2012 Lower Fraser Valley Air Quality Monitoring Report

Fraser Valley Regional District

metrovancouver

SERVICES AND SOLUTIONS FOR A LIVABLE REGION

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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 2012 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 26 air quality monitoring stations located from Horseshoe Bay in West Vancouver to Hope. Metro Vancouver operates 22 stations in Metro Vancouver, as well as 4 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 values.

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 2012 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. In 2012, a specialized study was completed in the Burrard Inlet areas of Vancouver, Burnaby and North Vancouver.

Also in 2012, a new Mobile Air Monitoring Unit (MAMU) was designed and built. Completed in early 2013, the new MAMU replaces the existing MAMU that has reached the end of its useful service after operating throughout the LFV for nearly 25 years.

Visual Air Quality

Visual air quality (sometimes referred to as visibility or haze) can also become degraded in the LFV, causing local views to become partially obscured. Haze may have different characteristics depending on where it occurs. 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 ammonia, $PM_{2.5}$ and particle constituents (for example, particulate nitrate, particulate sulphate, elemental carbon and organic carbon) and light scattering. Seven 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 pollution concentrations and their sources. The data collected provides important information for a multi-agency initiative to develop a visibility improvement 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, volatile organic compounds (VOC), and total reduced sulphur compounds (TRS).

Air Quality Health Index (AQHI)

The 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 as well as the AQHI forecasts (for today, tonight and tomorrow) and additional information about the AQHI are available at: www.airhealth.ca

www.bcairquality.ca/readings

www.weather.gc.ca/mainmenu/airquality_menu_e.html

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 believed to contribute significantly to the health effects described above. Instrumentation for $PM_{2.5}$ measurement is in operation that can be used to estimate the proportion of particles that originate from diesel engines.

Air Quality Objectives and Standards

Several pollutant-specific air quality objectives and standards are used as benchmarks to characterize air quality. They include the federal Canada-Wide Standards (for ozone and particulate matter), Metro Vancouver's ambient air quality objectives, and provincial objectives. As part of the 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 the most stringent objectives at the time.

In 2009, the provincial government established new 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.

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 significantly 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.

One air quality advisory was issued in 2012, on August 17. The advisory was caused by elevated levels of ground-level ozone in the eastern parts of Metro Vancouver and in the FVRD.

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. 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.

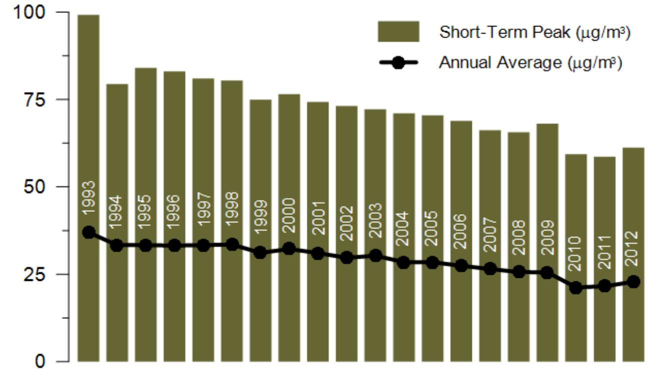


Figure S1: Nitrogen Dioxide Trend

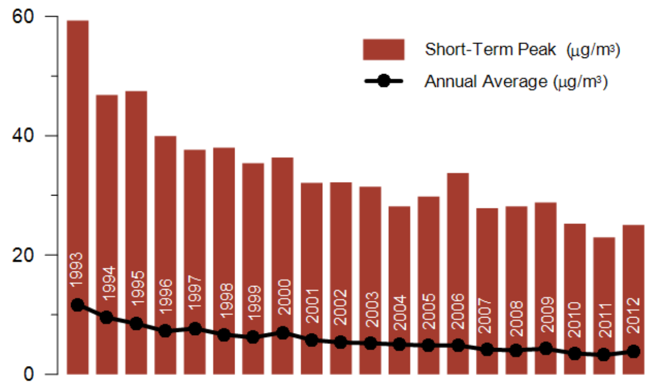


Figure S2: Sulphur Dioxide Trend

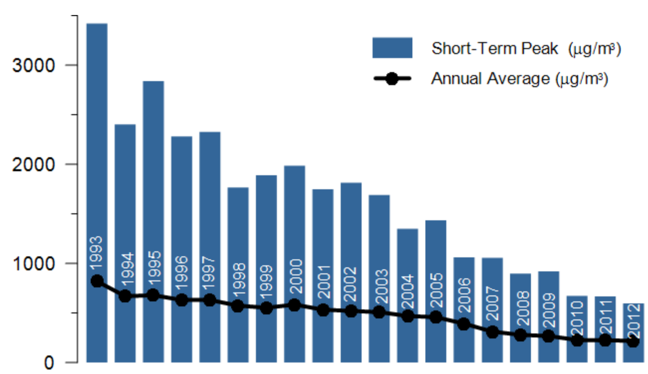


Figure S3: Carbon Monoxide Trend

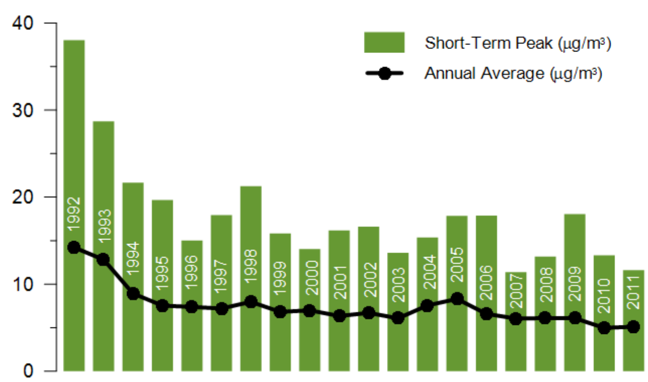


Figure S4: Particulate Matter ($PM_{2.5}$) Trend

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, emission reductions across a variety of sectors have brought about these improvements. Improved vehicle emission standards and the AirCare program are largely responsible for lower carbon monoxide (CO) and nitrogen dioxide (NO_2) levels.

Reduced sulphur in 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.

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

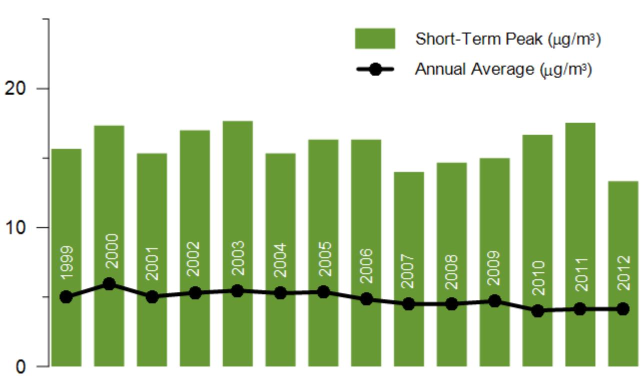


Figure S5: $PM_{2.5}$ Trends

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 may be rising and could be a reason for the observed increase in average levels.

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.

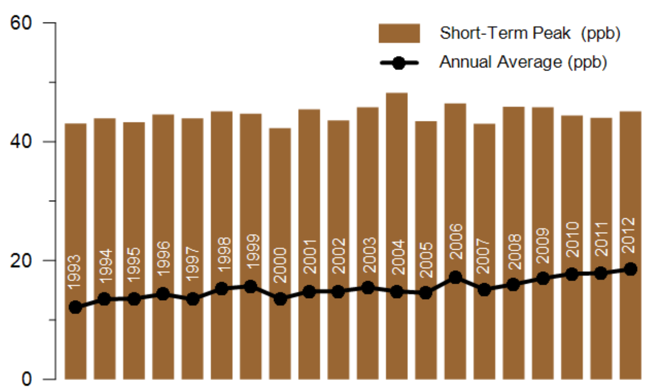


Figure S6: Ozone Trends

On-going research indicates that the highest ozone levels are occurring in the eastern parts of the LFV and that the location of the maximum has shifted eastward over time. A study led by UBC researchers was completed in 2011 to better understand ozone in the LFV and to suggest the most effective strategies to help reduce ozone levels. Findings from this study along with other research will inform a Regional Ground-Level Ozone Strategy to reduce emissions of ozone precursors and ground-level ozone concentrations.

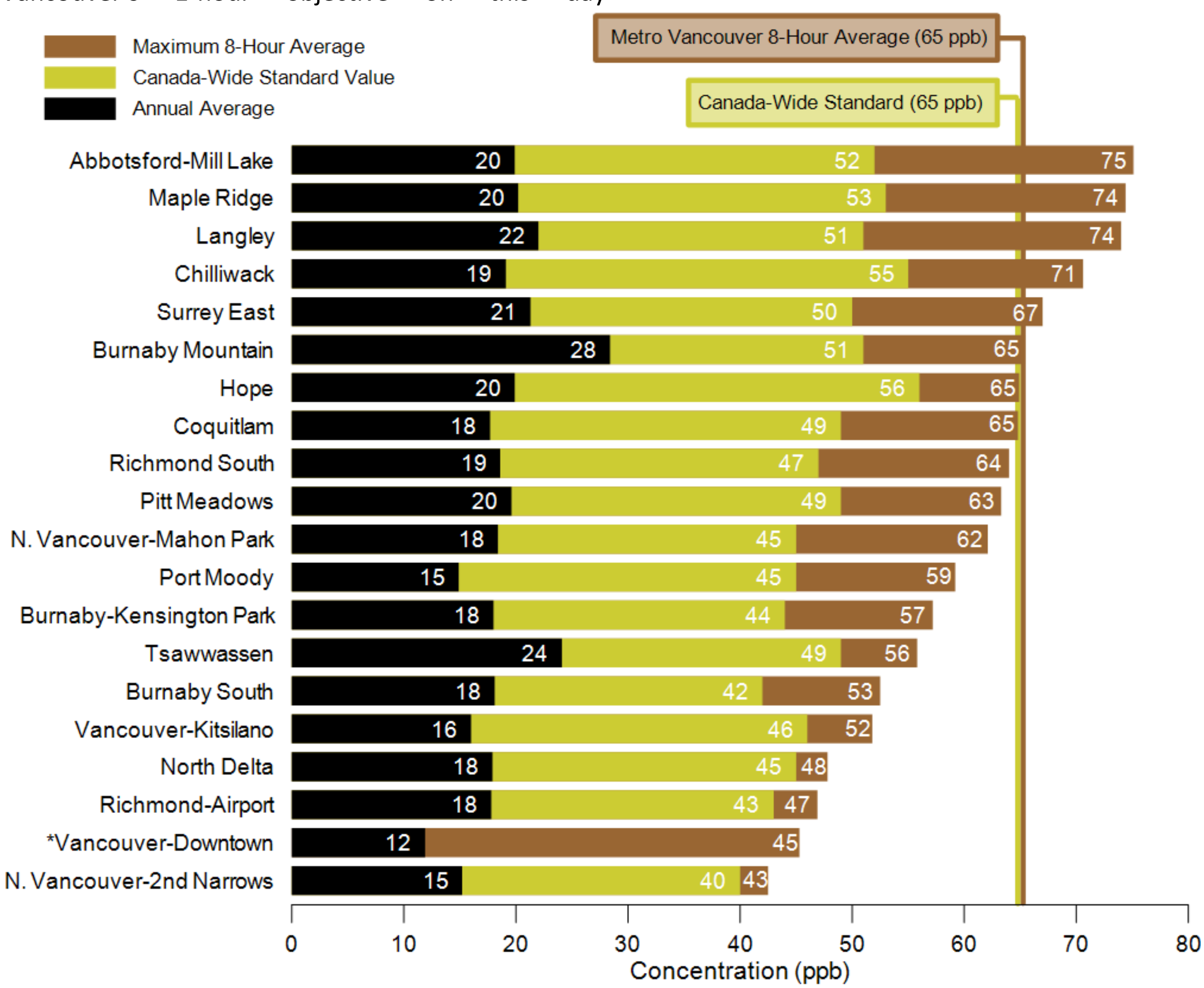
Ground-Level Ozone – 2012

Monitoring results for all ozone monitoring stations in 2012 are shown in Figure S7. The data show that peak ozone levels, as measured by the Canada-Wide Standard and maximum 8-hour rolling average values, occurred in the eastern parts of Metro Vancouver and in the FVRD during sunny and hot weather.

In 2012 the Canada-Wide Standard for ozone was met at all monitoring stations. However, Metro Vancouver has set a more stringent 8-hour objective to encourage better air quality in the Lower Fraser Valley. This objective was exceeded at one monitoring station on July 8th and several stations on August 17th. In addition, Maple Ridge, Langley, Abbotsford and Chilliwack also exceeded Metro Vancouver's 1-hour objective on this day (not shown). Because of these elevated ozone levels, an air quality advisory was issued on August 17th for one day.

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 and vegetation), cars, light trucks, and solvents found in industrial, commercial and consumer products.



* Data completeness criteria were not met at this station.

Figure S7: Ozone (O_3) 2012.

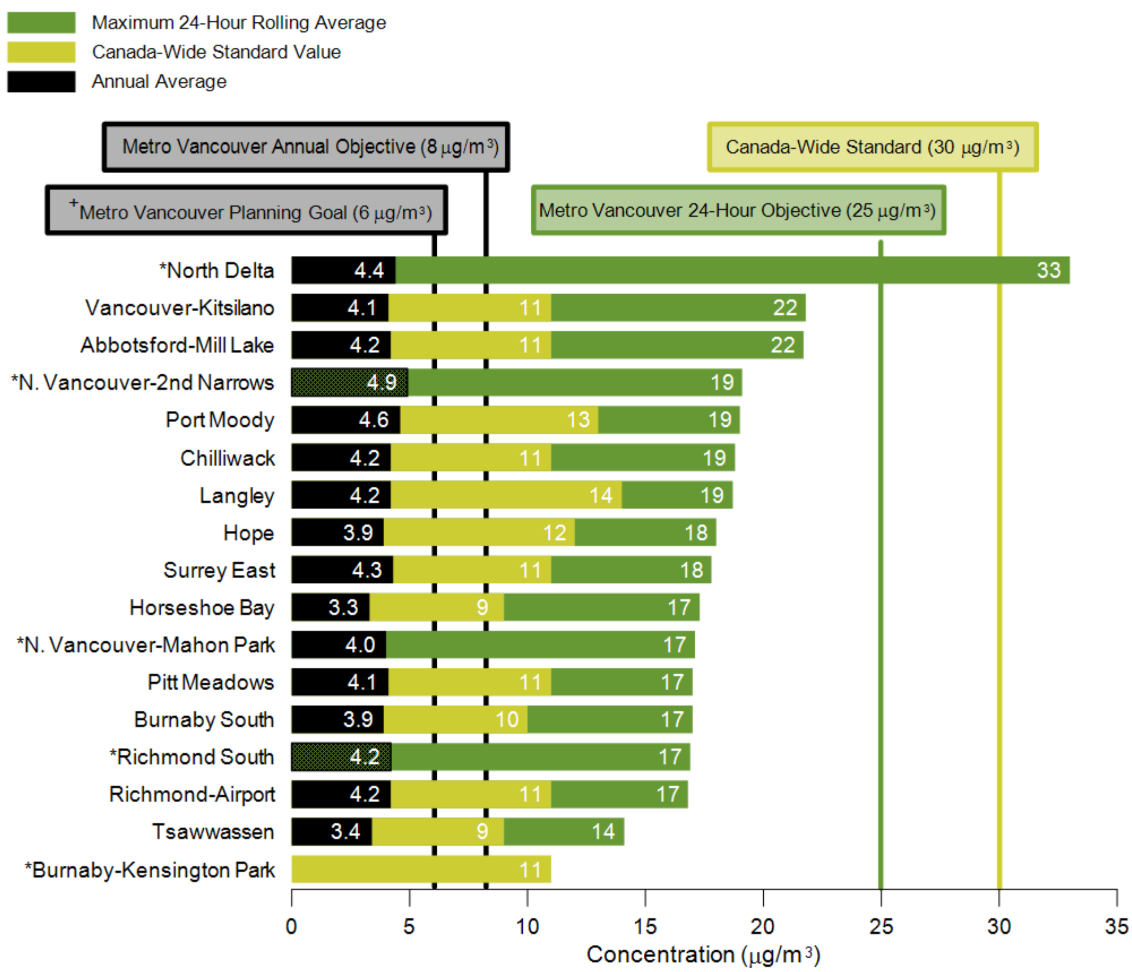
Fine Particulate Matter ($PM_{2.5}$) – 2012

Monitoring results for all $PM_{2.5}$ monitoring stations with sufficient data requirements are shown in Figure S8. The maximum 24-hour average for one station and Canada-Wide Standard values for four stations are not shown in Figure S8 because the data are incomplete for the year.

All stations were below (i.e., better than) Metro Vancouver's annual objective of 8 micrograms per cubic metre and annual planning goal of 6 micrograms per cubic metre. All locations were also well below the Canada-wide Standard for $PM_{2.5}$ (Figure S8). There was one exceedance of Metro Vancouver's 24-hour $PM_{2.5}$ objective at North Delta in November, due to elevated $PM_{2.5}$ for several hours on the evening of November 10.

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.

An active wildfire season in 2012 resulted in the transport of smoke long distances into the region from northern BC, the western United States and as far away as Siberia. The region was impacted by this smoke on several occasions in the summer, but $PM_{2.5}$ levels did not rise above the air quality advisory level. At times the smoke caused visual air quality to be degraded by a noticeable haze.



*Data completeness criteria were not met at these stations and annual averages were calculated from all available data for the year.

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

Figure S8: Fine Particulate Matter ($PM_{2.5}$) 2012.

Sulphur Dioxide – 2012

Monitoring results for all sulphur dioxide (SO_2) monitoring stations in 2012 are shown in Figure S9. Sulphur dioxide levels were below all applicable objectives at all stations throughout the year.

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 recorded near the Burrard Inlet area. Away from the Burrard Inlet area, sulphur dioxide levels are considerably lower.

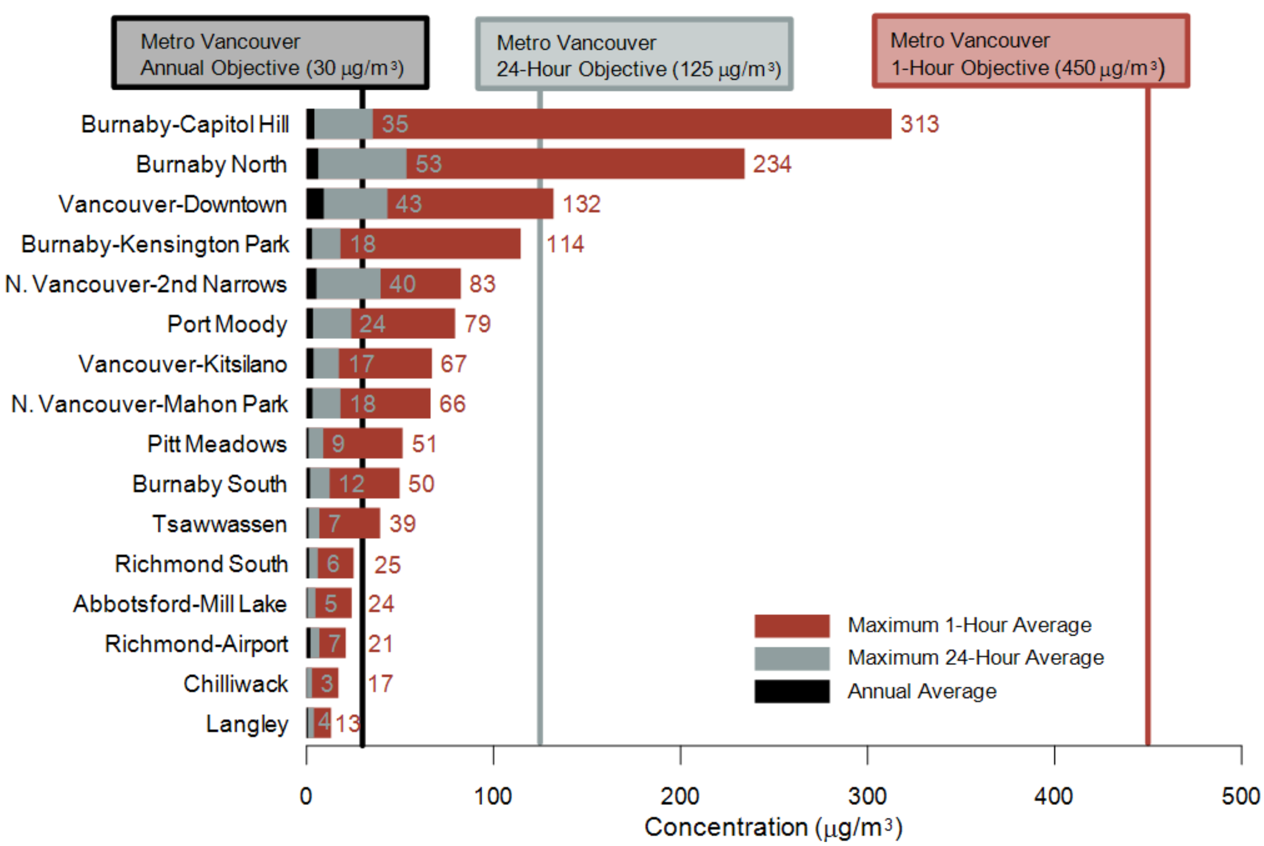


Figure S9: Sulphur Dioxide (SO_2) 2012.

Nitrogen Dioxide – 2012

Results for nitrogen dioxide (NO_2) monitoring in 2012 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 2012, 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.

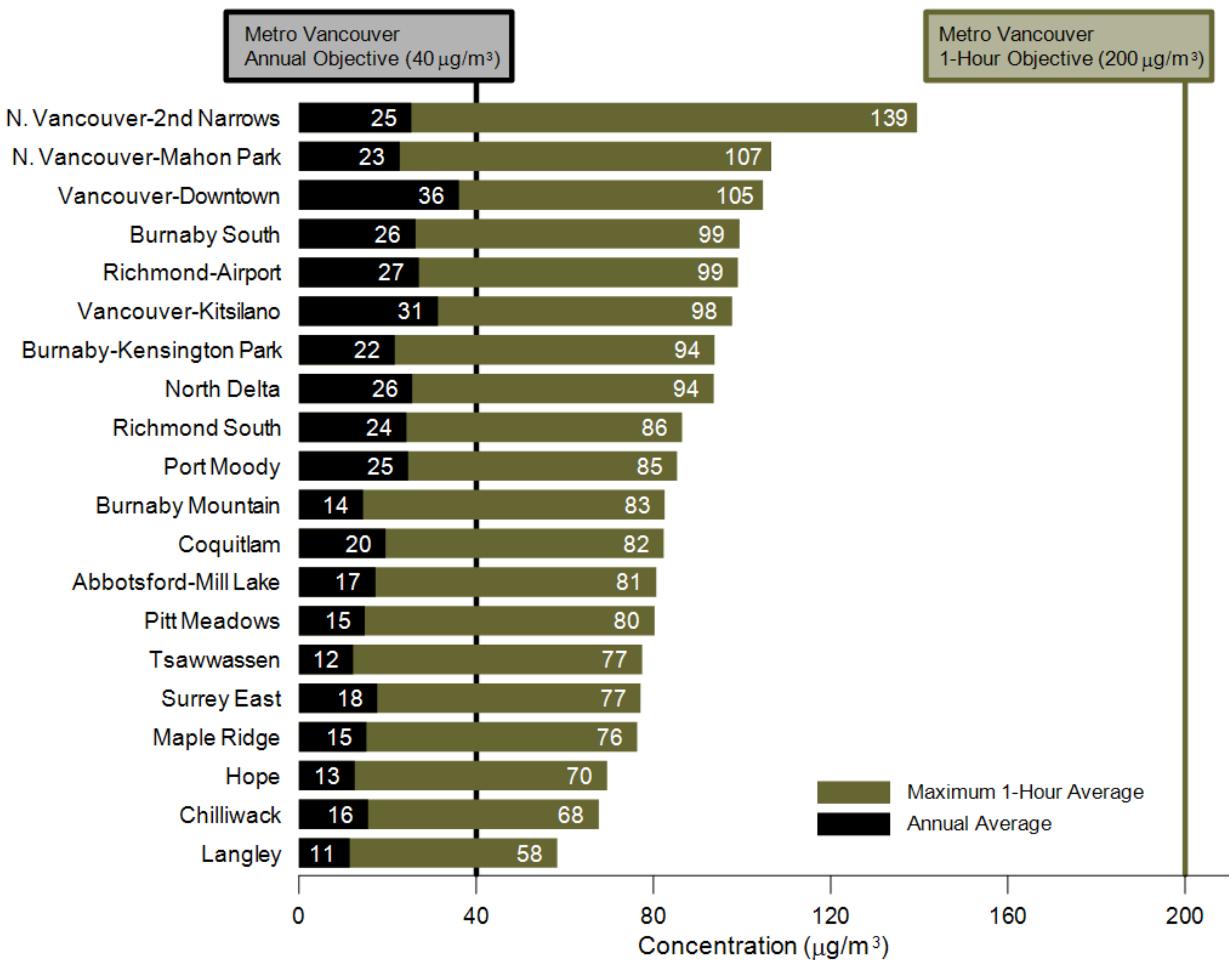
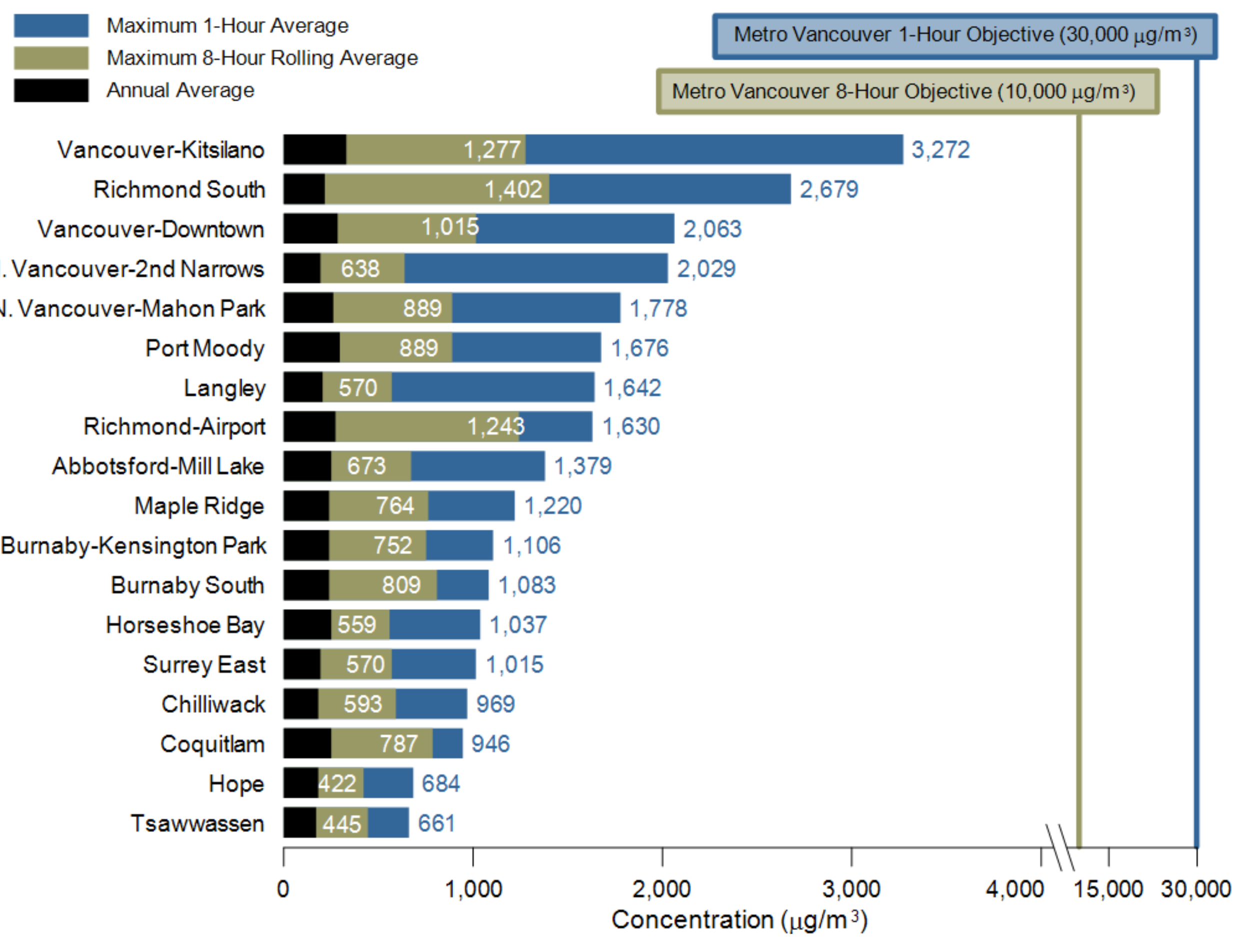


Figure S10: Nitrogen Dioxide (NO_2) 2012.

Carbon Monoxide – 2012

Carbon monoxide (CO) monitoring results for 2012 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 principle 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 4,000 and 10,000 µg/m^3. The highest concentration measured is almost ten times less than the objective.

Figure S11: Carbon Monoxide (CO) 2012.

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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
CO	Carbon Monoxide
CWS	Canada-Wide Standard
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 2012 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 2.6 million with 26 air quality stations located from Horseshoe Bay in West Vancouver to Hope in 2012. 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), odourous total reduced sulphur compounds (TRS) which are monitored primarily at stations near Burrard Inlet, and different forms of particulate matter such as that typically emitted from diesel engines. 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 the most 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 believed to contribute significantly to the health effects described above. Instrumentation for $PM_{2.5}$ measurement is in operation that 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 long-term regional trends for ground-level ozone show a more mixed 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.

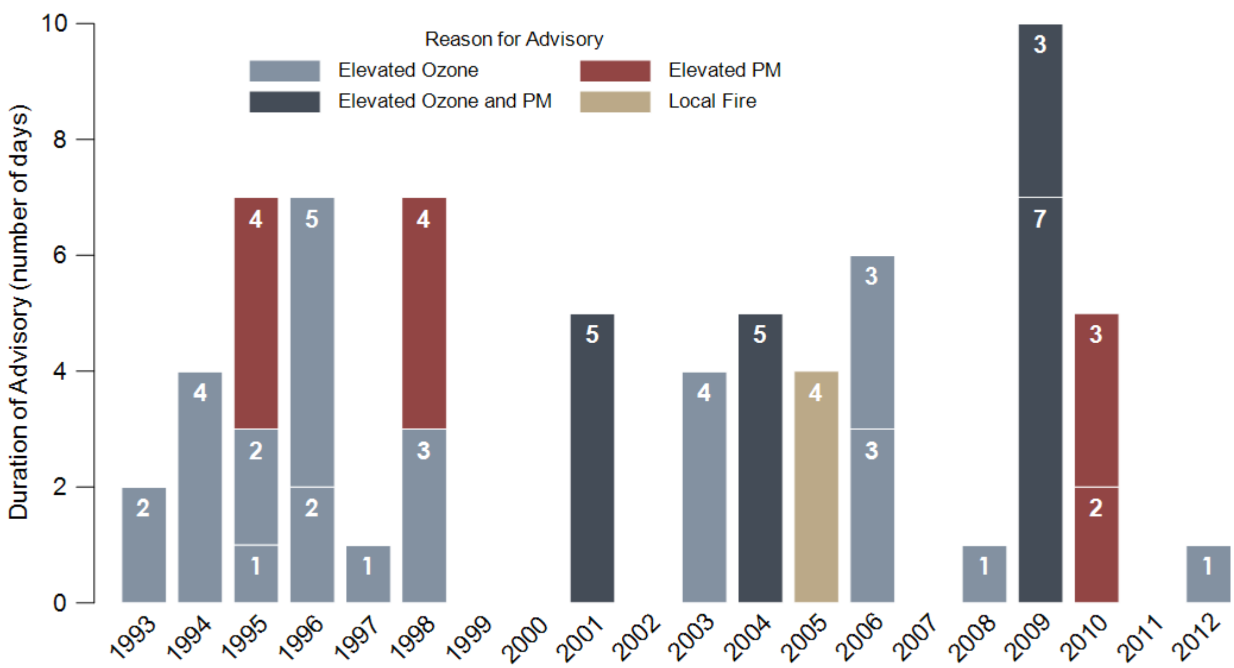
Air Quality Advisories

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.

One air quality advisory was issued in 2012, on August 17. The advisory was caused by elevated levels of ground-level ozone in the eastern parts of Metro Vancouver and in the FVRD.

Air quality advisories are issued to the public when air quality has deteriorated or is predicted 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 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. For example, in 1995 there were a total of seven advisory days during three separate advisory periods, lasting one, two and four days each. In the years 1999, 2000, 2002, 2007 and 2011 there were no air quality advisories. Years when an advisory was not issued typically had cooler and/or wetter summers than normal, thereby lessening the potential for forest fire smoke, secondary $PM_{2.5}$ and ozone formation.



Notes:

- 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.
- As 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 fire in Burns Bog.

Figure 1: Number of days of air quality advisories in 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:

http://airmap.ca
http://www.airhealth.ca
http://www.bcairquality.ca

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 haze. Smoke and windblown dust and soil can also affect visual air quality at times.

In 2012, nine automated digital cameras in six 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.

Near real-time images from six of the digital cameras in the network are made available online:

http://www.clearairbc.ca/community

Characterization of the haze-causing pollutants present in the air is needed to determine visual air quality impairment. In the LFV continuous 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 light scattering are being made to allow a quantitative assessment of visual air quality to be developed. 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 third, 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 measurements are described in Section E.

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.

Section B – Air Quality Objectives and Standards

Several air quality objectives and standards are used as benchmarks to characterize air quality including the federal Canada-Wide Standards (CWS), 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.

In June 2000, the Canadian Council of Ministers of the Environment (CCME) adopted Canada-Wide Standards to be implemented by 2010 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 Canada-Wide Standard 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 $PM_{2.5}$ CWS is attained when the CWS value is below 30 µg/m^3.

