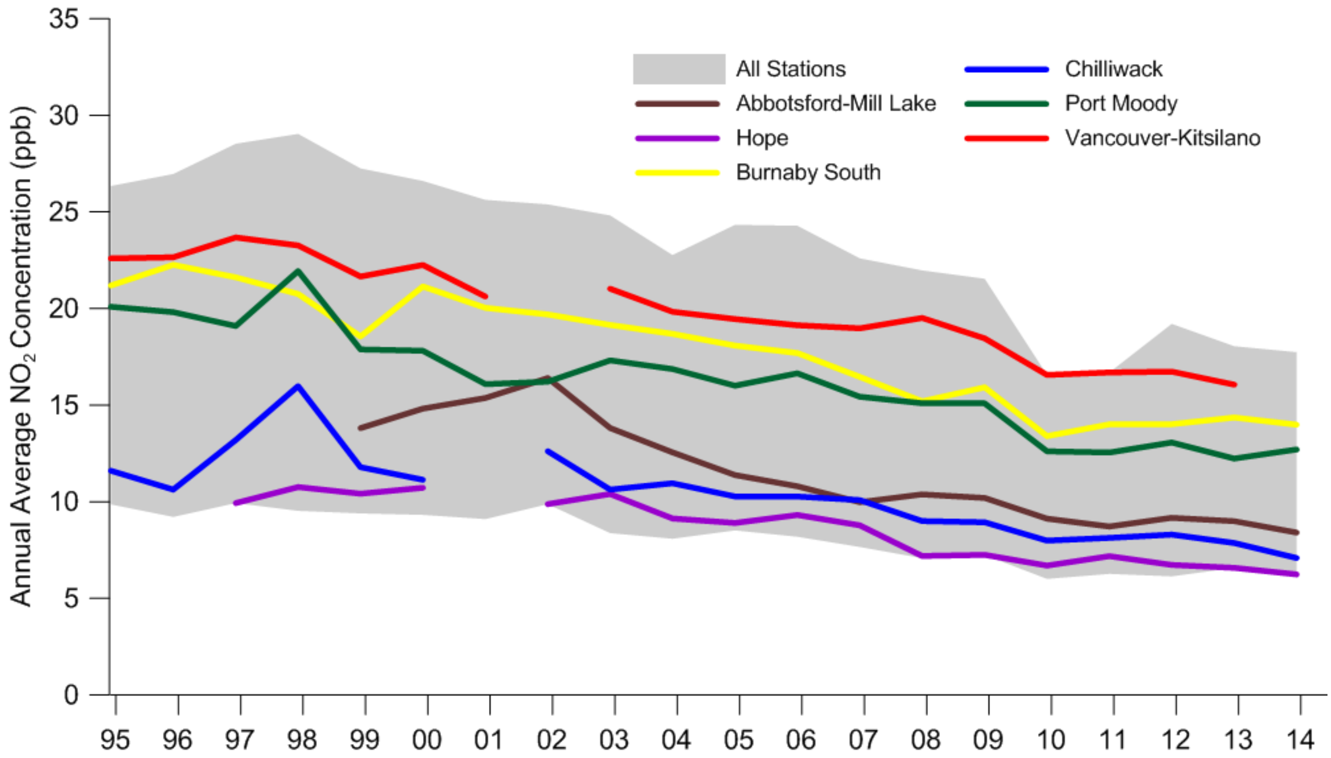


Figure 22: Annual nitrogen dioxide trend, 1995 to 2014.

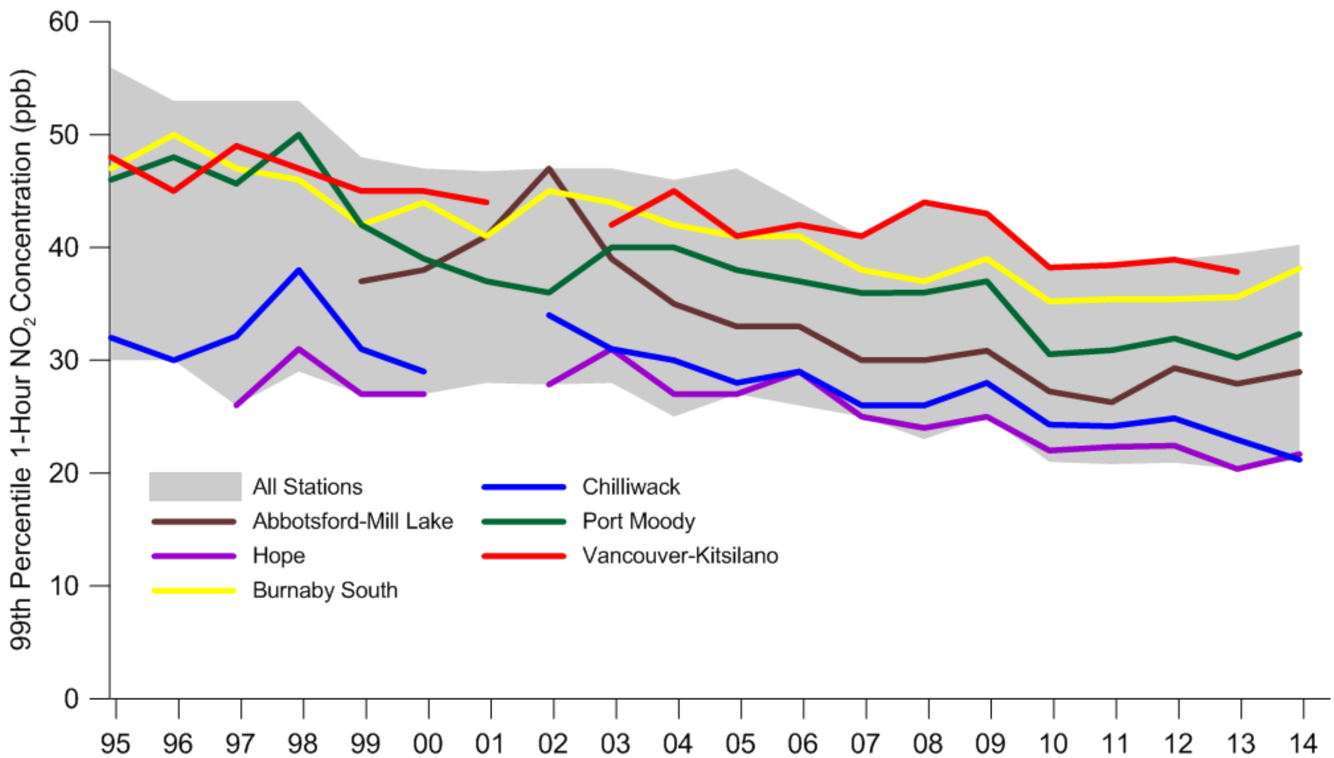


Figure 23: Short-term peak nitrogen dioxide trend, 1995 to 2014.

Carbon Monoxide (CO)

Characteristics

Carbon monoxide (CO) is a colourless, odourless and tasteless gas produced by the incomplete combustion of fuels containing carbon. It has a strong affinity for haemoglobin and thus reduces the ability of blood to transport oxygen. Long-term exposure to low concentrations may cause adverse effects in people suffering from cardiovascular disease.

Sources

Carbon monoxide is the most widely distributed and commonly occurring air pollutant. The principal sources are non-road engines and motor vehicles. In the LFV, over 94% comes from mobile sources which include cars, trucks, buses, planes, trains, ships and non-road engines. Other sources contributing to measured CO levels are building heating and commercial and industrial operations.

Monitoring Results

Figures 24 to 27 illustrate the results of CO monitoring for 2014. Figure 24 displays the value of the maximum 1-hour and 8-hour average as well as the annual average for each CO monitoring location. The same values are represented on maps in Figures 25, 26 and 27.

Measured carbon monoxide levels were well below Metro Vancouver's objectives at all stations throughout the LFV. The highest concentrations generally occurred in the west in highly urbanized areas that experience large volumes of traffic.

Average levels remained low throughout the LFV (less than 325 ppb) with the lowest readings recorded at stations away from heavily trafficked areas.

The seasonal trends for CO in 2014 are plotted as monthly average and maximum 1-hour concentrations in Figures 28 and 29, respectively. Overall, average CO concentrations were higher in the winter compared with the summer. This seasonal trend is typical of the region and is the result of lower atmospheric mixing heights in winter along with increased residential, commercial and industrial heating.

A series of diurnal plots are shown in Figure 30 for each station that monitors CO. Most stations exhibit higher winter concentrations on weekdays compared with weekends with many stations showing a large peak in the morning that corresponds relatively well with morning traffic patterns.

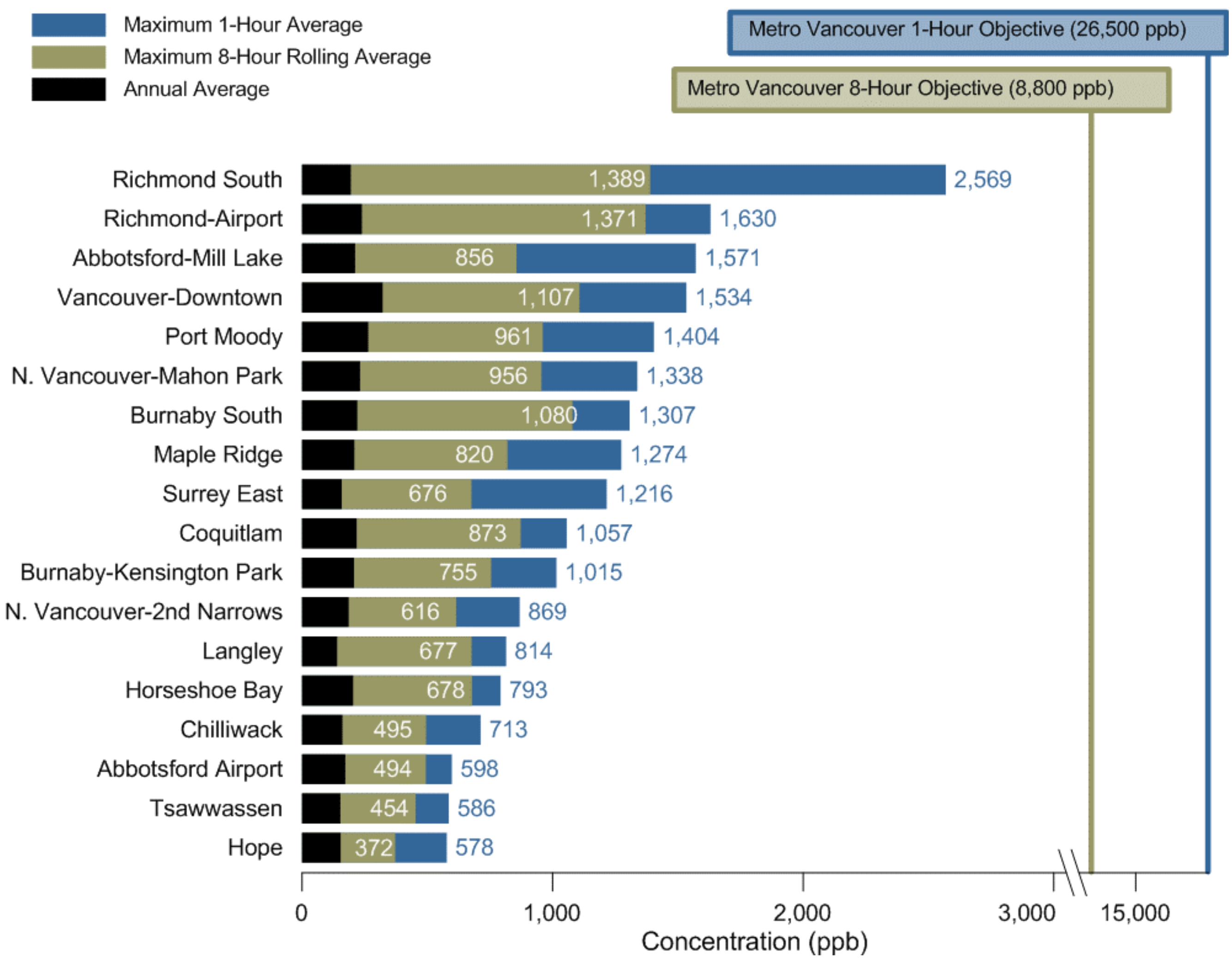
Stations that appear to be strongly influenced by CO emission sources such as traffic include Vancouver-Kitsilano, Richmond-South and Richmond-Airport where a well-defined peak is evident in the mornings on weekdays during the winter.

In the summer diurnal trends are much less apparent, however two stations (Port Moody and Horseshoe Bay) show higher CO concentrations on weekends in the summer compared with other stations. At Port Moody the trend is thought to be a result of summer festivals and the use of a nearby parking lot and boat launch located close to the monitoring station. Weekend ferry traffic is thought to influence the Horseshoe Bay station.

With the majority of CO released from cars, trucks, buses and non-road engines, dramatic improvements have occurred in the last two decades due to improved vehicle emission standards and vehicle testing.

Figures 31 and 32 illustrate the long-term average and peak CO trends in the LFV, respectively. Some yearly variation is evident in the peak trends, however long-term changes in air quality are mainly attributed to changes in emissions. Both the average and the short-term peak (99th percentile of the 1-hour values) continued to show an improving trend downward.

In the LFV region, average levels have decreased dramatically since the early nineties. Declining CO concentrations are largely due to improved vehicle emission standards and the AirCare program.



Note: The scale is broken in the x-axis between 3,000 and 8,000 ppb. The highest concentration measured is almost ten times less than the objective.

Figure 24: Carbon monoxide monitoring, 2014.

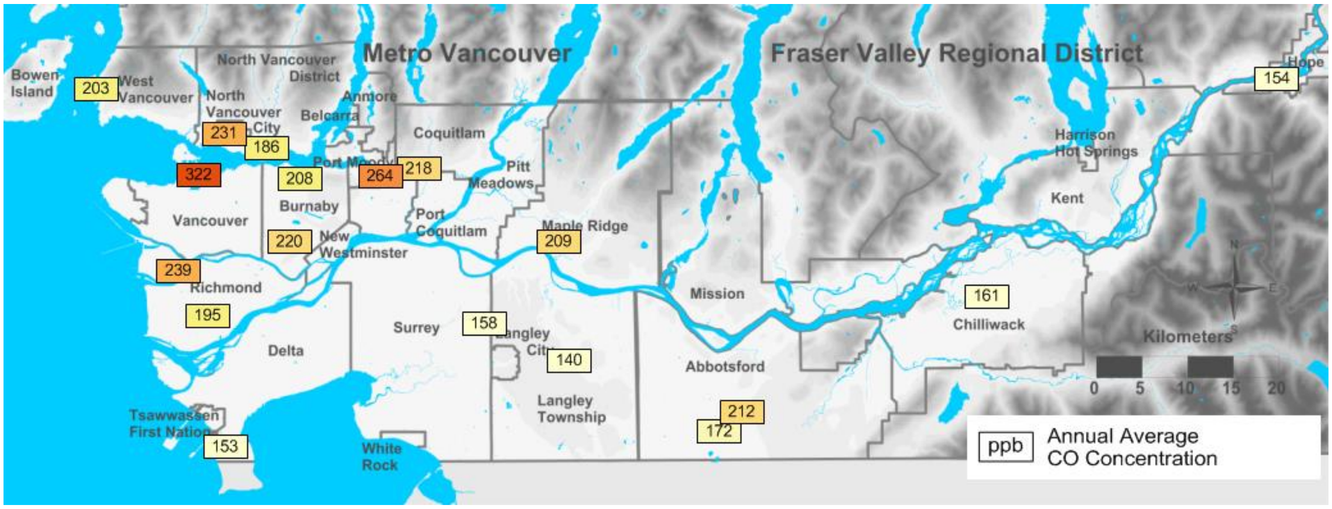


Figure 25: Annual average carbon monoxide in the LFV, 2014.

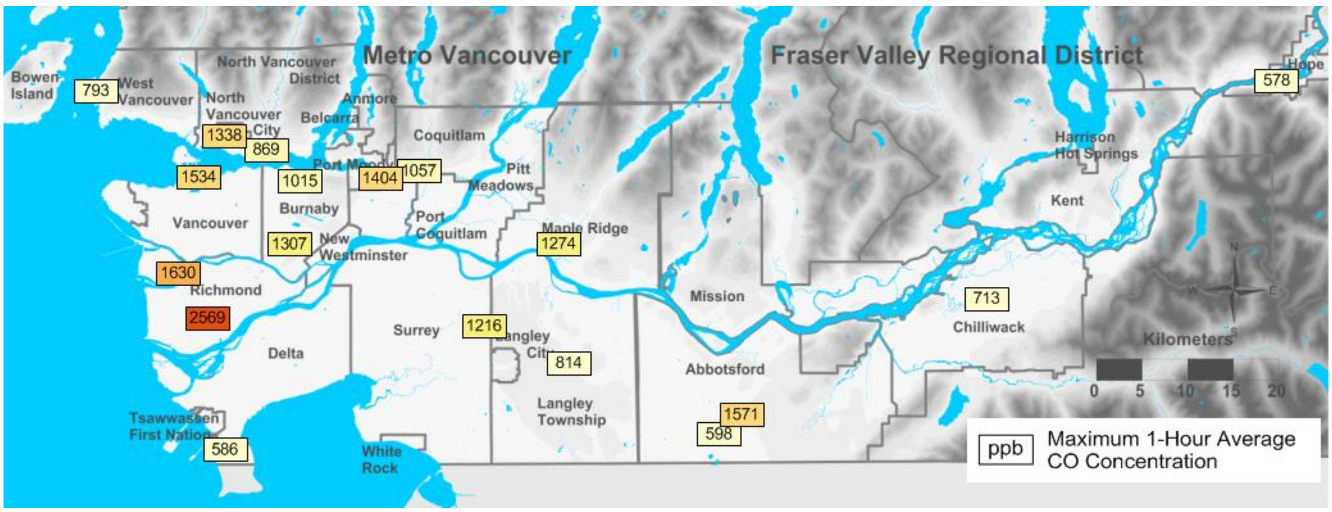


Figure 26: Short-term peak (maximum 1-hour) carbon monoxide in the LFV, 2014.

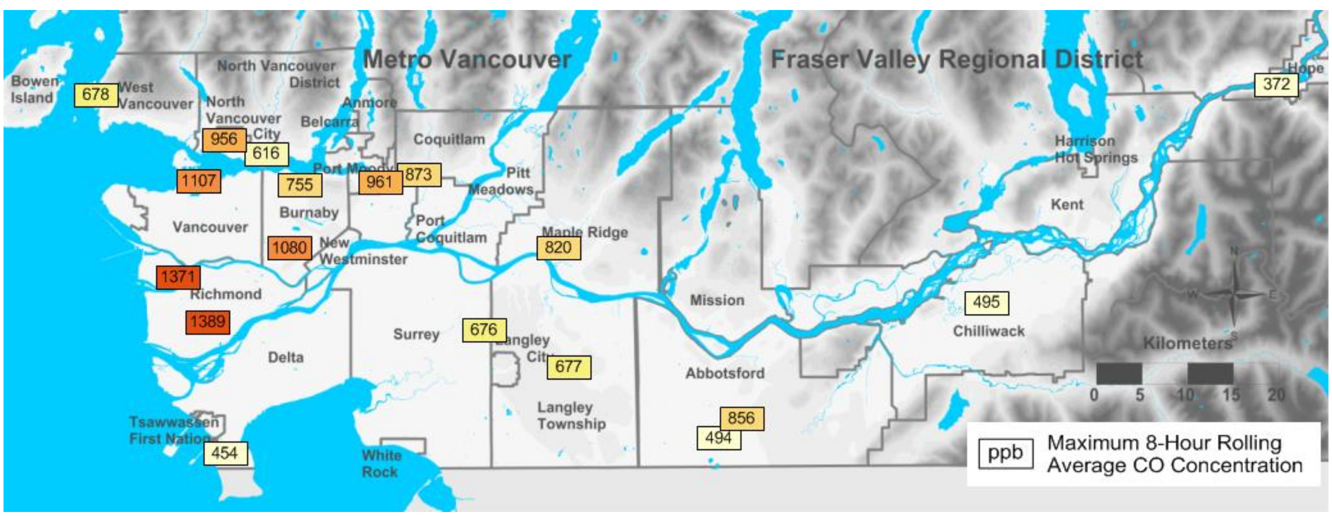


Figure 27: Short-term peak (maximum 8-hour) carbon monoxide in the LFV, 2014.

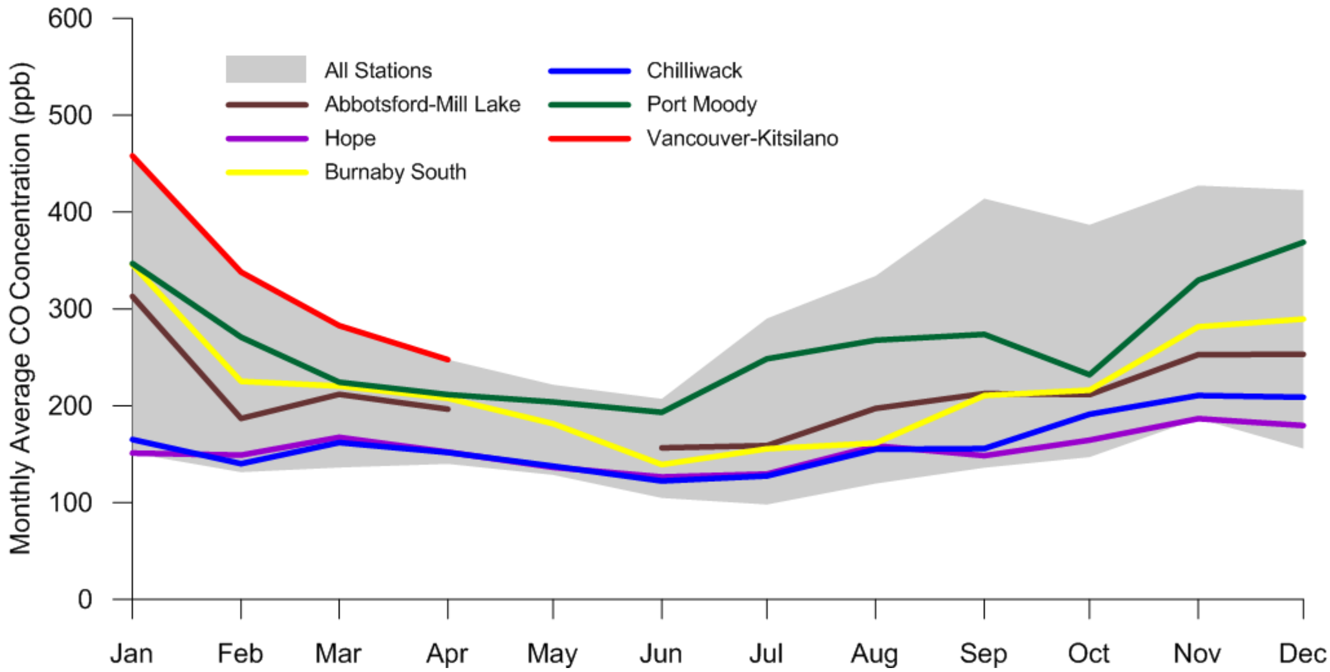


Figure 28: Monthly average carbon monoxide, 2014.

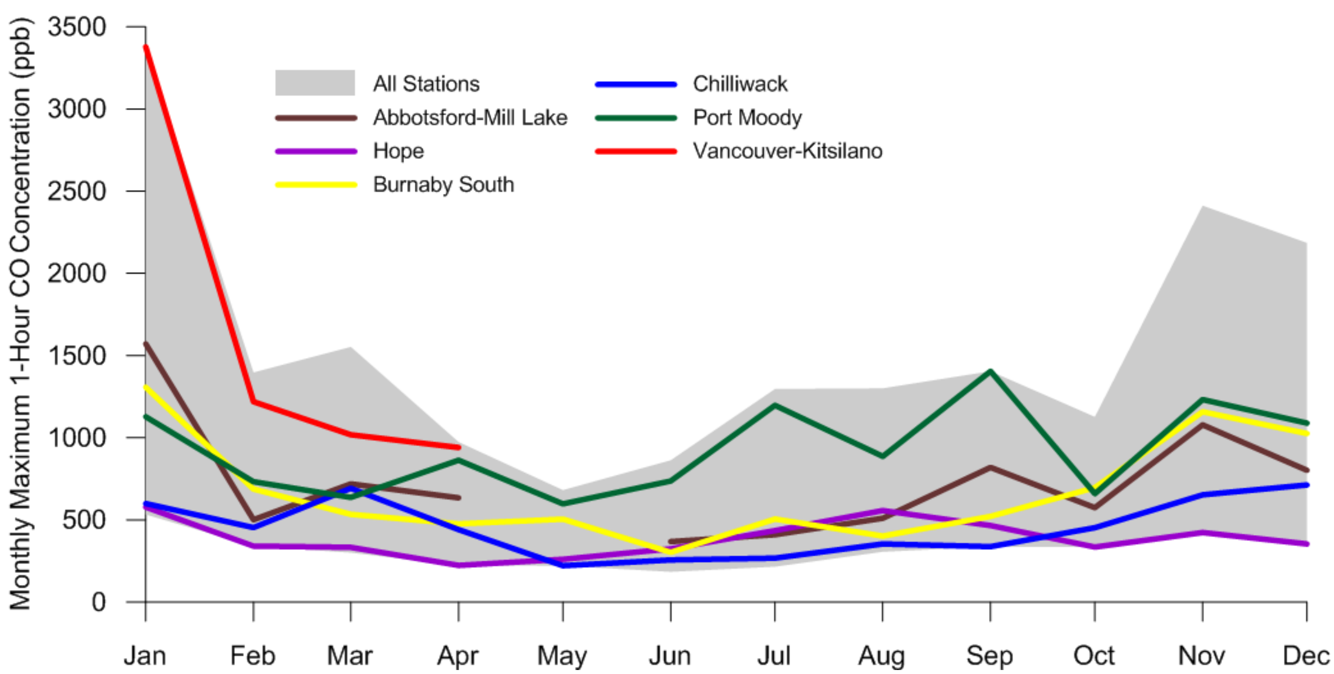
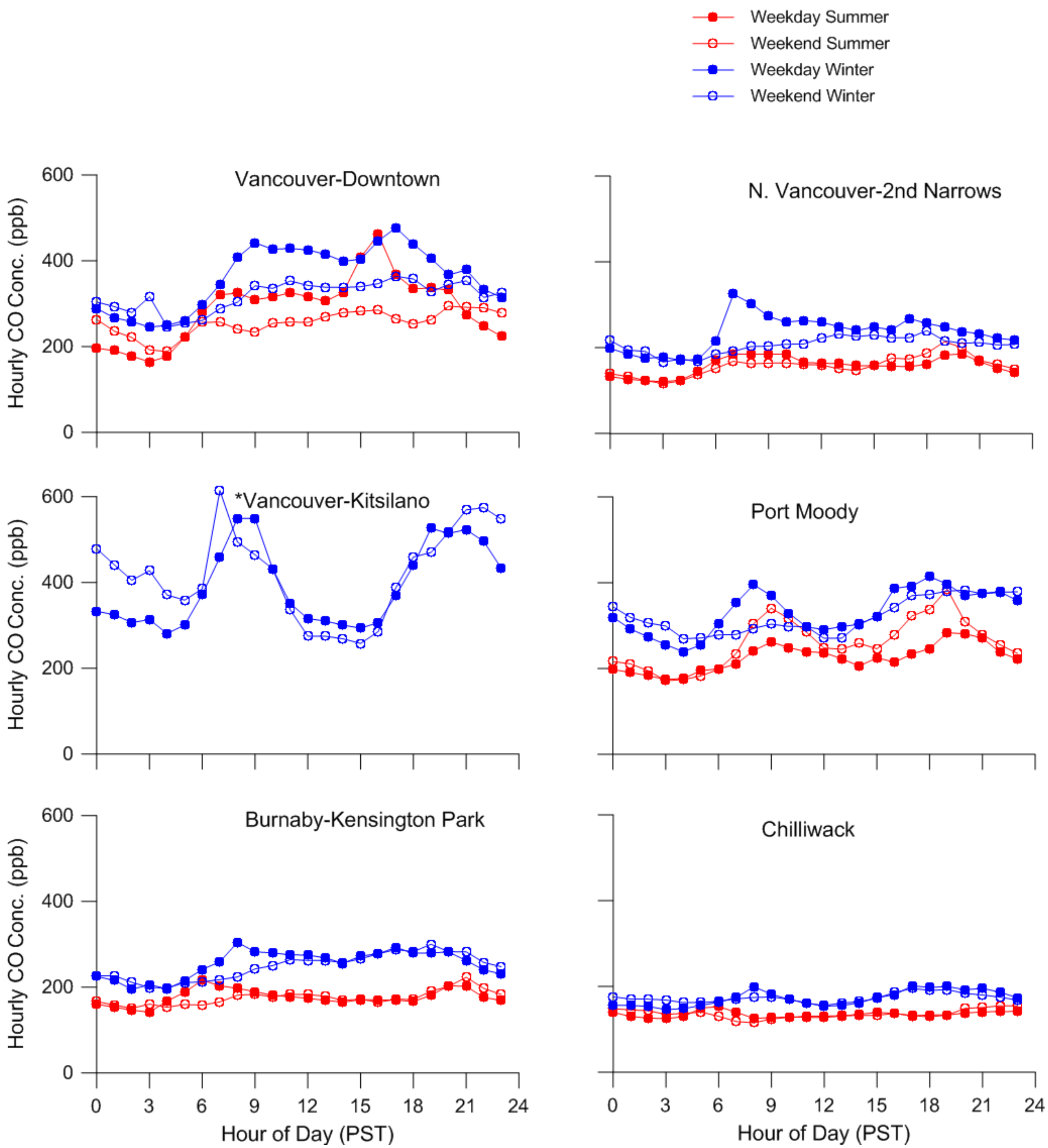


Figure 29: Monthly short-term peak carbon monoxide, 2014.



