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2011 Lower Fraser Valley Air Quality Monitoring Report Summary

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This report was prepared by the staff of the Air Quality Policy and Management Division of Metro Vancouver. The analysis and report was prepared by Geoff Doerksen with support from Ken Reid and Julie Saxton. The monitoring network is operated and maintained by a team including Tim Jensen, Michiyo McGaughey, Fred Prystarz, Scott Wong and Surjit Nizzar with instrumentation support provided by Dave Pengilly, Shawn Connelly, and Don Robertson.

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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 2011 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 2011 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 2011, specialized studies were continued from previous years in New Westminster, Surrey, and in the Burrard Inlet areas of Vancouver, Burnaby and North Vancouver. In Port Coquitlam, a wood smoke monitoring study was conducted from February to April, 2011.

Visual Air Quality

Visual air quality (also known as visibility and haze) can also be degraded in the LFV, causing local views to become partially obscured. This haze may have different characteristics depending on the location. In much of Metro Vancouver, especially the more urbanized areas to the west, the haze can have a brownish appearance due to emissions of nitrogen oxides from transportation sources. Further east in the LFV impaired visibility is often associated with a white haze, which is due to small particles ($PM_{2.5}$) in the air that scatter light.

Monitoring conducted for assessing visibility and haze includes continuous measurements of ammonia, $PM_{2.5}$ and important 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. When these photographs are examined alongside the pollutant measurements, visibility impairment can be related to pollution concentrations and their sources. The data being collected provide important information to a multi-agency initiative to develop a pilot 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 (TRS).

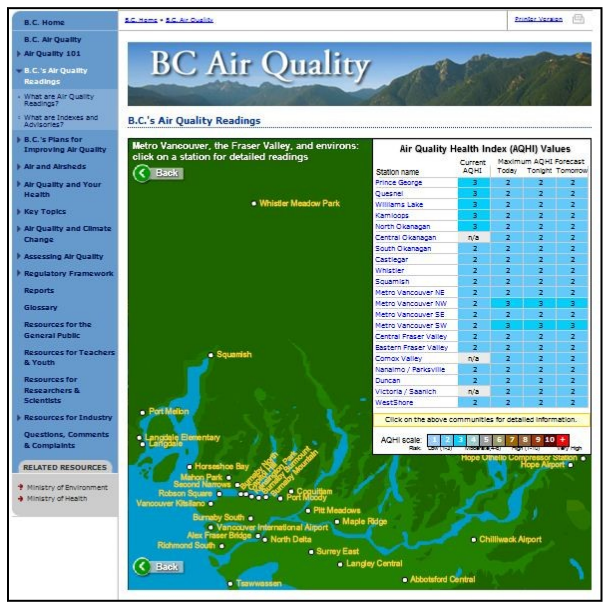
Priority Pollutants

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 the $PM_{2.5}$ emitted from diesel fuel combustion in car, truck, marine, rail and non-road engines. These particles ("diesel PM") are thought to contribute significantly to the health effects identified above. Reducing emissions from diesel engines is a priority of Metro Vancouver's diesel emission reduction program. New instrumentation for monitoring diesel particulate is being added to the network.

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: http://www.airhealth.ca, and http://www.bcairquality.ca/readings/



Air Quality Objectives and Standards

Several pollutant-specific air quality objectives and standards are used as benchmarks to characterize air quality. They include 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. No air quality advisories were issued in 2011.

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.