The Canada-Wide Standard 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 CWS is attained when the CWS value is below 65 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 objectives are more stringent than the Canada-Wide Standards for $PM_{2.5}$ and ozone. Metro Vancouver's $PM_{2.5}$ objectives adopted in 2005 were established in advance of any provincial objectives.

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.

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.

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

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	450	174
	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's Planning Goal of 6 µg/m³ 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 2012 are shown in Figure 2 while the pollutants and meteorology measured at each station are identified in Table 2.

In 2012, there were 26 fixed air quality monitoring stations in the network which includes 22 stations located in Metro Vancouver and 4 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 2012 are shown in Figures 3 to 6.

Portable equipment was used to carry out short-term air quality monitoring studies (specialized studies) in 2012. The equipment employed in specialized studies included 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: http://airmap.ca

Additional information on the LFV Air Quality Monitoring Network is available in the report "Station Information: Lower Fraser Valley Air Quality Monitoring Network", accessible at:

http://www.metrovancouver.org/about/publications/Publications/LowerFraserValleyAirQualityMonitoringNetwork2012StationInformation.pdf

Network Changes

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

Network improvement highlights for 2012 included the building of a new Mobile Air Monitoring Unit (MAMU), transition to improved $PM_{2.5}$ monitoring technology, and ongoing work to expand the monitoring network in the FVRD.

Changes to the network in 2012 include:

- Construction of a new Mobile Air Monitoring Unit (MAMU) began (construction photo shown on this page). Completed in early 2013, the new MAMU replaced the existing MAMU that had reached the end of its useful service after operating throughout the LFV for nearly 25 years.

- The transition to improved $PM_{2.5}$ monitoring technology was completed. All of the network's $PM_{2.5}$ TEOMs were replaced by the $PM_{2.5}$ SHARP and iSHARP which became operational in January 2013. The new PM monitors are certified by the US EPA as Federal Equivalent Methods and have the ability to measure a portion of particulates not previously measured. See infographic: http://www.metrovancouver.org/services/air/Documents/AirInfographic.pdf

- The Abbotsford Airport (T34) station was relocated 1.4 km east to a new site (T45). The previous station was taken out of service in May of 2010 as a result of planned airport expansion. The new station, also called Abbotsford Airport (T45), became operational in June of 2012.

- Work continued to establish new monitoring stations in Agassiz and Mission with cooperation from the FVRD. The new Agassiz (T44) station became operational in June 2013. The station, which monitors ground-level ozone, fine particulate matter, nitrogen oxides and meteorology will provide important information on air quality for the Agassiz community and help our understanding of how pollutants form and move around the region

- Improvements to meteorological observations continued with the addition of relative humidity instrumentation at Richmond South (T17), Burnaby-Capitol Hill (T23), Burnaby North (T24), and Maple Ridge (T30).

Figure 2: Lower Fraser Valley air quality monitoring network, 2012.

Table 2: Air quality monitoring network, 2012.

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															√	√		√		
T38	Annacis Island															√	√		√		√
T39	Tsawwassen	√		√	√	√				√						√	√		√	√	√
T45	Abbotsford Airport	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√
#20	White Rock														√						
Total Monitoring Units		**17**	**5**	**21**	**19**	**21**	**2**	**3**	**11**	**18**	**6**	**4**	**7**	**2**	**4**	**26**	**25**	**6**	**20**	**9**	**21**

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.

Figure 3: Ground-level ozone monitoring stations, 2012.

Figure 4: Nitrogen dioxide monitoring stations, 2012.

Figure 5: Fine particulate ($PM_{2.5}$) monitoring stations, 2012.

Figure 6: Sulphur dioxide monitoring stations, 2012.

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 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 2012 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 (30 $\mu g/m^3$) with relatively low levels of less than 10 $\mu g/m^3$ recorded at all stations. Hourly and 24-hour rolling average SO_2 concentrations were also well below Metro Vancouver objectives at all stations. The highest levels of SO_2 were 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 discernable trend in SO_2 concentrations throughout the year. The Downtown-Vancouver station experienced the highest average concentrations in February while the highest 1-hour measurements were recorded at Burnaby North and Burnaby-Capitol Hill in February, July and September.

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

The values in Tables 3 and 4 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, measured a winter peak around noon and bi-modal morning and evening peak 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 and Burnaby North stations show peak SO_2 concentrations day and night with less discernable diurnal trend. Measurements of SO_2 at these two stations are influenced by their 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 (99th percentile of the 1-hour values) and the annual average are markedly lower than they were in the early 1990s.

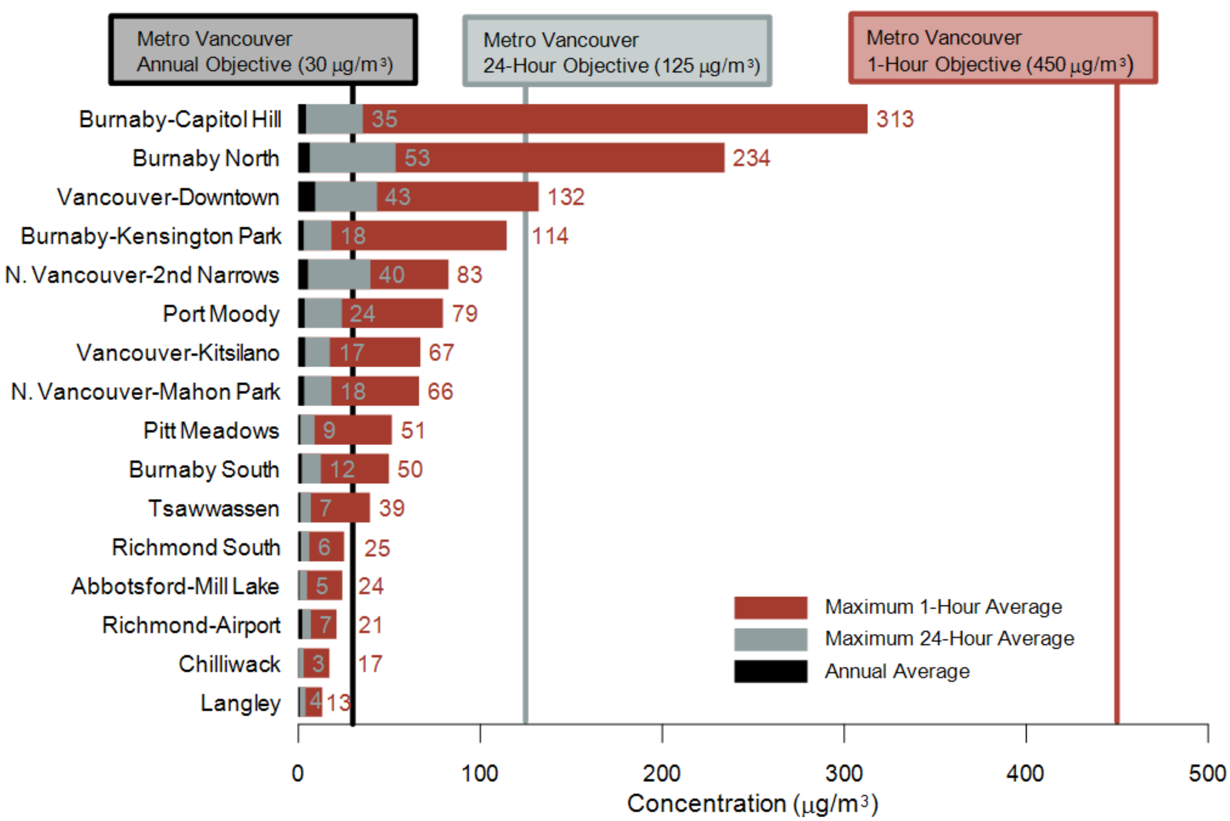


Figure 7: Sulphur dioxide monitoring, 2012.

Figure 8: Annual average sulphur dioxide in the LFV, 2012.

Figure 9: Short-term peak (maximum 24-hour) sulphur dioxide in the LFV, 2012.

Figure 10: Short-term peak (maximum 1-hour) sulphur dioxide in the LFV, 2012.

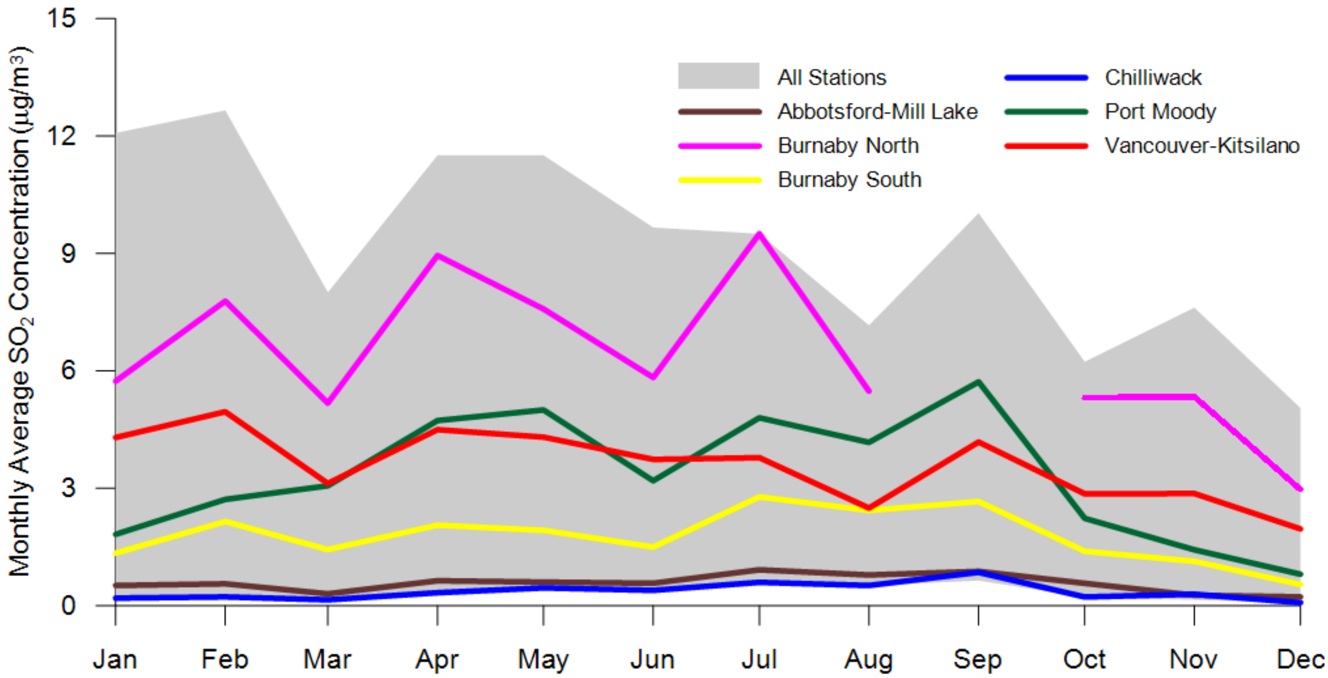


Figure 11: Monthly average sulphur dioxide, 2012.

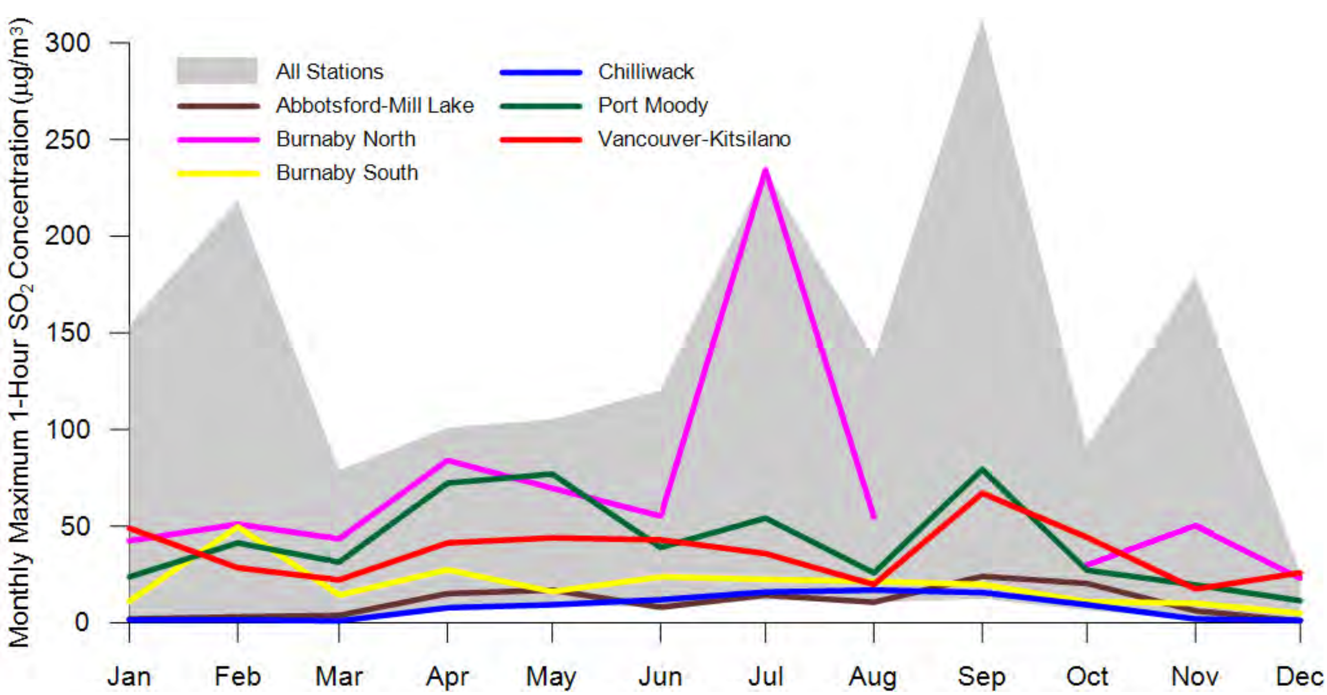


Figure 12: Monthly short-term peak sulphur dioxide, 2012.

Table 3: Frequency distribution of hourly sulphur dioxide, 2012.

SO_2 Concentration ($\mu g/m^3$)	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
0 to 15	6781	8400	8330	7757	7869	8561	8591	8512	8459	8157	7318	8230	8472	8484	8571	8568
15 to 30	1245	210	171	602	369	3	4	24	8	330	715	197		10	7	13
30 to 45	237	21	17	195	46			1		76	115	35				3
45 to 60	55	1	4	50	5			1	1	30	28	6				
60 to 75	27	2		17	4					15	4	3				
75 to 90	9			2	2					8	6					
90 to 105	3		1							5						
105 to 120	1		1							3						
120 to 135	3									3						
135 to 150										3						
150 to 165										3						
165 to 180										2	2					
180 to 195										1						
195 to 210										1						
210 to 225										1						
225 to 240											1					
240 to 255																
255 to 270																
270 to 285																
285 to 300																
300 to 315										1						
>=315																
Missing	423	150	260	161	489	220	189	246	316	145	595	313	312	290	206	200
Data Completeness	95%	98%	97%	98%	94%	98%	98%	97%	96%	98%	93%	96%	96%	97%	98%	98%

Table 4: Frequency distribution of 24-hour rolling average sulphur dioxide, 2012.

SO_2 Concentration (µg/m³)	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
0 to 3	912	4437	5435	3971	5336	8700	8245	7107	8352	5005	2216	5259	8532	6745	8656	8267
3 to 6	2081	2916	2006	2062	1380		462	1443	166	1588	2793	2142	40	1801	53	422
6 to 9	1900	1083	713	1145	1088		3	77	24	911	1518	747		43		33
9 to 12	1229	245	294	710	323			30		638	725	252				
12 to 15	987	46	121	382	153			2		285	546	89				
15 to 18	607	20	35	244	88					111	263	55				
18 to 21	416		2	93	24					63	80					
21 to 24	179			54	14					35	36					
24 to 27	52			35						29	28					
27 to 30	21			23						45	25					
30 to 33	22			23						31	10					
33 to 36	31			10						17	1					
36 to 39	9			6												
39 to 42	3			1							2					
42 to 45	4															
45 to 48											3					
48 to 51											5					
51 to 54											15					
54 to 57																
57 to 60																
60 to 63																
>=63																
Missing	331	37	178	25	378	84	74	125	242	26	518	240	212	195	75	62
Data Completeness	96%	100%	98%	100%	96%	99%	99%	99%	97%	100%	94%	97%	98%	98%	99%	99%

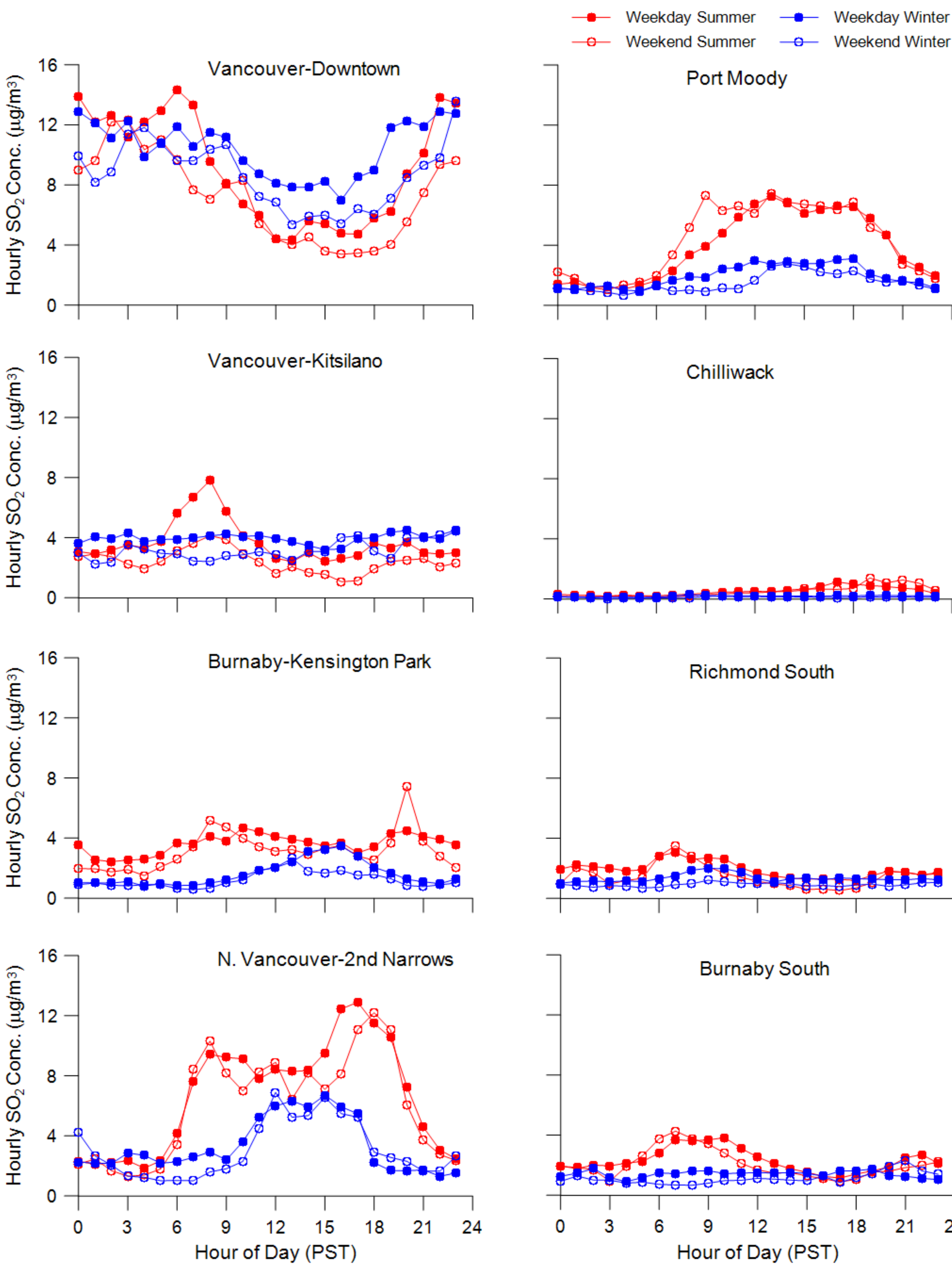


Figure 13: Diurnal trends sulphur dioxide, 2012.

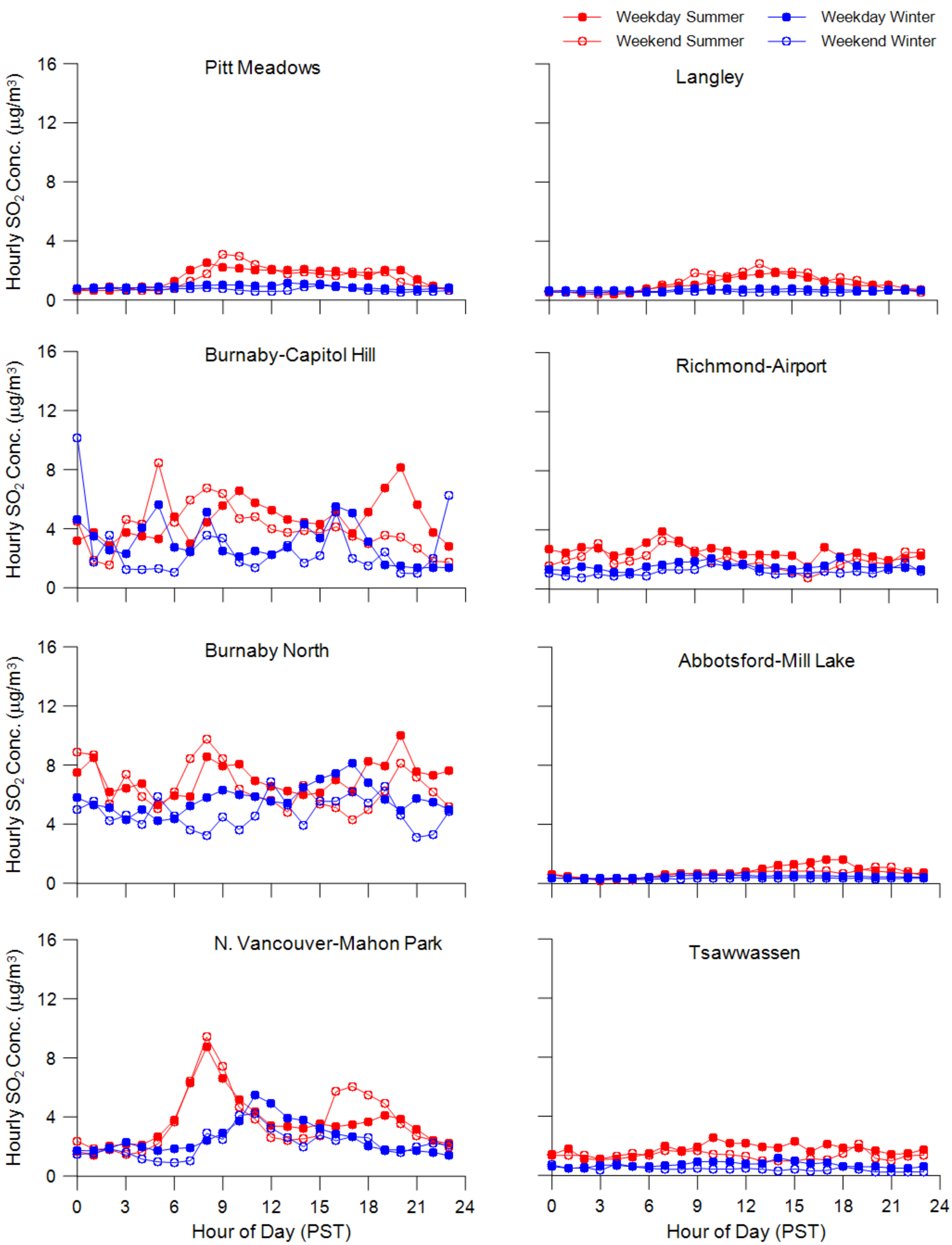


Figure 13: Cont. diurnal trends sulphur dioxide, 2012.

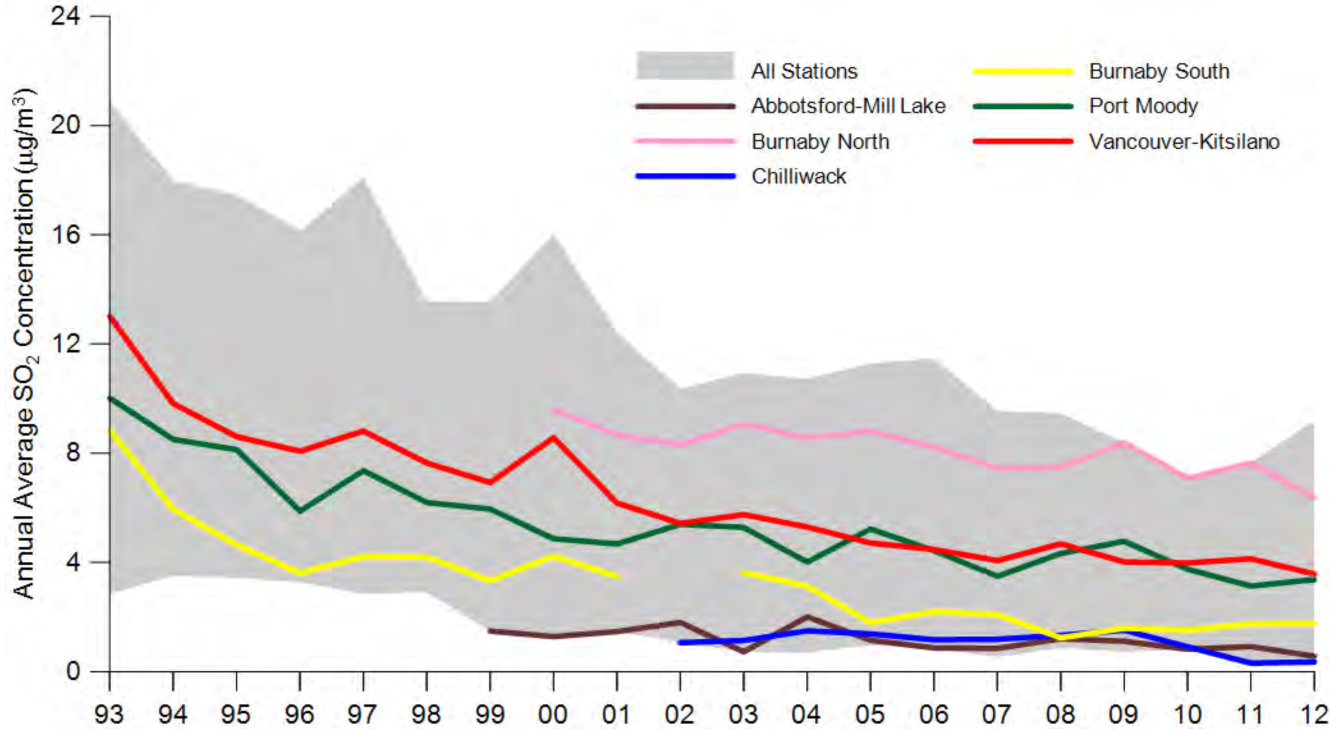


Figure 14: Annual sulphur dioxide trend, 1993 to 2012.

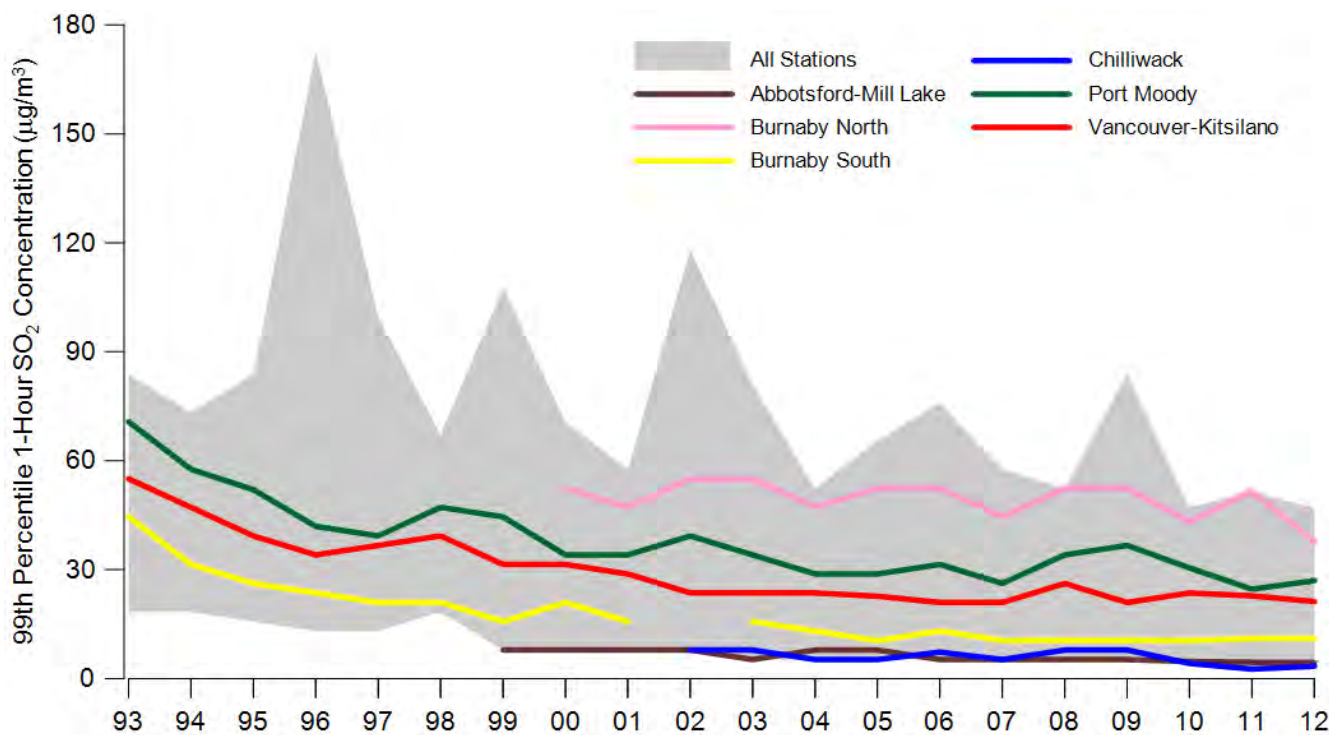


Figure 15: Short-term peak sulphur dioxide trend, 1993 to 2012.

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 2012, while Figures 17 and 18 shows the same values spatially.

All 1-hour NO_2 concentrations continued to be below Metro Vancouver objective at all times in 2012. Average levels for the year were also below Metro Vancouver's annual objective.

Emissions affecting NO_2 concentrations are dominated by transportation sources. The dominance of traffic influencing NO_2 is evident when reviewing 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 2012 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 traffic and residential, commercial and industrial heating.

The frequency distribution of hourly concentrations measured in 2012 is given in Table 5. The greatest frequency of low concentrations (0 to 10 $\mu g/m^3$) occur at the Hope, Langley and Tsawwassen stations. The highest concentrations (> 100 $\mu g/m^3$) occur infrequently at three stations: N. Vancouver 2nd Narrows, N. Vancouver-Mahon Park and Vancouver-Downtown.

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.

North Vancouver-2nd Narrows shows a slightly different trend than most, with a steep increase in the early morning hours of winter weekdays. In the summer there is a peak in the evenings. The North Vancouver-2nd Narrows station is situated on an active industrial property within half a kilometre from a large emitter of NOx in the region (a chemical plant), and a major roadway.

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.

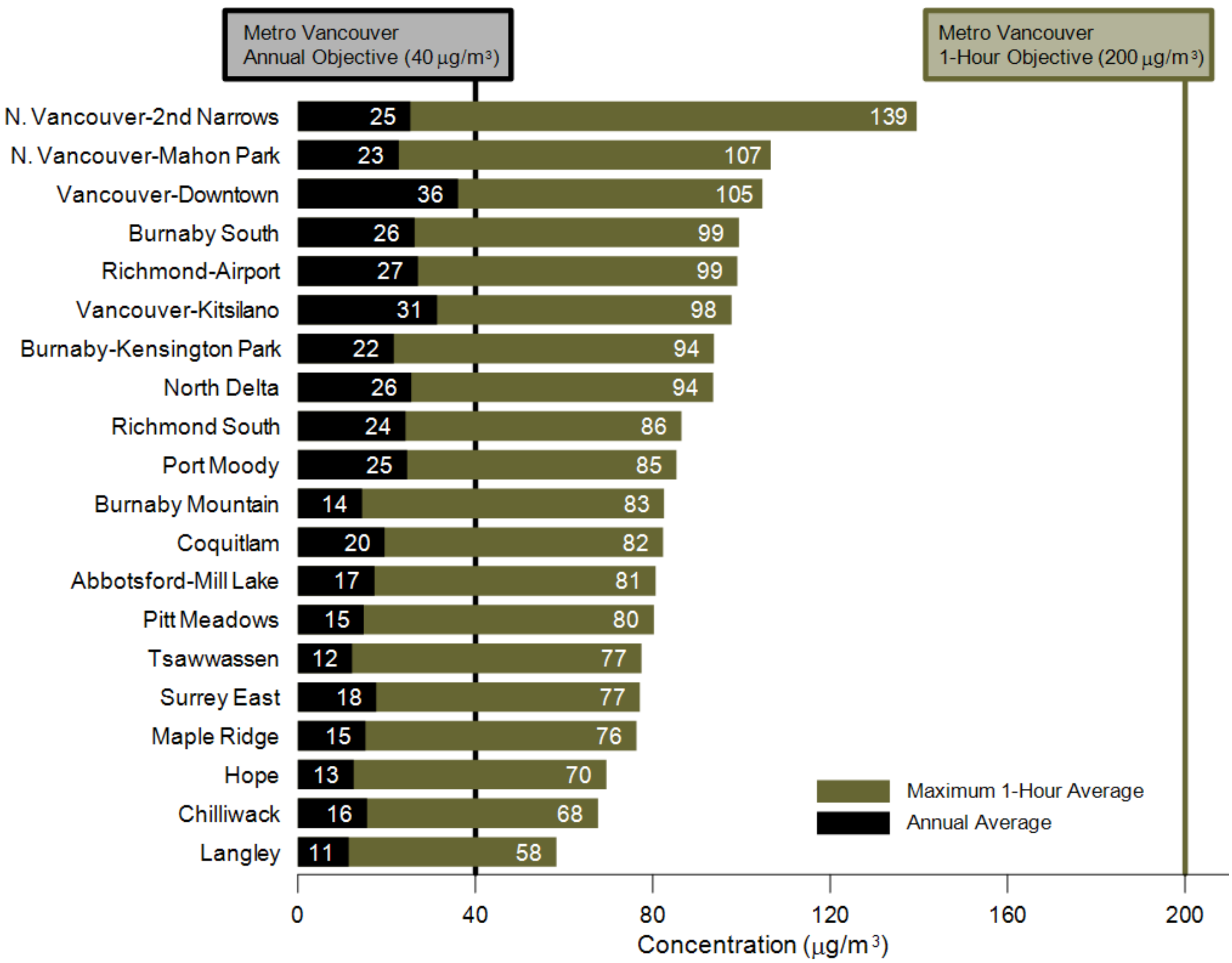


Figure 16: Nitrogen dioxide monitoring, 2012.