*Data completeness requirements were not met at this site in summer.

Figure 30: Diurnal trends carbon monoxide, 2014.

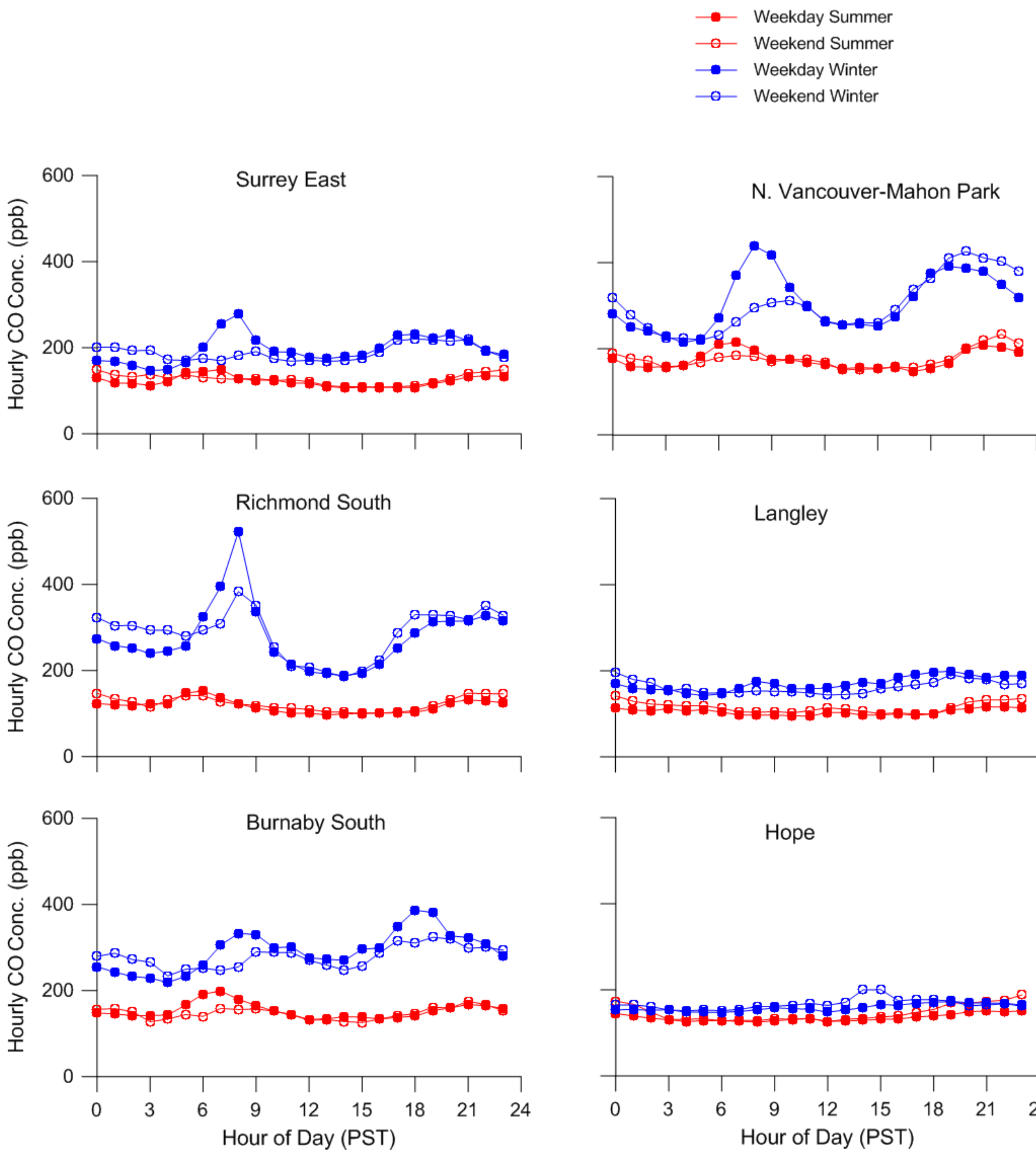


Figure 30: Cont. diurnal trends carbon monoxide, 2014.

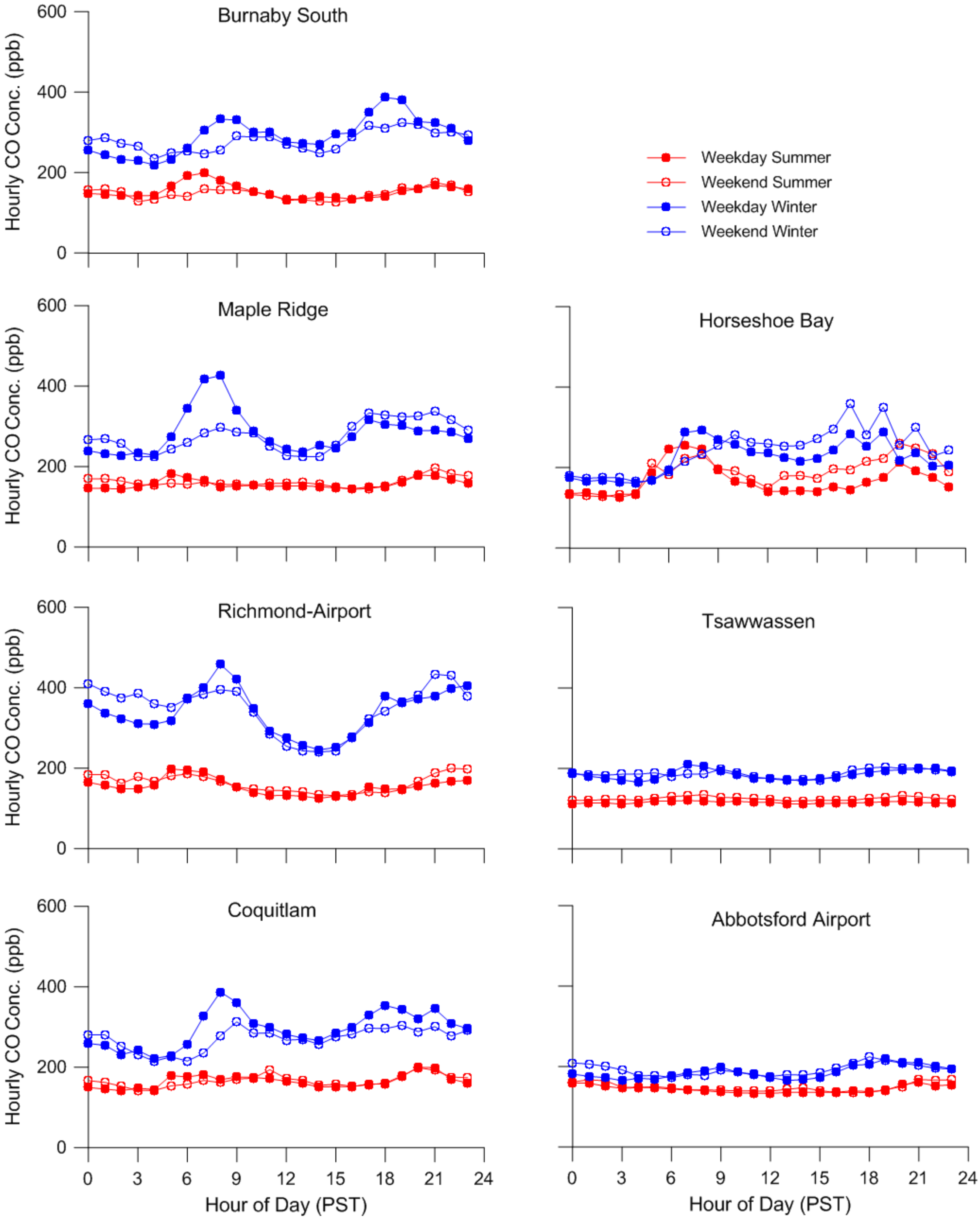


Figure 30: Cont. diurnal trends carbon monoxide, 2014.

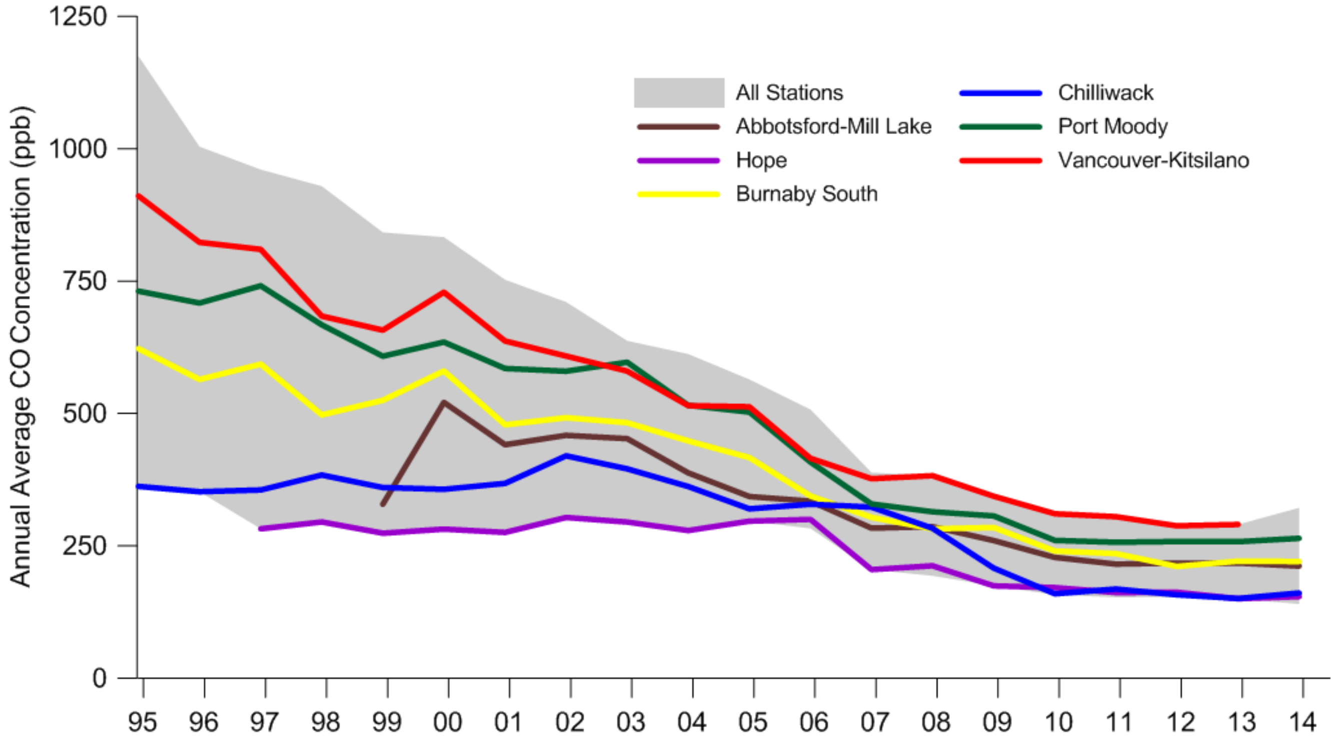


Figure 31: Annual carbon monoxide trend, 1995 to 2014.

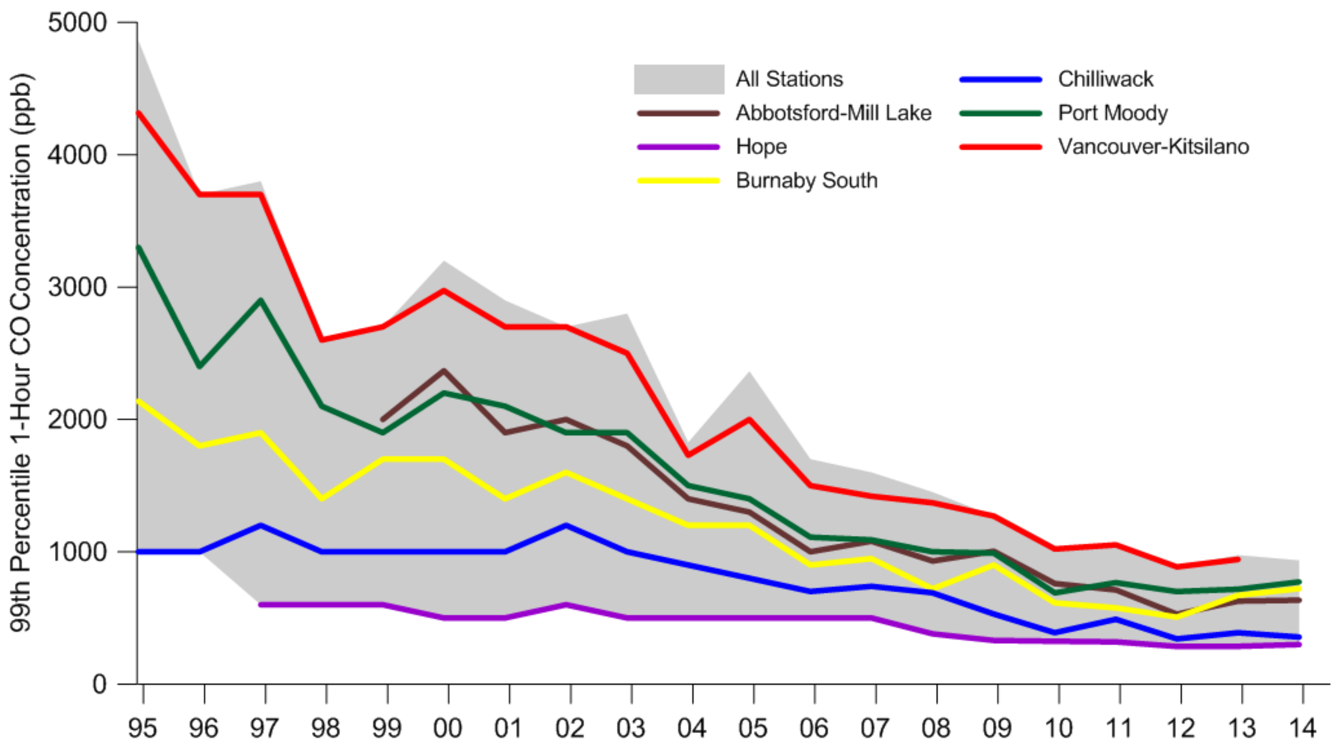


Figure 32: Short-term peak carbon monoxide trend, 1995 to 2014.

Ozone (O_3)

Characteristics

Ozone (O_3) is a reactive form of oxygen. It is a major pollutant formed when NO_X and reactive volatile organic compounds (VOC) react chemically in the presence of heat and sunlight. Sunlight plays a significant role in O_3 production and as such, local maximum O_3 concentrations are usually experienced during the summer in the LFV.

Naturally occurring O_3 in the upper level of the atmosphere, known as the stratosphere, shields the surface from harmful ultraviolet radiation. However at ground level, O_3 is a major environmental and health concern. Ozone is a significant oxidant and can irritate the eyes, nose and throat as well as reduce lung function. High concentrations can also increase the susceptibility to respiratory disease and reduce crop yields.

Sources

Ozone is termed a secondary pollutant because it is not usually emitted directly into the air. Instead, it is formed from chemical reactions involving pollutants identified as precursors, including NO_X and reactive VOC. The levels of O_3 measured depend on the emissions of these precursor pollutants.

Nitrogen oxide (NO_X) emissions are dominated by transportation sources. About 63% of the emissions come from cars, trucks, ships, rail and planes. Other sources include non-road engines, boilers and building heating systems.

The main contributors to VOC emissions are chemical products use (industrial, commercial and consumer products such as paints, varnishes and solvents), natural sources (trees and vegetation), cars and light trucks and non-road engines.

The formation of O_3 occurs readily during hot and sunny weather conditions with peak levels observed in the summer. Under these conditions, the highest levels generally occur downwind of major precursor emissions such as in eastern parts of Metro Vancouver and in the FVRD.

Monitoring Results

Figures 33 and 34 illustrate the results of O_3 monitoring in 2014. The annual average and Canadian Ambient Air Quality Standard values are shown in Figure 33 while the maximum 1-hour and 8-hour averages are shown in Figure 34. These are shown spatially in Figures 35 to 38.

In 2014, there were no exceedances of the Canadian Ambient Air Quality Standard (CAAQS). The Burnaby Mountain station measured the highest average ozone level which is typical given the station's high elevation on the top of Burnaby Mountain.

There were periods during the summer of 2014 where conditions were favourable for ozone formation resulting in elevated ozone levels in the LFV. The 1-hour Metro Vancouver objective was exceeded at three stations with the highest value of 86 ppb measured in Hope. Exceedances at these three stations occurred in the afternoon on July 13 with the Hope station exceeding for two hours, Maple Ridge and Agassiz for one hour. The 8-hour Metro Vancouver objective was exceeded on July 13 at six stations and on August 11 at a new monitoring station in Mission. On July 13 the objective was exceeded for six hours at Hope, five hours at Agassiz, and three hours at Maple Ridge, Abbotsford-Mill and Abbotsford-Airport and two hours at Chilliwack. An air quality advisory was issued on July 13 as a result of elevated levels. The air quality advisory was continued for a second day on July 14, on a precautionary basis, however ozone levels were less than anticipated late in the afternoon and objectives were not exceeded.

In 2014, elevated levels of ground-level ozone formed during hot and sunny weather. On two days there were exceedances of the 1-hour and/or 8-hour Metro Vancouver ozone objective.

The highest 8-hour value of 73 ppb was measured in the FVRD at Hope. On August 11 the objective was exceeded for two hours at Mission. Note that Mission is not shown in Figures 33 - 43 because the station began operating in August and therefore did not have sufficient data completeness for the year.

It can be seen that the highest short-term concentrations occur in the eastern parts of Metro Vancouver and in the FVRD (Figures 36, 37 and 38). The lowest annual O_3 averages (Figure 35) are seen to occur in highly urbanized areas due to O_3 scavenging. Ozone scavenging occurs in locations where higher levels of NO_x are found (e.g. urban areas or near busy roadways). In these areas, emissions containing NO_x, react very quickly with O_3 to form NO_2 (nitrogen dioxide) and O_2 (oxygen) thus decreasing O_3 concentrations.

The seasonal variation evident in Figures 39 and 40 is typical of historical ozone trends in the LFV with higher values in spring and summer, and lower values during fall and winter. Since O_3 is produced by photochemical reactions there is greater production in spring and summer with the presence of sunlight. Spring exhibits the highest average O_3 concentrations (Figure 39) while the highest short-term hourly concentrations (Figure 40) occur in the summer.

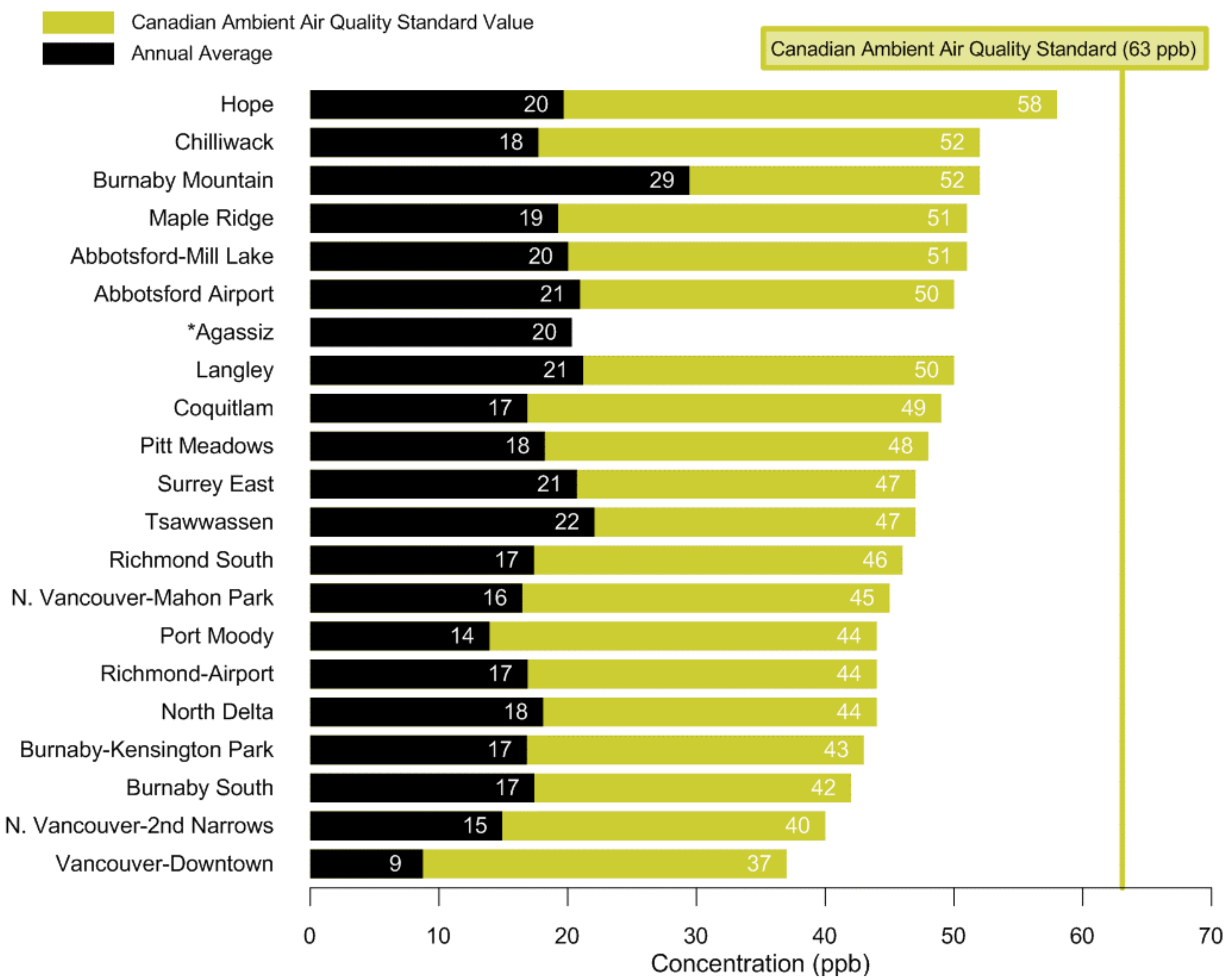
The frequency distribution for hourly and 8-hour rolling average concentrations is shown in Tables 7 and 8, respectively. The frequency distributions in these tables show how often various O_3 levels are reached. It can be seen that stations located in the eastern parts of Metro Vancouver and in the FVRD measured the greatest frequency of high O_3 concentrations.

A series of diurnal plots are shown in Figure 41 for each O_3 monitoring station. The diurnal plots illustrate the weekday/weekend differences along with summer/winter differences. Most of the stations exhibit similar diurnal trends. In the summer, O_3 concentrations are low through the night and begin increasing near sunrise with the highest (peak) concentration occurring in the afternoon. Examining the timing of the peak shows in general the stations in the west peak first while the stations in the east peak a few hours later with Hope typically experiencing the latest peak in the day. On very hot sunny days, typically during a summertime episode, the O_3 peak occurs later in the day. Winter shows a similar trend of an afternoon peak although it is greatly attenuated compared with the summer.

Figure 42 illustrates the long-term annual average O_3 trend in the LFV. Annual O_3 levels have shown an upward trend since 1995. Research indicates that background ozone concentrations are rising and is one factor for observed increases in average levels.

A short-term peak O_3 concentration trend (Figure 43) is less apparent. Yearly differences are likely related to variability in meteorology, however there doesn't appear to be a trend in peak concentrations. Peak ozone levels have been mostly unchanged during the last fifteen to twenty years, despite significant reductions in ozone precursor pollutants over the same time period.

In 2014, Metro Vancouver and the FVRD endorsed the Regional Ground-Level Ozone Strategy, which provides strategic policy direction for ozone management in the LFV based on local scientific research. Research indicates that a spatial understanding of the ozone precursor emission ratio is key to determining which precursors to reduce and which not to reduce. Reducing emissions of the wrong pollutant (NOx or VOCs) can result in either no reduction in ozone levels, or worse, inadvertently increase ozone. The region is predominantly VOC-limited, meaning that actions to reduce VOC emissions are preferred for improving ozone.



*The Agassiz station started operation in June 2013 and has not operated long enough to calculate the 3-year CAAQS value.

Figure 33: Ground-level ozone monitoring (Annual and CAAQS), 2014.

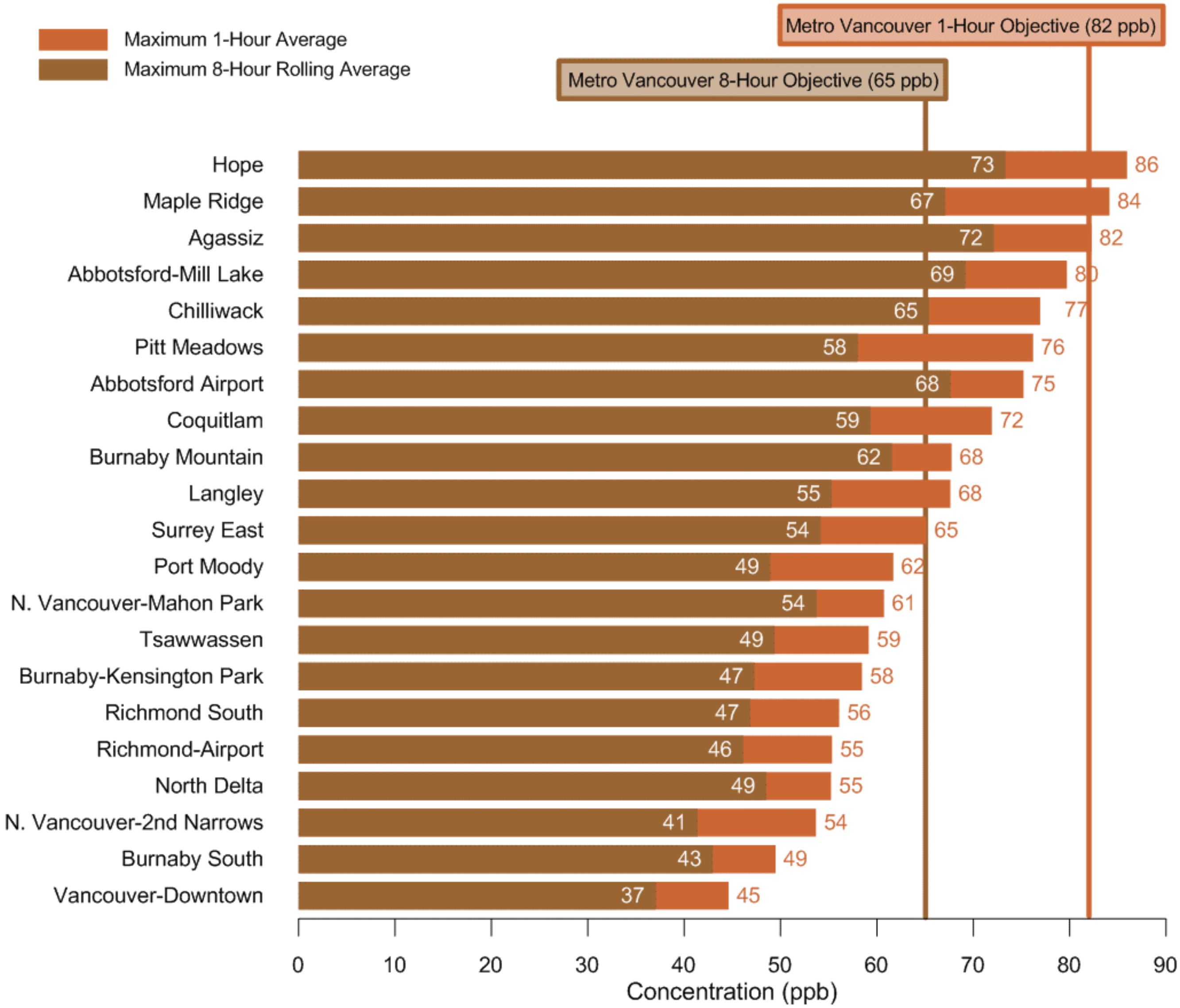


Figure 34: Ground-level ozone monitoring (1-hour and 8 hour), 2014.