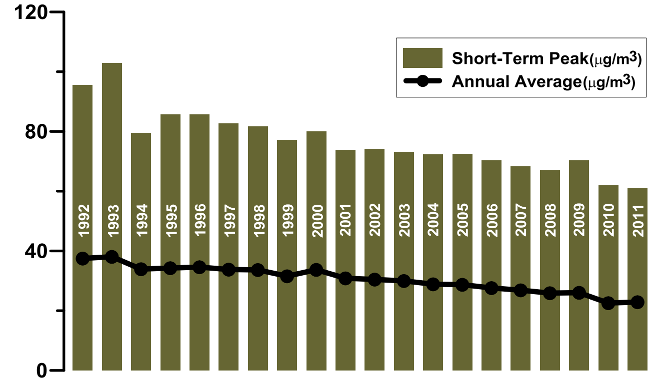


Figure S1: Nitrogen Dioxide Trend

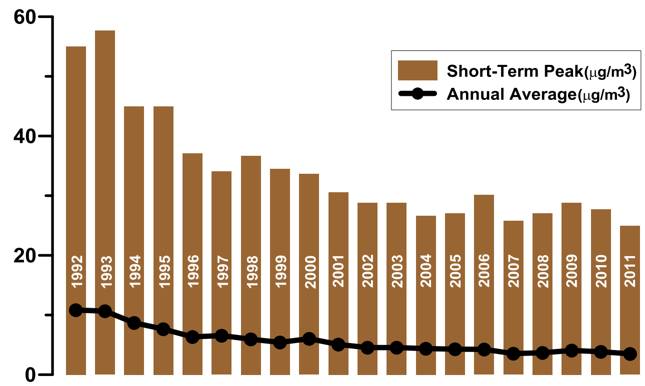


Figure S2: Sulphur Dioxide Trend

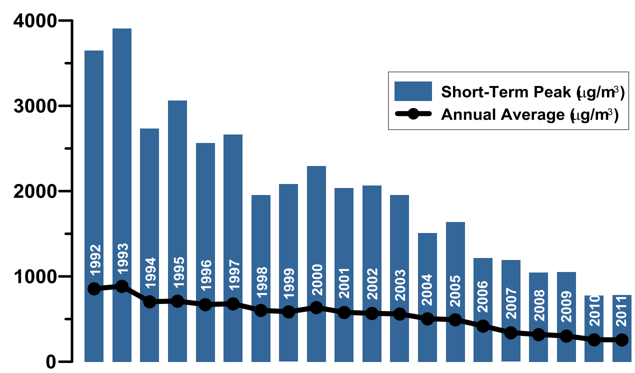


Figure S3: Carbon Monoxide Trend

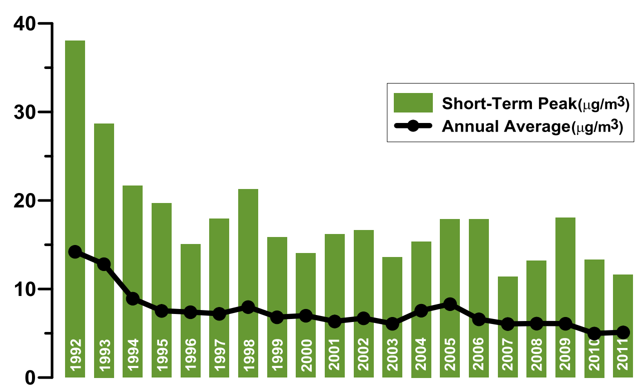


Figure S4: Particulate Matter ($PM_{2.5}$) Trend

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.

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.

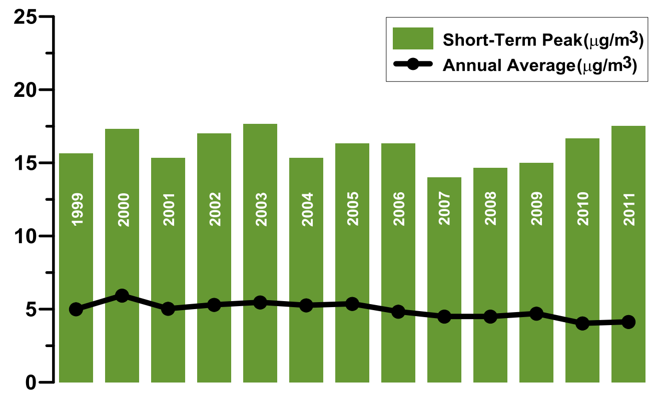


Figure S5: $PM_{2.5}$ Trends

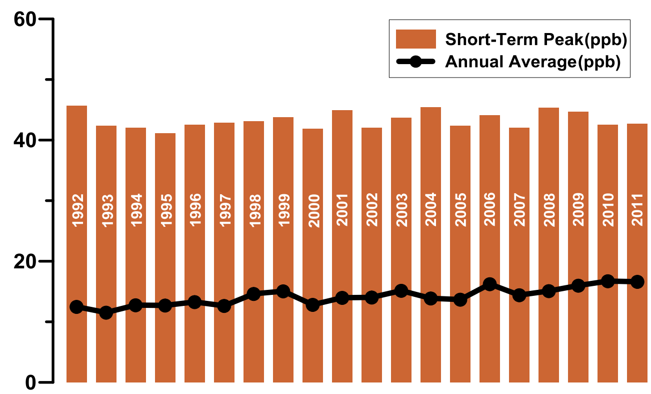


Figure S6: Ozone Trends

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. These findings are being incorporated into strategies in the new Integrated Air Quality and Greenhouse Gas Management Plan.