Figure 17: Annual average nitrogen dioxide in the LFV, 2012.

Figure 18: Short-term peak (maximum 1-hour) nitrogen dioxide in the LFV, 2012.

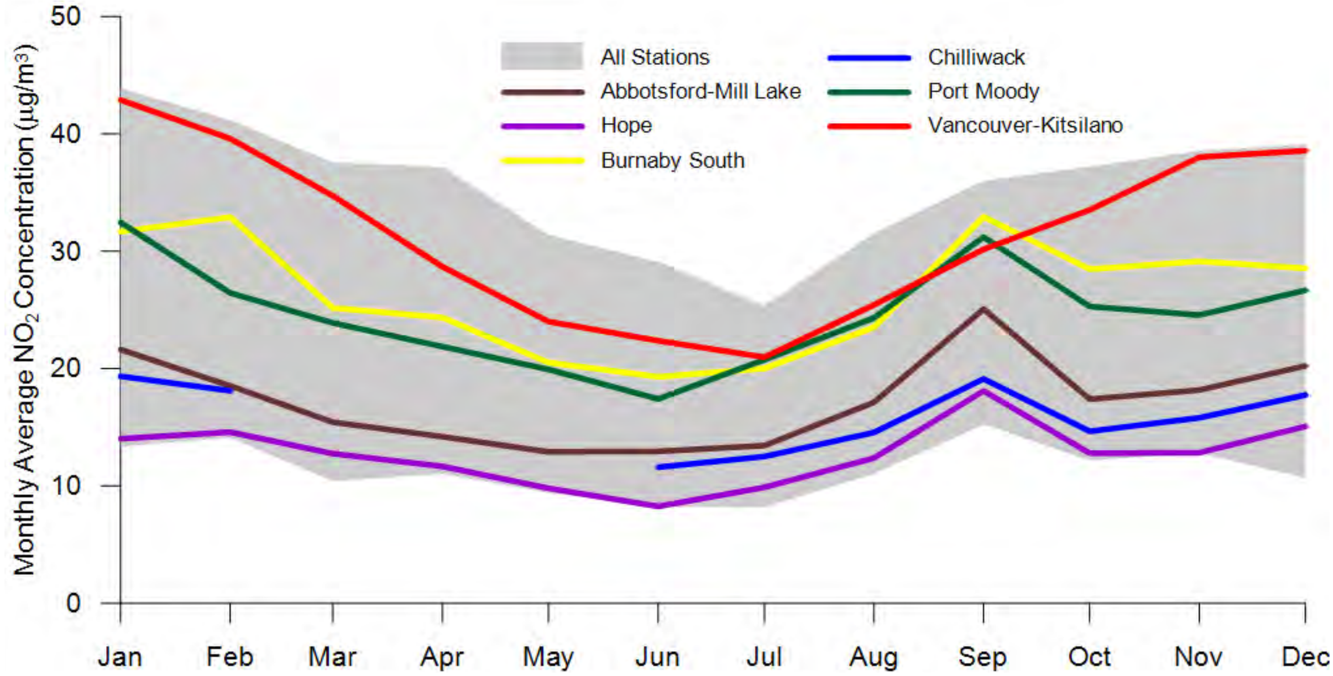


Figure 19: Monthly average nitrogen dioxide, 2012.

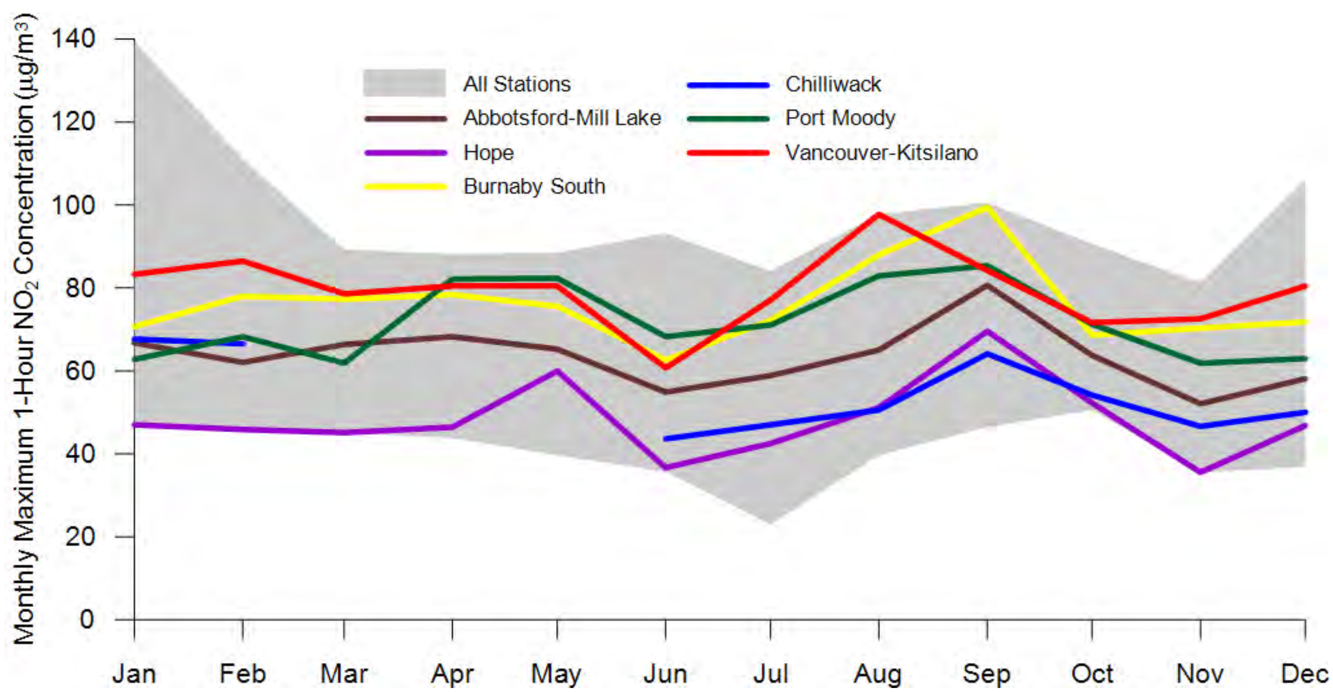
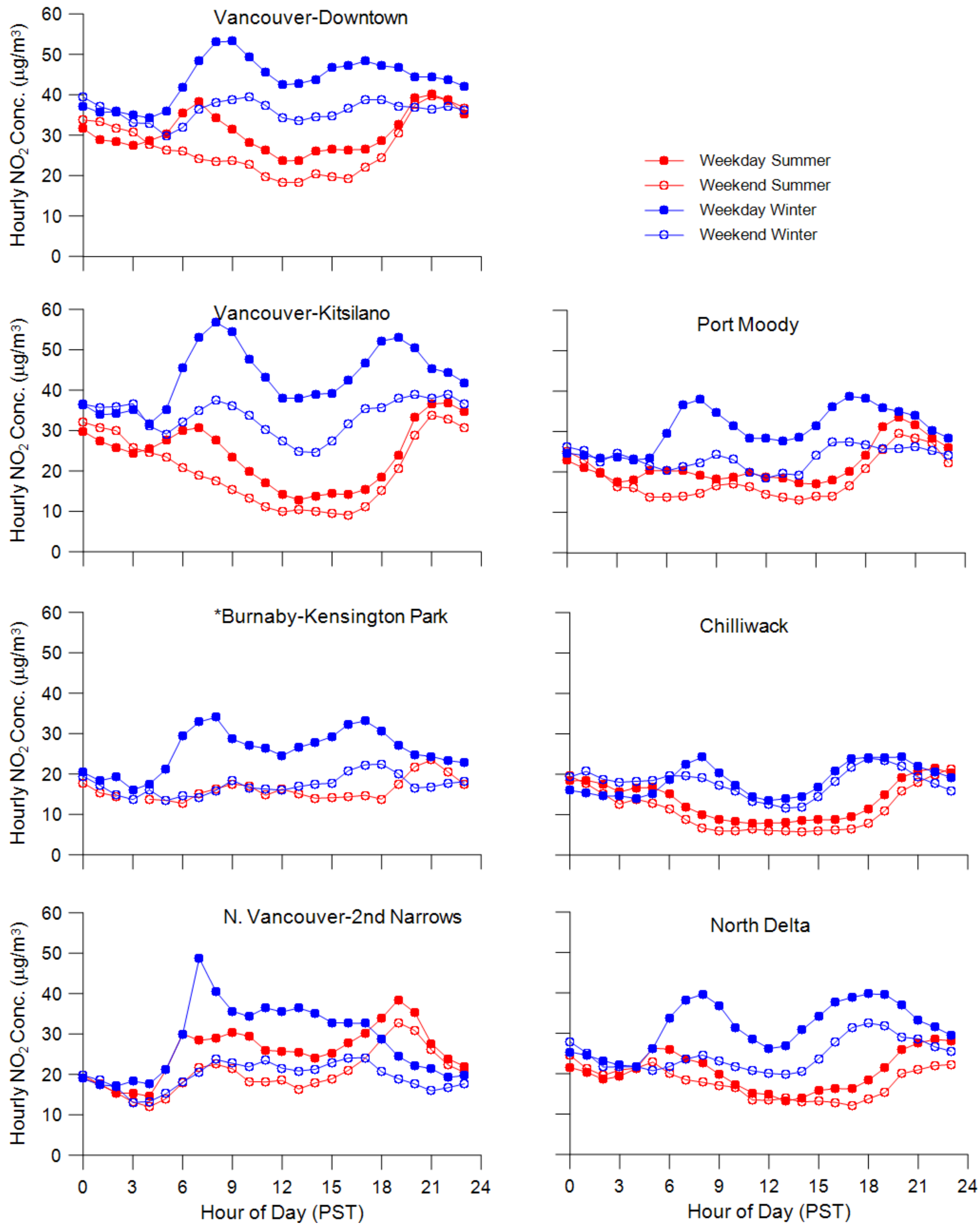


Figure 20: Monthly short-term peak nitrogen dioxide, 2012.

Table 5: Frequency distribution of hourly nitrogen dioxide, 2012.

NO_2 Concentration (µg/m³)	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
0 to 10	105	1272	1507	884	1092	2891	1512	3361	2881	2120	926	3662	1756	4604	4302	3305	1581	1989	2874	4915
10 to 20	1196	1463	2735	2875	2535	2759	2412	3382	2848	1985	2545	2405	2756	2785	2588	3046	1945	2965	2867	2088
20 to 30	1792	1414	1878	2162	2235	1396	1750	1222	1493	1497	2068	1311	1749	871	1161	1448	1488	1753	1539	866
30 to 40	1960	1540	952	1374	1495	553	1281	393	747	1291	1389	625	1105	244	380	523	1139	970	724	459
40 to 50	1753	1264	470	690	766	176	874	162	411	922	855	259	641	71	88	190	951	433	289	196
50 to 60	995	953	232	363	297	41	494	73	141	558	462	96	364	5	23	51	683	152	142	53
60 to 70	415	459	82	168	64	8	222	38	34	160	198	28	122		8	21	292	35	30	9
70 to 80	85	128	19	50	14		70	7	9	17	38	8	38			4	75	7	6	1
80 to 90	8	20	5	19	5		18	1		3	5	1	9				7	1	1	
90 to 100	6	1	1	4			1				2		3				5			
100 to 110	3			2									1							
110 to 120				1																
120 to 130																				
130 to 140				1																
>=140																				
Missing	466	270	903	191	281	960	150	145	220	231	296	389	240	204	234	196	618	479	312	197
Data Completeness	95%	97%	90%	98%	97%	89%	98%	98%	98%	97%	97%	96%	97%	98%	97%	98%	93%	95%	96%	98%



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

Figure 21: Diurnal trends nitrogen dioxide, 2012.

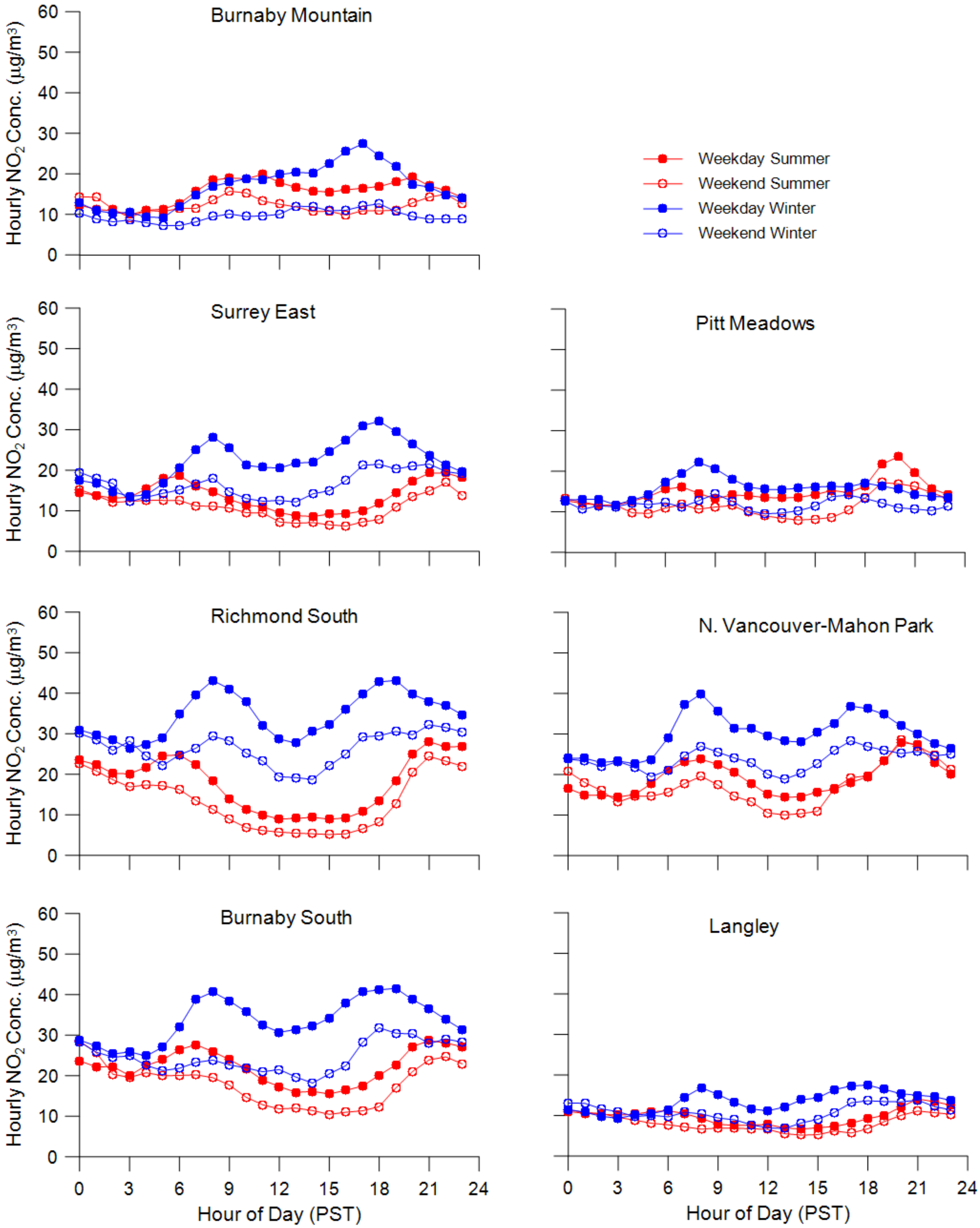


Figure 21: Cont. Diurnal trends nitrogen dioxide, 2012.

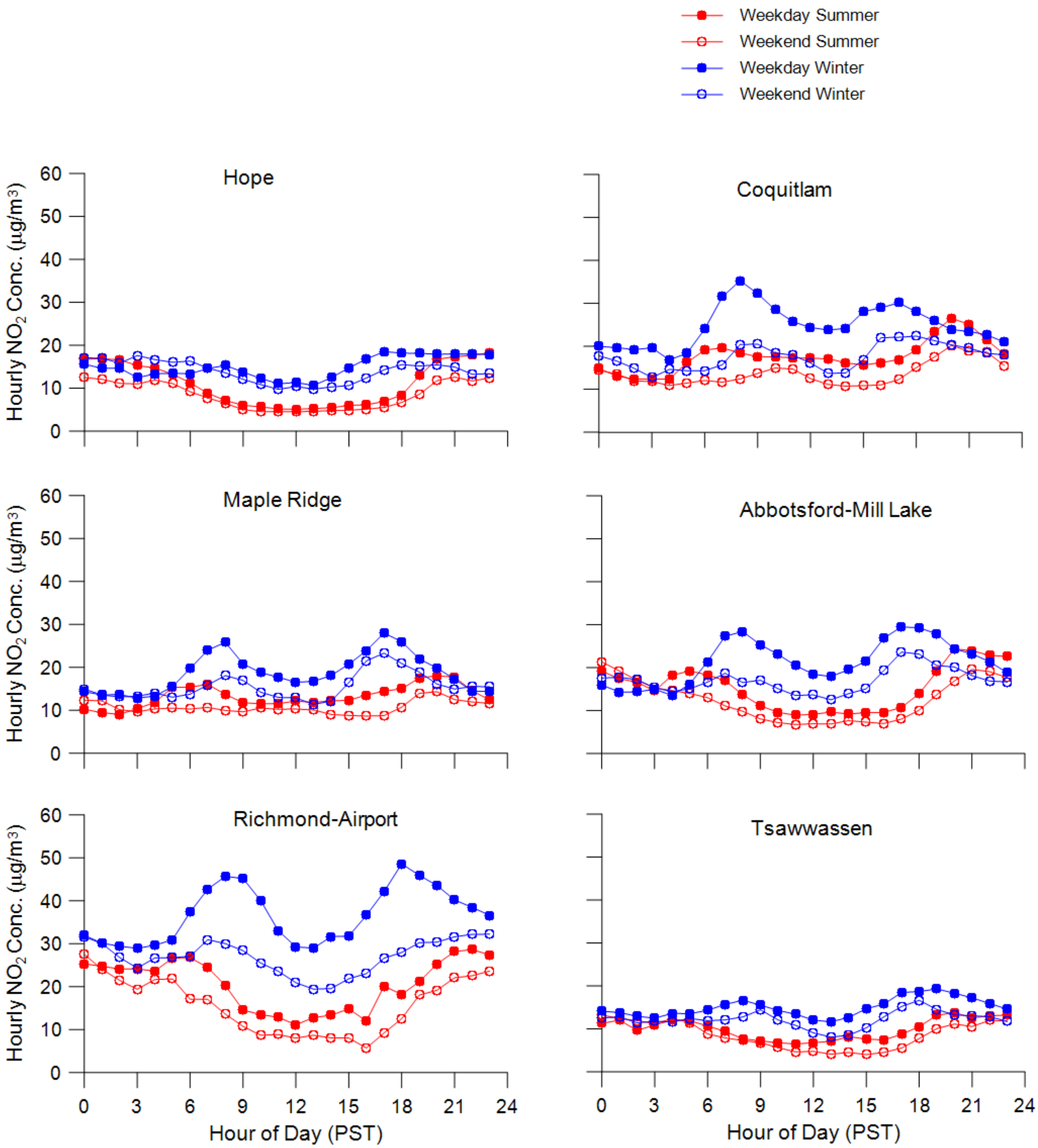


Figure 21: Cont. Diurnal trends nitrogen dioxide, 2012.

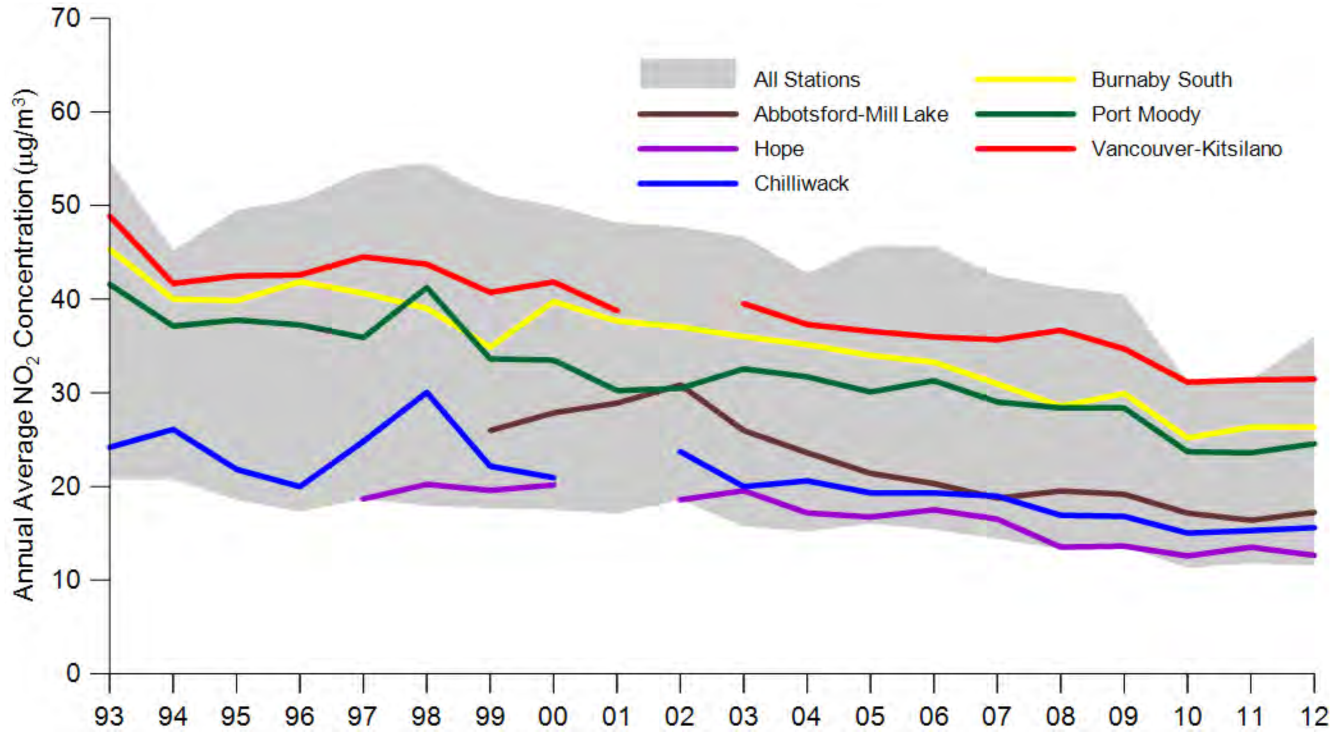


Figure 22: Annual nitrogen dioxide trend, 1993 to 2012.

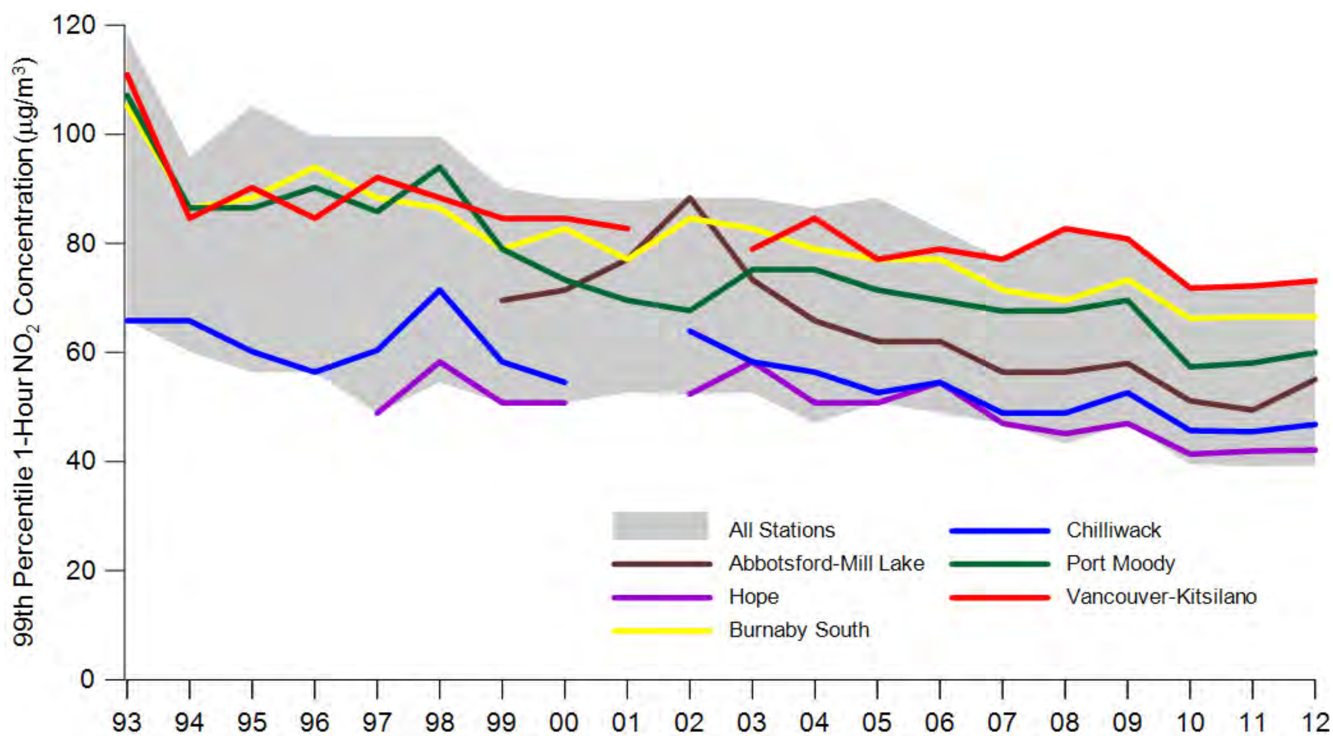


Figure 23: Short-term peak nitrogen dioxide trend, 1993 to 2012.

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 principle 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 2012. 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 335 $\mu g/m^3$) with the lowest readings recorded at stations away from heavily trafficked areas.

The seasonal trends for CO in 2012 are plotted as monthly average and maximum 1-hour concentrations in Figures 28 and 29, respectively. Overall, average CO concentrations were slightly 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 traffic and 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.

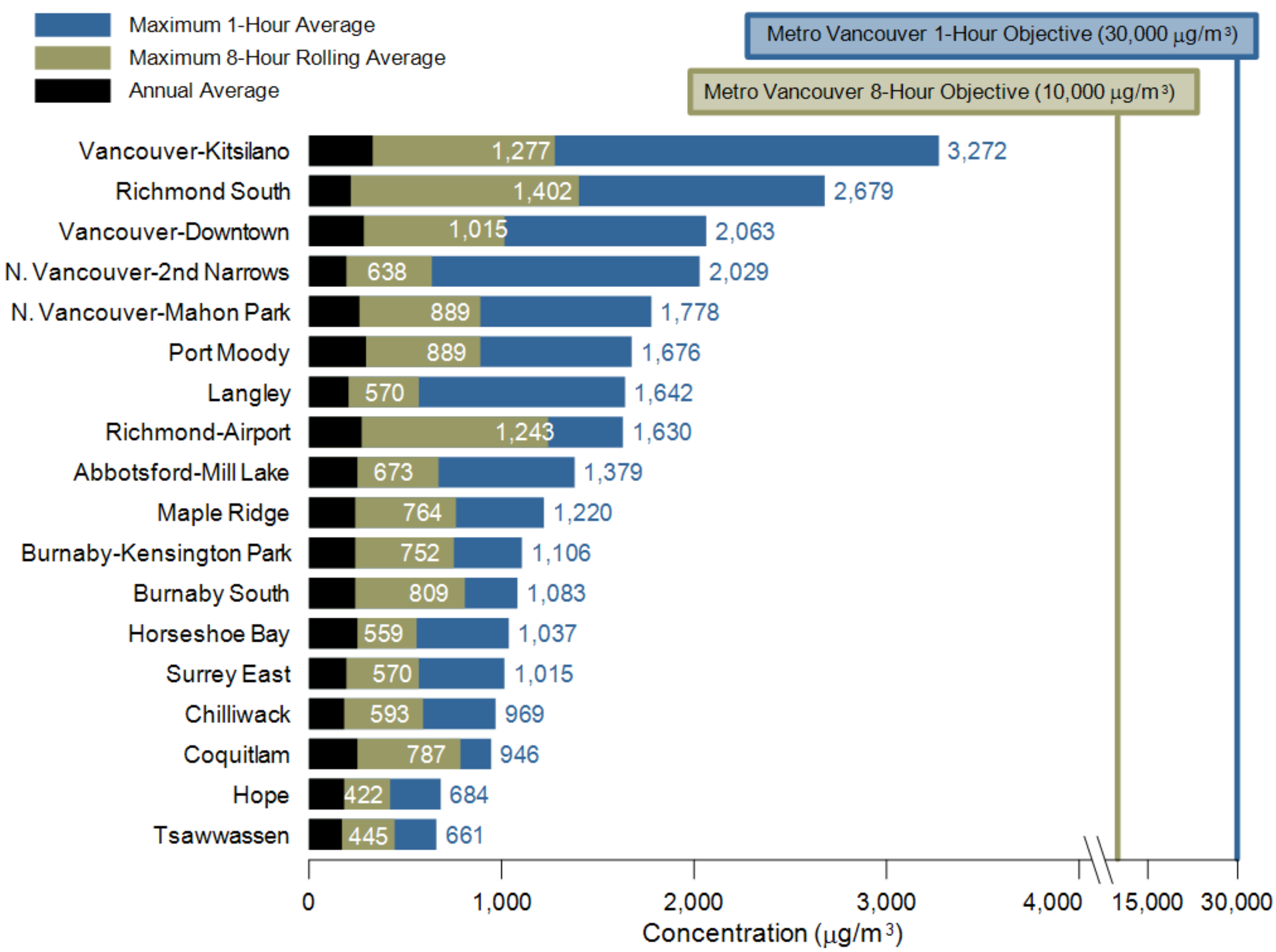
Stations that appear to be strongly influenced by CO emission sources such as traffic include Vancouver-Kitsilano, Richmond-South and Richmond-Airport where a well defined peak is evident in the mornings on weekdays during the winter.

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 the use of the Rocky Point Park parking lot and boat launch (located close to the monitoring station) and summertime weekend ferry traffic near 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.

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 (99^{th} 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 4,000 and 10,000 µg/m³. The highest concentration measured is almost ten times less than the objective threshold.

Figure 24: Carbon monoxide monitoring, 2012.

Figure 25: Annual average carbon monoxide in the LFV, 2012.

Figure 26: Short-term peak (maximum 1-hour) carbon monoxide in the LFV, 2012.

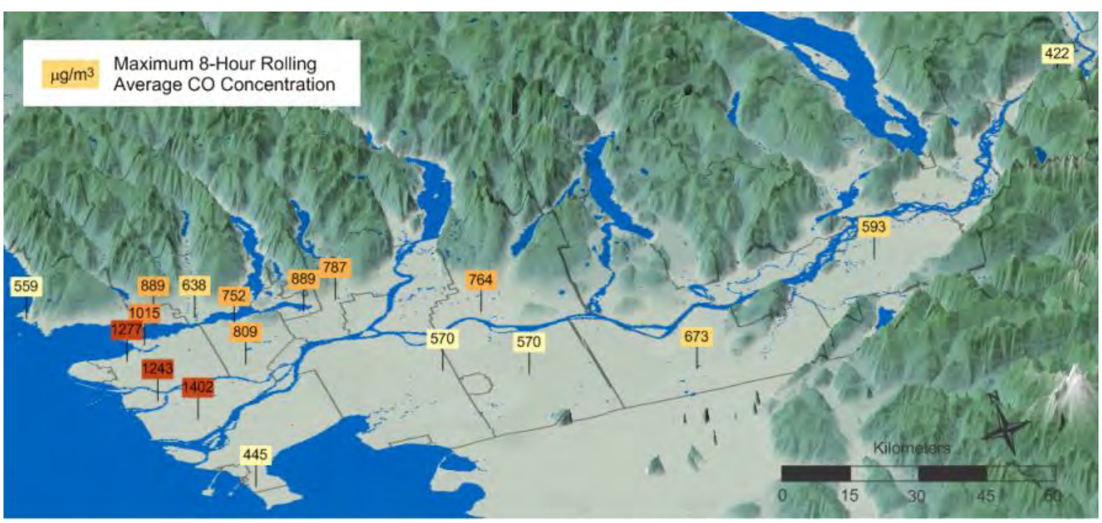


Figure 27: Short-term peak (maximum 8-hour) carbon monoxide in the LFV, 2012.