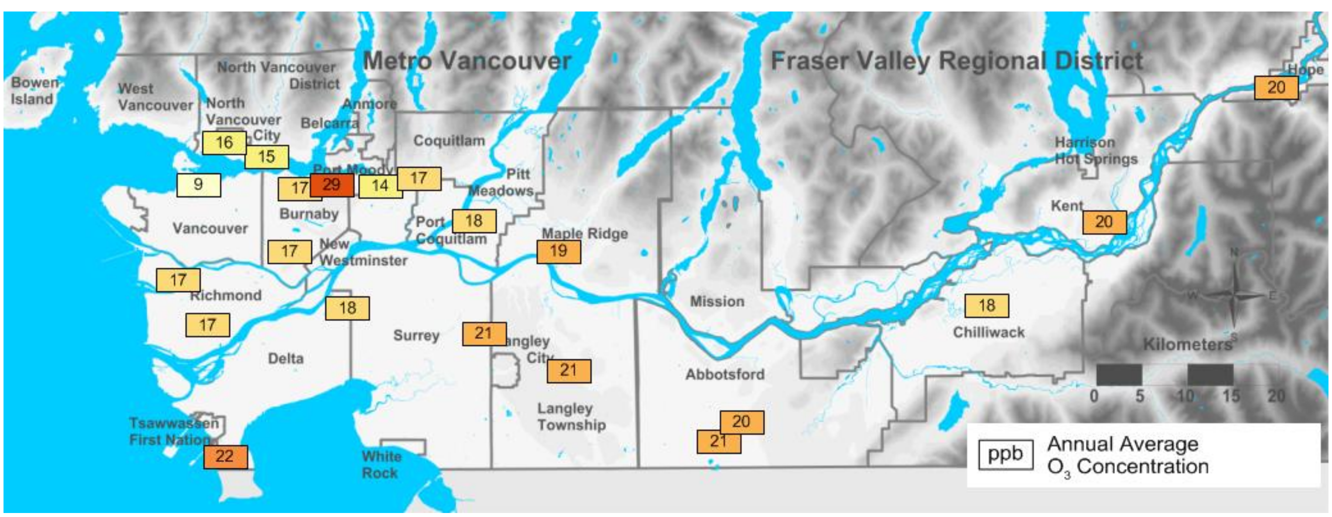


Figure 35: Annual average ozone in the LFV, 2014.

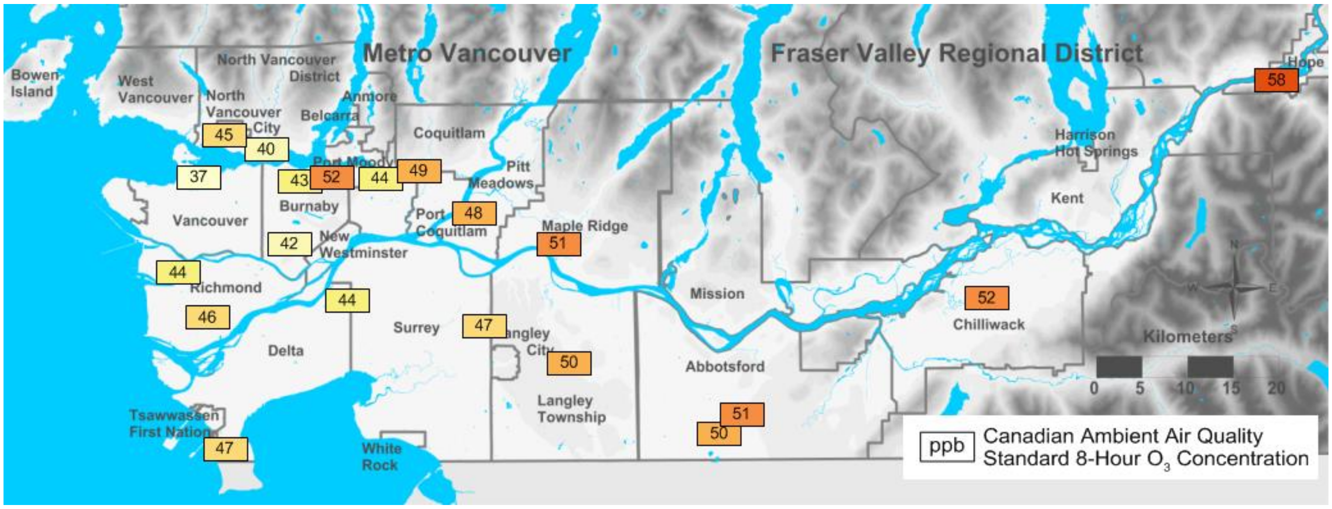


Figure 36: Canadian Ambient Air Quality Standard value for ozone in the LFV, 2014.

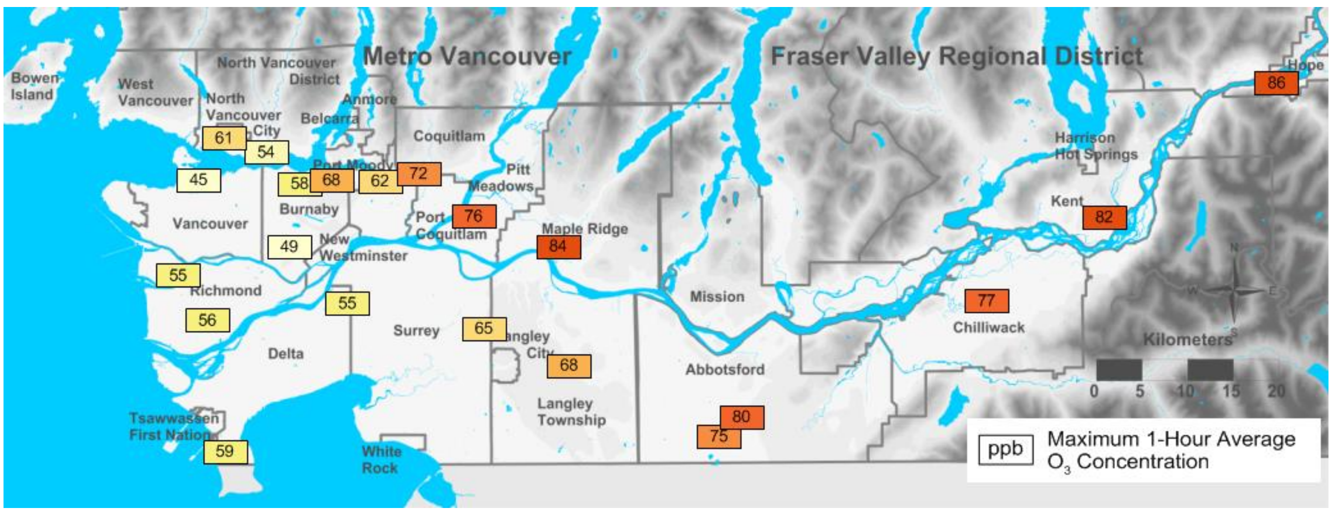


Figure 37: Short-term peak (maximum 1-hour) ozone in the LFV, 2014.

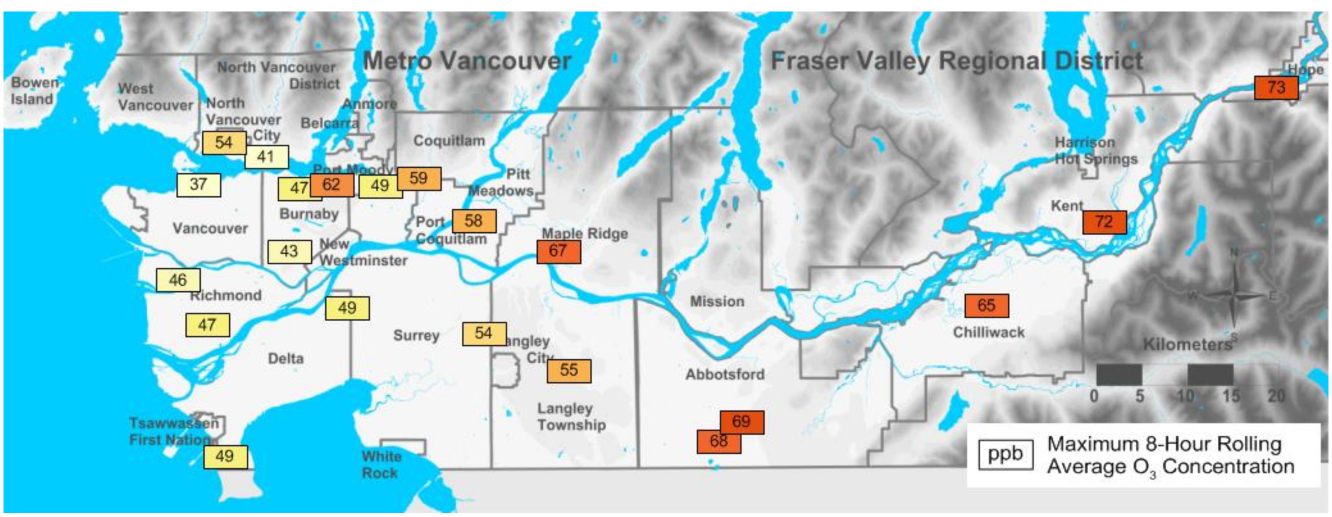


Figure 38: Short-term peak (maximum 8-hour) ozone in the LFV, 2014.

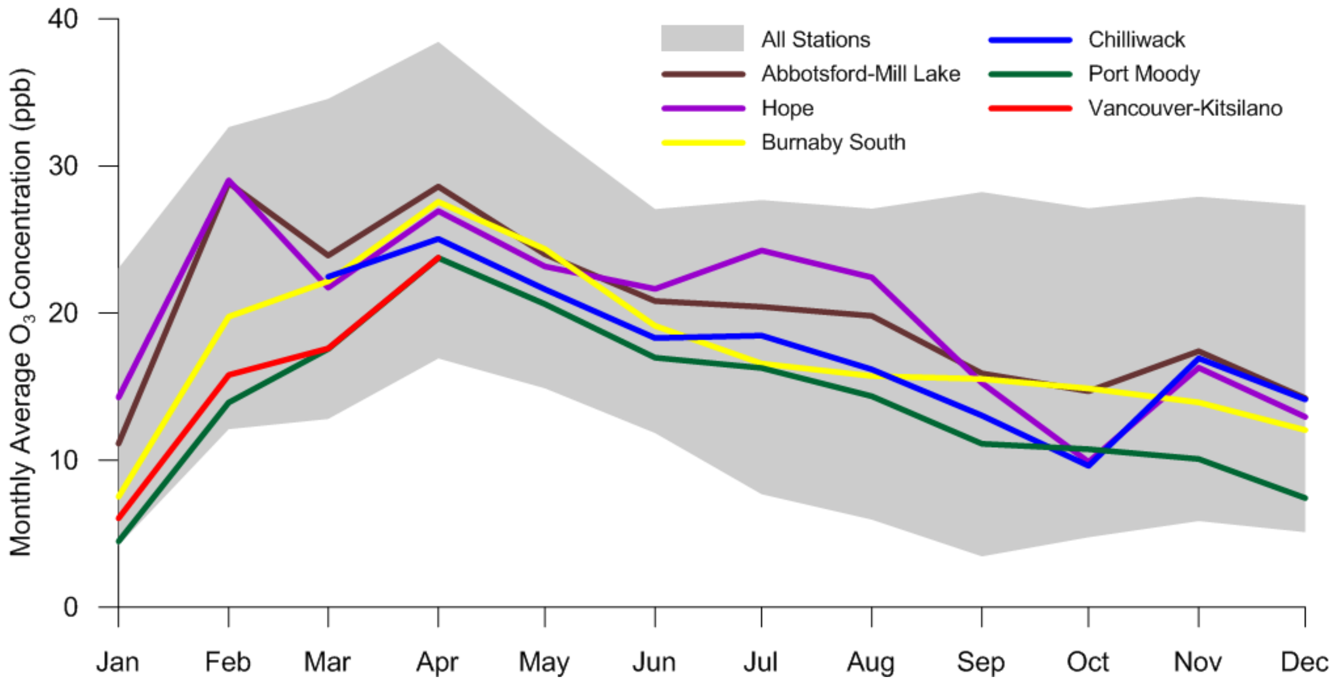


Figure 39: Monthly average ozone, 2014.

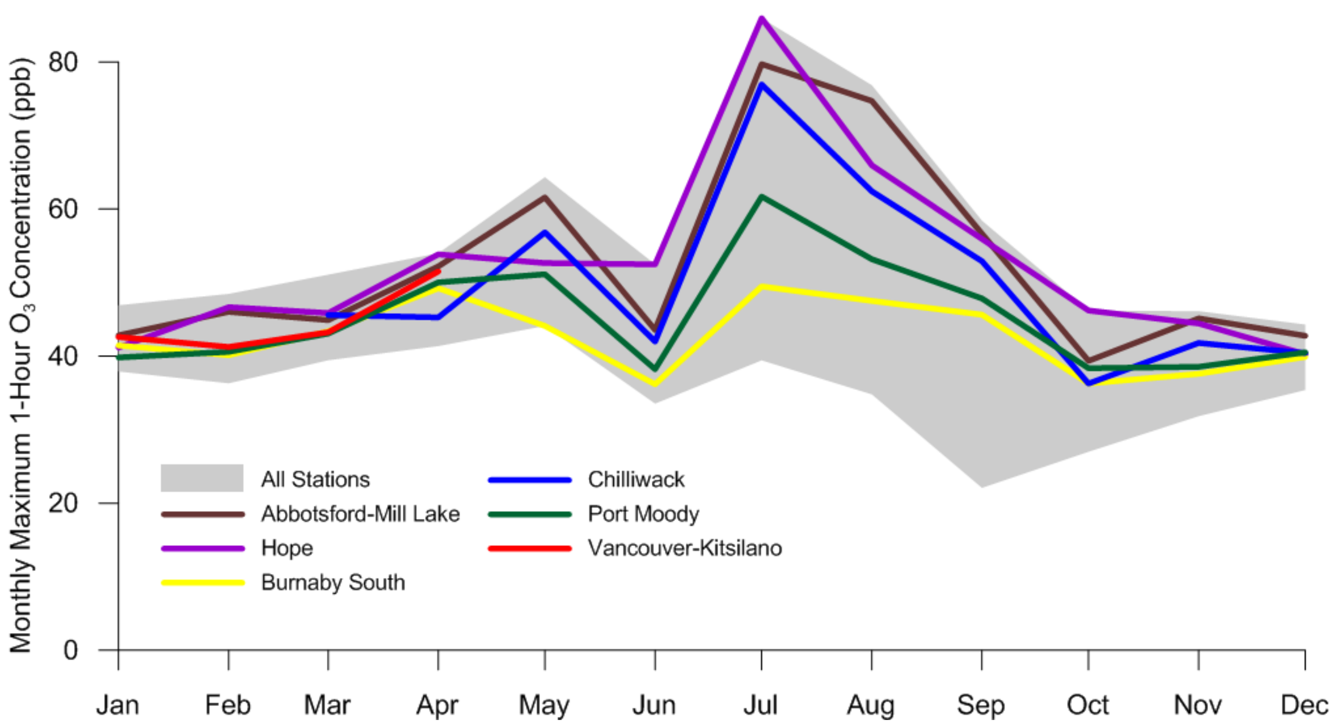


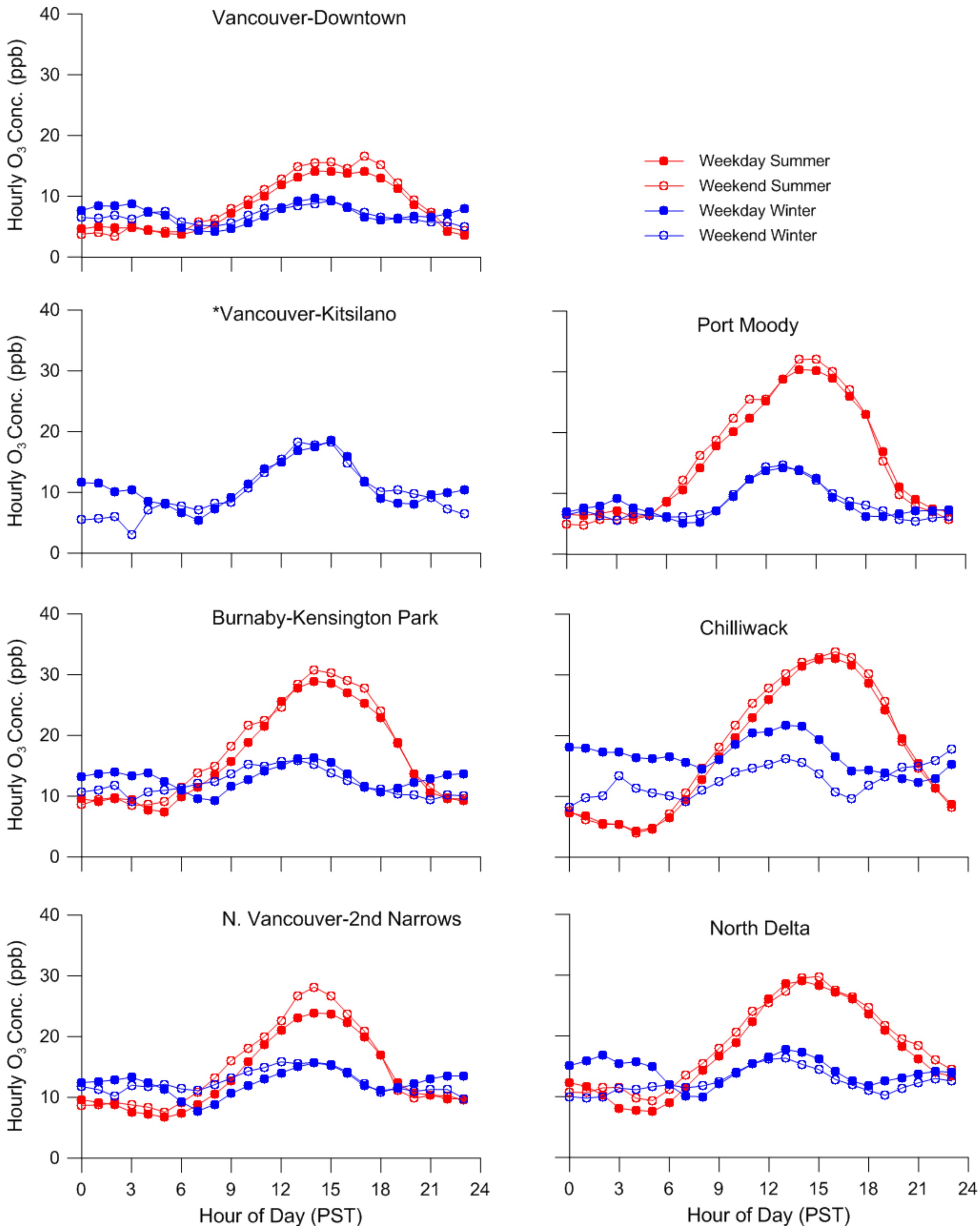
Figure 40: Monthly short-term peak ozone, 2014.

Table 7: Frequency distribution of hourly ozone, 2014.

O3 Conc. (ppb)	Vancouver-Downtown	Vancouver-Kitsilano	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	North Delta	Burnaby Mountain	Surrey East	Richmond South	Burnaby South	Pitt Meadows	N. Vancouver-Mahon Park	Langley	Hope	Maple Ridge	Richmond-Airport	Coquitlam	Abbotsford-Mill Lake	Tsawwassen	Agassiz	Abbotsford Airport
0 to 4	3641	951	1382	1276	2669	1251	1402	46	934	2124	1248	1870	1660	1129	1463	1310	1885	1770	1237	684	1173	1073
4 to 8	1468	265	931	1369	1006	794	762	119	604	656	776	689	838	553	719	730	703	947	768	405	732	723
8 to 12	1021	249	1065	1203	771	764	863	182	777	649	934	663	911	583	696	819	797	903	718	559	789	722
12 to 16	702	234	972	1054	691	677	915	387	896	709	1020	738	919	731	753	847	843	827	800	806	838	838
16 to 20	499	237	901	953	705	757	897	597	983	747	1029	745	932	826	790	795	864	759	774	1042	800	740
20 to 24	405	227	859	826	605	708	893	1035	898	743	996	769	865	805	771	772	812	757	755	1009	903	740
24 to 28	339	232	827	683	625	622	859	1289	945	761	830	777	766	880	585	798	758	698	679	885	807	727
28 to 32	272	229	696	510	541	587	734	1418	827	692	724	790	670	848	644	736	687	700	776	880	662	861
32 to 36	126	248	490	329	418	509	605	1409	717	579	538	711	499	825	658	720	545	542	851	782	745	913
36 to 40	45	214	279	146	262	325	384	1041	540	474	296	424	264	566	541	494	393	375	576	549	552	616
40 to 44	2	130	111	57	114	133	202	627	303	260	94	240	122	318	336	207	173	162	253	368	269	326
44 to 48	1	31	48	11	57	73	65	279	134	111	17	115	42	129	136	95	54	89	100	85	145	122
48 to 52		7	13	2	25	34	12	134	31	22	3	36	17	52	70	52	9	38	55	16	59	39
52 to 56			3	1	7	17	2	30	9	5		12	7	31	48	30	1	17	38	3	33	33
56 to 60			3		3	10		7	2	1		9	3	10	24	17		9	10	3	20	13
60 to 64					1	3		3	4			1	1	5	15	12		8	3		25	2
64 to 68								5	1					2	14	3		1	2		13	1
68 to 72						1						2			12	2		2	1		12	2
72 to 76						2									6				2		2	6
76 to 80						1						1			2				4		2	
80 to 82																1					1	
82 to 84															1						1	
>=84															1	1						
Missing	235	5504	177	339	251	1484	159	152	153	224	254	162	240	459	444	305	234	144	351	682	171	252
Data Completeness	97%	37%	98%	96%	97%	83%	98%	98%	98%	97%	97%	98%	97%	95%	95%	97%	97%	98%	96%	92%	98%	97%

Table 8: Frequency distribution of 8-hour rolling average ozone, 2014.

O3 Conc. (ppb)	Vancouver-Downtown	Vancouver-Kitsilano	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	North Delta	Burnaby Mountain	Surrey East	Richmond South	Burnaby South	Pitt Meadows	N. Vancouver-Mahon Park	Langley	Hope	Maple Ridge	Richmond-Airport	Coquitlam	Abbotsford-Mill Lake	Tsawwassen	Agassiz	Abbotsford Airport
0 to 5	3673	788	1217	1163	2460	986	1216	18	831	1716	1120	1588	1373	920	1271	1127	1568	1578	1039	600	920	884
5 to 10	2041	455	1332	1742	1271	1214	1035	110	825	1058	1060	1049	1262	760	1021	1005	1142	1231	1052	524	1084	1012
10 to 15	1192	378	1469	1658	1184	1131	1352	312	1165	1180	1445	1023	1440	1028	1053	1211	1289	1279	1098	985	1214	1131
15 to 20	770	349	1361	1612	1158	1114	1367	721	1370	1146	1538	1163	1460	1143	1210	1229	1284	1246	1177	1331	1196	1137
20 to 25	521	402	1315	1101	1002	978	1331	1374	1281	1130	1402	1166	1199	1151	1037	1228	1202	1193	1065	1462	1199	1015
25 to 30	297	340	1027	736	778	755	1064	1954	1307	965	1057	1107	967	1238	845	1022	1009	973	1058	1237	1056	1126
30 to 35	123	307	629	401	439	713	784	1944	985	704	681	883	660	1132	905	932	641	706	1041	1004	1042	1213
35 to 40	23	204	270	89	239	342	429	1402	668	525	277	507	224	662	612	561	381	365	718	707	589	791
40 to 45		75	70	15	67	88	119	650	251	199	32	174	58	258	280	147	114	117	184	295	244	248
45 to 50		1	3		11	37	8	209	23	18		35	2	77	90	58	5	24	61	14	68	47
50 to 55						10		21	4			9	4	16	36	18		12	16		36	11
55 to 60						2		4				3		2	33	10		4	4		27	5
60 to 65						2		3							14	2			2		9	1
65 to 70						2									3	3			3		2	3
>=70															3						3	
Missing	120	5461	67	243	151	1386	55	38	50	119	148	53	111	373	347	207	125	32	242	601	71	136
Data Completeness	99%	38%	99%	97%	98%	84%	99%	100%	99%	99%	98%	99%	99%	96%	96%	98%	99%	100%	97%	93%	99%	98%



*Data completeness requirements were not met at this site in summer.

Figure 41: Diurnal trends ozone, 2014.

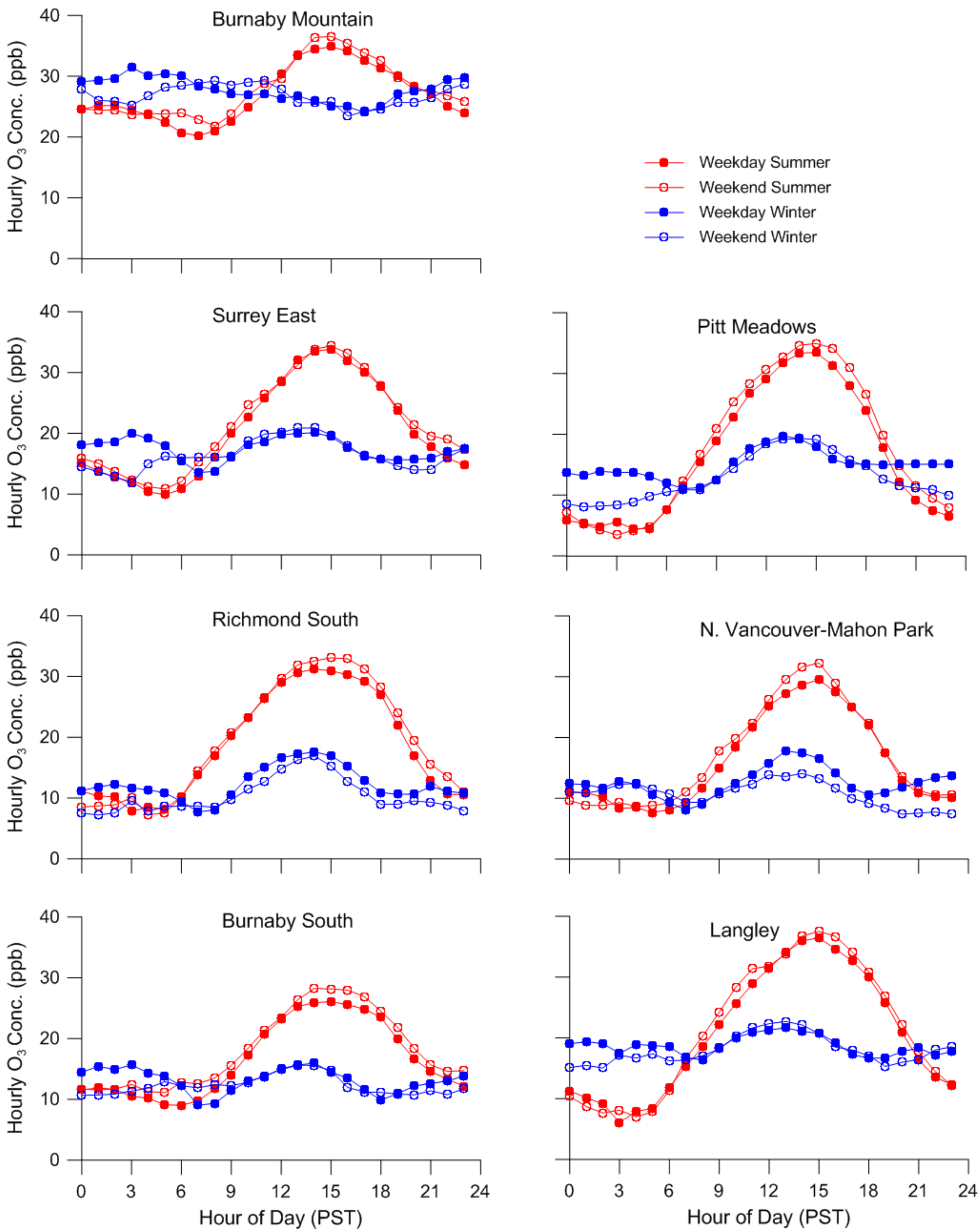


Figure 41: Cont. Diurnal trends ozone, 2014.