Ground-Level Ozone – 2011

Monitoring results for all ozone monitoring stations in 2011 are shown in Figure S7. The data show that peak ozone levels, as measured by the Canada-Wide Standard and maximum 1-hour average values, occurred in the eastern parts of Metro Vancouver and in the FVRD during sunny and hot weather.

Exceedances of the ozone objective have occurred in the LFV every year between the years 2001 and 2009, but 2011 was the second consecutive year of an improvement trend. In 2011, no objectives for ozone were exceeded at any monitoring stations. For the second year in a row, Metro Vancouver's more stringent eight hour ozone objective was also not exceeded (not shown). Overall 2011 was notable for its lower ozone levels relative to previous years, likely because of a lack of prolonged hot and sunny weather conditions that are conducive to producing high ozone concentrations. As a result, no air quality advisories were issued in 2011.

Ozone is termed a secondary pollutant because it is formed in the air from other contaminants such as nitrogen oxides (NO_X) and volatile organic compounds (VOC). The highest concentrations of ozone are generally formed during hot sunny weather.

NO_X emissions are dominated by transportation sources, with nearly 80% of the emissions coming from cars, trucks, marine vessels, and non-road engines. VOC are emitted from natural sources (e.g. emissions from vegetation), cars, light trucks, and solvent evaporation from industrial, commercial and consumer products.