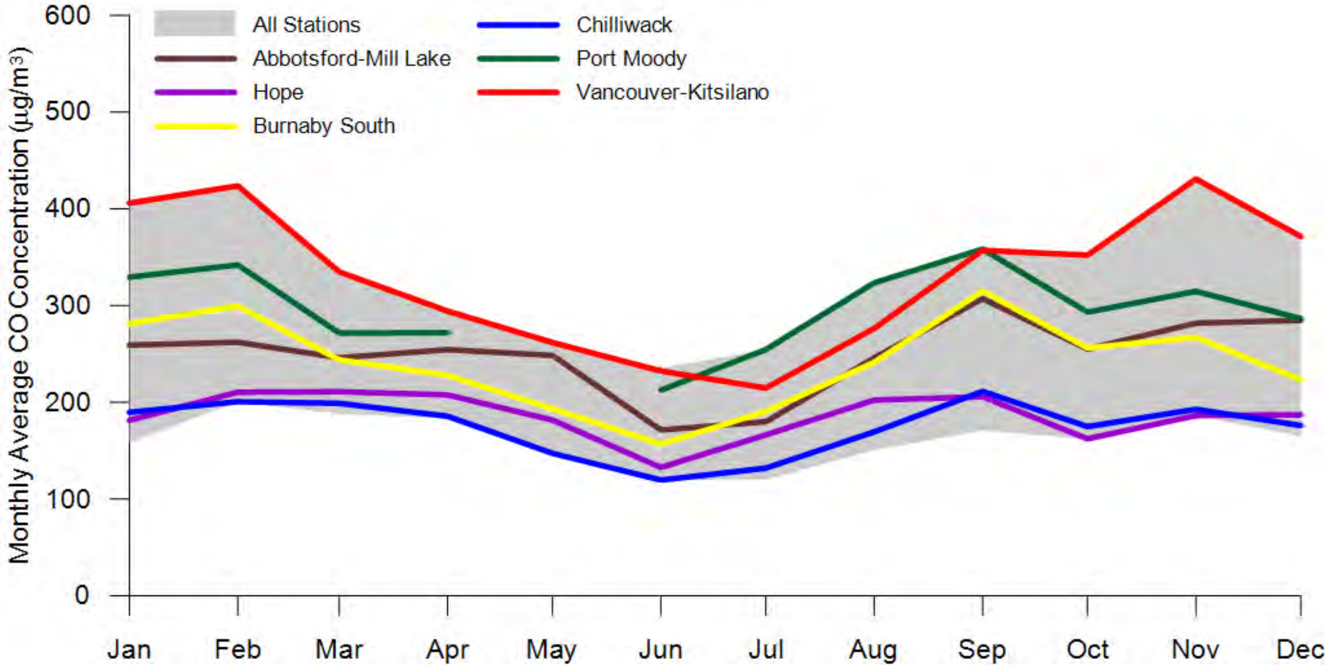


Figure 28: Monthly average carbon monoxide, 2012.

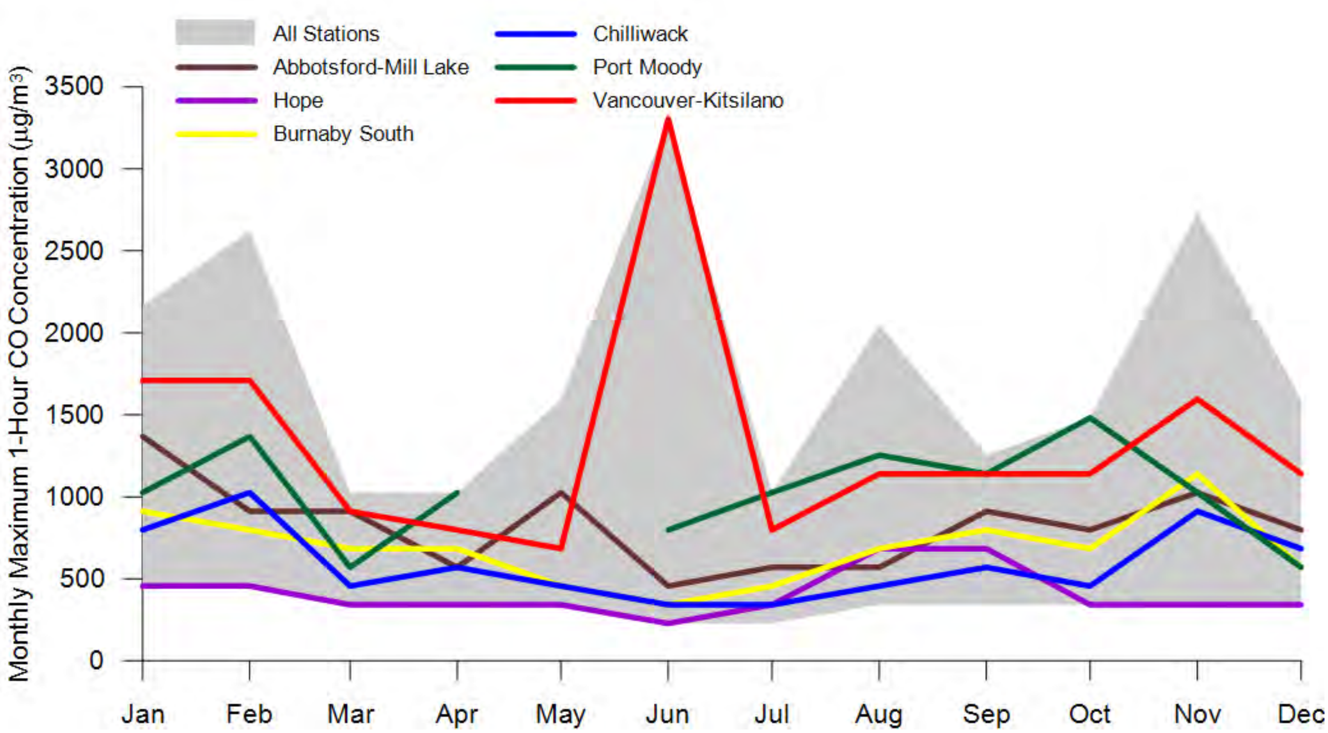


Figure 29: Monthly short-term peak carbon monoxide, 2012.

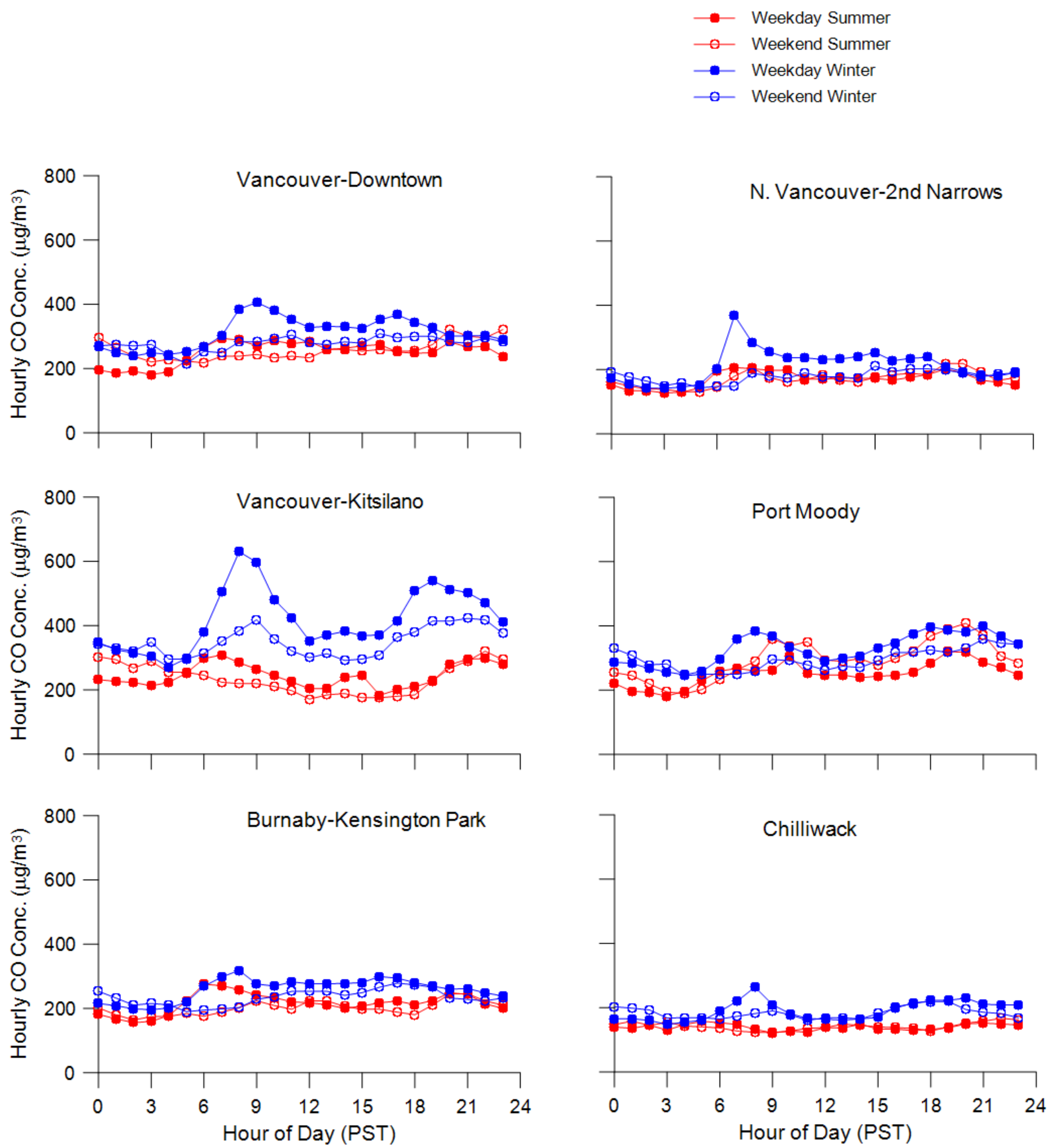


Figure 30: Diurnal trends carbon monoxide, 2012.

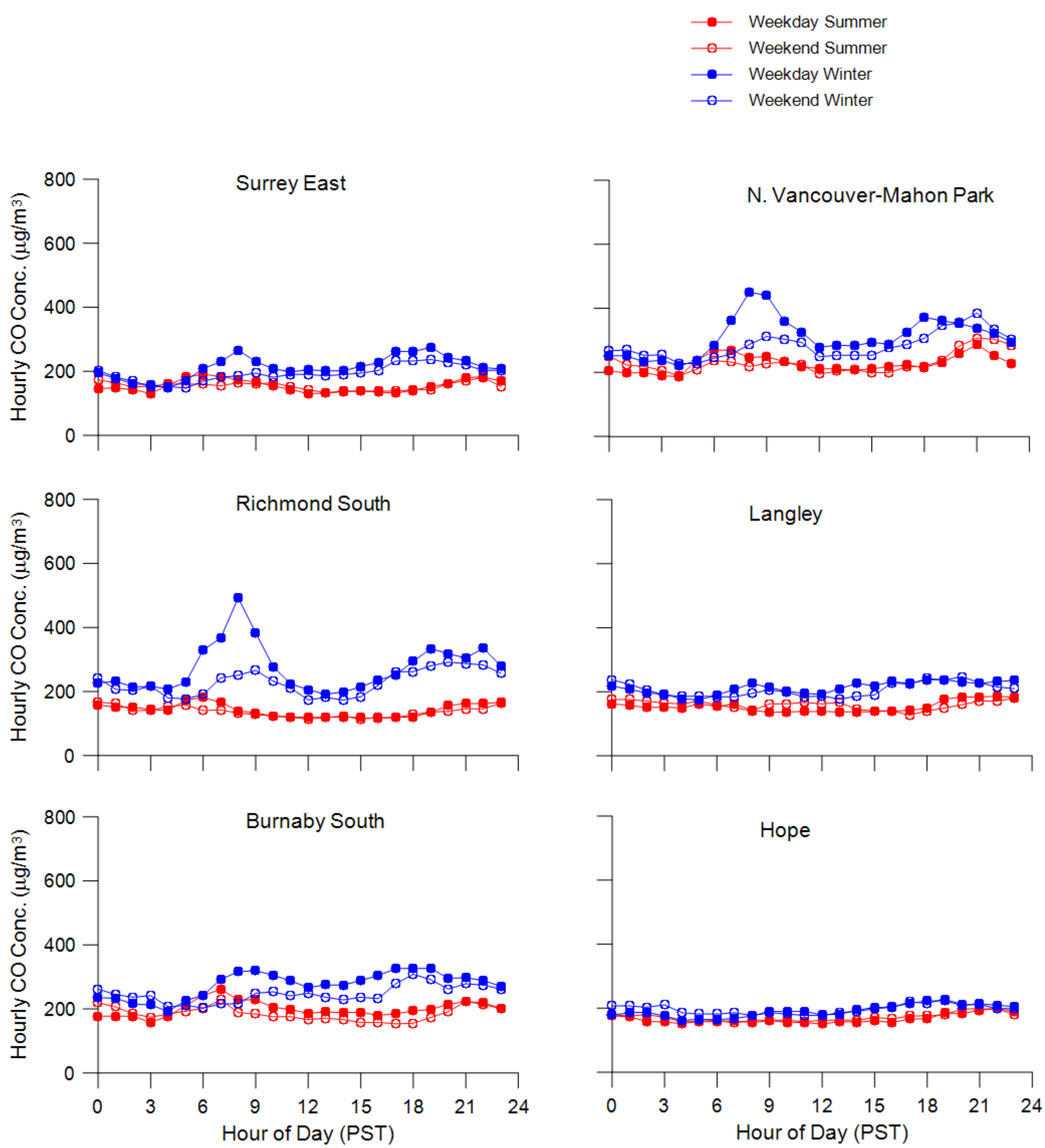


Figure 30: Cont. diurnal trends carbon monoxide, 2012.

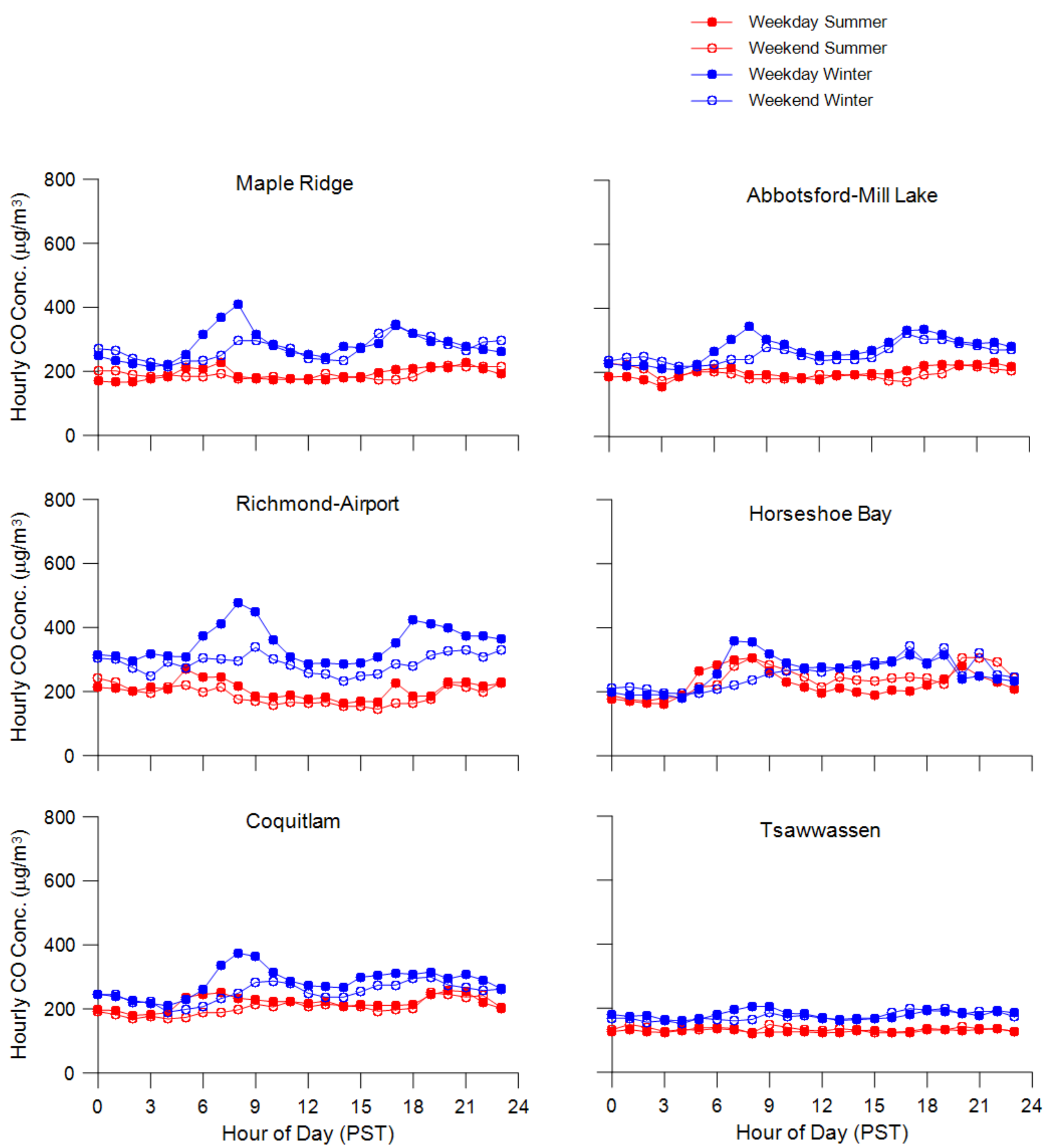


Figure 30: Cont. diurnal trends carbon monoxide, 2012.

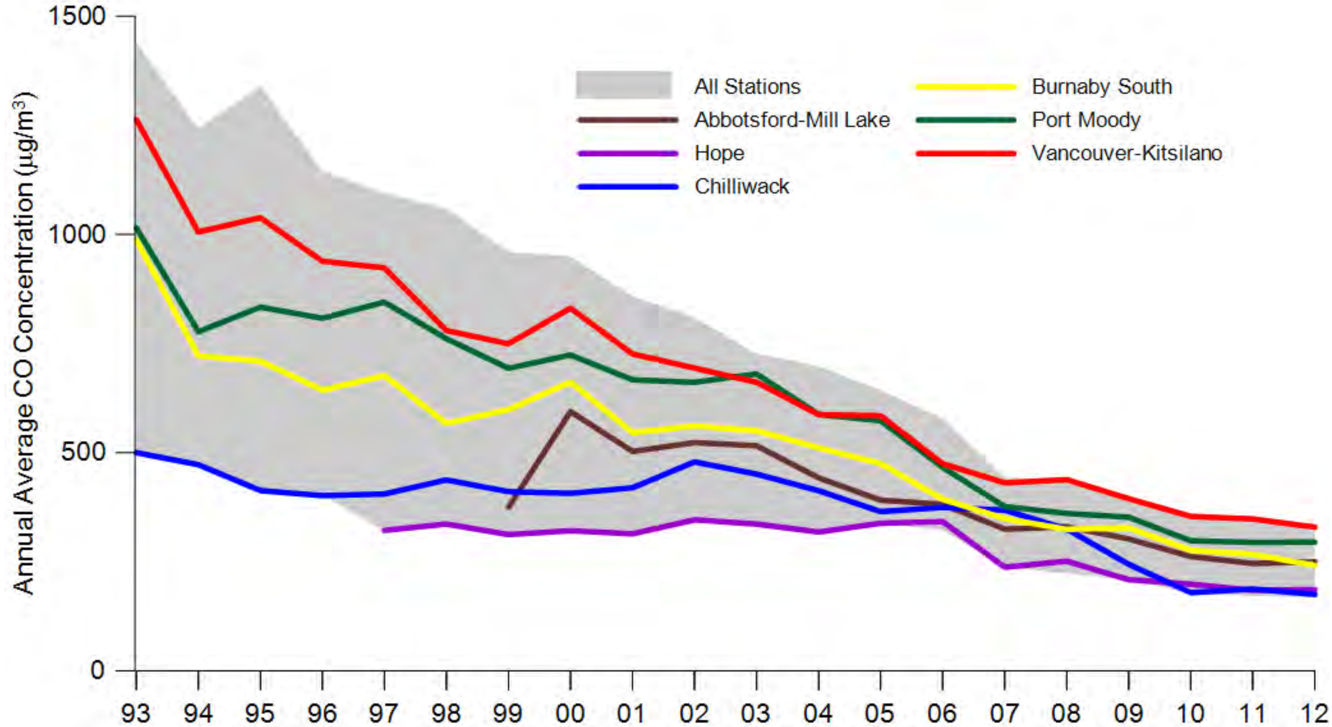


Figure 31: Annual carbon monoxide trend, 1993 to 2012.

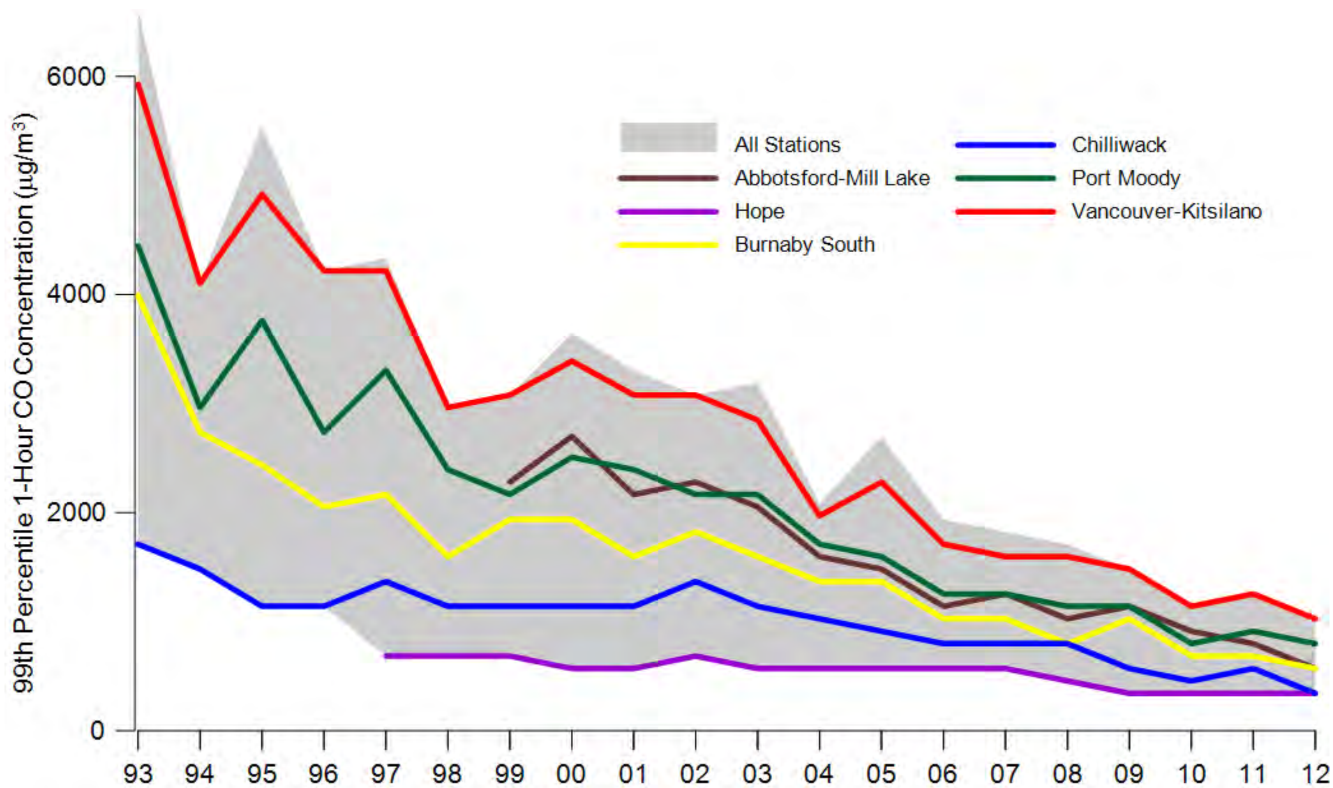


Figure 32: Short-term peak carbon monoxide trend, 1993 to 2012.

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.

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 strong 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 2012. The annual average and Canada-Wide 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 2012, there were no exceedances of the Canada-Wide Standard (CWS). Since 2006 there have not been any exceedances of the CWS in the LFV. The Burnaby Mountain station measured the highest average ozone level which is typical given the stations high elevation on the top of Burnaby Mountain.

The summer of 2012 was favourable for ozone formation resulting in high peak ozone levels at several locations in the LFV. The 1-hour Metro Vancouver objective was exceeded at four stations with the highest value of 88 ppb measured in eastern Metro Vancouver in Maple Ridge. Exceedances at these four stations occurred on August 17 in the afternoon with the Chilliwack station exceeding for three hours, Maple Ridge and Langley for two hours, and Abbotsford-Mill Lake for one hour. An air quality advisory was issued on this day as a result of elevated levels.

In 2012 there was hot and sunny weather that was conducive to ground-level ozone formation. On two separate days there were exceedances of the 1-hour and/or 8-hour Metro Vancouver ozone objective.

The 8-hour Metro Vancouver objective was exceeded on two separate days. On July 8th the 8-hour objective was exceeded for three hours at Chilliwack. On August 17th the objective was equalled or exceeded for six hours at Langley, five hours at Maple Ridge, four hours at Chilliwack and Abbotsford-Mill Lake, three hours at Surrey East and two hours at Burnaby Mountain. The highest 8-hour value of 75 ppb was measured in the FVRD at Abbotsford-Mill Lake.

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 averages of O_3 (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 the spring and summer, and lower values during the fall and winter. Given that O_3 is created through photochemical reactions there is much greater production in the 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 6 and 7, 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.

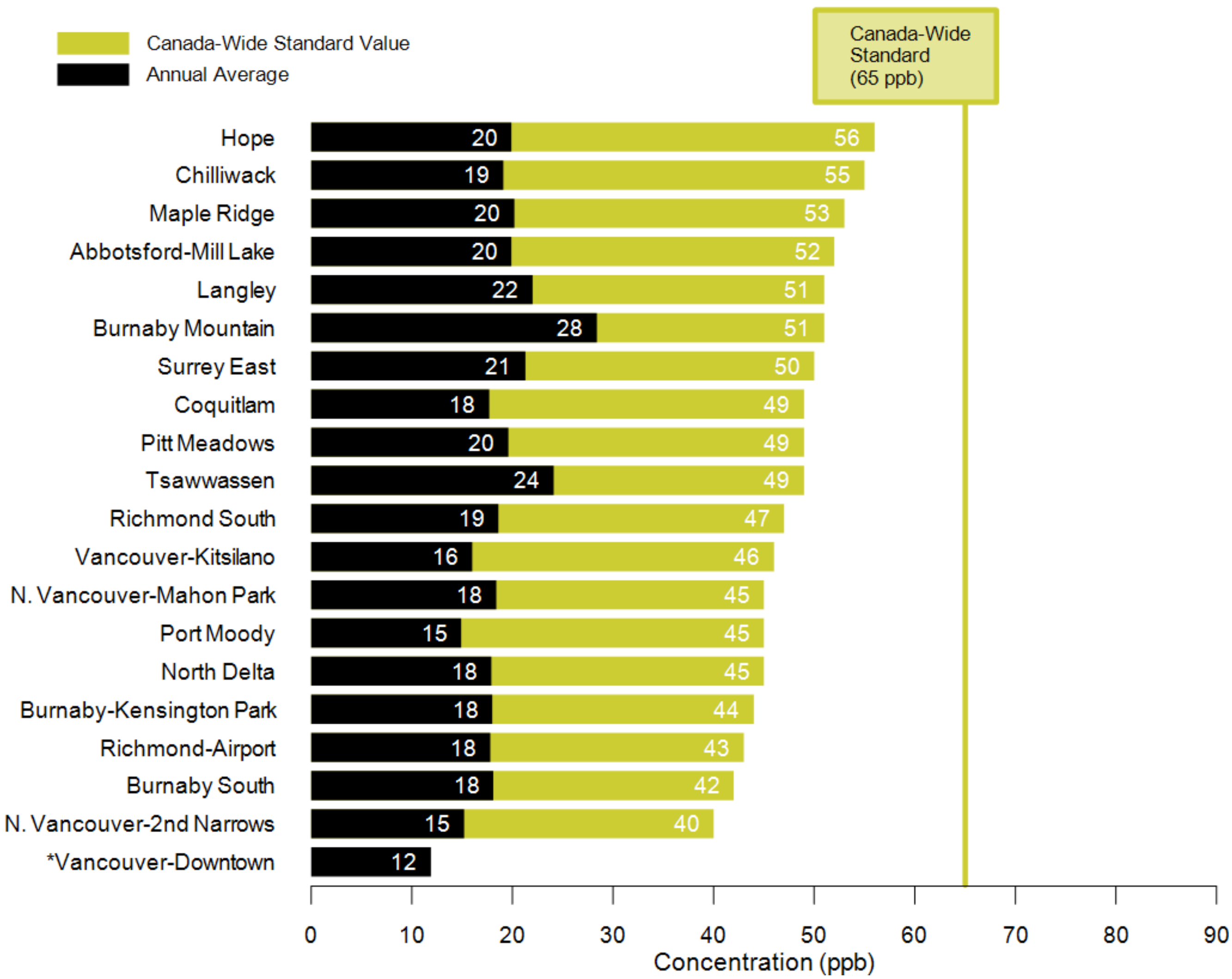
A series of diurnal plots are shown in Figure 41 for each O_3 monitoring station. The diurnal plots illustrate the weekday/weekend differences along with summer/winter differences. Most of the stations exhibit similar diurnal trends.

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 stations peak later in the day. Winter shows a similar trend of an afternoon peak although it is greatly attenuated compared with the summer.

Most stations experienced greater ozone on weekends compared with weekdays in the summer. This is consistent with 2011, when all stations experienced greater ozone on weekends.

Figure 42 illustrates the long-term annual average O_3 trend in the LFV. Annual O_3 levels have shown an upward trend since 1993. Research indicates that background ozone concentrations are rising and could be one factor for the observed increase in average levels.

A short-term peak O_3 concentration trend (Figure 43) is less apparent and difficult to describe for the region. There are yearly differences, which 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. On-going research is helping to suggest the most appropriate strategies to improve ozone levels.



* Data completeness criteria were not met at this station and therefore the Canada-Wide Standard value was not calculated.

Figure 33: Ground-level ozone monitoring (Annual and CWS), 2012.

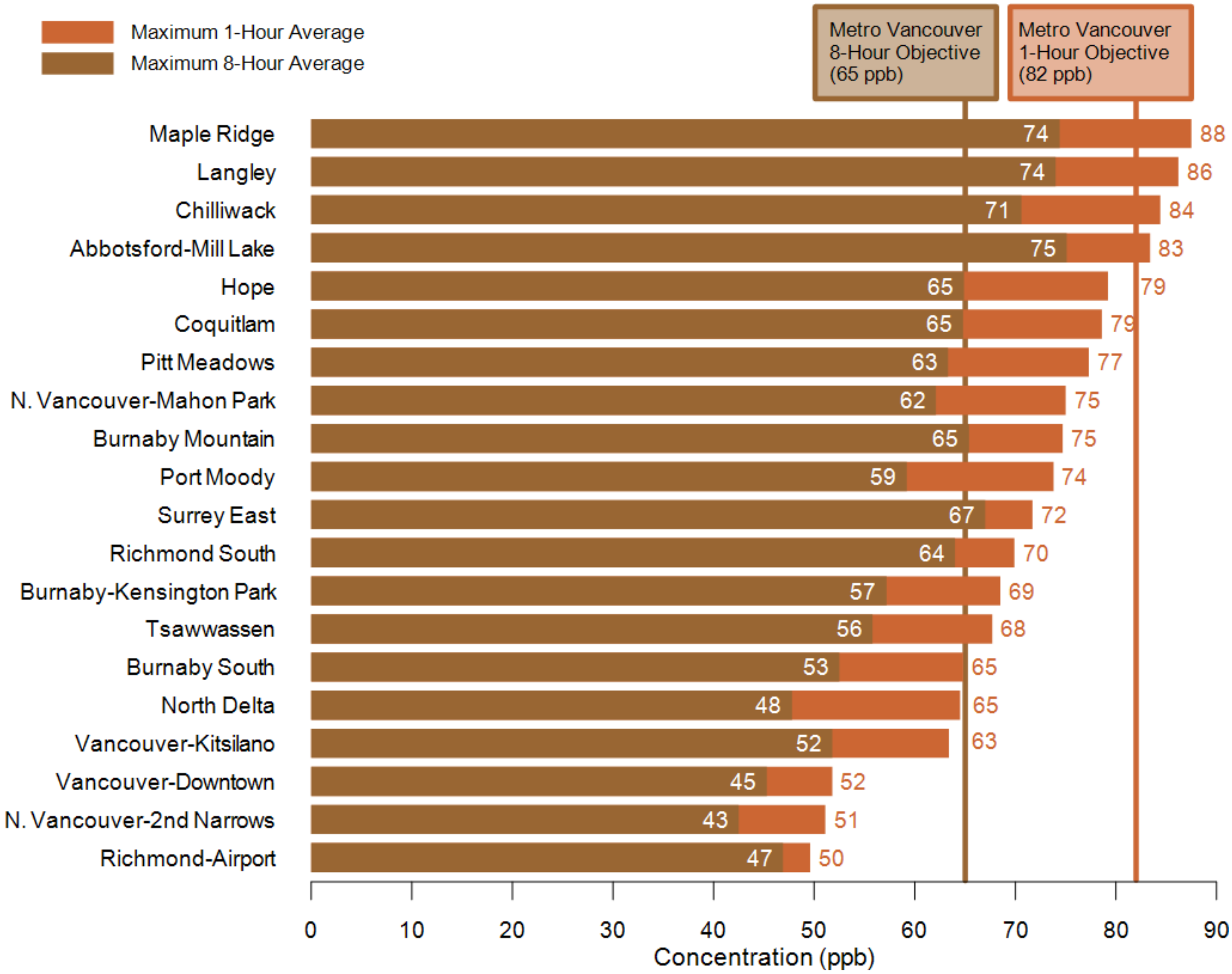


Figure 34: Ground-level ozone monitoring (1-hour and 8 hour), 2012.

Figure 35: Annual average ozone in the LFV, 2012.