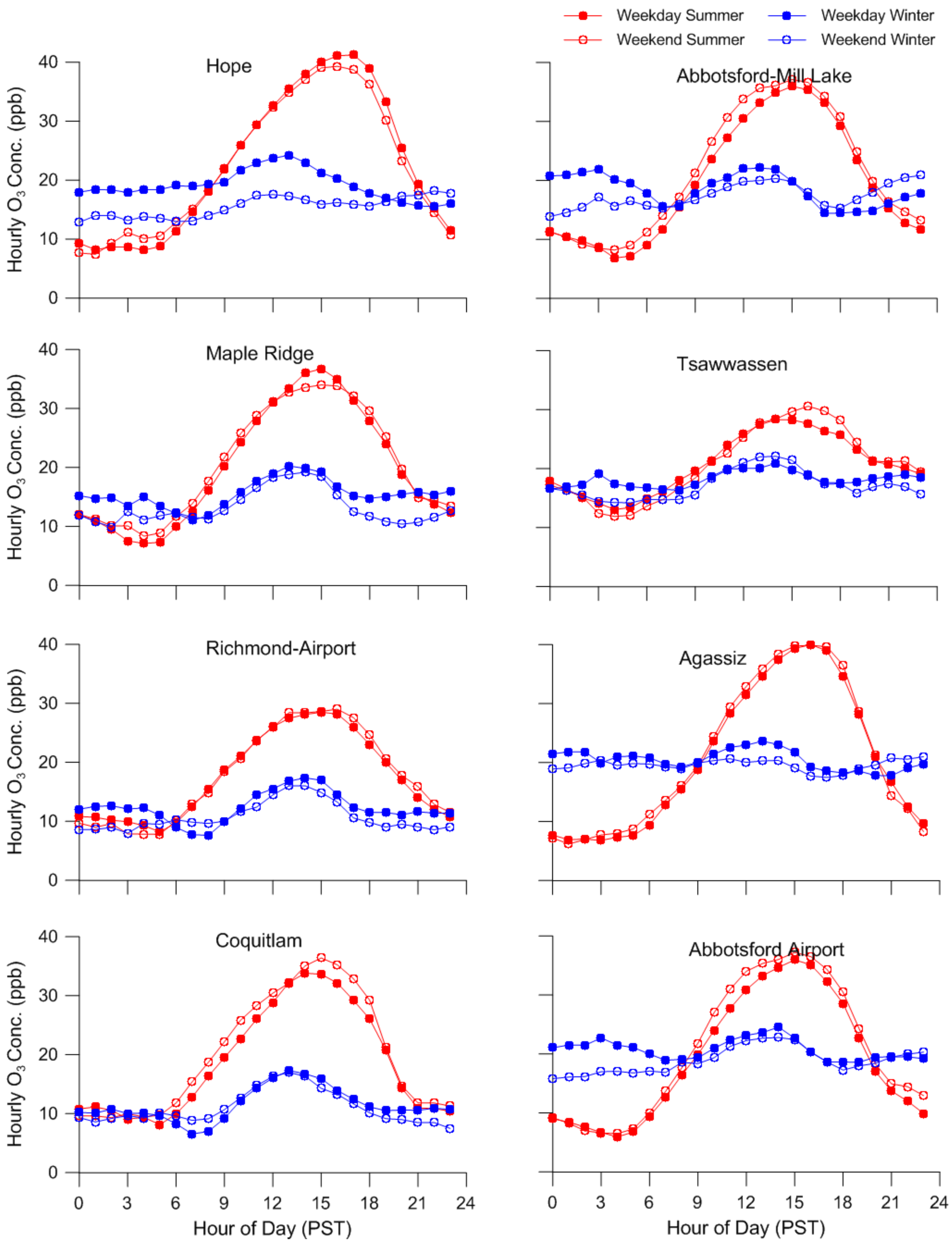


Figure 41: Cont. Diurnal trends ozone, 2014.

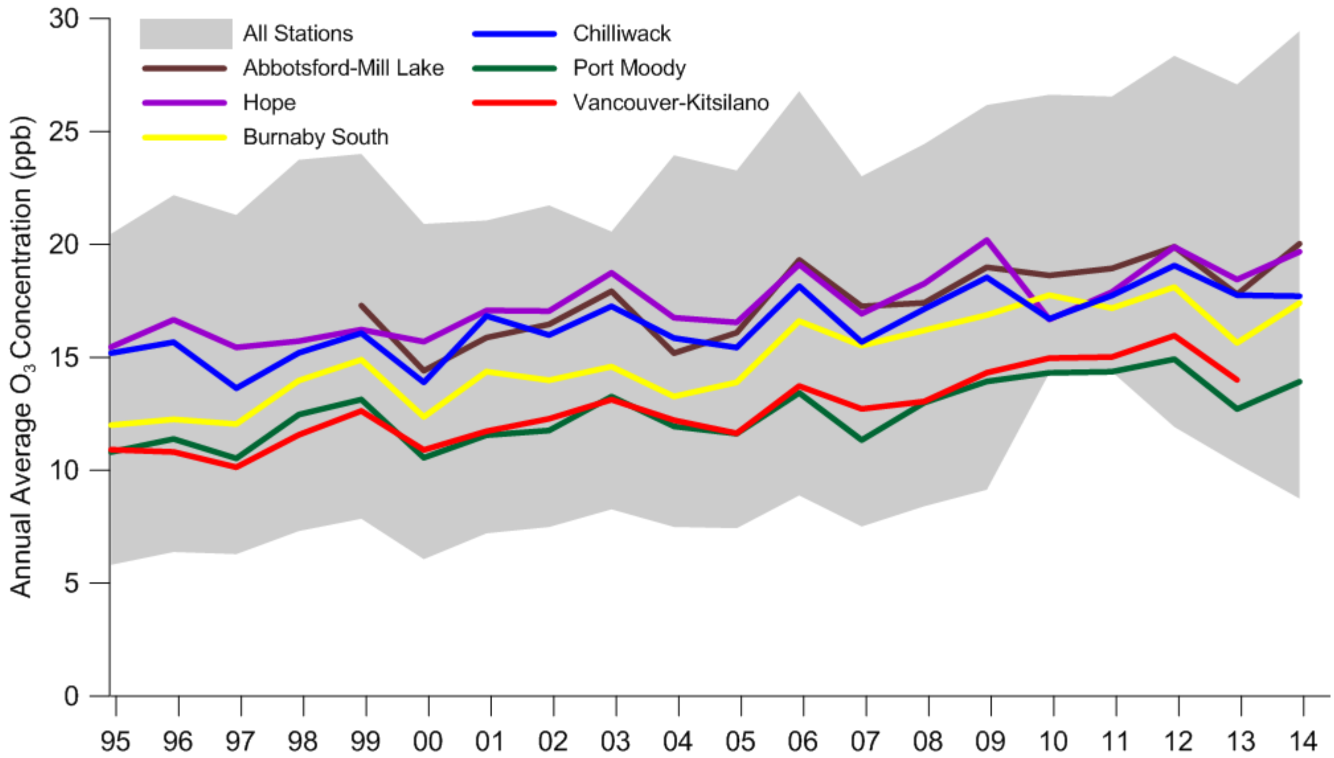


Figure 42: Annual ozone trend, 1995 to 2014.

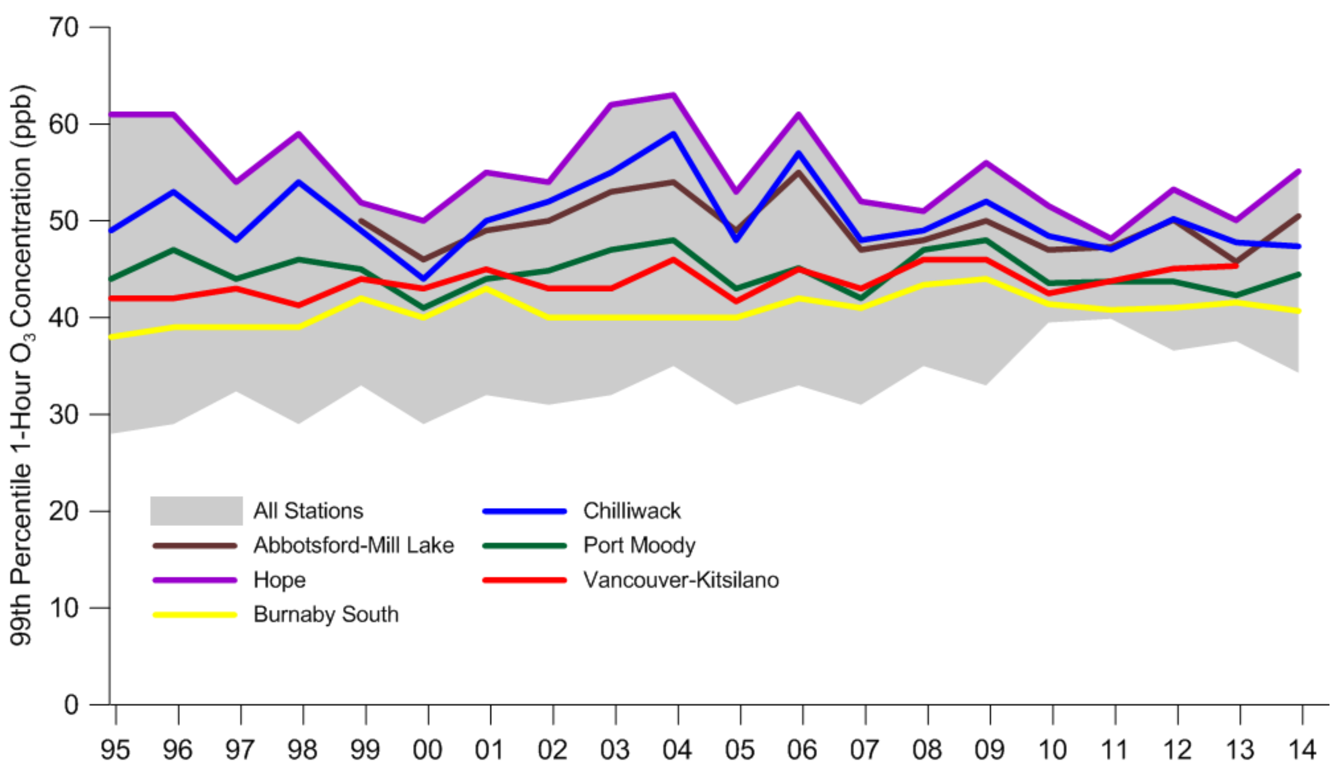


Figure 43: Short-term peak ozone trend, 1995 to 2014.

Fine Particulate ($PM_{2.5}$)

Characteristics

The term '$PM_{2.5}$' has been given to airborne particles with a diameter of 2.5 micrometres (μm) or less, also known as fine particulate matter. Particles of this size make up a fraction of PM_{10} (those particles with a diameter of 10 micrometres or less) which can vary with factors such as season and location. Within the LFV emissions of $PM_{2.5}$ represent approximately one-half of the PM_{10} emissions, which is a typical value for North American urban environments.

Given the very small size of these particles, they can penetrate into the finer structures of the lungs. As with inhalable particulate (PM_{10}), exposure to fine particulate ($PM_{2.5}$) can lead to both chronic and acute human health impacts, aggravate pulmonary or cardiovascular disease, increase symptoms in asthmatics and increase mortality. Fine particulate matter is considered by health experts to be an air pollutant of serious concern because of these health effects.

Fine particulate is also effective at scattering and absorbing visible light. In this role $PM_{2.5}$ contributes to regional haze and impaired visual air quality.

Sources

Emissions of $PM_{2.5}$ are dominated by heating, transportation, industrial sources and non-road engines. In addition to these local sources, $PM_{2.5}$ can be transported long distances in the air from sources such as large forest fires in other parts of western Canada, the US or more distant.

Scientific investigations in the LFV indicate that a considerable proportion of ambient $PM_{2.5}$ is also formed by reactions of NO_X and SO_2 with ammonia in the air (mainly from agricultural sources in the LFV). Fine particulate produced in this manner is called secondary $PM_{2.5}$ and accounts for a significant percentage of $PM_{2.5}$ in summer. Therefore, emissions of precursor gases of secondary $PM_{2.5}$ are also important sources in the region.

Monitoring Results

Monitoring technology was upgraded in 2013 to continuous particulate monitors that met the U.S. Environmental Protection Agency $PM_{2.5}$ Federal Equivalent Method (FEM). The FEM monitors have the ability to measure a portion of particulates not previously measured.

The $PM_{2.5}$ annual average, maximum 24-hour rolling average and Canadian Ambient Air Quality Standard (CAAQS) values are shown in Figure 44 for 2014. The same values are shown spatially in Figures 45, 46 and 47, respectively.

Elevated levels of regional $PM_{2.5}$ can occur when high pressure weather systems are present. In 2014, measurements of $PM_{2.5}$ exceeded the objective on two days in the summer during an air quality advisory and over a seven day period in the fall during a persistent high pressure system.

All stations with sufficient data available to calculate a CAAQS value were found to be below the Standard. Canadian Ambient Air Quality Standard values for 2014 ranged from 11 to 17 μg/m^3. In order to calculate the three year metric, TEOM data was used for the year 2012 while FEM data was used for the years 2013 and 2014.

All stations were below the Metro Vancouver annual objective of 8 μg/m^3 and half of the stations were below the planning goal of 6 μg/m^3. Metro Vancouver's planning goal is a longer term aspirational target to support continuous improvement.

There were several exceedances of Metro Vancouver's 24-hour $PM_{2.5}$ objective in 2014. Exceedances occurred at eleven stations during two separate periods in August and November. The objective was exceeded at the North Vancouver-Second Narrows station on August 12 and 13 and the

Hope station on August 12. Numerous exceedances were measured throughout the region during a seven day period from November 14 to 20 at a number of stations including North Delta, Richmond South, Burnaby South, Pitt Meadows, Langley, Hope, Richmond-Airport, Mission and Abbotsford-Airport.

On August 12 an air quality advisory was initiated in Metro Vancouver and the Fraser Valley Regional District because of elevated $PM_{2.5}$, primarily due to smoke from wildfires outside our region.

In mid-November a persistent high pressure weather system brought stagnant weather conditions that limited dispersion. Given the stagnant conditions it is likely that local or nearby emission sources were largely responsible for the exceedances at this time.

Table 9 gives the frequency distribution of $PM_{2.5}$ concentrations for the year. In 2014, Hope and Langley experienced the greatest frequency of higher $PM_{2.5}$ concentrations (> 25 $\mu g/m^3$) which was thought to be the result of a combination of stagnant weather conditions and local emission sources.

Seasonally, $PM_{2.5}$ levels have historically been higher in the summer with the highest values typically experienced during the dry summer months (Figures 48 and 49), due to secondary formation of $PM_{2.5}$ and smoke from forest fires. However, in 2014 peak levels were seen in the fall due to the timing of several high pressure weather systems.

A series of diurnal plots are shown in Figure 50 for each $PM_{2.5}$ monitoring station. The summer exhibited little diurnal variation while the winter displayed higher $PM_{2.5}$ concentrations in the evenings compared with the daytime.

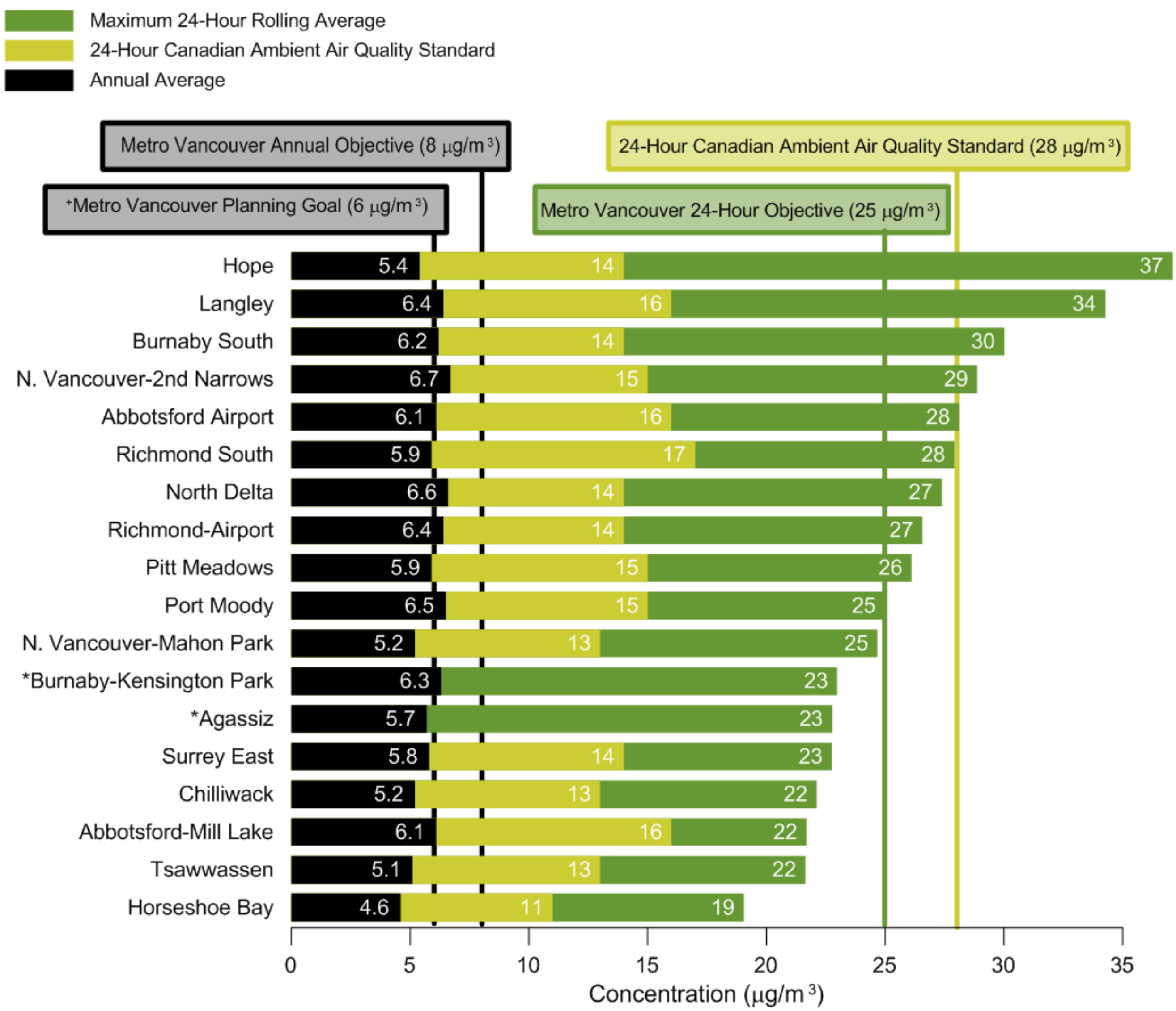
The evenings in winter were likely elevated due to reduced atmospheric mixing depths coupled with regional and local emissions sources.

Figures 51 and 52 illustrate the long-term $PM_{2.5}$ trends in the LFV with the annual average and peak concentrations shown respectively. The short-term peak concentrations reflect the highest levels that occur, represented by the 99^{th} percentile of the 24-hour rolling average for each year. Given that it will take several years to establish a long-term record of $PM_{2.5}$ with the new FEM monitor, both the TEOM and FEM data are shown together.

In Figures 51 and 52 the TEOM data is shown as solid lines with a gray band displaying the range of values from all TEOM stations, while the FEM data is shown as dotted lines with an orange band showing the range from all FEM stations.

It can be seen that the FEM monitor measures higher $PM_{2.5}$ concentrations compared to the TEOM monitor. Long-term trends of the TEOM data show that the year 2014 was not appreciably different than previous years. While the FEM data shows a step increase compared with the TEOM, this is a result of the FEM monitor's ability to measure particles not previously measured by the TEOM monitor.

The differences in peak trends from year to year are likely driven by meteorological variability and wildfire activities. Based on the TEOM data, the average long-term trend shows little variation. It will take several years to be able to establish and describe the long-term trend using data from the FEM monitor.



* Data completeness criteria for the 3-year CAAQS value were not met.

+ Metro Vancouver's Planning Goal of 6 µg/m³ is a longer term aspirational target to support continuous improvement.

Figure 44: Fine particulate ($PM_{2.5}$), 2014.

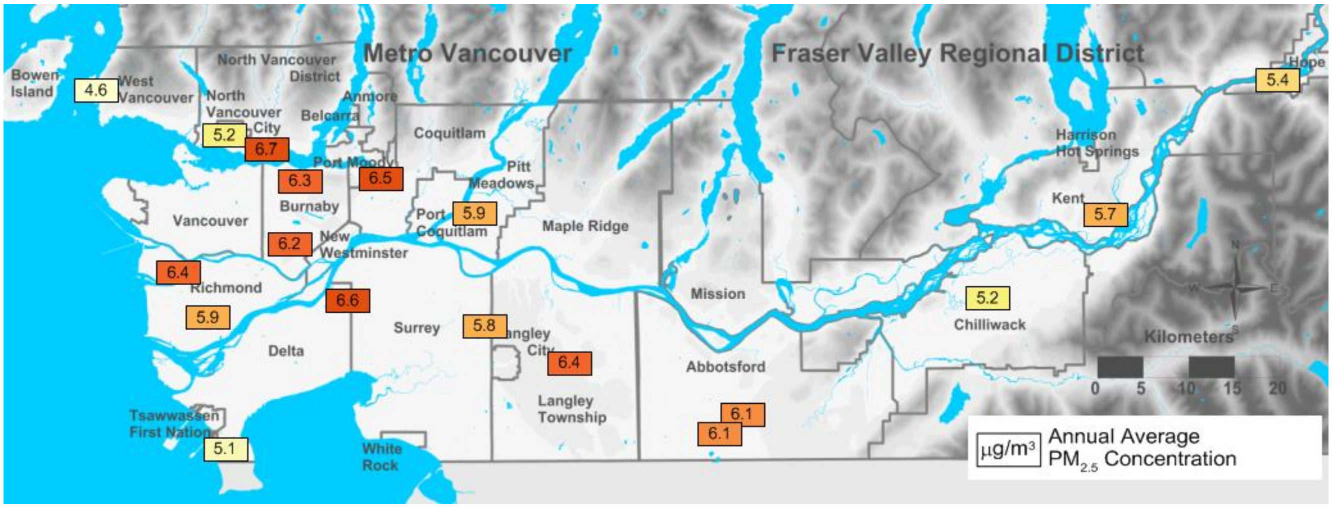


Figure 45: Annual average fine particulate ($PM_{2.5}$) in the LFV, 2014.

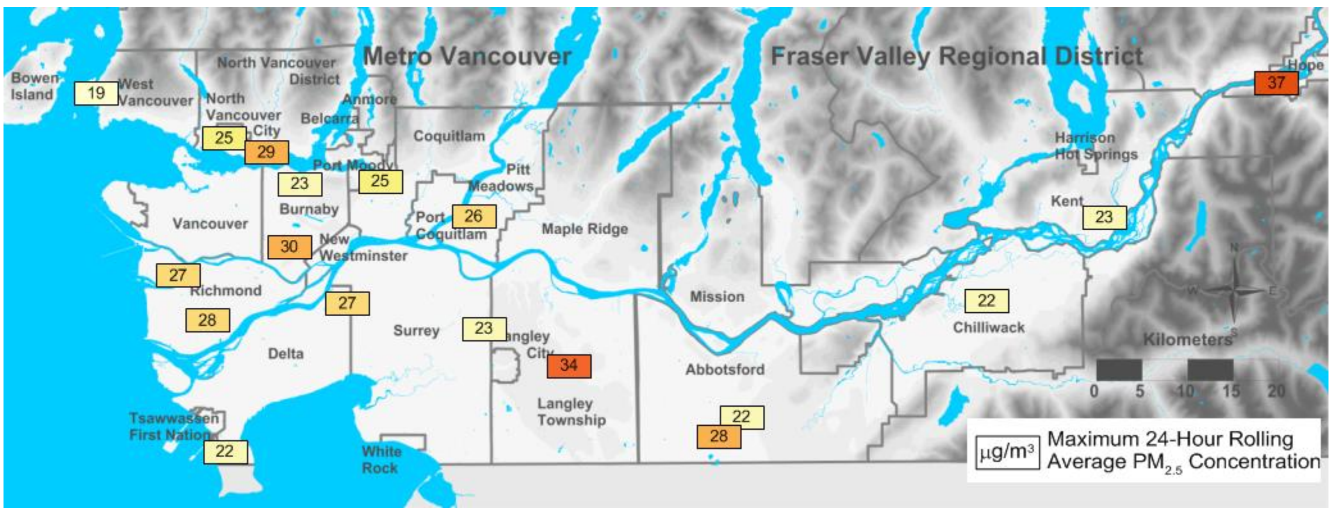


Figure 46: Short-term peak fine particulate ($PM_{2.5}$) in the LFV, 2014.

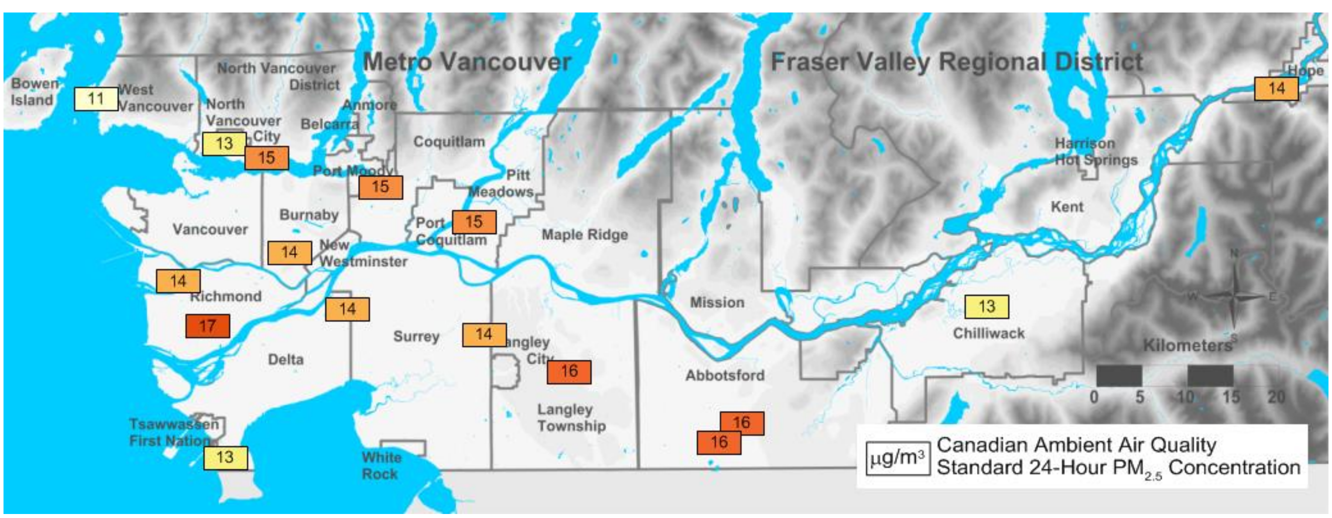


Figure 47: Canadian Ambient Air Quality Standard value for fine particulate ($PM_{2.5}$), 2014.

Table 9: Frequency distribution of 24-hour rolling average fine particulate ($PM_{2.5}$), 2014.

$PM_{2.5}$ Conc. ($\mu g/m^3$)	Vancouver-Kitsilano	Burnaby-Kensington Park	N. Vancouver-2nd Narrows	Port Moody	Chilliwack	North Delta	Surrey East	Richmond South	Burnaby South	Pitt Meadows	N. Vancouver-Mahon Park	Langley	Hope	Richmond-Airport	Abbotsford-Mill Lake	Horseshoe Bay	Tsawwassen	Agassiz	Abbotsford Airport
0 to 2.5	49	286	307	288	1444	553	655	608	579	1218	1512	535	1101	541	814	1248	893	859	720
2.5 to 5	851	3234	2780	2950	3483	2655	3147	3469	3203	3082	3408	3089	3627	2958	3094	4539	4227	3465	3254
5 to 7.5	739	2272	2498	2580	2097	2310	2301	2228	2037	2016	2093	2081	1830	2631	2430	2108	2121	2133	1995
7.5 to 10	344	1509	1630	1308	953	1463	1131	879	1343	1072	898	1030	779	1259	1174	451	824	1082	1307
10 to 12.5	189	636	817	651	271	657	339	419	450	507	424	613	245	469	445	164	279	526	510
12.5 to 15	91	193	283	293	152	374	187	217	304	281	209	290	66	316	265	111	115	233	175
15 to 17.5	46	146	130	134	88	180	95	132	94	158	88	148	98	120	145	45	49	94	128
17.5 to 20	16	27	62	32	44	35	40	82	54	53	9	59	32	88	91	21	16	29	89
20 to 22.5	16	14	6	17	45	16	36	22	26	71	7	40	23	24	63		18	38	39
22.5 to 25	4	5	9	23		16	11	35	7	16	9	25	17	22				5	7
25 to 27.5			8			23		19	7	9		34	26	32					14
27.5 to 30			8					3	17			11	10						8
30 to 32.5									1			7	5						
32.5 to 35												12	10						
>=35													21						
Missing Data	6415	438	222	484	183	478	818	647	638	277	103	786	870	300	239	73	218	296	514
Completeness	27%	95%	98%	95%	98%	95%	91%	93%	93%	97%	99%	91%	90%	97%	97%	99%	98%	97%	94%

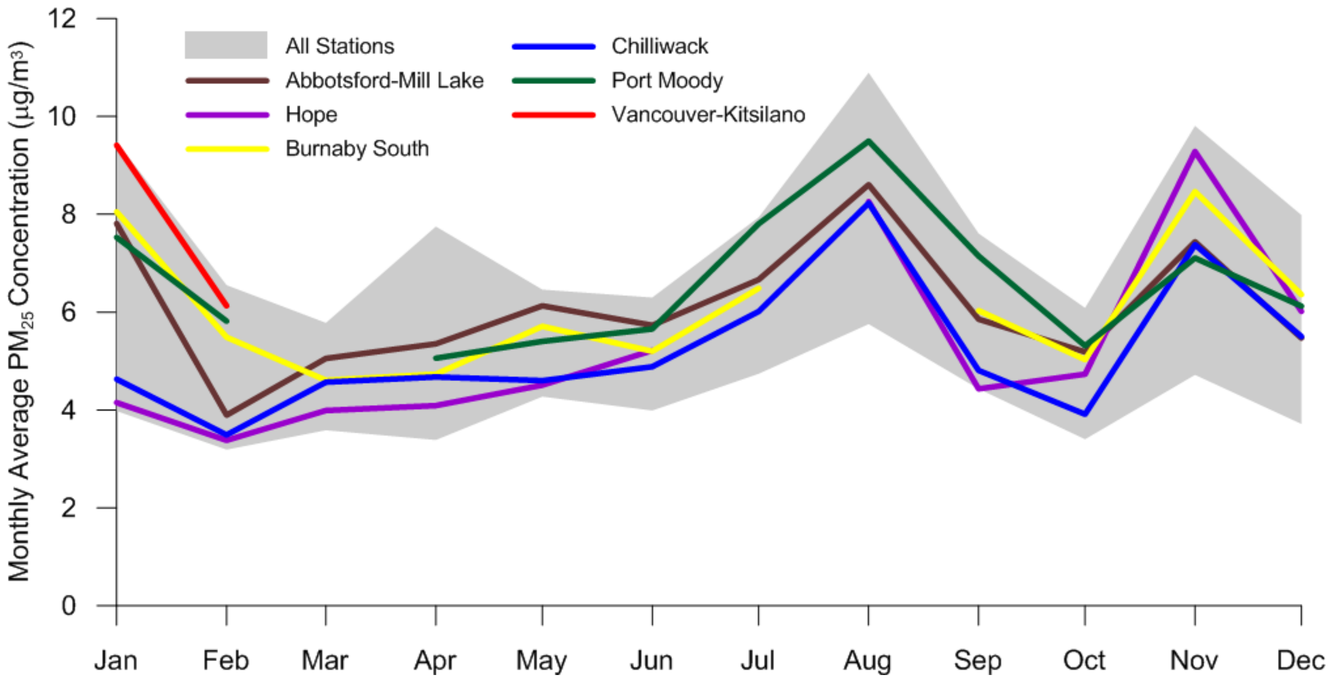


Figure 48: Monthly average fine particulate ($PM_{2.5}$), 2014.