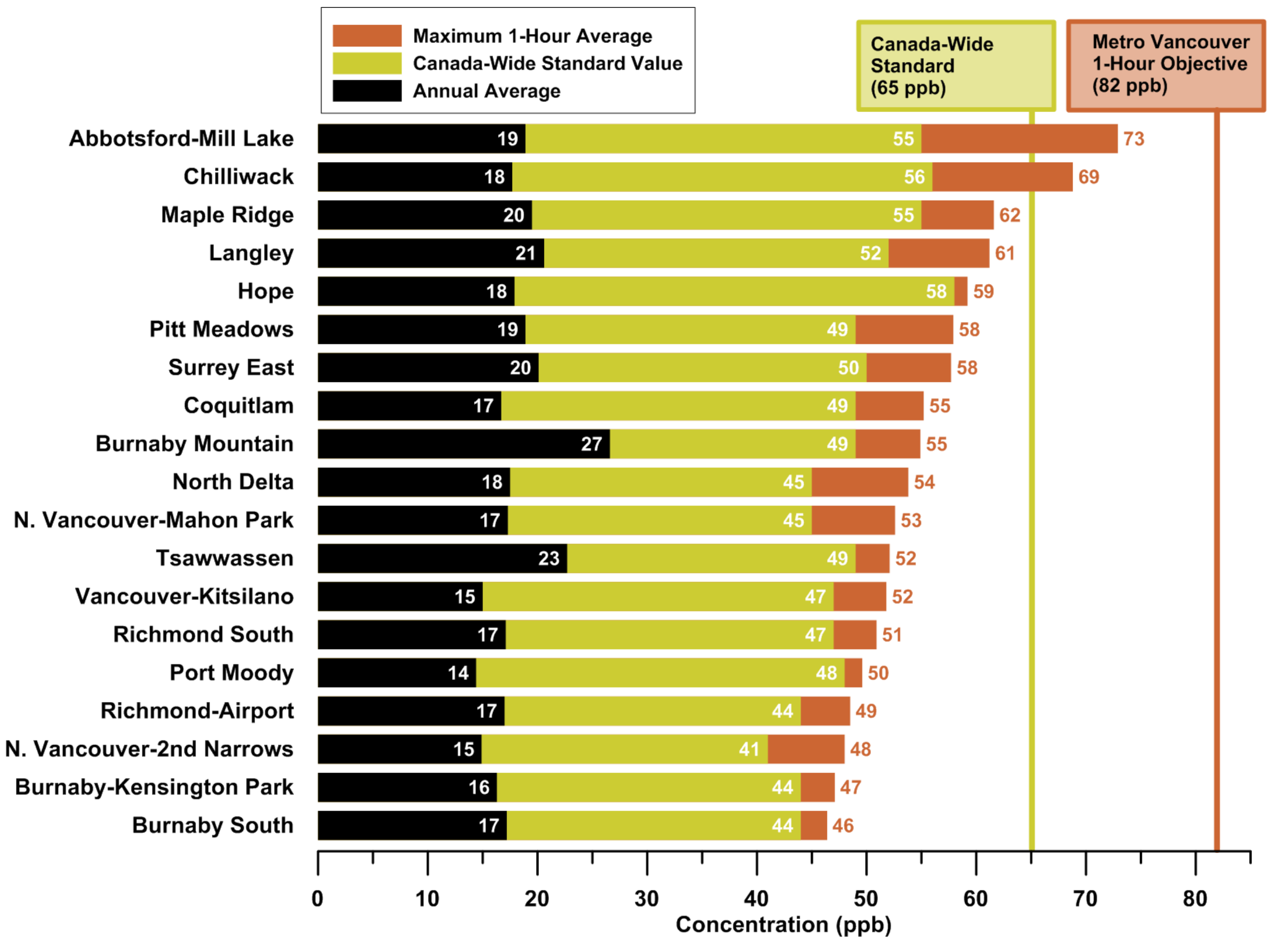


Figure S7: Ozone (O_3) 2011.

Fine Particulate Matter ($PM_{2.5}$) – 2011

Monitoring results for all $PM_{2.5}$ monitoring stations with sufficient data requirements are shown in both Figure S8 and S9. All stations were below Metro Vancouver's annual objective of 8 micrograms per cubic metre and annual planning goal of 6 micrograms per cubic metre. In addition, there were no exceedances of Metro Vancouver's 24-hour $PM_{2.5}$ objective at any of the stations.

The year 2011 lacked the consecutive days of hot and sunny weather conditions that are conducive to secondary $PM_{2.5}$ formation. Similarly, the lack of hot and dry weather resulted in an diminished forest fire season compared with the most recent years. In the past two years exceedances of the 24-hour objective were experienced in the LFV due to forest fire smoke transported from outside the region.