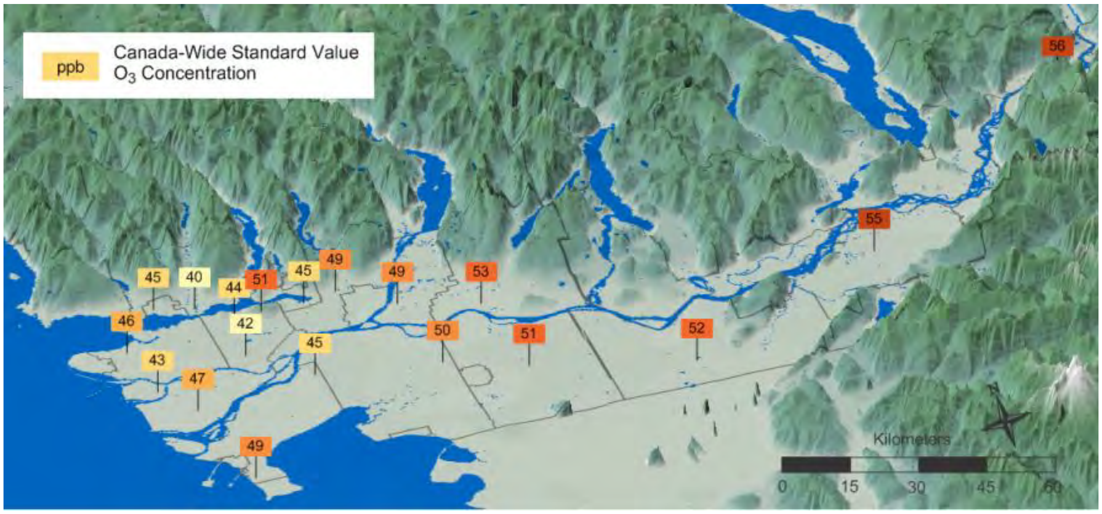


Figure 36: Canada-Wide Standard value for ozone in the LFV, 2012.

Figure 37: Short-term peak (maximum 1-hour) ozone in the LFV, 2012.

Figure 38: Short-term peak (maximum 8-hour) ozone in the LFV, 2012.

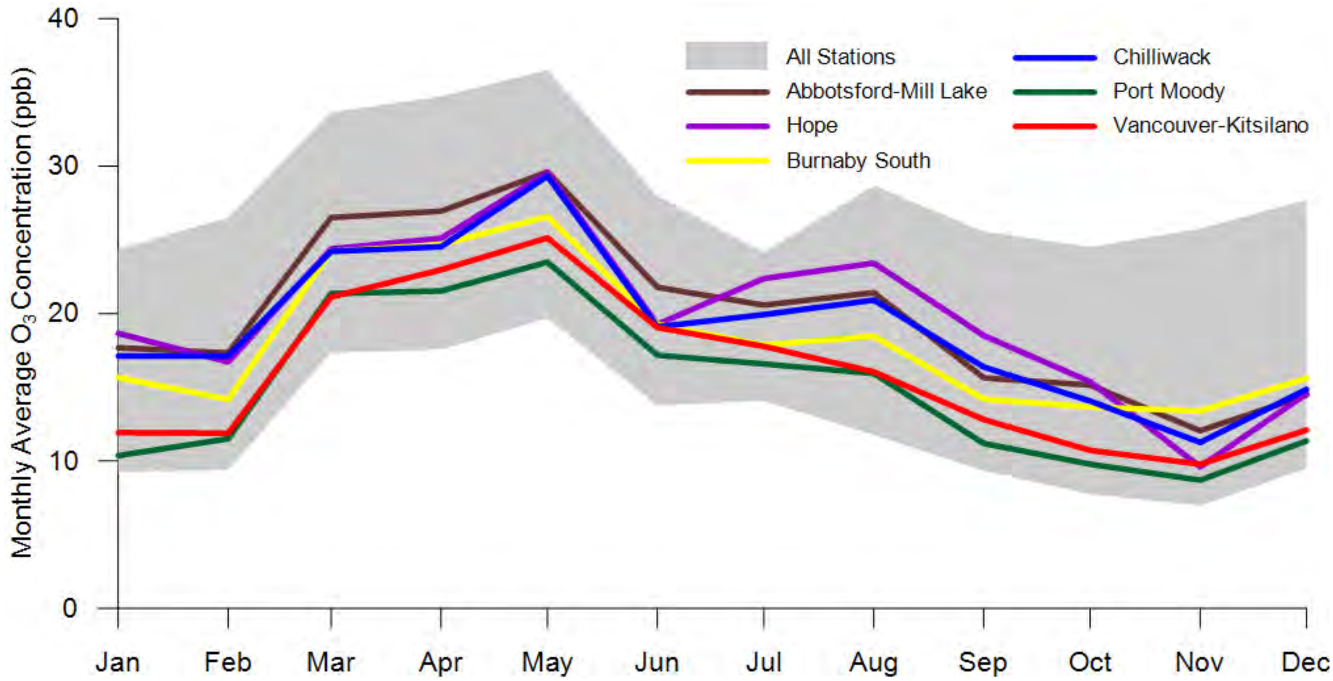


Figure 39: Monthly average ozone, 2012.

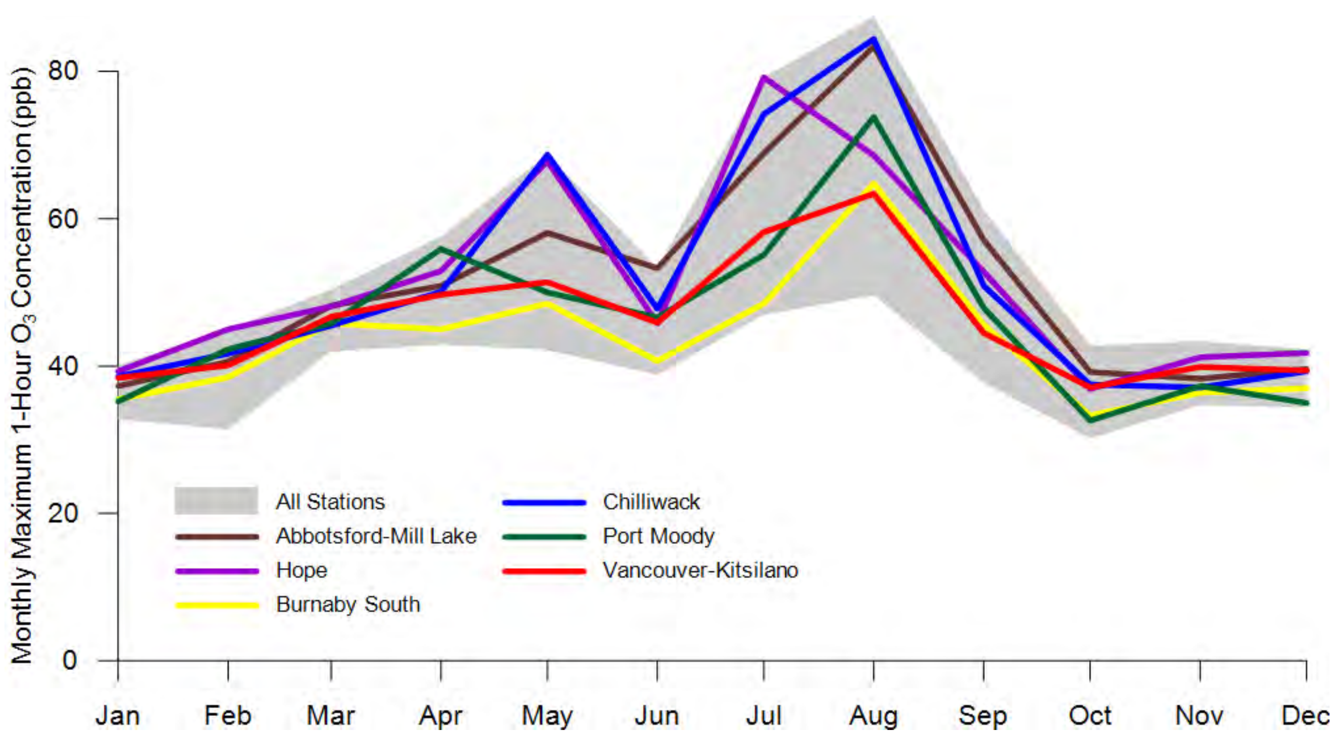


Figure 40: Monthly short-term peak ozone, 2012.

Table 6: Frequency distribution of hourly ozone, 2012.

O_3 Concentration (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
0 to 5	2885	2415	1064	1571	2531	1444	1422	93	774	1963	1170	1513	1314	1003	1476	1110	1796	1635	1321	500
5 to 10	1360	1099	1210	1488	1143	984	1034	173	742	808	1127	787	1013	655	924	933	896	1133	871	501
10 to 15	1128	1013	1372	1455	1091	1169	1224	436	1209	934	1233	900	1163	915	1041	1161	1022	1140	1045	873
15 to 20	1040	910	1254	1313	1023	1116	1260	906	1258	940	1259	1172	1252	1147	1021	1127	1065	1145	1128	1228
20 to 25	850	863	1268	1084	873	989	1197	1458	1266	976	1259	1126	1202	1193	1038	1204	1062	1065	1005	1329
25 to 30	604	843	1034	794	721	970	1019	1686	1145	892	1100	1132	1088	1236	907	1070	986	946	1097	1306
30 to 35	340	668	721	567	573	864	827	1784	1017	864	865	942	793	1122	845	898	885	700	900	1294
35 to 40	128	488	425	217	416	533	440	1205	572	650	391	592	481	712	624	598	565	499	558	956
40 to 45	18	252	141	55	191	291	162	601	343	395	115	279	156	397	356	284	191	232	301	466
45 to 50	5	72	28	7	50	112	40	195	125	105	13	114	48	133	156	118	30	74	122	114
50 to 55	1	10	1	1	8	35	5	68	28	8	3	24	9	52	77	62		33	55	10
55 to 60		3	2		2	26	1	22	11	2	1	11	3	9	43	15		15	16	7
60 to 65		4	1			9	2	5	5	2	2	4	1	4	10	2		5	5	1
65 to 70			2		2	8		1	3	4		1	2	3	9	4		1	6	2
70 to 75					2	6		3	2			1	1	4	1	3		1	1	
75 to 80						1						2	1		2	3		2	4	
80 to 85						3								1					2	
85 to 90														1		2				
>=90																				
Missing	425	144	261	232	158	224	151	148	284	241	246	184	257	197	254	190	286	158	347	197
Data Completeness	95%	98%	97%	97%	98%	97%	98%	98%	97%	97%	97%	98%	97%	98%	97%	98%	97%	98%	96%	98%

Table 7: Frequency distribution of 8-hour rolling average ozone, 2012.

O_3 Concentration (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
0 to 5	2349	1750	735	1221	1880	954	950	44	469	1333	835	1075	799	628	1091	728	1288	1118	872	310
5 to 10	1771	1449	1231	1554	1490	1161	1197	97	789	1092	1173	909	1194	755	1010	1035	1130	1289	995	453
10 to 15	1504	1373	1543	1726	1428	1428	1517	399	1342	1245	1480	1130	1408	1037	1148	1253	1337	1437	1263	992
15 to 20	1174	1148	1513	1642	1288	1357	1492	937	1378	1202	1450	1370	1555	1362	1248	1376	1244	1428	1326	1353
20 to 25	877	996	1502	1161	986	1109	1286	1514	1503	1102	1472	1339	1348	1360	1216	1431	1196	1203	1149	1473
25 to 30	500	924	1039	817	756	1087	1117	1941	1293	997	1202	1229	1106	1390	1150	1176	1062	959	1241	1409
30 to 35	229	545	701	464	518	833	730	1906	979	842	731	896	794	1113	799	870	797	724	881	1376
35 to 40	44	413	293	79	314	461	357	1234	529	554	276	501	336	665	533	507	447	397	472	919
40 to 45	3	134	39	9	68	179	83	502	244	248	26	199	72	275	271	215	86	129	226	359
45 to 50	1	22	3			58	8	119	63	25	3	43	5	88	96	87	7	31	67	53
50 to 55		2	2		2	21		48	4	2	3	6	1	13	45	12		9	17	5
55 to 60			2		4	16		9	1	2		4	3	6	22	4		3	7	1
60 to 65						4		5	3	3		4	2	1	4	4		4	5	
65 to 70						6		1	3					1		2			1	
>=70						1								5		3			3	
Missing	332	28	181	111	50	109	47	28	184	137	133	79	161	85	151	81	190	53	259	81
Data Completeness	96%	100%	98%	99%	99%	99%	100%	100%	98%	98%	99%	99%	98%	99%	98%	99%	98%	99%	97%	99%

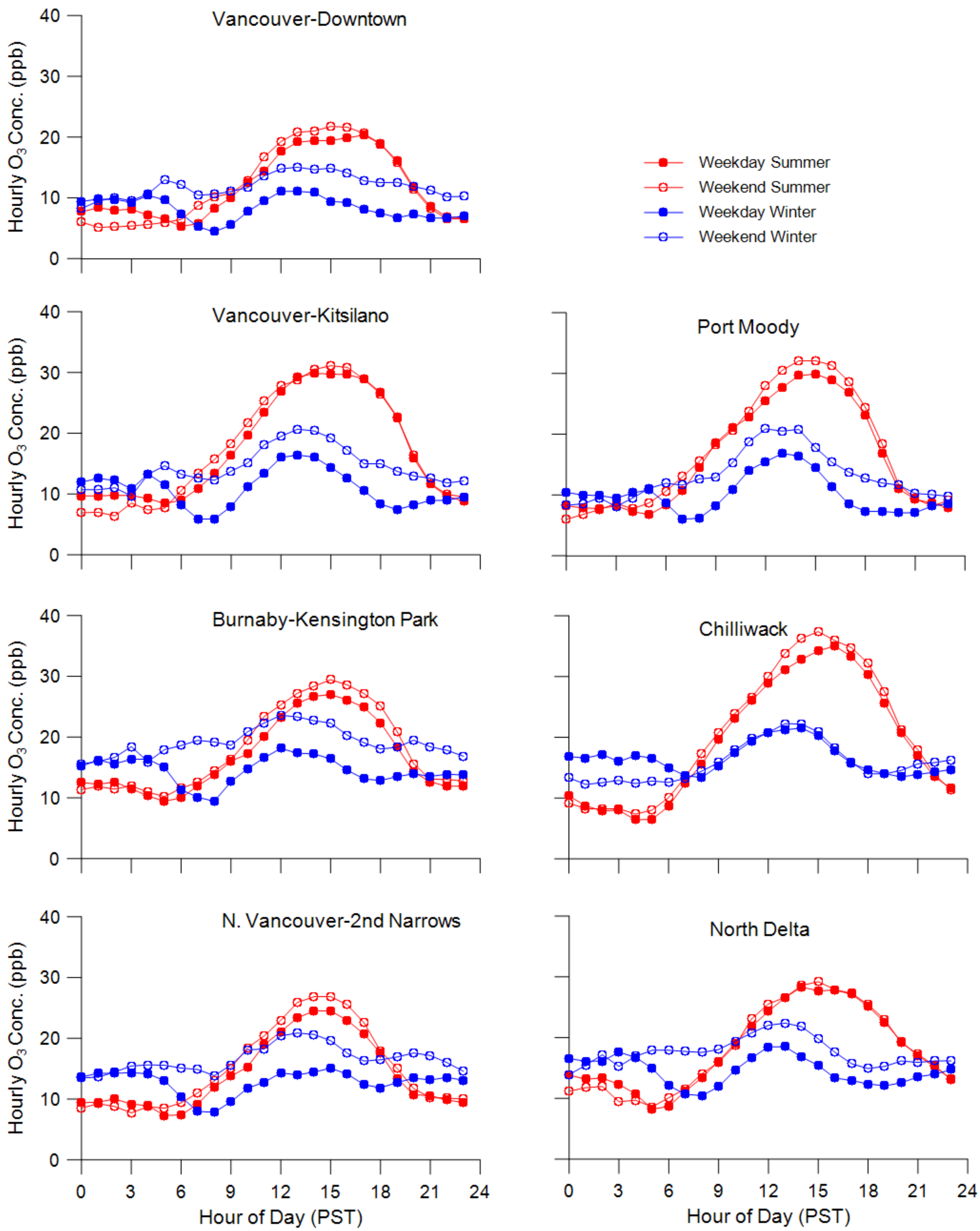


Figure 41: Diurnal trends ozone, 2012.

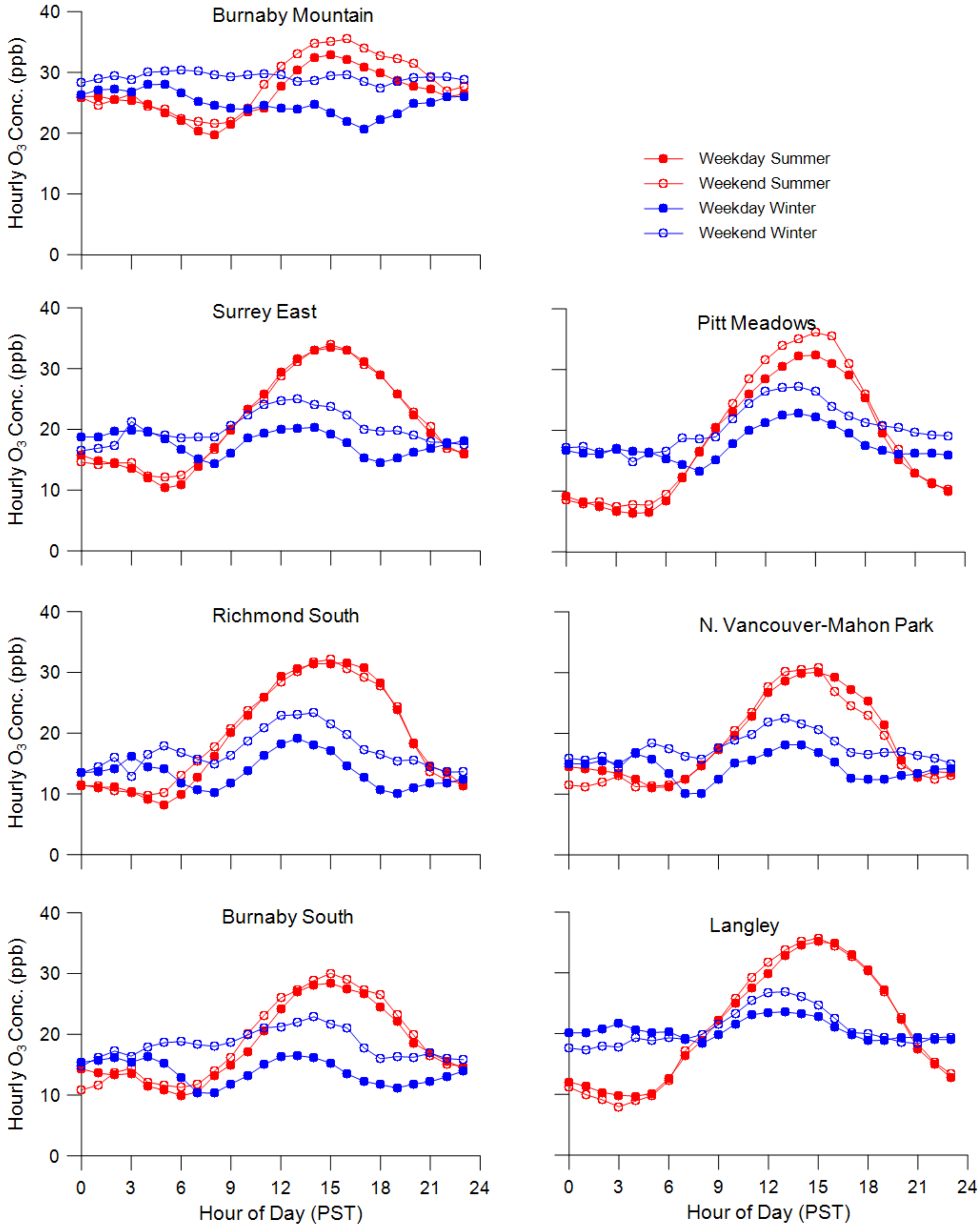


Figure 41: Cont. Diurnal trends ozone, 2012.

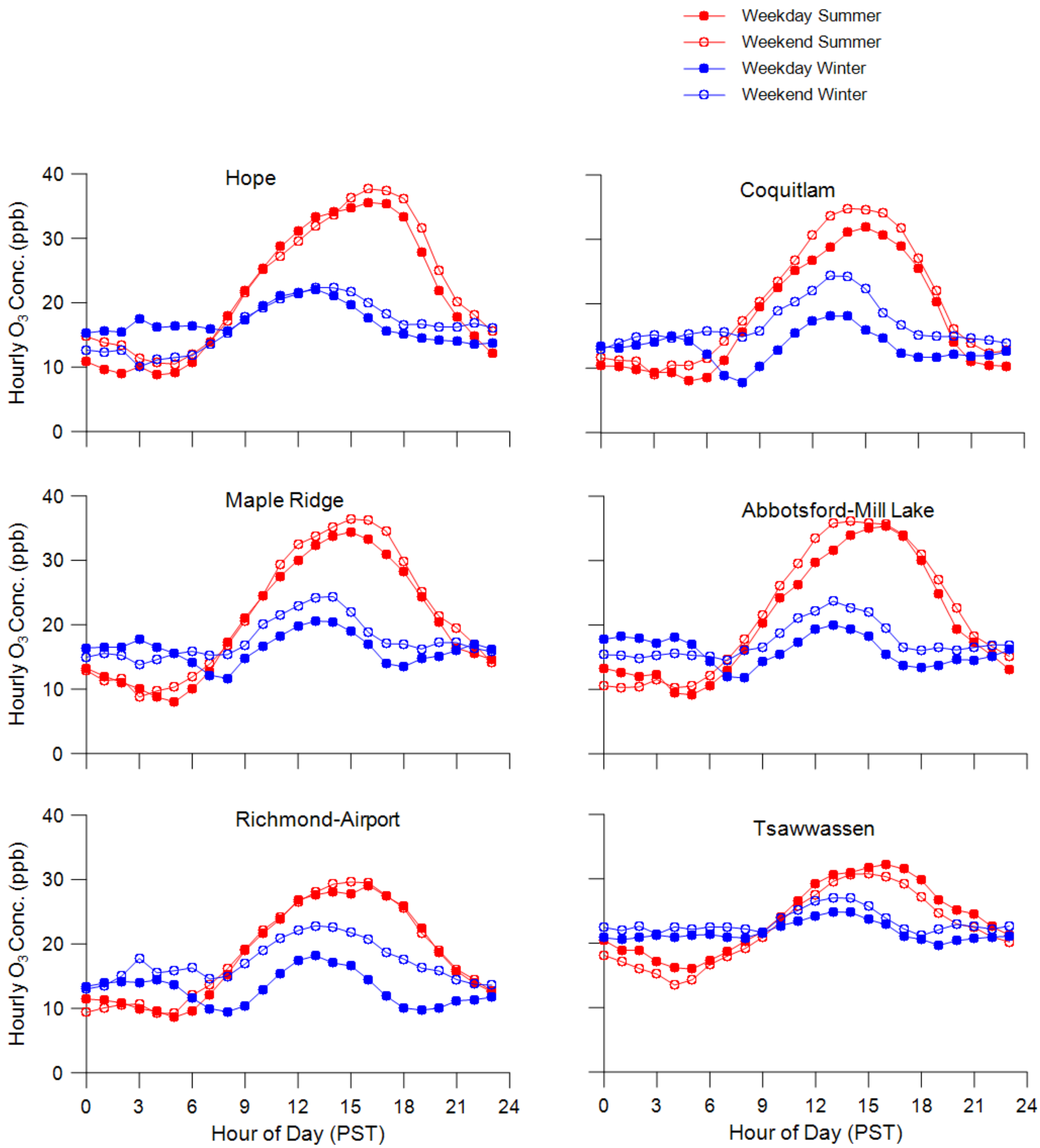
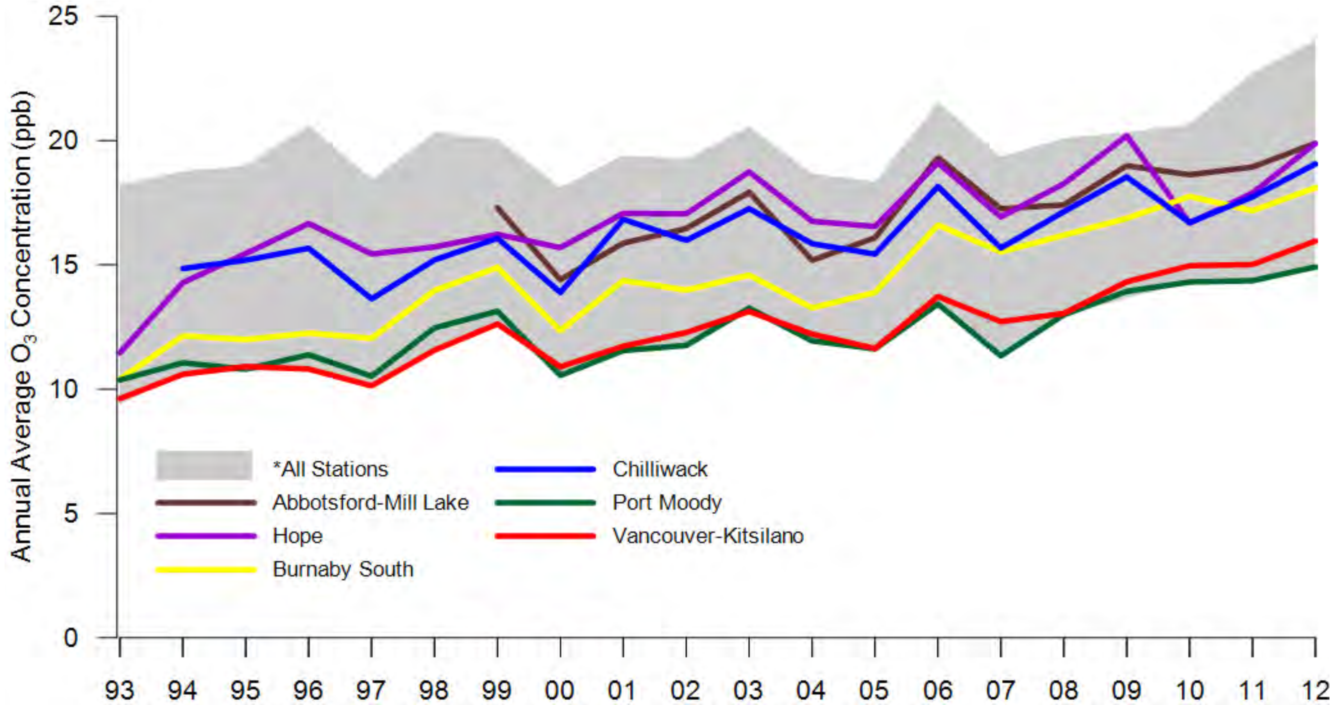
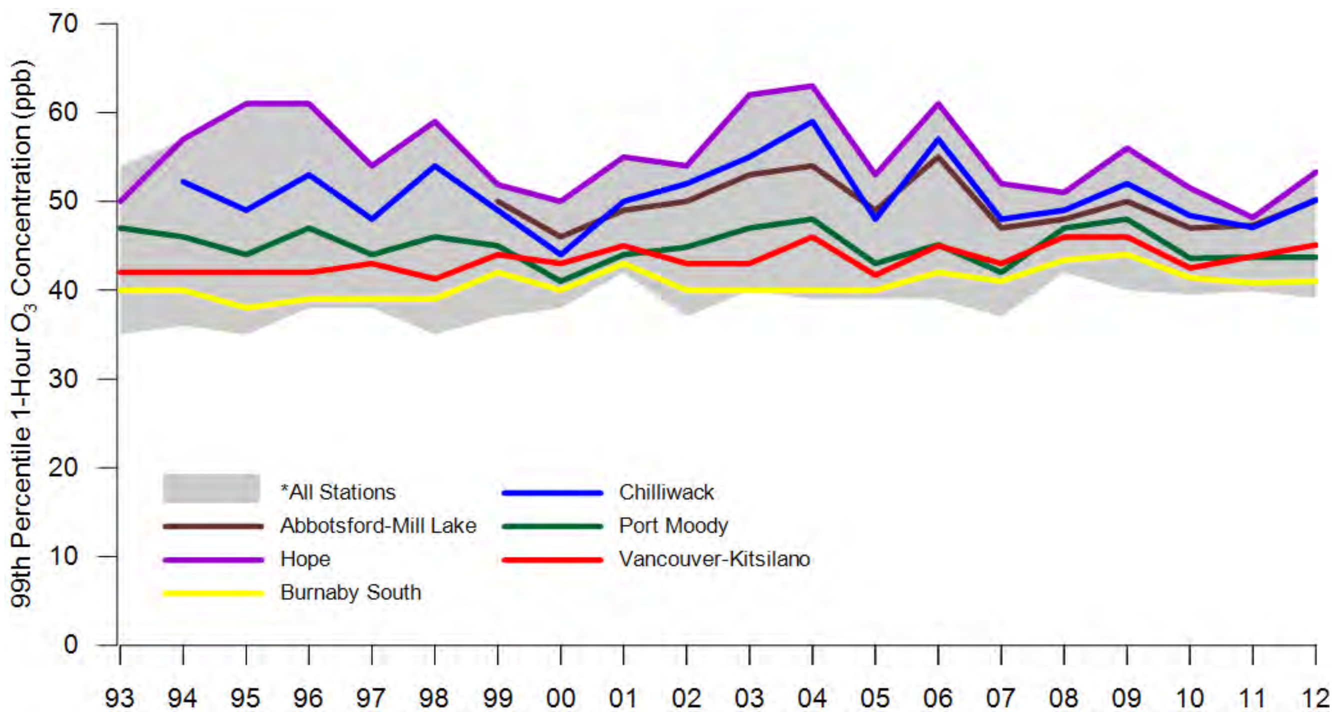


Figure 41: Cont. Diurnal trends ozone, 2012.



* Vancouver-Downtown (T1) and Burnaby Mountain (T14) stations not included.

Figure 42: Annual ozone trend, 1993 to 2012.



* Vancouver-Downtown (T1) and Burnaby Mountain (T14) stations not included.

Figure 43: Short-term peak ozone trend, 1993 to 2012.

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. 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

The $PM_{2.5}$ annual average, maximum 24-hour rolling average and Canada-Wide Standard values are shown in Figure 44 for 2012. The same values are shown spatially in Figures 45, 46 and 47, respectively. The annual averages were similar amongst the $PM_{2.5}$ monitoring locations with a value of less than 5 μg/m^3. These were all below the Metro Vancouver annual objective (8 μg/m^3) and planning goal (6 μg/m^3). Metro Vancouver's planning goal is a longer term aspirational target to support continuous improvement.

One station, North Delta, exceeded Metro Vancouver's 24-hour $PM_{2.5}$ objective in 2012. The exceedance occurred for several hours on November 11 due to elevated $PM_{2.5}$ occurring on the evening of November 10 and early morning of November 11 and reached a $PM_{2.5}$ concentration of 33 μg/m^3. The cause of this high $PM_{2.5}$ was thought to be the result of a local emission source as concentrations were significantly lower at other stations during this time.

All stations with sufficient data available to calculate a Canada-Wide Standard value were found to be below the Standard. Canada-Wide Standard values for 2012 ranged from 9 to 14 μg/m^3.

Elevated levels of regional $PM_{2.5}$ can occur during periods of hot weather. During hot and dry spells there is more potential for forest fire smoke and secondary PM. In 2012 summertime PM levels were better than the objective.

Table 8 gives the frequency distribution of $PM_{2.5}$ concentrations for the year. In 2012, North Delta experienced the greatest frequency of higher $PM_{2.5}$ concentrations (> 20 μg/m^3) which was thought to be the result of a local emission source noted above.

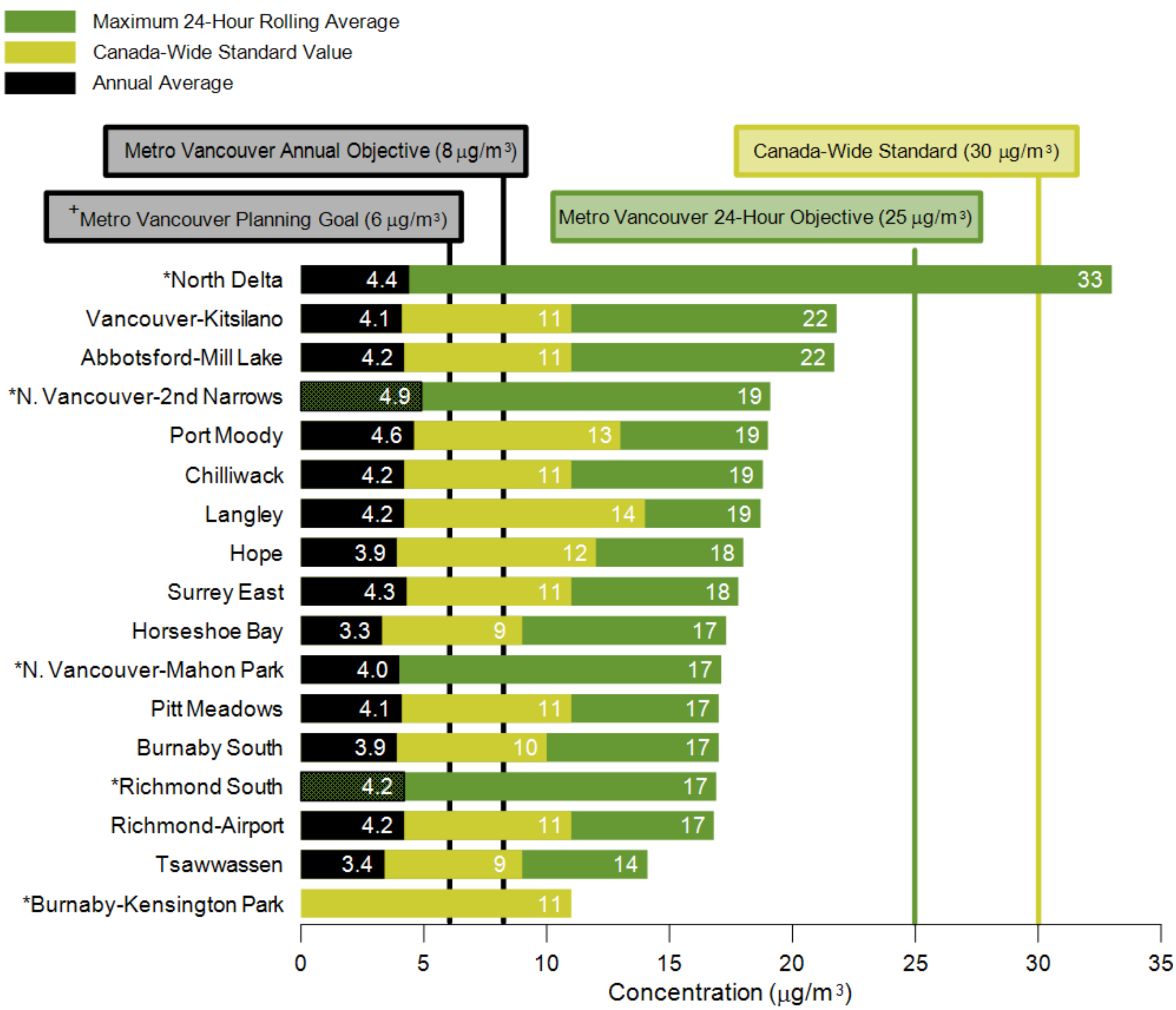
Seasonally, $PM_{2.5}$ levels are usually higher in the summer with the highest values typically experienced in July, August and September (Figure 48 and 49), due to secondary formation of $PM_{2.5}$ and smoke from forest fires. However, in 2012 peak levels were seen in November (North Delta) and May (Abbotsford-Mill Lake).