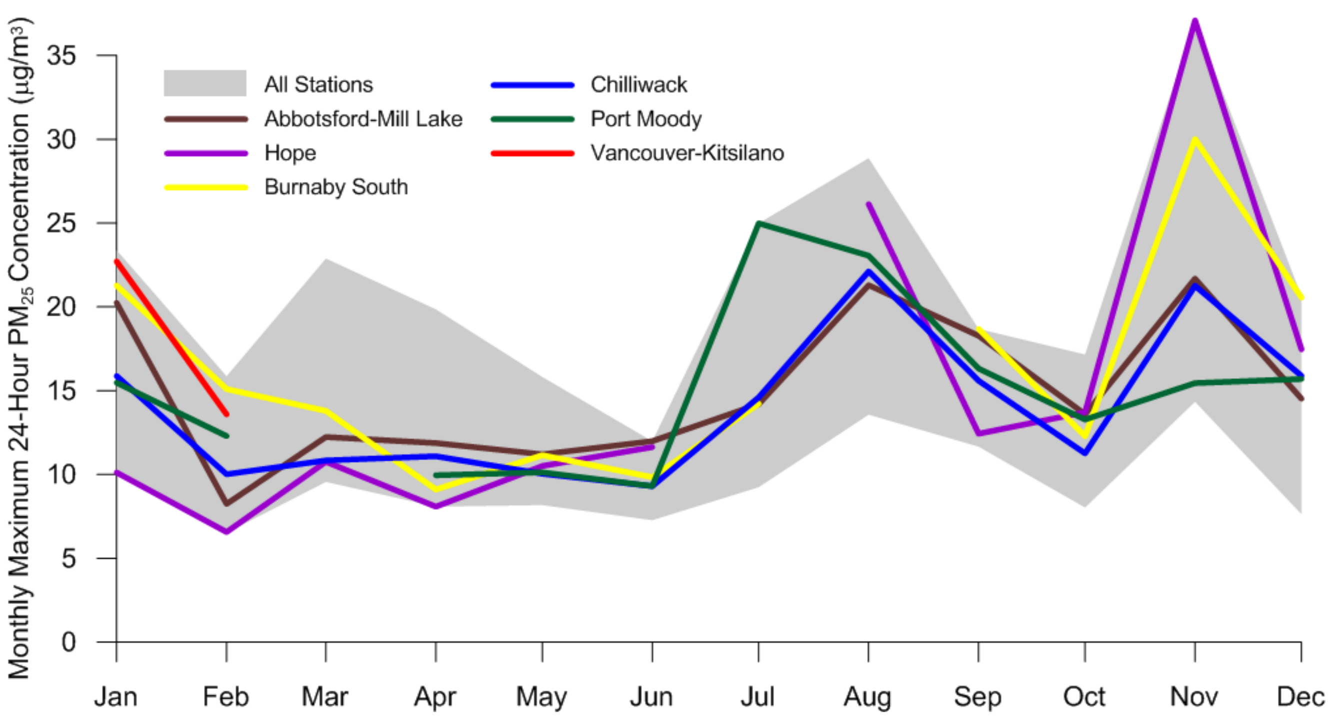
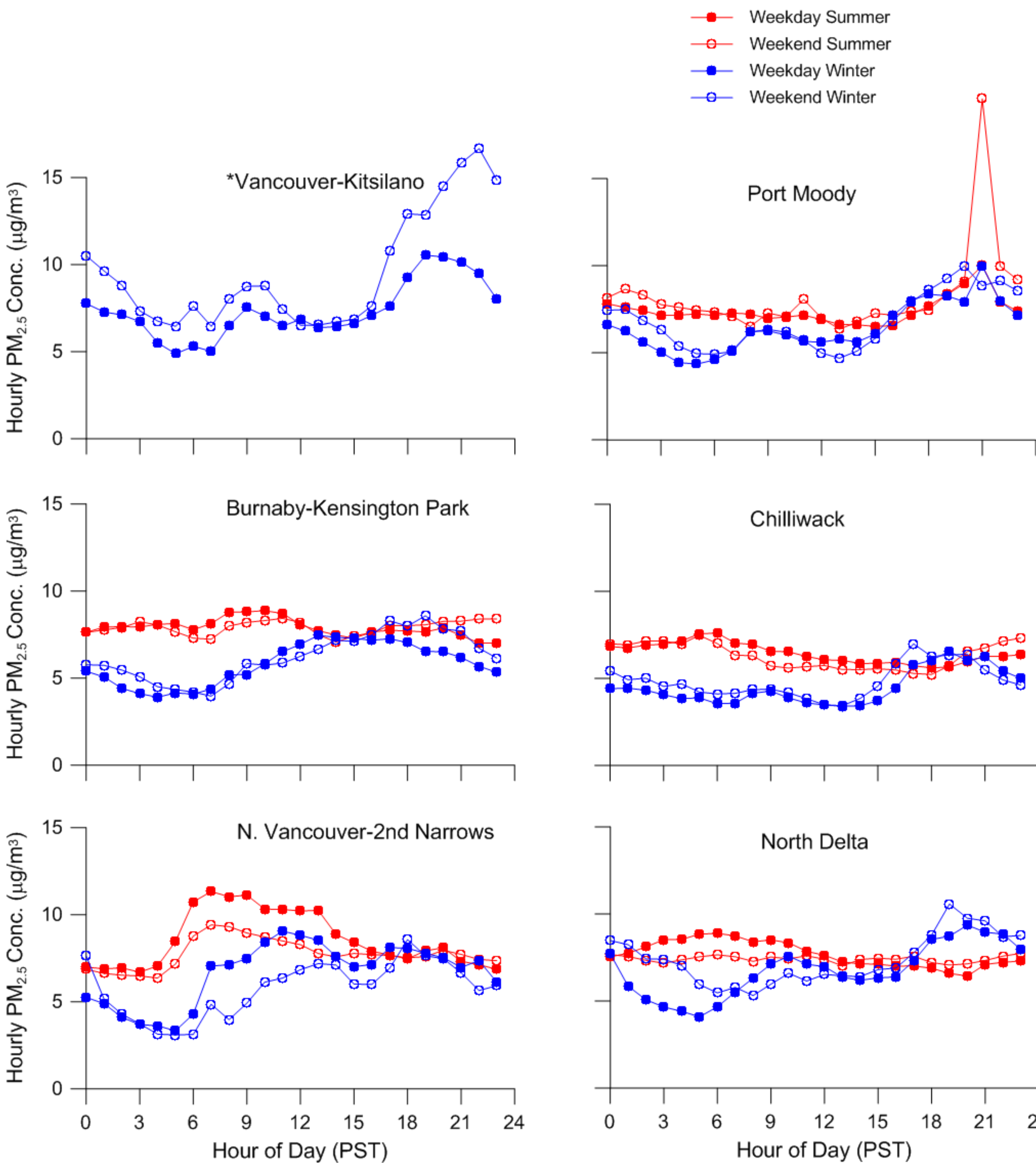


Figure 49: Monthly short-term peak fine particulate ($PM_{2.5}$), 2014.



*Data completeness requirements were not met at this site in summer.

Figure 50: Diurnal trends fine particulate ($PM_{2.5}$), 2014.

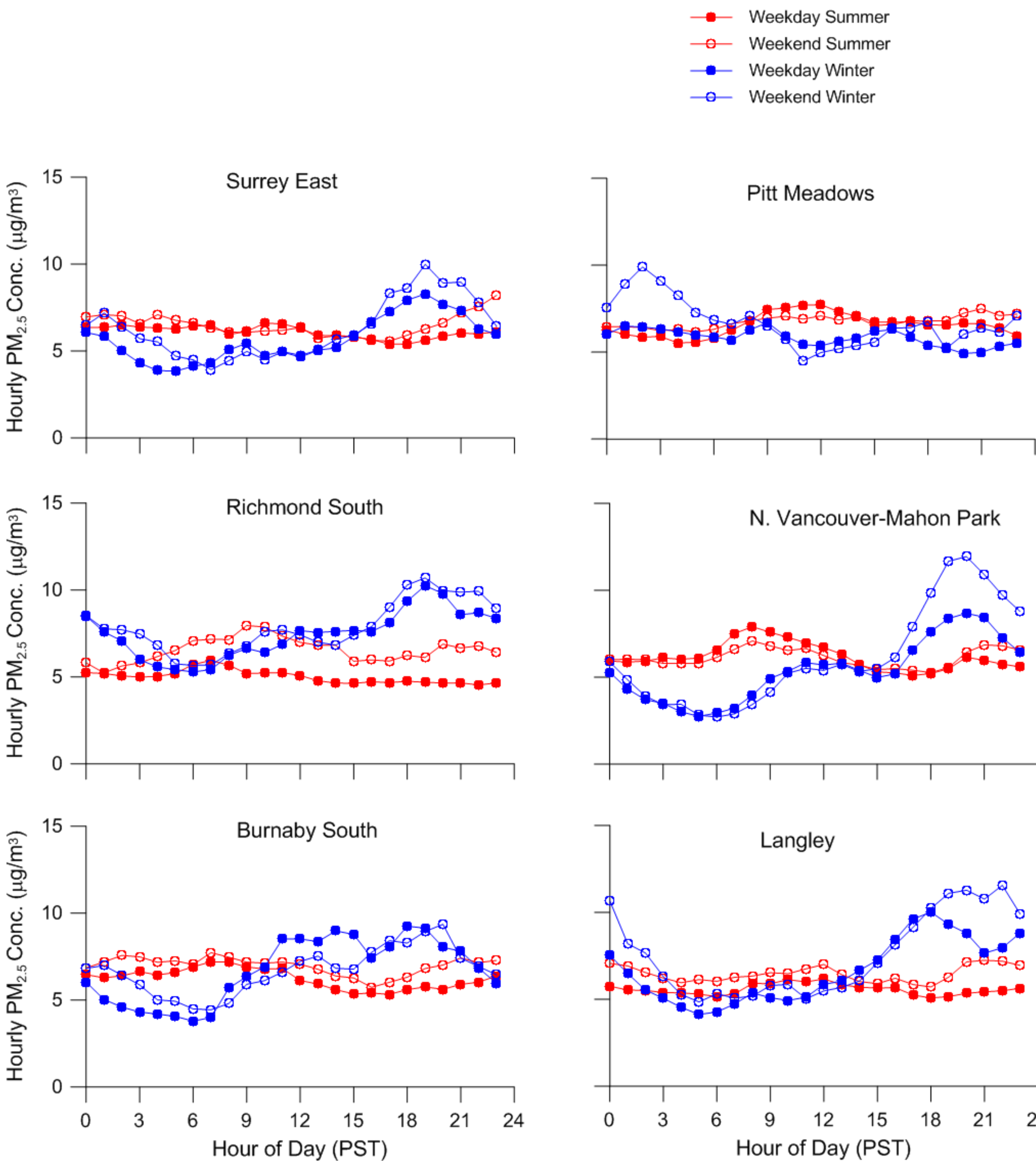


Figure 50: Cont. Diurnal trends fine particulate ($PM_{2.5}$), 2014.

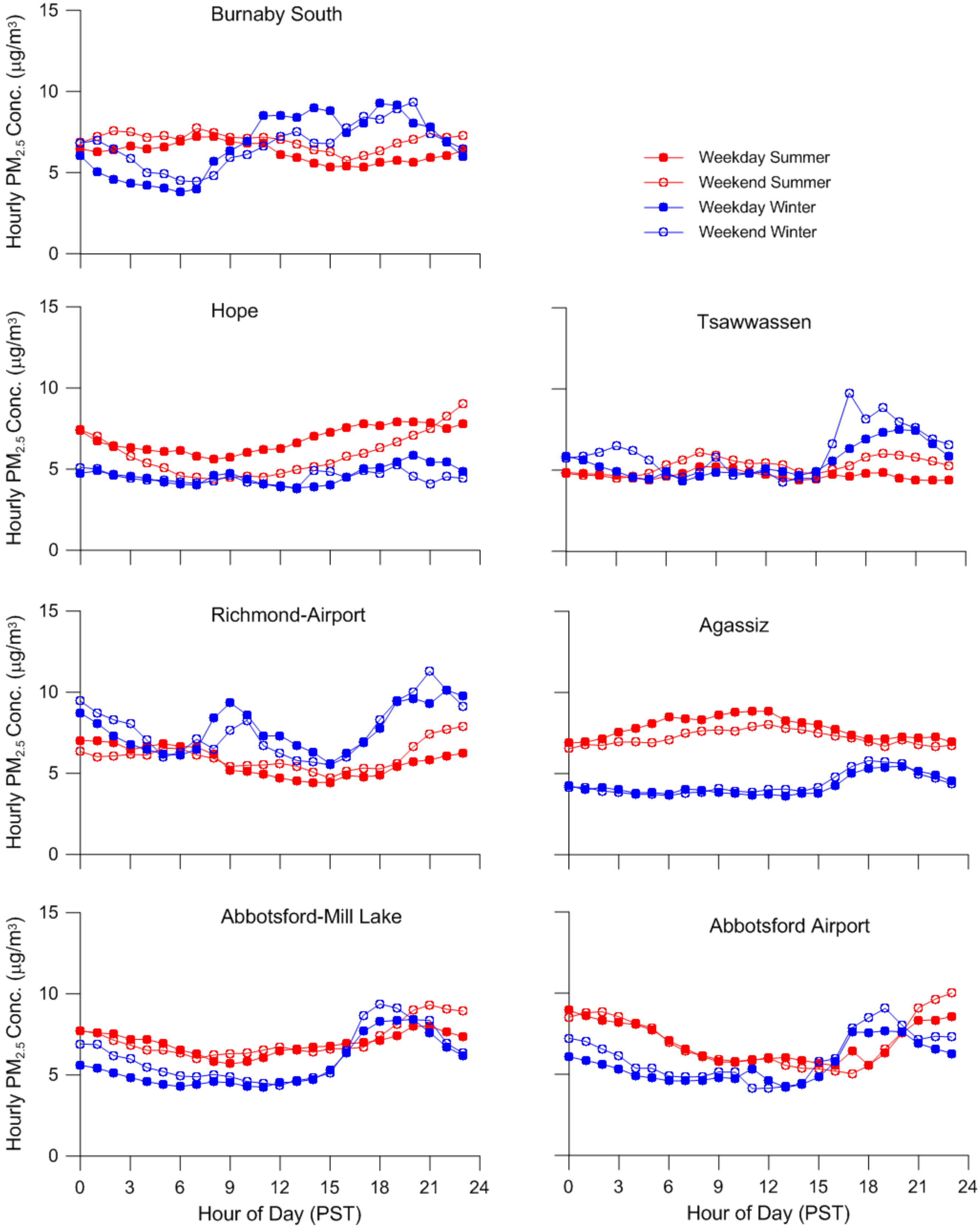


Figure 50: Cont. Diurnal trends fine particulate ($PM_{2.5}$), 2014.

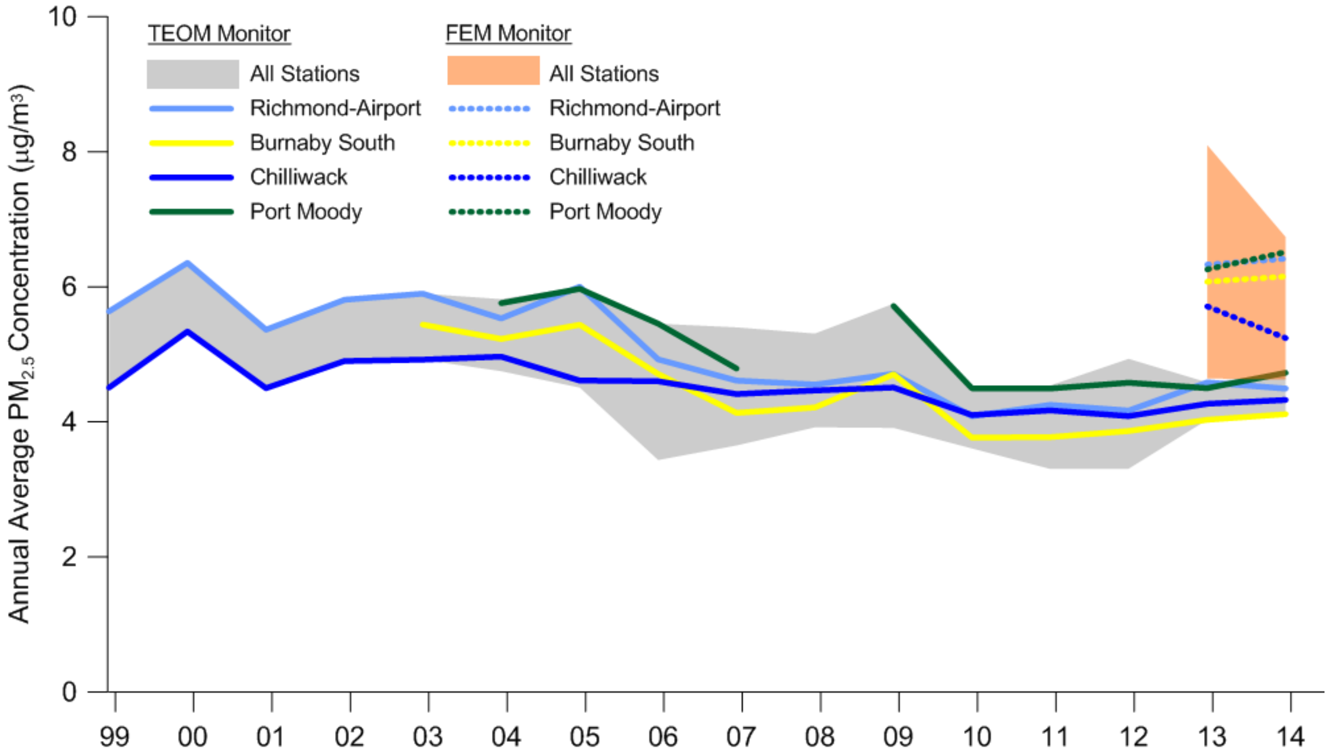


Figure 51: Annual fine particulate ($PM_{2.5}$) trend, 1999 to 2014.

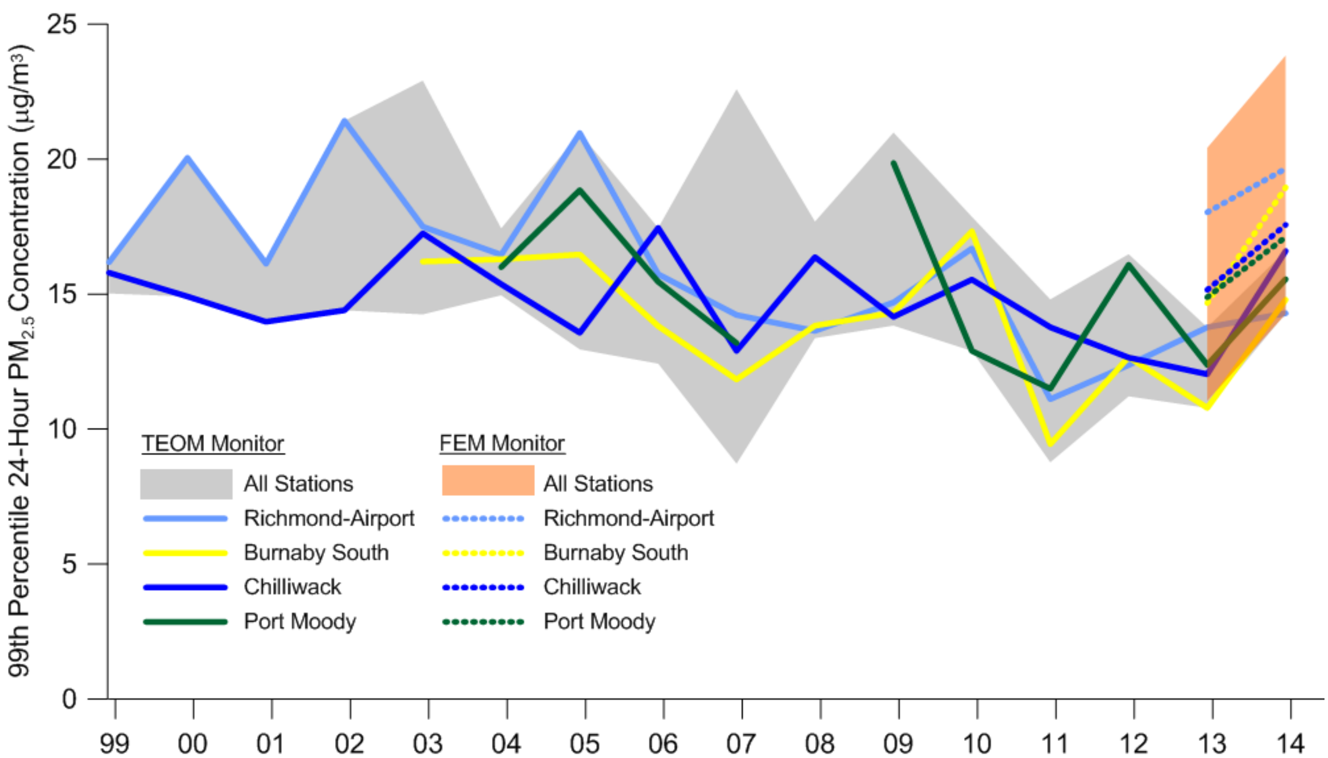


Figure 52: Short-term peak fine particulate ($PM_{2.5}$) trend, 1999 to 2014.

Inhalable Particulate (PM_{10})

Characteristics

The term 'PM_{10}' refers to airborne particles with a diameter of 10 micrometres (μm) or less. These particles are also known as inhalable particulate matter which, given their small size, can be inhaled and deposited in the lungs.

Exposure to PM_{10} can lead to both chronic and acute human health impacts, particularly pulmonary function. Inhalable particulate can aggravate existing pulmonary and cardiovascular disease, increase symptoms in asthmatics and increase mortality. High PM_{10} levels can also increase corrosion and soiling of materials, and may damage vegetation. The smaller particles also contribute to degraded visual air quality.

Sources

Inhalable particulate is emitted from a variety of sources with the largest contribution from road dust (35%). Road dust is made up of material that has been previously deposited on the road surface such as mud and dirt track-out, leaves, vehicle exhaust, tire debris, brake linings, and pavement wear. Traffic or wind re-suspends the road dust into the air. Other major contributors to PM_{10} are transportation, construction and demolition, residential wood heating, agriculture and industry. There are also natural sources of PM_{10} such as wind-blown soil, forest fires, ocean spray and volcanic activity.

Monitoring Results

Figure 53 illustrates the PM_{10} monitoring in 2014, while Figures 54 and 55 shows the same values spatially. Annual averages at all stations were quite similar with each other, about half the Metro Vancouver annual objective.

The Metro Vancouver 24-hour objective was exceeded at the Langley station in 2014 on November 17 and 18 during a persistent high pressure weather system that caused stagnant weather conditions that limited dispersion. Given the stagnant conditions it is likely that local or nearby emission sources were largely responsible for the exceedances during this time.

Table 10 gives the frequency distribution of PM_{10} concentrations for the year. It can be seen that Langley experienced the greatest frequency of high PM_{10} concentrations.

The seasonal trend of monthly average PM_{10} followed a pattern somewhat similar to previous years with the highest average concentrations occurring during hot and dry periods of the summer (Figure 56). The seasonal peak PM_{10} pattern (Figure 57) exhibited the highest levels in November.

A series of diurnal plots are shown in Figure 58 for each PM_{10} monitoring station. The plots show the differences between weekdays and weekends along with differences between summer and winter.

Improvements in PM_{10} concentrations have occurred in the last two decades, however exceedances of PM_{10} occurred at one station in the fall of 2014.

At most stations, weekdays exhibit higher concentrations than weekends, likely the result of greater traffic volumes (road dust) and work related activities (outdoor burning, agricultural activities, industrial processes, etc.).

The long-term PM_{10} trends are shown in Figures 59 and 60 between the years 1995 to 2014. The annual average trend is given in Figure 59 with the short-term peak trend given in Figure 60.

The annual average PM_{10} trend (Figure 59) shows a general improvement in the last 20 years. The peak trend, represented by the 99^{th} percentile of the 24-hour rolling average in Figure 60, also shows a slight improvement. The large peak measured in 1998 was attributed to a dust storm in Asia with dust transported to the LFV. The 2005 peak was the result of a large fire in Burns Bog located in Delta.

Table 10: Frequency distribution of 24-hour rolling average inhalable particulate (PM_{10}), 2014.

PM_{10} Conc. ($\mu g/m^3$)	Burnaby-Kensington Park	Port Moody	Chilliwack	Burnaby South	Burnaby North	Langley	Hope	Richmond-Airport	Abbotsford-Mill Lake	Abbotsford Airport
0 to 2.5	2		2	6		5			8	19
2.5 to 5	799	315	392	699	273	583	501	243	451	288
5 to 7.5	2985	1795	1495	2544	714	1644	2531	1573	1719	1377
7.5 to 10	2105	2329	1943	2298	406	2096	2027	2342	2086	1555
10 to 12.5	1499	1587	1617	1355	237	1553	1455	1827	1470	1422
12.5 to 15	578	1233	1159	876	61	792	794	1382	1090	1093
15 to 17.5	250	817	788	395	38	710	504	593	696	719
17.5 to 20	107	338	463	226		440	352	340	540	595
20 to 22.5	45	106	344	90		210	180	208	218	271
22.5 to 25	8	118	213	91		68	107	89	134	192
25 to 27.5	13	51	126	12		60	29	26	104	122
27.5 to 30	2	10	74	7		26	11	6	11	144
30 to 32.5		13	17	14		14	17	32	17	87
32.5 to 35			24	5		24	16	12	3	61
35 to 37.5			14			30	19			51
37.5 to 40			1			28	9			18
40 to 42.5						11				3
42.5 to 45						3				
45 to 47.5										
47.5 to 50						9				
50 to 52.5						9				
52.5 to 55						4				
>=55						2				
Missing	367	48	88	142	7031	439	208	87	213	743
Data Completeness	96%	100%	99%	98%	20%	95%	98%	99%	98%	92%

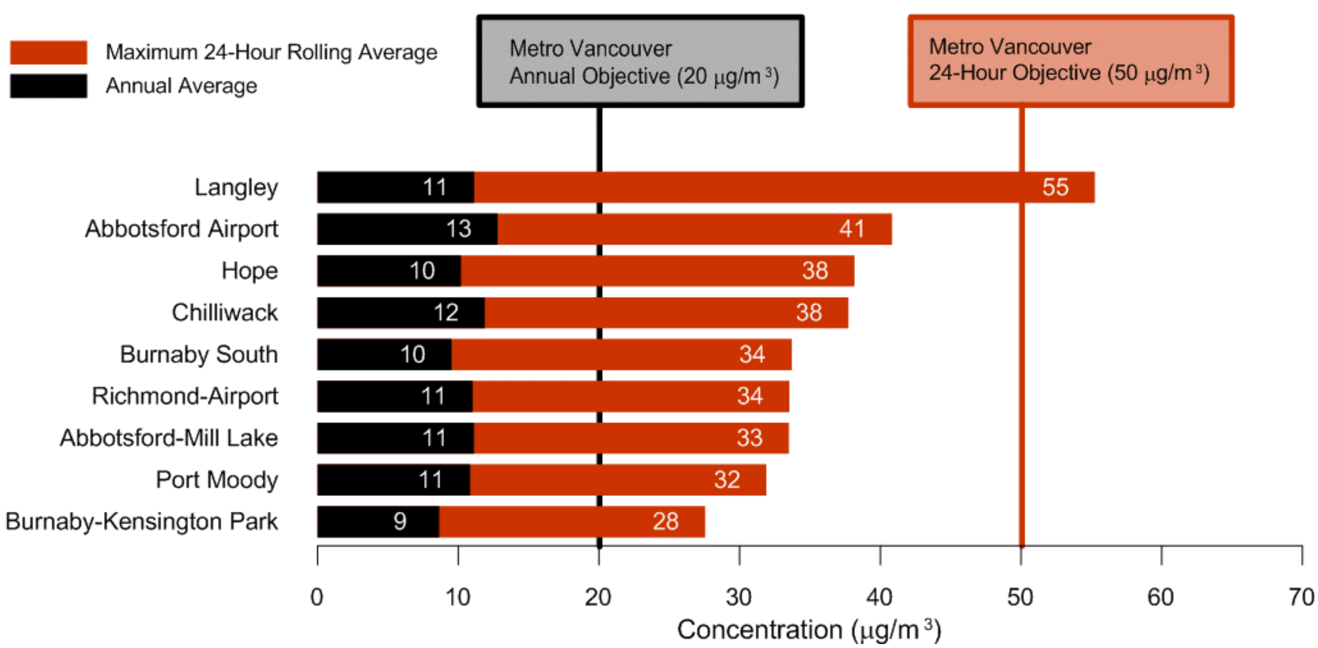


Figure 53: Inhalable particulate (PM_{10}) monitoring, 2014.