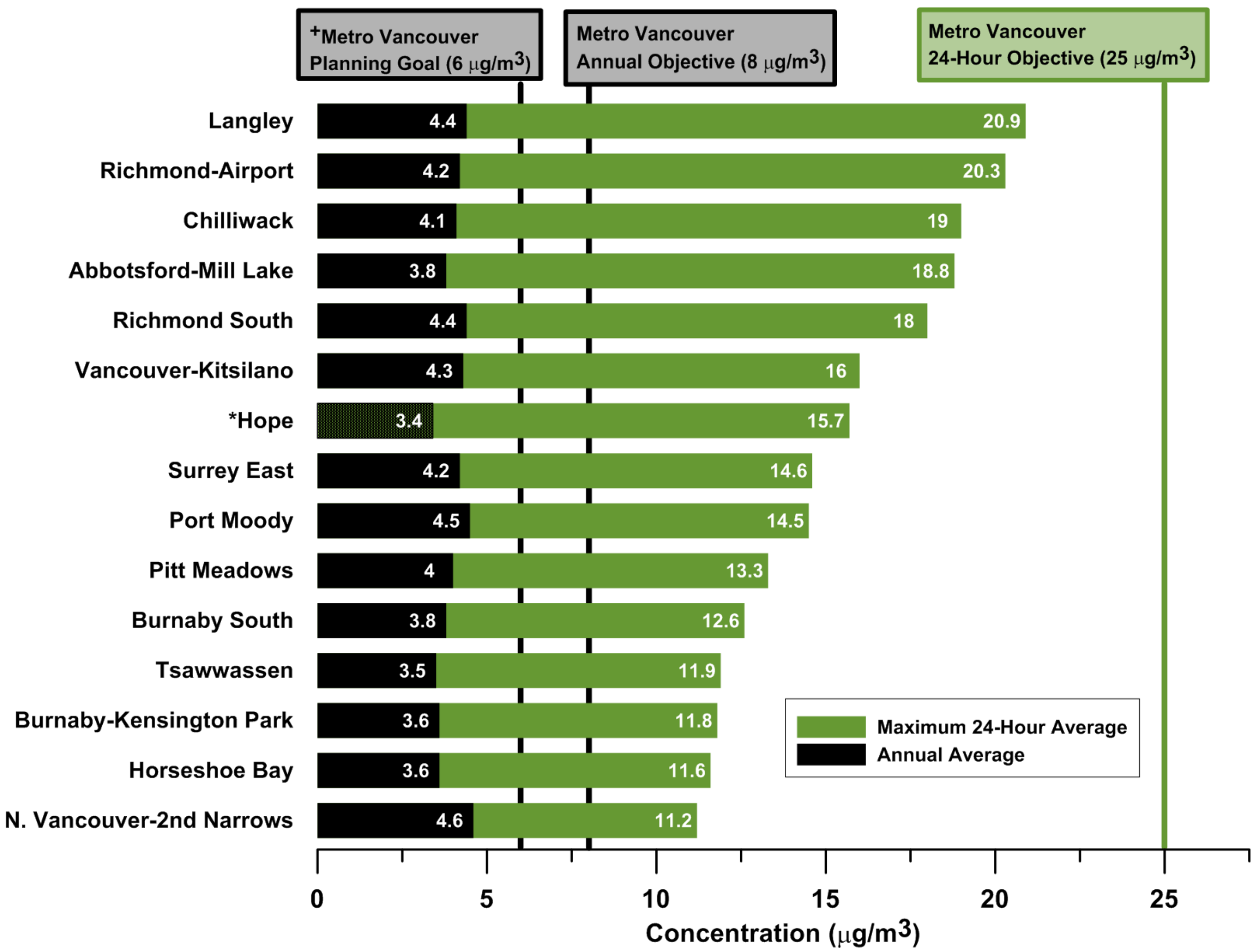


Figure S8: Fine Particulate Matter ($PM_{2.5}$) 2011.

** Data completeness criteria for the provincial annual average were not met at the Hope station. The annual average shown above for Hope was calculated from all available data for the year.*

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

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 percentage of $PM_{2.5}$

All locations were also well below the Canada-wide Standard for $PM_{2.5}$ (Figure S9). Insufficient $PM_{2.5}$ data were available for several of the stations in 2011 to calculate the Canada-Wide Standard value and therefore fewer stations are shown in Figure S9 than in Figure S8.

An exceedance of the Canada-Wide Standard for continuous $PM_{2.5}$ concentrations has never been measured in the LFV.

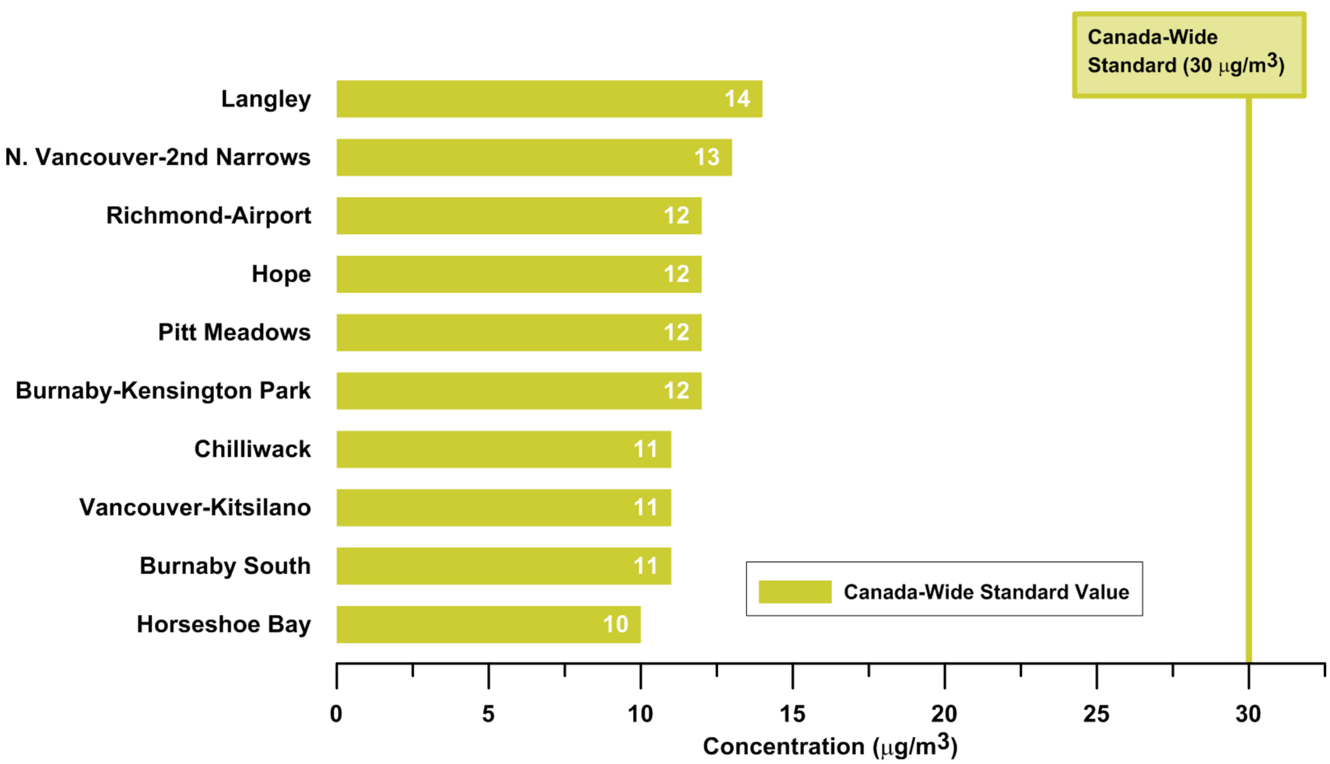


Figure S9: Fine Particulate Matter ($PM_{2.5}$) Canada-Wide Standard 2011.