A series of diurnal plots are shown in Figure 50 for each $PM_{2.5}$ monitoring station. In the winter, weekdays exhibit slightly higher $PM_{2.5}$ concentrations than weekends, likely the result of greater human activities (traffic, outdoor burning, agricultural activities, industrial processes, etc.).

In the summer there was less difference between weekdays and weekends with the exception of N. Vancouver-2nd Narrows where there are known local industrial emission sources nearby. The peak seen at Chilliwack in summer on the weekend is likely attributed to two elevated hours experienced during an air show event at the airport.

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 99th percentile of the 24-hour rolling average for each year.

The differences in peak trends from year to year are likely driven by meteorological variability and forest fire activities. Overall, the average long-term trend shows little variation and shows a slight improvement.



* Data completeness criteria were not met at these stations and therefore some of the values have not been shown.

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

Figure 44: Fine particulate ($PM_{2.5}$), 2012.

Figure 45: Annual average fine particulate ($PM_{2.5}$) in the LFV, 2012.

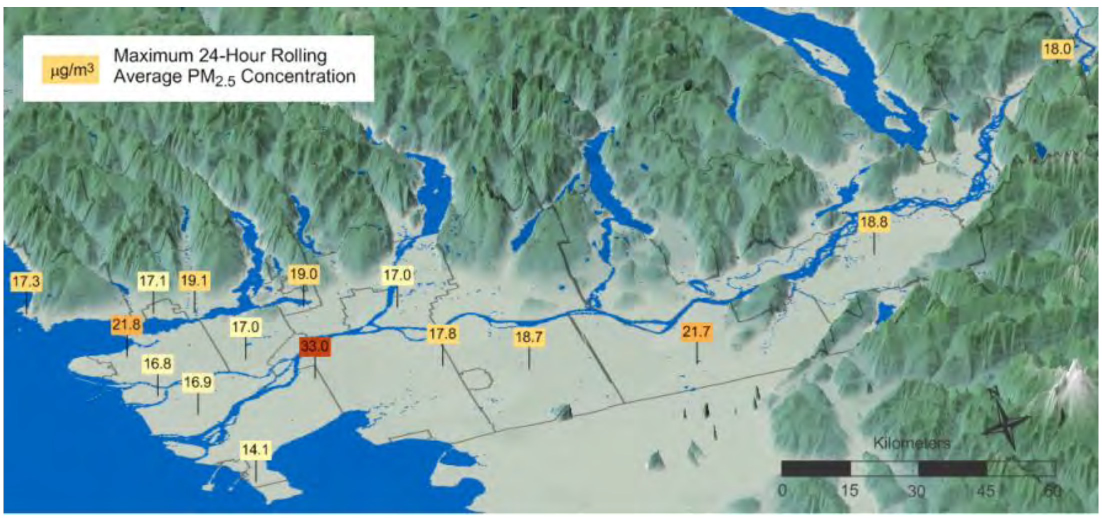


Figure 46: Short-term peak fine particulate ($PM_{2.5}$) in the LFV, 2012.

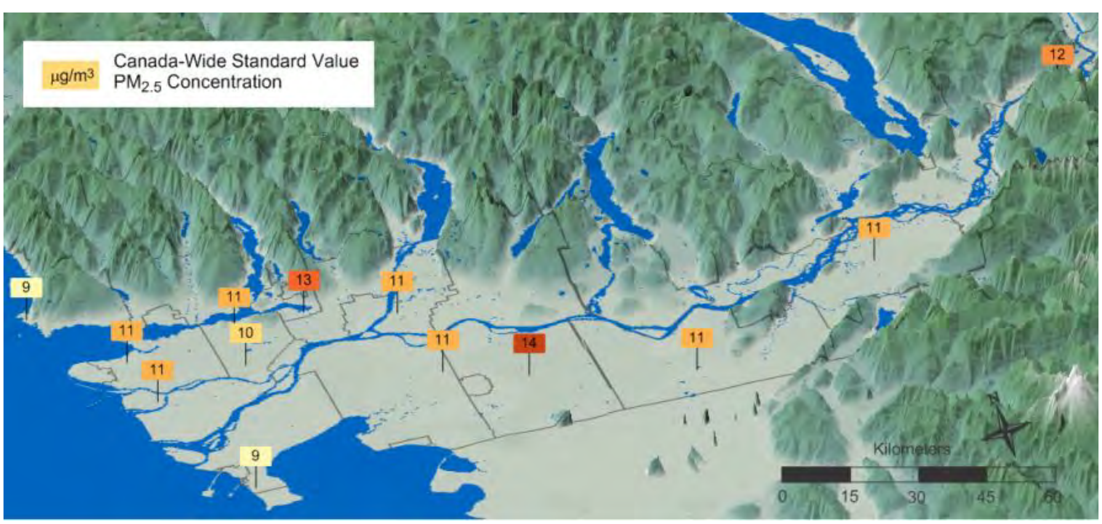


Figure 47: Canada-Wide Standard value for fine particulate ($PM_{2.5}$) in the LFV, 2012.

Table 8: Frequency distribution of 24-hour rolling average fine particulate ($PM_{2.5}$), 2012.

$PM_{2.5}$ Concentration ($\mu g/m^3$)	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
0 to 2	1686	1400	1027	1740	1787	1935	1730	1113	2049	2427	1977	2142	2571	1499	2301	2910	2393
2 to 4	3567	2343	2646	3129	3030	2902	3282	2668	3458	2829	3642	2871	3105	3351	2909	3312	3788
4 to 6	1747	1083	1893	1664	1840	1681	1781	1671	1701	1499	1457	1877	1477	2152	1693	1280	1683
6 to 8	784	443	858	946	816	1063	1078	647	795	872	765	951	651	894	953	550	521
8 to 10	302	291	594	670	398	489	356	272	376	657	340	362	308	364	342	250	158
10 to 12	128	82	261	280	194	200	205	167	159	207	158	242	234	219	251	78	151
12 to 14	123	56	114	121	106	130	150	52	85	97	117	144	87	96	163	63	27
14 to 16	73	26	92	94	17	72	50	31	34	97	91	63	81	19	42	55	3
16 to 18	5	41	70	73	8	13	13	7	8	17	23	17	42	5	10	14	
18 to 20	4		26	17	3	7						8	2		10		
20 to 22	17					3									16		
22 to 24																	
24 to 26						2											
26 to 28						1											
28 to 30						2											
30 to 32						3											
32 to 34						15											
>=34																	
Missing	348	3019	1203	50	585	266	139	2156	119	82	214	107	226	185	94	272	60
Data Completeness	96%	66%	86%	99%	93%	97%	98%	76%	99%	99%	98%	99%	97%	98%	99%	97%	99%

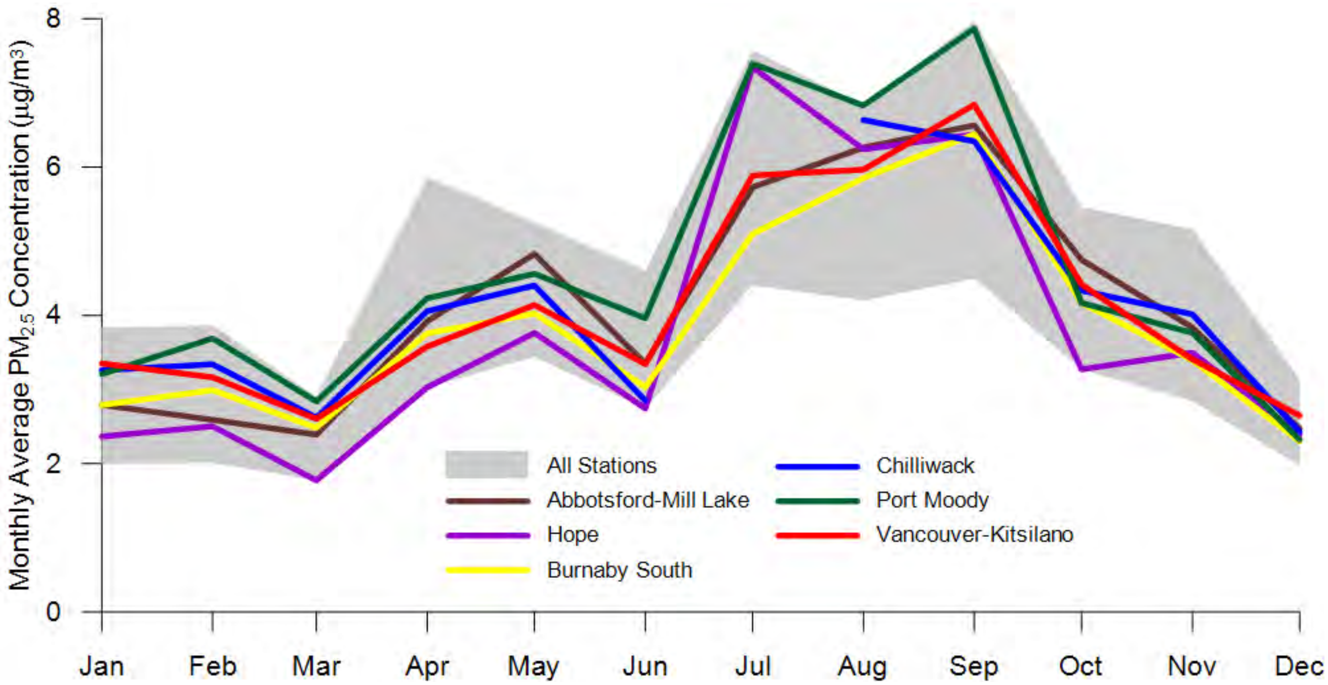


Figure 48: Monthly average fine particulate ($PM_{2.5}$), 2012.

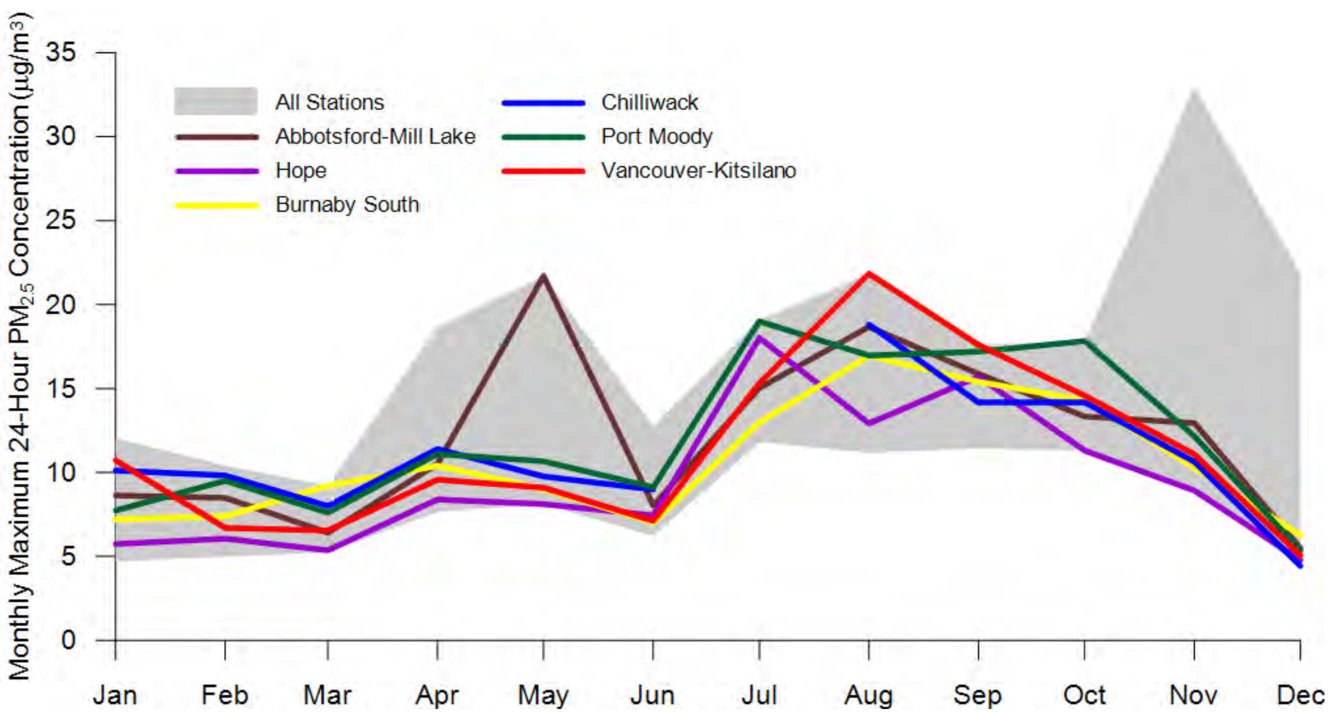
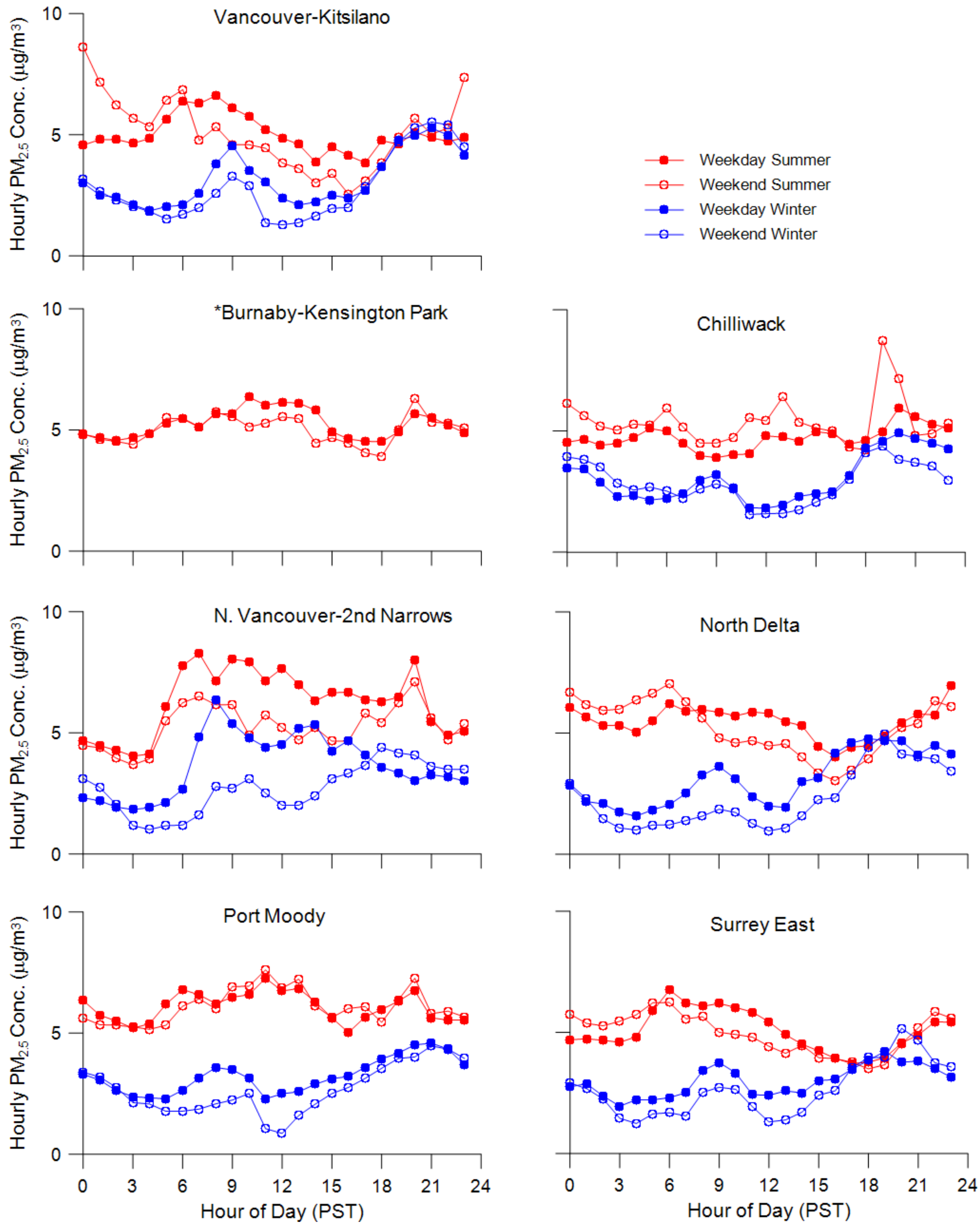
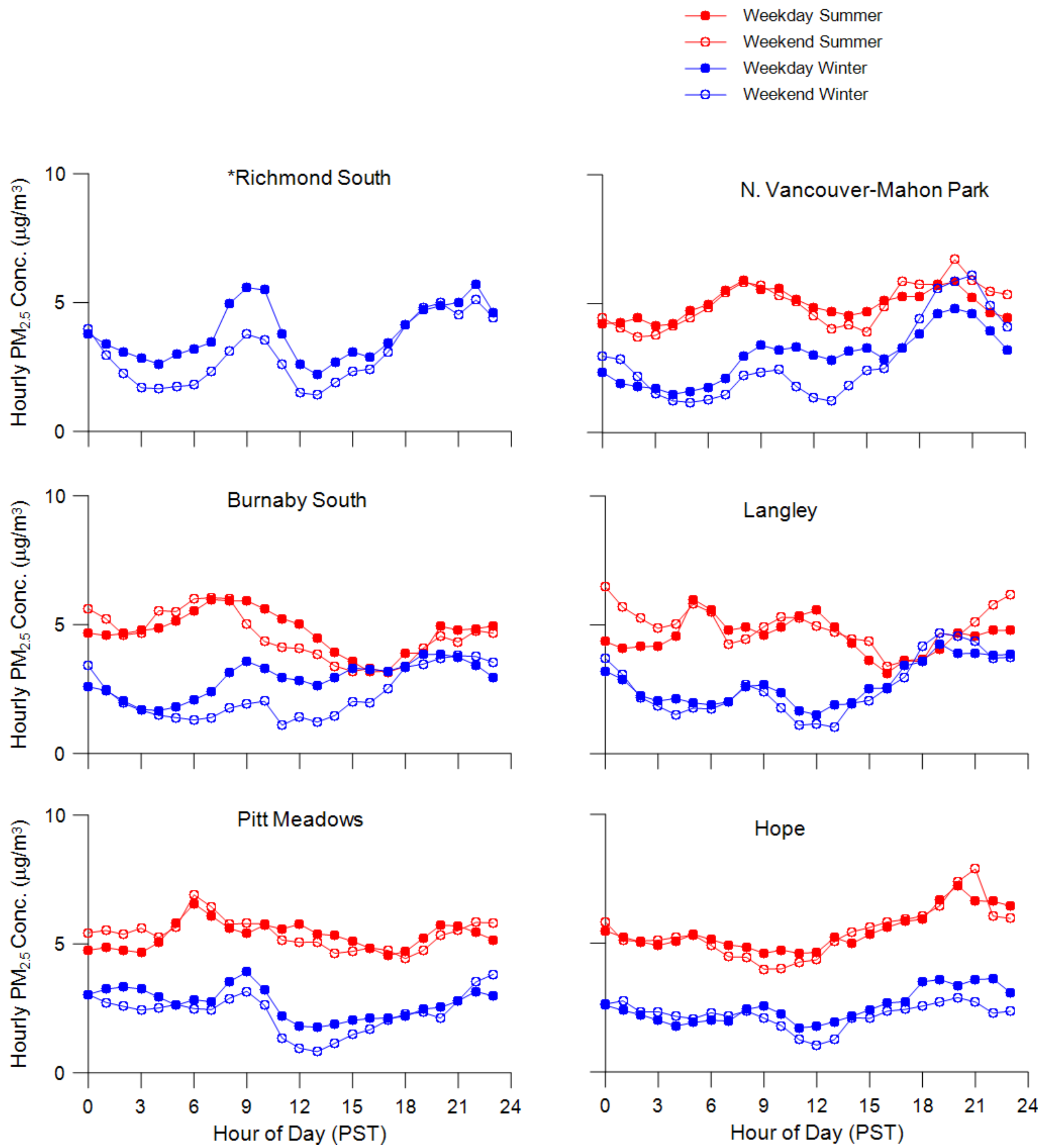


Figure 49: Monthly short-term peak fine particulate ($PM_{2.5}$), 2012.



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

Figure 50: Diurnal trends fine particulate ($PM_{2.5}$), 2012.



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

Figure 50: Cont. Diurnal trends fine particulate ($PM_{2.5}$), 2012.

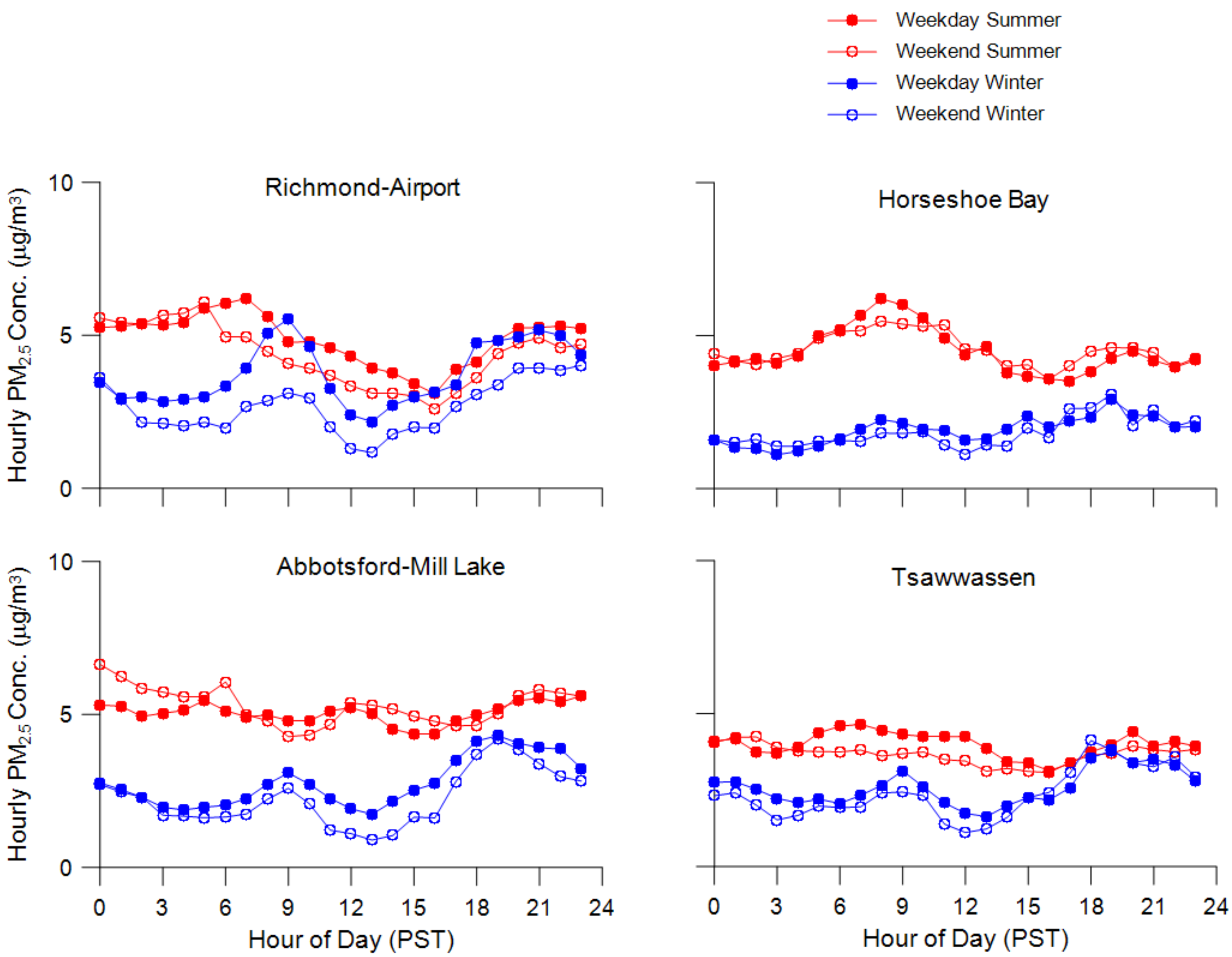
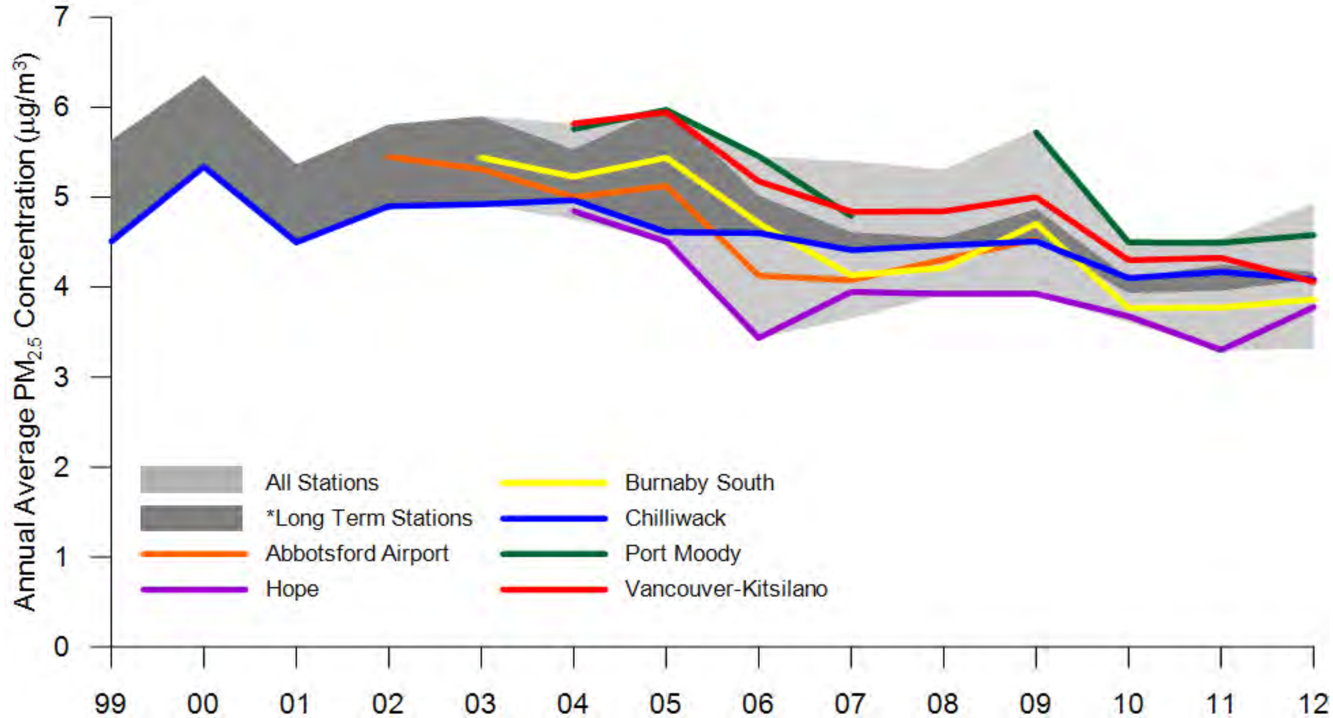
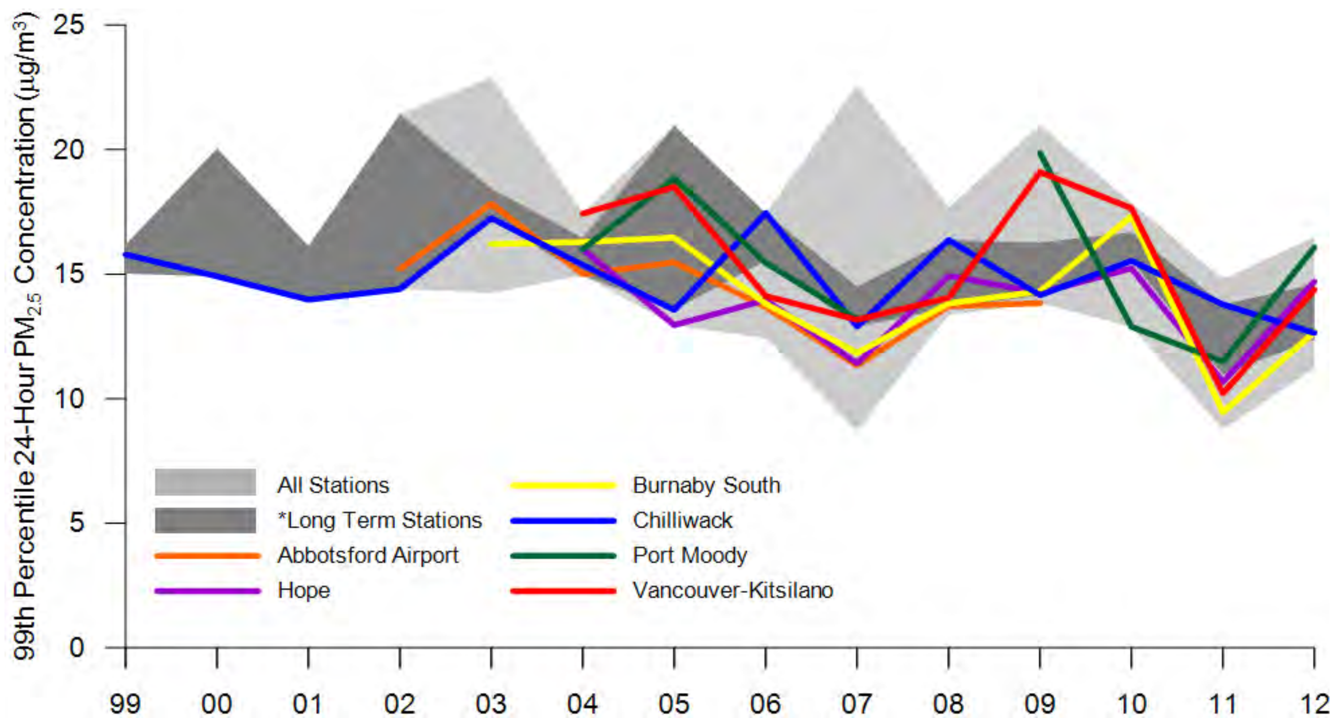


Figure 50: Cont. Diurnal trends fine particulate ($PM_{2.5}$), 2012.



*The long-term stations include Chilliwack, Pitt Meadows, and Richmond Airport which were the first three stations to continuously measure $PM_{2.5}$ in the region.

Figure 51: Annual fine particulate ($PM_{2.5}$) trend, 1999 to 2012.



*The long-term stations include Chilliwack, Pitt Meadows, and Richmond Airport which were the first three stations to continuously measure $PM_{2.5}$ in the region.

Figure 52: Short-term peak fine particulate ($PM_{2.5}$) trend, 1999 to 2012.

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 2012, 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 Chilliwack station in 2012 on October 9.

Table 9 gives the frequency distribution of various PM_{10} concentrations for the year. It can be seen that Chilliwack and Burnaby South experienced the greatest frequency of high PM_{10} concentrations (>30 $\mu g/m^3$).

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

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.

At most stations, in both the winter and summer, 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 1994 to 2012. 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 the dust carried to the LFV by the wind patterns at the time. The 2005 peak was the result of a large fire in Burns Bog located in Delta.

Table 9: Frequency distribution of 24-hour rolling average inhalable particulate (PM_{10}), 2012.