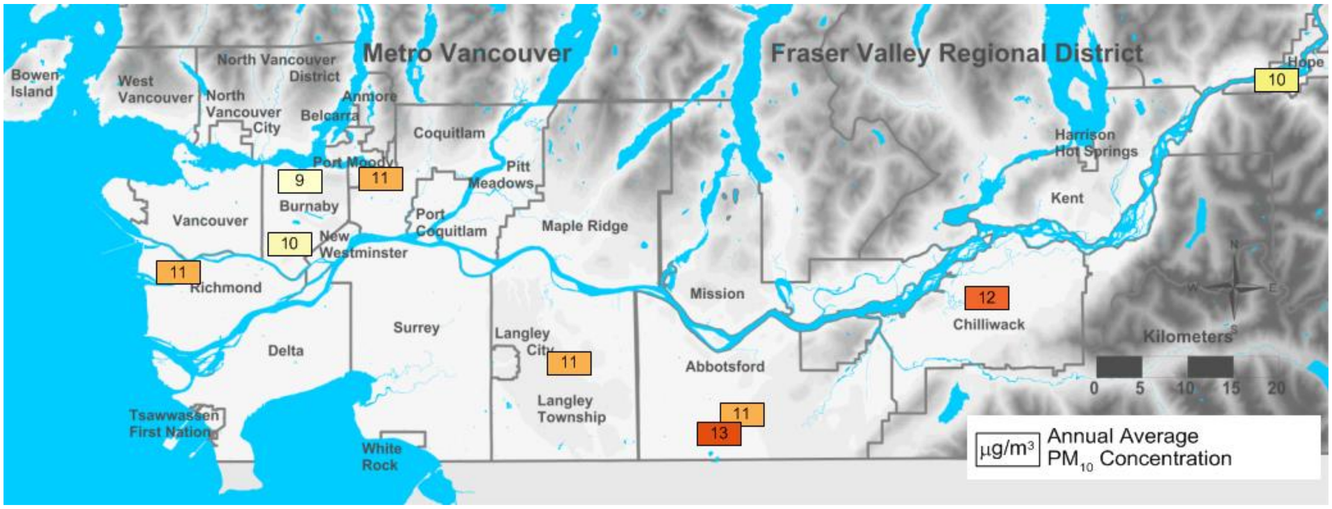


Figure 54: Annual average inhalable particulate (PM_{10}) in the LFV, 2014.

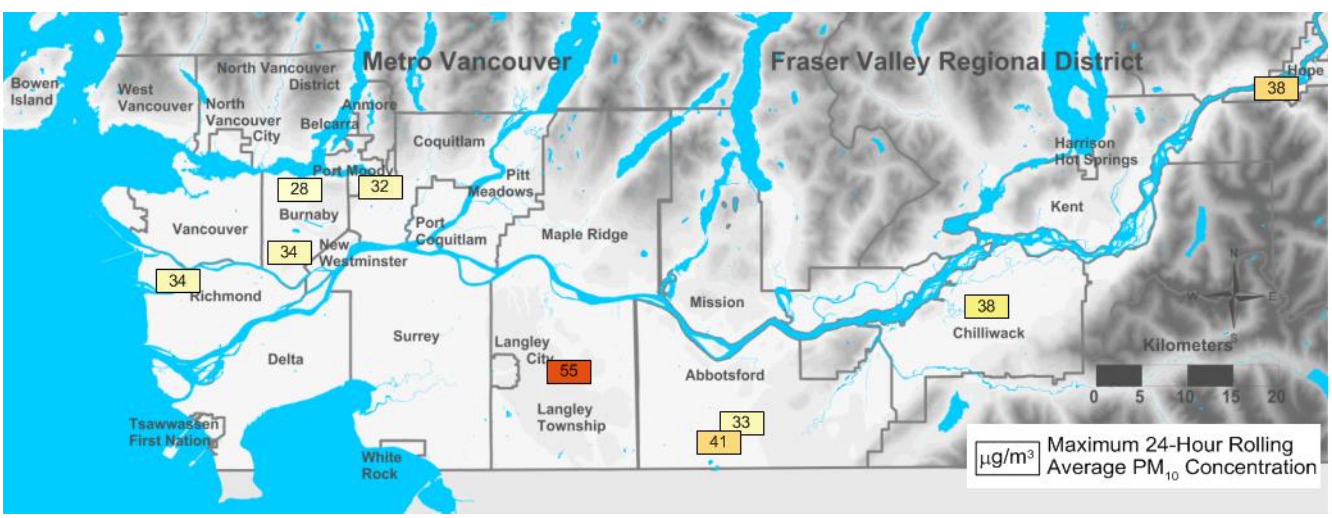


Figure 55: Short-term peak inhalable particulate (PM_{10}) in the LFV, 2014.

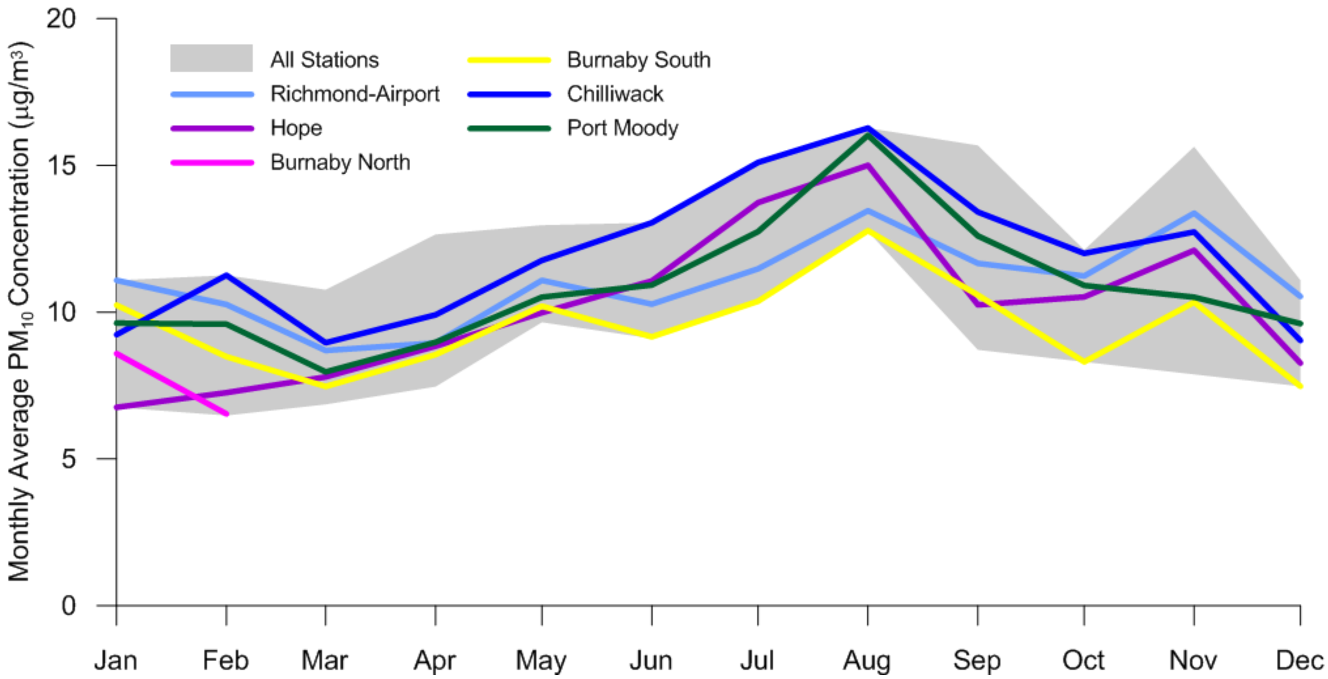


Figure 56: Monthly average inhalable particulate (PM_{10}), 2014.

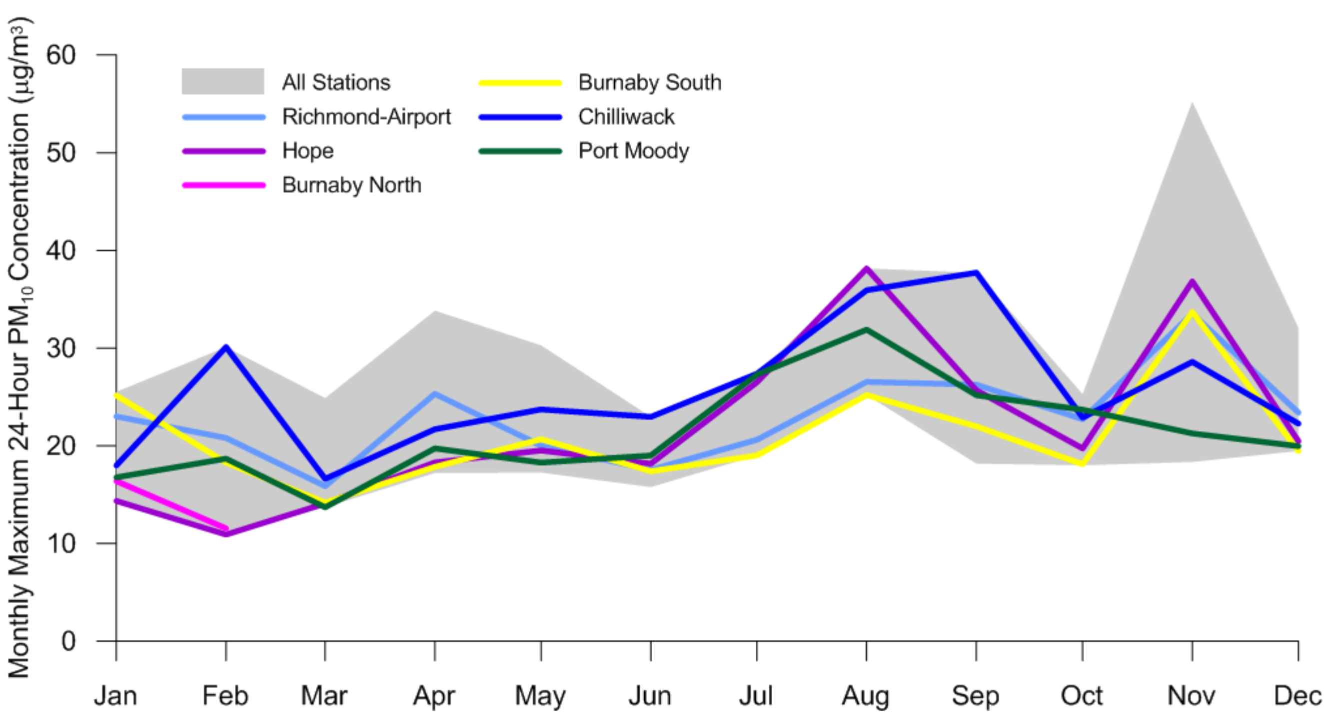
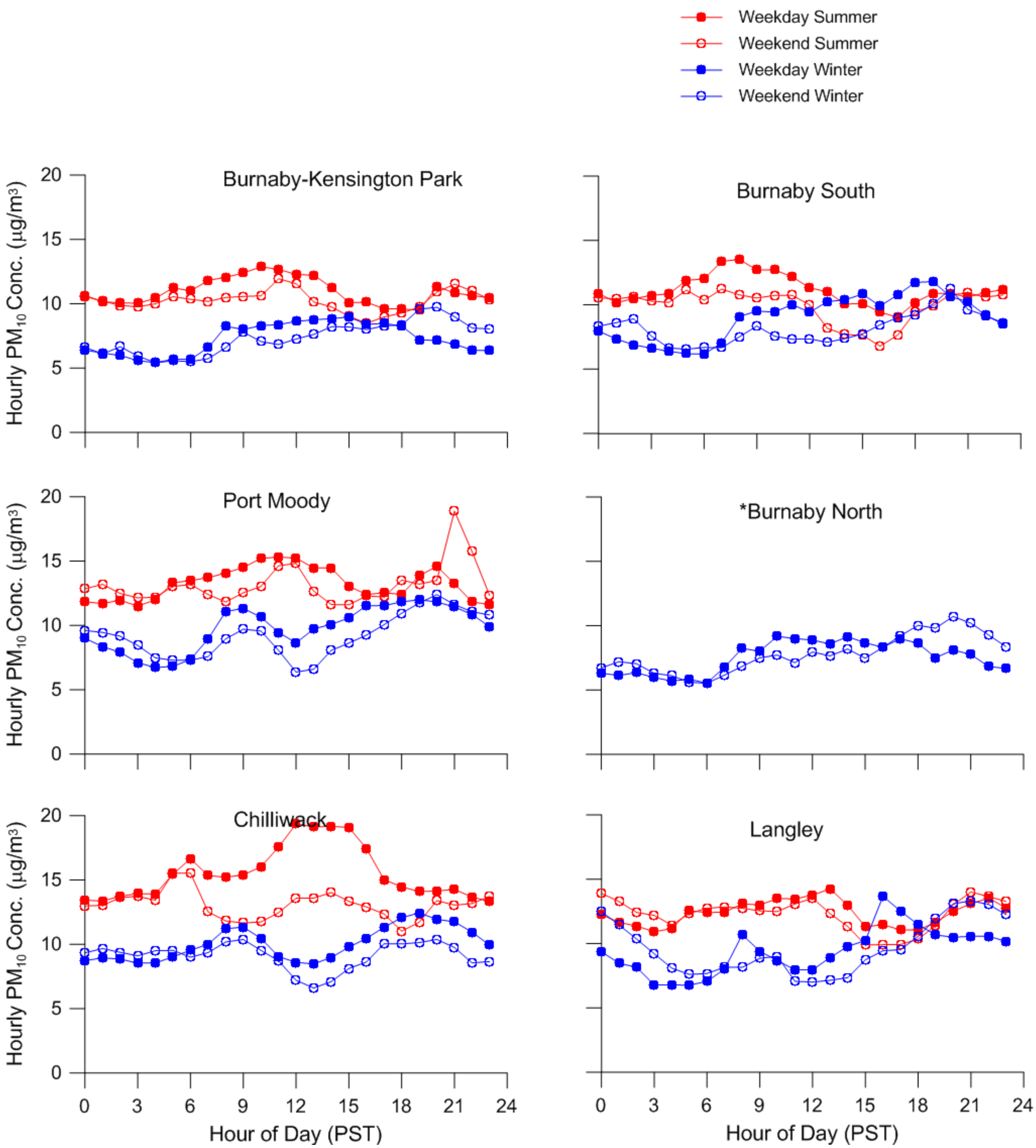


Figure 57: Monthly short-term peak inhalable particulate (PM_{10}), 2014.



*Data completeness requirements were not met at this site in summer.

Figure 58: Diurnal trends inhalable particulate (PM_{10}), 2014.

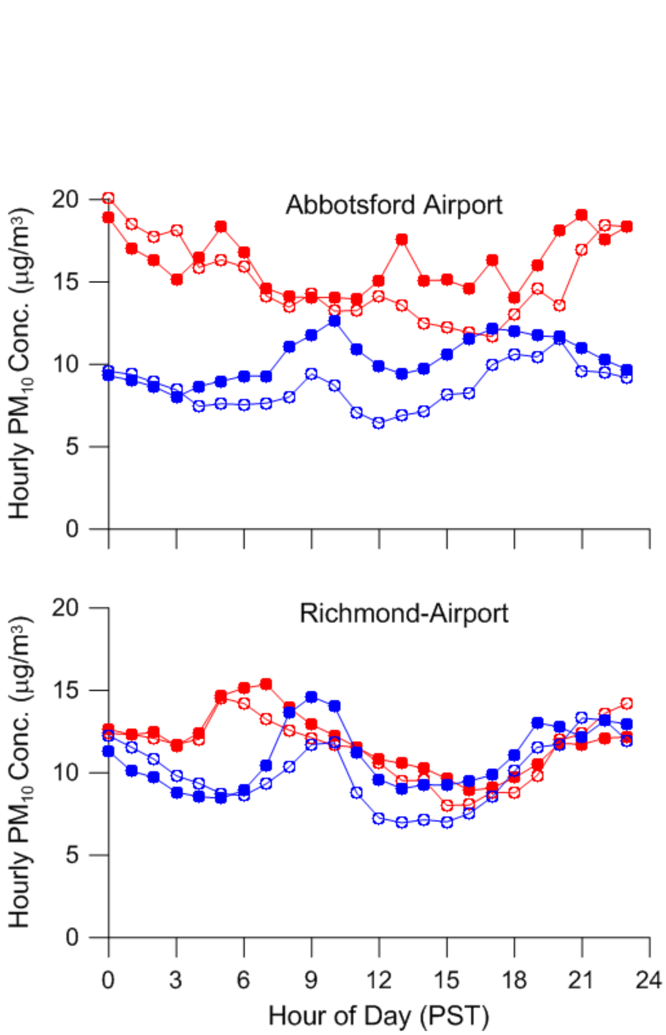


Figure 58: Cont. Diurnal trends inhalable particulate (PM_{10}), 2014.

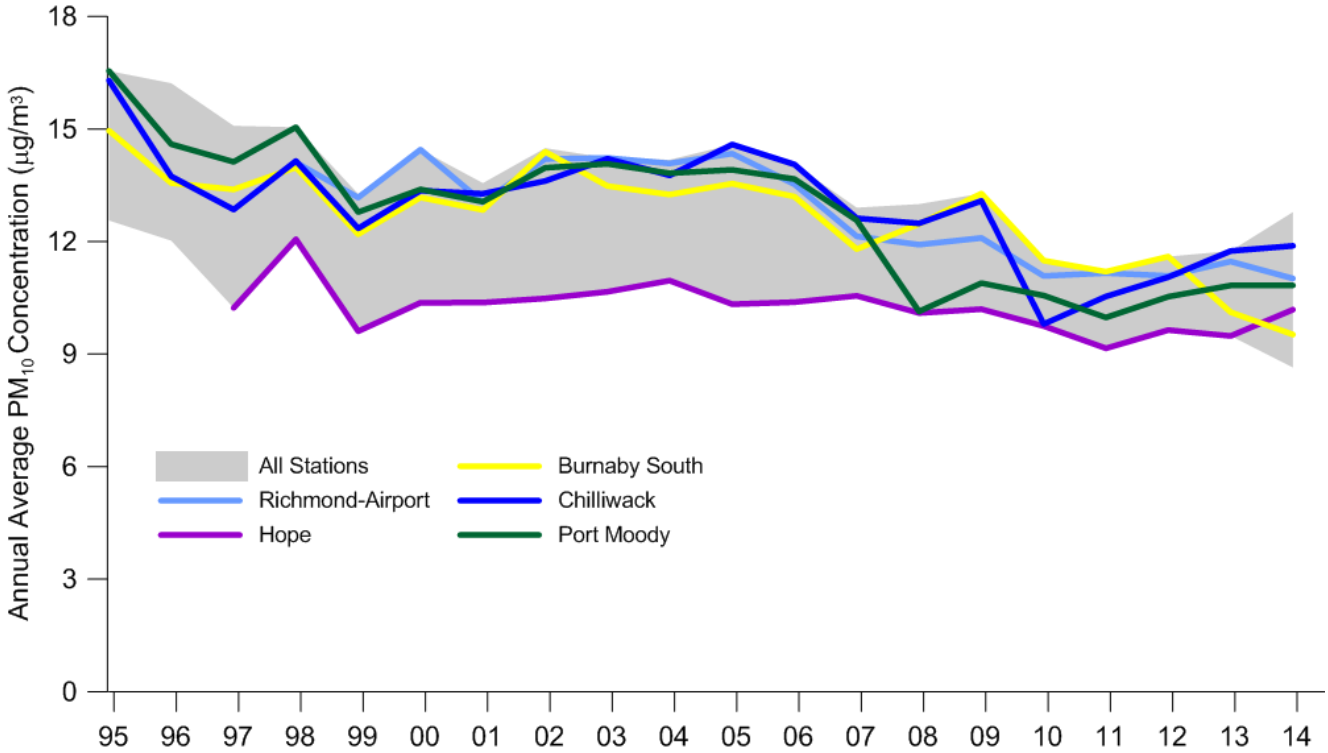


Figure 59: Annual average inhalable particulate (PM_{10}) trend, 1995 to 2014.

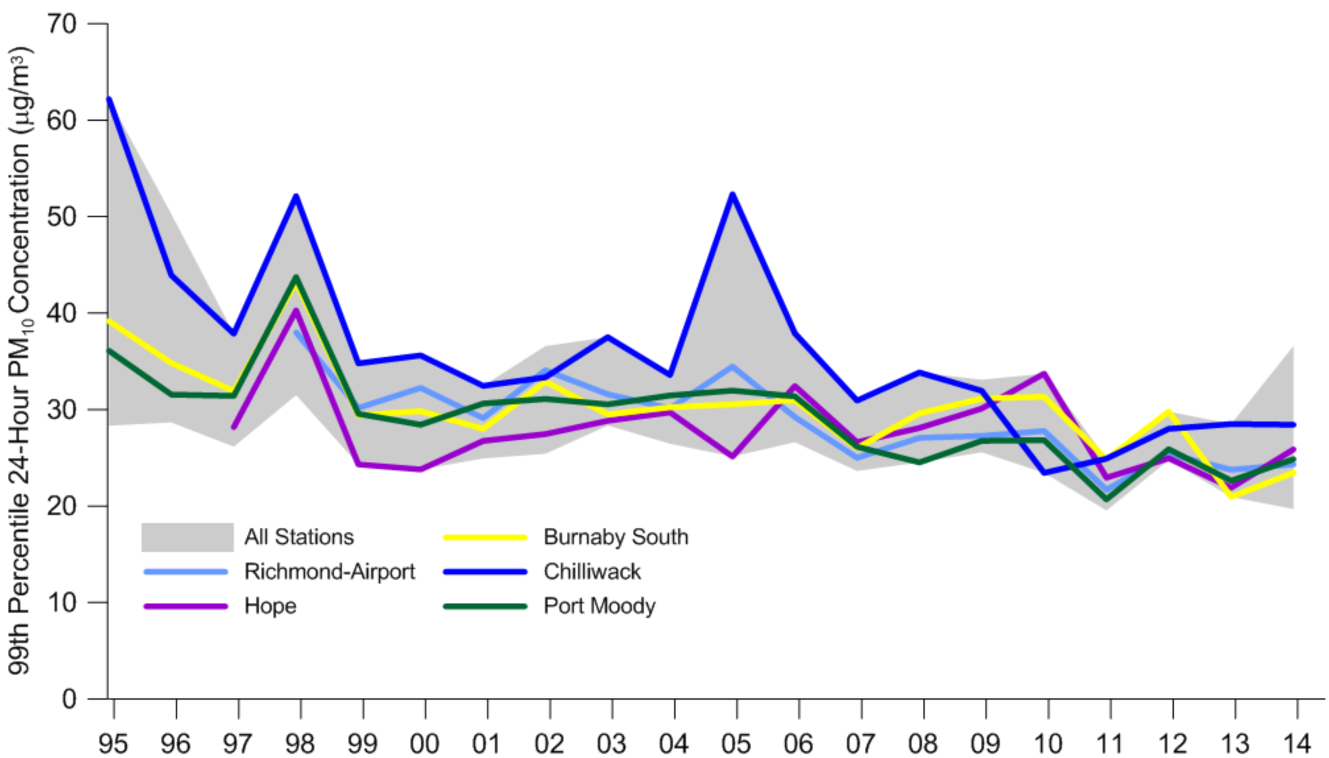


Figure 60: Short-term peak inhalable particulate (PM_{10}) trend, 1995 to 2014.

Black Carbon (BC)

Characteristics

Black carbon (BC) is carbonaceous material formed by the incomplete combustion of fossil fuels, biofuels, and biomass, and is emitted directly in the form of fine particles ($PM_{2.5}$). BC is a major component of "soot", a complex light-absorbing mixture that also contains some organic carbon.

The terms black carbon and soot are sometimes used interchangeably. Although BC has a very short residence time in the atmosphere (about a week), it is a strong absorber of solar radiation and can absorb much more energy than carbon dioxide (CO_2). As a result, BC is considered a "short-lived climate forcer". Black carbon contributes to the adverse impacts on human health, ecosystems, and visibility associated with fine particulate matter ($PM_{2.5}$).

Sources

Mobile sources are the largest contributors of BC emissions in the LFV, emitting over 80% of the BC emissions in the region. Non-road engines (primarily diesel fuelled), heavy duty vehicles, rail and marine vessels are significant sources of BC emissions. Other significant sources in the region are biomass burning operations, including agricultural burning, open and prescribed burning, wild fires and residential heating.

Monitoring Results

Figure 61 illustrates the results of continuous BC monitoring for 2014. Figure 61 displays the value of the maximum 1-hour and 24-hour average as well as the annual average for each BC monitoring location.

There are no provincial, federal or Metro Vancouver objectives for black carbon. The highest 1-hour average BC concentration occurred at Abbotsford-Airport, likely due to a local combustion source for a short period of time.

In Figures 62 and 63 the seasonal trends for BC shows average values higher in January, June and July with the highest peak level occurring in October. Black carbon is generally greater on weekdays compared with weekends, shown in Figure 64. This trend is especially evident at a station located in an industrial area, North Vancouver – Second Narrows, where greater amounts of BC are seen on weekdays compared with weekends.

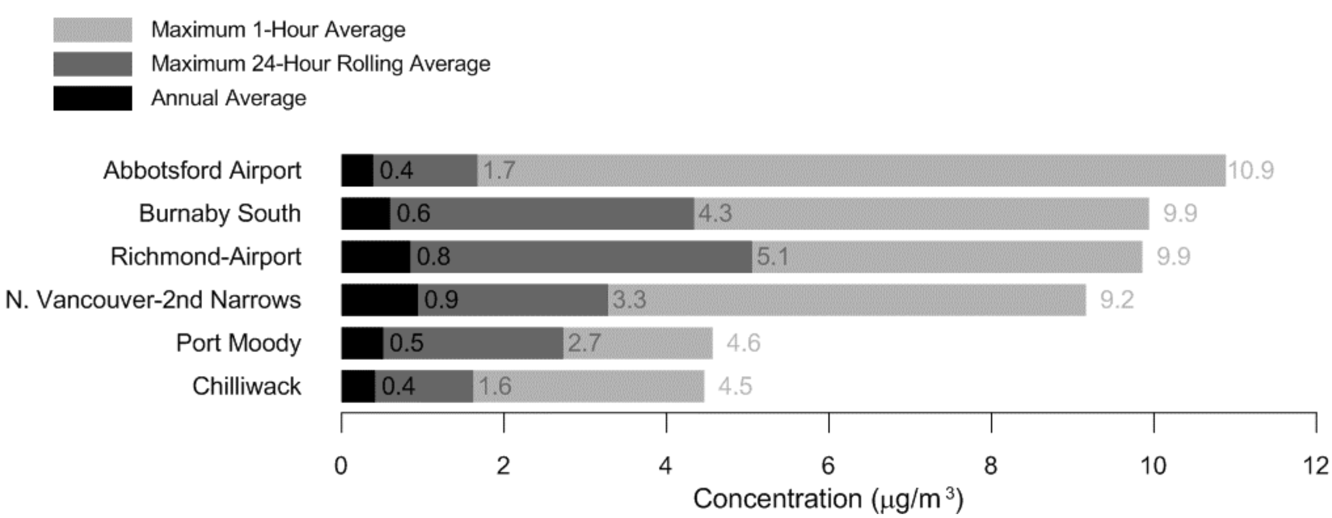


Figure 61: Black carbon monitoring, 2014.