Sulphur Dioxide – 2011

Monitoring results for all sulphur dioxide (SO_2) monitoring stations in 2011 are shown in Figure S10. Sulphur dioxide measurements 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.

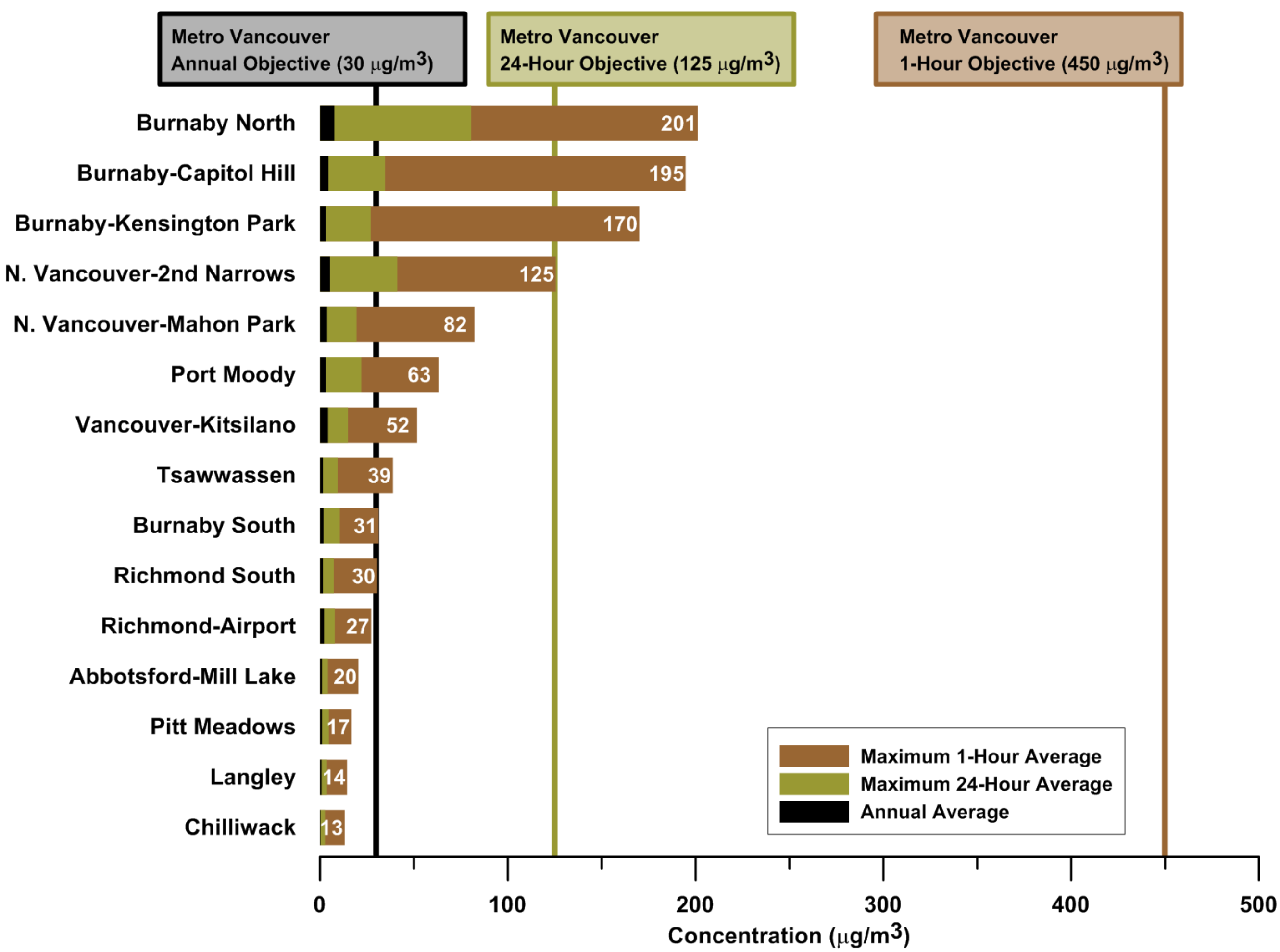


Figure S10: Sulphur Dioxide (SO_2) 2011.