PM_{10} Concentration ($\mu g/m^3$)	Burnaby-Kensington Park	Port Moody	Chilliwack	Burnaby South	Pitt Meadows	Burnaby North	Langley	Hope	Richmond-Airport	Abbotsford-Mill Lake
0 to 3	101	3	18	15	100	10	113	41	0	2
3 to 6	1200	1141	1487	966	836	2050	1458	2232	597	712
6 to 9	2208	2625	2715	2800	1557	2854	2714	2740	2840	1370
9 to 12	1254	1792	1681	1731	1032	1524	1666	1412	2360	877
12 to 15	448	1079	912	1106	454	1018	909	800	1242	510
15 to 18	306	566	752	867	299	646	568	570	879	344
18 to 21	204	362	463	481	186	288	285	414	326	200
21 to 24	100	210	355	281	122	230	133	283	229	69
24 to 27	37	127	224	199	118	104	92	131	135	3
27 to 30	33	46	83	146	24	13	36	5	27	
30 to 33			23	34			2			
33 to 36			3	36						
36 to 39			1	10						
39 to 42			6							
42 to 45			5							
45 to 48			4							
48 to 51			7							
>=51										
Missing	2893	833	45	112	4056	47	808	156	149	4697
Data Completeness	67%	91%	100%	99%	54%	100%	91%	98%	98%	47%

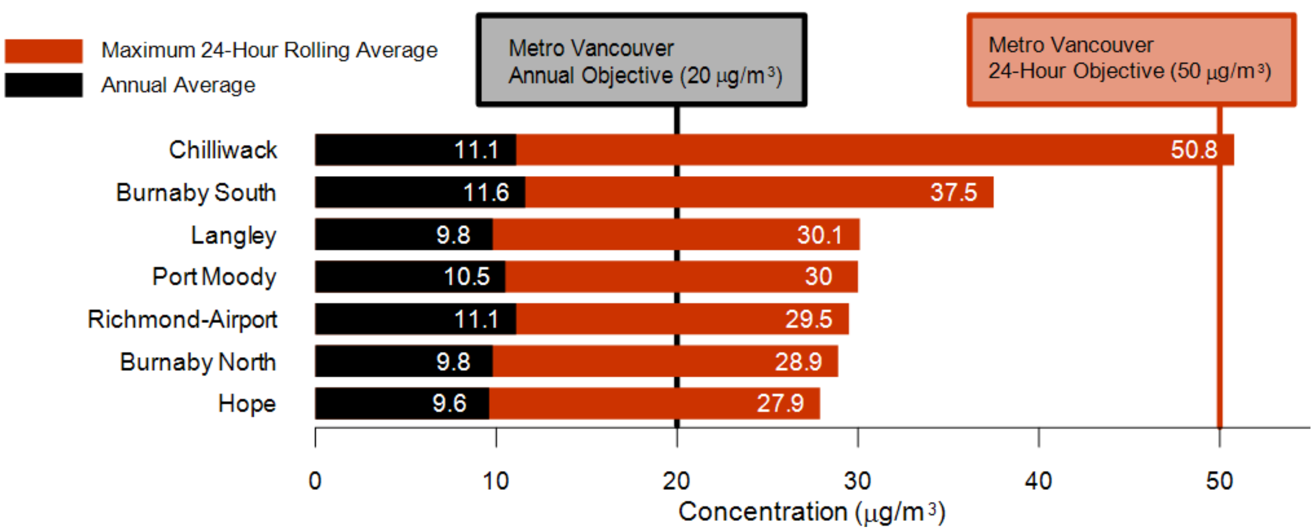


Figure 53: Inhalable particulate (PM_{10}) monitoring, 2012.

Figure 54: Annual average inhalable particulate (PM_{10}) in the LFV, 2012.

Figure 55: Short-term peak inhalable particulate (PM_{10}) in the LFV, 2012.

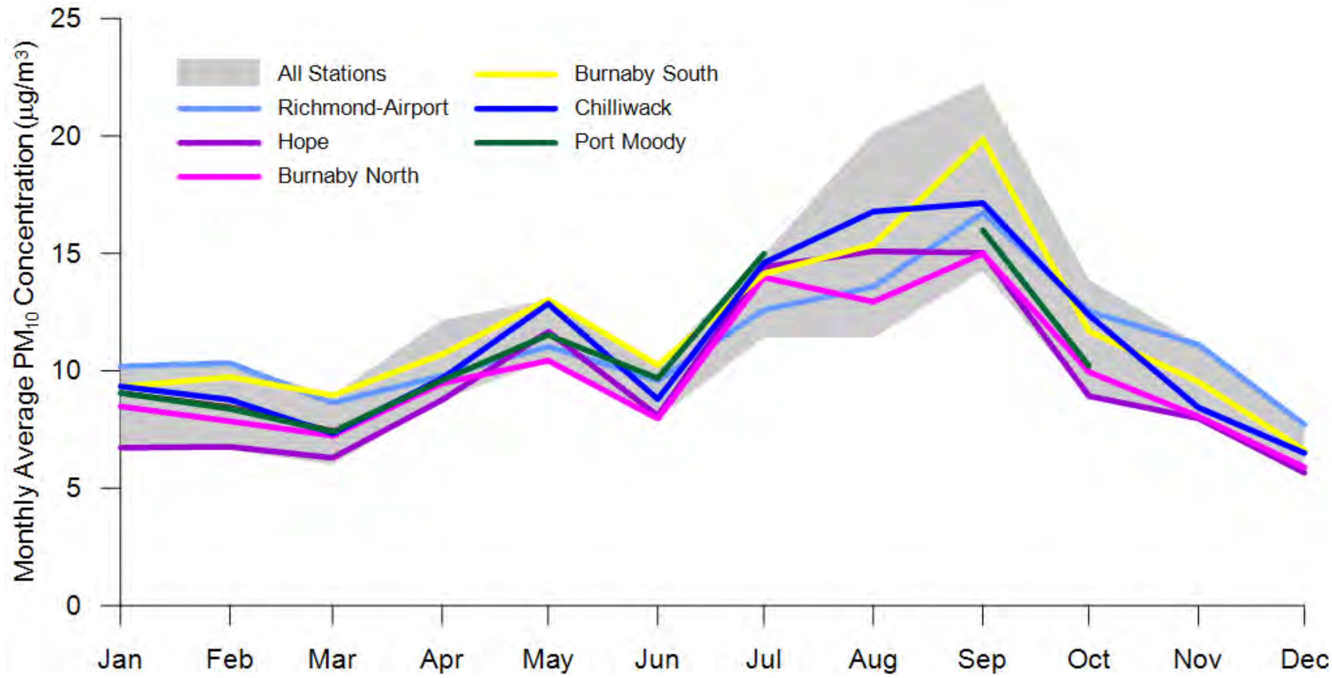


Figure 56: Monthly average inhalable particulate (PM_{10}), 2012.

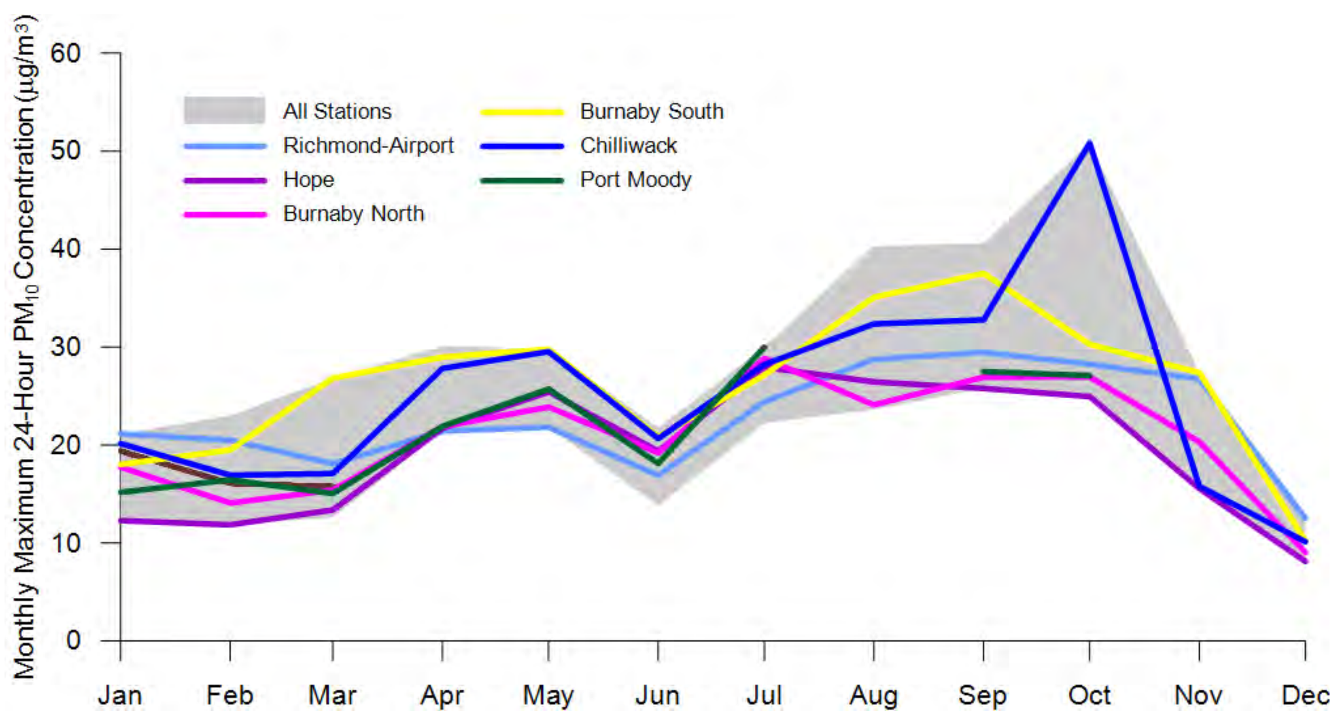


Figure 57: Monthly short-term peak inhalable particulate (PM_{10}), 2012.

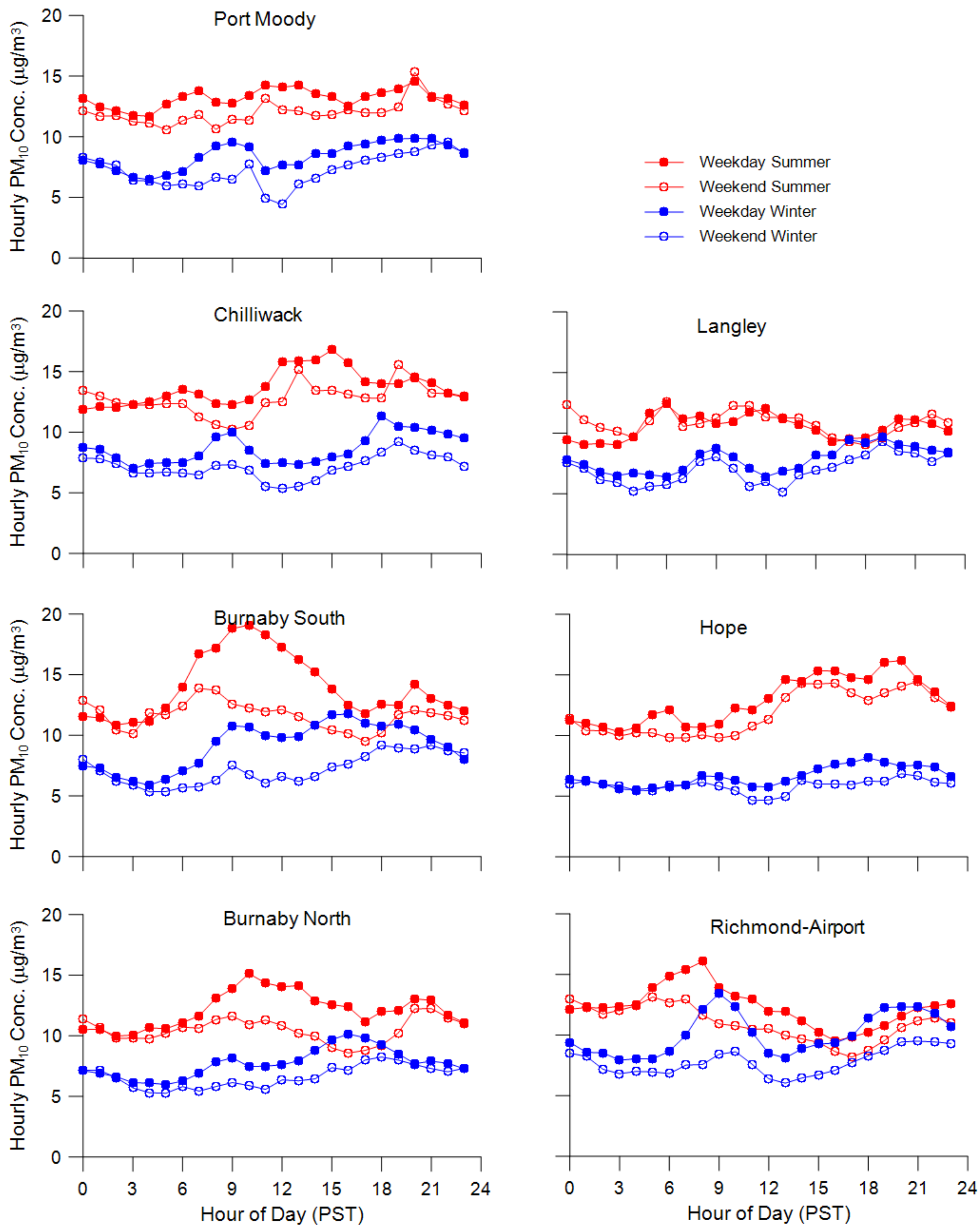


Figure 58: Diurnal trends inhalable particulate (PM_{10}), 2012.

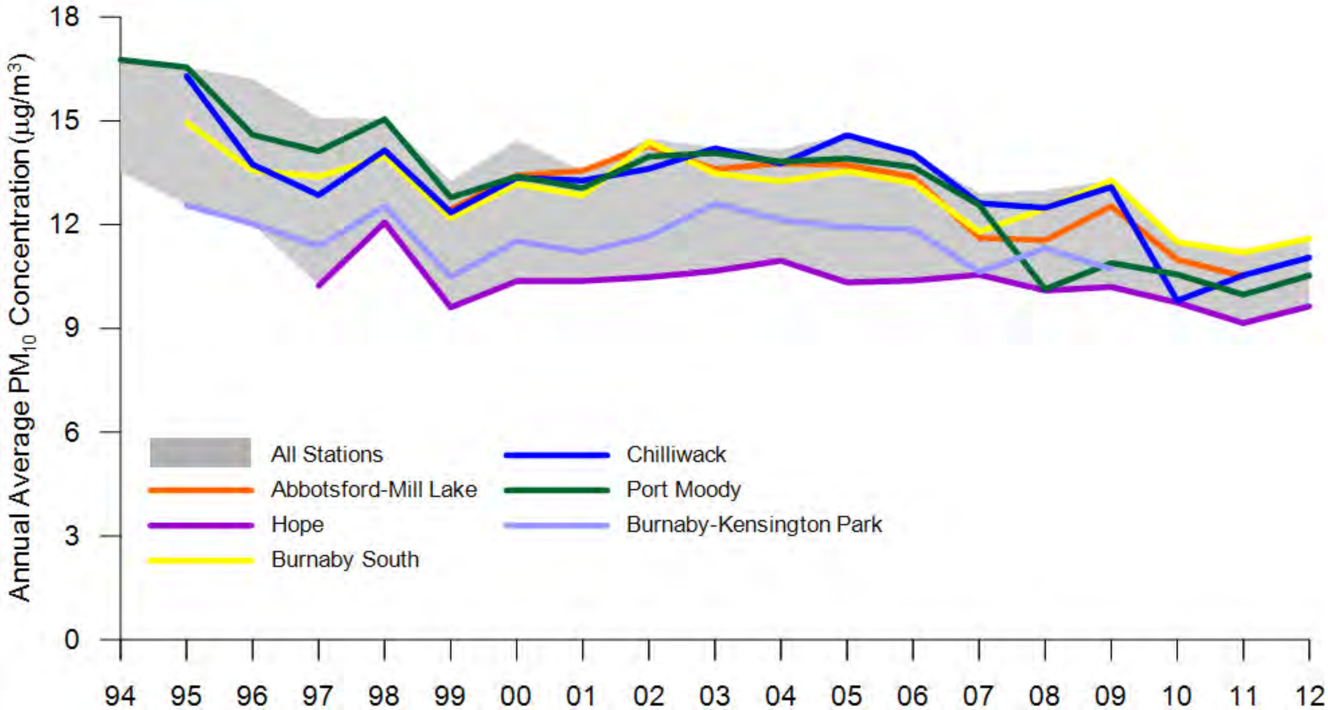


Figure 59: Annual average inhalable particulate (PM_{10}) trend, 1994 to 2012.

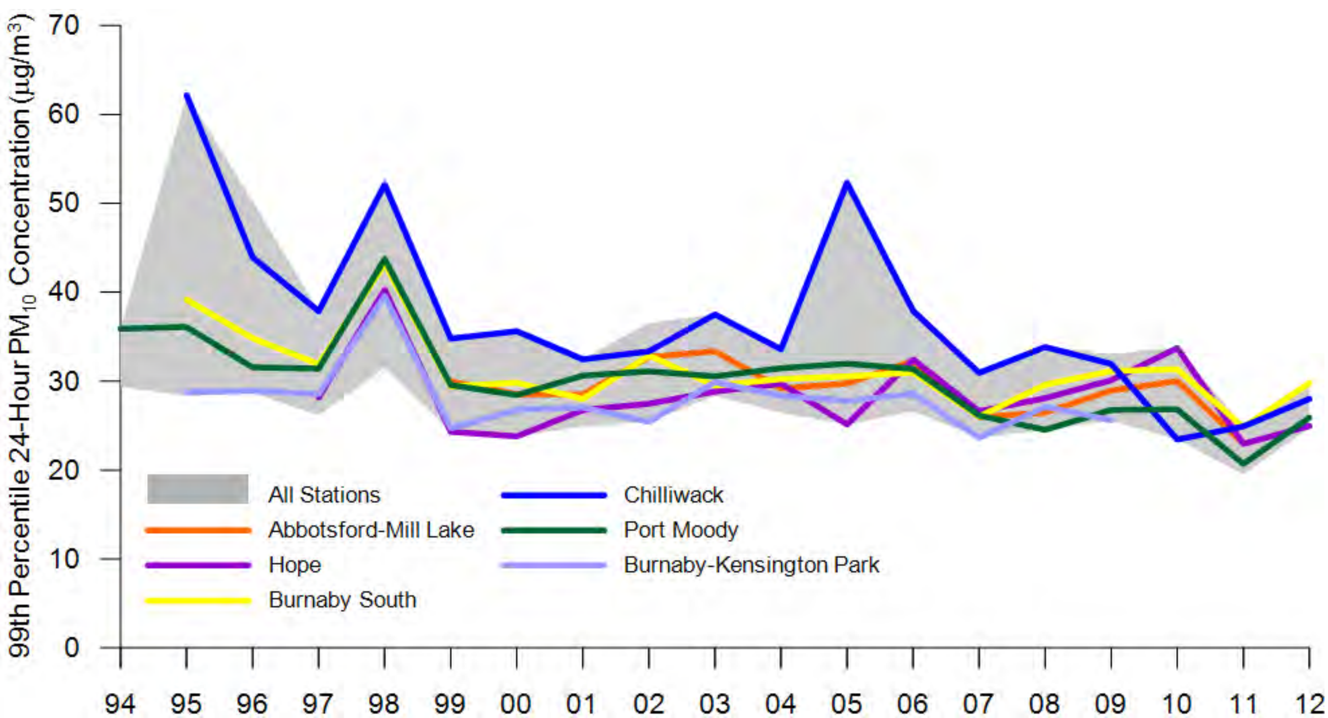


Figure 60: Short-term peak inhalable particulate (PM_{10}) trend, 1994 to 2012.

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 approximately one million times more energy than carbon dioxide (CO_2), per unit of mass in the atmosphere. 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 of BC emission 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 2012. 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 or standards for black carbon. The highest 1-hour average BC concentration occurred in Burnaby South, 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 August, September and November with the highest peak level occurring in April. In a year where forest fire impacts were largely absent, the seasonal trend is likely dominated by local emissions sources.

Black carbon is generally greater on weekdays compared with weekends, shown in Figure 64. This trend is especially evident at the industrial station, North Vancouver – Second Narrows where large values of BC are seen on weekdays with smaller values experienced on weekends.

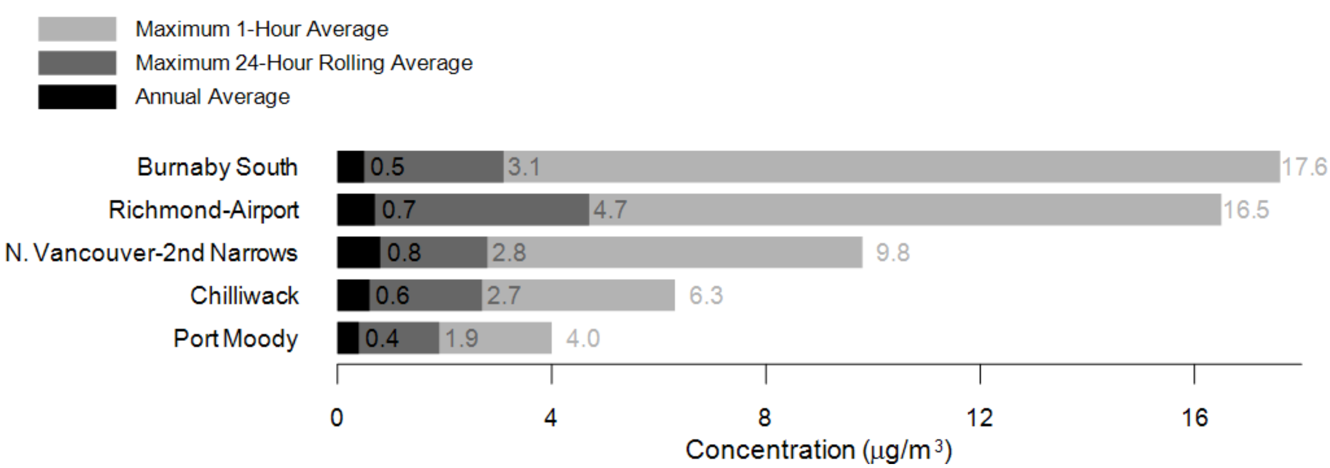


Figure 61: Black carbon monitoring, 2012.

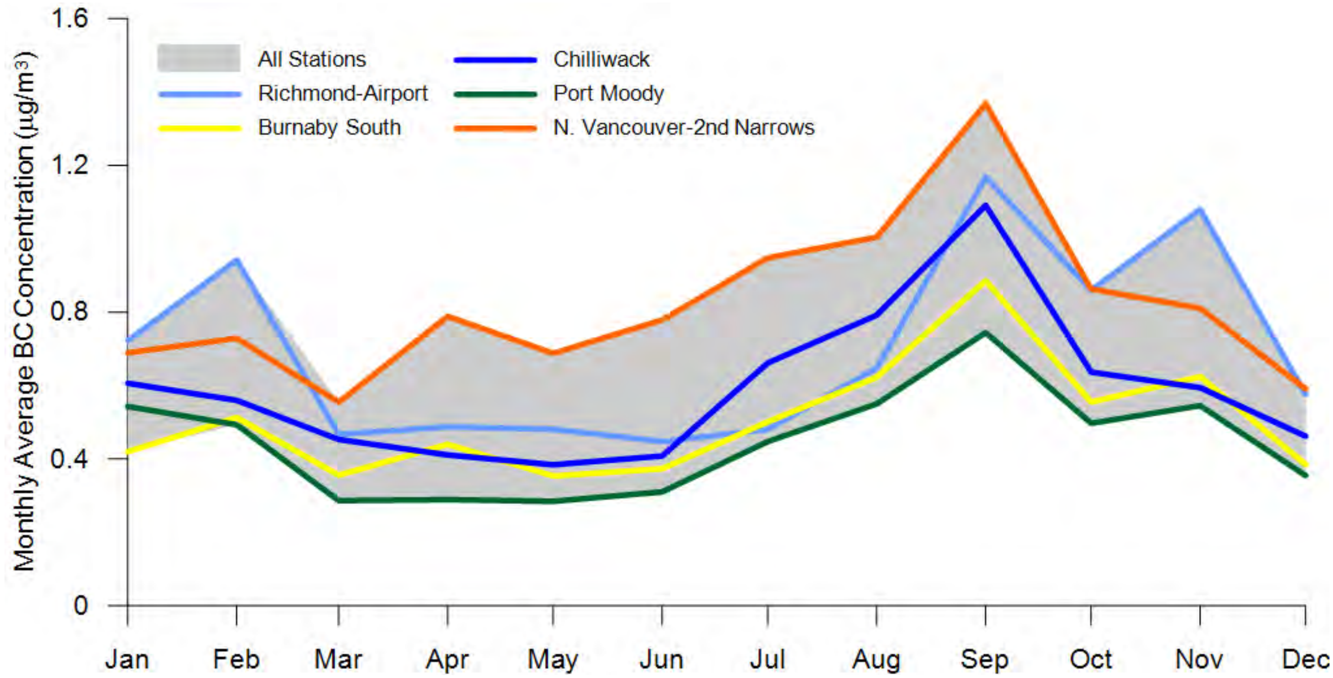


Figure 62: Monthly average black carbon, 2012.

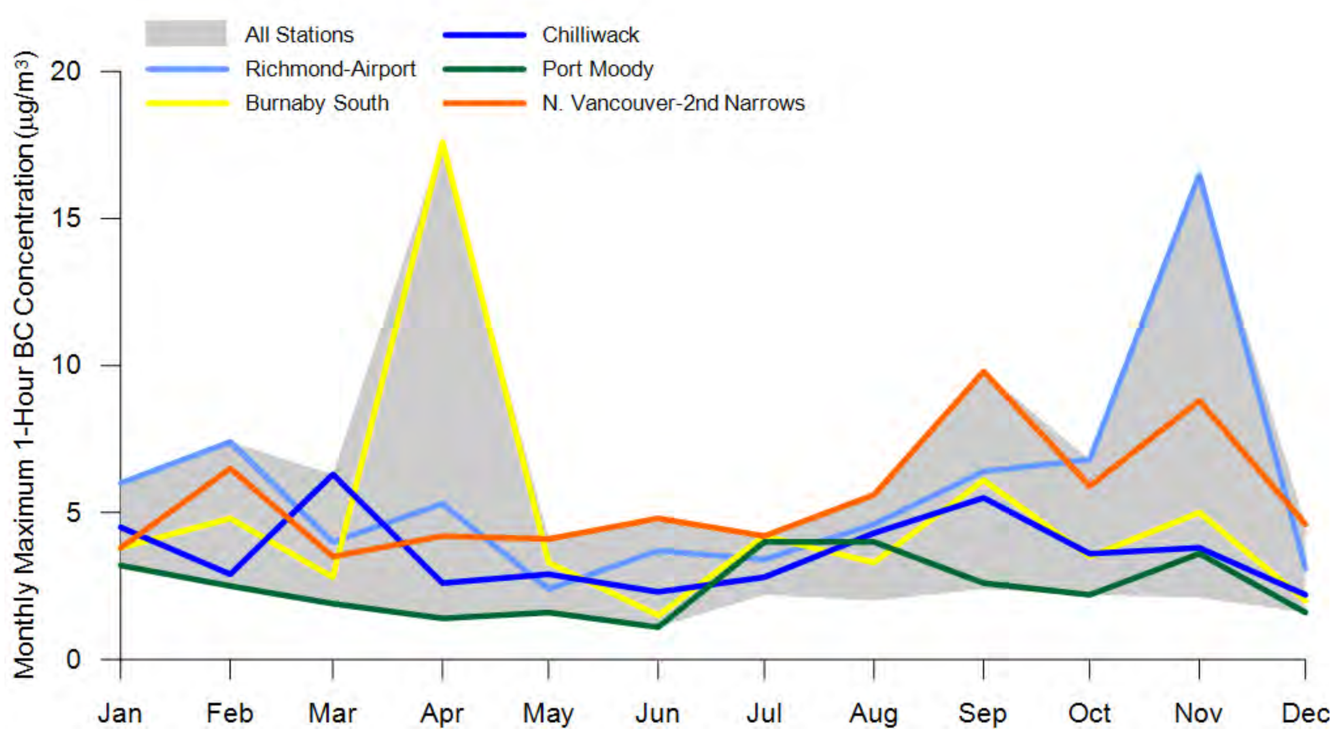
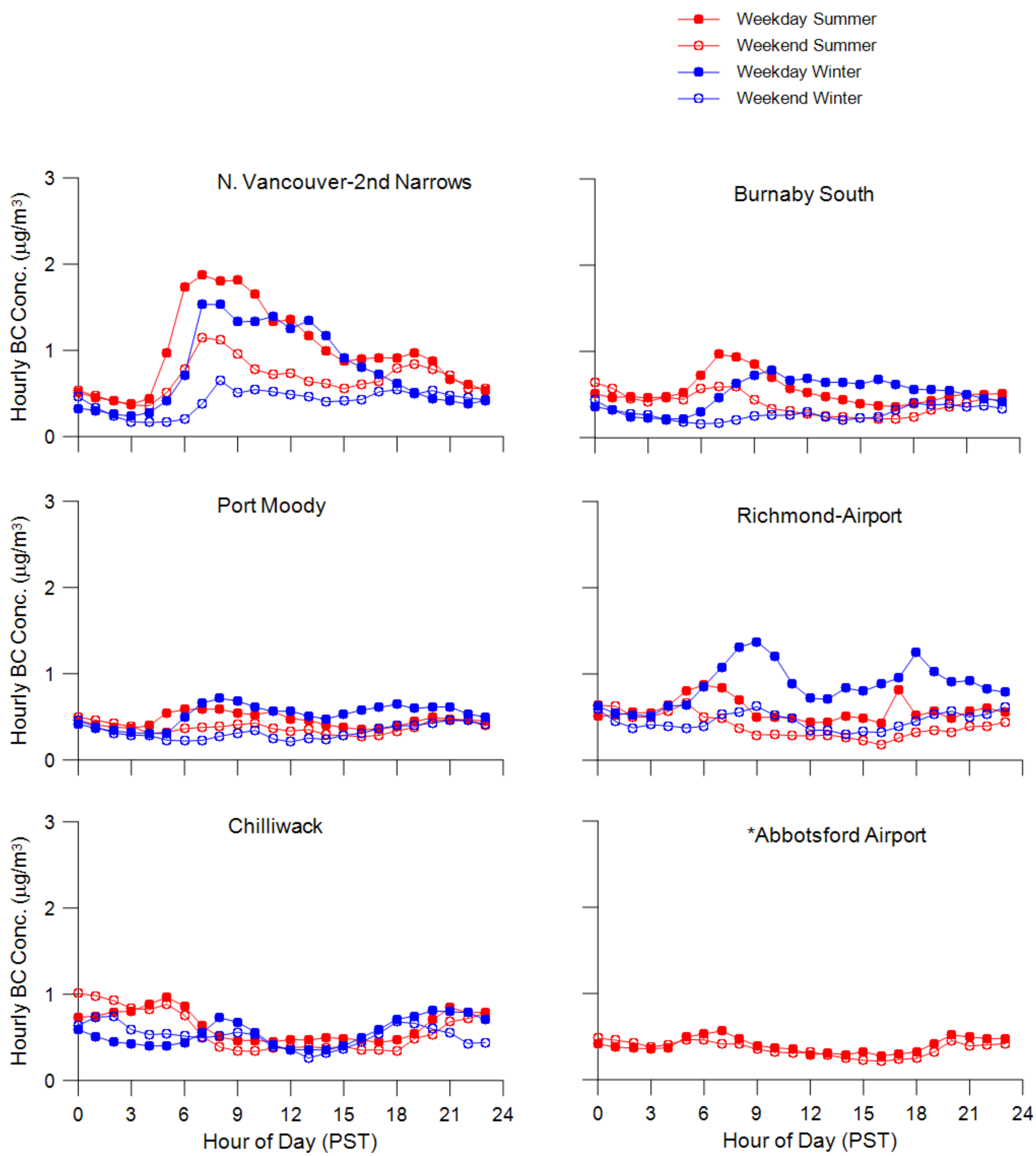


Figure 63: Monthly short-term peak black carbon, 2012.



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

Figure 64: Diurnal trends black carbon, 2012.

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 2012. Average levels continued to be near or below detectable limits. Peak levels during 2012, indicated by the maximum 1-hour value, exceeded the Desirable Objective for a total of 20 hours at Port Moody. The Acceptable Objective was also exceeded for 1 hour at this station. 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 with a few in the summer and fall.

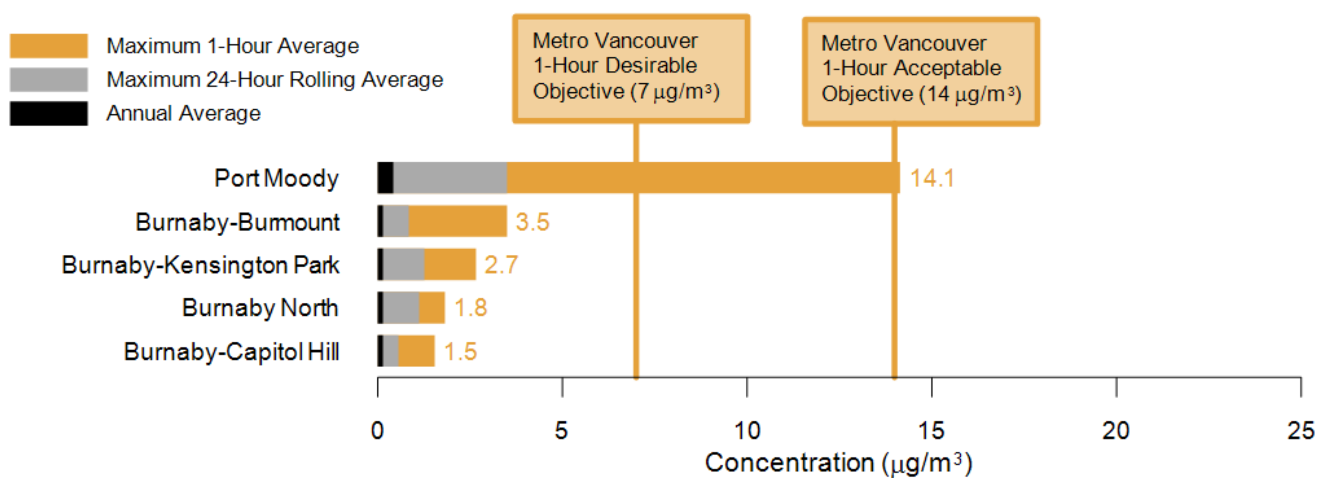


Figure 65: Total reduced sulphur monitoring, 2012.

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.