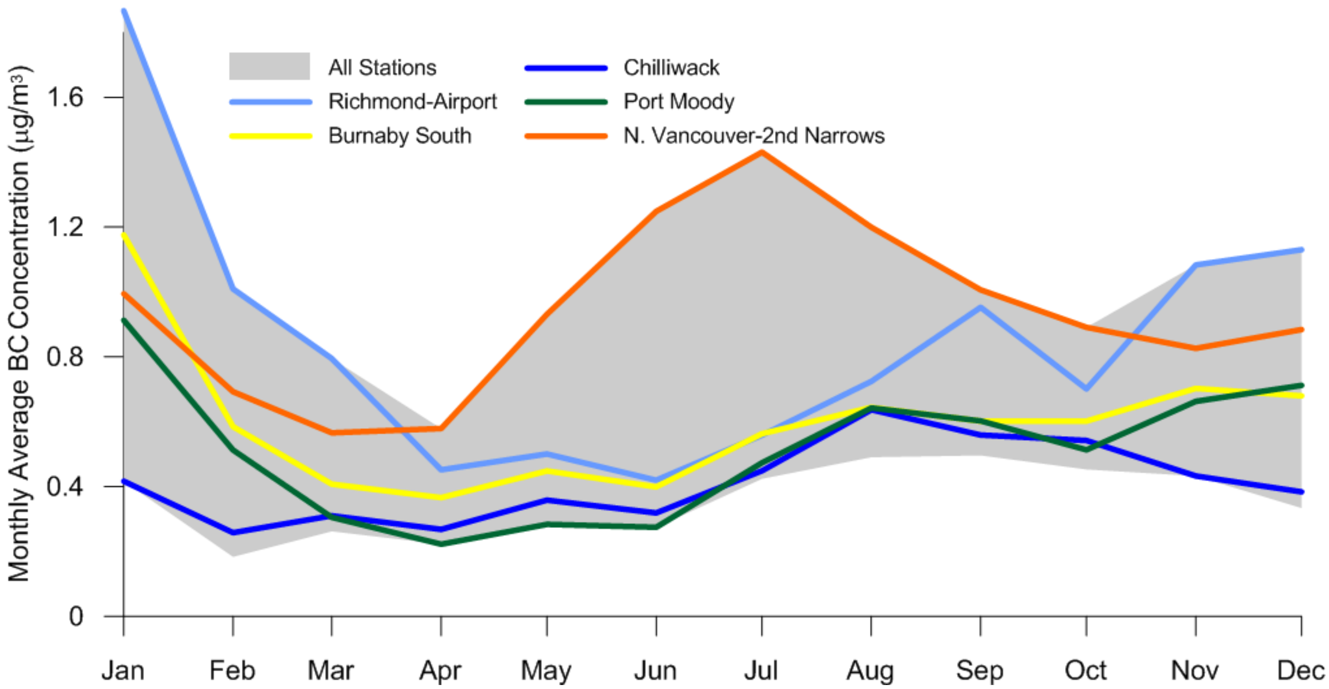


Figure 62: Monthly average black carbon, 2014.

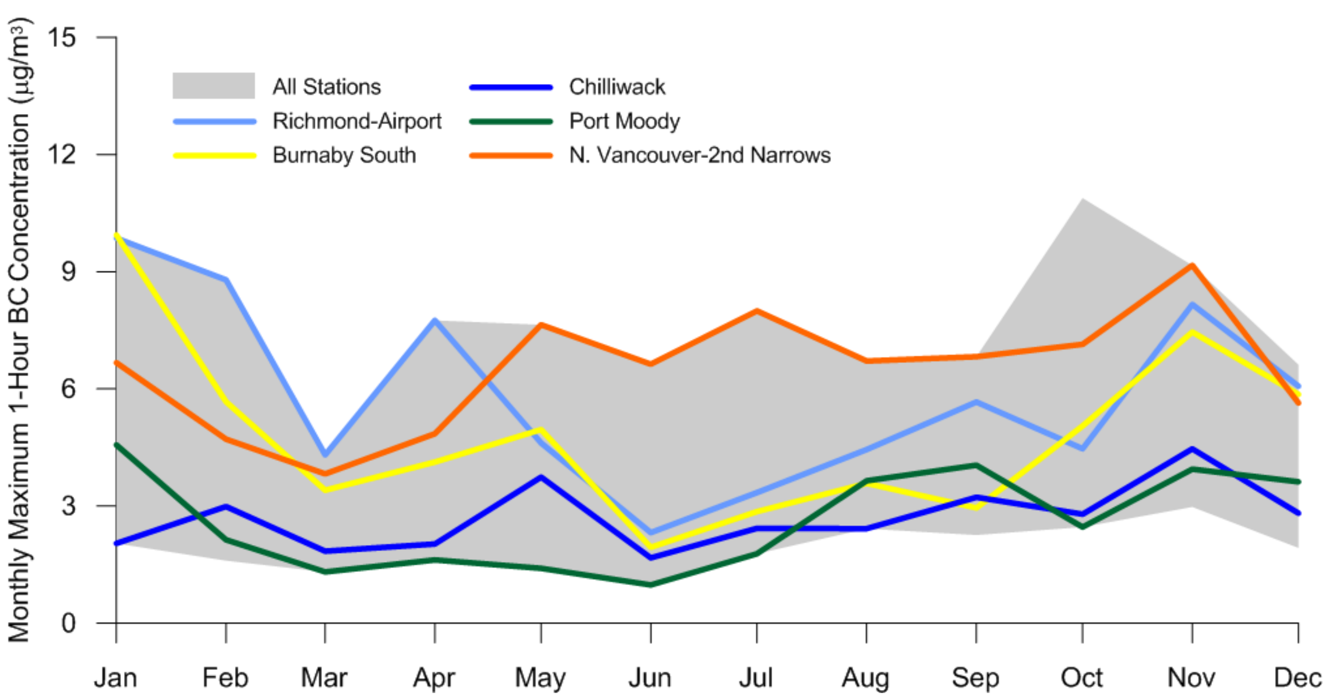


Figure 63: Monthly short-term peak black carbon, 2014.

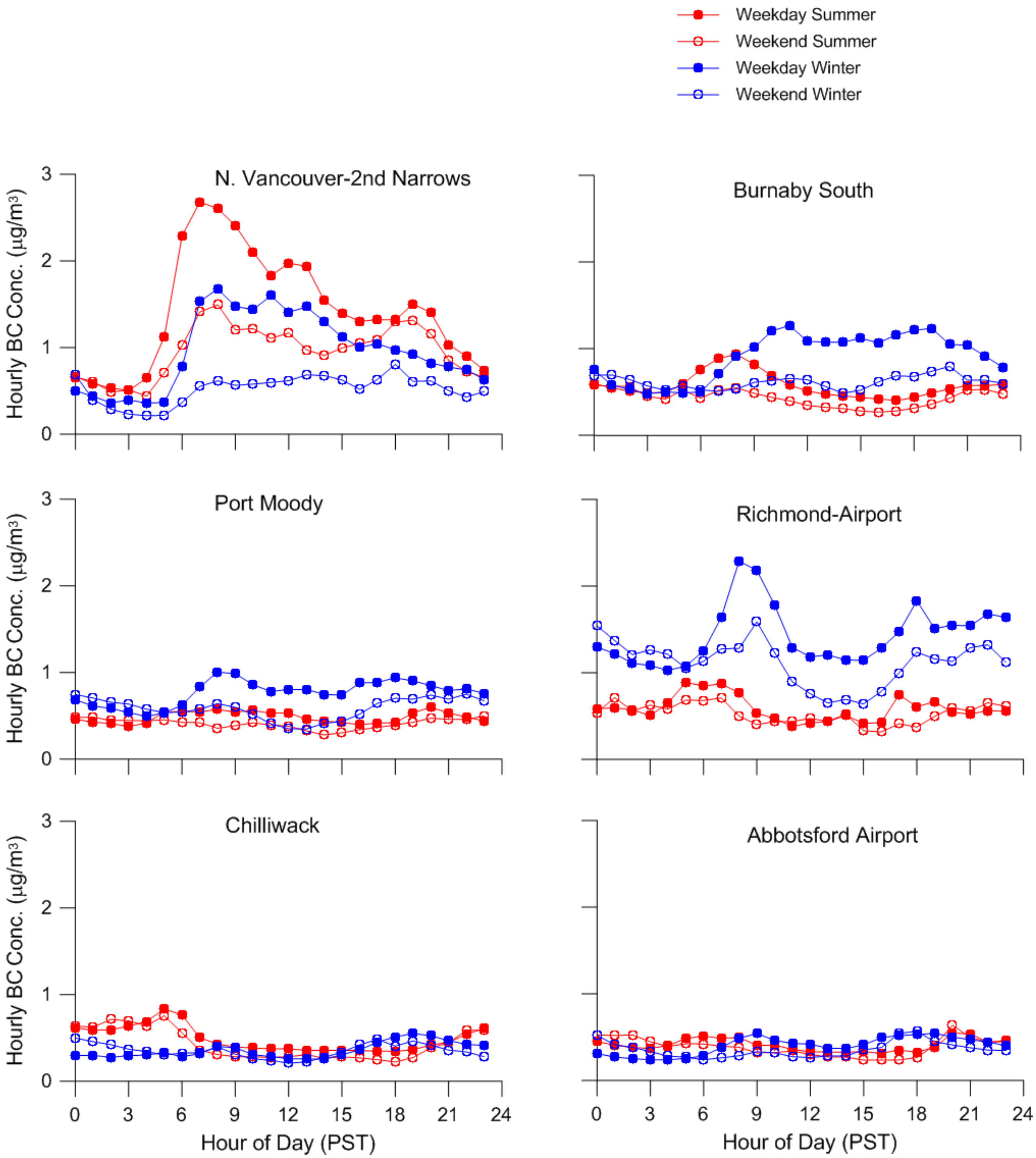


Figure 64: Diurnal trends black carbon, 2014.

Total Reduced Sulphur (TRS)

Characteristics

Total reduced sulphur (TRS) compounds are a group of sulphurous compounds that occur naturally in swamps, bogs and marshes. They are also created by industrial sources such as pulp and paper mills, petroleum refineries and composting facilities. These compounds have offensive odours similar to rotten eggs or rotten cabbage, and at high concentrations can cause eye irritation and nausea in some people.

Sources

Most public complaints regarding these odours are associated with composting facilities and with the petroleum refining and distribution industry located along Burrard Inlet. A few periodic inquiries also occur as a result of natural emissions from such locations as Burns Bog in Delta.

Monitoring Results

Figure 65 illustrates the TRS measurements in 2014. Average levels continued to be near or below detectable limits. Peak levels during 2014, indicated by the maximum 1-hour value, exceeded the Desirable Objective for a total of 54 hours and Acceptable Objective for a total of 6 hours at Port Moody. The occurrences of elevated TRS are of a short duration and generally occurred during the night or early morning. The majority of exceedances occurred in the winter.

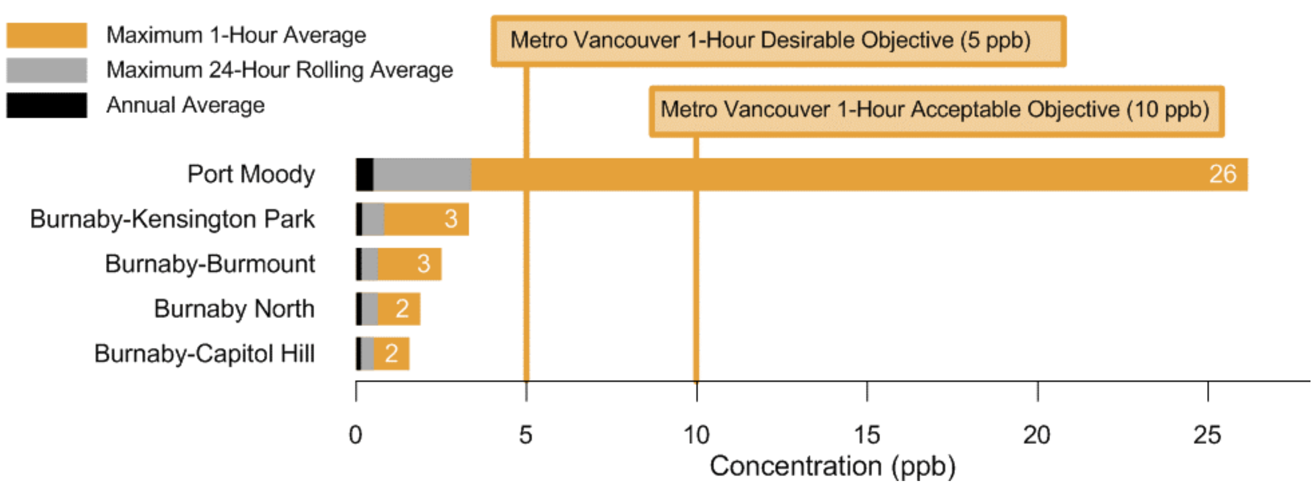


Figure 65: Total reduced sulphur monitoring, 2014.

Ammonia (NH_3)

Characteristics

Ammonia (NH_3) can contribute to the formation of fine particles when chemical reactions occur between ammonia and other gases in the atmosphere including sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). The resulting ammonium nitrate and ammonium sulphate particles are efficient at scattering light and can impair visual air quality with a white haze.

Sources

The largest contribution to ammonia in the LFV comes from the agriculture sector. The majority of ammonia emissions come from cattle, pig, and poultry housing, land spreading and storage of manure, and fertilizer application.

Monitoring Results

Continuous measurements of ammonia were made at three sites in the monitoring network in 2014. The 2014 data are presented in Figure 66, shown as the maximum 1-hour average, maximum 24-hour rolling average and annual average ammonia concentrations. There are no applicable objectives for ammonia.

Continuous measurements of ammonia began in 2005. Due to the relatively short period for which data are available, no clear long-term trend in ammonia is evident.

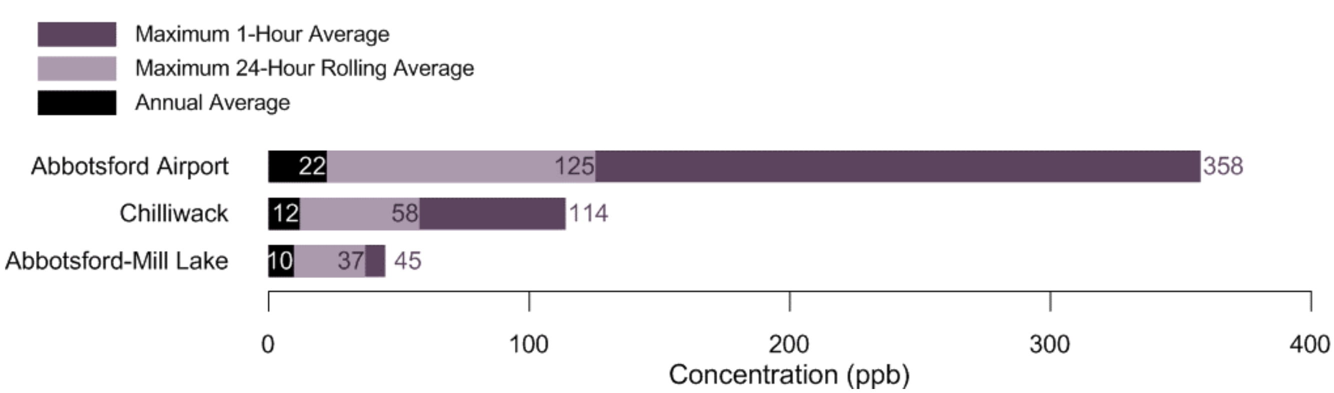


Figure 66: Ammonia monitoring, 2014.

Section E – Non-Continuous Pollutant Measurements

Non-continuous samples are collected in accordance with the National Air Pollution Surveillance (NAPS) program. After collection, samples are transported to and analyzed in a federal laboratory in Ottawa to determine pollutant concentrations.

The process of obtaining results of non-continuous sampling from the federal laboratory can take considerable time. Results for 2014 are not yet available to Metro Vancouver, but will be included when available in a subsequent publication.

Particulate Sampling

Non-continuous 24-hour (daily) $PM_{2.5}$ and PM_{10} samples are collected on filters every sixth day depending on the site. Non-continuous particulate samples are collected at four monitoring stations in the LFV and pollutant concentrations are determined. A detailed analysis is conducted by the federal laboratory for three of these stations (Port Moody, Burnaby South and Abbotsford Airport).

Using specialized PM speciation instrumentation, additional detailed information about the chemical composition of $PM_{2.5}$ is obtained from two stations in the network (Burnaby South and Abbotsford Airport) as a result of analysis carried out by the federal NAPS program. From the 24-hour samples collected at these two sites, the various compounds that form $PM_{2.5}$ are identified.

Volatile Organic Compounds (VOC)

Volatile Organic Compounds (VOC) refers to a combination of organic chemicals. A large number of chemicals are included in this group but each individual compound is generally present at relatively low concentrations in air compared to other common air contaminants. The gaseous VOC present in the air can originate from direct emissions and from volatilization (*i.e.* changing into the gas phase) of substances in the liquid or solid phase.

Locally, some VOC can be pollutants found in urban smog and are precursors of other contaminants present in smog such as ozone and fine particulates. Some materials in this class (*e.g.* carbon tetrachloride) can contribute to depletion of the stratospheric ozone layer and may contribute to climate change. Other VOC (*e.g.* benzene) can pose a human health risk.

Sources of VOC in Metro Vancouver include, but are not limited to emissions from the combustion of fossil fuels, industrial and residential solvents and paints, vegetation, agricultural activities, petroleum refineries, fuel-refilling facilities, the burning of wood and other vegetative materials, and large industrial facilities.

Under the Canadian Environmental Protection Act some VOC are included in the Toxic Substances List.

Emissions of some VOC are limited by permits and industry-specific regulations within Metro Vancouver.

Non-continuous 24-hour (daily) sampling of VOC is conducted every sixth or twelfth day on a national schedule. In 2014, VOC samples were collected at seven sites in the LFV. In cooperation with the federal National Air Pollution Surveillance (NAPS) program, canister sampling of VOC has been conducted in the LFV since 1988. Canisters sent to the federal laboratory are analyzed for up to 177 VOC. These data can then be used to help determine the emission sources contributing to contaminants in the air.

In addition to the canister sampling, continuous measurements of total hydrocarbons (THC) were made at two stations in 2014, Burnaby North (T24) and Burnaby-Burmount (T22) (results not shown). Both of these are adjacent to petroleum industry facilities.

Section F – Visual Air Quality Monitoring

Characteristics

When light between an object and the eye of an observer is scattered and/or absorbed by particles and gases in the air, views can look hazy or even be fully obscured. Visual air quality refers specifically to the effect air contaminants have on our ability to see through the atmosphere, or how clear the air is. The term does not refer to the direct effects of clouds, fog, rain or mist on a view.

Studies conducted in the region indicate that the major contributor to visual air quality impairment in the LFV is light scattering by $PM_{2.5}$.

Haze, or visual air quality impairment, may look noticeably different in different locations as it is dependent on the nature of the air contaminants present. In the more urbanized areas in the west of the LFV, haze can have a brownish colour. Nitrogen dioxide, emitted when fuels are burned from such sources as transportation, contributes to this brown appearance. Further east in the LFV, white haze caused by $PM_{2.5}$ may be observed. Windblown dust, soil, sea salt and smoke can also affect the appearance of haze.

Monitoring Program

To assess visual air quality impairment, Metro Vancouver, FVRD, and Environment Canada have jointly established a visual air quality monitoring network in the LFV. Continuous measurements of NO_2, $PM_{2.5}$, light scattering and absorption are being complemented by particulate speciation sampling and images of views along specific lines-of-sight. Measurements of air contaminants, views or both occur at seven locations in the LFV (Figure 67).

Light scattering measurements are made using nephelometers at five locations: Chilliwack, Abbotsford, Burnaby, Pitt Meadows and Richmond. Aethalometers and nitrogen dioxide analyzers are also located at these sites and are used to characterize light absorption. Analysis of the data from the nephelometers, aethalometers and nitrogen dioxide analyzers indicates that scattering by particles generally has the most influence on light extinction, and consequently visual air quality impairment.

Figure 67: Visual air quality monitoring locations in the LFV, 2014.

Ten automated digital cameras are operated in seven locations across Metro Vancouver and the FVRD: Chilliwack, Abbotsford, Pitt Meadows, Burnaby, Vancouver, Richmond and Lions Bay. Images are captured at 10 or 30 minute intervals along specific lines-of-sight with recognizable topographical features at known distances. Examples showing a range of visual air quality conditions recorded by the camera in Chilliwack in 2014 are shown in Figure 68.

Near real-time images from a selection of the visual air quality monitoring cameras can be viewed at

http://www.clearairbc.ca/community

Images from the cameras are used in conjunction with air contaminant data to relate the visual characteristics, such as the colour, clarity and definition of mountain ridges, of scenes from around the region to air contaminant concentrations and $PM_{2.5}$ composition. The information gathered by the visual air quality monitoring network is being used to further understanding of visual air quality in a LFV visual air quality pilot project being conducted through the BC Visibility Coordinating Committee (BCVCC).

Pilot Project

The results of studies conducted in the LFV indicate that people perceive degraded visual air quality even at low air contaminant concentrations, below Metro Vancouver's ambient air quality objectives for $PM_{2.5}$. To address the issue of visual air quality impairment, the BCVCC was established. Metro Vancouver is a partner with the FVRD, Environment Canada, Health Canada and BC Ministry of Environment in the BCVCC.

The LFV pilot project is being conducted to develop a visual air quality management strategy for the region. As part of this pilot, improvements have been made to the visual air quality monitoring network to enhance public reporting of visual air quality. The causes and impacts of impaired visual air quality are also being determined:

- Air contaminant measurements and modelling tools are being used to identify the effects of programs to reduce air contaminant concentrations on visual air quality.

- A visual air quality metric to measure and report visual air quality in the LFV was tested in 2014.

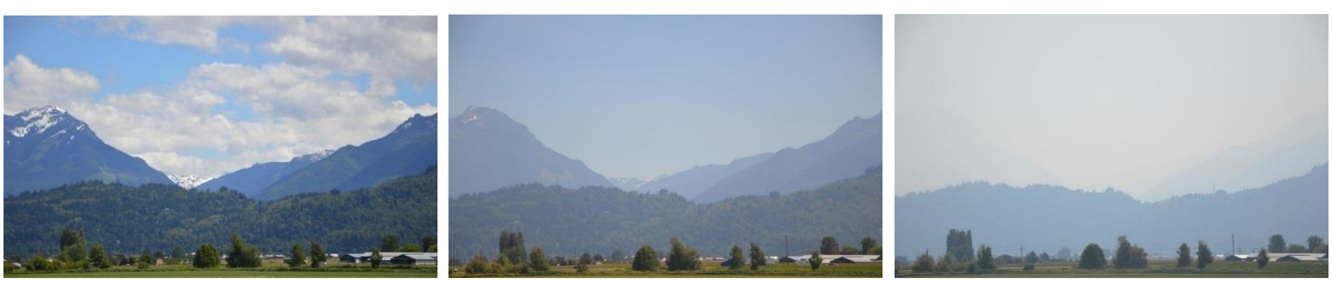


Figure 68: Images of the view south from Chilliwack airport under a range of visual air quality conditions (Summer 2014).

Section G – Meteorological Measurements

Purpose

An understanding of meteorology is integral in understanding and forecasting air quality and visual air quality patterns. The state of the atmosphere determines pollutant dispersion and the resultant ground-level concentration. Meteorology is observed at LFV air quality monitoring network stations for several purposes:

- To allow for a characterization of meteorological patterns throughout the LFV.
- To assist with the linkage between pollutant emission sources and ambient concentrations.
- To provide data to be used as input in dispersion modelling.
- To provide real-time data to numerous agencies including Environment Canada, which are used for weather and air quality forecasting in the region.

It should be noted that the LFV network's primary purpose is for the collection of air quality measurements and secondary purpose is for meteorological observation. Attempts have been made to site meteorological instruments to capture representative observation, however due to site restrictions at some stations, not all instruments are sited to capture spatially representative measurements.

Monitoring Program

Various meteorological parameters are observed as part of the LFV air quality monitoring network (see Section C Table 2).

Meteorological parameters observed in the network include:

- wind speed and direction
- air temperature
- relative humidity
- precipitation
- barometric pressure
- incoming solar radiation

Wind speed and direction observations allow for the characterization of pollutant transport and dispersion and are used to understand the relationships between pollutant sources and measurements at air quality monitoring stations.

Air temperature and incoming solar radiation measurements can be used to determine the potential for ozone formation during the summer. Ozone concentrations are dependent on sunshine to cause photochemical reactions among air pollutants. Higher air temperatures are necessary for these reactions to occur.

Humidity is important in the formation and growth of visibility reducing particles, and its measurement is a key to understanding the many factors responsible for visual air quality degradation.

Precipitation can wash pollutants out of the atmosphere and may help explain differences in air quality from one part of the region to another. In addition precipitation data are used by Metro Vancouver's Wastewater Collection and Watershed Management functions.

Meteorological Observations

Figure 69 shows the precipitation totals for 2014 at Lower Fraser Valley air quality monitoring network stations. The greatest precipitation was observed near the local mountains. Figure 70 displays the seasonal variation as observed by the LFV air quality network stations (shown as a blue band). Historical 30-year climate normals (1971-2000) obtained from Environment Canada are also shown in Figure 70 for Vancouver International Airport and Hope Airport.

Compared to climate normals, monthly precipitation in 2014 was drier in January, February, July, and August and wetter in March, May, October and November.

Figure 71 illustrates the seasonal variation of air temperatures observed throughout the monitoring network stations. The hourly maximum and minimum, daily maximum and minimum, and average temperatures are given with the range in values shown as bands. Also shown in Figure 71 are the 30-year climate normals (1971-2000) for Environment Canada's Vancouver International Airport and Hope Airport stations.

The data observed in 2014 suggest that average temperatures recorded in January, July, August, September, October and December were warmer than the 30-year average. During these months higher averages and daily maximums were experienced compared with the climate normals. The highest air temperature was measured in August. February and November were cooler than normal with lower daily maximums compared with the climate normals.

Table 11 provides the average temperature along with the lowest and highest hourly air temperatures observed throughout the year. Air temperatures are milder near the water and exhibit a greater range inland. The highest hourly temperature in 2014 was 36.2^{o}C observed at Hope.

Table 12 gives the frequency distribution of hourly air temperature for the year. Stations located inland, such as those in eastern parts of Metro Vancouver and the Fraser Valley Regional District exhibit the greatest frequency of both very low and high air temperatures.

Wind patterns vary between stations as shown by the frequency distributions in Figure 72. The distributions are shown as a “wind rose”, which is a bar chart in a polar format. The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 72 shows observed annual wind roses for selected stations including (in order of west to east): Horseshoe Bay, Richmond-Airport, Burnaby North, Pitt Meadows, Abbotsford Airport, Chilliwack, and Hope. The patterns shown during 2014 reflect the predominant winds in those areas. Richmond exhibits a predominant easterly wind with a smaller component from the west, and very little wind from either the north or south. Horseshoe Bay shows wind patterns aligned with Howe Sound with a strong north-south component.

The weather in 2014 included a warmer summer, fall and winter with the exception of a cooler February and November. Fall was wetter than normal.

Burnaby North shows several northerly wind components along with a predominant east-north east component. This wind pattern is reflective of the North Shore mountain wind flows and drainage flow from Indian Arm. Pitt Meadows shows a somewhat similar pattern with predominant directions from the valleys of Pitt Lake and Alouette Lake. Abbotsford, Chilliwack and Hope experience similar wind flow patterns, with strong east-west components driven by the channelling of winds in the narrower portion of the Fraser Valley.

Figures 73 to 76 show wind roses for winter, summer, spring and fall, respectively. The contrast between winter and summer can be seen in Figures 73 and 74 with winds predominantly from the east in winter switching to southwest in summer. The more westerly flow seen in the summer is the development of a daytime sea breeze during anticyclonic (high pressure) weather.