Nitrogen Dioxide – 2011

Results for nitrogen dioxide (NO_2) monitoring in 2011 are shown in Figure S11. All stations experienced 1-hour nitrogen dioxide averages that were below Metro Vancouver's objective. Annual averages were also below Metro Vancouver's annual objective at all stations with sufficient data completeness. In recent years the highest average nitrogen dioxide levels were measured in downtown Vancouver, in a dense urban environment and close to a busy street. Figure S11 does not include data from this station due to a temporary shut down during most of 2011.

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.

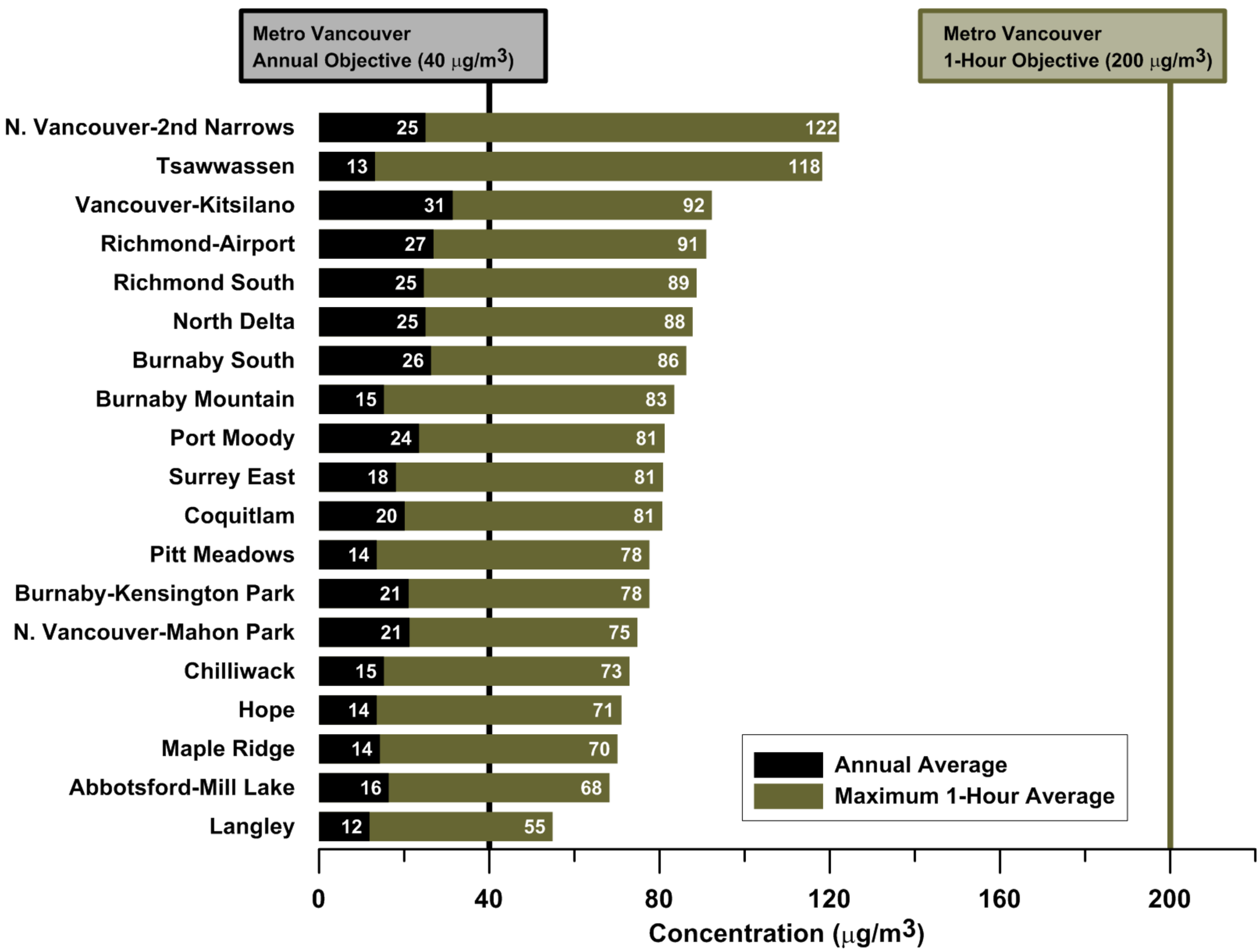


Figure S11: Nitrogen Dioxide (NO_2) 2011.