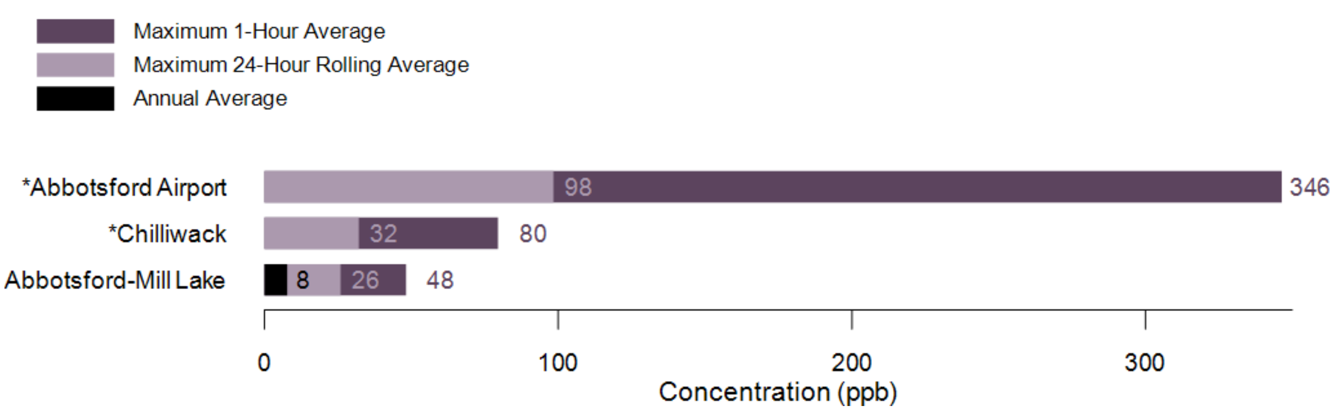
Sources

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 2012. The data for 2012 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 year-to-year trend in ammonia is evident.



*Abbotsford Airport and Chilliwack did not meet the data completeness requirements in 2012.

Figure 66: Ammonia monitoring, 2012.

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 2012 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 third or 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 material 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 2012, 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 2012, 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 effects of clouds, fog, rain or mist on our views.

Studies conducted in the region show 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 four locations: Chilliwack, Abbotsford, Burnaby 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 has the most influence on average light extinction, and consequently visual air quality impairment.

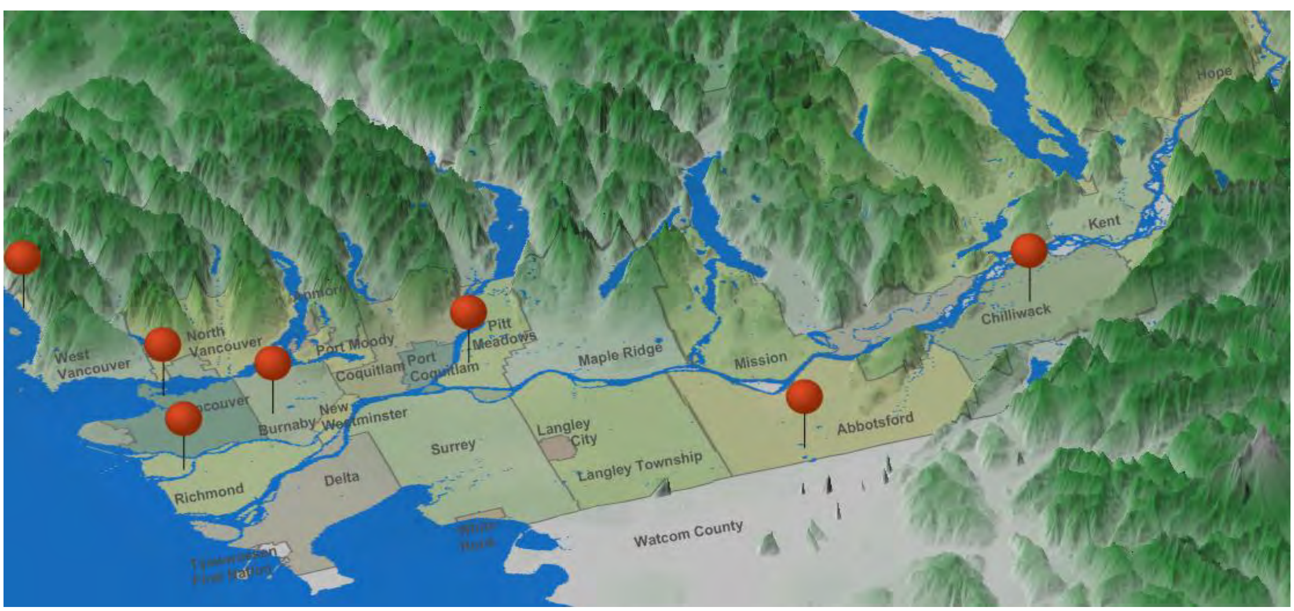


Figure 67: Visual air quality monitoring locations in the LFV, 2012.

Nine automated digital cameras are operated in six locations across Metro Vancouver and the FVRD: Chilliwack, Abbotsford, Pitt Meadows, Burnaby, Vancouver 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 2012 are shown in Figure 68.

Live images from 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 defined scenes to air contaminant concentrations and $PM_{2.5}$ composition. The information gathered by the visual air quality monitoring network is being used to further our understanding of visual air quality in the region.

Pilot Project

Metro Vancouver is a partner in the BC Visibility Coordinating Committee (BCVCC) with the FVRD, Environment Canada, Health Canada and BC Ministry of Environment. A pilot project is being conducted in the LFV by the BCVCC to develop a visual air quality management strategy for the region.

As part of the pilot, improvements have been made to the monitoring capacity which will 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 how to reduce air contaminant concentrations to improve visual air quality.

- Survey studies using photos captured by visual air quality monitoring equipment indicate that people perceive degraded visual air quality even at low air contaminant concentrations, less than Metro Vancouver's ambient air quality objective for $PM_{2.5}$.

- A visual air quality metric is being developed to measure and report visual air quality conditions.

Figure 68: Images at Chilliwack showing an excellent, good and poor day, respectively (Summer 2012).

Section G – Meteorological Measurements

Purpose

An understanding of meteorology is integral in understanding and forecasting air quality and visual air quality patterns. Often the state of the atmosphere determines how pollutants disperse 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 mount meteorological instruments so that spatially representative measurements are observed, 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. Air temperature measurements throughout the network can also indicate the presence of a temperature inversion, which confines pollutants close to the ground.

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.

Humidity is an important factor 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.

Meteorological Observations

Figure 69 shows the precipitation totals for 2012 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 grey 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.

Overall in 2012, precipitation amounts observed were fairly typical with the exception of a drier August and September and wetter October.

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 collected in 2012 suggest that temperatures recorded in March and June were slightly cooler than the 30-year average. During these months lower averages and daily maximums were experienced compared with the climate normals. November was slightly warmer than normal with slightly higher daily maximums compared with the climate normals. The highest air temperature was measured in August.

Table 10 provides the average temperature along with the lowest and highest hourly air temperatures observed during the year at each station. Air temperatures are milder near the water and exhibit a greater range inland. The highest hourly temperature in 2012, observed at Maple Ridge with a value of 34.2^{o}C, occurred on the same day as the highest 1-hour maximum ozone concentration measured at Maple Ridge.

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, Langley, Abbotsford-Mill Lake, Chilliwack, and Hope. The patterns shown during 2012 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 2012 was fairly typical with the exception of a drier than normal August and September and a wetter October.

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. Langley and Abbotsford both exhibit predominant winds from the south or south-west, a result of their location in the valley. 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.

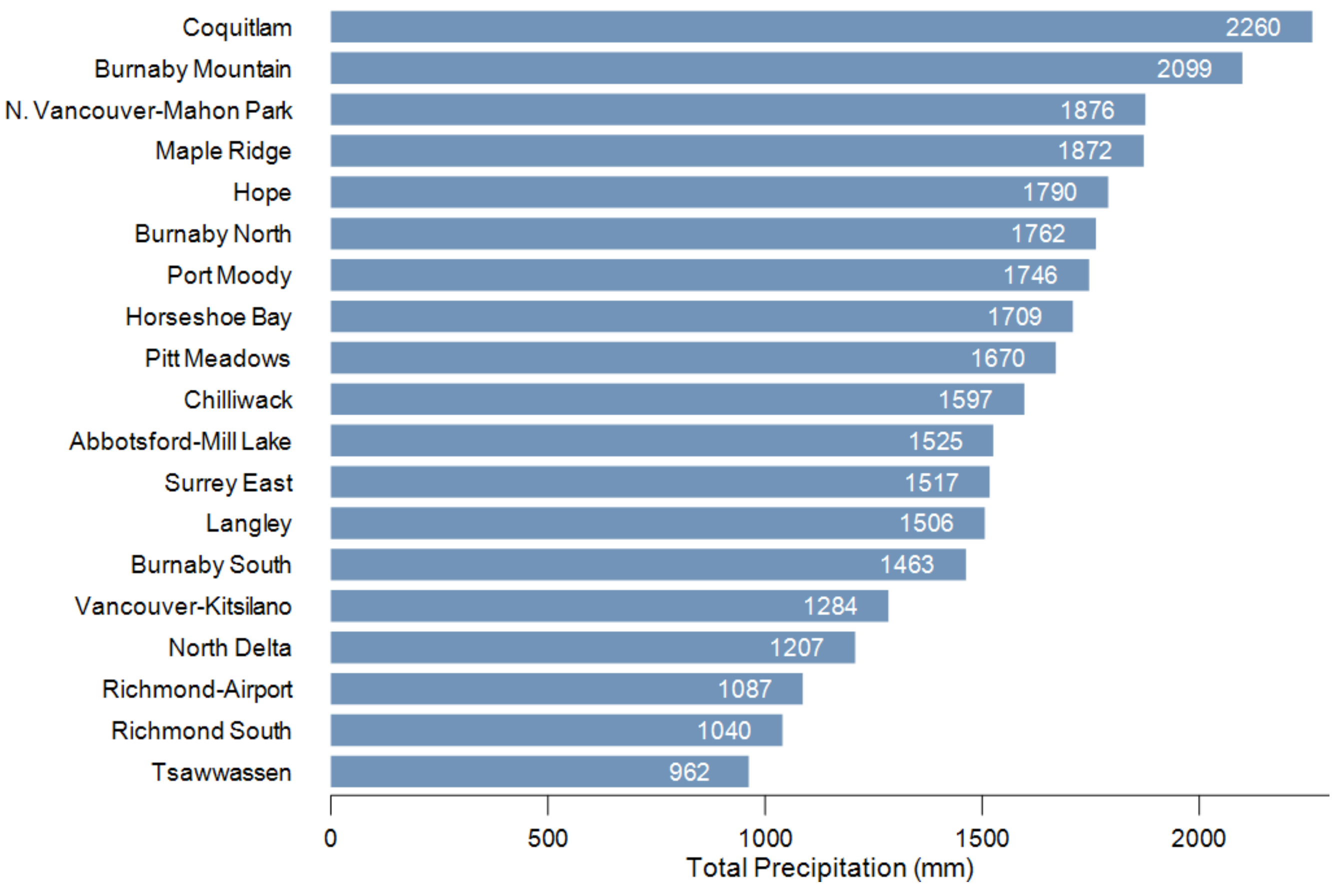
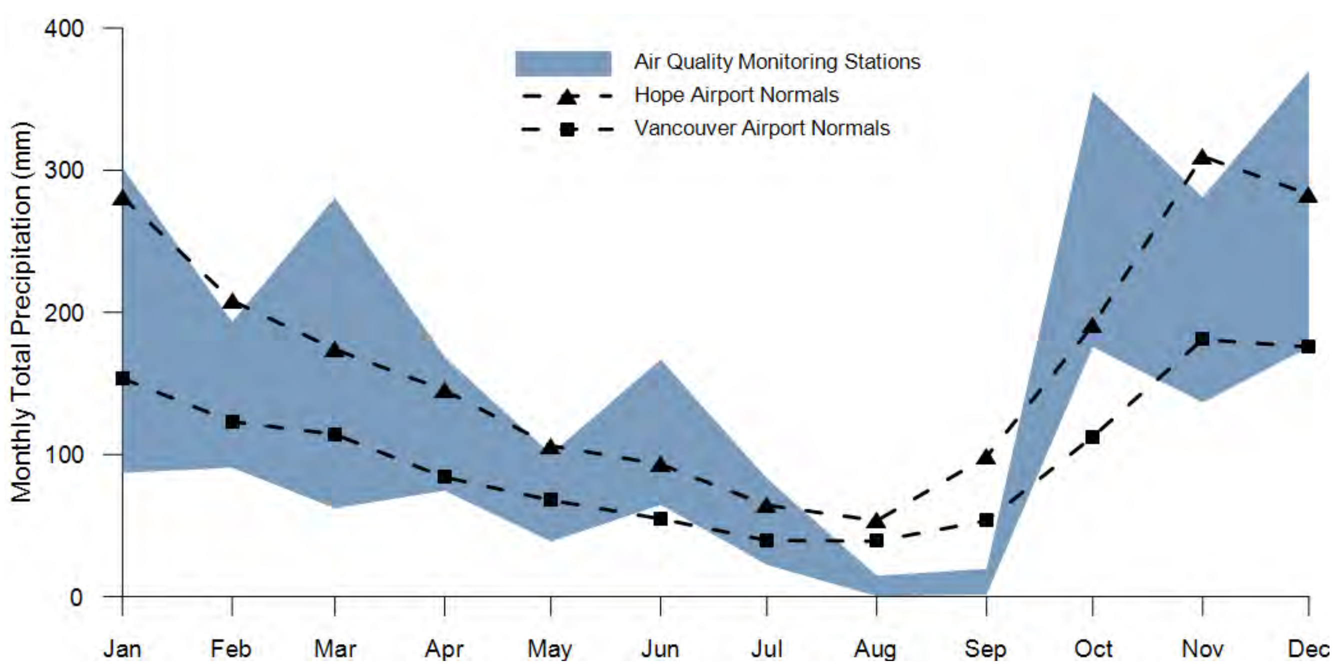
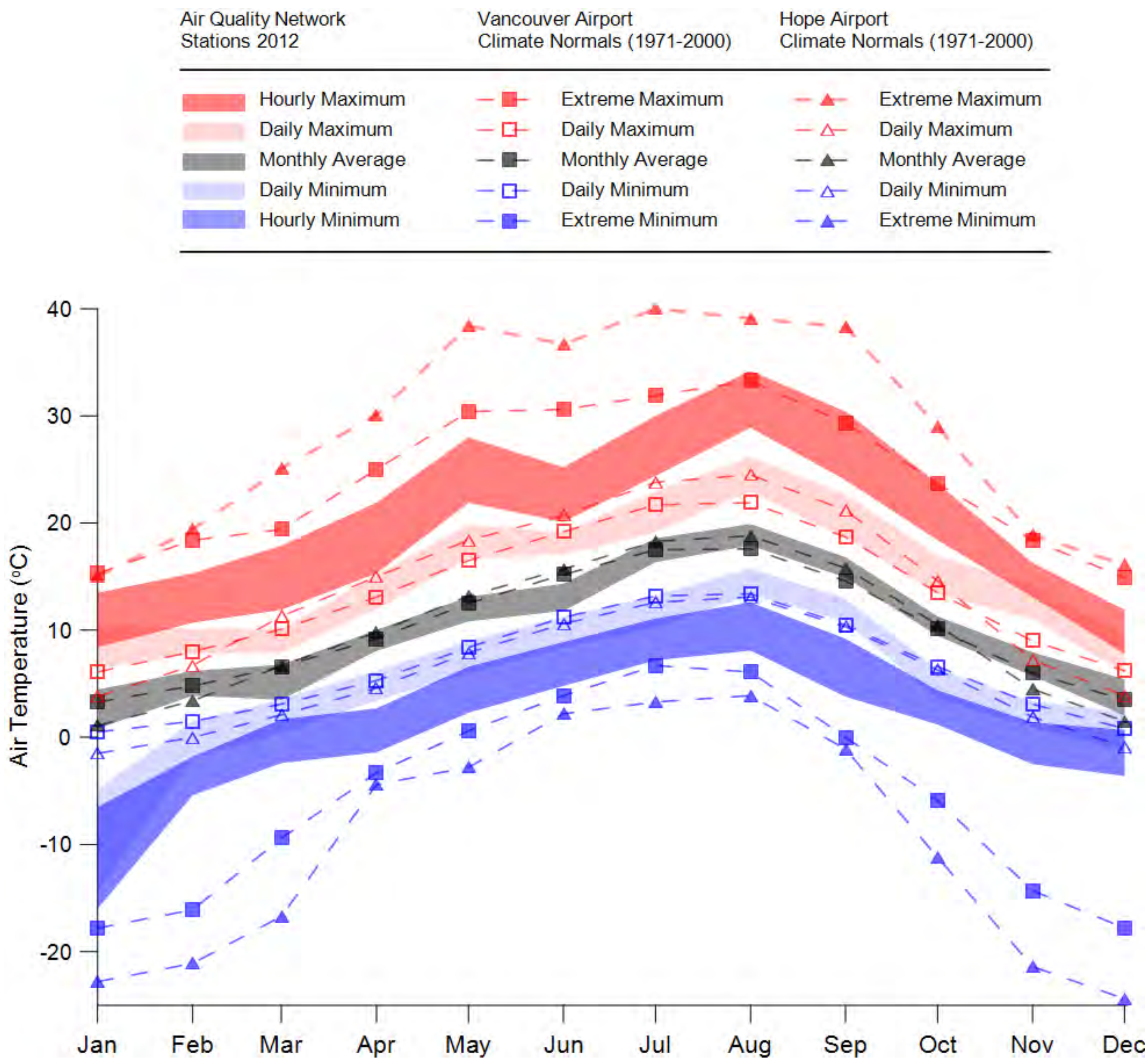


Figure 69: Precipitation totals in the LFV, 2012.



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, 2012.

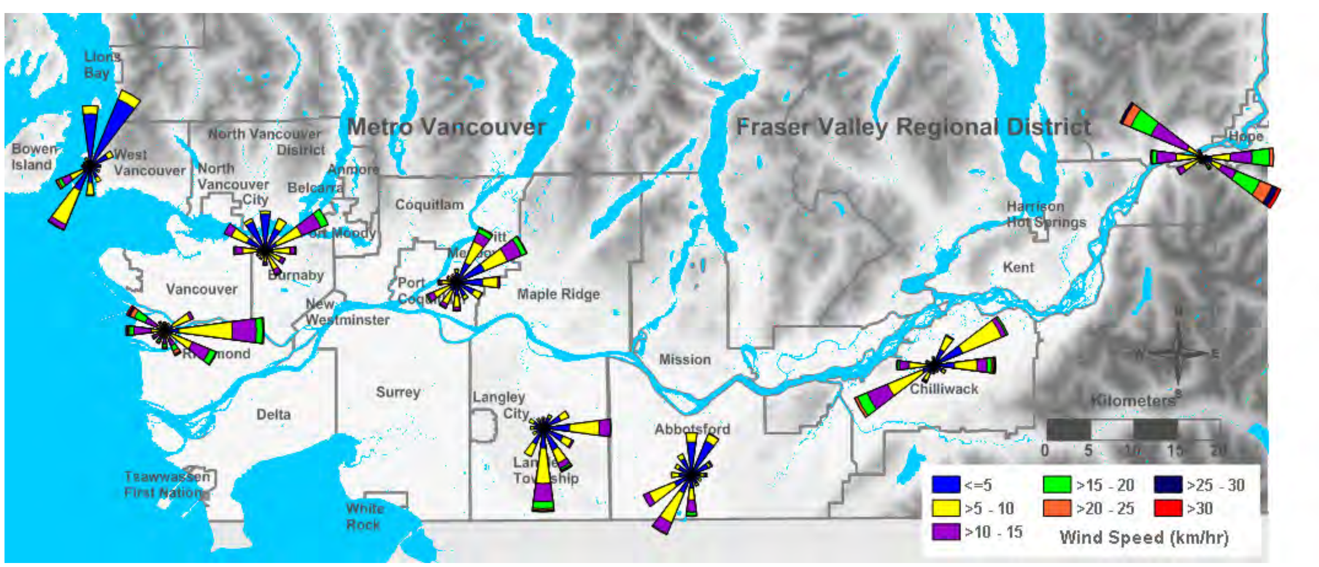


Note: LFV air quality network stations are shown as colour bands and Environment Canada 30-year climate normals are shown as dotted lines.

Figure 71: Monthly air temperatures in the LFV, 2012.

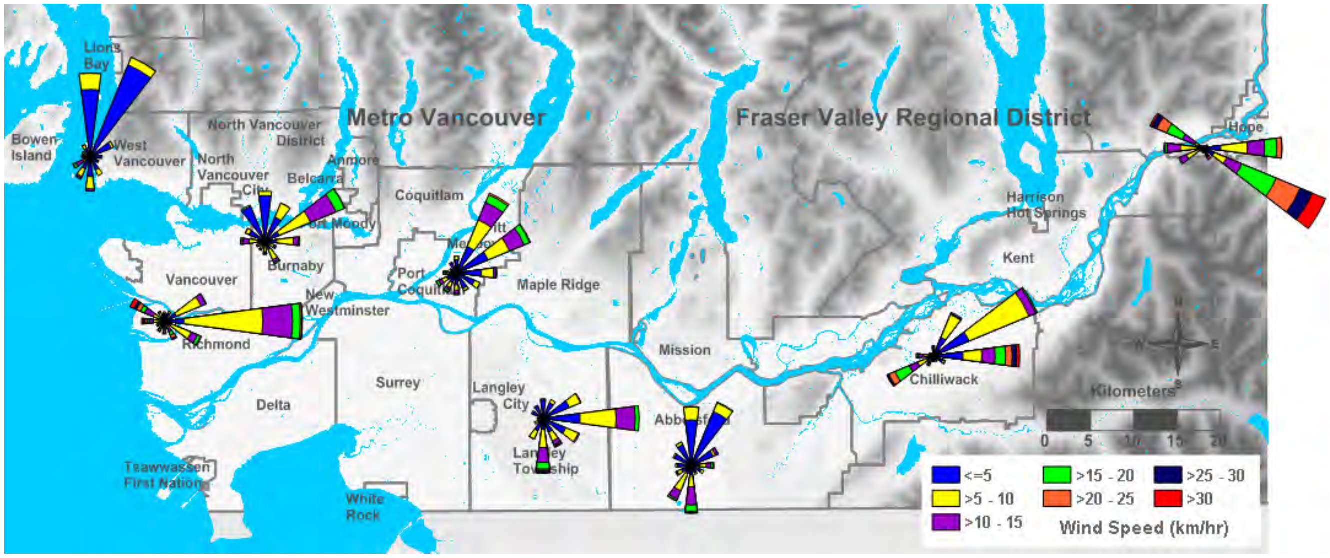
Table 10: Air temperature in LFV, 2012.

Station	Hourly Maximum (°C)	Hourly Minimum (°C)	Annual Average (°C)
Maple Ridge	34.2	-9.9	10.5
Abbotsford-Mill Lake	33.3	-11.9	10.4
Chilliwack	33.2	-14.4	10.4
Pitt Meadows	33.2	-10.2	10.0
Coquitlam	33.1	-8.9	10.5
Burnaby-Burmount	32.8	-8.6	10.9
Burnaby-Kensington Park	32.6	-8.1	9.7
Langley	32.6	-11.5	9.6
Hope	32.4	-16.0	9.9
North Delta	32.0	-10.2	9.3
Surrey East	32.0	-10.6	10.3
Richmond South	31.8	-7.6	10.6
Annacis Island	31.6	-8.1	10.7
N. Vancouver-Mahon Park	31.5	-7.0	10.5
Burnaby North	31.3	-7.0	10.6
Port Moody	31.0	-8.1	10.6
Burnaby South	30.5	-9.5	9.5
Burnaby-Capitol Hill	30.0	-9.0	9.3
Burnaby Mountain	29.8	-8.4	9.1
Vancouver-Kitsilano	29.6	-6.7	10.5
Richmond-Airport	29.0	-7.3	10.5
Horseshoe Bay	28.9	-6.5	10.1



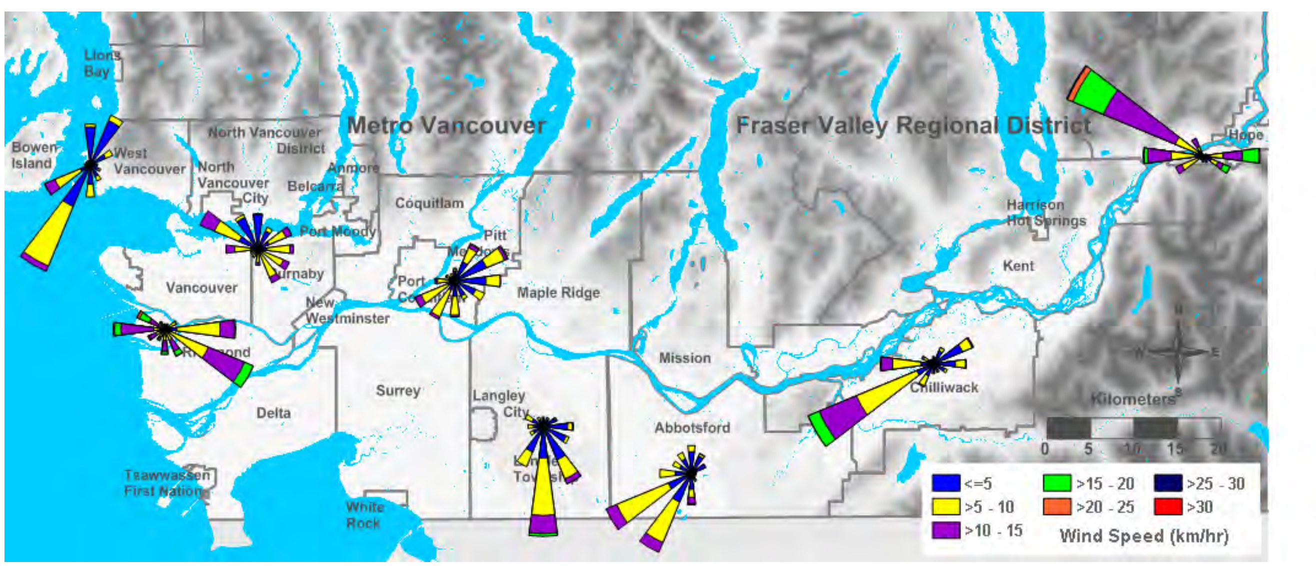
Note: The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 72: Selected annual wind roses throughout the LFV, 2012.



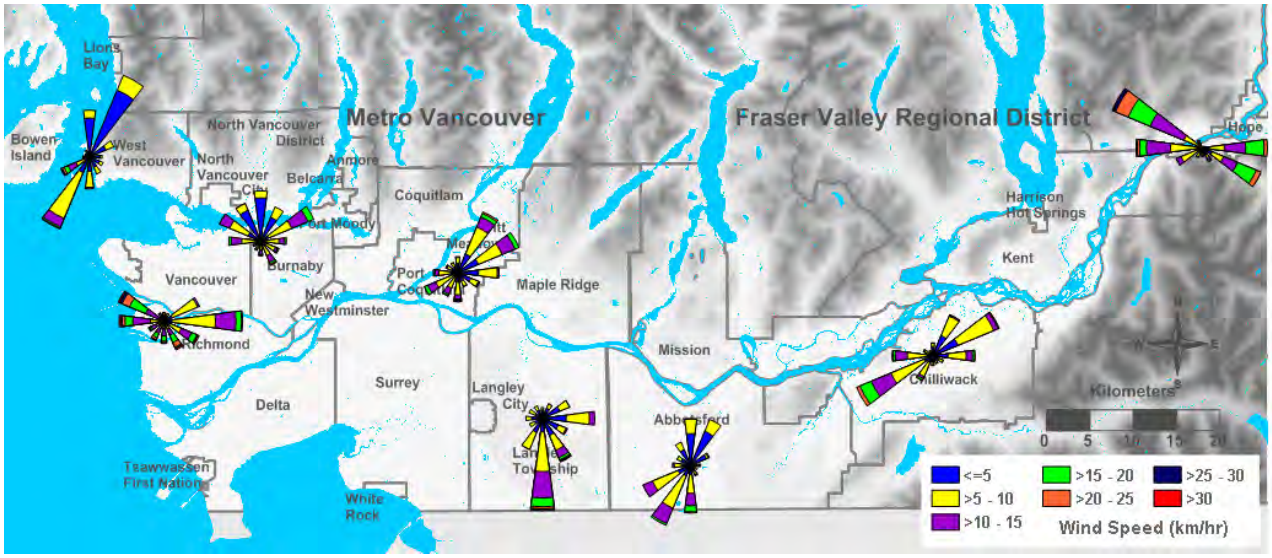
Note: The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 73: Winter (Dec 11, Jan 12, Feb 12) representative wind roses throughout the LFV, 2012.



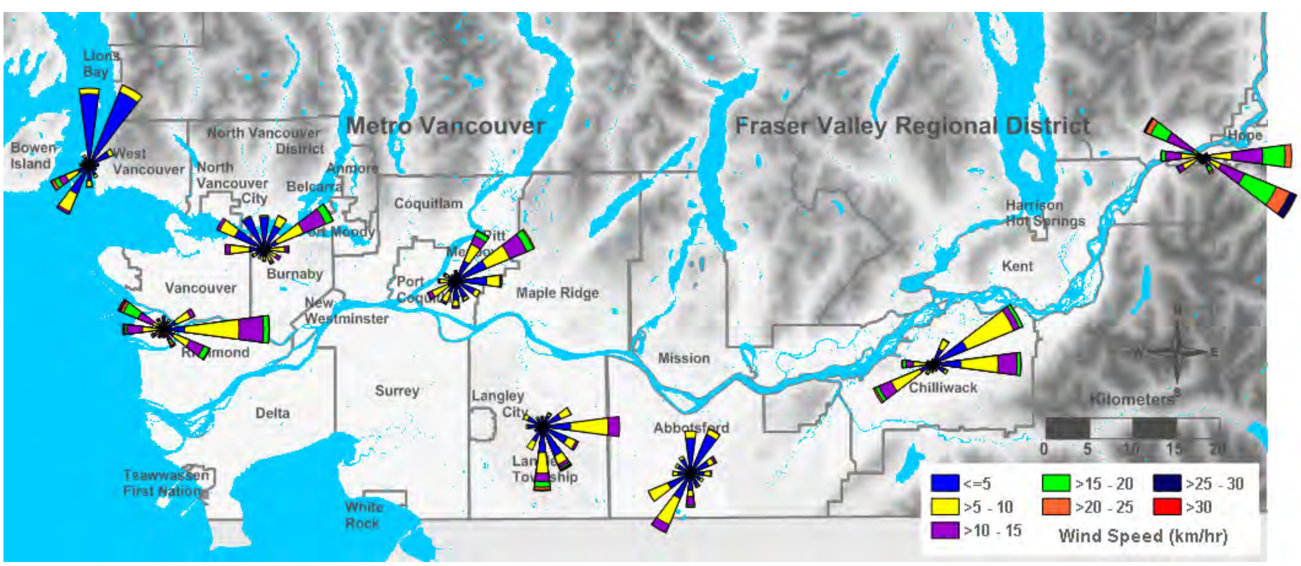
Note: The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence.

Figure 74: Summer (Jun, Jul, Aug) representative wind roses throughout the LFV, 2012.



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, 2012.



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, 2012.

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.

Construction of a new MAMU began in 2012 (shown on this page). Completed in early 2013, the new MAMU replaces the existing MAMU that has reached the end of its useful service after operating throughout the LFV for nearly 25 years.

Specialized study activity in 2012 included completion of a study in the Burrard Inlet areas of Vancouver, Burnaby and North Vancouver; assistance with a mini-ozone sensor study; and continued support of the background air quality station located in Ucluelet.

The Burrard Inlet Area Local Air Quality Study (BIALAQS) was initiated in 2008 with air quality measurements collected until the summer of 2010 at numerous locations. This two year study was large in scope with over 15 monitoring locations to investigate the air quality in the Burrard Inlet area. The study completed in 2012 with the completion of the analysis and final report.

A study was conducted to evaluate a new measurement technology by researchers from Environment Canada, University of British Columbia, University of Auckland and Aeroqual Ltd during the summer of 2012. Numerous small, lightweight, solar-powered sensors were deployed to measure ozone in the LFV and Sea-to-Sky airsheds. Sensors were installed, with the assistance of Metro Vancouver staff, at five LFV monitoring network stations to verify the calibration of the sensors and assess performance prior to field deployment and assess performance of the sensors compared to the standard network instruments. Results from the study will likely be published in peer-reviewed literature.

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.

Courtesy of City of Vancouver Archives (taken 1936).

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.

BC Hydro provides funding for three network stations, including Port Moody (T9), Burnaby Mountain (T14) and Surrey East (T15).

Kinder Morgan Canada provides funding for the Burnaby-Burmount (T22) station.

Port Metro Vancouver provides funding for the Tsawwassen (T39) station in Delta which became fully operational in 2010.

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.

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 the canisters and other sampling apparatus with Metro Vancouver staff providing field exchange of canisters, calibrations and routine maintenance of equipment. Canisters are then forwarded to the federal laboratory in Ottawa, for analysis of up to 177 VOC.
- A second program collects dichotomous particulate samples at three sites. This long-term program separates PM_{10} samples into two size fractions: 10 to 2.5 μm (coarse), and under 2.5 μm (fine). These samples are collected every third or sixth day, and returned to Ottawa for detailed chemical analysis.
- In 2003 a $PM_{2.5}$ speciation sampling program was initiated. Particulate speciation samplers were added to the Burnaby South and Abbotsford Airport stations. These samplers collect $PM_{2.5}$ samples every third day in specially designed cartridges which incorporate a series of filters and denuders. The samples are then forwarded to the federal laboratory in Ottawa where they are analyzed for various particulate species.

Quality Assurance and Control

Air quality monitoring data is constantly reviewed and validated. Technicians perform weekly inspections and routine maintenance of the monitoring equipment and stations. In addition, instrument technicians perform major repairs to any instrument in the network, as required. Through the data acquisition system, technicians can check on instruments remotely prior to 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 analyzers are subject to a performance audit 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 a central database using the internet, dedicated phone lines and radio links. Hourly averages for each analyzer 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.

Metro Vancouver completed installation of a new air quality data acquisition system and database to support the collection and reporting of air quality data. The new system replaced the legacy system during the summer of 2010, and vastly improves efficiency at both the operational and reporting levels.