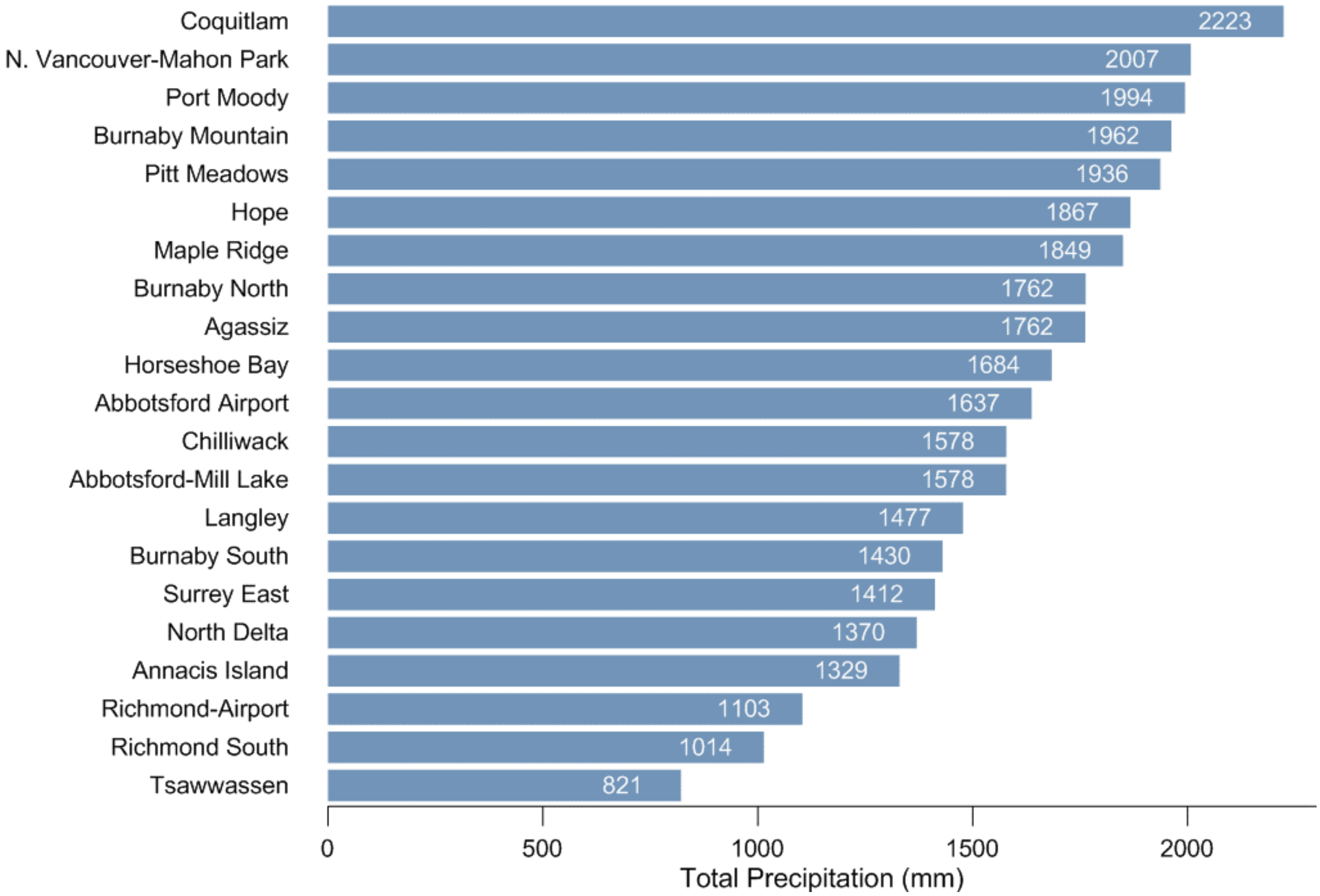
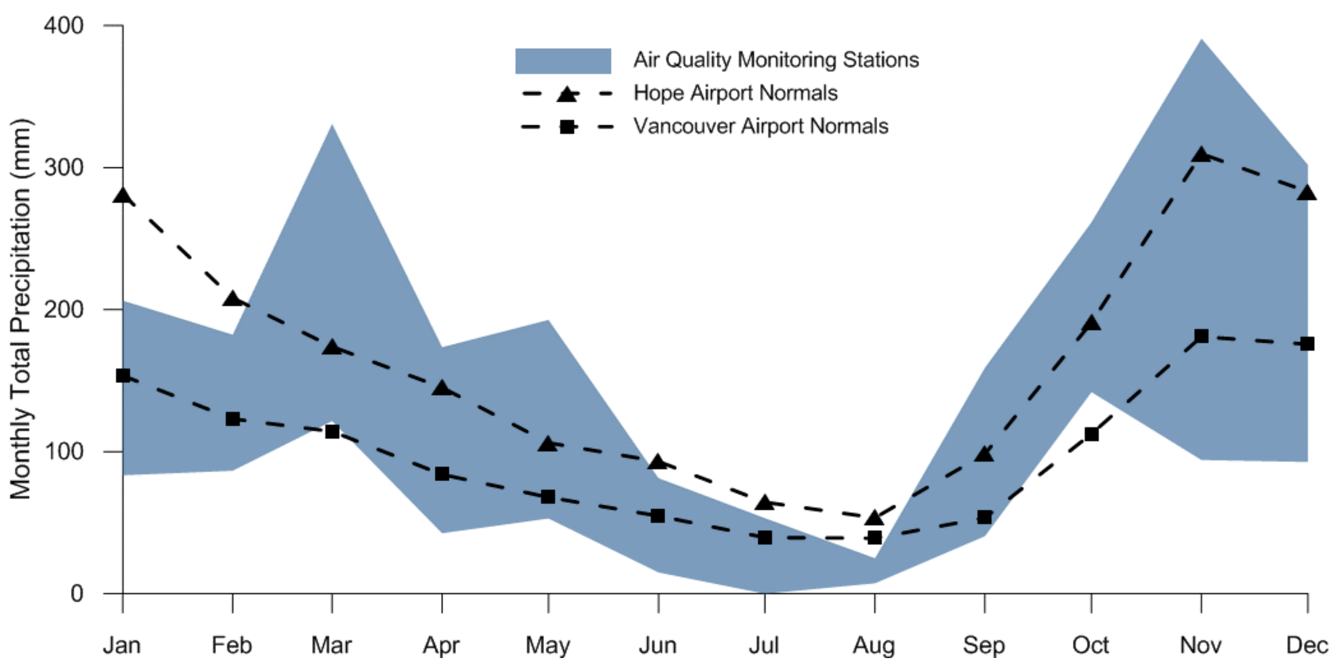
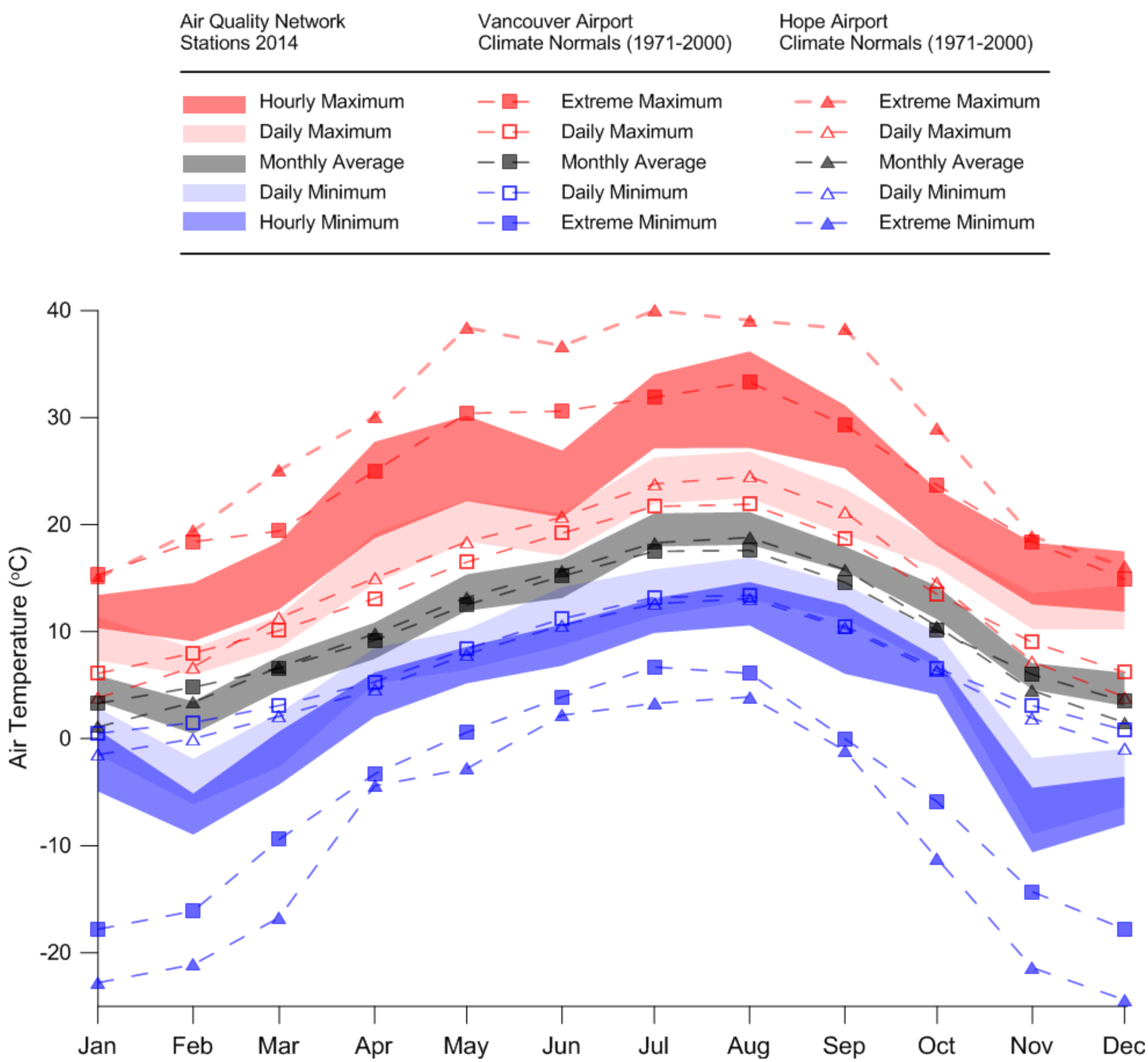


Figure 69: Precipitation totals in the LFV, 2014.



Note: The range of values observed at LFV air quality network stations are shown as a blue band and Environment Canada climate normals are shown as dotted lines.

Figure 70: Total monthly precipitation in the LFV, 2014.

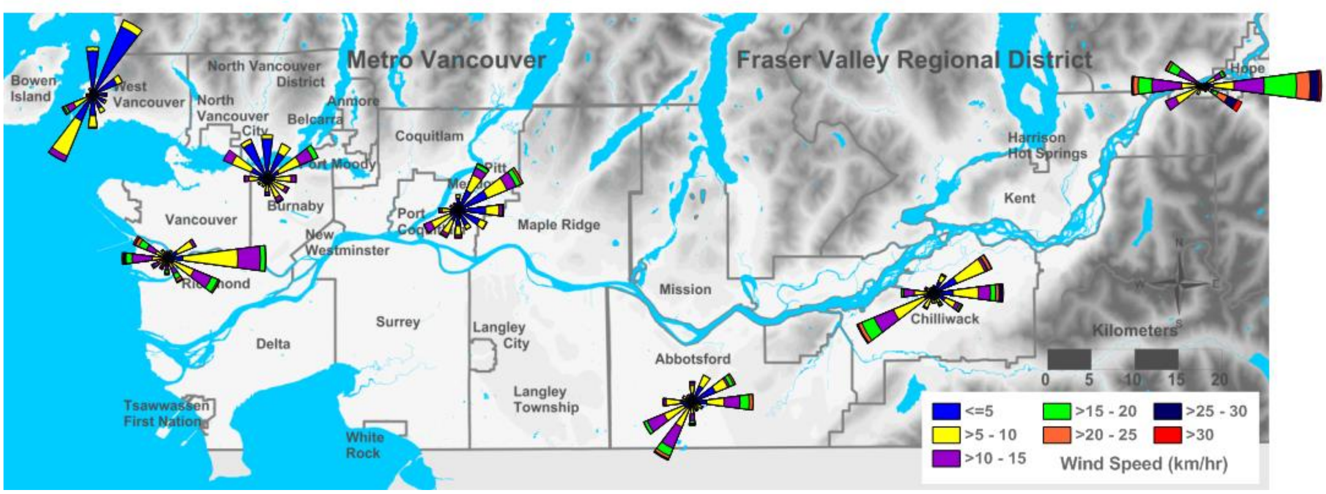


Note: LFV air quality network stations are shown as colour bands and Environment Canada 30-year climate normals are shown as dotted lines.

Figure 71: Monthly air temperatures in the LFV, 2014.

Table 11: Air temperature in LFV, 2014.

Station	Hourly Maximum (ºC)	Hourly Minimum (ºC)	Annual Average (ºC)
Hope	36.2	-10	10.9
Chilliwack	34.3	-7.4	11.6
Abbotsford-Mill Lake	34.3	-7.3	11.4
Maple Ridge	34	-10.4	11.1
Agassiz	33.9	-8.1	11.9
Langley	33.3	-7.5	11
Abbotsford Airport	33.3	-7.1	11.1
Pitt Meadows	33.1	-9.2	11.1
Burnaby South	32.9	-7.5	11.6
Coquitlam	32.8	-6.5	12.3
Burnaby-Burmount	32.4	-7.1	11.8
Surrey East	32.1	-7.4	11.2
North Delta	31.9	-8.6	10.7
Burnaby-Kensington Park	31.4	-7.5	10.9
Burnaby Mountain	30.7	-7.5	9.5
Burnaby North	30.4	-7.6	11.1
Burnaby-Capitol Hill	30.2	-6.8	10.3
Horseshoe Bay	30.2	-6.6	10.8
Port Moody	29.7	-7.5	11.4
N. Vancouver-Mahon Park	29.4	-7.2	11.1
Richmond South	29.2	-9.2	10.8
Richmond-Airport	28.7	-6.9	11.4
Annacis Island	28.3	-8.8	10.5
Tsawwassen	27.2	-7	10.9

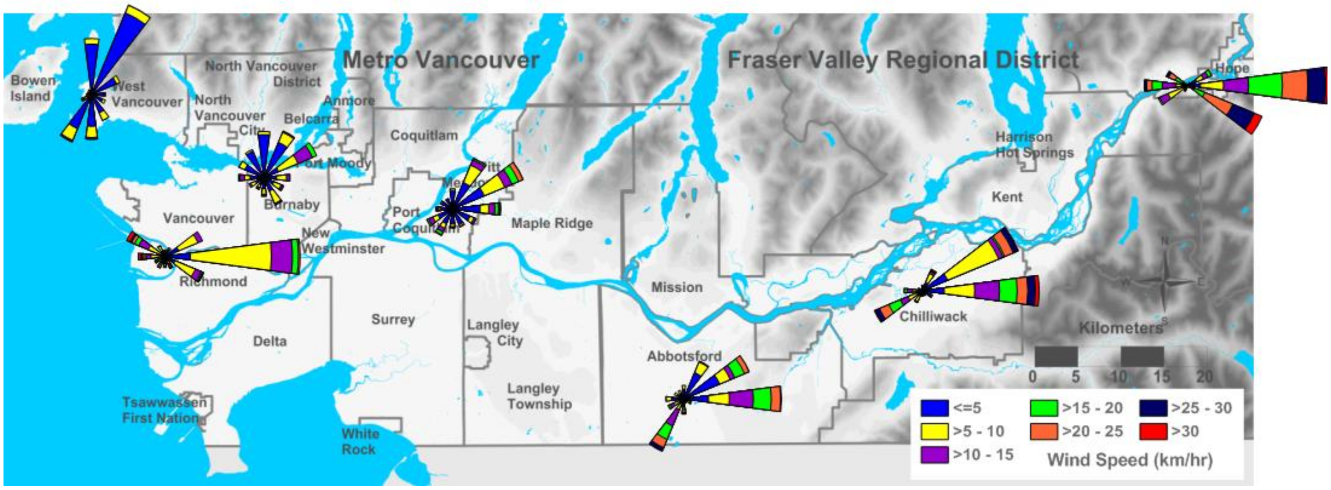


Note: The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 72: Selected annual wind roses throughout the LFV, 2014.

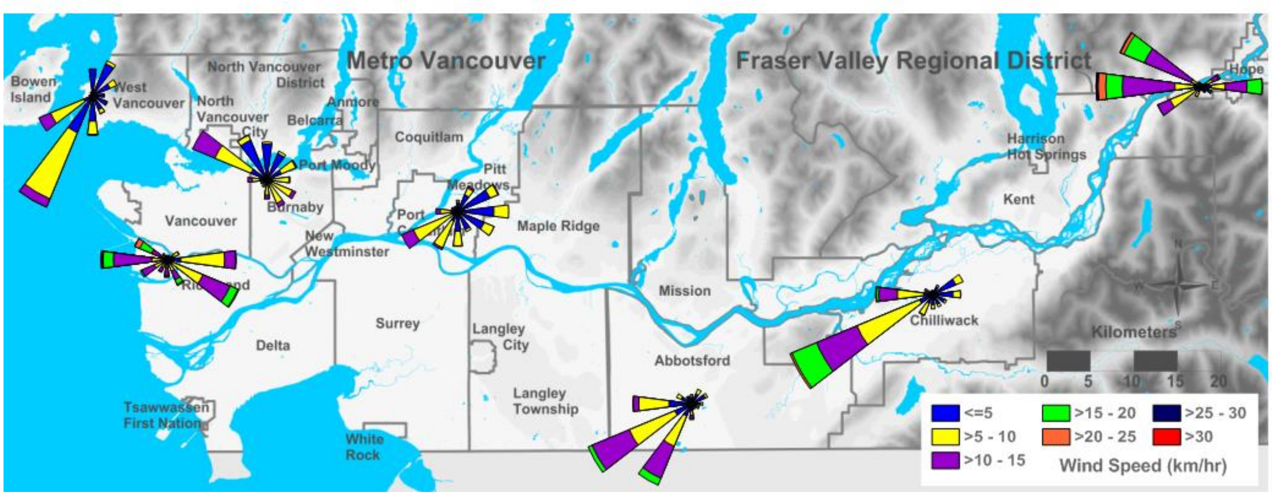
Table 12: Frequency distribution of hourly air temperature, 2014.

Air Temperature (°C)	Burnaby-Kensington Park	Port Moody	Chilliwack	North Delta	Burnaby Mountain	Surrey East	Richmond South	Burnaby South	Pitt Meadows	Burnaby-Burmount	Burnaby-Capitol Hill	Burnaby North	N. Vancouver-Mahon Park	Langley	Hope	Maple Ridge	Richmond-Airport	Coquitlam	Abbotsford-Mill Lake	Horseshoe Bay	Annacis Island	Tsawwassen	Mission	Agassiz	Abbotsford Airport
-12 to -9							2		1						13	9							2		
-9 to -6	12	13	22	24	65	2	29	13	17	13	17	11	15	25	91	33	9	8	16	3	19	4	49	29	27
-6 to -3	86	90	131	114	134	16	141	62	16	77	111	8	85	149	178	144	56	51	131	55	45	87	73	144	145
-3 to 0	285	298	33	36	294	3	335	133	394	167	297	262	246	338	344	363	24	229	281	248	292	252	155	219	338
0 to 3	72	22	562	731	882	598	548	568	586	534	734	647	614	629	732	646	53	564	549	781	417	5	348	48	537
3 to 6	1289	713	1164	1363	1691	1128	1199	1144	199	18	1515	1235	1126	159	1212	1139	153	862	11	1324	818	1154	26	18	1136
6 to 9	1433	1198	1282	1387	136	1411	1371	1559	1319	15	1377	1476	1458	1283	172	1299	1417	1339	1324	1317	1356	155	48	1438	1325
9 to 12	191	692	122	1175	1172	12	1282	1158	1181	1243	196	114	1167	1284	1152	1245	1224	1239	1249	112	1189	1323	58	1226	1269
12 to 15	1225	637	1174	1115	1198	1293	1254	1115	1418	128	129	1193	115	1238	1131	1225	1325	1245	1252	1338	1157	1439	554	1158	1354
15 to 18	1174	1280	113	197	957	1229	1259	1372	112	1246	168	1237	1238	119	129	172	1486	133	1235	1389	876	1381	495	1121	1155
18 to 21	769	775	753	718	55	771	755	892	648	826	672	788	83	652	716	714	863	97	749	814	396	758	276	872	693
21 to 24	382	48	476	386	327	376	35	43	419	434	371	447	452	398	452	414	437	53	416	349	58	288	129	497	38
24 to 27	25	52	289	29	112	227	164	24	232	232	155	183	168	228	276	245	113	281	241	87	15	64	84	291	213
27 to 30	7	89	182	13	1	69	2	59	138	115	36	43	24	131	169	156	5	149	134	12	6	2	28	17	1
30 to 33	5	3	35	16	2	12		8	27	18	1	2		18	27	41		53	22	1				31	15
33 to 36			7						1					3	2	1			4					4	2
>=36															1										
Missing Data	32	537	48	16	6	20	51	70	18	67	101	16	214	306	163	5	2	0	57	30	1729	3	5427	0	71
Completeness	100%	94%	100%	100%	100%	100%	99%	99%	100%	99%	99%	100%	98%	97%	98%	100%	100%	100%	99%	100%	80%	100%	38%	100%	99%



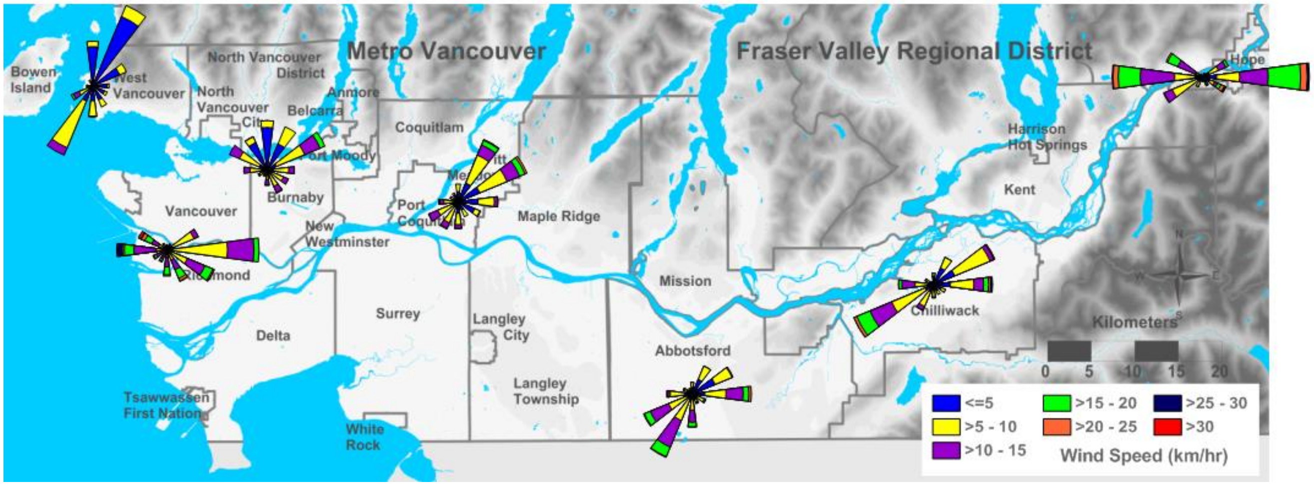
Note: The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 73: Winter (Dec 13, Jan 14, Feb 14) representative wind roses throughout the LFV, 2014.



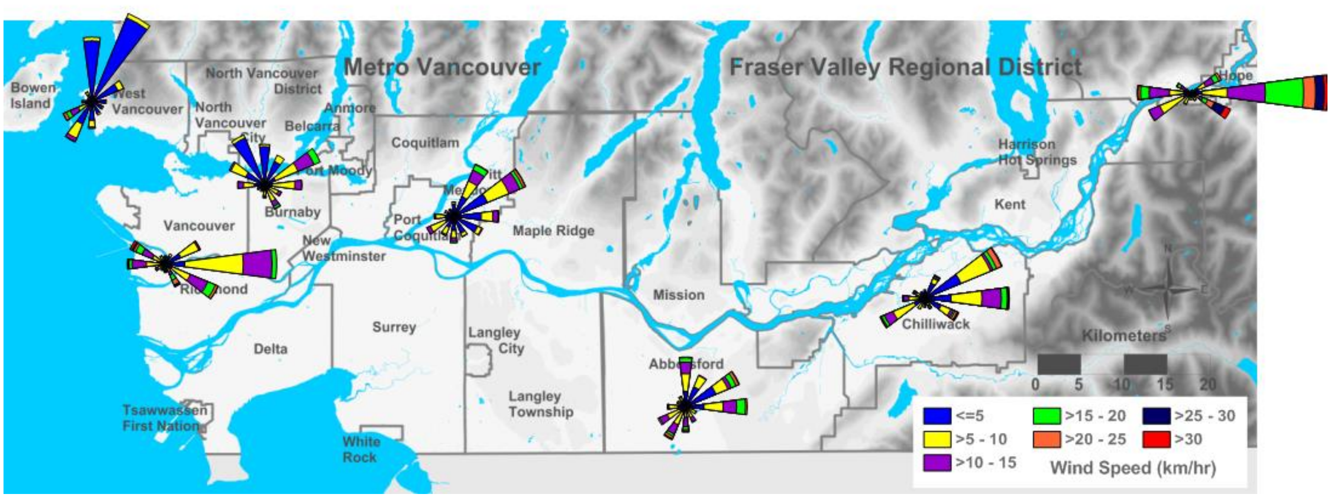
Note: The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 74: Summer (Jun, Jul, Aug) representative wind roses throughout the LFV, 2014.



Note: The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 75: Spring (Mar, Apr, May) representative wind roses throughout the LFV, 2014.



Note: The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 76: Fall (Sep, Oct, Nov) representative wind roses throughout the LFV, 2014.

Section H – Specialized Monitoring Initiatives

Specialized air quality monitoring studies complement the fixed monitoring network. The studies typically allow for characterization of air quality at finer spatial scales, such as at the neighbourhood scale, and allow investigation of air quality problems on the local scale. The fixed monitoring network may not address local scale issues and therefore performing specialized local air quality studies is an important component to characterizing air quality in the LFV.

A Mobile Air Monitoring Unit (MAMU) that is capable of monitoring particulate and gaseous pollutants along with meteorology is utilized throughout the region to conduct specialized air quality studies. In addition to MAMU, Metro Vancouver utilizes small mobile units along with several portable air quality monitors.

Specialized study activity in 2014 included the initiation of monitoring in the City of North Vancouver and two specialized studies to assess the impact of coal transport by trains in White Rock and Delta.

A specialized study was initiated in the Moodyville neighbourhood of North Vancouver. MAMU was deployed for ten months beginning in April of 2014 to help answer questions raised about air quality related to nearby transportation projects and industries. MAMU was deployed for a five-week study in White Rock in September and October of 2014.

Continuous measurements of particulate matter and gas-phase pollutants were made near the railway line close to the seaside promenade. Filter samples were also collected at this location and at White Rock City Hall to determine the coal content in the particulate matter sampled.

A year-long monitoring study in Delta was conducted in conjunction with dustfall sampling carried out by the Corporation of Delta. Sampling started in June 2014 with installation of portable particulate matter samplers (E-samplers) at three locations close to railway lines and one in a residential neighbourhood to measure PM_{10} and collect particulate matter samples on filters. The filter samples were collected for a laboratory analysis to determine the coal content in the particulate matter sampled.

In partnership with the BC Ministry of Environment and Environment Canada, Metro Vancouver continues to provide support for the West Coast Marine Boundary Layer Background Station located in Ucluelet on Vancouver Island. The background station, located at the Amphitrite lighthouse, is a remote station located to monitor background air quality in the lower atmosphere on the west coast of British Columbia. The station, established in 2010, will allow a more complete understanding of the effect of background air masses transported into British Columbia on local and regional air quality.

Section I – Monitoring Network Operations

Network History

Air monitoring in the region began in 1949, when the City of Vancouver established a dustfall monitoring network. Monitoring for total suspended particulate was added in later years. Following the Pollution Control Act (1967), provincial air quality programs initiated monitoring of dustfall and total suspended particulate in other areas of the region.

In 1972, provincial and municipal air quality responsibilities were transferred to Metro Vancouver, including operation of air quality monitoring programs. In 1998, a Memorandum of Understanding established cooperative management of the monitoring network by both Metro Vancouver and the Fraser Valley Regional District.

Continuous monitoring of gaseous pollutants began in 1972 under the auspices of the federal National Air Pollution Surveillance (NAPS) program. Several new stations were established to measure SO_2, O_3, CO, NO_X and VOC. Over the years, stations and equipment have been added or removed in response to changing air quality management priorities. Mobile Air Monitoring Units and portable instruments provide added flexibility to carry out measurements at many locations. Some monitoring is part of co-operative programs with industry and other governments.

Monitoring Network Partners

Several partners contribute to the on-going management and operation of the Lower Fraser Valley Air Quality Monitoring Network. The government partners include:

- Fraser Valley Regional District
- Environment Canada
- BC Ministry of Environment

Other monitoring network partnerships:

- The Vancouver International Airport Authority provides partial funding for the Vancouver International Airport station (T31).
- Chevron Canada Ltd. provides funding for the Burnaby North (T24) and Capitol Hill (T23) stations.
- Kinder Morgan Canada provides funding for the Burnaby-Burmount (T22) station.
- Port Metro Vancouver provides funding for both the Tsawwassen (T39) station in Delta and the passive SO_2 monitoring network.

Metro Vancouver continues to operate and maintain the monitoring stations and equipment, and to collect real-time data from the regional monitoring network on behalf of all partners.

Courtesy of City of Vancouver Archives (1960).

Federal Government

Metro Vancouver co-operates with the federal government by providing field services for three major nation-wide sampling programs under the National Air Pollution Surveillance (NAPS) program of Environment Canada.

- Canister sampling of VOC has been conducted in the LFV since 1988. The federal government supplies equipment and Metro Vancouver staff provide field exchange of canisters, calibration and routine maintenance. Sample canisters are sent to the federal laboratory in Ottawa, for analysis of up to 177 VOC.
- A second program involves dichotomous particulate sampling at three sites. This long-term program samples PM at two size fractions: 10 to 2.5 μm (coarse), and under 2.5 μm (fine). Samples are collected every sixth day, and returned to Ottawa for detailed chemical analysis.
- In 2003 a $PM_{2.5}$ speciation sampling program was initiated. Particulate speciation samplers are operated at the Burnaby South and Abbotsford Airport stations. $PM_{2.5}$ samples are taken every sixth day in specially designed cartridges. The samples are sent to the federal laboratory in Ottawa where they are analyzed for various particulate species.

Quality Assurance and Control

Air quality monitoring data is regularly reviewed and validated. Technicians perform regular inspections and routine maintenance of the monitoring equipment and stations.

In addition, technicians perform major repairs to any instrument in the network, as required. Through the data acquisition system, technicians can check on instruments remotely prior site visits. This system also allows for calibration of the instruments either automatically or upon demand. Portable calibration equipment is used to evaluate instrument performance.

Continuous air quality monitors are subject to performance audits and multi-point calibration every fourth month. In addition, all other instruments and samplers in the network are subjected to annual and/or biannual calibrations. All reference materials and quality control procedures meet or exceed Environment Canada and/or U.S. Environmental Protection Agency requirements. Metro Vancouver coordinates quality assurance procedures and activities with both the provincial and federal government.

Database

Data from continuous air quality analyzers are transmitted to Metro Vancouver's central database using internet, phone lines and cellular links. Hourly averages for each monitor are calculated from the one minute data and stored in the database. For a measurement to be considered valid (and stored for further use), at least 75% of the relevant data must be available. Calibration data and instrument diagnostics are also retained by the data acquisition system