Carbon Monoxide – 2011

Carbon monoxide (CO) monitoring results for 2011 are shown in Figure S12. 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.

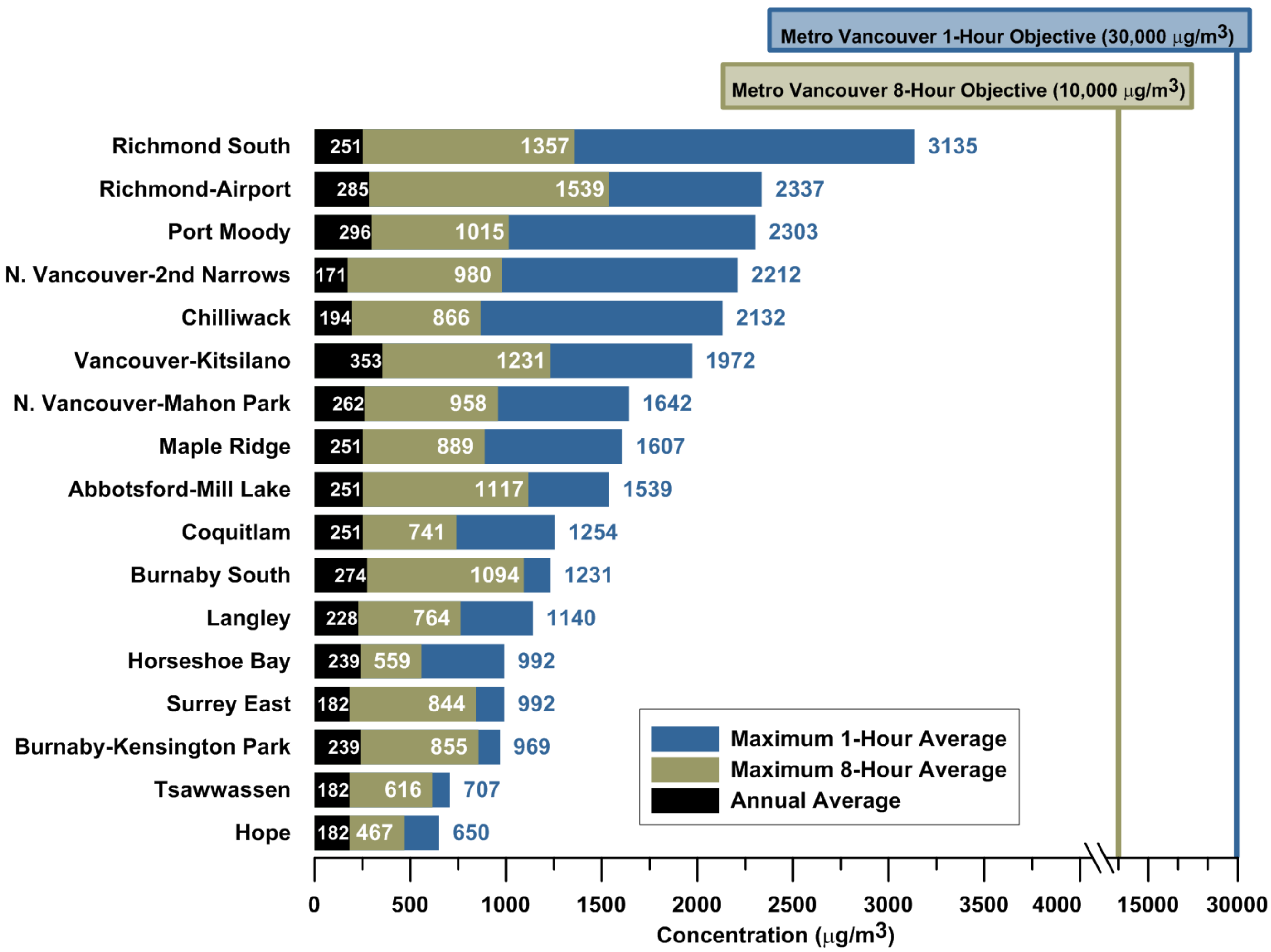


Figure S12: Carbon Monoxide (CO) 2011.

Note: The scale is broken in the x-axis between 4,000 and 10,000 $\mu g/m^3$. The highest concentration measured is almost ten times less than the objective threshold.